	Northern	Southern	Central
110kV line (cct-km)	0.63	0.39	1.37
Transformer	0.45	0.32	0.36

For lines, the future requirements in circuit-km per GWh sales are estimated referring to actual figures of Thailand and Malaysia, which seem to correspond to the future Viet Nam, to be 0.27km per GWh sales for the northern system, 0.25km for the southern system and 0.3km for the central system.

For transformer capacity, the necessary capacity was assumed to be 0.45MVA per GWh sales, and 70% of which to be power company's facilities and remaining 30% to be user's facilities. Only for the southern system, additional capacity of 120MVA was added for each year during the period of 1996 to 2000 taking into account possible conversion of the existing 66kV system to 110kV.

(2) **Distribution System**

The 1993 total length of high tension (HT) lines, covering all voltage classes of 6kV to 35kV, and of low tension (LT) lines and total capacity of distribution transformers for GWh energy sales of each regional system are given below:

	Northern	Southern	Central
HT lines (km)	4.63	2.79	6.40
LT lines (km)	2.58	1.62	1.55
Distribution Tr.(MVA)	0.95	0.61	0.80

For HT lines, line length of 3.5km per GWh sales up to 2000 and 3.0km thereafter were assumed for the northern and southern systems, and 5.0km per GWh sales and 4.0km for the central system.

The above actual length of LT lines is too short compared with actual length of other countries, probably reflecting low rate of electrification to local households. Expecting future effort for rural household electrification, the same rate of 4km per GWh sales was assumed for all regional systems.

The same rate of 0.85 MVA distribution transformer per GWh sales was assumed for all regional systems.

(3) **Consumer Connections**

The current number of connections of each regional system was assumed to be 2,280 thousand for the northern, 1,840 for the southern and 560 for the central systems, though exact data are not available. Expecting all household electrification by 2010 in the whole country, the number of annual connections is assumed at 300 thousand for the northern, 260 for the southern 130 for the central systems covering the entire period up to 2010.

10.4 Estimation of Necessary Fund

Fund necessary for power system extension as mentioned above was calculated for each regional system for each year of 1996 to 2010. The necessary fund was calculated using the 1994 unit rates for both foreign currency and local currency portions, in equivalent US Dollar. Information for 1994 unit rates in Viet Nam were obtained from IEV, PIDC1 and PIDC2. Assumed unit rates for construction of transmission lines are shown in Table 10.9, those of substations facilities in Table 10.10 and those of distribution facilities in Table 10.11.

Adopted particulars for estimation of each category are explained below:

(1) 500/220kV System

The required time for completion of each line was determined based on the power plant commissioning plans of the power development study in this report and requirements from the results of power flow calculations.

Two year disbursement was assumed for long lines exceeding 50km in length and one year for shorter lines. For substations, two year disbursement was assumed only for large groups of substations and one year for other substations.

(2) 110kV and Distribution Facilities

The 110kV lines will actually include various types of lines, and the rate of US$ 17,700 in FC portion and US$ 24,800 in LC portion was assumed as the average of construction cost per circuit-km.

For estimating 110kV substation costs, a 25MVA substation with one 25MVA transformer, two 110kV circuits and five 20kV circuits is assumed as the typical construction. The estimated total cost of this substation divided by 25, US$ 37,200 in FC portion and US$ 11,000 in LC portion, was taken as the average cost per MVA installation.

One year disbursement was assumed for all items in this category.

The available unit rates in Table 10.11 were used to estimate the construction cost of distribution facilities.

(3) System Control and Communication Facilities

This category covers the system control represented by the load dispatching system and communication facilities for system control.

The FC portion of the cost of this category was assumed to be 5% of the FC portion of the total substation cost of both 500/220kV and 110kV systems, and the LC portion to be 20% of the FC portion.

Table 10.1 Estimated Load of Each 220kV Substation

Northern Region

(Unit: MW)

No.	Substation	2000	2005	2010
1.	Hoa Binh	33	50	65
2.	Lam Thao	70	80	107
3.	Ha Dong	125	208	290
4.	Chem	125	200	290
5.	Mai Dong	155	210	290
6.	Da Phuoc	114	220	280
7.	Thai Nguyen	109	173	260
8.	Bac Giang	61	80	150
9.	Pho Noi	82	110	257
10.	Pha Lai	104	160	220
11.	Hai Phong	110	160	280
12.	Trang Bac	80	110	200
13.	Hoang Bo	46	95	162
14.	Vat Cach	80	100	200
15.	Ninh Binh	74	130	193
16.	Nam Dinh	72	132	191
17.	Thai Binh	46	78	124
18.	Thanh Hoa	70	132	195
19.	Nghi Son	50	84	113
20.	Vinh	61	65	116
21.	Dinh Vu		100	200
22.	Yen Bai		56	94
23.	Dai Thi		16	39
24.	Son La		22	38
25.	Hai Duong		92	152
26.	Ha Tinh		47	88

Note: In actual application for power flow analysis, the above substation demands (Lam Thao, Yen Bai, Thai Nguyen and Da Phuoc) were deducted by the estimated output of the Thac Ba power station.

Southern Region

No.	Substation	2000	2005	2010
1.	Phu Lam	200	330	480
2.	Hoc Mon	250	400	530
3.	Nha Be	200	330	480
4.	Thu Duc	180	330	480
5.	Cat Lai	150	250	450
6.	Long Binh	180	300	480
7.	Tri An	100	150	220
8.	Cay Lai	103	156	202
9.	Vinh Long	72	101	166
10.	Tra Noc	134	216	220
11.	Thot Not	80	128	175
12.	Rach Gia	77	124	160
13.	Long Thanh	140	200	330
14.	Ba Ria	110	60	125
15.	Bao Loc	18	29	45
16.	Da Nhim	50	65	90
17.	Ham Thuan	18	29	50
18.	Tao Dan		220	450
19.	Vung Tau		180	330
20.	Dai Ninh		30	50
21.	Bac Lieu		62	105
22.	Kieng Luong			43
23.	Tay Ninh			113

Note: For power flow analysis, output of Thac Mo was deducted.

Central Region

1.	Ba Don	10	15	25
2.	Dong Hoi	29	48	75
3.	Da Nang	151	136	220
4.	Hoa Khanh	100	100	150
5.	Pleiku	26	45	73
6.	Qui Nhon	70	107	163
7.	Krong Buk	27	40	60
8.	Nha Trang	119	170	239
9.	Hue		95	143
10.	Quan Ngai		54	84

Note: In actual application to power flow calculation, estimated output of 110kV power plants (Dray Linh, Buon Coup, Song Con and Rao Quan) was deducted from the above figures.

Table 10.2 Future 220kV Line Extension Plan for theNorthern System

(Number of circuit and route length in km)

No.	Section	Conductor	1995	1996-2000	2001-2005	2006-2010
1.	Pha Lai – Hai Phong	AC400	1-55			
2.	Hoa Binh – Da Phuoc	AC500	1-90			
3.	Ninh Binh – Nam Dinh	2AC330	1-33		1-33/1	
4.	Pha Lai –Trang Bach – Hoang Bo	2AC330	2-110			
5.	Da Phuoc – T. Nguyen	AC500		1-40		
6.	Nho Quan –Thanh Hoa	AC300		1-71		
7.	Mai Dong connection	AC400		2-7.5		
8.	Hoa Binh – Ha Dong (Third Circuit)	AC500		1-60		
9.	Hoa Binh – Lam Thao	AC400		1-78		
10.	Nam Dinh – Thai Binh – Hai Phong	2AC330		1-90	1-90/1	
11.	Pha Lai – Bac Giang	AC500		1-30		
12.	Bac Giang – T. Nguyen	AC400		1-60		
13.	Pha Lai – Da Phuoc	2AC330		2-60		
14.	Trang Bac – Vat Cach	AC500		2-20		
15.	Hai Duong connection	AC400		2-8		
16.	Pha Lai – Hoang Bo	2AC330				2-110/2
17.	Lam Thao – Yen Bai	AC500			1-70	
18.	Vat Cach – Hai Phong	AC500			2-9	
19.	Hai Phong – Dinh Vu	AC500			2-7	
20.	Ban Mai – Vinh	AC500				2-135/2
21.	Lam Thao – Son La	2AC330			1-160	
22.	Da Phuoc – Chem	2ACSR330				2-30/1
23.	Thanh Hoa – Nghi Son – Vinh	AC300			1-167/1	
24.	Ha Tinh – Vinh	AC300			1-50/1	
25.	Ha Tinh Connection	AC300			3-5/1	
26.	Dai Thi – Yen Bai	AC500				1-95/1
27.	Dai Thi – Thai Nguyen	AC500				1-100/1
28.	Ninh Binh – Nho Quan	AC300			1-20/1	
29.	New lines	2AC330				2-50/1
	Total in circuit km		398	620	637	845

Note: /1: Proposed additions based on the results of power system analysis.
/2: Execution schedule is proposed to be delayed.

Table 10.3 Future 220kV Substation Plans for the Northern System

(Quantity of units and capacity in MVA)

No.	Substation	1995	1996-2000	2001-2005	2006-2010	Replace
1.	Da Phuoc	1-250	1-250			
2.	Hoang Bo	1-125	1-125			
3.	Pho Noi	1-125	1-125		1-125/2	
4.	Ninh Binh	1-125	1-125			
5.	Mai Dong		2-125			
6.	Thai Nguyen		2-125		1-125/2	
7.	Bac Giang		1-125	1-125/1		
8.	Lam Thao		1-125	1-125/1		
9.	Trang Bach		2-125			
10.	Vat Cach		1-125	1-125/2		
11.	Nam Dinh		1-125	1-125/1		
12.	Thai Binh		1-125		1-125/1	
13.	Nghi Son		1-125		1-125/2	
14.	Vinh		1-125			
15.	Ha Dong			2-250		2-125
16.	Chem			2-250		2-125
17.	Yen Bai			1-125		
18.	Hai Duong			1-125	1-125/1	
19.	Dinh Vu			2-125		
20.	Thanh Hoa			1-125		
21.	Ha Tinh			1-125/1		
22.	Son La			1-63		
23.	Hai Phong				2-250/2	2-125
24.	New substation				2-250/2	
	Total	625	2250	1938/3	1375/3	

Note: /1: Shifting from another substation.
/2: Proposed additions based on the results of power system studies.
/3: Not include transformers shifted from other stations.

Table 10.4 Future 220kV Line Extension Plan for the Southern System

(Number of circuit and route length in km)

No.	Section	Conductor	1995	1996-2000	2001-2005	2006-2010
1.	Phu Lam – Cay Lai – Tra Noc	AC400	1-137			
2.	Tra Noc – Rach Gia	AC400	1-75			
3.	Long Binh – Ba Ria	AC400	1-67			
4.	Ham Thuan – Bao Loc	AC400		1-30		1-30/1
5.	Ham Thuan – Da Mi	AC500		2-20		
6.	Da Mi – Phu My	AC500		1-150		
7.	Da Mi – Long Binh	AC500		1-140		
8.	Phu My – Nha Be	2AC330		2-50		
9.	Nha Be – Phu Lam	AC500		2-20		
10.	Phu My connection	AC400		4-5/1		
11.	Phu My – Cat Lai	2AC330		2-45		
12.	Cat Lai – Tao Dan	AC500		2-10/1		
13.	Phu Lam – Tao Dan	Cap400		2-12/2		
14.	Cat Lai – Thu Duc	2AC400		2-10/1		
15.	Phu My – Cai Lay	AC400		2-140		
16.	Nha Be – Cat Lai – Thu Duc	AC400		2-25/2		
17.	Cai Lay – Thot Not	AC400		1-75		1-75/1
18.	Thot Not – Rach Gia	AC400		1-35		
19.	Rach Gia – Kien Luong	AC400		1-75		
20.	Ba Ria – Vung Tau	2AC330			1-17	
21.	Omon – Thot Not	2AC400			2-30/3	
22.	Rach Gia – Bach Lieu	AC400			1-110/2	
23.	Thot Not – Bach Lieu	AC400			1-120/1	
24.	Dai Ninh – Bao Loc	AC500			2-75	
25.	Bao Loc – Long Binh	2AC330			1-135	1-135/1
26.	Hoc Mon – Tay Ninh	AC400				1-65/1
27.	Dong Nai 4 – Bao Loc	AC400				2-50/1
28.	Long Binh – Thu Duc	2AC330				2-18/1
29.	Thu Duc – Hoc Mon	2AC330				2-15/1
30.	New lines	2AC330				2-100/1
31.	New lines	AC400				2-100/1
	Total in circuit km		279	1189	592	871

Notes:

- /1: Proposed additions based on the results of power flow analysis.
- /2: Items in the Master Plan but proposed to be redesigned.
- /3: Change of conductor size is proposed.

Table 10.5 Future 220kV Substation Plan for the Southern System

(Quantity of unit and capacity in MVA)

No.	Substation	1995	1996-2000	2001-2005	2006-2010	Replace
1.	Thu Duc	1-125		2-250		
2.	Phu Lam	1-125	2-250			2-125
3.	Hoc Mon		2-250			2-125
4.	Nha Be		2-250			
5.	Cat Lai		2-125			
6.	Tao Dan			6-100		
7.	Long Binh	1-125	2-250			2-125
8.	Tri An	1-63			1-125/2	
9.	Long Thanh		1-125	1-125		
10.	Vung Tau			1-125/1	2-125/2	
11.	Cai Lay	1-125	1-125/1			
12.	Vinh Long		1-125/1		1-125/2	
13.	Tra Noc	1-125			1-125/2	
14.	Thot Not		1-125/1	1-125		
15.	Rach Gia	1-125		1-125/1		
16.	Bac Lieu			1-125/1		
17.	Kien Luong				1-125/2	
18.	Tay Ninh				2-125/2	
19.	Da Nhim		1-63			
20.	Bao Loc		1-63			
21.	Ham Thuan			1-63		
22.	Dai Ninh			1-63		
23.	New SSs of HCM				4-250/2	
	Total	813	2501	1476	2000	

Note:

/1: Shifting from another substation.

/2: Proposed additions based on the results of power flow analysis.

/3: Not include transformers shifted from other stations.

Table 10.6 Future 220kV Line Extension Plan for the Central System

(Number of circuit and route length in km)

No.	Section	Conductor	1995	1996-2000	2001-2005	2006-2010
1.	Pleiku – Krong Buk	AC500	1-147			
2.	Krong Buk – Nha Trang	AC500	1-145			
3.	Da Nang – Hoa Khanh	AC500		1-10		1-10/2
4.	Da Nhim – Nha Trang	AC500		1-120		
5.	Hoa Khanh – Hue	AC400			1-90	1-90/2
6.	Pleikrong – Pleiku	AC400			1-45	
7.	Pleikrong – Quang Ngai	AC400			1-125	
8.	Quang Ngai – Da Nang	AC400			1-130	
9.	Tun Kontum - Pleiku	AC400			1-70	
10.	Sesan 3 – Pleiku	2AC330/1			2-40	
11.	Sesan 3 – Sesan 4	2AC330				2-10/2
12.	Pleiku – Qui Nhon	2AC330				1-146/2
	Total in circuit km		292	130	540	266

Note:

/1: The conductor size of AC400 was modified to transfer the Sesan 4 power together with the Sesan 3 power.

/2: Proposed additions based on the results of power flow analysis.

Table 10.7 Future 220kV Substation Plan for the Central System

(Number of unit-Capacity in MVA)

No.	Substation	1995	1996-2000	2001-2005	2006-2010	Replace
1.	Krong Buk	1-63				
2.	Nha Trang	1-125	1-125			
3.	Da Nang	1-125				
4.	Hoa Khanh		2-125			
5.	Qui Nhon		1-63		1-125/1	
6.	Hue			1-125	1-125/1	
7.	Quang Ngai			1-125		
8.	Ba Don	1-63				
	Total in MVA	376	438	250	250	

Note: /1: Proposed addition based on the results of power flow analysis.

Table 10.8 500kV System Extension Plan of the Country

A. Transmission Lines

(Number of circuit and route length in km)

No.	Section	Conductor	1996-2000	2001-2005	2006-2010
1.	Yali – Pleiku	3AC330	2-30		
2.	Pleiku – Bao Loc	4AC330		1-330	
3.	Bao Loc – Cat Lai	4AC330		1-150	
4.	Cat Lai – Phu Lam	4AC330		1-35	
5.	Phu My – Cat Lai	4AC330		1-45	
6.	Phu My – Phu Lam	4AC330		1-70	
7.	Phu Lam – Thot Not	4AC330		1-175	
8.	Phan Thiet – Phu My	4AC330			2-140
9.	Phan Thiet – Bao Loc	4AC330			1-90
10.	Son La – Hoa Binh(S)	4AC330			2-205
11.	Hoa Binh(S) – Hanoi(S)	4AC330			1-80
12.	Hanoi(S) – Hai Phong	4AC330			1-100
13.	Son La – Hanoi(N)	4AC330			1-250
14.	Hanoi(N) – Hai Phong	4AC330			1-115
	Total in circuit-km		60	805	1325

B. Substations

No.	Substation	2001-2005	2006-2010
1.	Phu My	2-450	
2.	Cat Lai	2-450	
3.	Thot Not	2-450	
4.	Bao Loc		1-450
5.	Son La		1-450
6.	Hanoi(S)		2-450
7.	Hanoi(N)		1-450
8.	Hai Phong		2-450
9.	Da Nang		1-450
10.	Pleiku		1-450
	Total in MVA	2700	4050

Table 10.9 Unit Construction Costs of Transmission Lines

1. General

- The construction cost per km is indicated in equivalent US Dollar including local currency portion.
- The construction cost is not classified according to difficulty classes.

2. 500kV lines

Unit: US Dollar

		Total	FC port.	LC port.
1-cct	3 x 330 sq.mm	221,000	122,000	99,000
2-cct	3 x 330	336,000	185,000	151,000
1-cct	4 x 330	245,000	132,000	113,000
2-cct	4 x 330	394,000	224,000	170,000

3. 220kV lines

(1) Single circuit lines

	Total	FC port.	LC port.
AC300	82,000	44,300	37,700
AC400	91,000	49,100	41,900
AC500	100,000	54,000	46,000
2 x ACSR330	122,300	66,900	55,400

(2) Double circuit lines

		Total	FC port.	LC port.
AC300	2-cct erection	127,000	58,400	68,600
	1-cct erection	95,000	45,200	49,800
	2nd cct string	32,000	13,200	18,800
AC400	2-cct erection	141,000	64,900	76,100
	1-cct erection	106,000	50,100	55,900
	2nd cct string	35,000	14,800	20,200
AC500	2-cct erection	155,000	71,300	83,700
	1-cct erection	116,000	55,100	60,900
	2nd cct string	39,000	16,200	22,800
2 x AC330	2-cct erection	188,500	86,700	101,800
	1-cct erection	146,700	68,200	78,500
	2nd cct string	41,800	18,500	23,300
2 x AC400	2-cct erection	206,400	95,000	111,400
	1-cct erection	160,600	74,700	85,900
	2nd cct string	45,800	20,300	25,300

4. **110kV lines**

4.1 **Concrete pole lines**

For this type of lines, it is assumed that steel towers are erected at important points, deadends, railway and highway crossings, etc.

AC120	37,000	14,100	22,900
AC150	40,000	15,200	24,800
AC185	43,600	16,600	27,000
AC240	47,300	18,000	29,300

4.2 **Steel tower lines**

(1) **Single circuit lines**

AC120	44,500	22,500	22,000
AC150	48,200	24,300	23,900
AC185	52,400	26,500	25,900
AC240	56,800	28,700	28,100

(2) **Double circuit lines**

AC120	2-cct erection	69,000	34,800	34,200
	1-cct erection	51,800	24,500	27,300
	2nd cct string	17,200	10,300	6,900
AC150	2-cct erection	74,700	37,700	37,000
	1-cct erection	56,000	26,900	29,800
	2nd cct string	18,000	10,800	7,200
AC185	2-cct erection	81,200	41,000	40,200
	1-cct erection	60,900	28,800	32,100
	2nd cct string	20,300	12,200	8,100
AC240	2-cct erection	88,000	44,400	43,600
	1-cct erection	66,000	31,200	34,800
	2nd cct string	22,000	13,200	8,800

5. **35kV lines**	20,000	14,000	6,000

Table 10.10 Unit Rates of Substation Facilities

1. General

For major facilities, the FC portion consists of CIF importation cost and engineering service cost, and the LC portion covering local transport, erection, foundations and local consumables, is assumed to be 30% of the FC portion.

2. Land preparation and other common facilities

		Total	FC Port.	LC port.
500kV	substation	600,000	240,000	360,000
220kV	substation	400,000	160,000	240,000
110kV	substation	250,000	100,000	150,000

3. Main transformers

The costs include arresters, steel structures, conductors, insulators and fittings, related control gear, miscellaneous materials, etc. Foundation costs are also included.

		Total	FC Port.	LC port.
(1)	**500/220/35 kV**			
	450 MVA	6,500,000	5,000,000	1,500,000
(2)	**220/110/20 kV**			
	63 MVA	1,170,000	900,000	270,000
	125 MVA	2,210,000	1,700,000	510,000
	250 MVA	4,290,000	3,300,000	990,000
(3)	**110/35/20 kV**			
	10 MVA	364,000	280,000	84,000
	16 MVA	397,000	305,000	92,000
	25 MVA	455,000	350,000	105,000
	40 MVA	650,000	500,000	150,000

4. Static capacitors (per kVA capacity)

Costs include control equipment, miscellaneous materials, etc.

		Total	FC Port.	LC port.
35kV	large unit	11.0	8.5	2.5
20kV	small unit	15.0	7.0	8.0

5. Series capacitors (500kV)

Costs include control equipment, miscellaneous materials, etc.

	Total	FC Port.	LC port.
41.5 ohm	3,320,000	2,550,000	770,000
30.5 ohm	3,110,000	2,390,000	720,000
21.5 ohm	2,780,000	2,140,000	640,000

6. **Shunt reactors (500kV)**

Costs include control equipment, miscellaneous materials, etc.

174 MVA	(3x58MVA)	3,080,000	2,370,000	710,000
128 MVA		2,390,000	1,840,000	550,000
91 MVA		2,020,000	1,550,000	470,000

7. **Switchgear and ancillary facilities per circuit**

500kV	1,570,000	1,210,000	360,000
220kV	450,000	350,000	100,000
110kV	280,000	220,000	60,000

Table 10.11 Unit Rates of Distribution Facilities

1. General

Construction cost per km for lines and cost per kVA for transformers are evaluated in equivalent US Dollar.

			Total	FC port.	LC port.
2.	**20kV lines**	OHL	12,000	3,500	8,500
		UGC	37,000	26,000	11,000
3.	**Low tension lines**		7,200	2,100	5,100
4.	**Distribution transformers (per kVA)**		42.0	6.0	36.0
5.	**Consumer connections**		80.0	20.0	60.0
6.	**20kV switchgear in cubicle**		32,000	28,000	4,000

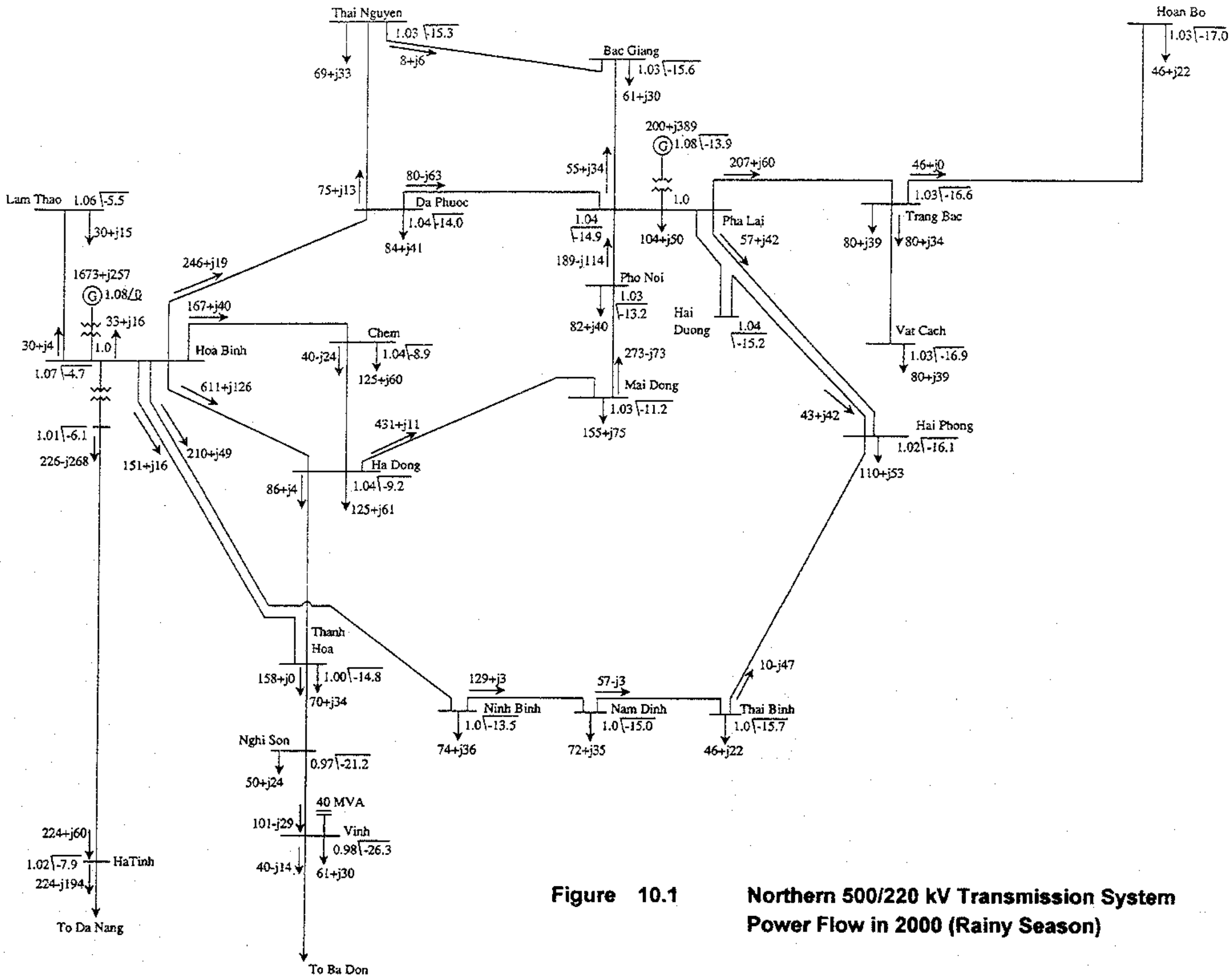


Figure 10.1 Northern 500/220 kV Transmission System Power Flow in 2000 (Rainy Season)

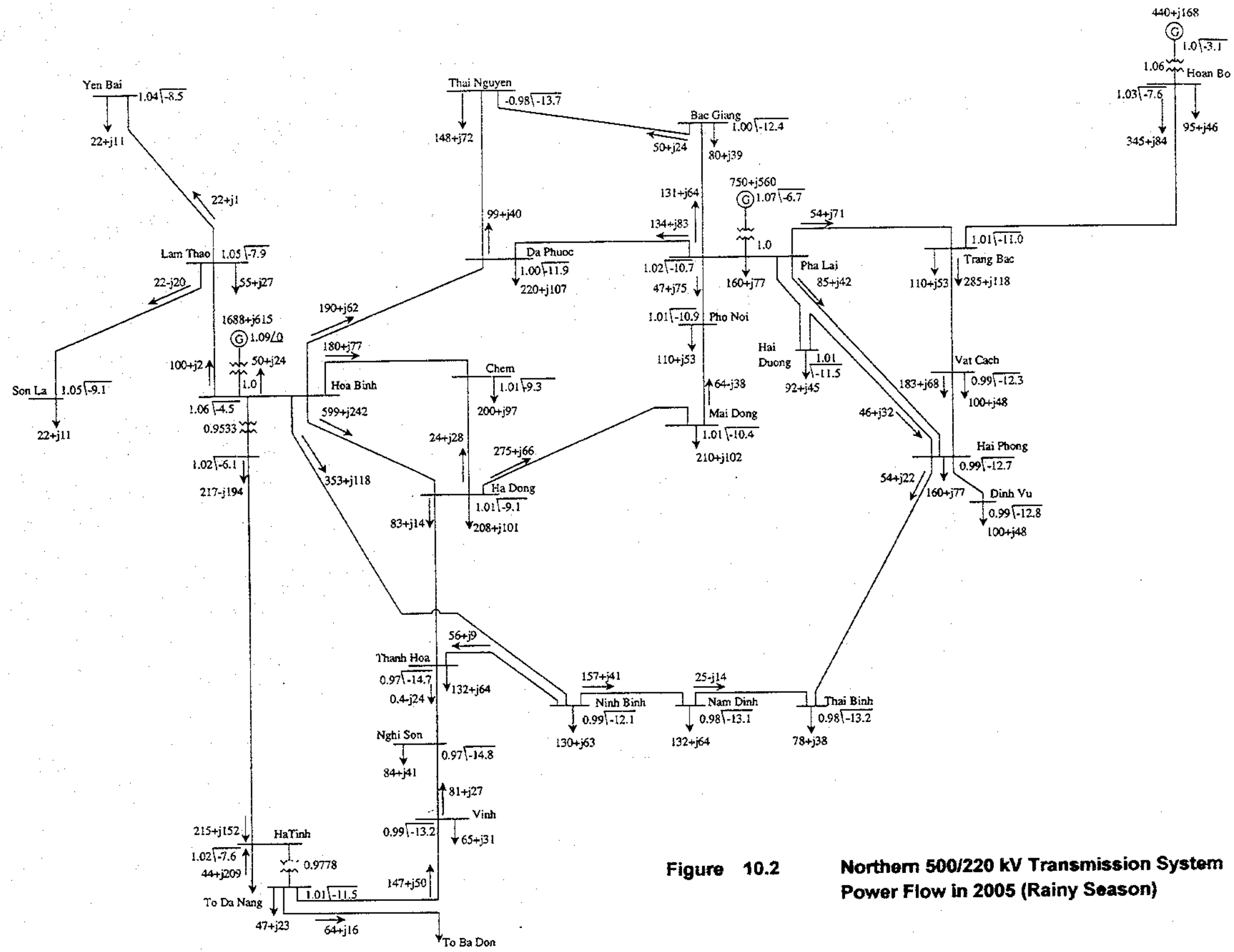


Figure 10.2 Northern 500/220 kV Transmission System Power Flow in 2005 (Rainy Season)

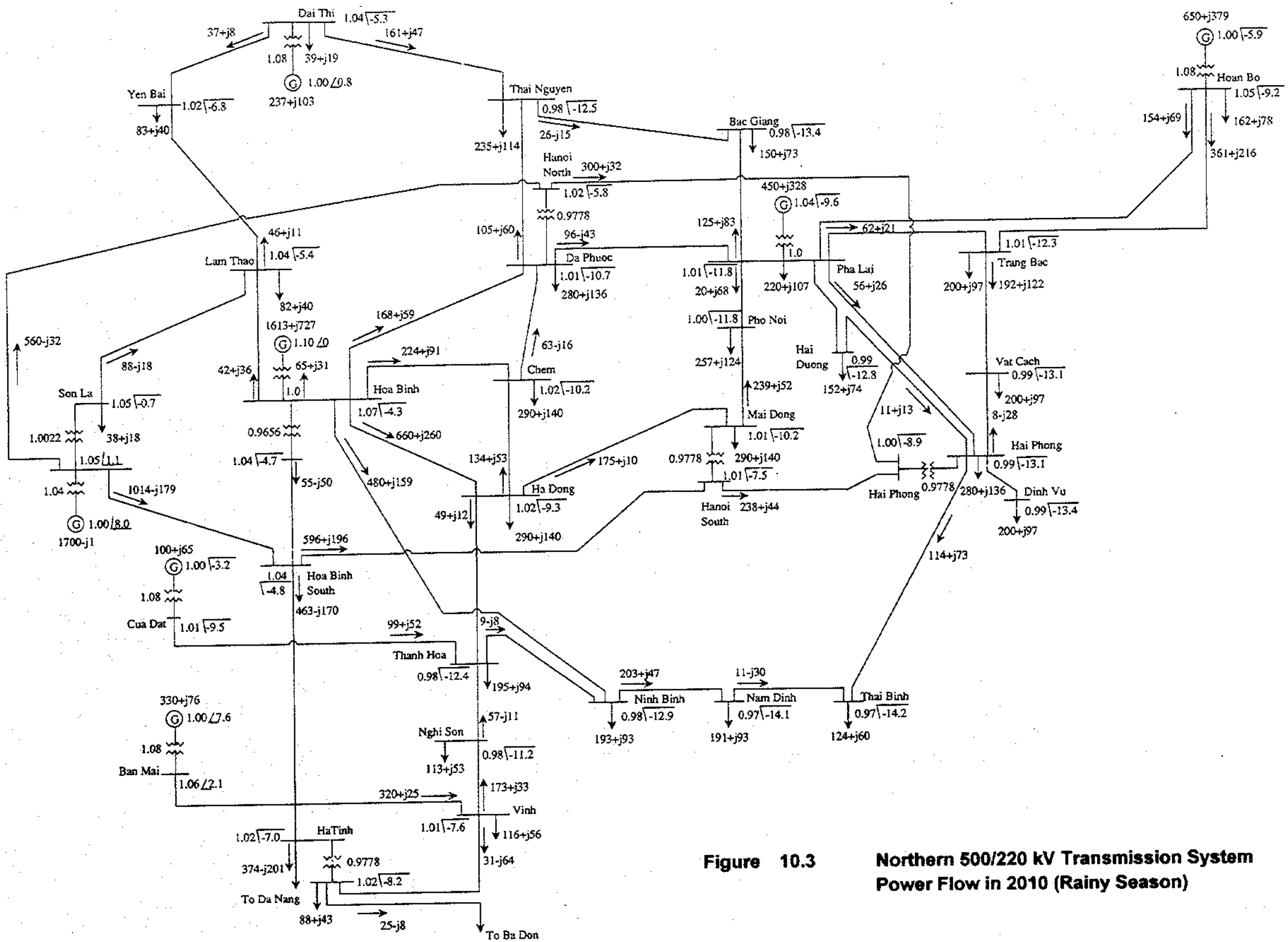


Figure 10.3 Northern 500/220 kV Transmission System Power Flow in 2010 (Rainy Season)

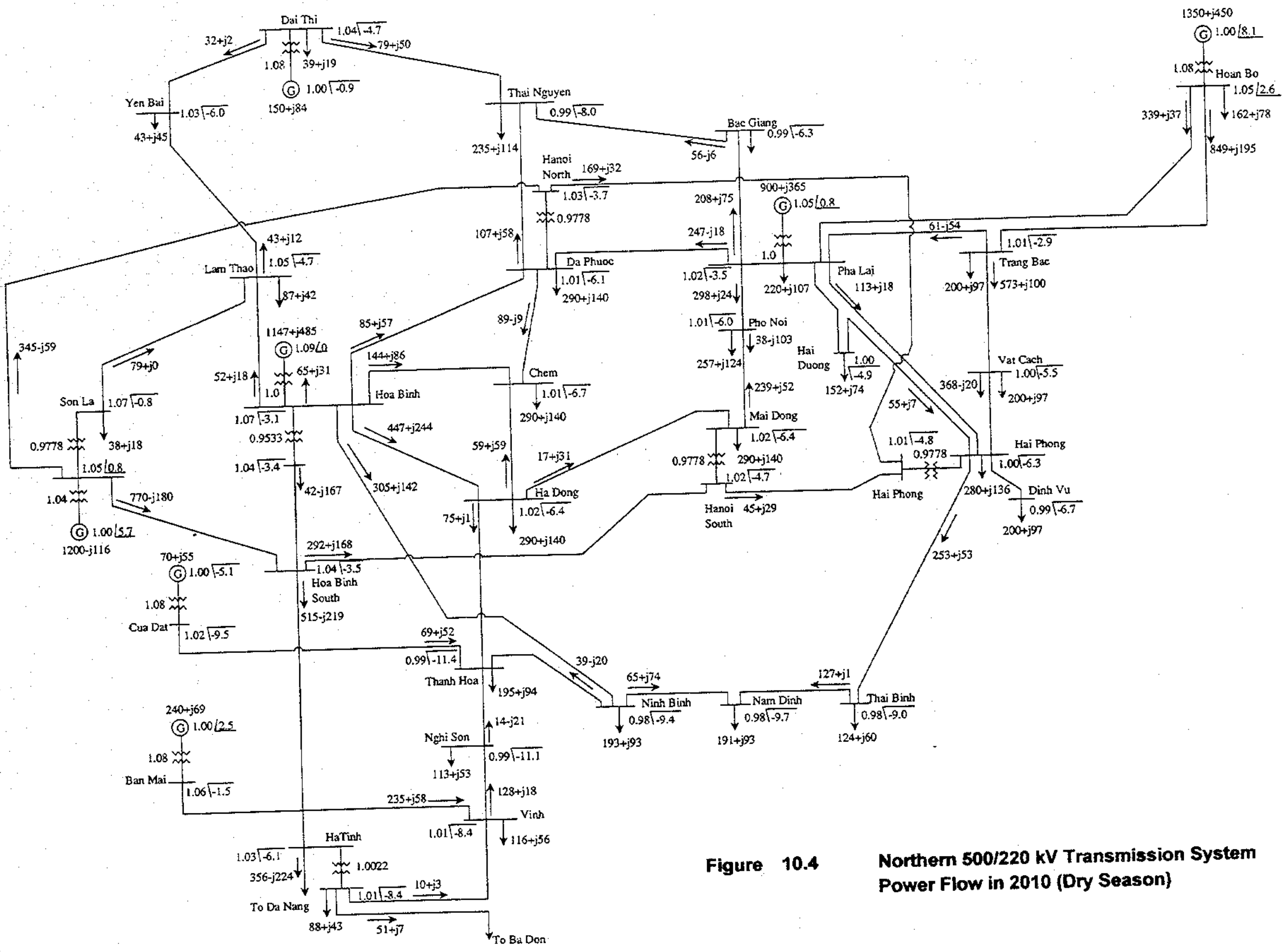


Figure 10.4 **Northern 500/220 kV Transmission System Power Flow in 2010 (Dry Season)**

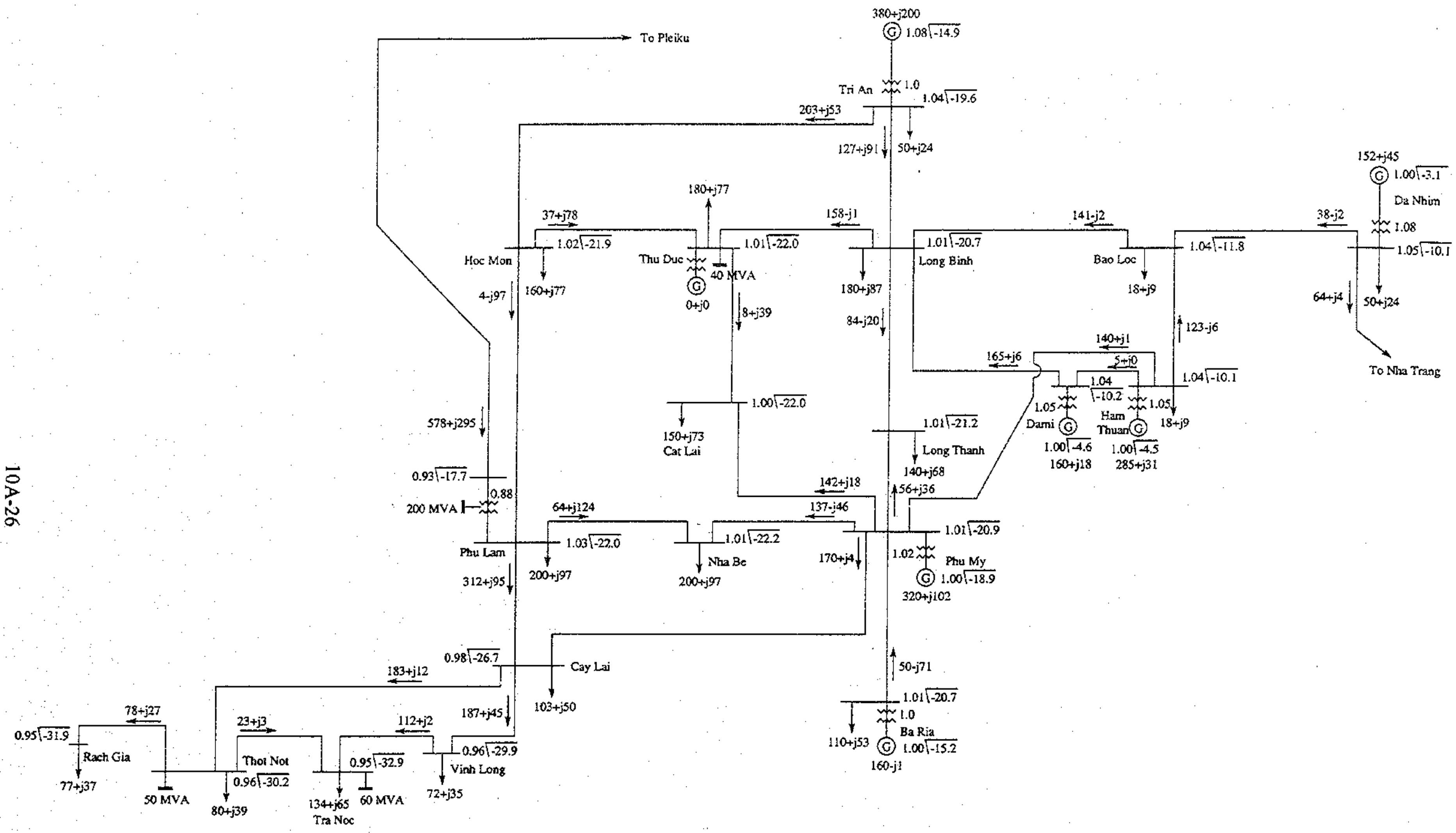


Figure 10.5 Southern 500/220 kV Transmission System Power Flow in 2000 (Rainy Season)

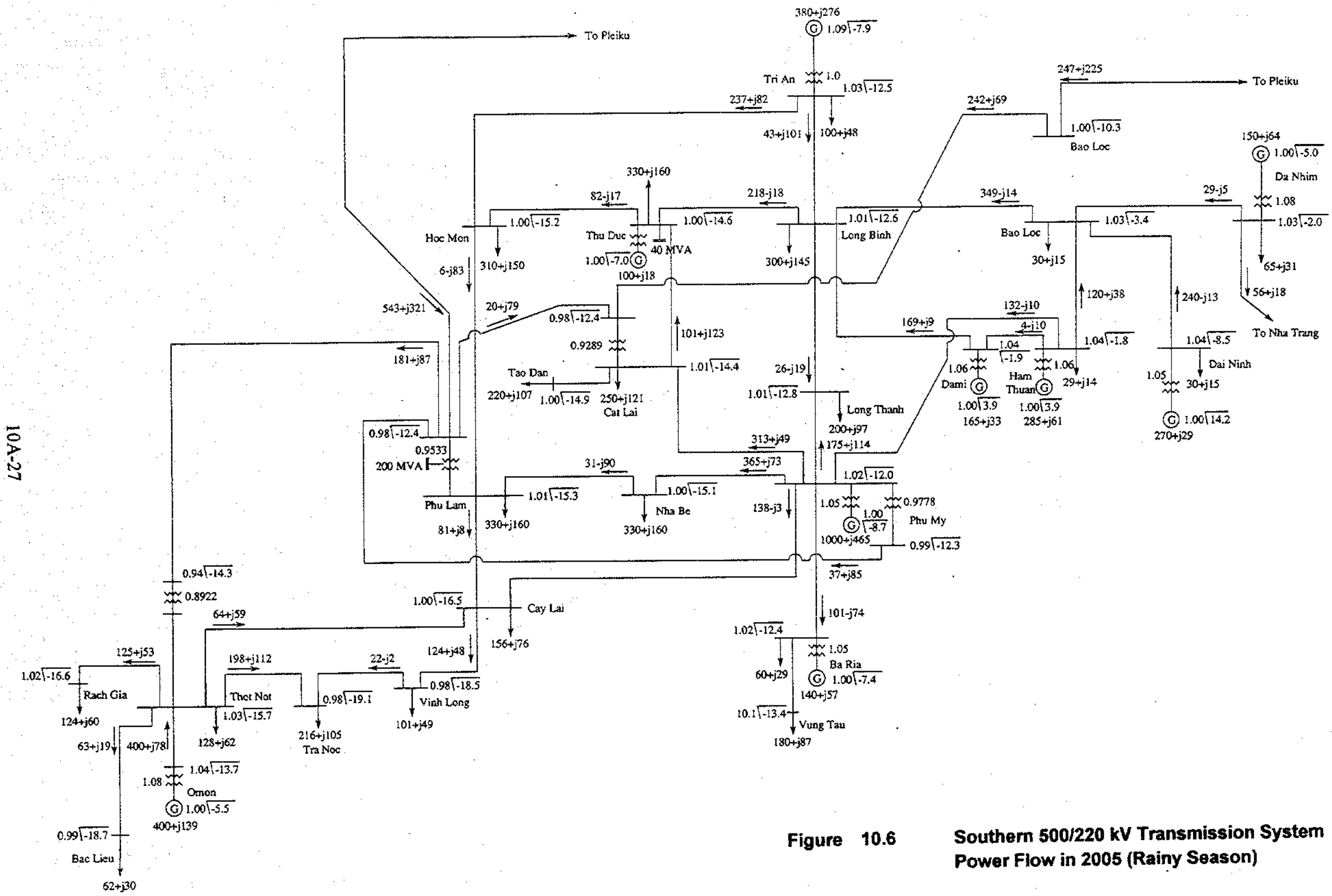


Figure 10.6 **Southern 500/220 kV Transmission System Power Flow in 2005 (Rainy Season)**

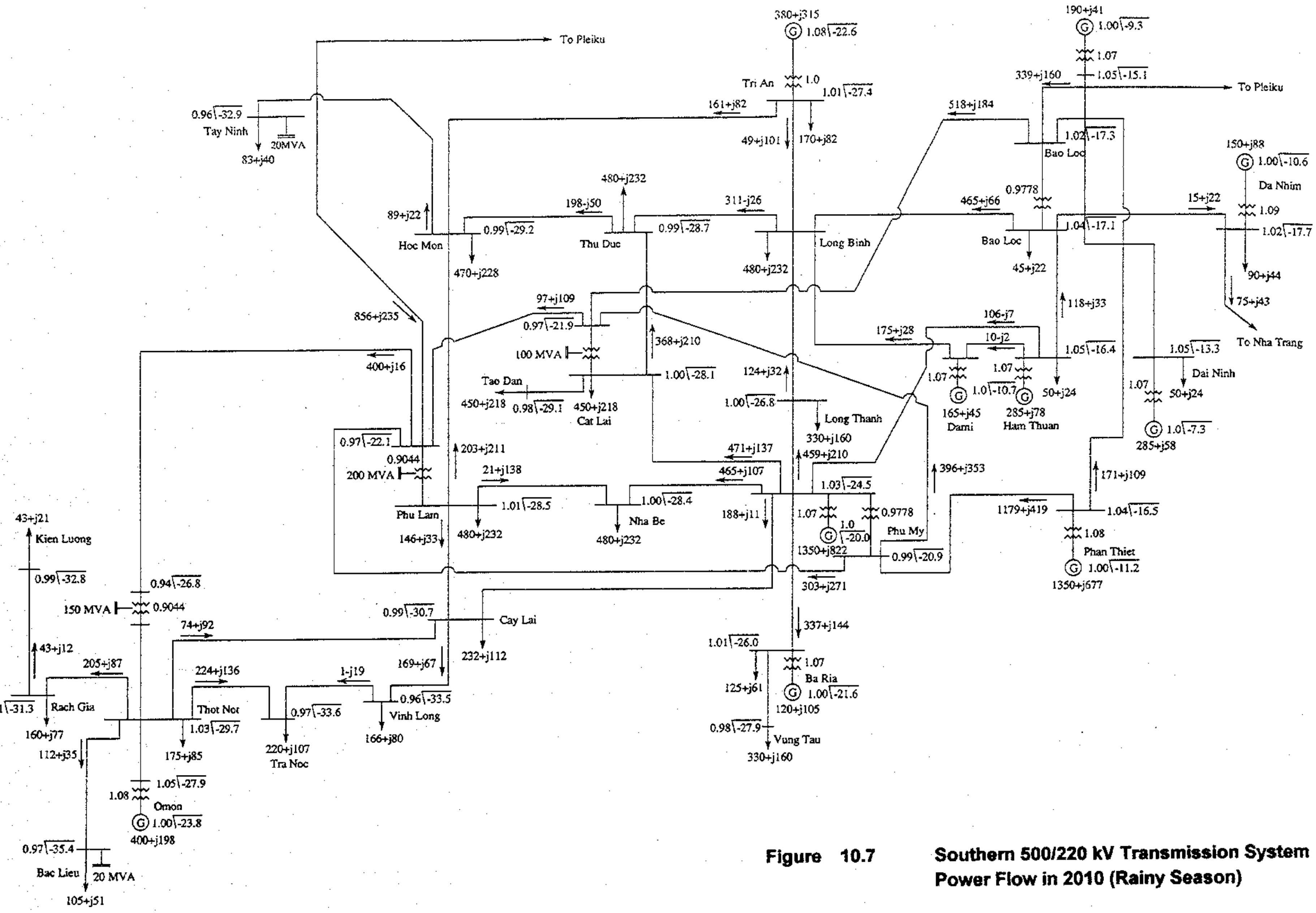


Figure 10.7 Southern 500/220 kV Transmission System Power Flow in 2010 (Rainy Season)

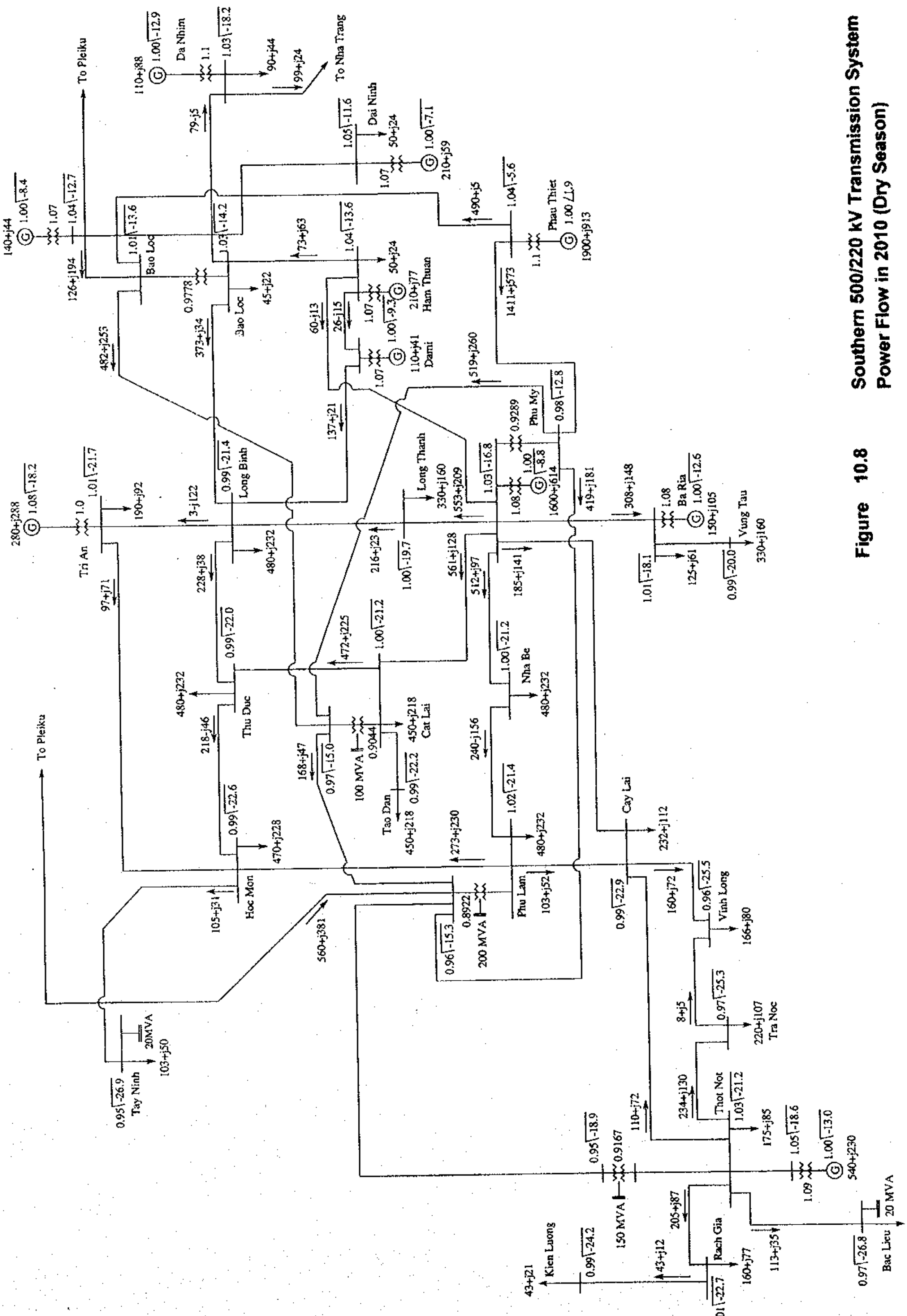


Figure 10.8 Southern 500/220 kV Transmission System Power Flow in 2010 (Dry Season)

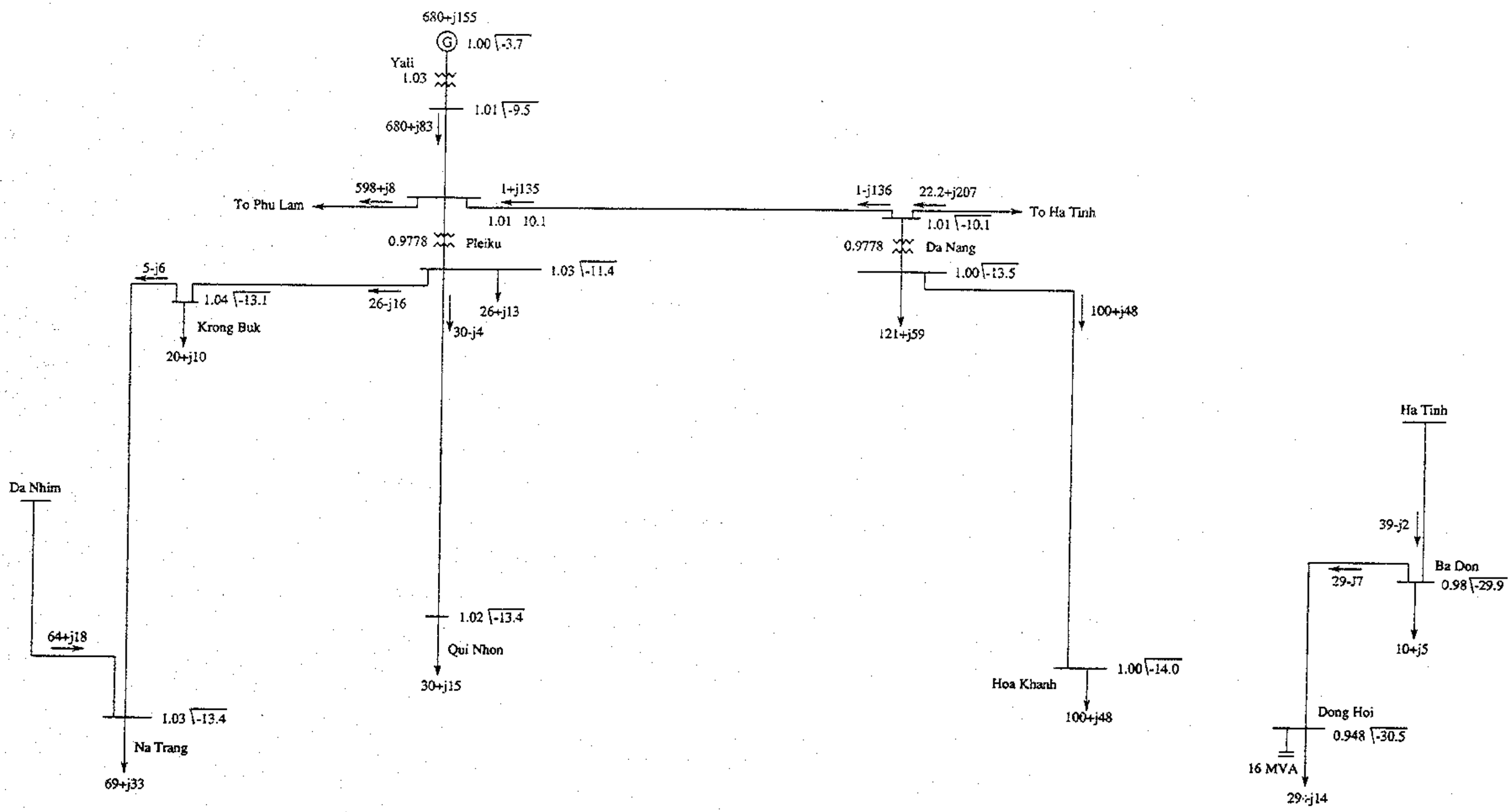


Figure 10.9 **Central 500/220 kV Transmission System Power Flow in 2000 (Rainy Season)**

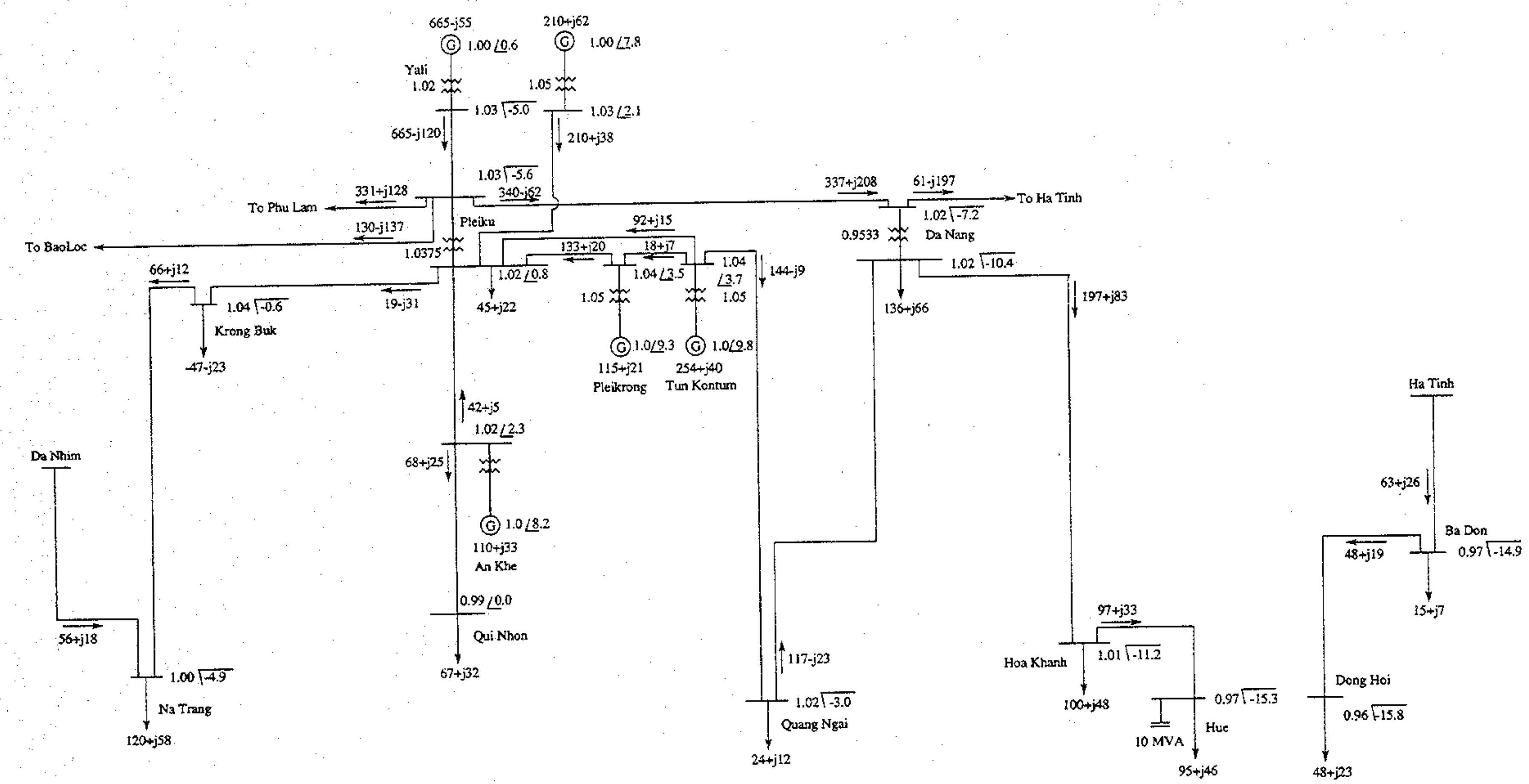


Figure 10.10 Central 500/220 kV Transmission System Power Flow in 2005 (Rainy Season)

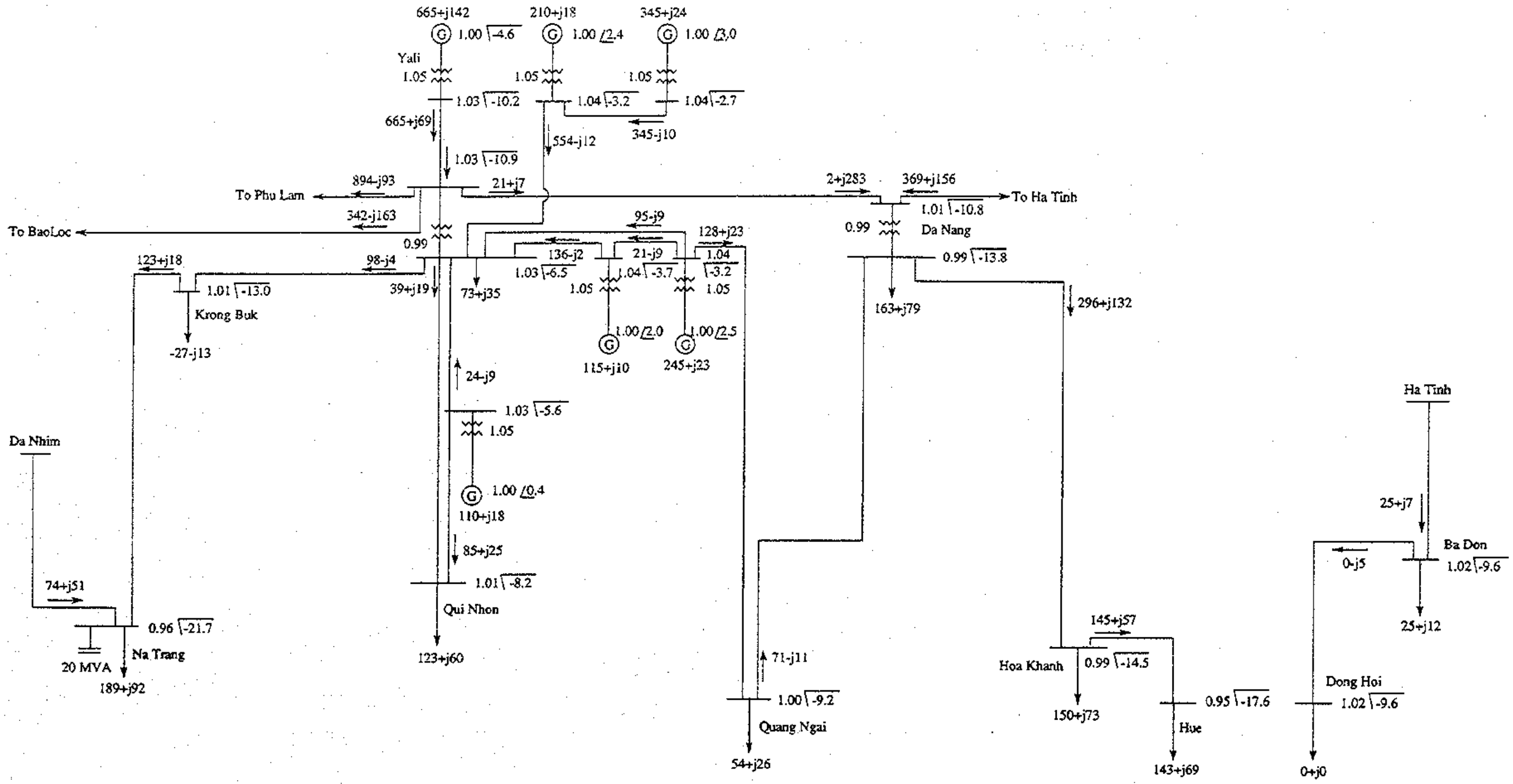


Figure 10.11 **Central 500/220 kV Transmission System Power Flow in 2010 (Rainy Season)**

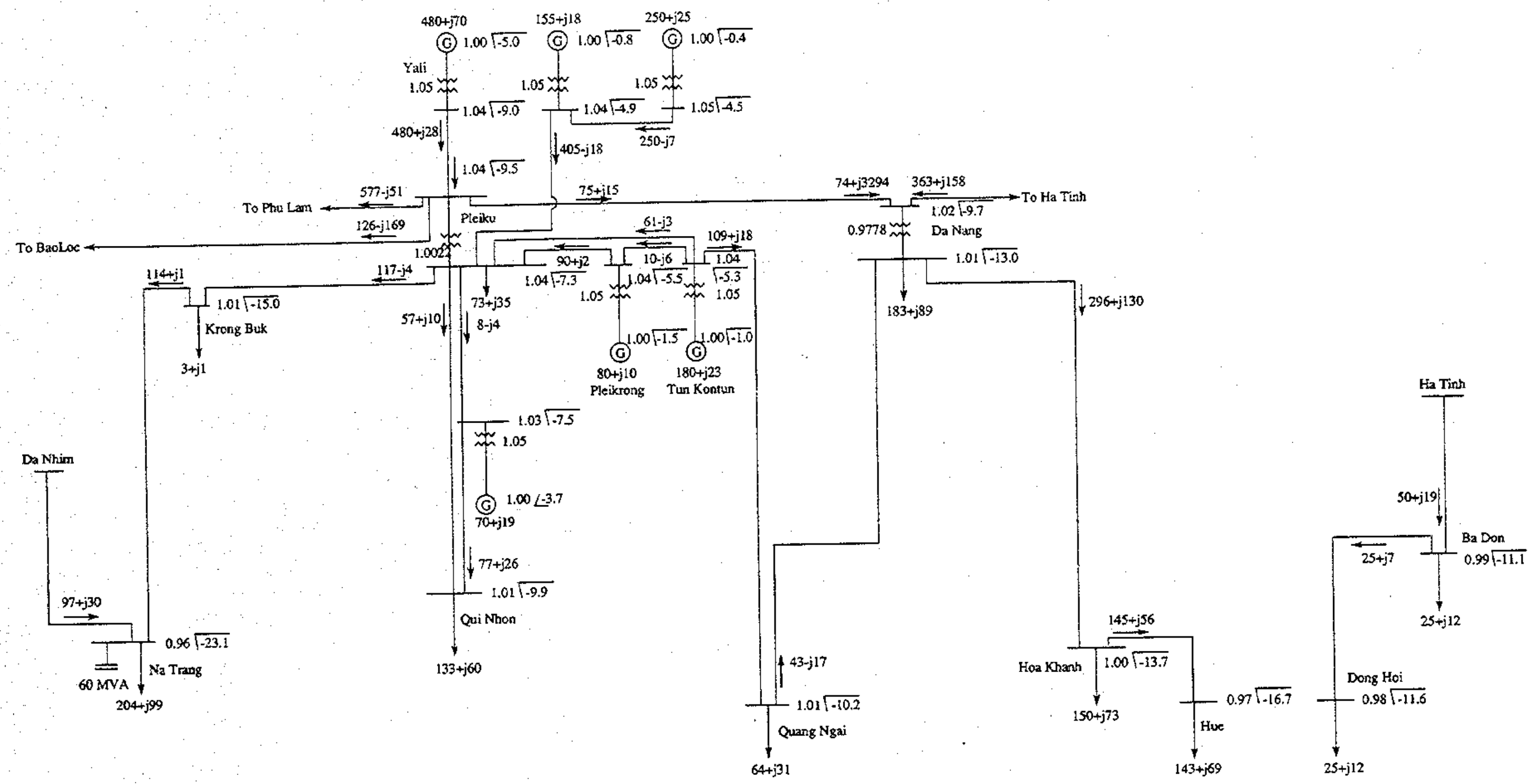


Figure 10.12 **Central 500/220 kV Transmission System Power Flow in 2010 (Dry Season)**

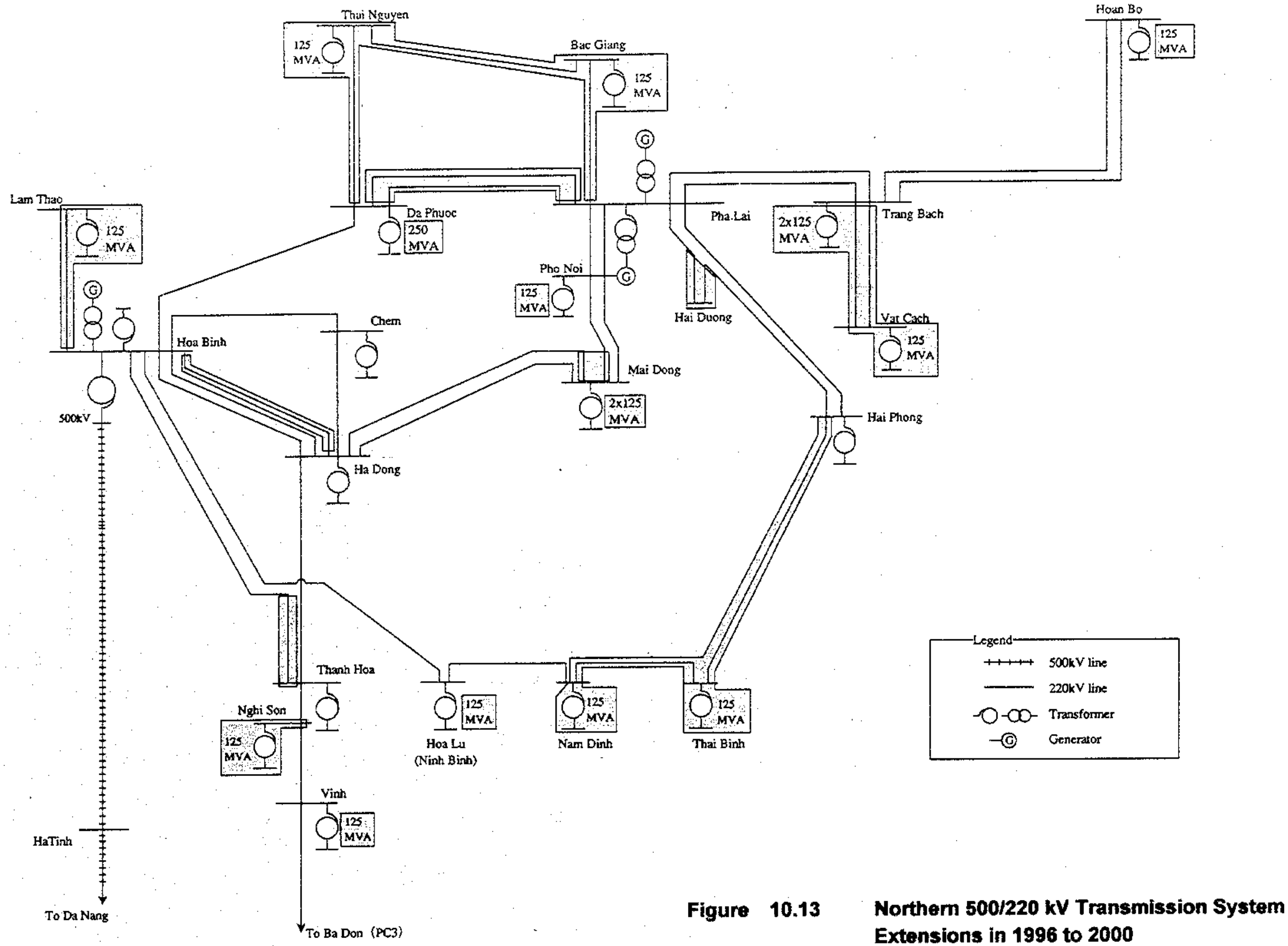


Figure 10.13 Northern 500/220 kV Transmission System Extensions in 1996 to 2000

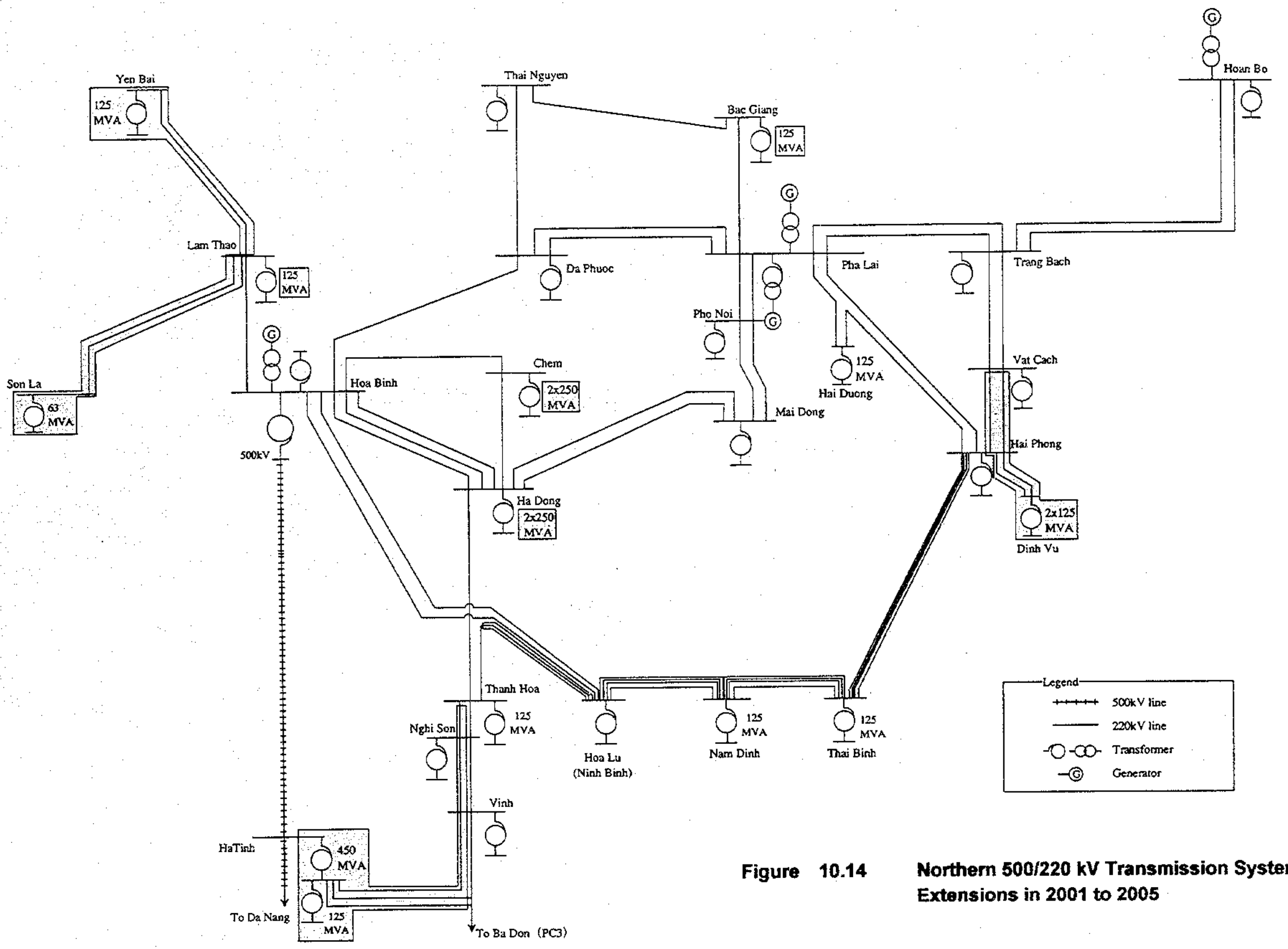


Figure 10.14 Northern 500/220 kV Transmission System Extensions in 2001 to 2005

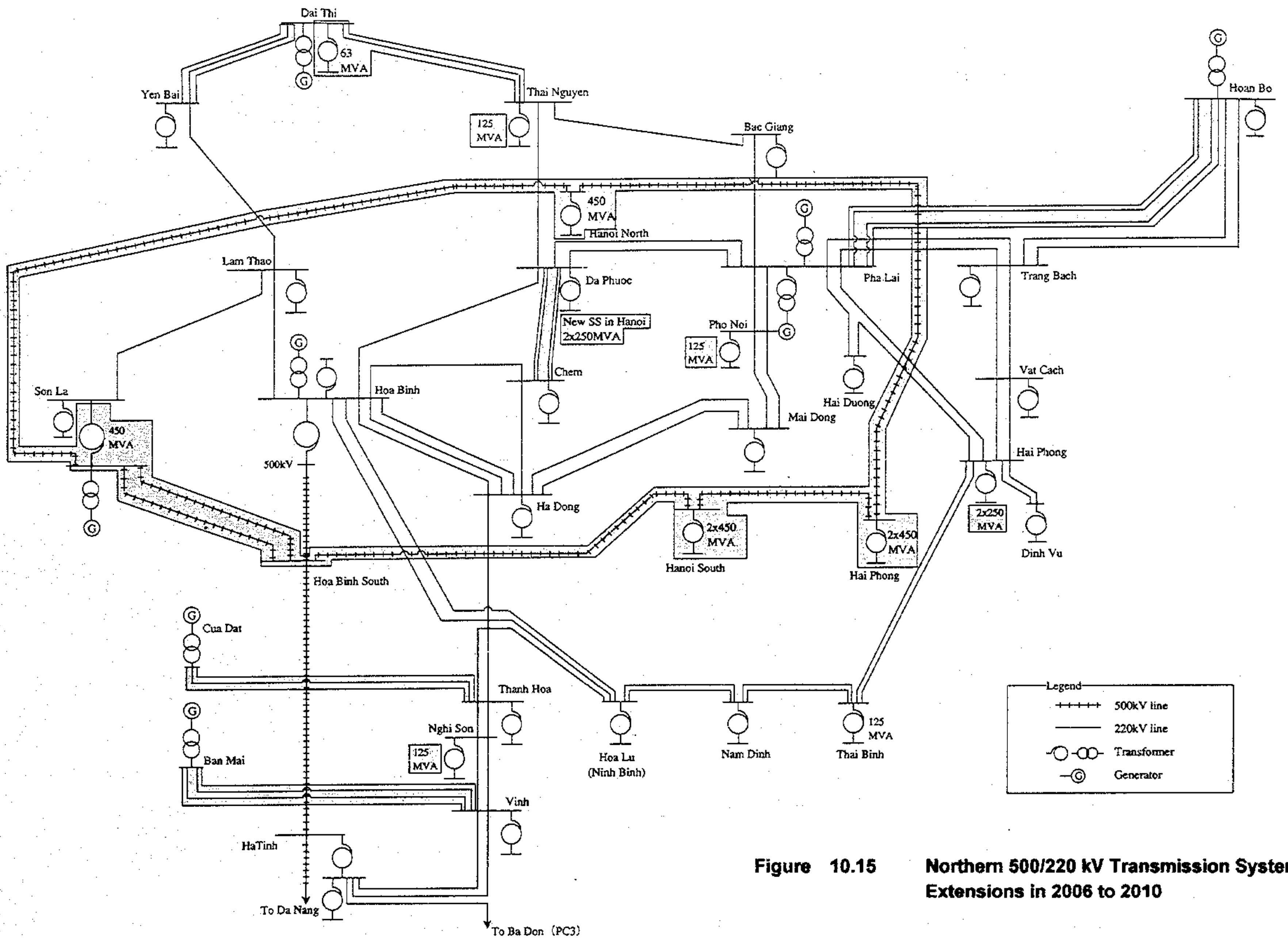


Figure 10.15 Northern 500/220 kV Transmission System Extensions in 2006 to 2010

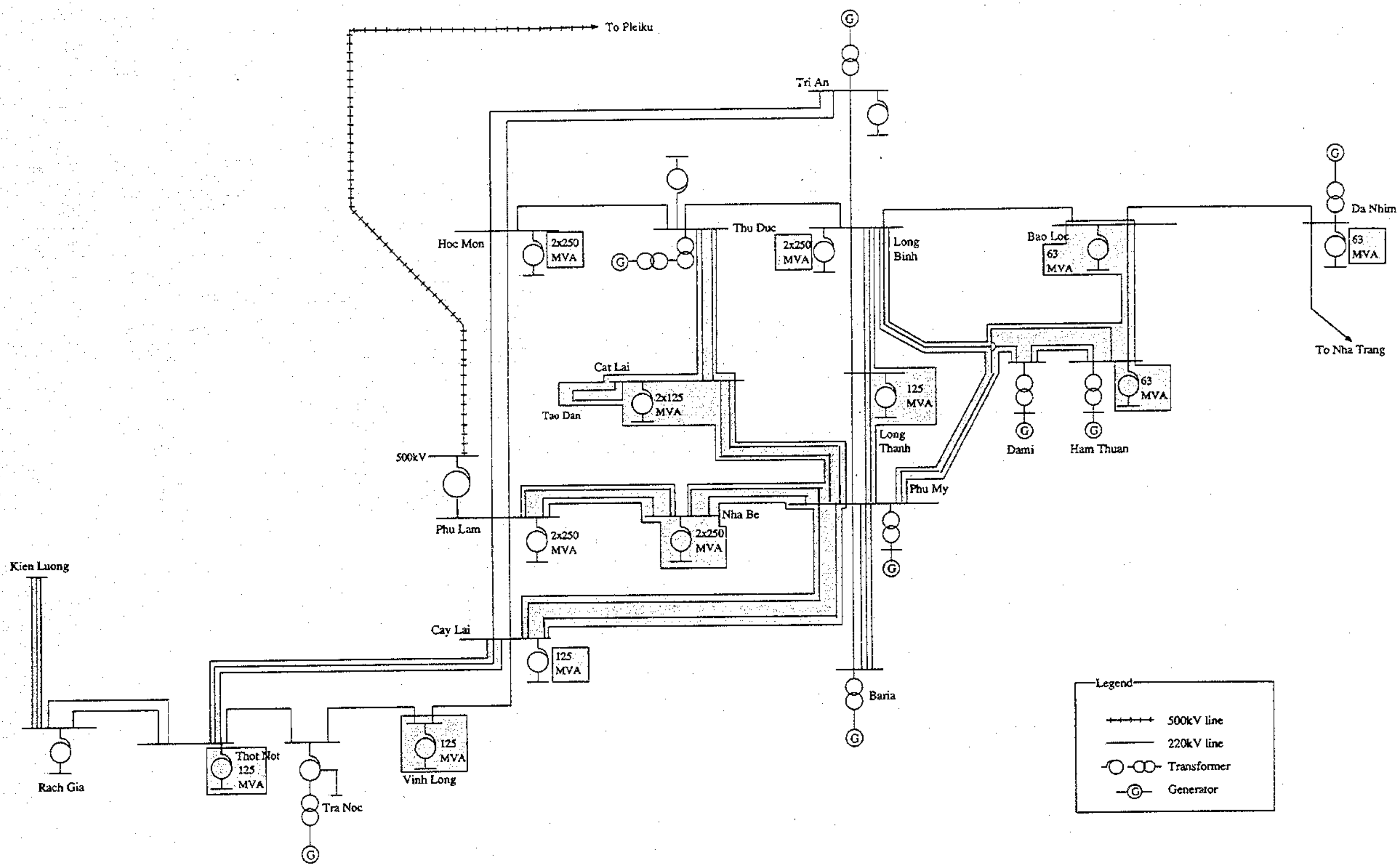


Figure 10.16 Southern 500/220 kV Transmission System Extensions in 1996 to 2000

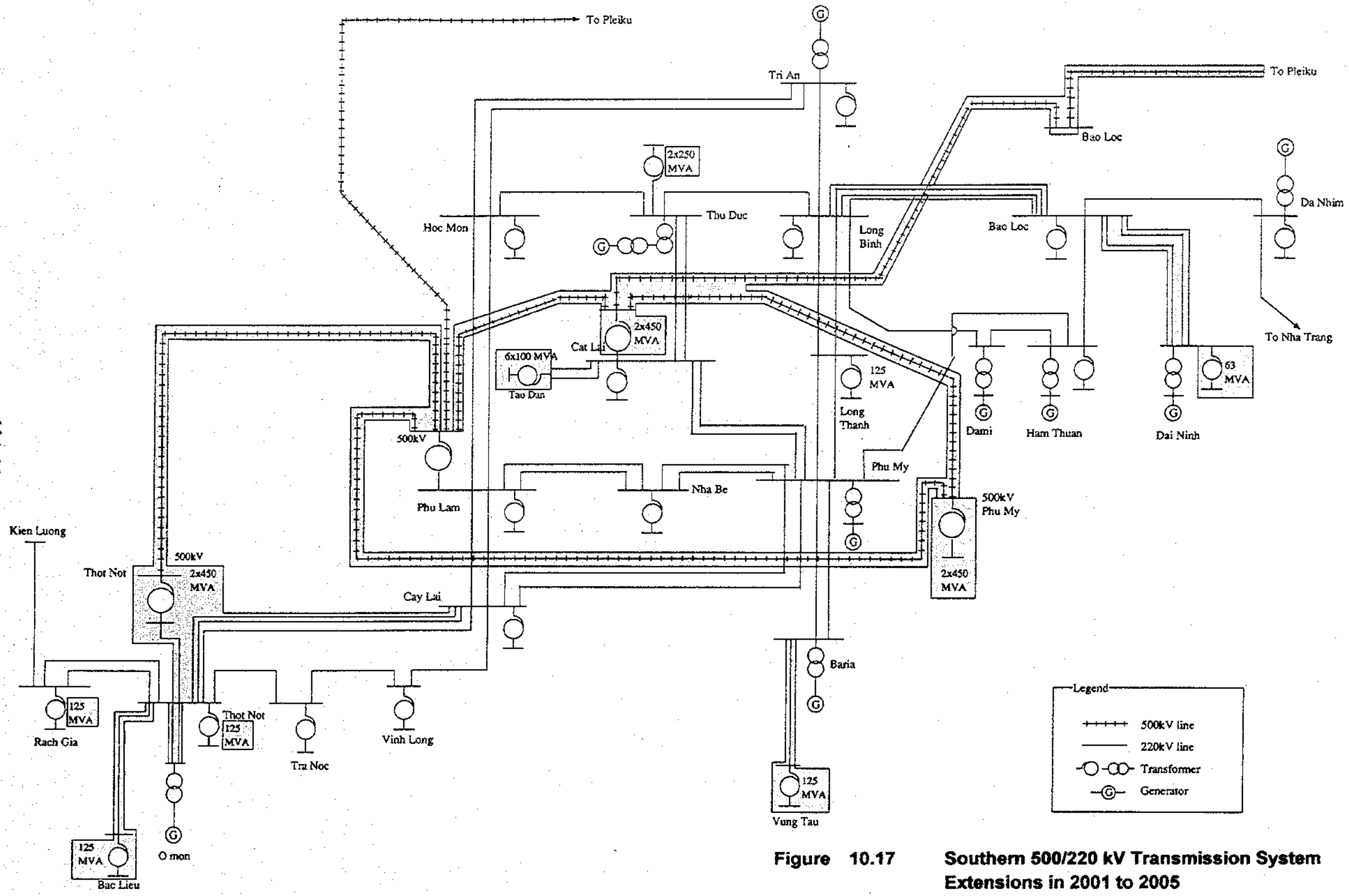


Figure 10.17 Southern 500/220 kV Transmission System Extensions in 2001 to 2005

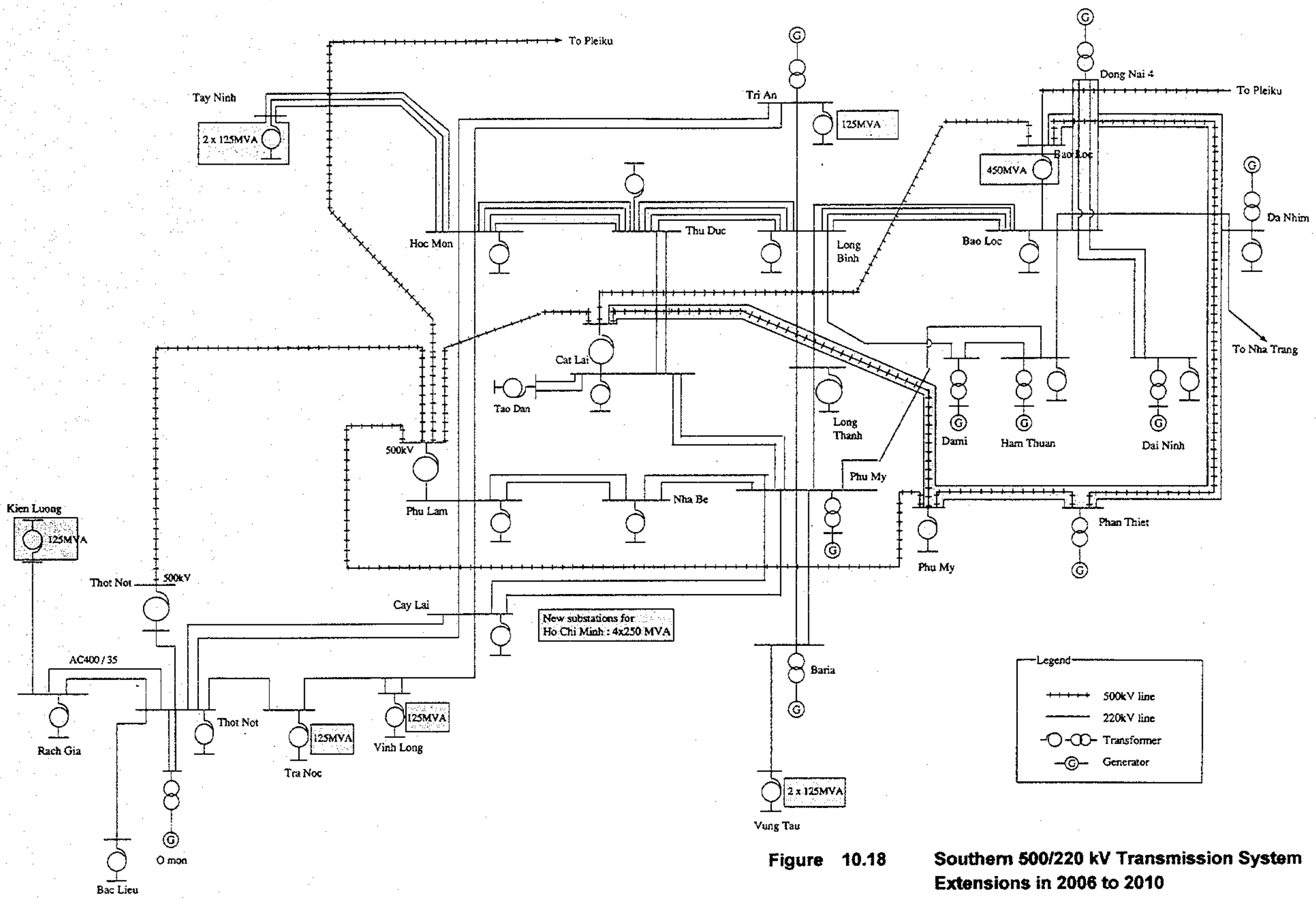


Figure 10.18 Southern 500/220 kV Transmission System Extensions in 2006 to 2010

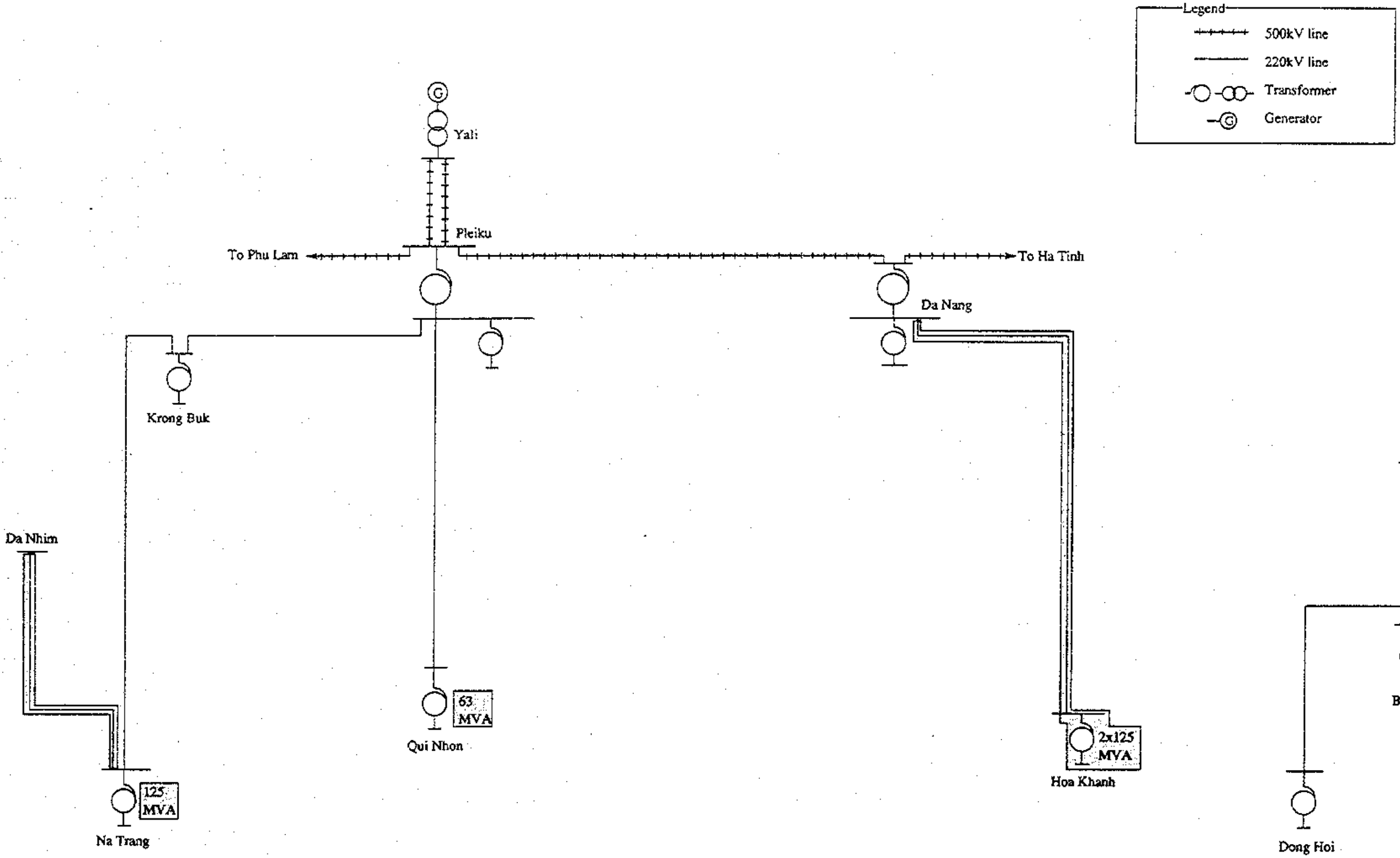


Figure 10.19 Central 500/220 kV Transmission System Extensions in 1996 to 2000

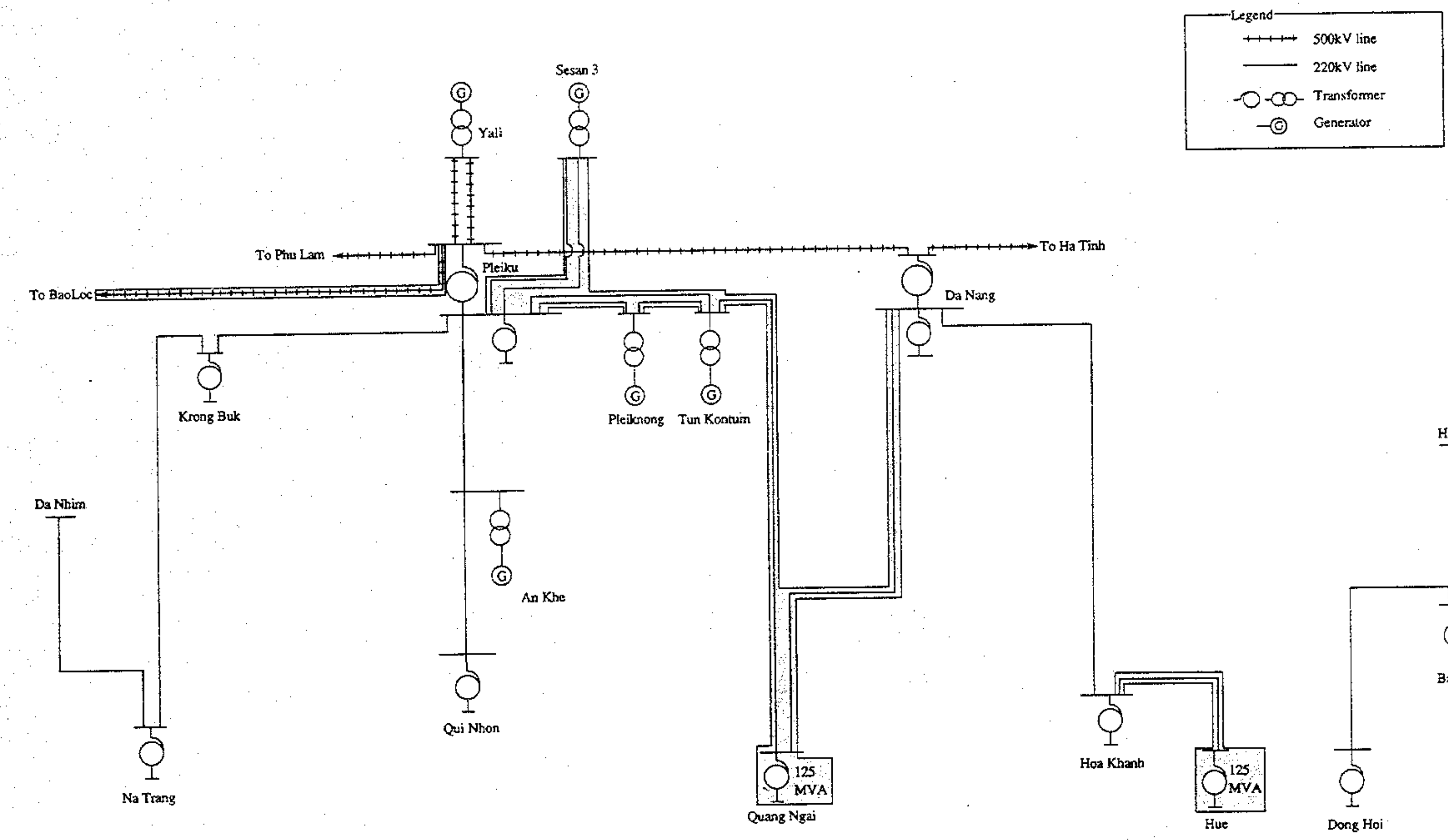


Figure 10.20 Central 500/220 kV Transmission System Extensions in 2001 to 2005

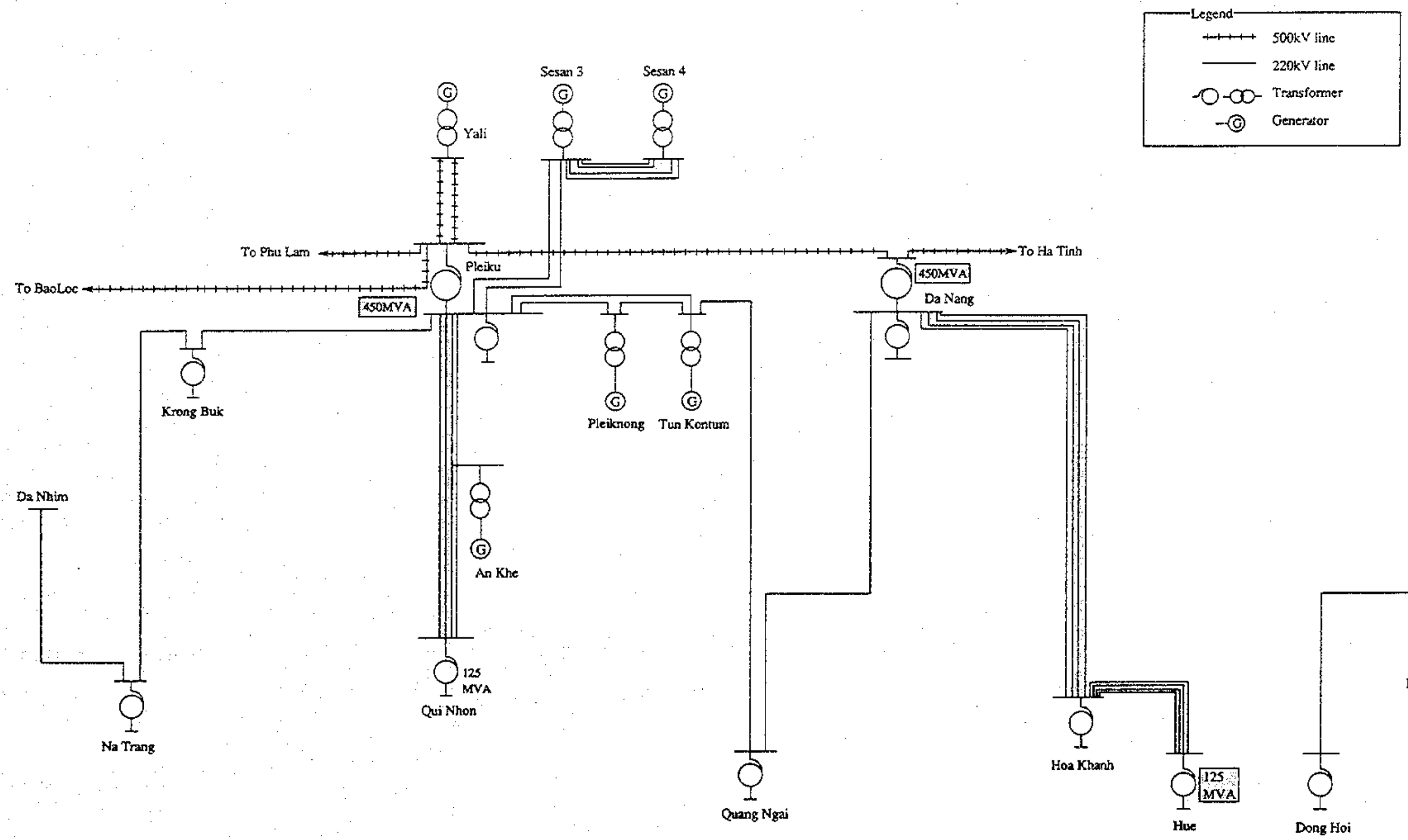


Figure 10.21 Central 500/220 kV Transmission System Extensions in 2006 to 2010

CHAPTER 11

STUDY AND EVALUATION OF THE ENERGY SAVING PLAN

CHAPTER 11 STUDY AND EVALUATION OF THE ENERGY SAVING PLAN

11.1 Energy-Saving Measures in Thermal Power Plants

11.1.1 Efficient Operation of Thermal Power Plants

(1) Loss factors

Loss factors (ratios) of thermal power units will be as shown in Figure 11.1 as for an example. Efficient operation of individual units will be carried out based on the analysis, survey and review of the respective factors, and the actual measurers can be roughly divided into "reduction of heat loss and recovery of heat", "maintaining and enhancing heat efficiency for the steam cycle" and "saving in-house power and auxiliary steam." (refer to The investigation for thermal power plant in Viet Nam)

An extent of each measure for contribution to energy conservation is made by Large (L), Medium (M) and Small (S).

(2) Reduction of heat loss and recovery of heat

(a) Optimization of excess air ratio of boilers (L)

The excess air ratio is optimized while maintaining the steam temperature and the stability of combustion such as dust and soot and NOx, and also close daily management, inspection and care are performed even for combustion equipment such as burners.

(b) Optimization of exhaust gas temperature of a boiler (L)

For the exhaust gas from a boiler, its waste heat is recovered by a fuel economizer and air preheater, but these are carefully managed by considering the corrosion prevention at the low temperature portion of the exhaust gas.

(c) Reduction of starting and stopping losses (M)

Starting and stopping losses at midnight and on holidays are increasing mainly in the medium- and small-capacity units, and the losses are reduced by using patterned running operations, improvement of water treatment method during starting (re-examining the reference values), reducing starting time and saving blow water.

(3) Maintenance and improvement of heat efficiency related to steam cycle

(a) Management of the vacuum degree in a condenser (M)

The steam turbine unavoidably has a relatively large amount of radiated heat from the condenser, so that the maintenance of the vacuum degree in a condenser is the most important point in the thermal power unit. For this reason, the preparation of detailed condenser management criteria and the partial strengthening of the facilities such as the washing of the cooling capillary of a condenser (continuous cleaning equipment) and the installation of back washing equipment of the condenser.

(b) Execution of the operation under reduced pressure in a partial load zone (M)

Where the turbine load is low, the loop loss at the governor valve can be reduced by the operation with the steam pressure decreased below the specified value. Also the steam temperature can be maintained at the specified value up to the relatively low load, so that the heat efficiency can be improved higher than that at the operation under specified steam pressure.

(c) Performance management of a heat exchanger and others (S)

It is important to maintain the value of the state at respective parts of the heat exchanger (such as an air preheater, feedwater heater, etc.) as close as possible to the standard deigned values. Also, soot blower has to be properly carried out.
In addition, the following is required in the maintenance phase:

- Inspection and replacement of cooling capillary for the condenser
- Replacement of the capillary for feed water heater and the adjustment of drain control
- Replacement of the heat exchange element for the prevention of leakage loss in the air preheater
- Washing boiler tube

(4) Saving in-house power and auxiliary steam, etc.

(a) Saving in-house power for circulating water pumps and others (L)

The loss factor of plant-home use increases as the operation for partial load increases. For this reason, it becomes important to survey in detail the influence upon the performance and efficiency of each equipment for every unit and also to prepare the judging criteria for the number of units operated within the range where the stable operation of the units will not be disturbed.

The number of units operated can be reduced during a partial load, and the possibility of this reduction can be considered for circulating a water pump, feedwater pump, forced draft fan, condensate pump, fuel pump and coal pulverizer.

(b) Saving auxiliary steam and others (S)

Situation of the use of the auxiliary steam in the whole plant is determined, daily patrol inspection is fully conducted, operation criteria for the auxiliary steam is re-examined, and the drain is recovered.

11.1.2 Efficiency Enhancement for Thermal Power Plants by Modification or Alteration

(1) Use of air preheater sensor drive (L)

Regenerative air preheater previously had the problem of heat loss due to the leakage of combustion air into the gas side. However, an automatic adjusting device for sealed equipment was newly developed, and this device can greatly reduce the leak by automatically adjusting the gap created by the deformation due to heat during operation.

(2) Installation of automatic condenser tube cleaning equipment (M)

Automatic condenser tube cleaning equipment using sponge balls can be installed for washing during operation. This can prevent a decrease in the vacuum degree in a condenser.

(3) Turbine performance improvement measures (S)

Deterioration due to corrosion and wear progresses after many years of operation in thermal power plants, and the performances of the equipment is gradually degraded.
To cope with this problem, various measures for enhancing the performances can be taken in parallel with the time of periodic inspection.

(4) Employment of Energy Saving Equipment (Speed Control and Movable Vane) (L)

(5) Combined Cycle Systems for Existing Thermal Power Plants (L)

Generating capacity and thermal efficiency can be improved if a combine cycle system is provided for existing thermal power plants with high efficiency and large capacity gas turbines.

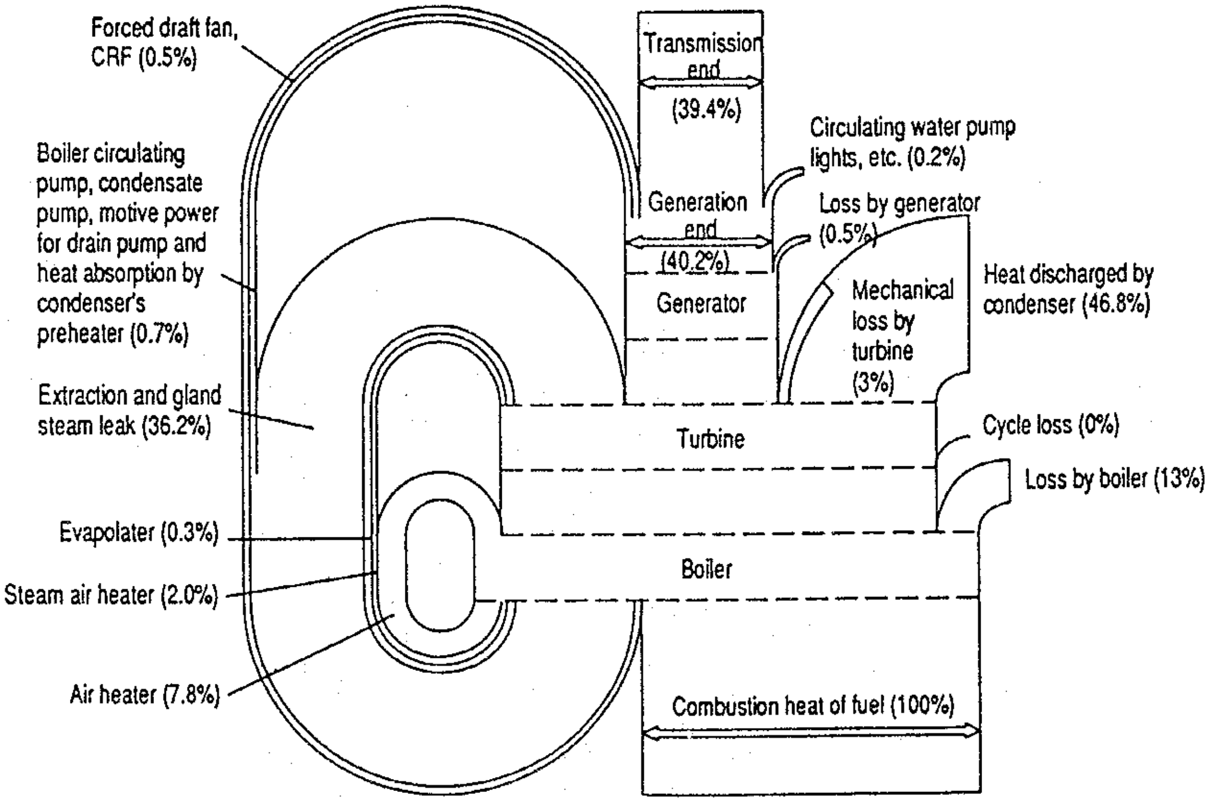
If such systems are being adopted, it should be noted that there are two systems; the standard combine cycle system that uses existing systems only to recover exhaust gas, and the exhaust gas reheating system that reheats exhaust gas in boilers using oxygen remained in exhaust gas.

Table 11.1 General Description of Flow Control Equipment for Auxiliary Systems

System		Description and Special Feature	Current Status of Utilization
Speed Control	Turbine-drive	Overall efficiency of units can greatly be improved because electric power is not required. This system is often used for large auxiliary systems and most often used boiler feedwater pumps (BFP) in thermal power plants.	Adopted for boiler feedwater pumps of all units, except for small units.
	Hydraulic coupling	This system is widely used for small and middle size BFP's fans, and small pumps.	Adopted for electric motor-driven BFP's and gas fans of existing thermal power plants.
	Inverter	This system covers a large space for installation, but is highly efficient.	Being adopted for steam condenser booster pumps in new thermal plants.
	Multiple disc clutch	This system is mainly used for general industrial pumps and fans, but also used in thermal power plants.	--
Movable Vane	Fan movable vane	This system is mainly used for FDF and IDF.	Being adopted by new thermal plants.
	Pump movable vane	This system is often used for recirculation water pumps in thermal power plants	Being adopted by new thermal plants. Also adopted by some existing thermal plants to replace deteriorated system.

Source: Chubu Electric Power Co., Ltd. of Japan

Figure 11.1 Typical Loss Rate of Thermal Power Plant



Questionnaire sheet
Thermal power station in Vietnam

1. General items

								Check
(1)Name of station								
(2)Location								
(3)Nominal capacity			MW					
			Main duty for load dispatching					
(4)Unit	Capacity	Number	Base	Middle	Gov	Co-gen	Peak	
#1								
#2								
#3								
#4								
#5								
#6								
#7								
#8								
#9								
#10								
Total								

2. Operating condition

2-1 Station total

(1)Annual generating output			1990	1991	1992	1993	1994		Average	
a.Nominal generating										MWH
b.Actual generating										MWH
c.Running factor										Hr
d.Actual sending										MWH
e.Actual heat sending										Gcal
f.Maximum generating output/hour										kW/h
g.Maximum generating output/day										Mwh/D
h.Maximum generating output/month										Mwh/M
(2)Annual fuel consumption	S.H.V		1990	1991	1992	1993	1994		Average	
a.Coal		Kcal/Kg								t
b.Crude oil		Kcal/Kg								t
c.Fuel oil		Kcal/Kg								t
d.Waste oil		Kcal/Kg								t
e.Natural gas		Kcal/Nm3								Nm3
f.Gasified coal		Kcal/Nm3								Nm3
g.Diesel oil		Kcal/Kg								t
h.etc.										
(3)Coal situation (/Kg)			1990	1991	1992	1993	1994		Average	
a. Heat value										Kcal
b. Ash										wt%
c. H/C ratio										
d. Sulfur										wt%
(4)Annual expenditure										
a. Running expenditure										
b. Fuel										
c. Maintenance										
d.Investment for improvement										

2-2 Operating condition by each unit (#)

(1)Annual generating output		1990	1991	1992	1993	1994		Average	
a. Nominal generating									MWH
b. Actual generating									MWH
c. Running factor									Hr
d. Actual sending									MWH
e. Actual heat sending									Gcal
f. Maximum generating output/hour									KW/h
g. Maximum generating output/day									Mwh/D
h. Maximum generating output/month									Mwh/M
(2)Annual fuel consumption	S.H.V	1990	1991	1992	1993	1994		Average	
a. Coal	Kcal/Kg								t
b. Clude oil	Kcal/Kg								t
c. Fuel oil	Kcal/Kg								t
d. Waste oil	Kcal/Kg								t
e. Natural gas	Kcal/Nm3								Nm3
f. Gasified coal	Kcal/Nm3								Nm3
g. Diesel oil	Kcal/Kg								t
h. etc.									
(3)Coal situation (/Kg)		1990	1991	1992	1993	1994		Average	
a. Heat value									Kcal
b. Ash									wt%
c. H/C ratio									
d. Sulfur									wt%
(4)Combustion way									
a. Stoker									
b. Pulverized coal									
c. Oil mix									
d. etc.									

2-3 Boiler condition(#)

	1990	1991	1992	1993	1994		Average	
(1)Combustion air & flue gas								
a. FDF outlet draft								mmHg
b. Air flow								Nm3/h
c. Air-heater inlet air draft								mmHg
d. Air-heater outlet air draft								mmHg
e. Combustion chamber inlet air draft								mmHg
f. Combustion chamber draft								mmHg
g. Super-heater inlet gas draft								mmHg
h. Super-heater outlet gas draft								mmHg
i. Economizer outlet gas draft								mmHg
j. Boiler outlet gas draft								mmHg
k. Air-heater outlet gas draft								mmHg
(2)Boiler heat-balance								
a. Combustion chamber inlet air temp.								deg C
b. Combustion chamber temp.								deg C
c. 1'ry super-heater inlet gas temp.								deg C
d. 1'ry super-heater outlet gas temp.								deg C
e. Re-heater inlet gas temp.								deg C
f. Re-heater outlet gas temp.								deg C
g. super-heater inlet gas temp.								deg C
h. super-heater outlet gas temp.								deg C
i. Economizer inlet gas temp.								deg C
j. Economizer outlet gas temp.								deg C
(3)Condition of exhaust gas								
a. Boiler outlet temp.								deg C
b. Oxygen								deg C
c. Carbon monoxide								%
d. Stack inlet gas temp.								deg C
e. Oxygen								%
f. Carbon monoxide								deg C

The investigation for thermal power station in Vietnam.

	1990	1991	1992	1993	1994		Average	
(4)Condition of boiler feed water								
a. Deaerator internal press.								Kg/cm2
b. Deaerator internal temp.								deg C
c. Deaerator feed water flow								t/h
d. L.P.Heater outlet temp								deg C
e. Feed water pump outlet press.								Kg/cm2
f. Feed water outlet temp.								deg C
g. 1'ry H.P.Heater outlet temp								deg C
h. 2'nd H.P.Heater outlet temp.								deg C
i. 3'rd H.P.Heater outlet temp.								deg C
j. 4'th H.P.Heater outlet temp.								deg C
k. 5'th H.P.Heater outlet temp.								deg C
l. Economizer inlet feed water temp.								deg C
m. Economizer outlet feed water temp.								deg C
n. Boiler feed water flow								t/h
(5)Boiler main steam condition								
a. Main drum internal press.								Kg/cm2
b. Evaporating flow								t/h
c. Super-heater outlet steam press.								Kg/cm2
d. Super-heater outlet steam temp.								deg C
e. Super-heater outlet steam flow								t/h
f. Re-heater outlet steam press.								Kg/cm2
g. Re-heater outlet steam temp.								deg C
h. Re-heater outlet steam flow.								t/h

2-4 Condition of turbine

			1990	1991	1992	1993	1994		Average	
(1)Top turbine										
a. Main steam pressure										Kg/cm2
b. Main steam temperature										deg C
c. Main steam flow										t/h
d. Pressure after 1'st stage										Kg/cm2
(2)Reheat turbine										
a. Steam pressure										Kg/cm2
b. Steam temperature										deg C
c. Steam flow										t/h
(3)Extraction										
a-1. 1'st extraction steam press.										Kg/cm2
a-2. 1'st extraction steam temp.										deg C
a-3. 1'st extraction steam flow										t/h
b-1. 2'nd extraction steam press.										Kg/cm2
b-2. 2'nd extraction steam temp.										deg C
b-3. 2'nd extraction steam flow										t/h
c-1. 3'rd extraction steam press.										Kg/cm2
c-2. 3'rd extraction steam temp										deg C
c-3. 3'rd extraction steam flow										t/h
d-1. 4'th extraction steam press.										Kg/cm2
d-2. 4'th extraction steam temp.										deg C
d-3. 4'th extraction steam flow										t/h
(3)Condenser										
a. Vacuum degree										mmHg
b. Cooling water temp.										deg C
c. Cooling water flow										t/h
d. Condensate temperature										deg C
e. Condensate flow										t/h
(4)Generator										
a. Generating power										Mwh/h
b. Generating voltage										Kv
c. Generating current										A
d. Power factor										%

2-5 Feed water treatment

			1990	1991	1992	1993	1994		Average	
(1)Source water										
a. Water flow										t/h
b. pH										
c. Conductivity										ohm-cm
d. Cl										ppm
e. Si										ppm
f. Ca										ppm
g. CO3										ppm
h. Fe										ppm
i. Cu										ppm
j. NH4										ppm
k. SO4										ppm
(2)Demineralizer										
a. Flow										t/h
b. pH										
c. Conductivity										ohm-cm
d. Na										ppm
e. Fe										ppm
d. Cu										ppm
f. Si										ppm
g. Melted oxygen										ppm
(3)Condensate										
a. pH										
b. Conductivity										ohm-cm
c. Cl										ppm
d. Fe										ppm
e. Cu										ppm
(3)Deaerator inlet water										
a. pH										
b. Conductivity										ohm-cm
c. Fe										ppm
d. Cu										ppm
e. Si										ppm
f. Melted oxygen										ppm

The investigation for thermal power station in Vietnam.

			1990	1991	1992	1993	1994		Average	
(4)Boiler feed water										
a. pH										
b. Conductivity										ohm-cm
c. Fe										ppm
d. Cu										ppm
e. Si										ppm
f. Remained oxygen										ppm
(5)Boiler drum water										
a. pH										
b. Conductivity										ohm-cm
c. Fe										ppm
d. Cu										ppm
e. Si										ppm
f. Remained oxygen										ppm

3. Specification of key facilities in each unit

(1)Boiler		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
a. Type											
b. Evaporation	t/h										
c. Evaporating press.	Kg/cm2										
d. Evaporating temp.	deg C										
e. Reheating temp.	deg C										
f. B.F.W. temp.	deg C										
(2)Turbine											
a. Type											
b. Output	Mw										
c. Inlet steam press.	Kg/cm2										
d. Inlet steam temp.	deg C										
e. No. of extraction stage											
f. Vacuum degree	mmHg										
(3)Generator											
a. Capacity	KVA										
b. Voltage	Kv										
c. Power factor	%										
d. Cooling type	air/H2										
(4)Auxiliary equipment											
a. B.F.W. pump	Capa.										
	Number										
b. Fun											
b-1. F.D.F.	Capa.										
	Number										
b-2. I.D.F.	Capa.										
	Number										
(5)Non-operating hours											
a. Annual total	Hr										
b. For maintenance	Hr										

The investigation for thermal power station in Vietnam.

4. Re-construction in past

(1)For maintenance	
(2)Capacity up	
(3)Efficiency up	
(4)According network duty	
(5)For pollution	
(6)etc.	

5.Other facilities

	Type	Capa.	Line
(1)Demineralizer			
(2)Dust catcher			
(3)De-sulfurization plant			
(4)etc.			

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