CHAPTER 3

CURRENT STATUS OF ELECTRIC POWER SECTOR

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3.1 Organization of Electric Power Sector

Until the end of 1994

MOE controls administrative organizations relating to the electric power sector, consisting of IEV, 2 PIDCs, 3 PCs, etc. MOE also controls coal production sector consisting of 4 coal companies. Oil and gas sector is directly controlled by the Government, consisting of Petrovietnam (upstream refinery petrochemical), Vietgas (to develop gas) and Vietsovpetro (developing Bach Ho oil field, a joint venture with Russia). PCs are enterprises operating power system facilities of generation, transmission and distribution. PCs also implement the construction works as the owner. When required PCs become the borrower of the fund under the governmental guarantees. 3 PCs' operating area consist with the Northern, the Southern and the Central regions as already described in 2.2.1. IVE prepares the energy policies and the Master Plan on the energy and the electric power development. PIDCs take charge of engineering studies on generation and transmission facilities (Refer to Figure 3.1-1).

After the beginning of 1995

EVN is established based on the Decision of Prime Minister (Number 562/TTg) dated Oct. 10, 1994. EVN with the juridical personality, has the organizational structure consisting of Management Board, General Director and Member Units which are independently accounting state-owned enterprises, dependently accounting state-owned enterprises and non-production units. Each member unit is organized and operates in accordance with its separate "Charter" in conformity with provisions of the laws and the Charter (Number 14/CP) (Refer to Figure 3.1-2).

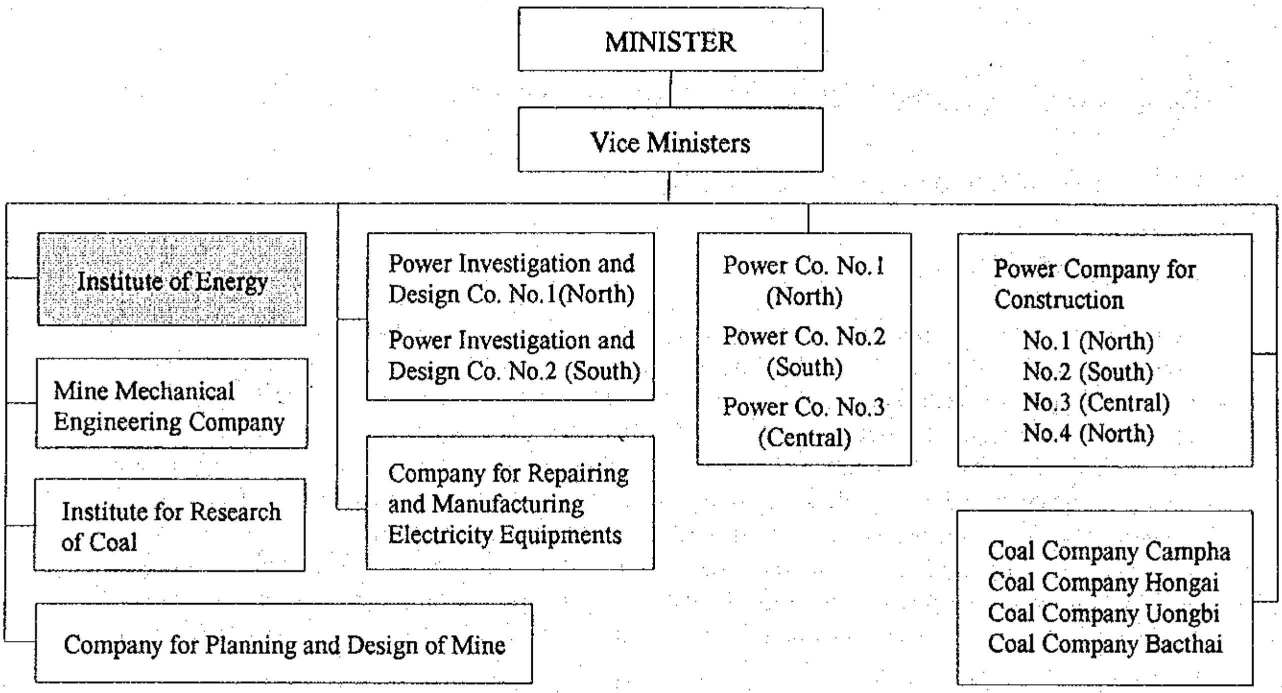

Figure 3.1-1 Organization Chart of MOE until the end of 1994

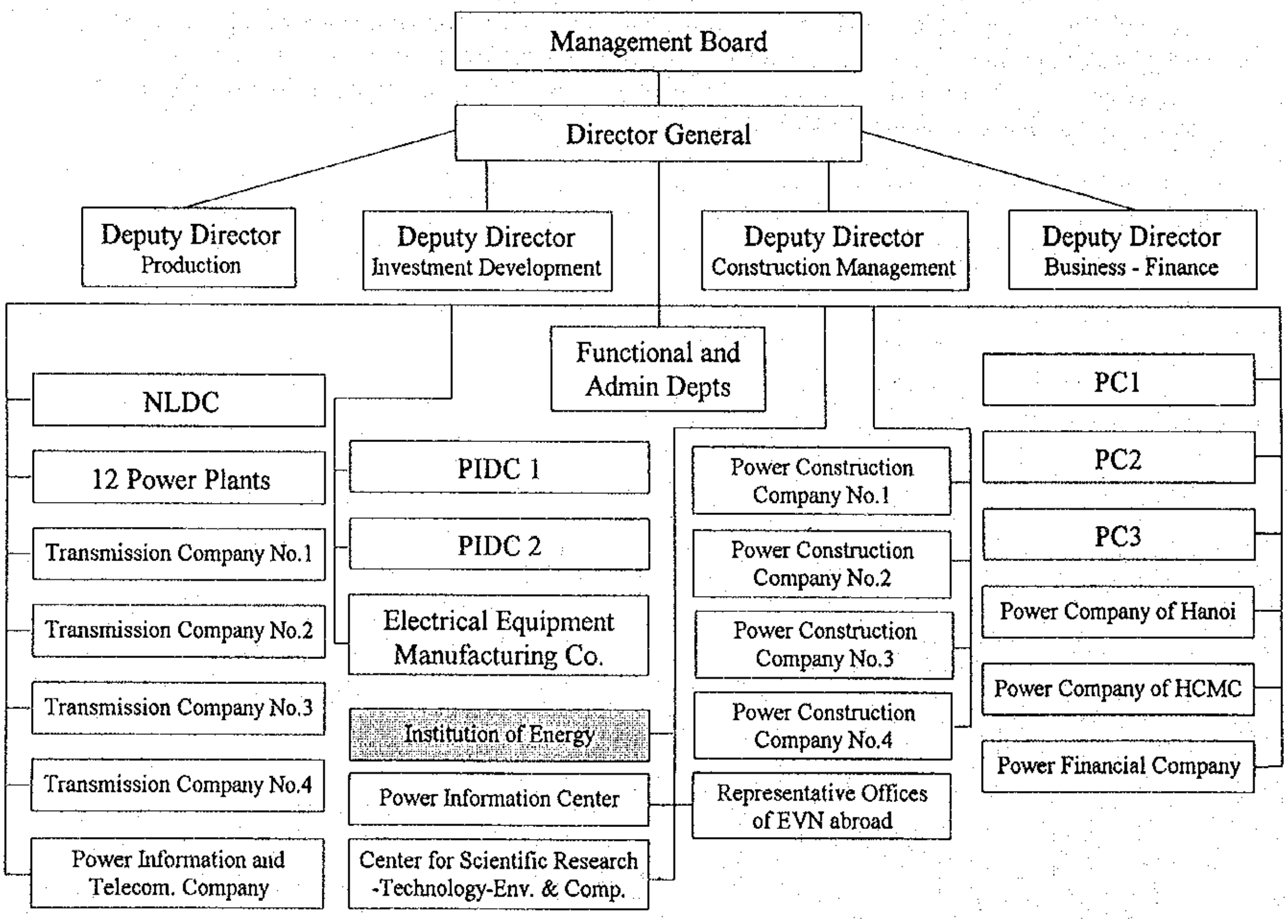

Figure 3.1-2 Organization Chart of EVN after the beginning of 1995

3.2 Power Demand and Supply

3.2.1 Power Demand and Supply

The historical trends of electric power demand and supply in the country are summarized in Table 3.2-1 through 3.2-4.

Electric power demand (sales power) not including power plant auxiliaries and system losses increased from 2,670 GWh in 1980, to 6,187 GWh in 1990 and 9,198 GWh in 1994. Growth rate per annum during 1980-1994 of total demand was 9.24%. Growth rates of industrial, non-industrial, transport and residential demand were 7.89%, 8.49%, 6.93%, and 11.01% respectively. Leading drive force of electricity consumption was the rapid increase of residentail demand, mainly lighting demand supposedly. These data show that household electrification in urban areas progressed in the 1980's and rural electrification began to improve from the beginning of the 1990's.

The demand for industrial sector was 4,059 GWh accounting for 44% of the total demand, followed by residential sector which consumed 3,800 GWh (41%) in 1994. Non-industrial, agricultural, and transport sectors are minor users of electricity. In the Southern region, industrial demand accounted for 50% of the regional demand and the share of residential demand was 36% in 1994. On the other hand, the share of industrial and residential demand in the Northern region were 40% and 47% respectively (1994).

Electric power generation increased from 3,559 GWh in 1980, to 8,679 GWh in 1990 and to 12,195 GWh in 1994. Hydropower generation recorded 8,872 GWh accounting for 73% of the total power in 1994 (1,488 GWh, 42% in 1980, 1,472 GWh, 29% in 1985 and 5,369 GWh, 62% in 1990). Such a large increase has been achieved by putting into operation the Hoa Binh hydropower plant (1,920 MW, the Northern region) and Tri An hydropower plant (400 MW, the Southern region). Power generated by thermal power plants decreased from the peak of 4,433 GWh (65.4%) in 1988 to 1,776 GWh (16.6%) in 1993, because of increase in the hydropower generation described above.

In 1994, the completion of 500 kV transmission line made it possible to send the surplus power and energy in the North to the South. As the result, regional demand in the South and the Center recorded the growth rates of 21.7% and 19.8% respectively in 1994. The thermal power generation increased again in addition to hydropower in the Northern region. Actually the thermal power generation in the Northern region increased from 636 GWh in 1993 to 1,288 GWh in 1994, and the generation in the Southern region decreased from 1,140 GWh (1993) to 960 GWh (1994). The hydropower generation in the Norhtern region increased from 5,091 GWh (1993) to 5,834 GWh (1994).

Interchanged electric power among the three regions in 1993 and 1994 are shown in Table 3.2-3. In 1993, the Northern and Southern regions exported electric power to the Central reigon. However in 1994, the Northern region exported the surplus electric power to the other two regions through 500 kV transmission line.

3.2.2 Power Supply System

Table 3.2-5 shows the supply capability of existing power plants as of the end of 1994.

The supply capability in the whole country is enough amount for the peak power (2,300 MW in 1994). However, supply situations were different by region until recently. The Northern region with large hydropower plant has surplus capacity after the completion of Hoa Binh hydropower project in April

1994. By contrast, the Southern supply system tends to suffer power shortages, especially in dry season (during October to April) despite additional installation of gas turbines at Ba Ria thermal power plant.

The Center with light and scattered customers mainly relies on its power sources on the import from the North via 220 kV, Hoa Bin-Vinh-Dong Hoi, long distance transmission line (approx. 550 km) and from Da Nhim hydropower plant in the South by 110 kV system to Nha Trang.

The completion of the 500 kV transmission line changed this situation and began to contribute to balance power supply situations among three regions. The demand in the South jumped up when it became possible to consume enough electricity, being imported 800 GWh only in the latter half of 1994. Annual average increase of the demand in the South recorded 21.7% last year. This increase is considered to continue in 1995 and this will cause more generation at three coal thermal power plants in the North.

Though Hoa Binh power plant will be operated at its full capability in 1995, annual planned generating energy is estimated to be 80% level as compared with annual average energy.

The Center is also benefited by the 500 kV line, changing its receiving point from Dong Hoi substation to Da Nang and Pleiku 500 kV substations. At present the demand growth in Da Nang area may be suppressed due to limitation of middle voltage transformer capacities in the connected substations. However, following the improvement of transmission and distribution systems, (Pleiku-Quy Nhon 220 kV system is completed. Pleiku-Krong Buk-Nha Trang 220 kV system will be completed in the near future) demand in the Center is forecast to grow at higher ratio than other regions.

Near future power projects

The government decided to develop large scale power projects aiming at those commissioning within this decade. They are,

Region	Plant Name	Type	Output	Commissioning Year
North	Pha Lai II	Coal	2 x 300 MW	1999/2000
Center	Yaly	Hydro	720 MW	1999/2000
	Song Hinh	Hydro	70 MW	1997
South	Phu My	Gas	3 x 200 MW	1998/1999/1999
	Ham Thuan/Da Mi	Hydro	472 MW	2000

Yaly and Song Hinh hydro projects entered in construction, but other three are under engineering stages.

3.2.3 Power Transmission by 500 kV Transmission Line

The 500 kV transmission line began its 1st stage operation in June 1994, with maximum 300 MW of sending power capability, between Hoa Binh substation in the North and Phu Lam substation in the South with approximately 1,500 km distance. The 2nd stage of the project completed in September 1994 with maximum 500 MW of sending power capability to the South and tapping 2 substations in the Central region (Da Nang and Pleiku). Its operation results in 1994 are as follows.

	Hoa Binh	Da Nang	Pleiku	Phu Lam
Energy (GWh)	990	106	14	770
Max. Power (MW)	574	121	49	418

The transmission line has been successfully operating without substantial trouble since its commissioning.

In December 1994, it transmitted 256 GWh of energy in a month which means, approximately 70% of monthly load factor for the designed transmission capability of 500 MW. The maximum sending power of 630 MW was recorded at Hoa Binh substation and the maximum receiving power of 478 MW at Phu Lam substation in January 1995.

3.2.4 Monthly Peak and Daily Load Curve

Monthly peak load curves in past years and typical daily load curves are shown in Figure 3.2-1. These figures are selected in the Northern and Southern regions.

In general, the maximum values of monthly peak recorded are taken around November (dry season) in the Southern region and around September or November in the Northern region. The minimum values of the monthly peak are able to be taken around April of the end of rainy season.

As shown in both daily load curves of the Northern and Southern regions, daily peak time is from 19:00 (in December) to 20:00 (in April) in the Northern region, and from 18:00 (in December) to 19:00 (in April) in the Southern region. Electricity consumption in this time zone is due to lighting demand for meal time in households.

The electric power consumption in the day time (9:00 - 12:00) is supposed to be raised by industrial demand. As the share of industrial sector to the total electric power demand is projected to be expanded, the load difference between the day time and the dinner time zones might be lightened relatively.

Table 3.2-1 Consumption

(Unit: GWh, %)

	1980	1985	AGR (%) 85/80	1990	AGR (%) 90/85	1993	AGR (%) 93/90	1994	AGR (%) 94/93	AGR (%) 94/80
Whole Country	2,670	3,869	(7.70)	6,187	(9.85)	8,007	(8.97)	9,198	(14.88)	(9.24)
N. Region	1,414	2,150	(8.74)	3,164	(8.03)	3,879	(7.02)	4,186	(7.92)	(8.06)
C. Region	145	274	(13.62)	434	(9.64)	638	(13.66)	764	(19.82)	(12.60)
S. Region	1,111	1,444	(5.38)	2,589	(12.38)	3,491	(10.48)	4,248	(21.70)	(10.05)

Note: AGR = Annual Growth Rate (%)

Table 3.2-2 Generation

(Unit: GWh, %)

	1980	1985	AGR (%) 85/80	1990	AGR (%) 90/85	1993	AGR (%) 93/90	1994	AGR (%) 94/93	AGR (%) 94/80
Whole Country	3,559	5,065	(7.31)	8,679	(11.37)	10,729	(7.33)	12,195	(13.66)	(9.20)
N. Region	1,870	2,849	(8.79)	4,869	(11.31)	5,814	(6.09)	7,142	(22.84)	(10.04)
C. Region	145	249	(11.53)	357	(7.44)	247	(-)	253	(2.43)	(4.06)
S. Region	1,545	1,966	(4.94)	3,453	(11.92)	4,668	(10.58)	4,800	(2.83)	(8.43)

Note: AGR = Annual Growth Rate (%)

Table 3.2-3 Actual Interchanged Power

(Unit: GWh)

	1993			1994		
from \ to	N.	C.	S.	N.	C.	S.
N. Region	-	441	0	-	552	900
C. Region	-441	-	-161	-552	-	-220
S. Region	0	161	-	-900	200	-

Table 3.2-4 Demand Structure in 1994

<Consumption> (Unit: GWh, %)

	Industry	Non I.	Trans.	Agri.	House	Total
Whole Country	4,059 (44)	742 (8)	82 (1)	516 (6)	3,800 (41)	9,199 (100)
N. Region	1,678 (40)	221 (5)	30 (1)	304 (7)	1,953 (47)	4,186 (100)
C. Region	258 (34)	81 (11)	12 (1)	87 (11)	327 (43)	765 (100)
S. Region	2,123 (50)	440 (10)	40 (1)	125 (3)	1,520 (36)	4,248 (100)

Table 3.2-5 Supply Capability of Existing Power Plants (1994)

(Unit: MW)

Region		Hydro-power	Thermal Power		Gas Turbine	Diesel	Total
			Fuel Oil	Coal			
North	Installed	2,028	0	645	28	0	2,701
	Available	2,028	0	640	12	0	2,680
South	Installed	713	205	0	388	201	1,507
	Available	713	193	0	287	78	1,271
Center	Installed	85	0	0	0	177	262
	Available	85	0	0	0	115	200
Whole Country	Installed	2,826	205	645	416	378	4,470
	Available	2,826	193	640	299	193	4,151

Source: IEV, PC1, PC2 and PC3

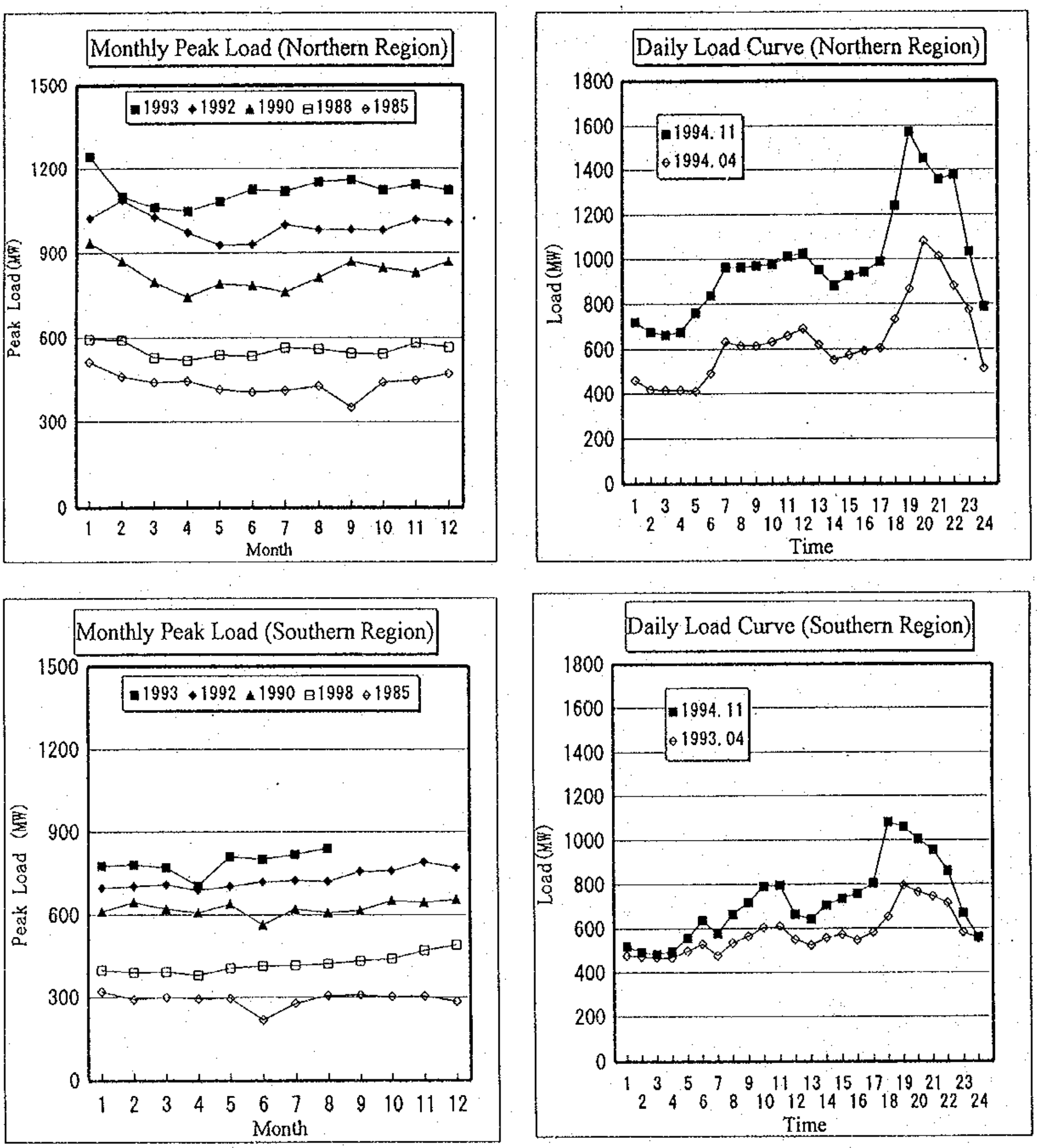

Figure 3.2-1 Monthly Peak and Daily Load Curve

3.3 Power Generation Facilities

Existing installed capacity of power stations in the country is 4,470 MW as of the end of 1994 as shown in Chapter 3.2.2.

The list of generation facilities is shown in Table 3.3-1, and the location of the facilities is shown in Figure 3.3-1.

3.3.1 Thermal Power Generation Facilities

Facilities in the north are conventional thermal 645 MW and gas turbine 28 MW. In the south, they are conventional thermal 205 MW, gas turbine 388 MW and diesel power generation 201 MW.

Development lags behind in the central regions. Here, the thermal power generation facilities are small scale diesel power facilities scattered throughout the area. The installed capacity is 177 MW from 208 units, although the effective capacity is only 78 MW due to aging, poor maintenance conditions and other factors.

The salient features of thermal power plants are shown in Table 3.3-2.

(1) Pha Lai Thermal Power Plant

Pha Lai thermal power plant has four former U.S.S.R. made 110 MW units and is the largest and most important power plant in the north. The unit is a two-boiler type, and the fuel is Mao Khe coal and Hong Gai coal (both are anthracite). The four units were commissioned in 1983, 1984, 1985 and 1987 respectively, and operated at base load until the Hoa Binh hydropower plant was completed in 1989. In that period, power shortage continued in the north and the Pha Lai thermal power plant was an important power supply source. For that reason, there was a lack of consideration towards operating efficiency, environmental protection measures and infrastructural contributions to the regional society.

With the completion of the Hoa Binh hydropower plant, the Pha Lai thermal power plant's energy generation decreased and, also due to shortages of main spare parts, its operating performance is lowering.

Currently, the power plant units are undergoing rehabilitation.

(2) Ninh Binh Thermal Power Plant

Ninh Binh thermal power plant is in Ninh Binh Town located about 100 km south of Hanoi. This is a coal-fired thermal power plant with four 25 MW units which uses Hong Gai coal as its fuel.

The first unit was commissioned in 1974, and until the commissioning of the Pha Lai thermal power plant in 1983, it operated at full capacity. Since then, however, due to shortages of spare parts and for various other reasons, the plant factor lowered. Currently, the power plant at 25 MW - 30 MW capacity, conducts frequency regulation operation and also supplies reactive power to regulate voltage of power system.

Although the power plant is surrounded by 96 m - 102 m high mountains, the stack is only 80 m high. This is because air raids had to be considered at the time of construction. Since 1994, however, the Ninh Binh Power Plant, with its technological and environmental problems, is expected to increase its power generating capacity due to growing power demands in the north and also to transmit electricity to the south.

Plant rehabilitation should be aimed toward prolonging the service life as much as possible, anticipating that this plant will be in operation until 2007, when the large-scale Son La hydropower plant will be commissioned.

(3) Uong Bi Thermal Power Plant

Commissioned in 1975, the Uong Bi thermal power plant is in the Province of Quang Ninh.

The plant has a 50 MW unit and a 55 MW unit. Its available plant capacity is less than 100 MW and the unit is a two-boiler type. In recent years, the Uong Bi thermal power plant is reserve power and should, therefore, also be rehabilitated to prolong its life as much as possible so that it may contribute to the power supply.

(4) Thu Duc Thermal Power Plant

The oil-fired Thu Duc thermal power plant is located on the outskirts of Ho Chi Minh City, and is equipped with one 33 MW unit (commissioned in 1966) and two 66 MW units. The Thu Duc Power Plant is the largest and most important thermal power plant in the south. Due to obsolescence, the available plant capacity is 30 MW and 60 MW per each unit, a total of 150 MW. The units were made in the U.S.A.

With these, the power plant had three obsolete gas turbines (Total capacity 50.6 MW). In 1992/1993, two 37.5 MW gas turbines were added, and the total gas turbine output became 125 MW and available plant capacity became 97 MW.

Thu Duc thermal power plant is operating well. This is because, from 1980 to 1988, with financial and technical aid from Sweden (SIDA), the boilers were rehabilitated and various accessories were replaced. This rehabilitation was, however, only a short term measure, and it is now recommended that a long term rehabilitation project be planned and implemented.

(5) Ba Ria Thermal Power Plant

Ba Ria thermal power plant is located in the Vung Tau district southeast of Ho Chi Minh City, and two old-type 23.4 MW gas turbines were transferred here from the north in 1990. These turbines have technical problems and are no longer in operation. Later, five 37.5 MW gas turbines were installed, and the available plant capacity is 160 MW. A fuel conversion project from oil to natural gas (associated gas) for these turbines is now underway. A gas pipeline for that purpose, running from an offshore oil field to Vung Tau, was completed in mid 1995. This fuel conversion will contribute greatly to lowering the Ba Ria Power Plant's generating cost.

(6) Tra Noc (Can Tho) Thermal Power Plant

Tra Noc thermal power plant was commissioned in 1975. It has only one 33 MW oil-fired unit. This power plant is, however, located in the fertile and rapidly developing northern part of the Mekong delta region, and although the power transmission network is not strengthened, it plays an important role in supplying power and is continuing to operate at full capacity.

The Tra Noc Power Plant also has two obsolete gas turbines (Total capacity 28.9 MW) but these are not in operation.

The operation records for the past ten years for these thermal power plants are shown in the table below

The principal data of these thermal power plants are shown in Table 3.3-3.

3.3.2 Hydropower Generation Facilities

The hydropower generating facilities in the north are Thac Ba hydropower plant (108 MW) and Hoa Binh hydropower plant (1,920 MW), providing a total of 2,028 MW. In the south, there are Da Nhim (160 MW), Tri An hydropower plant (400 MW), and the just completed Thac Mo hydropower plant (160 MW). These three plants provide a total of 710 MW. In the Central region there were only three small hydropower plants, but in the latter half of 1994, Vinh Son hydropower plant (66 MW) was commissioned.

The principal data of these power plants are shown in Table 3.3-4.

(1) Thac Ba Hydropower Plant

Thac Ba hydropower plant is located by the Chay River in Thac Bay Town, 44 km from the Province of Yen Bai. The power plant has a multi-purpose dam and a capacity of 108 MW.

- Power generation, contribution to flood control during the rainy period, fishing grounds, navigation, irrigation

Aided by the former U.S.S.R., construction started in 1961 and the plant was commissioned in 1972.

(2) Hoa Binh Hydropower Plant

Hoa Binh hydropower plant is situated by the Da River located in Hoa Binh Town in the Province of Hoa Binh, 100 km from Hanoi. The power plant has the following purposes;

- Flood prevention of the Red River delta area where Hanoi is located.
- Power generation
- Contribution to city water, farming water and industrial water.
- Improvement of navigation in the Da River and the Red River.

Construction started in 1979 and the No. 1 unit was commissioned in 1988. The final No. 8 unit was commissioned in April, 1994. The former U.S.S.R. aided in the construction. The rock fill dam capacity is 22 million m^3, the spillway capacity is 37,800 m^3/s, and the reservoir effective capacity is 565 billion m^3.

At 1,920 MW capacity, the average annual energy generation is 8,300 GWh.

(3) Da Nhim Hydropower Plant

Da Nhim hydropower plant is located by the Da Nhim River, a tributary of the Dong Nai River, about 50 km northeast of Da lat City. Its total capacity is 160 MW. 80 MW was commissioned in 1963 and 80 MW commissioned in 1964. The annual energy generation is about 1,000 GWh.
Its reservoir capacity is small but has a net head of 800 m, thereby providing a power plant with a high head.

(4) Tri An Hydropower Plant

Tri An hydropower plant is located in the lower reaches of the Dong Nai River, 65 Km northeast of Ho Chi Minh City. Its capacity is 400 MW with an annual energy generation of 1,700 GWh. While the main purpose of this power plant is power generation, it also contributes greatly to the development of the local community in the south.

The power plant also supplies irrigation water to the Provinces of Dong Nai and Song Be, and to Ho Chi Minh City. It also contributes to preventing the backflow of seawater into the lowermost reaches of the river.

The construction of the Tri An hydropower plant took seven years and was completed in 1991. Although the construction was aided by the former U.S.S.R., the Vietnamese Government fully supported the construction and it contributed greatly to the people of the south. Dam height 40 m, dam length 420 m and reservoir effective capacity is 2,500 x 10^6 m^3.

(5) Thac Mo Hydropower Plant

Thac Mo hydropower plant is located by the Be River, 120 km north of Ho Chi Minh City with a capacity of 150 MW. Its main purpose is power generation and irrigation water supply to 39,000 ha of farmland in the river basin. Also, increasing the discharge during the Be River dry season will help to prevent backflow of seawater into the lower reaches. There are also plans to make the area into a fishing grounds and recreational area. The plant was completed in 1994 with the cooperation of the Ukraine. The dam height is 42 m and the dam length is 414 m. The annual energy generation is 590 GWh.

(6) Vinh Son Hydropower Plant

Commissioned in 1994, the Vinh Son hydropower plant is located by the Kon River in the Province of Binh Dinh, 120 km northwest of Quy Nhon Town. Its capacity is 66 MW, annual energy generation is 230 GWh, and the net head is about 600 m and is high. Although the power plant's capacity is not large, as it is located in an area where 110 kV transmission line from the north and south have not been sufficiently laid, it will contribute greatly to improving the transmission line system in the future.

The study for this power plant started in 1983, although construction only started in 1991. The construction was done by a domestic construction company and the generating equipment was provided by the Cegelec Company of France.

(7) Dray Linh Hydropower Plant

Dray Linh hydropower plant is located by the Srepoc River, 20 km west of Buon Ma Thuot Town in the central highlands of Dac Lac Province. This is a small hydropower plant with a capacity of 12 MW and an annual energy generation of 91 GWh. It was commissioned in 1989.

The operation records of the main power plants are shown in Table 3.3-5

Table 3.3-1 List of Generation Facilities

(As of 1994/E)

Region	Name of Power Station		Inst. Cap. (MW)	Avail Cap. (MW)	Commissioning Year	Remarks
North	Hydro	Thac Ba	3 x 36	108	#1('70), #2('71), #3('73)	
		Hoa Binh	8 x 240	1,920	#1('88), #2('89), #3('91), #4('91), #5('93), #6('93), #7('93), #8('94)	
			(2.028)	(2,028)		
	Thermal	Ninh Binh	4 x 25	100	#1('74), #2('75), #3('75), #4('76)	
		Uong Bi	1 x 50 1 x 55	100	'75 '77	
		Pha Lai	4 x 110 (645)	440 (640)	#1('83), #2('84), #3('85), #4('86)	
	GT	Thai Binh	2 x 14	12		
	Total		2,701	2,680		
South	Hydro	Da Nhim	4 x 40	160	#1('63), #2('63), #3('64), #4('64)	
		Tri An	4 x 100	400	#1('88), #2('88), #3('89), #4('89)	
		Thac Mo	2 x 75	150	'94	
		Suoi Vang	3.1 (713)	3 (713)	'57	
	Thermal	Thu Duc.	1 x 33 2 x 66	156	'66 '72	
		Tra Noc	1 x 33	32	'75	
		Old	1 x 7.2 (205)	3 (193)		
	GT	Thu Duc GT1	23.4	15	'91	
		GT2	12.5	7	'91	
		GT3	14.7	11	'91	
		GT 4/5	2 x 37.5	64	'92,	
		Ba Ria GT1/2	2 x 23.4	30	'91	
		GT3/7	5 x 37.5	160	'92, '94	
		Tra Noc GT1/2	2 x 14 (388)	0 (287)	'68	
	Diesel	Urban	126	41		
		Province	75 (201)	37 (78)		
	Total		1,507	1,271		
Center	Hydro	Vinh Son	2 x 33	66	'94	
		Dray Linh	12.0	12.0		
		An Diém	5.4	5.4		
		Pha Minh	2.0 (85)	1.6 (85)		
	Diesel		177.4	115		
	Total		262	200		
Grand Total			4,470	4,151		

Source: IEV

Table 3.3-2 Salient Features of Thermal Power Plants

Thermal Power Plants

Region	Name of Power Plant	Output (MW)	Boiler Unit x Capacity (t/h)	Fuel	Turbine Unit x Capacity (MW)	Generator Capacity	Manufacturer	Remarks
Northern Region	Pha Lai	440	8 x 220	Coal	4 x 110	110 MW	USSR	
	Ninh Binh	100	8 x 130	Coal	4 x 25	25 MW	China	
	Uong Bi	105	2 x 110	Coal	1 x 50	50 MW	USSR	
			2 x 110	Coal	1 x 55	55 MW	USSR	
Southern Region	Thu Duc	165	1 x 160	F.O.	1 x 33	39 MVA	GE	
			2 x 300	F.O.	2 x 66	82.5 MVA	GE	
	Tra Noc	33	1 x 160	F.O.	1 x 33	39 MVA	HITACHI	

Gas Turbine

Region	Name of Power Station	Output (MW)	Gas Turbine (Unit x MW)	Generator Capacity (MVA)	Manufacturer	Remarks
Southern Region	Thu Duc	125.6	1 x 23.4	28.15	J.Brown/Alsthom	ex. Hai Phong
			1 x 12.5	15.98	W.H	
			1 x 14.7	19.375	ABB	
			2 x 37.5	41.925	J.Brown/Alsthom	
	Ba Ria	234.3	2 x 23.4	28.15	J. Brown	ex. Hai Phong
			5 x 37.5	41.925	J.Brown/Alsthom	

Source : IEV

Table 3.3-3 Operation Results of Main Thermal Power Plants

Region			1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
North	Uong Bi	MW	153	153	153	153	105	105	105	105	105	105
	(Coal)	GWh	288	350	390	485	327	239	104	50	51	114
	Ninh Binh	MW	100	100	100	100	100	100	100	100	100	100
	(Coal)	GWh	379	326	346	403	317	268	256	182	189	215
	Pha Lai	MW	440	440	440	440	440	440	440	440	440	440
	(Coal)	GWh	1508	1904	2276	2551	2074	1493	1005	619	397	700
South	Thu Duc	MW	165	165	165	165	165	165	165	165	165	165
	(Oil)	GWh	509	765	835	789	584	665	852	794	928	864
	Tra Noc	MW	33	33	33	33	33	33	33	33	33	33
	(Oil)	GWh		207	236	205	156	176	207	242	204	200
	Thu Duc	MW	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	125.6	125.6
	(DO/Gas)	GWh									292	340
	Ba Ria	MW	46.8	46.8	46.8	46.8	46.8	46.8	46.8	46.8	121.8	234.3
	(DO/Gas)	GWh									296	350

Source: IEV

Table 3.3-5 Operation Results of Main Hydropower Plants

		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Thac Ba	MW	108	108	108	108	108	108	108	108	108	108
	GWh	370	478	355	293	295	457	386	345	327	405
Hoa Binh	MW	-		-	-	480	480	960	1,200	1,680	1,920
	GWh	-	-	-	-	1,295	2,400	3,306	4,188	4,744	5,660
Da Nhim	MW	160	160	160	160	160	160	160	160	160	160
	GWh	1,068	903	998	841	781	774	800	918	958	1,033
Tri An	MW	-	-	-	200	400	400	400	400	400	400
	GWh	-	-	-	633	1,437	1,697	1,738	1,685	1,832	1,990

Table 3.3-4 Specification of Main Hydro Power Facilities

			The Nortern Region		The Central Region	The Southern Region		
Project Name		Unit	Thac Ba	HoaBinh	Vinh Son*	Tri An	Da Nhim	Thac Mo*
River System		-	Chay	Da	Vinh Son	Dong Nai	Da Nhim	Be
Catc hment Area		km^2	6,140	51,700	214	14,600		2,200
Operation Started		-	5/1972	4/1994		1991	1965	1994
Generation	Maximum Power	MW	108	1920	66	400	160	160
	Firm Power	MW		631	15.2	100		45
	Annual Energy	GWh	438	8324	229	1726	1025	589
Discharge	Maximum	m^3/s	240	2400	133	888	26.4	192
	Firm	m^3/s	190	1800	3.3	222		59
Effective Head	Maximum	m	37	101.6	614			104
	Design	m	30	88	588	52	800	90
Reservoir	Capacity	10^6m^3	3940	9450	131	2761	165	1470
	Effective Capacity	10^6m^3	2160	5650	102	2542		1311
	H.W.L.	m	61	120	775	62	1042	218
	L.W.L.	m	46	75	765	50	1018	197
Main Dam	Type	-	Rock-Fill	Rock-Fill	Earth-Fill	Rock-Fill	Earth-Fill	Earth-Fill
	Length	m	557	640	710	644	1450	414
	Height	m	41	128	37	30	38	42
	Volume	m^3	1,500,000	22,000,000			3,470,000	
Water Way	Type	-	Concrete Shaft	Tunnell		Channel	Tunnel	
	Number	-	3	8	2	1	1	
	Length	m		240	666		4878	
Penstock	Number	-			1		2	
	Length	m			1677		2340	
Power House	Type	-	Open	Underground	Open		Open	
	Number of unit	-	3	8	2	4	4	2
	Unit Power	MW	36	240	33	100	40	40

Source: IEV

*: now under construction

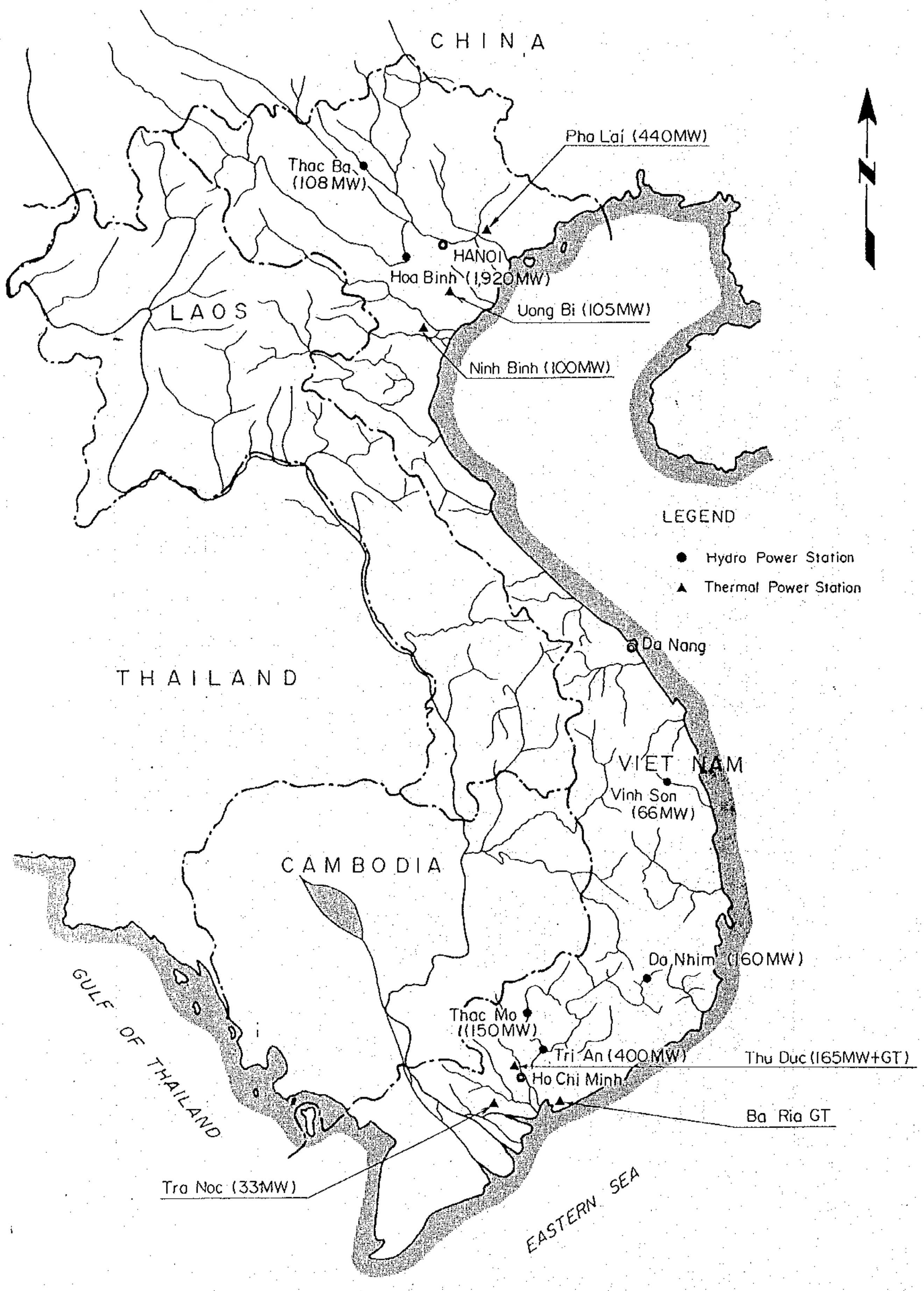

Figure 3.3-1 Location of the Facilities

3.4 Transmission and Distribution Facilities

3.4.1 Transmission System Facilities

The existing transmission system of Viet Nam has been formulated based on the Soviet standard. The major transmission system voltage is 220 kV and 110 kV. 220 kV is applied for major transmission systems and 110 kV for secondary systems.

The North-South 500 kV transmission system which interconnects three regions of the country was completed in two stages by the end of September 1994 and commenced its operation.

Summary of transmission lines of the three regions as of the end of 1994 is tabulated in Table 3.4-1 and that of substations in Table 3.4-2.

The present power system diagram of the 500 and 220 kV systems of the whole country is shown in Figure 3.4-1, and locations in Figure 3.4-2.

(1) **Northern Power System**

The backbone of the northern power system consists of 220 kV transmission lines. For power supply to the capital city of Hanoi, multi-circuit 220 kV lines were constructed both from Hoa Binh hydropower plant and from Pha Lai thermal power plant. A single circuit line was extended from Pha Lai to the port city of Hai Phong. A double circuit line was constructed between Hoa Binh and Nho Quan for power supply to the southern provinces and for 220 kV extension to important centers of the central-south provinces. Toward the south, a single circuit line was extended to Thanh Hoa and Vinh, and further to Dong Hoi of the central region. In the central south provinces a single circuit line has been constructed from Nho Quan to Ninh Binh.

The 110 kV transmission system is connected to the secondary sides of 220/110 kV substations. This system supplies power to individual load centers in the areas covered by the 220 kV system. While in rural areas not covered by the 220 kV system, like the north-eastern direction from Pha Lai and Hai Phong to Quang Ninh and wide areas of northern to north-western provinces from Hanoi, the 110 kV systems are the main system for power supply. The length of 110 kV lines is very long and exceeds 200 km in total at several locations.

The transformer capacities of 220 kV to 110 kV and 110 kV to medium tension voltage seems sufficient considering from the existing total capacity and the total demand.

Power system equipment in the northern system are almost entirely from the former Soviet Union.

(2) **Southern Power System**

The first 220 kV transmission line of the southern system was Da Nhim - Thu Duc line constructed in 1963 under the Da Nhim hydropower project. In recent years, three major 220/110 kV substations of Hoc Mon, Long Binh and Phu Lam were constructed to strengthen the supply capability to the Ho Chi Minh area, and the new power stations of Tri An hydropower plant and Ba Ria thermal power plant were connected with the 220 kV system. The 220 kV system was also extended to Tra Noc near Can Tho to reinforce power supply to the Mekong delta area.

The 500 kV power from the northern system is received at Phu Lam substation and delivered to the southern system through the 220 kV lines.

The main secondary system voltage is 110 kV, and the 110 kV system is supplying power to major load centers and as well as to district cities and towns. Some old 66 kV facilities from USA and Japan are still in service in Ho Chi Minh city to Mekong delta area, and for local supply from Da Nhim hydropower plant. System conversion from 66 kV to 110 kV is progressing. The existing 66 kV lines are mostly insulated at 132 kV with consideration for possible future voltage upgrading. Therefore, there is no problem to use the most of existing lines for 110 kV operation. For system conversion from 66 kV to 110 kV, only replacement of substation facilities is required.

Power system equipment in the Southern system include those from France, USA, Japan, etc.

(3) Central Power System

The construction of 220 kV system is limited. At Dong Hoi in Quang Binh province, power from Vinh of the Northern region has been received at 220 kV. Under the 500 kV transmission system project, 220 kV facilities were provided at Da Nang and Pleiku. At Da Nang substation no 220 kV line has been constructed, and at Pleiku substation a 220 kV line to Qui Nhon was constructed. The power supply situation of the central region was significantly improved by starting operation of the 500 kV system and commissioning of Vinh Son hydropower plant.

Within the central region, the 110 kV system is operated as major transmission system interconnecting load centers along the sea coast. As there are no large power source in the central region, power is imported at Da Nang and Pleiku through the 500 kV line. The above Pleiku - Qui Nhon 220 kV line interconnected the seacoast system with the inland system. There are still many isolated systems operated with diesel power and small hydro. The Buon Ma Thuot system is the largest one.

The transmission system of the Central region is still in a primitive stage and construction of lines to interconnect isolated centers is in progress.

(4) National System Interconnection

The North-South 500 kV transmission system was constructed to interconnect the three regions of the country, for national interchange of power, and in its initial stage to transfer the surplus power in the North to the South, which is suffering from power shortage.

The 500 kV transmission line is of single circuit construction and nearly 1,500 km in total route length starting from the Hoa Binh hydropower plant site and terminating at Phu Lam substation in the suburb of Ho Chi Minh. Three intermediate substations were constructed at Ha Tinh in the Northern region and Da Nang and Pleiku for the Central region. No transformer was provided at Ha Tinh substations in the initial stage. The Yaly hydropower plant of 720 MW capacity will be connected to the Pleiku substation at 500 kV.

(5) Protection

For transmission line protection, the power line carrier (PLC) aided distance relaying system has been applied to the 220 kV transmission lines and the distance relaying system not accompanying interchange of carrier signal for the 110 kV lines. To the recent 500 kV transmission line, digital current differential protection associated with the single-pole rapid reclosing practice is applied. The relaying system from the Soviet Union consists of old-modeled mechanical relays of electromagnetic type. Its reliability of operation is low and it is not possible to attain coordination with recent semiconductor-based digital relaying systems from advanced countries.

3.4.2 Distribution Facilities

From difference in history of development, various types of distribution system with different medium voltage classes are in operation in the country. MOE has decided to adopt 20 kV as the future standard medium tension voltage covering the whole country. In cities, provincial towns and rural areas of the Mekong delta, 20 kV will be applied exclusively replacing all the existing voltage classes. While, in mountainous and highland areas, and remote rural areas, higher voltage of 35 kV will also be applied depending on economic feasibility of installation.

In the Northern system, all the distribution systems have been formulated based on the Soviet practice. The 35 kV system covers all the area for delivering power to urban and local centers. In urban areas, the distribution voltage is either 10 kV (new) or 6 kV (old) by stepping down directly from 110 kV and from 35 kV. The neutral points of these systems, all 35, 10 and 6 kV, are not grounded.

The low tension service is being made by the 3-phase, 4-wire system of 380-220 V. In urban areas, the distribution voltage of 10/6 kV is stepped down to low tension voltage, while in rural areas 35 kV is directly stepped down to low tension voltage.

In the Southern system, the main distribution voltage is 15 kV based on the French design. The neutral point of this system is solidly grounded. The 35/31.5 kV systems are operated partly, and 10 kV systems are also operated where Soviet transformers were installed. The low tension service voltage is same as that of the Northern system.

In the Central system, the density of demand is low. The 35 kV system covers relatively small load centers scattered widely. The distribution voltage in major cities is 15 kV, same as that of the Northern and Southern systems.

3.4.3 Transmission and Distribution Losses

The historical loss factors from 1986 to 1994 are shown in Table 3.4-3.

The loss is the balance between generated and sold energy, which means the sum of loss in the transmission and distribution systems, and station use of the power companies.

The power loss in the transmission and distribution systems is considered to consist of two portions of technical loss, e.g. ohmic loss in transmission and distribution lines, transformer loss, etc., and commercial loss, e.g. illegal use, pilferage, etc.

The highest loss factor of the Northern system seems to be caused by too much concentration of power generation at Hoa Binh power station, which resulted in long distance power transmission. Lower high tension distribution voltage compared to the Southern system, 10/6 kV against 15 kV, is another cause of large loss. The use of bare conductors for low tension distribution lines causes pilferage. Though the loss factor of the Northern system had been in an increasing trend, it decreased in 1993 and 1994, probably due to the improvement effort on the distribution system of Hanoi and Hai Phong.

3.4.4 Power System Control and Communication

(1) Load Dispatching Facilities

The northern system has a load dispatching center in Hanoi. System equipment were supplied by the former USSR. Telecontrol arrangement is not provided, and instructions for operations and switching information of other stations are being sent over telephone. The automatic data acquisition is possible from a limited number of important stations only, and the manual indication is combined. Thus, this load dispatching center does not satisfy SCADA functions.

Due to limitation in availability of PLC channels, the out-of-voice frequency in 4 kHz bands is utilized for data transmission with a speed of 100/200 bps.

At present, there are no established load dispatching facilities for southern and central systems. The load dispatching functions, acquisition of data and instructions for operations, are being performed over telephone on PLC channels. The press-to-talk radio equipment are also used for local systems.

For power supply to Ho Chi Minh, a SCADA system with the help of radio channels, which was installed under Swedish assistance, is in operation.

Under the North-South 500 kV transmission system project, the National Load Dispatching Center (NLDC) was constructed in Hanoi for supervisory control of the 500 kV system and management of nation-wide power generation. However, due to non-availability of communication channels (the existing Soviet-made PLC system on transmission lines does not conform to the CCITT recommendations and can not be used for the system), information from the existing stations is limited.

(2) Communication Systems

The existing communication network for power system operation has been established mainly with the PLC channels on transmission lines. The most of the existing PLC equipment were supplied from former USSR, not conforming to the CCITT recommendations. Therefore, interconnection with a system based on international practices is not possible. For establishing a new load dispatching and data exchange systems, completely new communication systems must be established.

For telephone communication for power system operation. PABXs from former Soviet Union are provided over the PLC channels. The press-to-talk radio channels, mainly of 150 and 400 MHz, are provided for standby communications among the load dispatching center and stations.

For the 500 kV system, the optical communication system was introduced with the OPGW (Composite Optical Fiber Ground Wire) to meet augmented communication needs for up-to-date relaying, data transmission and telephone uses. A half of optical fibers in the OPGW are for public communication use. As a part of this system, an up-to-date communication system utilizing the digital technology, microwave channels, PABXs etc. was established for communication among LDCs, power companies, etc. aiming modernization of the communication system for power system operation.

Table 3.4-1 Summary of Existing Transmission Lines (As of end-1994)

(Unit: circuit-km)

	North	South	Center	Total
500kV line	-	-	-	1,488
220kV lines *1	1,044	657	349	2,050
110/66kV lines *1	2,685	1,630	1,132	5,447
35/31.5kV lines *2	6,455	1,390	978	8,823
15/8.6kV lines *2,4	-	8,056	1,805	9,861
10kV lines *2	8,986	70	652	9,708
6kV lines *2	2,512	227	646	3,385
Total	21,682	12,030	5,562	40,762
Low tesnions lines*2	10,000	5,655	990	16,645

Note: *1. Sum of recently obtained data. *2. 1993 data. *3. 1991 data. *4. 8.6 = $15/\sqrt{3}$

Table 3.4-2 List of Existing Substations (As of end-1994)

		Number of Stations	Number of Transformer	Total Capacity (MVA)
500/220kV		4	6	2,700
North	220/110kV *1	8	14	1,876
	110/35, 10, 6kV *1	63	94	2,083
	35/10kV *2	196	294	620
	35/6kV *2	129	198	599
	35/0.4-0.2kV *2	2,422	2,591	781
	10/0.4-0.2kV *2	6,044	6,277	1,607
	6/0.4-0.2kV *2	3,766	4,068	1,300
South	220/110kV *1	9	12	1,169
	110/66/15kV *1	59	64	1,376
	35/31.5kV *2	42	47	81
	15/8.6kV *2,*3	16,926	24,939	2,089
	10kV *2	51	54	8
	6.6kV *2	257	337	34
Center	220/220kV *1	4	5	439
	110-66/35,15,10,6kV	14	15	328
	35/15,10,6kV *2	--	--	152
	35/0.4kV *2	--	--	11
	15/0.4kV *2	--	--	267
	10-6/0.4kV *2	--	--	234

Notes: *1. Sum of recently obtained data. *2. 1993 data. *3. 8.6 = $15/\sqrt{3}$

Table 3.4-3 Trend of Losses

Region	1986	1987	1988	1989	1990	1991	1992	1993	1994
North	26.5	25.4	26.1	31.3	33.6	30.6	30.5	25.7	25.5
Center	15.7	16.4	18.1	17.9	22.5	26.6	25.5	24.9	21.2
South	23.1	21.7	24.3	22.1	21.1	21.8	22.3	21.8	21.6
Whole Country	25.0	23.9	25.4	27.3	28.7	28.0	28.2	25.4	24.6

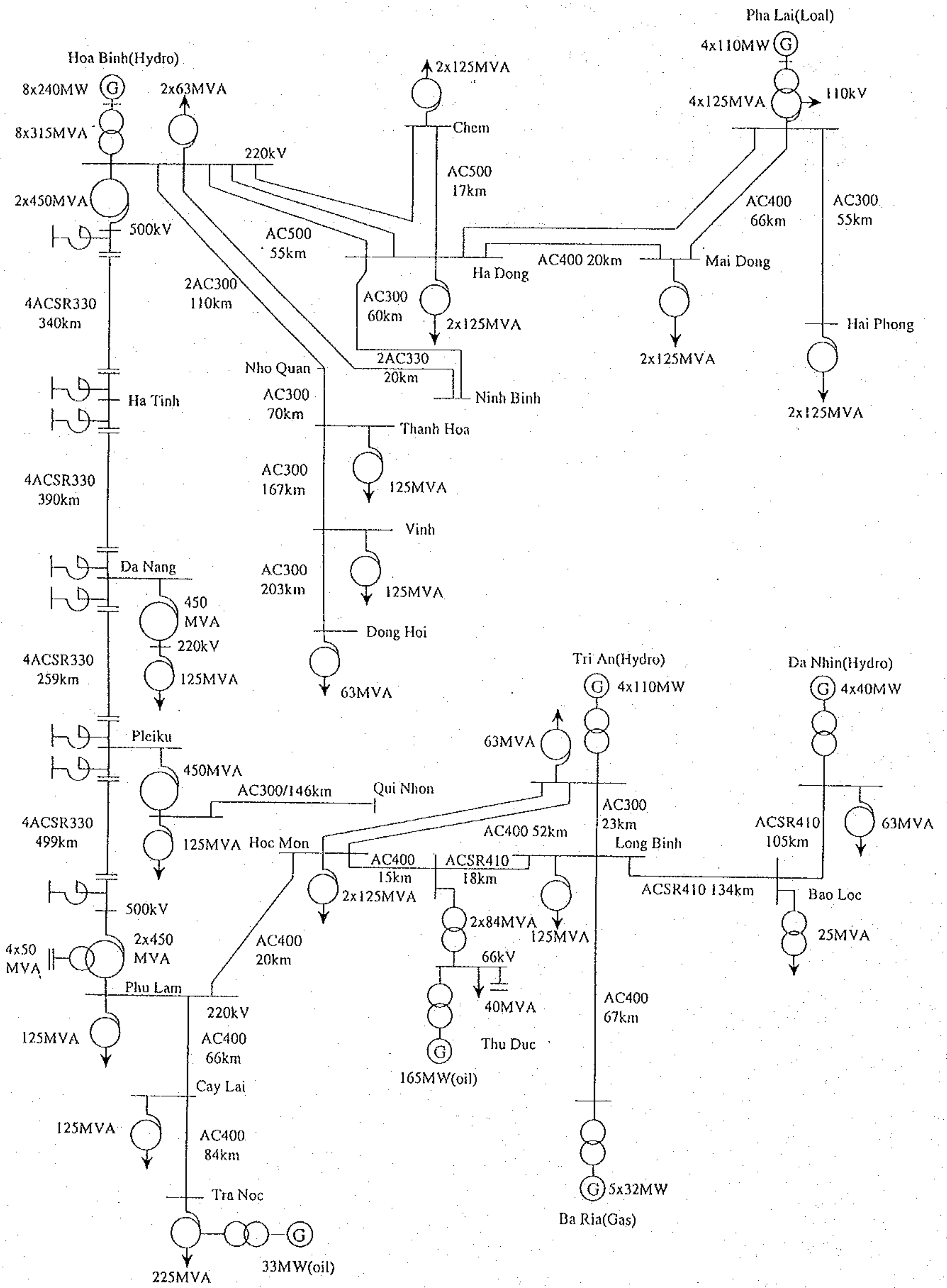

Figure 3.4-1 Existing 500/220 kV Power System Diagram

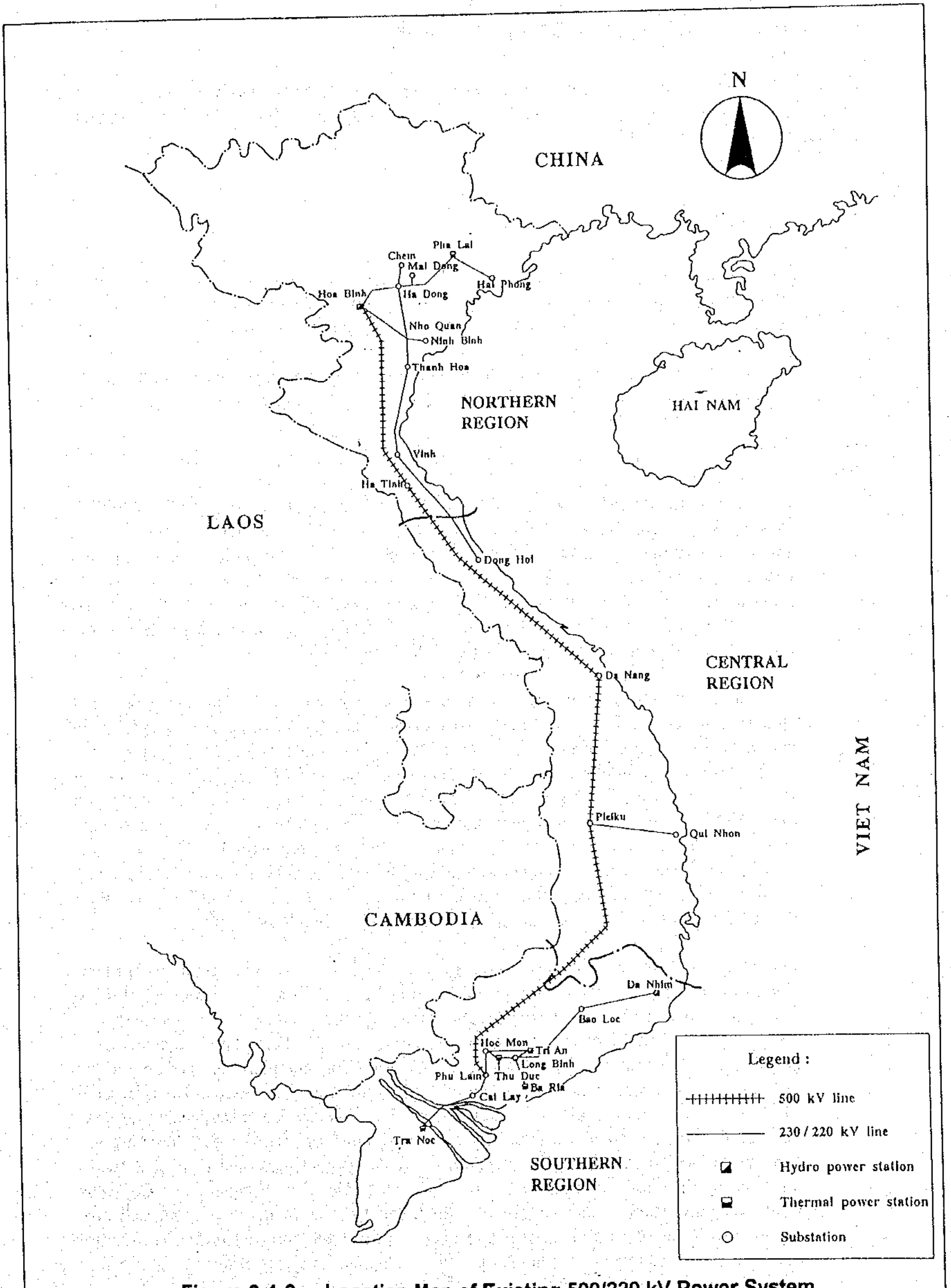

Figure 3.4-2 Location Map of Existing 500/220 kV Power System

3.5 Demand and Supply of Energy Resources

Majority of fuels supplied to the thermal power plant in Viet Nam is coal, and only minor part of it is petroleum product and natural gas. Fuel oil consists both heavy fuel oil and diesel oil, and natural gas is in northern inland small field.

(1) Hydropower

Theoretical hydropower potential in the whole country is estimated to be approximately 300 billion kWh annually. Among them, 100 billion kWh of energy is economically feasible to be exploited. Followings are resources by the river systems.

At present approximately 12,000 GWh of hydropower resources has been exploited, which is equivalent 10% of economically feasible figures (Refer toTable 3.5-1).

(2) Coal

Coal consumption in thermal power plant had been rather large quantity in 1980s; 2 million tons every year, totally 19.77 million tons in 1981 to 1990. In 1990s, completion and commencement of power generation at the Hoa Binh hydropower plant in 1992 affected the necessity of thermal power plants and thermal power electricity generation had largely dropped down; 920 thousand tons in 1991, 592 thousand tons in 1992 and 538 thousand tons in 1993 of its coal use. However, the coal burning amount at the thermal plants increased to 900 thousand tons in 1994 (Refer to Table 3.5-2).

Four major state coal companies; Uong Bi Coal, Hong Gai Coal, Cam Pha Coal, and Domestic (former No.3) Coal companies, two of the first half companies extract and supply anthracite for thermal power plant in Viet Nam. Total coal production of these four companies were 4.2 million tons in 1991, 4.5 million tons in 1992 and 5.0 million tons in 1993, 1994, in clean coal base. (Table 3.5-3) Those four coal companies had been belonged to the MOE, but there were other companies not belonging to the Ministry, which extracted about one million tons of coal a year. Among the total coal production, anthracite shares the majority; 96% in 1992. Total production capacity of raw coal is about 10 million tons a year and clean coal production capacity is 8 million tons. In this current Five Year Plan (1991-95), Vietnamese coal production is projected 6-7 million tons in 1995.

There are three main thermal power plants in north Viet Nam; Pha Lai thermal power plant, Uong Bi thermal power plant and Ning Binh thermal power plant. Coal demand of these three power plants were expected 300 thousand, 300 thousand and 350 thousand tons respectively in 1993. However the actual coal consumption in these plants were decreased and showed far less amount than this figure. Uong Bi Coal company supplied coal to the Pha Lai thermal power plant as the geographically nearest supply source. Uong Bi Coal Company will continue the extraction of coal from Mao Khe and Vang Danh coal mines for this supply and the company will develop a new mine of Yen Tu for this purpose. However, Mao Khe and Vang Danh mines are under-ground mine and their coal seems rather costly than open pit mine coal. In future, Hong Gai Coal Company and Cam Pha Coal Company which do not supply coal for thermal power plants at present, will also supply coal to the Pha Lai thermal power plant. Production and transportation facilities of each mines, cleaning coal facilities, loading and shipping facilities of these all companies should be renewed and expanded.

Production and transportation cost of coal for the thermal power plants are rather high. Electricity generation companies compare the cost of thermal and hydropower generation and select the choice. The electricity companies depress coal purchasing price at low level. Electricity generation cost at Hoa Binh hydropower plant is 100-130 Dong/kW, while the cost of Pha Lai thermal power plant is 370 Dong/kW. Coal price at Pha Lai power thermal power plant are $15.50 per ton of No.5 pulverized coal and $16-17 per ton of No.4B coal, in September 1994., at coal mine, and with addition of the transportation cost of $3.00 by river boat, Pha Lai thermal power plant's average purchasing cost of coal is about $20.00 per ton.

Future increasing of coal price at thermal power plants will be unavoidable and it is expected that coal price will be $25.00 per ton in 2000. This price is mine head price and does not include transportation cost. Transportation cost to northern power station is $3.00, and southern power station will be $10.00 per ton. Production and transportation cost with adequate profit and tax to the coal companies will be rather high in future and it will make difficult issue for the electricity generation fuel supply in future.

It is recommended that production and transportation facilities of each mines, cleaning coal facilities, loading and shipping facilities of these all companies should be renewed and expanded.

(3) Petroleum Product

Fuel oil demand and supply at thermal power plant in 1993 was rather small amount; 300 thousand tons of heavy fuel oil and 400 thousand tons of diesel oil, all of which were imported. There is a plan to build an oil refinery in Viet Nam and heavy fuel oil and diesel oil used at thermal power plant will be supplied by this refinery domestically in future. Petroleum products total consumption in the country has been 4.5 million tons in 1994. Crude oil production in Viet Nam in 1994 was about 6.7 million tons and it will increase in future, therefore supplying of it to the new refinery will be adequate.

(4) Natural Gas

There is a small thermal power plant using natural gas in Thai Binh province in north Viet Nam. Tien Hai gas field supplied 20-40 million m^3 of gas yearly to the station, however this small gas field seems to be exhausted its production and fuel of the power station will probably be replaced by oil product.

Table 3.5-1 Hydropower Resources

Region	Name of River	Potential (10^9 kWh)	Feasible (10^9 kWh)	Feasible (MW)
North	Da	71	31.6	6,260
	Lo-Gam	40	4.8	1,070
	Ma-Chu	12	1.3	320
	Ca	11	2.6	560
	Others	46	19.1	-
Center	Vugia-Thubon	15	4.6	990
	Ba	10	2.1	400
	Se San	22	8.0	1,490
	Srepoc	13	2.6	500
	Others	26	6.7	-
South	Dong Nai	28	11.6	2,500
	Others	6	5	-
Total		**300**	**100**	**14,120**

(Source: IEV, Sept. 1994)

Table 3.5-2 Coal Production & Coal Sale of Companies under MOE (in the period 1955 - 1994, certified figures)

(Unit: 10^3 ton)

Year	Clean Coal	Rock & overburden (10 m^3)	Sale: Total	Sale: Domestic	Sale: Export	Industry: Electricity	Industry: Cement
1955	439	818	166	101	66	64	-
1956~1957	2,302	5,445	2,361	781	1,580	240	15
1958~1960	6,342	20,416	6,241	3,508	2,733	644	89
1961~1965	17,159	71,324	17,393	8,539	8,854	2,888	451
1966~1970	11,831	50,768	12,016	8,957	3,059	2,518	197
1971~1975	15,765	71,236	15,382	12,471	2,911	3,207	439
1976~1980	28,009	93,779	27,810	22,243	5,567	6,473	586
1981~1985	27,960	80,433	27,663	24,602	3,061	8,640	1,343
1986~1990	26,242	107,415	26,080	23,740	2,340	11,126	1,523
Total (1955~1990)	136,049	501,634	135,112	104,942	30,171	35,800	4.643
1991	4,205	15,269	4,123	3,203	920	920	225
1992	4,499	12,894	4,852	3,528	1,324	592	238
1993	5,029	11,149	5,351	3,527	1,824	538	280
1994	5,068	16,696	5,005	2,947	2,058	900	276
Total (1991~1994)	154,850	557,642	154,443	118,147	36,297	38,750	5,662

(Source: IEV, 1975)

Table 3.5-3 Clean Coal Production in Viet Nam

(Unit: 10^3 ton)

	Total	Produced by MOE's Companies				Other Producer
		Total	Anthracite	Long Frame Coa (Lignite)	Fat Coal	
1980	5,200	4,987	4,946	41	-	213
1981	5,900	5,725	5,681	44	-	175
1982	6,280	6,040	5,957	84	-	240
1983	6,300	6,085	5,966	111	8	215
1984	5,000	4,819	4,687	119	13	181
1985	5,700	5,327	5,188	122	17	273
1986	6,121	5,953	5,811	120	21	447
1987	6,332	6,428	6,284	117	27	411
1988	6,051	6,334	6,185	141	9	466
1989	5,130	3,403	3,269	134	-	457
1990	5,124	4,128	4,075	130	13	(905)
1991		4,205	4,064	122	19	
1992		4,499	4,331	118	40	
1993		5,029				
1994	6,218	5,068				1,150

(Source: IEV, 1975)

PART I DATABASE SYSTEM AND DEMAND FORECAST

CHAPTER 4

DATABASE SYSTEM

CHAPTER 4 DATABASE SYSTEM

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4.1 Introduction

4.1.1 Objectives

To help advance industrial development and increase welfare for the general public, energy, above all electricity, is of vital importance for Viet Nam. For this reason, the Vietnamese government is now driving power development plans forward. Meanwhile, the country nationwide is now in transition from conventional planned economy to a market economy, and data organization efforts are under way as well.

Amid such an economic environment, this study focuses on Viet Nam's electricity sector, and is designed to assess currently available database, like statistics on electricity status-quo, then develop additional database necessary. On top of furnishing the newly-developed database, all the technologies involved will be disclosed to Vietnamese counterpart, so that they can improve/extend the database by themselves ahead.

4.1.2 Basic Concept of Database Management System

In general a database is an aggregate of data on specific themes. In this report, it is defined as a database in electronic-file forms which allows computer processing. Data can roughly be grouped in three by type. Those grouped in the first type are names of place, person and the like, which are rarely variable. Data falling in the second group include equipment specifications, which remain unchanged for a certain period. The third group consists of data of which contents need to be renewed/updated regularly or irregularly.

Those in the first group are called key codes, or simply codes, because they are often employed as keys in sorting/reshuffling specific data. Those in the second group are called master data, or master, because many of them serve as a base for specific data. On the other hand, those in the third group are called transaction data, or data, named after commercial transactions.

4.1.3 Newly-developed Database

Vietnamese data used in forecasting electricity demand/preparing electricity statistics have been kept in either form of printed matters or computer-based spread sheets. However, at least as of October 1994, we could not confirm any presence called an electricity database system in Viet Nam. Based on its firsthand study results, the JICA Study Team recognized two sorts of database necessary, then developed them. They are "database on electricity" and "database on energy/economy."

The "electricity database" is designed to reflect exact situations peculiar to Viet Nam, and technically represents a structure of planning-use database. Therefore, with this database, a special emphasis is put on report-style outputting in technical terms. The "energy/economic database" provides external information necessary for forecasting electricity demand and preparing power development plans, and technically represents a structure of general-purpose database. As a result, with this database, technical priorities are given on how to improve data editing and make information retrieval easier.

4.2 Requisites for Electricity Database and Database Management System

4.2.1 Database Requisites for Electricity Demand Forecasting/Supply Planning

What's required for a database used in electricity demand forecasting/supply planning is to allow intensive data collection/organization relative to any issue of pressing needs, rather than a full-range data coverage. Given that such an issue generally involves data usable in case studies, easy data inputting also forms an important requisite. Among others, given the need to simulate various cases with varying assumptions, functions to transmit/receive data to/from spreadsheets must be provided as well.

In the meantime, because electricity demand forecasting/supply planning can be made with a relatively limited amount of data, ready-made spreadsheets, like Lotus 1-2-3, could also be employed as its database system.

4.2.2 Database Requisites for Electricity Statistics

Electricity statistics are necessary, not merely for electricity demand forecasting/power development planning themselves, but to smoothen such forecasting/planning processes. For this reason, electricity statistics must be designed well, by selecting proper items to be covered, setting an appropriate period and employing an adequate manner of data organization, among others, so that the statistics can fully satisfy given objectives.

If data are collected from different sources and processed in different ways each time, reliable statistics could never be produced. Just like data used in any other statistics, continuity and consistency is essential to those embedded in electricity statistics. It is important to practice periodical data collection and stick to a constant manner data processing every time. Periodical publications of major output are very significant as well.

Accordingly, as far as a database for electricity statistics is concerned, any data, once input and becoming definite, must be kept in the database unchanged without special reasons. This requires full heed be paid to data security. Ready-made database management systems satisfy this requirement. By the way, while such spreadsheets as Lotus 1-2-3 and MS-Excel are also given a simplified database function, their data storage capacity is so limited, 8,192 and 16,384 each in number of data, that they should have difficulties in meeting the need to store as many data as involved in electricity statistics.

4.2.3 System Operation-related Requisites

From the system operation aspect, a database management system (DBMS) should ensure the security of database first. Given future developments, responses to networking are necessary as well. Security of database requires those who are responsible for database management to be furnished with some measures to fulfill following goals.

(1) Protection from illegal access
(2) Protection from accidents
(3) Prevention of information leakage
(4) Protection from system destruction

Computer systems (incl. hardware and operating system) to run a database themselves require management systems to permit the following, among other things.

(1) Integration of files for system security control
(2) Exclusion control
(3) Record locking

Ready-made database management systems now on market fully satisfy what are needed for system operations. On the other hand, the database function given to spread sheets meet none of the requisites listed above and, therefore, is not viable from the system operation aspect.

4.2.4 Recommended Database Management System

While there is a variety of database management systems, Approach available from Lotus, Inc., Paradox from Boland, Inc., and FoxPro and its upgraded version, Access, from Microsoft, Inc. above all are popularly in use worldwide. Particularly, Microsoft's Access is an outstanding database software developed by the company by making in-depth analyses on advantages embedded in highly-reputed database management systems of its own and/or from its competitors, with some put to best use in it. While meeting the requisites listed above, Microsoft's Access not only permits easy data inputting by users as well as easy system upgrading, but also has various graphic display functions for presentation purpose.

Among others, Microsoft's Access is superior in extension, if necessary in the future, because it is provided with Access Basic, a programming language which allows automated processing and interconnection with the plural number of systems. Thus, Microsoft's Access is considered optimal as a database system for Vietnamese electricity planning.

4.3 Concept of Newly-developed Database

4.3.1 Official Database and Personal-use Database

Database is available in two types. One is an official database managed by institutions, organizations and the like. The other is a personal-use database built and managed by individual database users. An individual user is able to obtain beneficial information to his/her own by extracting specific data and processing them on his/her personal-use database. An official database is designed to provide all users with data on unified standards, and furnish all the concerned with correct information, thus being capable of eliminating infertile debates, misunderstandings, etc. JICA study team developed/provided an "electricity database" and an "energy/economic database" as official database models.

4.3.2 Heeds to Database Operation/Management

While the need to take heed of database operation/management must be substantiated in the form of functions given to a database management system, different sorts of consideration are required at system designing stage. Given a public database is accessed by many users concerned, its security becomes a matter of great concerns. For this reason, data to be strictly managed should clearly be separated from those which can be left accessible to a larger number of users.

Viet Nam's electricity database is designed to store data categorized beforehand into groups of Code, Master, Statistics and Data. Of them, the groups of Code and Master require strict management, of which updating must be allowed only to those who are responsible for database management. In order to limit updating to the responsible staff alone, security functions given to a database can be in use.

4.4 Basic Design of Newly-developed Database

Data in a database empirically have four significant differences, and data hangers (tables) need to be designed in reflection to the differences.

(1) Code Table

With information processing, data are generally managed by code. So are they with a database. Because data are identified and organized by code, it is essential to put standard codes on all data. Accordingly, the codes must be managed only by a responsible staff for database management, and anyone else should not be allowed to add and/or change any codes. Code Table is designed to disclose codes to users, so that they can process all data in accordance with the standard codes. Thus, users are allowed to read out the Code Table. Writing, however, is allowed to a responsible staff for database management alone.

(2) Data Table

Data Table is designed to store changing data in time, such as yearly data and forecasting/planning data. Operations to input data and rewrite them are managed by a responsible staff for database management. As for codes, only the standard codes registered in the table are in use so that a responsible staff for database management can assure quality of the database. Data Table is designed by taking quality assurance/control into account. For example, a pull-down menu, if running to refer to Code Table while data inputting, allows to design error-free code inputting. It is also crucially important to check essential data.

(3) Master Table

Master Table is designed to store fixed data which remain unchanged in time series, such as past electricity supply/demand data, plant sites, date of plant completion, and plant specifications. Therefore, once fixed, Master Table generally remains unchanged unless any errors should be found. But, part of Master Table can be updated if original data are changing. In this case, updating operations are managed by a responsible staff for database management.

(4) Statistics Table

Stored in Statistics Table include past electricity-related data, statistics on area-by-area population, the national economy and industry. These data, once stored, won't be renewed unless some errors should be found, though additional data are regularly input.

4.5 Database User Training

Individual database users, who hope to access a public database and construct their own database useful in their works, need technical training. The JICA Study Team Study Team had a 24 hours' database training course to transfer basic technology necessary for constructing, improving and expanding a database. All six attendants to the course successfully finished the course getting Certificates. In the course, the structure and operation of "database on electricity" and "database on energy/economy" developed by the JICA Study Team were opened, and the database systems were transferred to IEV.

4.6 Recommendations on Future Developments of Database

Under this study, Vietnamese energy-related organizations introduced a database running on a database management software for the first time. The database is run with a personal computer. The advent of database-based data management is expected to cut open a new stage, in both qualitative and quantitative terms, compared with conventional data processing with word-processors and spread sheet systems. The newly-introduced database also provides a powerful tool in the preparation of master plans for various energies as well as power development plans.

Continuously updated data on energy and electricity fields can be an asset common to energy-related sectors all. IEV, once acquiring this database technology, would be allowed to construct its own sophisticated database system to process energy statistics/information. The database, if put to best use, would enable the IEV to act as an energy information center. Also, drafted long-term energy development plans could be submitted to the MOE more promptly than ever. In Viet Nam too, rapid penetration of computers is likely not in the far future, thus enabling the IEV to regularly publish database-based energy statistics. It would also become possible to send energy information at home and abroad through communication circuits. This sort of service is likely to bring about an opportunity of new viable activities.

Viet Nam is now in the process toward a market economy. Perhaps social structural reforms of this kind can cause changes to electricity demand structure. To detect such changes and forecast future electricity demand as accurately as possible critically requires the collection and careful analysis of a broad range of data. With these in mind, it is recommended to take following measures from now on.

- Even if the IEV intends to make accurate demand forecasting and/or supply optimization, electricity supply/demand data currently available are insufficient. Given that to collect data minute enough to describe exact pictures of energy consumption/economic activity is as time-consuming as requiring years, efforts to establish a data collection system must be initiated as soon as possible.

- A database system must be put to best use in order to secure reliability of past data and make them useful for multi-purposes.

- Data must continuously be updated.

- In addition to the database, the software provided by the JICA Study Team to help energy demand forecasting/optimal supply planning must be put to effective use in preparing rolling plans for electricity development and long-term energy plans.

To implement these measures, it is recommended to initiate following to begin with.

(1) Scenario-making for Database Use

While to prompt the greater use of database and its upgrading becomes an important subject from now on, a database inevitably gets confused as it is enlarged with an increasing number of data. At some point, therefore, individual tables need to be put in order, then rearranged/integrated by category; Code, Master, Data and Statistics Tables. To this end, it is recommended to carry out such a plan by dividing a period into a greater-use prompted period for the first 1-2 years, an application expanded period for the subsequent 2-3 years, and a rearranging/integrating period for the following 1-2 years, for instance.

(2) Integration/Establishment of Data Collection System

Electricity demand forecasting/supply planning needs a comprehensive judgment by taking into account such factors as status-quo of electricity demand structure and technical/financial prospects. Accordingly, while data in different groups are usually managed independently, in such forms as an electricity supply/demand database and a financial database, it becomes necessary to link these independent databases somehow. If computerized, electricity statistics could be prepared more promptly and accurately than now. Data used in the preparation of electricity statistics are recommended to be accumulated also in the electricity/energy database. To this end, a system for data collection/inputting must be established, preferably with some legal backing.

(3) Appointment of Responsible Staff for Database Management

Database quality assurance also involves attention from operating aspect. Namely, with a public database accessed by many users concerned, its security is so important that data to be strictly managed should clearly be separated from those left accessible to a larger number of users. For instance, it will be worthy to institutionalize how to manage Code, Master or Statistics Tables.
In order to practice institutionalized management and assure data quality as well as database security, it is necessary to appoint a responsible staff for database management. Among others, the database manager is responsible for keeping or improving database structure by him/herself or by instructing his/her staff. He/she is also accountable for such important tasks as protecting the public database with passwords and/or key locks from a foul access by outsiders.

(4) Database Training and Expansion of Users' population

What's important above all is to boost the population of database users. To this end, by appointing instructors and preparing training programs/textbooks, continuous database training needs to be given to those who are concerned.

(5) Data Sharing among Organizations Concerned

A final goal is to construct a broader-range official database by virtue of a common computer system to all organizations concerned. This can broaden a common basis for data, which in turn contributes to improving consistency among various data, thus increasing efficiency of data processing.

CHAPTER 5

ELECTRIC POWER DEMAND FORECAST

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5.1 Concept

Speaking of electric power demand forecasting methods in general, there are two different approaches. One is process engineering method (a kind of build-up system), while the other is based on econometrics (an econometric method). Naturally each has its own advantages and disadvantages. Taking data collection as an example, the former involves a wide variety of data, but few time-series data. In specific terms, to forecast residential/commercial electricity demand with a process engineering method, detailed data on various household electric appliances including their efficiency and operating hours, are essential. In contrast, the latter requires few data of this kind but time-series data in the long run (ten years or longer).

Results forecast by a process engineering method are easily understandable, as they are based on neatly-organized data of various kinds or many assumptions related to end-use efficiencies. In case of an econometric method, the results which reflect economic growth and demand structure at macroscopic viewpoint can be easily compared with other countries on the same ring, however, the background of forecast results can hardly be explained in detail and be altered artificially because macro economic/social indicators are incorporated as exogenous variables.

In this study, an econometric approach is applied simply because data on energy efficiencies of specific appliances and energy intensities can hardly be collected. Therefore, while historical trends on sector-by-sector GDP and population etc. are in use, what will be these macro indicators ahead is assumed by preparing scenarios by region (the Northern, Central and Southern regions) and by sector (agriculture, industry and others), and each consisting of three (low, base, high) cases.

Basic framework of electric power demand forecast outlined in this report is as follows:

Forecasting scope:	1. Nationwide 2. By region (northern, central, southern) 3. By prefecture (23 in Northern, 11 in Central, 29 in Southern regions)
By-region economic scenarios:	1. Low case 2. Base case 3. High case
Categories of consuming sectors:	1. Agricultural sector 2. Industrial sector 3. Residential/commercial sector 4. Others
Period:	1. Base year 1993 2. Target year 2010

5.2 Economic Scenarios used in Electric Power Demand Forecasting

5.2.1 Historical Trends of GDP

Table 5.2-1 shows historical trends of sector-by-sector GDP (in million U.S. dollars) and annual average growth rates (%) in Viet Nam in the past (1976-92). GDP values are expressed at 1989 constant price, with exchange rate set at 1,912 dongs/US$.

As shown in Table 5.2-1, total GDP grew at an annual average pace at the 5% level during the 1980s, and the 6~8% level from 1990 and on. Above all the service and financial sectors grew as high as outpacing 10% per year since 1985. The growth of the industrial sector hit the 9% mark in 1990 and afterward. The biggest contributors to GDP were the agricultural and service sectors, accounting for 19% and 16% each of total GDP (in 1992).

Meanwhile, GDP is categorized into industrial, agricultural and service/others sectors in this study in correspondence to the categories used in the economic scenarios which provide GDP projection as described later. Figure 5.2-1 illustrates historical trends of GDP by sector in Viet Nam. Major contributors to GDP growth were agriculture and others. Figure 5.2-2 shows relationship between GDP and electric power demand since 1976. It is noted that the both demonstrate similar trends in their past records.

5.2.2 Economic Scenarios

Three economic scenarios (low, base and high cases) were prepared at five year intervals, 1990-1995-2000-2005-2010, for each of the Northern, Central and Southern regions. As already mentioned, consuming sectors were categorized into industry, agriculture and others (see Appendix). Namely, from by-region by-sector GDP growth rates (%) up to 2010, calculated are by-region by-sector GDP and regional total GDP values, and from which nationwide sector-by-sector GDP growth rates (%) and total GDP values are computed. Table 5.2-2 shows total GDP values and growth rates in each region.

As noted from Table 5.2-2 and Appendix, GDP growth rate varies depending on regions. Up to 2000, a high economic growth precedes in the South. This scenario also assumes that economic activities in the North will be accelerated from 2000 and on, and the Central region will catch up subsequently after 2005. By-sector economic scenarios for industry and others are akin to the aforementioned total GDP scenarios. Compositions of economic activity put the South in the so-called first runner position, and the North in the second runner. GDP growth rates in the agricultural sector are assumed at the levels of 4% for the North, 4-5% for the Center, and 6% for the South.

Vietnamese GDP in the base case of scenarios is expected to be doubled from 1992 to 2000 and also doubled by 2010. As shown in Table 5.2-2, GDP (in the base case) would increase from 15.1 billion US$ in 1992 to 31.6 billion US$ in 2000, to 48.3 billion US$ in 2005 and to 71.1 billion US$ by 2010, up 8% per year on the average growth rate.

Comparing these figures above with actual GDP values in Asian countries, GDP scale of Viet Nam will reach Singapore's levels as of 1992 around 2000, Malaysia around 2005 and Thailand around 2010 (see Appendix "Energy Indicators in Selected Asian Countries).

Table 5.2-3 shows per capita GDP (at constant price in 1989 US$), calculated from GDP scenario by region. In the base case, nationwide per capita GDP is expected to be doubled in ten years from 1995. The projected economic level, 754 (US$/capita), is presumed being as almost similar as those of about 1963 of Taiwan, 1969 of South Korea and 1983 of Thailand.

Speaking of regional gaps, it is allowed to mention that gaps among regions will widen year by year up to the middle of 2000s and will shrink from about 2005 onward. Per capita GDP of the Southern region will keep widening from twice to 2.6 times over it of the Northern region, and 2.5 - 3.6 times of the Central region. The economic level of the South (1,252 US$/capita) would reach to the present Thai level as of 2010 in the base case. Taking the high case, the South's level (1,471 US$/capita) as of 2010 is estimated to be almost equal to the beginnings of 1970s and 1980s of Taiwan and South Korea respectively (See Appendix).

Table 5.2-1 Gross Domestic Product by Sector

(at constant prices of 1989, Million US$)

	Agricul-ture Forestry	Industry	Construc-tion	Other Material	Trade	Transport Com-munication	Finance Insurance	Service Private	Total
1976	3,312	1,422	405	64	1,070	226	436	583	7,518
1980	3,421	1,439	381	66	1,065	201	486	668	7,727
AGR(%)	0.81	0.29	-1.50	0.75	-0.13	-2.91	2.79	3.45	0.69
1985	4,480	2,074	432	87	1,276	264	683	967	10,264
AGR(%)	5.54	7.59	2.54	5.77	3.70	5.63	7.01	7.69	5.84
1990	5,223	2,449	478	117	1,649	328	1,147	1,964	13,356
AGR(%)	3.12	3.37	2.02	6.05	5.26	4.47	10.94	15.22	5.41
1992	5,492	2,922	517	124	1,772	366	1,530	2,407	15,129
AGR(%)	2.54	9.23	4.00	2.90	3.65	5.64	15.49	10.69	6.43

Source: IEV

Note: 1912 dong/US$, AGR=Annual Growth Rate (%)

Table 5.2-2 GDP and GDP Growth Rate by Scenario

(Unit: Million US$ at 1989 constant price, %)

		1990	1995	90-95 AGR(%)	2000	95-00 AGR(%)	2005	00-05 AGR(%)	2010	05-10 AGR(%)
Northern Region	Low case	4,792	5,888	4.20	8,165	6.76	11,915	7.85	17,328	7.78
	Base case	4,792	6,167	5.17	8,877	7.56	13,544	8.82	20,576	8.72
	High case	4,792	6,289	5.59	9,353	8.26	14,835	9.67	23,521	9.66
Central Region	Low case	1,447	1,810	4.58	2,406	5.86	3,305	6.56	4,681	7.21
	Base case	1,447	1,877	5.35	2,626	6.95	3,723	7.24	5,472	8.01
	High case	1,447	1,919	5.81	2,776	7.67	4,080	8.01	6,251	8.91
Southern Region	Low case	7,890	11,884	8.54	17,901	8.54	25,912	7.68	35,651	6.59
	Base case	7,890	12,446	9.54	20,132	10.10	30,986	9.01	45,090	7.79
	High case	7,890	12,960	10.43	21,529	10.68	34,910	10.15	52,993	8.71
Whole Nation	Low case	14,129	19,581	6.74	28,472	7.77	41,132	7.63	57,660	6.99
	Base case	14,129	20,489	7.72	31,634	9.08	48,253	8.81	71,138	8.07
	High case	14,129	21,169	8.42	33,658	9.72	53,826	9.84	82,765	8.99

Note: AGR= Annual Growth Rate (%)

Table 5.2-3 Per Capita GDP and Growth Rate by Scenario

(Unit: Million US$ at 1989 constant price, %)

		1990	1995	2000	95-00	2005	00-05	2010	05-10
Northern Region	Pop. (million)	30.8	34.8	37.8	1.66	40.3	1.31	42.7	1.13
	Low case	155.6	169.1	216.0	5.01	295.4	6.46	406.0	6.57
	Base case	155.6	177.2	234.8	5.80	335.8	7.41	482.1	7.50
	High case	155.6	180.7	247.4	6.49	367.8	8.25	551.1	8.43
Central Region	Pop. (million)	9.5	11.6	13.1	2.48	14.4	1.97	15.7	1.65
	Low case	152.3	156.1	183.6	3.30	228.9	4.50	298.7	5.47
	Base case	152.3	161.9	200.4	4.36	257.9	5.17	349.2	6.25
	High case	152.3	165.6	211.9	5.06	282.6	5.92	398.9	7.14
Southern Region	Pop. (million)	25.2	28.2	31.2	2.01	33.8	1.59	36.0	1.32
	Low case	313.1	421.0	573.9	6.40	767.7	5.99	989.5	5.21
	Base case	313.1	440.9	645.5	7.92	918.1	7.30	1,251.5	6.39
	High case	313.1	459.1	690.3	8.50	1,034.4	8.43	1,470.8	7.29
Whole Nation	Pop. (million)	65.5	74.6	82.1	1.93	88.5	1.51	94.4	1.29
	Low case	215.7	262.4	346.8	5.74	464.8	6.03	610.9	5.62
	Base case	215.7	274.5	385.3	7.01	545.2	7.19	753.7	6.69
	High case	215.7	283.6	410.0	7.65	608.2	8.21	876.9	7.59

Note: AGR= Annual Growth Rate (%)

Figure 5.2-1 Historical Trends of GDP in Viet Nam

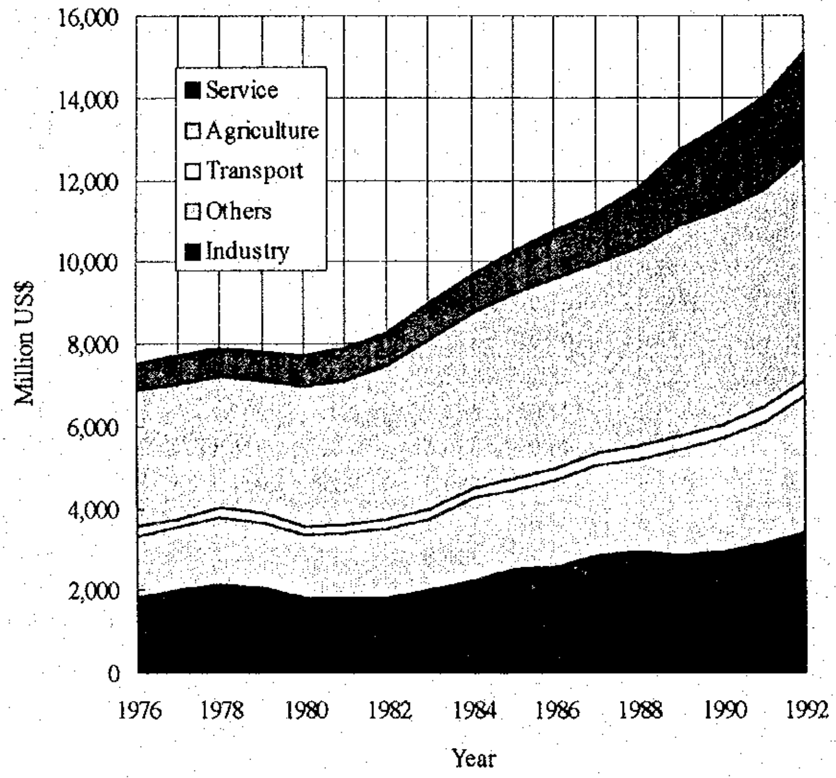
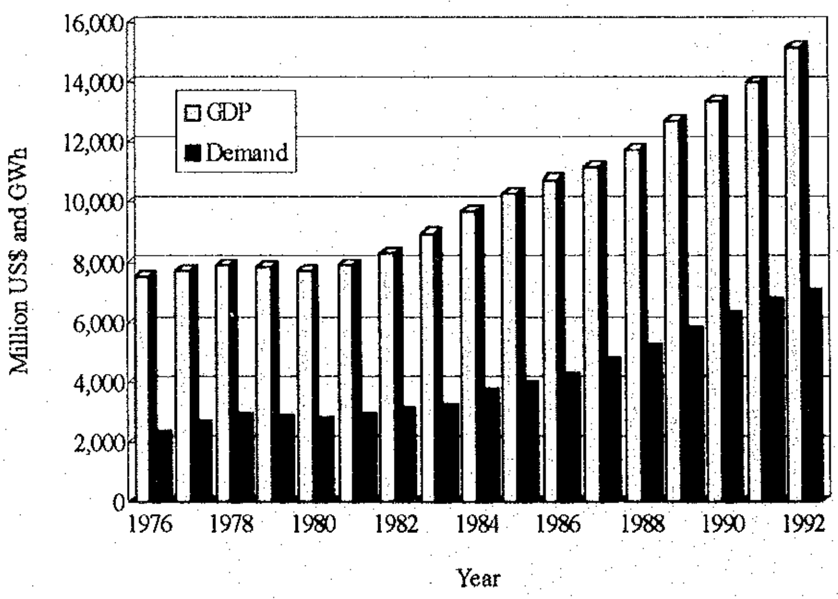


Figure 5.2-2 Historical Trends of GDP and Power Demand



5.3 Electric Power Demand Forecasting Models

5.3.1 Flow of Models

Figure 5.3-1 shows the flow diagram of the demand forecast. The portions enclosed with dotted lines are given as exogenous variables. In accordance with the chart, the flow is explained below.

(1) Nationwide

Electric power demand forecast was made first at nationwide level. The greatest reason is that time-series data, which provide past socio-economic indicators necessary for model building, are available only at nationwide levels. Accordingly, the nationwide model was built by making regression analyses on the relationship between past trends of by-sector GDP, population and the number of electricity consumers and those of by-sector electric power consumption. In order to forecast the demand nationwide, a model (a system of simultaneous equations) resulting from the analyses above was used in making scenario-by-scenario calculations. Nationwide scenarios in use were set by accumulating what were prepared for the low, base and high cases in each region. If time-series data on the past GDP would become available by region and by sector, it sounds natural to consider the option to forecast the regional demand first.

(2) Northern, Central and Southern Regions

The region-by-region demand forecasting model is designed to calculate each year's region-wide demand by use of given scenarios to each region (sector-by-sector GDP projection, etc.) in accordance with the whole country demand already projected by the nationwide model. The social and economic indicators adopt exogenous variables in the low, base and high cases already mentioned.

After the calculation of the regional demand, power generation by region is computed by taking total loss factor (technical + non-technical losses) as an exogenous variable. Likewise, peak load by region is calculated by taking load factor as an exogenous variable. Nationwide power generation and peak load are obtained by adding up the calculated values for regional generation and peak load.

At this stage, total loss factor at nationwide level is calculated back from power generation and demand (sales power), and load factor at nationwide level from power generation and peak load.

(3) Prefectures

Electric power demand by prefecture is obtained by dividing region-wide (the Northern, Central, or Southern region) demand into prefectural units in proportion to their shares in actual demand and estimated substation (transformer) capacity . Demand is forecast for the sections of the years 1995, 2000, 2005 and 2010.

<Note>

As described just before, total loss rates and annual load factors were introduced by region as exogenous variables. Total loss rates in each region are expected to be steadily improved from 1993 values (28% in the North, 25% in the Center and 23% in the South) to 20% in 2000, to 19% in 2005 and to 15-17% in 2010 (See Appendix). As the result, total loss rate nationwide would be decreased from 25.4% in 1993 to 20% (2000), to 19% (2005) and to 16% (2010). Excluding non-technical loss and own use rates from the total loss rate 16% as of 2010, residual transmission/distribution loss rate is estimated to be around 10% which is corresponding to Thailand' level today.

Annual load factors were also introduced by region. In 1993, the load factors were 57% (North), 51% (Center) and 63% (South) respectively, and the regional gaps are expected to be shrunk in proportion to advancing of system network nationwide. In the Northern region, the load factor is set at 59% (1999-2005) and 62% (2006-2010), from reason why the share held by heavy-chemical industry in total industrial electric power demand will be up and leveling of peak load be easier in the North than the South. In the Southern region, the peak leveling is considered to be more difficult than in the North, because weight held by light industry and service/commercial sector is heavier in the South. The load factor of 60% is set during 1999-2010. In the Central region, taking that electricity will be able to be supplied through system network by shifting from isolated power sources, the load factor is set to be gradually increased from 51% in 1993 to 58% in 2010 (See Appendix). As the result, annual load factor nationwide would increase slightly from 59% in 1993 to 61% in 2010.

5.3.2 Model Structure

Three types of electric power demand forecasting models (nationwide, region-wide, prefecture-wide) are shown in Appendix. Concepts and structures of the three models are described below.

(1) Nationwide

This model is based on the relations among electric power consumption by-sector, GDP, electrification ratio, etc. Sectors are categorized into industrial, agricultural, residential/ commercial, and others. Following functional relations are assumed for the model building.

DI = f (GDPi)
DA = f (GDPa)
DO = f (GDPo)
DR = f (No. of electricity consumers),

No. of electricity consumers = electrification ratio x population
Electrification ratio = f (GDP/capita)

DT = DI + DA + DO + DR

Where,
DI = Demand for industrial use
DA = Demand for agricultural use
DO = Demand for others
DR = Demand for residential/commercial use
DT = Demand in total

GDP = Gross Domestic Product; The affixed letters of i, a and o stand for industry, agriculture, and others, respectively.

The model is constructed by making regression analyses on the functional relations above, with 1976-93 time-series data in use.

(2) Northern, Central and Southern Regions

Electric power demand by region is calculated by using by-sector by-year elasticity. Naturally, the sum total of demand by sector (agricultural, industrial, residential/ commercial, others), forecast with a nationwide model, must be identical to the sum total of region-by-region demand.

The region-wide model has a mechanism to make calculations based on given sector-by-sector scenarios to each region, while linked to year-by-year elasticity got from the nationwide model. Functional relations among sector-by-sector demand, GDP and electrification ratio etc. are the same as adopted in the nationwide model. Its basic structure is described below by taking the industrial sector as an example.

<Industrial sector>

$$DI(t)_n = f(Ei(t), GDPi(t)_n, GDPi(t-1)_n, DI(t-1)_n)$$
$$DI(t)_c = f(Ei(t), ei(t), GDPi(t)_c, GDPi(t-1)_c, DI(t-1)_c)$$
$$DI(t)_s = f(Ei(t), GDPi(t)_s, GDPi(t-1)_s, DI(t-1)_s)$$
$$DI(t) = DI(t) + DI(t)_c + DI(t)_s$$
$$GDPi(t) = GDPi(t)_n + GDPi(t)_c + GDPt(t)_s$$
$$Ei(t) = ((DI(t)-DI(t-1))/DI(t))/((GDPi(t)-GDPi(t-1))/GDPi(t))$$

Where,

DI(t), GDPi(t): Industrial demand and industrial GDP in t year
Ei(t), ei(t): Industrial demand elasticity and adjustment term in t year
The affixed letters of n, c, s stand for the Northern, Central, and Southern regions, each.

Thus, this calculation method is designed first to compute by-year by-sector elasticity from the results forecast by nationwide model, then compute demand in t year based on a given economic scenario to each region (GDP etc.), and on demand in t-1 year. The sum total of sector-by-sector demand in each region represents regional total demand.

Meanwhile, the adjustment term was introduced to meet fine differences between the sum total of by-region by-sector demand and the nationwide model-based forecast results. The adjustment term was applied to the Central region. Though policy adjustment term was not introduced this time, a possibility remains of applying an adjustment term on energy policy.

(3) Prefectures

As already described, electric power demand by prefecture was obtained by allocating the total demand in a given region to the prefectures within the region. Prefectural demand was forecast only for the sections of the years 1995, 2000, 2005 and 2010. Prefectural demand was not considered by sector. Methodologically, demand is estimated not merely from actual demand by prefecture, but by allocating incremental demand during a target period to concerned prefectures in proportion to their shares in substation capacity (estimated). For instance, a northern prefecture p's demand in 1995 is calculated as follows. Likewise, other prefectural demand is calculated for remaining northern prefectures.

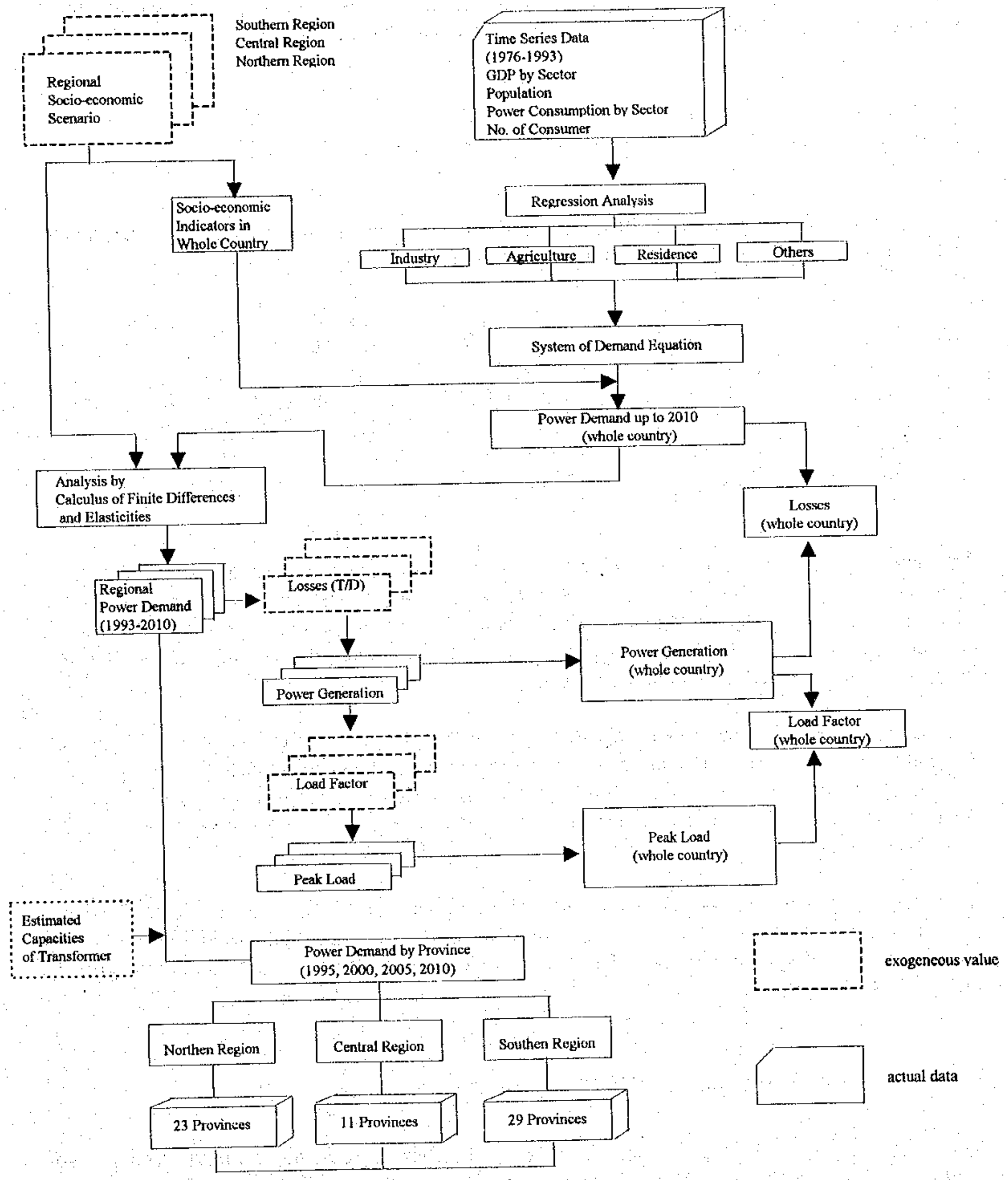
$$Dp(1995) = Dp(1993) + \triangle DT_n \times Share$$

Where.

Dp(1995)	= p's prefectural demand (in 1995)
Dp(1993)	= p's prefectural demand recorded in 1993
$\triangle DT_n$	= Northern region's incremental demand during 1993-95
Share	= p's share in substation capacity installed in the Northern region.

As this model has few independent variables for a reason of data availability, it is better to build up a model adding new variables in the future rolling plan. For instance, an electricity-price term was not incorporated into the demand forecasting model built this time. It is because Vietnamese pricing system in the past differed from the mechanism of a market economy and because statistically reliable price elasticity could not be calculated due to hyper-inflation since the 1980s (ex. 600-800% in 1986). From now on, along with advancing moves to a market economy, it is quite probable that electricity pricing not merely produces impacts on electric power demand but has massive influences on efficient ways of electricity use as well as popularization of more-efficient electric appliances. Thus, if adequate advice by use of models be made on electricity pricing policy and others, it is recommended to make in-depth reviews periodically on the relations among price, income and electric power demand for the future.

Figure 5.3-1 Flow Diagram for Power Demand Forecasting



5.4 Electric Power Demand Forecast

5.4.1 Demand Forecast by IEV

Before as of October 1994, required electric power (generation) in the country was projected in the period 1992-2000 as follows. The figures show values in the low and high cases in GWh terms.

	Nationwide	North	Center	South
1995	13,800-15,800	6,500- 7,000	1,000-1,600	6,300- 7,200
2000	20,000-27,200	9,400-12,000	1,700-3,000	8,900-11,800

Entering December 1994, MOE adopted following figures as likely power generation for the years to 2010 (on Dec. 15, 1994). As shown immediately above, the figures are in GWh terms.

		Nationwide	North	Center	South
2000	Low case	- (22,621)	- (8,985)	- (1,874)	- (11,762)
	Base case	25,310 (24,412)	9,781 (9,740)	2,279 (2,009)	13,250 (12,662)
	High case	27,465 (26,047)	10,695 (10,387)	2,442 (2,111)	14,328 (13,550)
2010	Low case	56,061	19,316	4,684	32,061
	Base case	68,369	24,183	5,267	38,919
	High case	75,203	27,003	6,021	42,179

The demand was forecast by two different methods (IEV), namely, one was estimated with a build-up system, while another was projected by use of relevant elasticity with respect to GDP. MOE adopted only the base and high cases of results obtained by the former method for the 2000 demand, and all cases by the latter for the 2010 demand. As a reference, the 2000 values projected by the latter method are shown in brackets above.

Introducing of electric power demand forecasting method applied by IEV in brief, category of demand sector is classified into industrial, agricultural, residential and others including transport and non-industrial sector, same as JICA Study Team. By-region (the Northern, Central, Southern) economic scenarios of three cases (low, base, high) and by-region by-sector elasticity are set as exogenous values.

In consequence, industrial demand is computed from growth rate in industrial GDP and elasticity (with respect to industrial GDP), and agricultural and others are also calculated from the GDP growth rates and elasticities of the respective sectors. Residential demand is related to urban growth rates and the elasticities.

5.4.2 Demand Forecast by JICA Study Team

Results of nationwide demand are shown in Annex 1, while those in the Northern, Central and Southern regions are shown in Annex 2, Annex 3 and Annex 4 respectively. By-prefecture demand forecast results are contained in Annex 5 (See Appendix).

(1) Total Demand

Forecast results are summarized in Table 5.4-1 (demand), Table 5.4-2 (generation) and Table 5.4-3 (peak load). Figure 5.4-1 shows forecast results for the years to 2010 by scenario (low, base and high cases). Figure 5.4-2 also presents the demand by region in the base case.

(a) Nationwide

In the base case, Vietnamese total electric power demand nationwide would increase at average growth rate of 12.8% per year from 8,007 GWh in 1993 to 18,631 GWh in 2000, up 2.3 times over the 1993 value. From 2000 to 2010, the total demand would increase 11.6% per year on the average and reach 55,948 GWh by 2010 (almost sevenfold demand of 1993).

In generation (in base case), 10,729 GWh recorded in 1993 is likely to rise to 23,289 GWh by 2000 (up 11.7% per year), and reach 66,600 GWh by 2010 (up 11.1% per year), each representing 2.2 times and 6.2 times over the 1993 record. In peak load (in base case), 2,083 MW in 1993 is expected to reach 4,526 MW by 2000 (up 11.7% per year), and further 12,550 MW by 2010 (up 11.1% per year). They represent 2.2 times and 6.0 times over the 1993 value, respectively.

Electric power demand, generation and peak load in the low and high cases deviate from corresponding figures in the base case as much as -9.3% (low case) and +6.2% (high case) as of 2000, and -18.3% (low case) and +16.4% (high case) as of 2010. Naturally deviations from the base case keep widening year by year.

(b) Demand by region

Regarding by-region electric power demand, the highest demand growth is marked in the South, where the demand is likely to grow from 3,491 GWh in 1993 to 9,211 GWh by 2000 (up 14.9% per year) and reach 27,454 GWh by 2010 (up 11.5% per year) in the base case. In the Northern region, the demand is expected to climb from 3,879 GWh in 1993 to 7,322 GWh in 2000 (up 9.5% per year) and reach 22,813 GWh by 2010 (up 12.0% per year). In the Central region, the demand is projected to boost from 638 GWh in 1993 to 2,098 GWh by 2000 (up 18.5% per year), and to 5,682 GWh by 2010 (up 10.5% per year). The massive growth in the Central region is explained by that the region's denominator (1993 demand) is smaller by a digit than the other two regions.

As a result, the share held by the North in nationwide demand is expected to fall from 48.4% in 1993 to 39.3% (2000) and to 40.8% (2010). On the other hand, the South will increase its share from 43.6% (1993) to 49.4% (2000) and to 49.1% (2010), and the Central region from 8.3% (1993) to 11.3% (2000) and to 10.2% (2010).

By region, deviations of the demand in the low and high cases from the base case amount to -5.2% , +5.4% for the North, -16.3% , +8.6% for the Center, and -10.9% , +6.2% for South as of 2000. By 2010, the deviations amount to -13.3% , +14.9% for the North, -27.6% , +19.5% for the Center, and -20.5% , +17.0% for the South. Judging from the above, considerable deviations are likely for the Southern and Central regions, particularly the latter. Moreover, the results show wider downward deviations (toward low case) likely in the Southern and Central regions. These trends are also common to the power generation and peak load forecasts.

(2) **Demand Structure by Sector**

Sector-by-sector demand forecast results are summarized in Tables 5.4-4 and 5.4-5.

(a) **Nationwide**

Examinations of by-sector demand in the country show that the industrial sector is likely to record the highest growth, followed by the residential/commercial sector. In the base case, industrial demand is assumed to grow from 3,645 GWh in 1993 to 9,795 GWh by 2000 (up 15.2% per year), and reach 34,572 GWh by 2010 (up 13.4% per year). They are 2.7 times and 9.5 times above the 1993 demand. As a result, the share held by the industrial sector in total demand will be up from 45.5% in 1993 to 52.6% in 2000, and to 61.8% in 2010.

Residential and commercial demand in the base case is expected to rise from 3,236 GWh in 1993 to 6,689 GWh in 2000 (up 10.9% per year) and to 18,200 GWh in 2010 (up 10.5% per year), standing 2.1 times and 5.6 times each above the 1993 demand. The share in total demand will be down from 40.4% in 1993 to 35.9% in 2000, and to 32.5% in 2010. A steady demand growth is also likely in the agricultural sector and transport/others (Refer to Table 5.4-4).

Deviations of low- and high-case figures from the base case are particularly sharp in the industrial sector, and amount to -11.2%, +7.7% as of 2000, and to -21.1%, +20.6% as of 2010. These suggest that, as of 2010, the demand can fluctuate as much as 20% depending on advances of economic development within given scenarios. In the agricultural sector and others, deviations from the base case are limited.

(b) **Regions**

In the base case, industrial demand in the South will register a marked growth in the years to 2000, but the North will outgrow the South from 2000 and on. The Central region too is likely to record a high growth up to 2000, but it simply reflects the extremely low 1993 demand (see Table 5.4-5). As a result, industrial demand in the North will expand from 1,680 GWh (1993) to 3,447 GWh (2000) and to 13,155 GWh (2010), while the demand in the South up from 1,740 GWh (1993) to 5,327 GWh (2000) and to 18,128 GWh (2010).

Residential demand will be also up from 1,713 GWh (1993) to 3,069 GWh (2000) and to 8,452 GWh (2010) in the North, while the demand in the South up from 1.263 GWh (1993) to 2,869 GWh (2000) and to 7,859 GWh (2010). The demand for agricultural use and others will grow as shown in Table 5.4-5.

Differences in demand structure between the South and North are that the demand for the industrial sector and others will be kept higher in the South than in the North, and that residential and agricultural demand is kept higher in the North than in the South. In other words, the industrial sector and others account for larger shares in region-wide demand in the South than in the North, while weight held by the residential and agricultural sectors in region-wide demand is heavier in the North than in the South (Refer to Table 5.4-5).

(3) **Demand by Prefecture**

Of 53 prefectures which make up the country, only a few prefectures have massive electric power demand. For instance, demand forecast results (in the base case) show that the number of prefectures likely to consume more than 1,000 GWh as of 2010 is seven (Hanoi, Hai Phong, Hai Hung, Thanh Hoa, Nam Ha, Bac Thai and Quang Ninh) in the South, only one (Da Nang) in the Central region, and four (Ho Chi Minh, Dong Nai, Ba Ria-Vung Tau and Can Tho) in the North. Prefectures expected to consume more than 4,000 GWh number only four and include Hanoi (5,808 GWh) and Hai Phong (4,262 GWh) in the North and Ho Chi Minh (12,174 GWh) and Dong Nai (4.322 GWh) in the South. To sum up, it is allowed to say that regional gaps will not disappear as of 2010 yet (Refer to Figure 5.4-3).

As of 1993, Ho Chi Minh occupies 57% of region-wide demand in the South. In the base case, its share is likely to decline to 50% by 2000 and to 44% by 2010. But, in absolute terms, the prefectural demand will expand from 1,989 GWh (1993) to 4,578 GWh (up 2.3 times) by 2000, and to 12.174 GWh (up 6.1 times) by 2010. In the North, the share held by Hanoi in the region-wide demand will stay at around 26%, while its demand in absolute terms is likely to grow from 1,044 GWh (1993) to 1,922 GWh (up 1.8 times) by 2000, and to 5,808 GWh (up 5.6 times) by 2010.

Table 5.4-1 Summary of Forecasted Power Demand

(Unit:GWh)

Year		Whole Country	AGR (%)	Northern Region	AGR (%)	Central Region	AGR (%)	Southern Region	AGR (%)
1993		8,006.8		3,878.7		637.6		3,490.5	
2000	Low case	16,902.5	11.26	6,938.8	8.66	1,755.4	15.57	8,208.4	12.99
	Base case	18,630.8	12.82	7,322.2	9.50	2,097.7	18.55	9,210.9	14.87
	High case	19,777.9	13.79	7,715.6	10.32	2,278.0	19.95	9,784.4	15.86
2010	Low case	45,726.0	10.46	19,776.0	11.04	4,115.8	8.89	21,834.3	10.28
	Base case	55,948.3	11.62	22,812.6	12.03	5,681.5	10.48	27,454.2	11.54
	High case	65,130.1	12.66	26,208.6	13.01	6,788.2	11.54	32,133.4	12.63

Note: AGR=Annual Growth Rate (%)

Table 5.4-2 Summary of Forecasted Power Generation

(Unit:GWh)

Year		Whole Country	AGR (%)	Northern Region	AGR (%)	Central Region	AGR (%)	Southern Region	AGR (%)
1993		10,728.9		5,374.0		848.1		4,506.8	
2000	Low case	21,128.5	10.17	8,673.4	7.08	2,194.2	14.54	10,260.5	12.47
	Base case	23,288.5	11.71	9,152.7	7.90	2,622.1	17.50	11,513.6	14.34
	High case	24,722.4	12.67	9,644.4	8.71	2,847.4	18.89	12,230.5	15.33
2010	Low case	54,414.3	9.92	23,265.8	10.37	4,842.1	8.24	26,306.4	9.87
	Base case	66,599.8	11.08	26,838.4	11.36	6,684.1	9.81	33,077.3	11.13
	High case	77,534.6	12.11	30,833.6	12.32	7,986.1	10.86	38,714.9	12.21

Note: AGR=Annual Growth Rate (%)

Table 5.4-3 Summary of Forecasted Peak Load

(Unit:MW)

Year		Whole Country	AGR (%)	Northern Region	AGR (%)	Central Region	AGR (%)	Southern Region	AGR (%)
1993		2,082.7		1,076.3		189.8		816.6	
2000	Low case	4,102.9	10.17	1,678.2	6.55	472.6	13.92	1,952.1	13.26
	Base case	4,526.2	11.73	1,770.9	7.37	564.8	16.86	2,190.6	15.14
	High case	4,806.3	12.69	1,866.0	8.18	613.3	18.24	2,327.0	16.14
2010	Low case	10,241.8	9.58	4,283.7	9.82	953.0	7.27	5,005.0	9.87
	Base case	12,550.3	10.74	4,941.5	10.81	1,315.6	8.82	6,293.3	11.13
	High case	14,614.8	11.76	5,677.1	11.77	1,571.8	9.87	7,365.8	12.21

Note: AGR=Annual Growth Rate (%)

Table 5.4-4 Summary of Power Demand by Sector (Whole Country)

(Unit: GWh)

		Industry	AGR(%)	Agriculture	AGR(%)	Others	AGR(%)	Residential	AGR(%)	Total
1993	Actual	3,644.7		429.5		696.2		3,236.4		8,006.8
	(Share %)	45.5		5.4		8.7		40.4		100.0
2000	Low case	8,698.0	13.23	724.1	7.75	1,307.1	9.42	6,172.9	9.66	16,902.1
	(Share %)	51.5		4.3		7.7		36.5		100.0
	Base case	9,795.3	15.17	743.8	8.16	1,403.1	10.53	6,688.5	10.93	18,630.7
	(Share %)	52.6		4.0		7.5		35.9		100.0
	High case	10,557.6	16.41	743.8	8.16	1,461.9	11.18	7,014.6	11.68	19,777.9
	(Share %)	53.4		3.8		7.4		35.5		100.0
2010	Low case	27,275.6	12.11	1,057.7	3.86	1,834.3	3.45	15,558.5	9.69	45,726.1
	(Share %)	59.6		2.3		4.0		34.0		100.0
	Base case	34,572.3	13.44	1,175.6	4.68	2,000.7	3.61	18,199.6	10.53	55,948.2
	(Share %)	61.8		2.1		3.6		32.5		100.0
	High case	41,687.1	14.72	1,175.6	4.68	2,129.9	3.84	20,137.6	11.12	65,130.2
	(Share %)	64.0		1.8		3.3		30.9		100.0

Note: AGR= Annual Growth Rate (%)

Table 5.4-5 Summary of Power Demand by Region (Base Case)

(Unit: GWh)

		Industry	AGR(%)	Agriculture	AGR(%)	Others	AGR(%)	Residential	AGR(%)	Total
1993	Northern R.	1,680.0		259.7		226.5		1,712.5		3,878.7
	(Share %)	43.3		6.7		5.8		44.2		100.0
	Central R.	224.8		74.2		78.1		260.5		637.6
	(Share %)	35.3		11.6		12.2		40.9		100.0
	Southern R.	1,739.9		95.6		391.6		1,263.4		3,490.5
	(Share %)	49.8		2.7		11.2		36.2		100.0
	Country	3,644.7		429.5		696.2		3,236.4		8,006.8
	(Share %)	45.5		5.4		8.7		40.4		100.0
2000	Northern R.	3,446.5	10.8	381.1	5.6	425.7	9.4	3,068.8	8.7	7,322.1
	(Share %)	47.1		5.2		5.8		41.9		100.0
	Central R.	1,022.1	24.2	176.3	13.2	148.4	9.6	750.9	16.3	2,097.7
	(Share %)	48.7		8.4		7.1		35.8		100.0
	Southern R.	5,326.7	17.3	186.4	10.0	828.9	11.3	2,868.9	12.4	9,210.9
	(Share %)	57.8		2.0		9.0		31.1		100.0
	Country	9,795.3	15.2	743.8	8.2	1,403.0	10.5	6,688.6	10.9	18,630.7
	(Share %)	52.6		4.0		7.5		35.9		100.0
2010	Northern R.	13,154.5	14.3	571.1	4.1	635.0	4.1	8,452.0	10.7	22,812.6
	(Share %)	57.7		2.5		2.8		37.0		100.0
	Central R.	3,289.9	12.4	296.4	5.3	206.4	3.4	1,888.8	9.7	5,681.5
	(Share %)	57.9		5.2		3.6		33.2		100.0
	Southern R.	18,127.9	13.0	308.2	5.2	1,159.2	3.4	7,858.9	10.6	27,454.2
	(Share %)	66.0		1.1		4.2		28.6		100.0
	Country	34,572.3	13.4	1,175.7	4.7	2,000.6	3.6	18,199.7	10.5	55,948.3
	(Share %)	61.8		2.1		3.6		32.5		100.0

Note: AGR= Annual Growth Rate (%)

Figure 5.4-1 Power Demand up to 2010 (Whole Country)

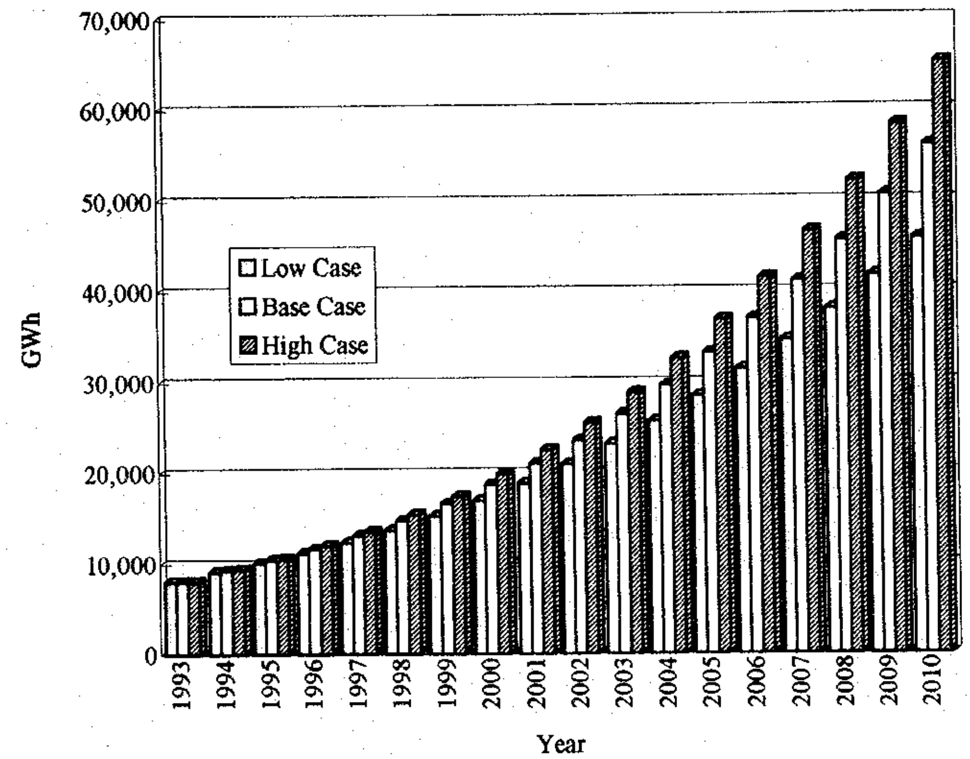
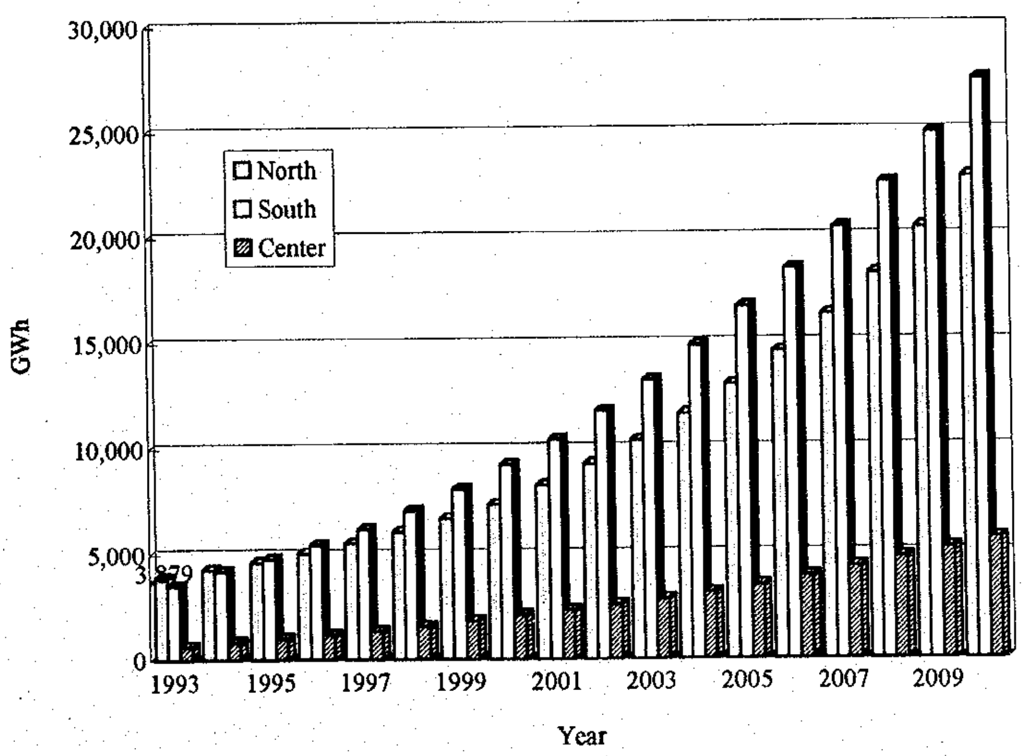


Figure 5.4-2 Power Demand by Region (Base Case)



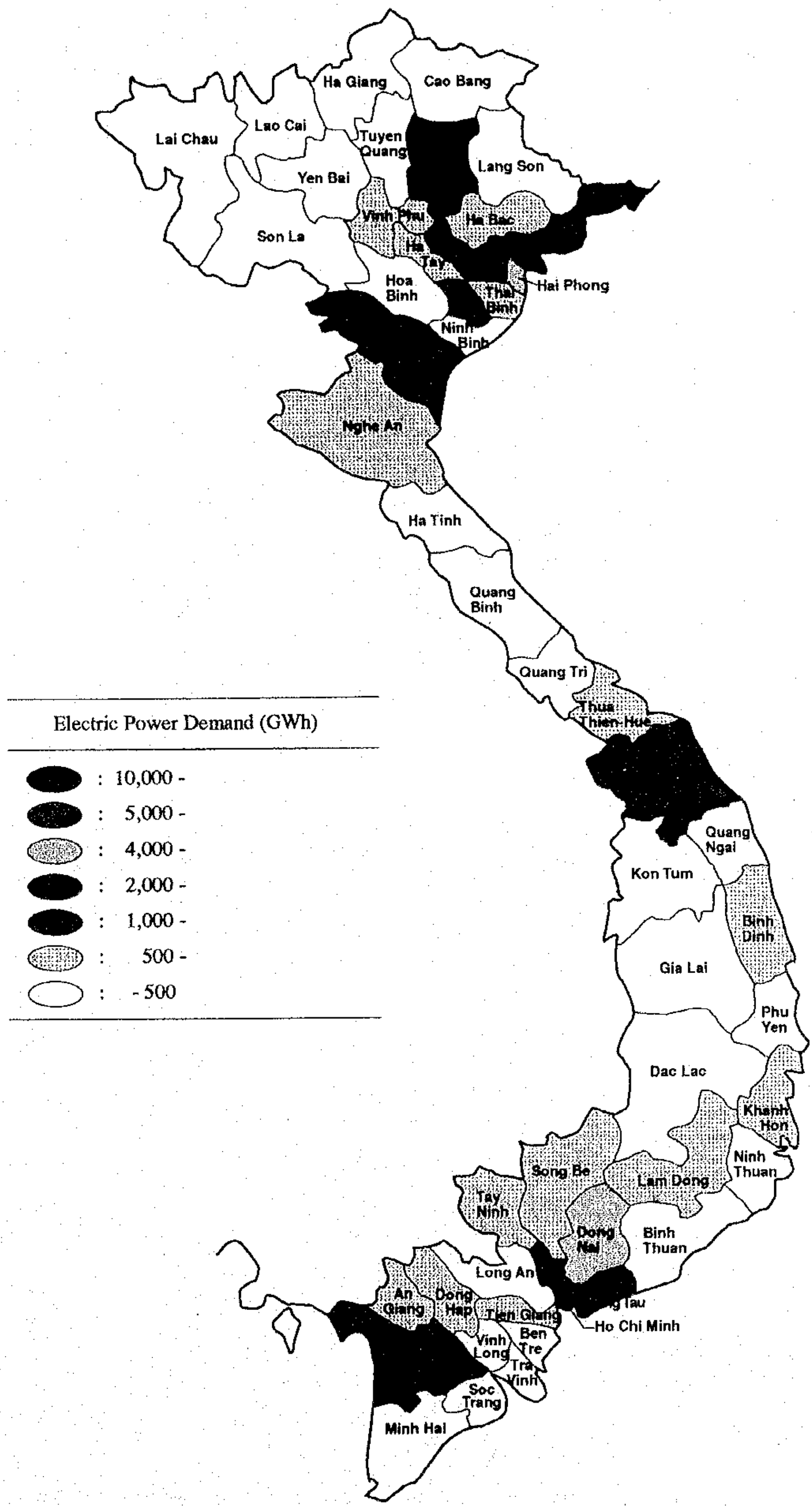


Figure 5.4-3 Prefecture Electric Power Demand Forecast as 2010 (Base Case)

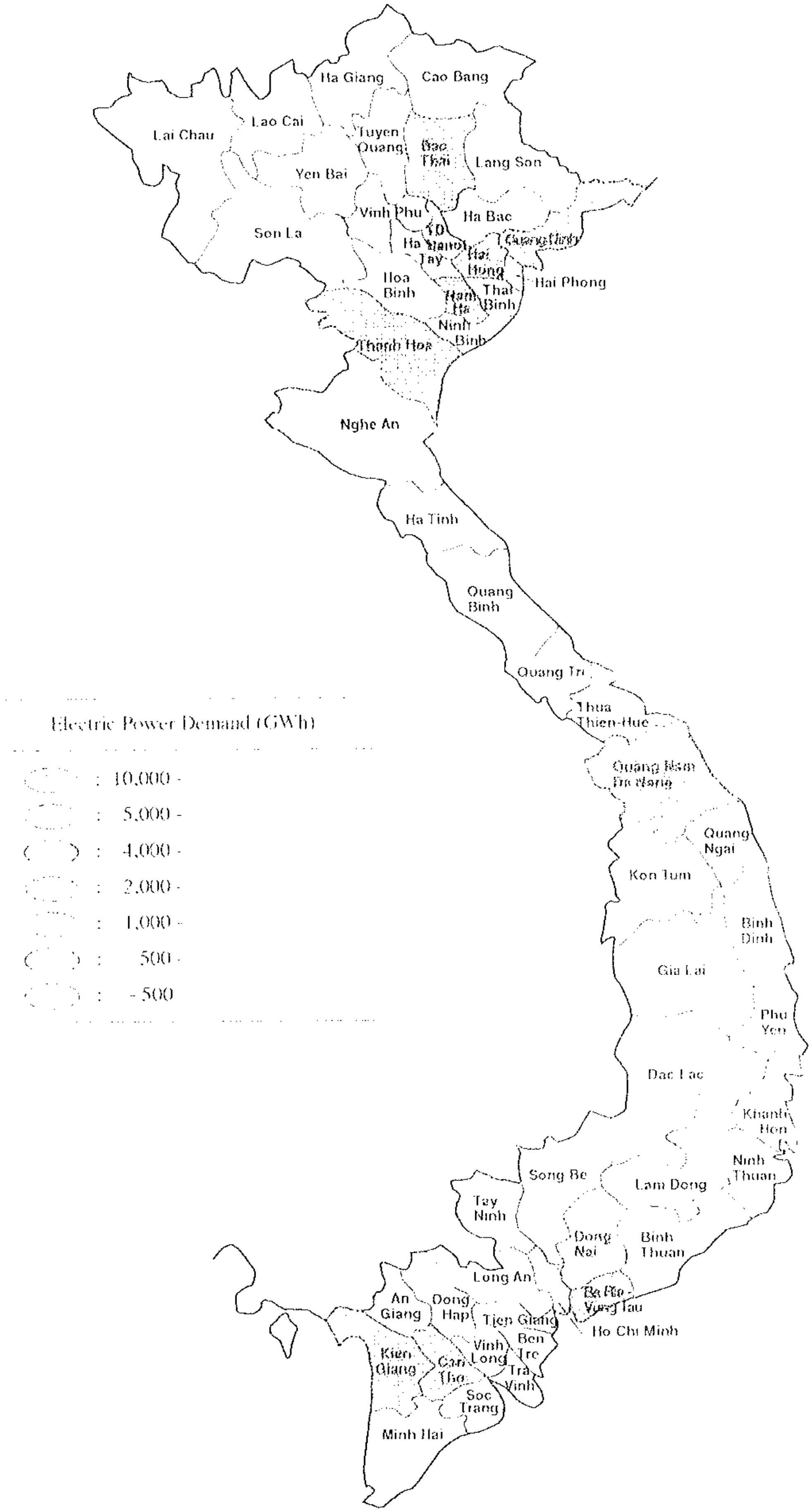


Figure 5.4-3 Prefecture Electric Power Demand Forecast as 2010 (Base Case)

5.5 Comparison with Some Asian Countries

5.5.1 Economic Level and Electric Power Consumption

(1) Electric Power Consumption and GDP

Figure 5.5-1 shows the historical trends in relations between electric power consumption and GDP in selected Asian countries. In the figure, demand forecast results of the base case are also plotted by black circles with arrows in 2000, 2005 and 2010. The Vietnamese future line (forecast this time) seems reasonable, because the relationship between power consumption and GDP approaches main flow line of typical Asian countries such as Taiwan, Malaysia and Thailand.

Table 5.5-1 shows results obtained by regression analyses on the same data of electric power consumption (GWh) and GDP (US$ at 1987 constant price). Regression formula is simplified as ℓn (D) = a + b ℓn (GDP), where D is end-use consumption (GWh). Coefficient b means long-term elasticity got by the regression of data in the given period.

"b" value, long-term GDP elasticity of 1.44, in Viet Nam is similar to Malaysia and Thailand's values. In general, power elasticity with respect to GDP represents relation between electric power consumption and economic activity at macroscopic viewpoint. GDP elasticity has a tendency to decrease with advancing of economy or shifting of economic and demand structure.

(2) Per Capita Electric Power Consumption and Per Capita GDP

Figure 5.5-2 shows the historical trends in relations between per capita power consumption and economic level (per capita GDP). As can be seen in the figure, the relationship per capita power consumption (kWh/capita) and economic level (1987 US$/capita) is classified into three groups, namely Bangladesh - Viet Nam - Pakistan lines, Indonesia - Thailand lines, and South Korea - Malaysia - Taiwan lines. The lines of Bangladesh, Viet Nam and Pakistan are found leftmost, and those of Indonesia and Thailand adjoining them immediately right. In the figure as well, results from demand forecast (base case) in 2000, 2005 and 2010 are plotted by black circles with arrows. The Vietnamese future lines are assumed to disjoin from the Bangladesh - Viet Nam - Pakistan lines and keep close to the Indonesia - Thailand ones.

Table 5.5-2 shows results obtained by regression analysis on the same data (time series data of GWh/capita and GDP/capita). Regression formula is ℓn (GWh/capita) = a + b ℓn (GDP/capita), and coefficient b means long-term elasticity.

Vietnamese per capita electric power consumption in 1993 was 112.2 kWh, or 150.3 kWh/capita in power generation terms as shown in the following.

	Population (millions)	Consumption (kWh)	Generation (kWh)
Northern region	33.45	116.0	160.7
Central region	10.96	58.2	77.4
Southern region	26.98	129.4	167.0
Nationwide	71.39	112.2	150.3

These figures are identical to the situation in Taiwan during the 1950s, South Korea during the second half of the 1960s, Thailand during the first half of 1970s, or Indonesia