4.5 ASSOCIATED TRANSMISSION LINE AND SUBSTATIONS

4.5.1 Existing Transmission Line and Substations in Southern Region

In Vietnam, the national power transmission lines have three voltage level: 500kV, 220kV and 110kV. The schematic view of the existing 500kV transmission system in 2011 is shown in Fig. 4.5-1. In the figure, the location of each substation is shown as a ballpark position and the geographical construction situation of transmission lines is disregarded. And the existing transmission system around O Mon power complex in 2010 is shown in Fig. 4.5-2 (The solid lines in the figure show the existing transmission lines).

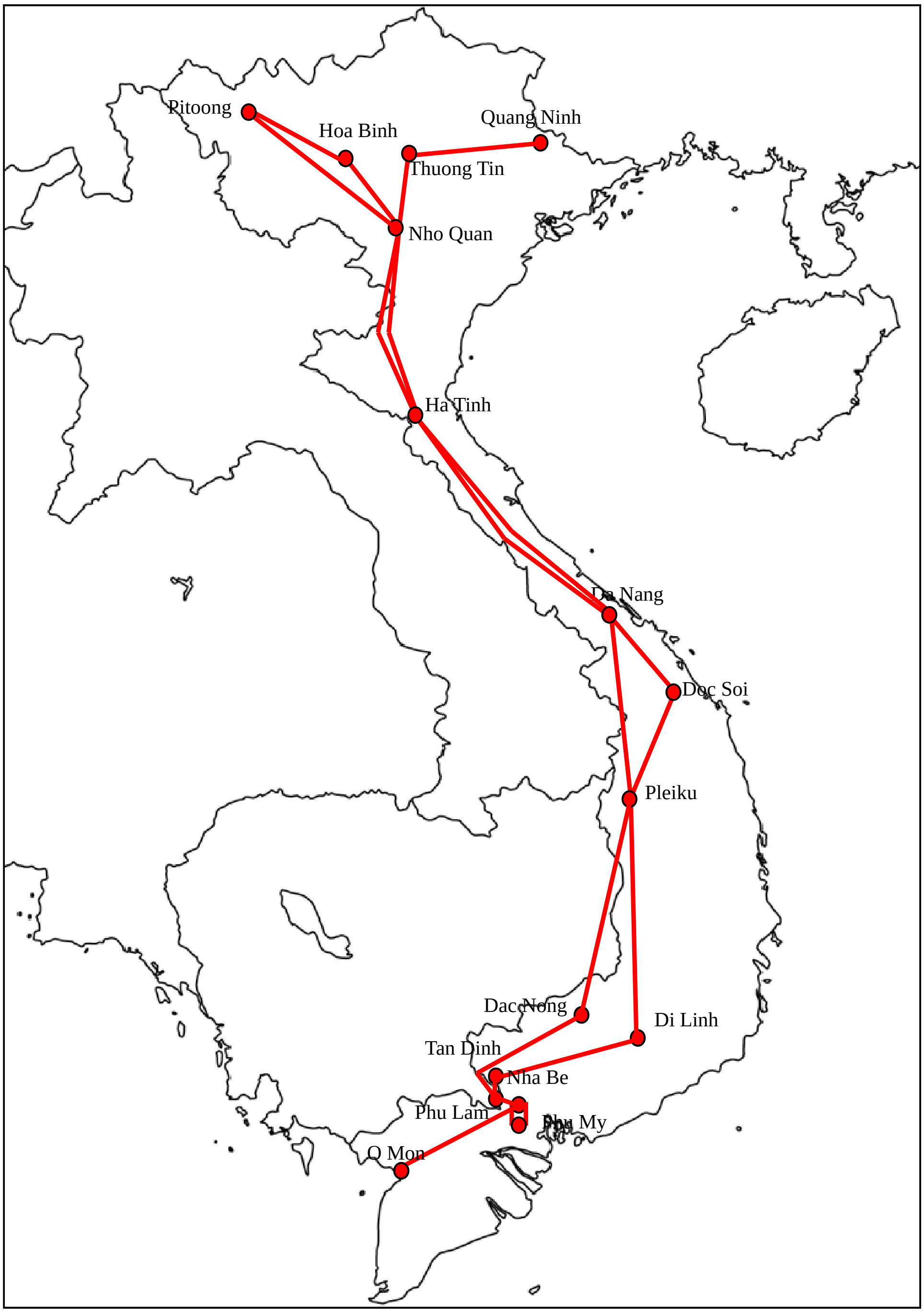
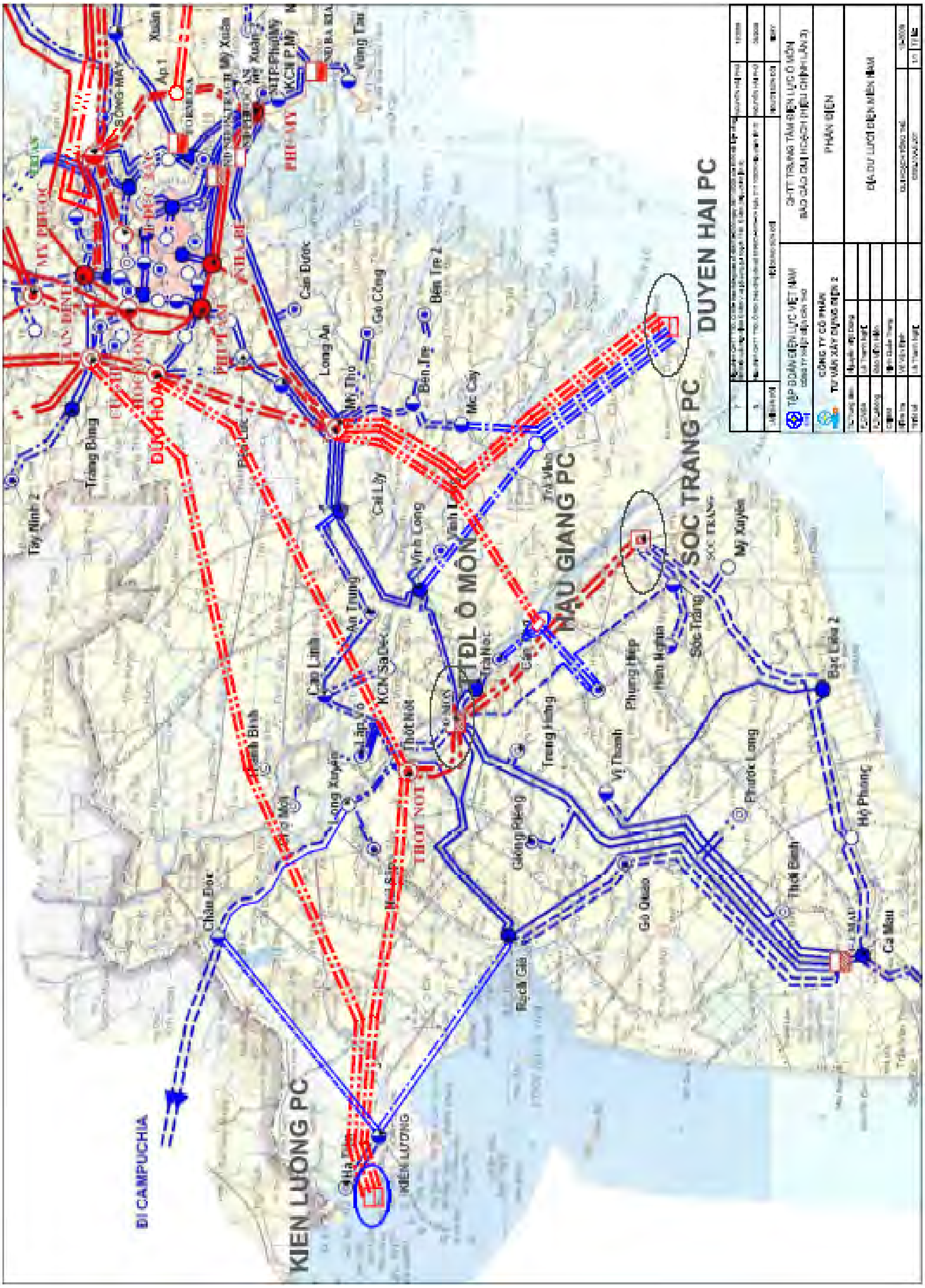


Fig. 4.5-1 Schematic View of the Existing 500kV Transmission System in 2011

Source : The Study Team created from various data



Source: CTTP

Fig. 4.5-2 Existing Transmission System around O Mon Power Complex in 2010

4.5.2 Associated Transmission Line and Substations to be connected to O Mon 3

As described in Section 4.4.3, O Mon Power Complex is planned with four power plants, O Mon 1, O Mon 2, O Mon 3 and O Mon 4, and there are the 500kV switchyard, the 220kV switchyard and the 110kV switchyard as their common equipment. The generated power of the power plants is transferred to the power transmission system via the switch yards. Each switchyard is interconnected by the 500/220kV transformer and the 220/110kV transformer. Therefore, for O Mon 3 power plant, an original plan of interconnection to the national transmission system does not exist but the plan turns into one as the whole O Mon Power Complex.

In addition, for O Mon Power Complex, the switchyards are included with its management boundaries. Then the transmission lines and substations which are to be connected to and the routing of transmission lines, construction schedule of transmission lines and substations will be determined on the PDP7 of EVN. The substations which is and will be connected to O Mon Power Complex in this time as a result of the interview from CTTP and PECC2 are shown in Table 4.5-1 (The scheduled completion year in the table is based on the PDP7).

Table 4.5-1 Connected Substation of O Mon Power Complex (at Present and the Plan)

Voltage	cct	Connected Substation	
		present	plan
500	2	NHA BE S/S (2 × 600MVA)	MY THO S/S (1 × 900MVA) [2015]
		CAI LAY S/S (2 × 125MVA) This connection is operating as 220kV.	
	2	-	THOT NOT S/S (1 × 600MVA) [2015]
	2	-	LONG PHU S/S (1 × 450MVA) [2015]
220	2	THOT NOT S/S (2 × 125MVA)	Same as on the present
	1	CAI LAY S/S (2 × 125MVA)	Same as on the present
	2	TRA NOC S/S (125 + 100MVA) Only 1 cct is operating.	Same as on the present
	2	CA MAU 1 P/S (3 × 250MW)	Same as on the present
	2	SOC TRANG S/S No.2 (125MVA)	Same as on the present
	1	RACH GIA S/S No.2 (125 MVA)	RACH GIA S/S (250 MVA)
110	2	BINH MINH S/S (25WVA) KCN SONG HAU S/S (40MVA)	BINH MINH S/S (25WVA) KCN SONG HAU S/S (40MVA) SA DEC S/S (2 × 25MVA)
		KCN CAN THO S/S (25MVA + 63MVA)	Same as on the present
	2	TRA NOC S/S (125 + 100MVA)	Same as on the present
		PT NAM BO S/S (2 × 16MVA)	Same as on the present
	1	LONG XUYEN (2 × 40MVA)	Same as on the present

*The figure in [ ] is the scheduled completion year described in the PDP7.

4.5.3 Power Flow Analysis and Power System Stability Analysis

(1) The year and System for Analysis

In the F/S Report, power flow analyses and N-1 analyses were carried out at the peak demand of the dry season in 2015 based on the PDP6 and the output of O Mon Power Complex will be 2,910MW. On the other hand, according to each plant construction schedule of O Mon Power Complex shown in Table 4.5-2, O Mon 3 power plant will be operated in 2016, and the installed capacity of the whole O Mon Power Complex will become 2,160 MW at the time since O Mon 2 power plant will not be operated. However, in this analysis, in order to make influence of O Mon Power Complex to the power system into a service side, it is assumed that O Mon 2 power plant is also operated in 2016. Moreover, as shown in Table 4.3-2, the net power output of the latest F type gas turbine combined cycle power plants is expected to be 819 MW as an average and 860 MW as the maximum. Therefore, in this study, the power flow analysis and the system stability analysis are carried out in the state in 2016 where all the power plants of O Mon Power Complex are operated and the net power output of each combined cycle power plant is 860 MW to consider the influence of O Mon Power Complex to a service side.

500kV and 220kV system were the target system for the analysis.

Table 4.5-2 Power Plant Construction Schedule of O Mon Power Complex

Plant No.	Type	Installed Capacity	Operation Year
1	Conventional	660MW	2009(1A), 2014(1B)
2	Combined Cycle	750MW	2017
3	Combined Cycle	750MW	2016
4	Combined Cycle	750MW	2015

Source: CTTP

(2) Acquisition Data

For power flow analysis and system stability analysis, the data which came to hand is shown in from Table 4.5-3 to Table 4.5-9.

Table 4.5-3 Acquisition Data for Power Flow Analysis and System Stability Analysis

No.	Obtained data	Place to obtain	Remark
1	The existing 500kV power transmission grid (the end of 2007)	JICA (Feasibility Report)	See Table 4.5-4 and Table 4.5-5
2	The construction plan of 500kV power transmission grid in the South in the stage 2007 -2010 based on the Master Plan VI	JICA (Feasibility Report)	See Table 4.5-6 and Table 4.5-7
3	The construction or rehabilitation plan of 220kV power transmission grid in the South in the stage 2007 -2010 based on the Master Plan VI	JICA (Feasibility Report)	See Table 4.5-8 and Table 4.5-9
4	One line diagram of the entire power system of Vietnam (2011)	CTTP and PECC2	See Fig. 4.5-3
5	Power flow diagram of the Southern system (2015)	PECC2 (a part of Vietnamese Feasibility Report, PL-TLSC-DN-2015-01)	See Fig. 4.5-4
6	The Construction plan of Power Sources in the stage 2011 -2016	PECC2 (Vietnamese Master Plan VII)	See Table 4.5-10
7	The construction plan of 500kV power transmission grid in the Central and Southern Vietnam in the stage 2011 -2015	PECC2 (Vietnamese Master Plan VII)	See Table 4.5-11 and Table 4.5-12
8	The construction plan of 220kV power transmission grid in the Central and Southern Vietnam in the stage 2011 -2015	PECC2 (Vietnamese Master Plan VII)	See Table 4.5-13 and Table 4.5-14
9	Power system operation standard (criteria)	PECC2 (Vietnamese Transmission System Regulation : MOIT Circular No.12-2010)	See Table 4.5-15

Table 4.5-4 List of 500kV Transmission Lines in the end of 2007

No.	Name of transmission line			No. of circuits × km
Northern Part				
1	Hoa Binh	-	Ha Tinh	1 × 341
2	Nho Quan	-	Ha Tinh	1 × 297
3	Nho Quan	-	Thuong Tin	1 × 76
4	Transitory connection to 500kV Nho Quen substation			2 × 32
Central Part				
1	Ha Tinh	-	Da Nang (line 1)	1 × 390
2	Ha Tinh	-	Da Nang (line 2)	1 × 392
3	Da Nang	-	Pleiku	1 × 259
4	Da Nang – Doc Soi – Pleiku			1 × 297
5	Yaly	-	Pleiku	2 × 23
Southern Part				
1	Pleiku	-	Phu Lam (line 1)	1 × 496
2	Pleiku	-	Phu Lam (line 2)	1 × 542
3	Phu My	-	Nha Be	2 × 43
4	Nha Be	-	Phu Lam	1 × 16
5	Nha Be	-	O Mon	1 × 77.4

Table 4.5-5 List of Substations in the end of 2007

No.	Name of substation	Number of transformer × MVA	Rating-MVA
Northern Part			**2,250**
1	Hoa Binh	2 × 450	900
2	Nho Quan	1 × 450	450
3	Thuong Tin	1 × 450	450
4	Ha Tinh	1 × 450	450
Central Part			**1,800**
1	Pleiku	1 × 450	900
2	Di Linh	1 × 450	450
3	Da Nang	2 × 450	900
Southern Part			**3,000**
1	Phu Lam	2 × 450	900
2	Phu My	1 × 450	450
3	Tan Dinh	1 × 450	450
4	Nha Be	2 × 600	1,200

Table 4.5-6 500kV Transmission Lines constructed from 2007 to 2010

No.	Name of transmission line			No. of circuits × km		
1	Nha Be	-	O Mon	1	×	152
2	Phu Lam	-	O Mon	1	×	148.7
3	Branch to Dong Nai 3&4			2	×	2
4	Phu My	-	Song May	2	×	63
5	Song May	-	Tan Dinh	2	×	40
6	Than Vinh Tan	-	Song May	2	×	260
7	Branch to Cau Bong			2	×	0.5

Table 4.5-7 500kV Substations constructed from 2007 to 2010

No.	Name of substation	Number of transformer x MVA			Rating-MVA
1	Phu My	1	×	450	450
2	Tan Dinh	1	×	450	450
3	Di Linh	1	×	450	450
4	Nhon Trach	1	×	450	450
5	Song May	1	×	600	600
6	Cau Bong	1	×	600	600
7	O Mon	2	×	450	900
8	Dak Nong	2	×	450	900

Table 4.5-8 Construction or Rehabilitation Plan of 220kV Transmission Line in the South (2007-2010)

No.	Name of transmission line			No. of circuits × km		
1	Ba Ria	-	Vung Tau	2	×	14
2	Da Lat	-	Da Nhim	1	×	28
3	Dai Ninh	-	Di Linh	2	×	39
4	TD Dong Nai 3	-	Dak Nong	2	×	25
5	TD Dong Nai 4	-	Dak Nong	2	×	15
6	TD Dak Tih	-	Dak Nong	1	×	10
7	Di Linh	-	Tan Rai	2	×	10
8	Tan Dinh	-	My Phuoc	2	×	50
9	My Phuoc	-	Binh Long	2	×	38
10	Branch Xuan Loc			4	×	5
11	Branch Hiep Binh	-	Phuoc	4	×	2
12	Branch Nam SG			2	×	1
13	Branch Binh Tan			2	×	1
14	Branch Thaun An			2	×	1
15	Branch Long An			2	×	1
16	Branch Song May – Tri An – Long Binh			4	×	5
17	Branch Song May – Bao Loc – Long Binh			4	×	10
18	Branch Song May	-	Long Binh	2	×	15
19	Phu My	-	My Xuan	2	×	3
20	Ba Ria	-	Vung Tau	2	×	18
21	Branch Phu My 2 IP			2	×	4
22	Phu My	-	Ba Ria	2	×	25
23	Ham Thuan	-	Phan Thiet	2	×	50
24	Song May	-	Uyen Hung	2	×	20
25	Uyen Hung	-	Tan Dinh	2	×	20
26	Branch Cu Chi vao – Tan Dinh – Trang Bang			4	×	1
27	Cau Bong 500kV	-	Hoc Mon	2	×	10
28	Cau Bong 500kV	-	Binh Tan	2	×	10
29	ND Nhon Trach	-	Cat Lai	2	×	20
30	ND Nhon Trach	-	Nha Be	2	×	10
31	Tam Phuoc - ND Nhon Trach – Song May			2	×	36
32	Nha Be	-	Phu Lam	2	×	15
33	Phu Lam	-	Hoc Mon	2	×	19
34	Cat Lai	-	Thu Duc	2	×	9
35	ND O Mon	-	Soc Trang	1	×	73
36	ND Ca Mau	-	Rach Gia	2	×	110
37	ND Ca Mau	-	Bac Lieu	2	×	76
38	ND O Mon	-	Thot Not	2	×	22
39	Kien Luong	-	Chau Doc	1	×	72
40	Soc Trang	-	Bac Lieu	2	×	50
41	Branch	-	Cao Lanh	2	×	3
42	Thot Not	-	Chau Doc	2	×	70
43	My Tho	-	Ben Tre	2	×	21
44	ND O Mon	-	Vinh Long	2	×	40
45	Vinh Long	-	Tra Vinh	2	×	70
46	ND O Mon	-	Tra Noc	2	×	10

Table 4.5-9 Construction or Rehabilitation Plan of 220kV Substations in the South (2007-2010)

No.	Name of substation	Number of transformer × MVA	Rating-MVA
1	Soc Trang	1 × 125	125
2	My Phuoc	2 × 250	500
3	My Tho	1 × 125	125
4	My Xuan	1 × 250	250
5	Song May	1 × 125	125
6	Vung Tau	2 × 250	500
7	The south Sai Gon	2 × 250	500
8	Xuan Loc	1 × 250	250
9	Bac Lieu	1 × 125	125
10	Nhon Trach Power Plant	1 × 250	250
11	O Mon	2 × 125	250
12	Tan Dinh	1 × 250	250
13	Ben Tre	2 × 125	250
14	Tan Rai	2 × 125	250
15	Binh Long	2 × 125	250
16	Binh Tan	2 × 250	500
17	Tao Dan	1 × 250	250
18	Hiep Binh Phuoc	2 × 250	500
19	Phan Thiet	1 × 125	125
20	Dai Ninh	1 × 63	63
21	Cao Lanh	2 × 125	250
22	Cat Lai	1 × 250	250
23	Chau Doc	2 × 125	250
24	Phu My 2 IP	1 × 250	250
25	Cu Chi	2 × 250	500
26	Kien Luong	1 × 125	125
27	Thot Not	1 × 125	125
28	Da Lat	1 × 125	125
29	Thaun An	1 × 250	250
30	Tra Vinh	2 × 125	250
31	Long An	2 × 125	250
32	Trang Bang	1 × 250	250
33	Long THanh	1 × 250	250
34	Uyen Hung	1 × 250	250

Table 4.5-10 Construction Plan of Power Sources in the Stage 2011-2016 (PDP7)

No.	Name of Power Plant	Installed Capacity(MW)	Investor
Works into operation in 2011		**4,187**	
Hydro			
1	Son La #2,3,4	1,200	EVN
2	Nam Chien #1	100	Tap doan Song Da
3	Na Le (Bac Ha) #1,2	90	LICOGI
4	Ngoi Phat	72	IPP
5	A Luoi #1,2	170	Cong ty phan Dien Mien Trung
6	Song Tranh 2 #2	95	EVN
7	An Khe - Kanak	173	ENV
8	Se San 4A	63	Cong ty co phan TD Se San 4A
9	Dak My 4	190	IDICO
10	Se Kaman3 (Lao)	250	Cong ty co phan Viet Lao
11	Dak Rtih	144	Tong cong ty Xay dung so 1
12	Dong Nai 3 #2	90	EVN
13	Dong Nai 4 #1	170	EVN
Thermal			
14	Uong Bf MR #2	300	EVN
15	Cam Pha II	300	TKV
Cross Compound			
16	Nhon Trach 2	750	EVN
	Wind power + Renewable Energy	30	
Works into operation in 2012		**2,805**	
Hydro			
1	Son La #5,6	800	EVN
2	Dong Nai 4 #2	170	EVN
3	Nam Chien #2	100	Tap doan Song Da
4	Ban Chat #1,2	220	EVN
5	Hua Na #1,2	180	Cong ty co phan TD Hua Na
6	Nho Que3 #1,2	110	Cong ty co phan Bitexco
7	Khe Bo #1,2	100	Cong ty co phan Dien luc
8	Ba Thuoc II #1,2	80	IPP
9	Dong Nai 2	70	IPP
10	Dam Bri	75	IPP
Thermal			
11	An Khanh I #1	50	Cong ty co phan ND An Khanh
12	Vung Ang I #1	600	PVN
13	Formosa #2	150	Cong ty TNHH Hung Nghiep Formosa
	Wind power + Renewable Energy	100	
Works into operation in 2013		**2,105**	
Hydro			
1	Nam Na 2	66	IPP
2	Dak Rinh #1,2	125	PVN
3	Sre Pok 4A	64	Cong ty co phan TD Buon Don
Thermal			
4	Hai Phong II #1	300	EVN
5	Mao Khe #1,2	440	TKV
6	An Khanh I #2	50	Cong ty co phan ND An Khanh
7	Vung Ang I #2	600	PVN
8	Nghi Son I #1	300	EVN
9	Nong Son	30	PVN
	Wind power + Renewable Energy	130	
Works into operation in 2014		**4,279**	
Hydro			
1	Nam Na 3	84	IPP

No.	Name of Power Plant	Installed Capacity(MW)	Investor
2	Yen Son	70	Cong ty co phan XD&DL Binh Minh
3	Thuong Kontum #1,2	220	Cong ty CTD Vinh Son – S.Hinh
4	Dak Re	60	Cong ty co phan TD Thien Tan
5	Nam Mo (Lao)	95	IPP
Thermal			
6	Hai Phong 2 #2	300	EVN
7	Nghi Son I #2	300	EVN
8	Thai Binh II #1	600	PVN
9	Quang Ninh II #1	300	EVN
10	Vinh Tan II #1,2	1200	EVN
11	O Mon I #2	330	EVN
12	Duyen Hai I #1	600	EVN
	Wind power + Renewable Energy	120	
Works into operation in 2015		**6,540**	
Hydro			
1	Huoi Quang #1,2	520	EVN
2	Dong Nai 5	145	TVK
3	Dong Nai 6	135	Cong ty Duc Long Gia Lai
4	Se Ka man 1 (Lao)	290	Cong ty co phan Viet Lao
Thermal			
5	Quang Nihn II #2	300	EVN
6	Thai Binh II #2	600	PVN
7	Mong Duong II #1,2	1,200	AES/BOT
8	Luc Nam #1	50	IPP
9	Duyen Hai III #1	60	EVN
10	Long Phu I #1	600	PVN
11	Duyen Hai I #2	600	EVN
12	Cong Thanh #1,2	600	Cong ty co phan ND Cong Thanh
Cross Compound			
13	O Mon III	750	EVN
	Wind power + Renewable Energy	150	
Works into operation in 2016		**7,136**	
Hydro			
1	Lai Chau #1	400	EVN
2	Trung Son #1,2	260	EVN
3	Song Bung 4	156	EVN
4	Song Bung 2	100	EVN
5	Dak My 2	98	IPP
6	Dong Nai 6A	106	Cong ty Duc Long Gia Lai
7	Hoi Xuan	102	IPP
8	Se Kaman 4 (Lao)	64	BOT
9	Ha Se San 2 (Campuchia 50%)	200	EVN-BOT
Thermal			
10	Mong Duong I #1	500	EVN
11	Thai Binh I #1	300	EVN
12	Hai Duong #1	600	Jak Resourse – Malaysia/BOT
13	An Khanh II #1	150	Cong ty co phan ND An Khanh
14	Long Phu I #2	600	PVN
15	Vinh Tan I #1,2	1,200	CSG/BOT
16	Duyen Hai III #2	600	EVN
Cross Compound			
17	O Mon IV	750	EBN
18	O Mon II	750	BOT
	Wind power + Renewable Energy	200	

Table 4.5-11 Construction Plan of 500 kV Substation in the Central and Southern Region in the Stage 2011-2015 (PDP7)

No.	Name of substation	Number of transformer × MVA	Rating-MVA	Remark
Central Part			**900**	
1	Thanh My	2 × 450	900	New construction
Southern Part			**9,450**	
1	Phu Lam	1 × 900	900	Replace
2	Song May	2 × 600	1200	2013
3	Cau Bong	2 × 900	1800	3 transformers design
4	Duc Hoa	1 × 900	900	
5	Tan Uyen	1 × 900	900	(Tram Thu Duc Bac doi ten)
6	Thot Not	1 × 600	600	
7	My Tho	1 × 900	900	
8	O Mon	1 × 450	450	Transformer No.2
9	Long Phu	1 × 450	450	Plan for DZ 500kV Long Phu – O Mon delayed compared to ND Long Phu 1, 2
10	Duyen Hai	1 × 450	450	
11	Vinh Tan	2 × 450	900	Overall by ND Vinh Tan 2

Table 4.5-12 Construction Plan of 220 kV Substation in the Central and Southern Region in the Stage 2011-2015 (PDP7)

No.	Name of substation	Number of transformer × MVA	Rating-MVA	Remark
Central Part			**3,925**	
1	Thanh My	1 × 125	125	(Dau noi thuy dien)
2	Doc Soi	1 × 125	125	Replace of 63MVA
3	Dung Quat 2	2 × 125	250	
4	Son Ha	2 × 150	300	
5	Tuy Hoa	1 × 125	125	Transformer No.2
6	Hue	1 × 250	250	Transformer No.2
7	Chan May	1 × 250	250	Transformer No.1
8	Phong Dien	1 × 125	125	Transformer No.1
9	Hoa Khanh	1 × 250	250	Replace Transformer No.1
10	Quan Ba (Ngu Hanh Son)	1 × 125	125	Transformer No.1
11	Da Nang	1 × 250	250	Replace Transformer No.1
12	Tam Ky	1 × 125	125	Transformer No.2
13	Tam Hiep	1 × 125	125	Transformer No.1
14	Dung Quat	1 × 125	125	Transformer No.2
15	An Nhon	1 × 250	250	Transformer No.1
16	Nha Trang	1 × 250	250	Replace Transformer No.1
17	Van Phong	1 × 250	250	Transformer No.1
18	Kom Tum	1 × 125	125	Transformer No.1
19	Plei Ku	1 × 125	125	Transformer No.2
20	Ba Don	1 × 125	125	
21	Buon Kuop	1 × 125	125	Transformer No.2
22	Song Tranh 2	1 × 125	125	New construction

No.	Name of substation	Number of transformer × MVA			Rating-MVA	Remark
Southern Part					**9,450**	
1	Bac Loc	1	×	125	125	Replace of 63MVA
2	Duc Trong	1	×	125	125	
3	Thap Cham	1	×	125	125	
4	Phan Thiet	2	×	125+250	375	Replace+Trans. No.2
5	Ham Tan	1	×	250	250	
6	Cat Lai	1	×	250	250	Transformer No.2
7	Nam Sai Gon	2	×	250	500	
8	Hiep Binh Phuoc	2	×	250	500	
9	Binh Tan	2	×	250	500	
10	Cu Chi	2	×	250	500	
11	Cau Bong	2	×	250	500	
12	TP. Nhon Trach	2	×	250	500	
13	Tan Uyen	2	×	250	500	
14	Tan Cang	2	×	250	500	
15	Quan 8	2	×	250	500	
16	Binh Long	2	×	125	250	
17	Tay Ninh	2	×	250	500	
18	My Phuoc	1	×	250	250	Transformer No.2
19	Thuan An	2	×	250	500	
20	Uyen Hung	2	×	250	500	
21	Ben Cat	2	×	250	500	
22	Tan Dinh 2	1	×	250	250	
23	Song May	2	×	250	500	
24	Xuan Loc	2	×	250	500	
25	Vung Tau	2	×	250	500	
26	KCN Phu My 2	2	×	250	500	
27	My Xuan	2	×	250	500	
28	Chau Duc	1	×	250	250	
29	Long An	2	×	250	500	Replace of 2x125MVA
30	Ben Luc	1	×	250	250	
31	Duc Hoa	2	×	250	500	
32	Can Duoc	1	×	250	250	
33	Cao Lanh	1	×	125	125	Transformer No.2
34	KCN Sa Dec	1	×	250	250	
35	Chau Doc	2	×	250	500	Replace of 2 Transformers
36	Long Xuyen 2	1	×	250	250	
37	My Tho	1	×	250	250	Replace of Transformer No.1
38	Cai Lay	1	×	250	250	Replace
39	Vinh Long 2	1	×	250	250	Replace
40	Ben Tre	1	×	250	250	Replace
41	Thot Not	1	×	250	250	Replace
42	Phung Hiep	2	×	125	250	
43	Tra Vinh	2	×	125	250	
44	Soc Trang	1	×	125	125	Transformer No.2
45	Ca Mau	1	×	250	250	Transformer No.2
46	Vinh Long	2	×	125+250	375	
47	Bac Lieu	1	×	125	125	

Table 4.5-13 Construction Plan of 500 kV Transmission Lines in the Central and Southern Region in the Stage 2011-2015 (PDP7)

No.	Name of Project			No. of circuits × km		
Central Part						
1	Pleiku – My Phuoc – Cau Bong			2	×	437
2	HatXan	-	Pleiku	2	×	100
3	Ha Tinh	-	Da Nang	Capacity >=2000A		
Southern Part						
1	Song May	-	Tan Dinh	2	×	41
2	Phu My	-	Song May	2	×	66
3	Vinh Tan	-	Song May	2	×	235
4	Branch to		Cau Bong	4	×	1
5	Branch to		Duc Hoa	4	×	8
6	Song May	-	Tan Uyen	2	×	22
7	My Tho	-	Duc Hoa	2	×	60
8	ND Duyen Hai	-	My Tho	2	×	113
9	ND Long Phu	-	O Mon	2	×	84
10	O Mon	-	Thot Not	2	×	16
11	Branch to		My Tho	4	×	1
12	Phu My	-	Phu My	2	×	1
13	Pleiku – Dak Nong – Phu Lam			Capacity >=2000A		
14	Pleiku – Di Linh – Tan Dinh			Capacity >=2000A		

Table 4.5-14 Construction Plan of 220 kV Transmission Lines in the Central and Southern Region in the Stage 2011-2015 (PDP7)

No.	Name of Project			No. of circuits × km		
Central Part						
1	Dong Hoi	-	Dong Ha	2	×	108
2	Dong Ha	-	Hue	2	×	68
3	TD A Luoi – Branch to Dong Ha – Hue			2	×	28
4	Phong Dien – Branch to Hue – Hoa Khanh			4	×	5
5	Chan May – Branch to Hue – Hoa Khanh			4	×	8
6	Hue	-	Hoa Khanh	2	×	110
7	SeKaman 3	-	Thanh My	2	×	120
8	Nhanh re tram Quan 3 (Ngu Hanh Son)			2	×	12
9	Doc Soi	-	Quang Ngai	2	×	60
10	Tam Hiep	-	500kV Doc Soi	2	×	20
11	Son Ha	-	500kV Doc Soi	2	×	50
12	Quang Hgai	-	Quy Nhon	2	×	143
13	Dau noi TD Song Bung 2, Song Bung 4			2	×	20
14	Dak My 1	-	Dak My 4	2	×	15
15	Dac My 4	-	Thanh My 500kV	2	×	50
16	Dau noi cum thuy dien SeSan ve TBA 220kV TD SeSan 4			2	×	33
17	Buon Kuop	-	Dak Nong	1	×	85
18	Pleiku	-	Kon Tum	2	×	30
19	Thuong Kon Tum	-	Quang Ngai	2	×	767
20	An Khe	-	An Nhon	2	×	30

No.	Name of Project			No. of circuits × km		
21	Dau noi 220kV ND Van Phong	-	Tram cat Ninh Hoa	2	×	20
22	Branch to tram cat Ninh Hoa	-	Tram cat Ninh Hoa	4	×	6
23	Branch to An Nhon			2	×	6
24	Tuy Hoa	-	Nha Trang	2	×	147
25	Nha Trang	-	Cam Ranh	2	×	60
26	Krong Buk	-	Nha Trang	1	×	147
27	Branch to Van Phong			2	×	2
28	Pleyku	-	Krong Buk	1	×	143
Southern Part						
1	Cam Ranh	-	Thap Cham	2	×	45
2	Thap Cham	-	Vinh Tan	2	×	44
3	Thap Cham	-	Da Nhim	1	×	40
4	Vinh Tan	-	Phan Thiet	2	×	100
5	Phan Thiet	-	Ham Tan	2	×	63
6	Ham Tan	-	Chau Duc	2	×	62
7	Chau Duc	-	KCN Phu My 2	2	×	21
8	Nhanh branch	-	KCN Phu My 2	2	×	14
9	Ba Ria	-	Vung Tau	2	×	14
10	Binh Long	-	Tay Ninh	2	×	64
11	Dong Nai 2	-	Di Linh	2	×	15
12	Di Linh	-	Da Nhim	1	×	80
13	Di Linh	-	Tan Rai	2	×	10
14	Song May	-	Uyen Hung	2	×	21
15	Uyen Hung	-	Tan Dinh	2	×	18
16	Song May	-	Bao Loc	1	×	124
17	Di Linh	-	Bao Loc	1	×	37
18	Ham Thuan	-	Bao Loc	1	×	39
19	Duc Trong – Branch to Da Nhim – Di Linh			2	×	2
20	Branch to Xuan Loc			4	×	5
21	Branch to Hiep Binh Phuoc			2	×	2
22	Branch to Nam Sai Gon			4	×	3
23	Branch to Binh Tan			4	×	3
24	Branch to Thuan An			4	×	3
25	Song May – Branch to Tri An – Long Binh			2	×	5
26	Song May – Branch to Bao Loc – Long Binh			4	×	10
27	Branch to Song May	-	Long Binh	2	×	15
28	Branch to My Xuan			4	×	2
29	Branch to Phu My – Ba Ria – KCN Phu My 2			4	×	2
30	Thu Duc Bac – Branch to Thu Duc – Long Binh			4	×	3
31	500kV Tan Uyen – Branch to Thu Duc Bac – Thu Duc			4	×	8
32	500kV Tan Uyen	-	Uyen Hung	2	×	15
33	Dak Nong – Phuroc Long – Binh Long			2	×	130
34	Ben Cat - Branch to My Phuoc – Binh Long			2	×	11
35	Cu Chi – Branch to Tan Dinh – Trang Bang			4	×	3
36	Cau Bong 500kV	-	Hoc Mon	6	×	16
37	Cau Bong 500kV	-	Cu Chi	6	×	22

No.	Name of Project			No. of circuits × km		
38	Replace of Cau Bong – Hoc Mon(4cct) to Vinh Loc – Hoc Mon			2	×	5
39	Branch to Vinh Loc – Phu Lam – Binh Tan			4	×	3
40	Nha Be	-	Phu Lam	2	×	15
41	Phu Lam	-	Hoc Mon	2	×	19
42	Cat Lai	-	Thu Duc	2	×	9
43	Tan Cang	-	Cat Lai	2	×	12
44	Nam Sai Gon	-	Quan 8	2	×	6
45	500kV Duc Hoa	-	Duc Hoa 1	4	×	22
46	Duc Hoa 1	-	Cu Chi	4	×	8
47	500kV Duc Hoa – Branch to Phu Lam – Long An			2	×	20
48	ND Nhon Trach	-	TP Nhon Trach	2	×	12
49	Trang Bang	-	Tay Ninh	2	×	44
50	Tay Ninh	-	KamPong Cham	2	×	116
51	Ben Luc – Branch to PhuLam – Long An			2	×	5
52	Can Duoc – Branch to Phu My – My Tho			4	×	7
53	500kV My Tho – Branch to Long An – Cai Lay			4	×	2
54	500kV My Tho – Branch to My Tho – Cai Lay			4	×	2
55	ND Duyen Hai	-	Mo Cay	2	×	77
56	Mo Cay	-	Ben Tre	2	×	20
57	My Tho	-	Ben Tre	1	×	18
58	ND Duyen Hai	-	Tra Vinh	2	×	45
59	Vinh Long	-	Tra Vinh	2	×	62
60	KCN Sa Dec – Branch to Vinh Long 2 – O Mon			2	×	5
61	Cao Lanh	-	Cai Lay	1	×	54
62	Cao Lanh	-	Thot Not	1	×	27
63	ND Long Phu	-	Soc Trang	4	×	25
64	ND Long Phu – Can Tho – Tra Noc			2	×	95
65	Phung Hiep – Branch to O Mon – Soc Trang			4	×	6
66	Long Xuyen 2 – Branch to Chau Doc – Thot Not			4	×	5
67	ND Ca Mau	-	Ca Mau	1	×	5
68	Phu Lam	-	Cai Lay	2	×	70
69	Phu My	-	Long Thanh	2	×	25
70	Long Thanh	-	Long Binh	4	×	25

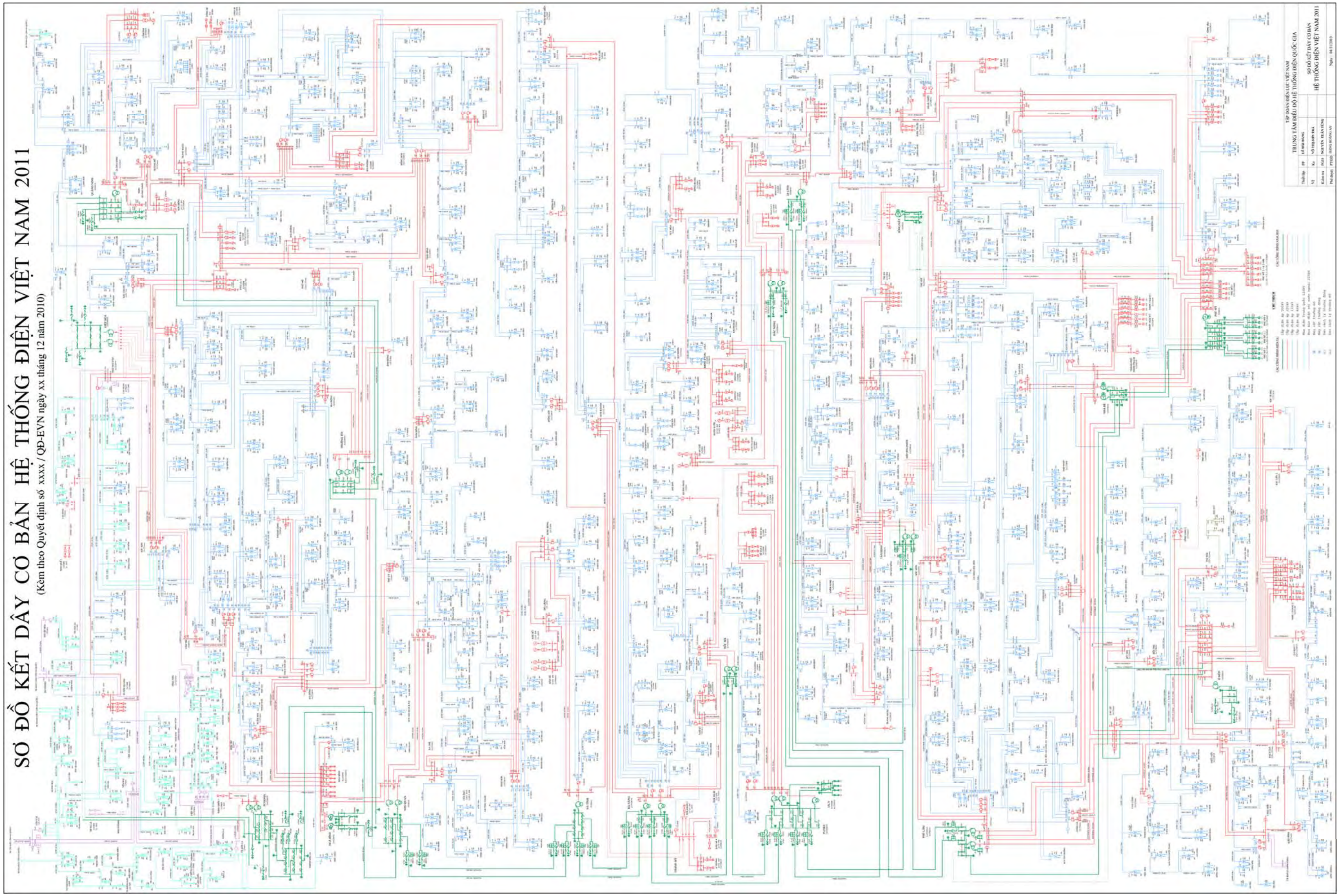


Fig. 4.5-3 National Power Grid Diagram of Vietnam (2011)

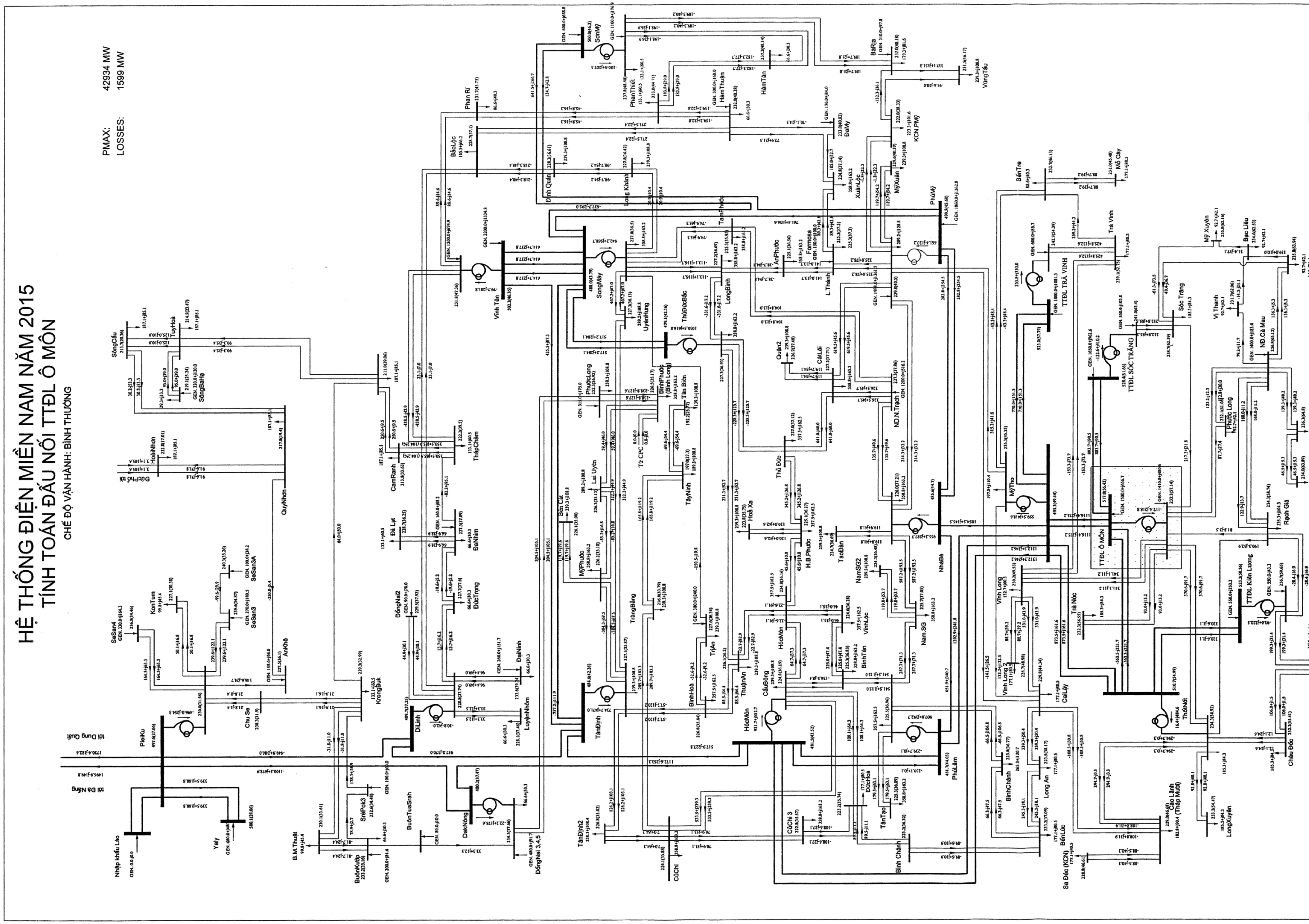


Fig. 4.5-4 Power Flow Diagram in the Southern Region (2015)

(3) Model of O Mon Power Complex

O Mon power complex will consist of four power plants, as shown in Table 4.5-2, O Mon 1 power plant and O Mon 2 power plant will be connected to the 220kV bus, and O Mon 3 power plant and O Mon 4 power plant will be connected to the 500kV bus.

O Mon 1 plant is a conventional type and has two generators, 1A and 1B. And the others are combined cycle types equipped with one set of generator model, respectively. The model of O Mon power complex for the power flow analysis and the system stability analysis is shown in Fig. 4.5-5.

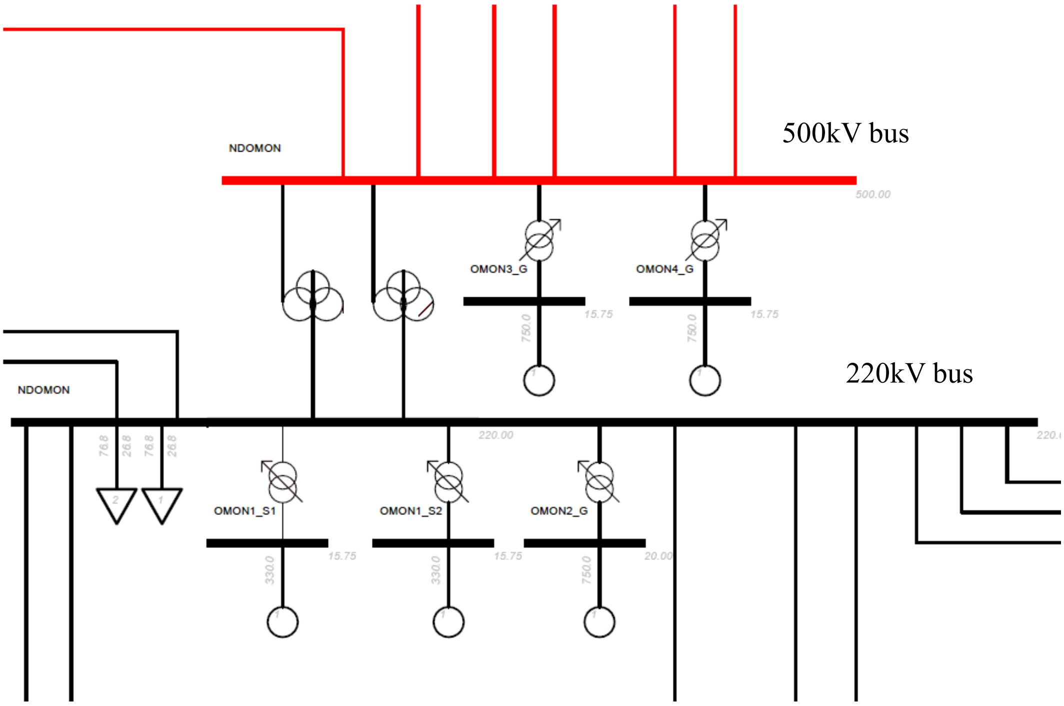


Fig. 4.5-5 Model of O Mon Power Complex

(4) Operation Criteria of Power System

As the operation criteria of power system, frequency and voltage standard are specified in Transmission System Regulation. The detailed criteria are shown in Table 4.5-15.

Table 4.5-15 Operation Criteria for Frequency and Voltage

		Normal operation	Emergency condition
Frequency[Hz]		49.8 - 50.2	49.5 – 50.5
Voltage	500kV	475 - 525	450 - 550
	220kV	209 - 242	198 - 242
	110kV	104 - 121	99 - 121

(5) Power Flow Analysis

The data for the power flow analysis supposing the system structure and demand in 2016 came to hand and the power flow analysis was carried out for 2016 when O Mon 3 power plant is in operation. PSS/E Version32 developed by of Siemens Power Technologies International was used for the power flow analysis.

1) Outline and changed part of acquisition data

The data which came to hand is of the 500 kV and 220 kV system of the Vietnam whole country, demand is 34,836 MW and loss is 733 MW. Regarding O Mon power complex, O Mon 1A, 1B, 2, 3 and 4 are operating, and those outputs are 330, 330, 750, 750 and 750 MW, respectively. As the data for the power flow analysis, the power output of O Mon 2, 3 and 4 was set as 860 MW, and a part for the increase was adjusted with the power output of the generators of the Northern region system.

2) Result of power flow analysis

As the result of the power flow analysis, the power flow diagram of the Southern 500 kV system is shown in Fig. 4.5-6.

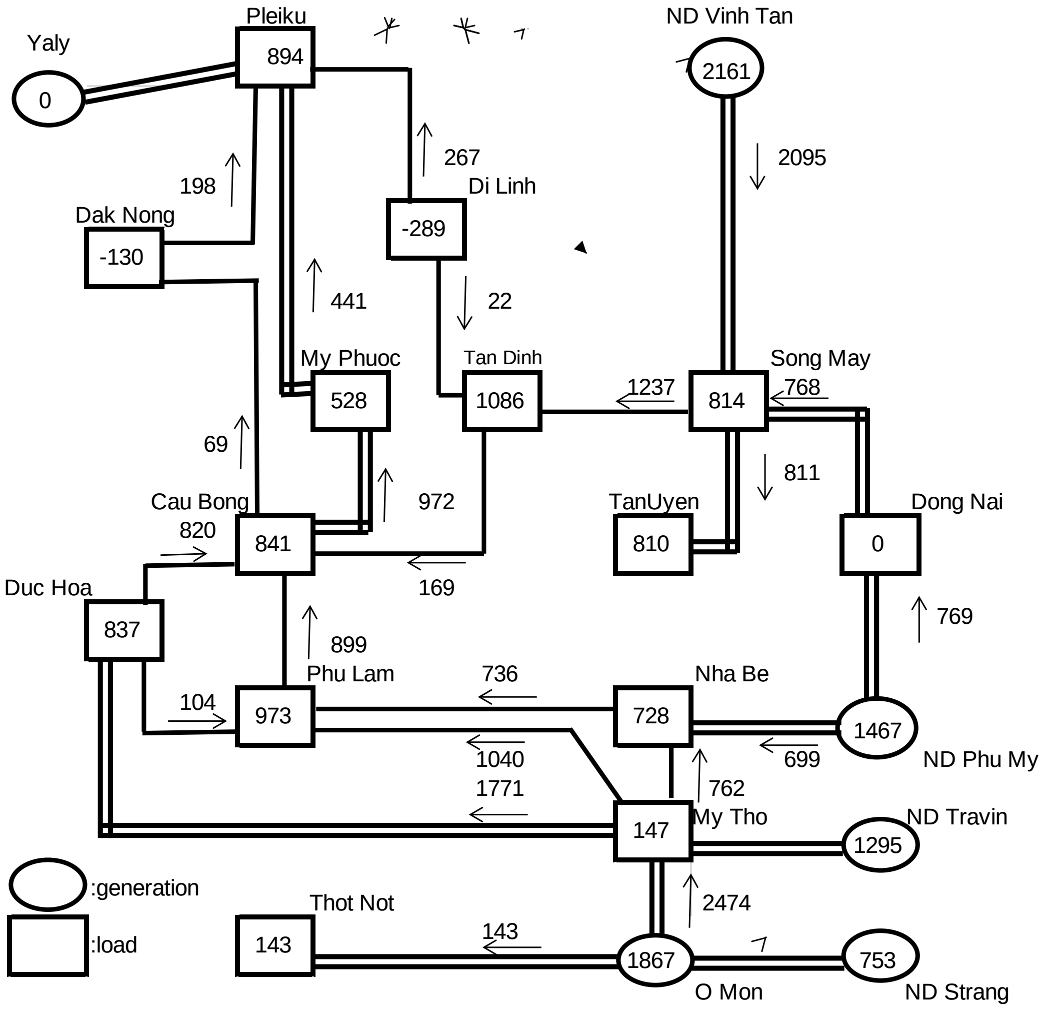


Fig. 4.5-6 Result of Power Plow Analysis

(6) System Stability Analysis

The generator and control system (AVR and Governor) data came to hand and the system stability analysis in the power flow profile shown in "(5) Power Flow Analysis" was carried out by using PSS/E Version32 developed by Siemens Power Technologies International.

1) Fault sequence

The fault sequence of the dynamic stability analysis was assumed as follows by the voltage class of the fault point.

a) 500kV
2sec : Occurring the fault (3 phases short circuit at 1 cct)
2.08sec : Opening of the faulted circuit
10sec : End of calculation

b) 220kV
2sec : Occurring the fault (3 phases short circuit at 1 cct)
2.10sec : Opening of the faulted circuit
10sec : End of calculation

2) Result of system stability analysis

Cases for the stability analysis are shown in Table 4.5-16. The cases have been some difference from the open circuit of the N-1 analysis in the F/S Report because the target power system is different. The view of that mainly targeting 2 circuits are connected to O Mon power complex is the same.

For each case, the graphs of the system frequency, the 500kV bus voltages and the phase angle, active power and reactive power of the generators in O Mon power complex, are shown in Fig. 4.5-9 to Fig. 4.5-14, and the result of the stability analysis is shown in Table 4.5-16.

Table 4.5-16 Cases of System Stability Analysis and Results

Case	Fault line	Voltage	Stability
1	O Mon – My Tho	500kV	Stable
2	O Mon – Thot Not	500kV	Stable
3	My Tho – Thot Not	500kV	Stable
4	O Mon – Thot Not	220kV	Stable
5	O Mon – Vinh Long	220kV	Stable
6	Interchange transformer at O Mon	500kV	Stable

*Fault point is located near the left-side bus in the above fault line

Based on the above results, it could be said that the connection of the power plants of O Mon power complex, O Mon 1A, 1B, 2, 3 and 4 to the power system would not affect the stability of the whole system provided that the power system in 2016 assumed in this Study is completed as planned and the demand estimate is correct.

The construction plan related to transmission lines and substations around O Mon power complex is shown in Table 4.5-17 extracting from Table 4.5-11 to 4.5-14. The existing system and the planed system in 2016 around O Mon power complex are shown in Fig.

4.5-7. In this figure, a solid line indicates an existing transmission line, and lines other than a solid line indicate the transmission line which is to be constructed (red lines: 500kV, blue lines: 220kV). The result of the power flow for the Southern region from Ho Chi Minh City of the 2016 system described in “(5) Power Flow Analysis” is shown in Fig. 4.5-8. In this figure, a dashed line indicates the transmission line which is to be constructed. Although a solid line indicates an existing transmission line, the substation to which each transmission line connects is not exactly in agreement with the situation of the present system. Figs. 4.5-7 and 4.5-8 show that the generated power of O Mon Power Complex is transmitted in the direction of Ho Chi Minh City through the 500kV transmission lines via My Tho substation. And they also show it is transmitted to the area of the north side of O Mon and in the direction of Ho Chi Minh City through the 220kV transmission lines via Thot Not substation. Therefore, it could be said that the following construction plans are important for O Mon power complex especially.

- Construction of My Tho 500kV substation
- Construction of 500kV transmission lines for connection with the direction of Ho Chi Minh City via My Tho substation (O Mon – My Tho, My Tho – Phu Lam, My Tho – Duc Hoa)[7]
- Formation of 2 circuits of the 220kV transmission lines of “Thot Not – Cao Lanh – Cai Lay”.

Table 4.5-17 Construction Plan around O Mon Power Complex (2011-2015) (PDP7)

No.	Name of substation	Number of transformer × MVA			Rating-MVA	Remark
500kV Substations						
1	Phu Lam	1	×	900	900	Replace
2	Duc Hoa	1	×	900	900	
3	Thot Not	1	×	600	600	
4	My Tho	1	×	900	900	
5	O Mon	1	×	450	450	Transformer No.2
6	Long Phu	1	×	450	450	Plan for DZ 500kV Long Phu – O Mon delayed compared to ND Long Phu 1, 2
7	Duyen Hai	1	×	450	450	
220kV Substations						
1	Long An	2	×	250	500	Replace of 2x125MVA
2	Ben Luc	1	×	250	250	
3	Duc Hoa	2	×	250	500	
4	Can Duoc	1	×	250	250	
5	Cao Lanh	1	×	125	125	Transformer No.2
6	KCN Sa Dec	1	×	250	250	
7	Chau Doc	2	×	250	500	Replace of 2 Transformers
8	Long Xuyen 2	1	×	250	250	
9	My Tho	1	×	250	250	Replace of Transformer No.1
10	Cai Lay	1	×	250	250	Replace
11	Vinh Long 2	1	×	250	250	Replace
12	Ben Tre	1	×	250	250	Replace
13	Thot Not	1	×	250	250	Replace

7 The construction plan of 500kV transmission lines, “O Mon – My Tho – Phu Lam”, does not exist in Table 4.5-17. These transmission lines are supposed to have been constructed in 2010, as shown in Table 4.5-6. However, it was only between O Mon – Cai Lay of which construction was completed when this Study was conducted.

No.	Name of substation	Number of transformer × MVA	Rating-MVA	Remark
14	Phung Hiep	2 × 125	250	
15	Tra Vinh	2 × 125	250	
16	Soc Trang	1 × 125	125	Transformer No.2
17	Ca Mau	1 × 250	250	Transformer No.2
18	Vinh Long	2 × 125+250	375	
19	Bac Lieu	1 × 125	125	

No.	Name of Project		No. of circuits × km
500kV Transmission Lines			
1	My Tho	- Duc Hoa	2 × 60
2	ND Duyen Hai	- My Tho	2 × 113
3	ND Long Phu	- O Mon	2 × 84
4	O Mon	- Thot Not	2 × 16
5	Branch to	My Tho	4 × 1
220kV Transmission Lines			
1	500kV Duc Hoa – Branch to Phu Lam – Long An		2 × 20
2	Ben Luc – Branch to Phu Lam – Long An		2 × 5
3	Can Duoc – Branch to Phu My – My Tho		4 × 7
4	500kV My Tho – Branch to Long An – Cai Lay		4 × 2
5	500kV My Tho – Branch to My Tho – Cai Lay		4 × 2
6	ND Duyen Hai	- Mo Cay	2 × 77
7	Mo Cay	- Ben Tre	2 × 20
8	My Tho	- Ben Tre	1 × 18
9	ND Duyen Hai	- Tra Vinh	2 × 45
10	Vinh Long	- Tra Vinh	2 × 62
11	KCN Sa Dec – Branch to Vinh Long 2 – O Mon		2 × 5
12	Cao Lanh	- Cai Lay	1 × 54
13	Cao Lanh	- Thot Not	1 × 27
14	ND Long Phu	- Soc Trang	4 × 25
15	ND Long Phu – Can Tho – Tra Noc		2 × 95
16	Phung Hiep – Branch to O Mon – Soc Trang		4 × 6
17	Long Xuyen 2 – Branch to Chau Doc – Thot Not		4 × 5
18	ND Ca Mau	- Ca Mau	1 × 5
19	Phu Lam	- Cai Lay	2 × 70

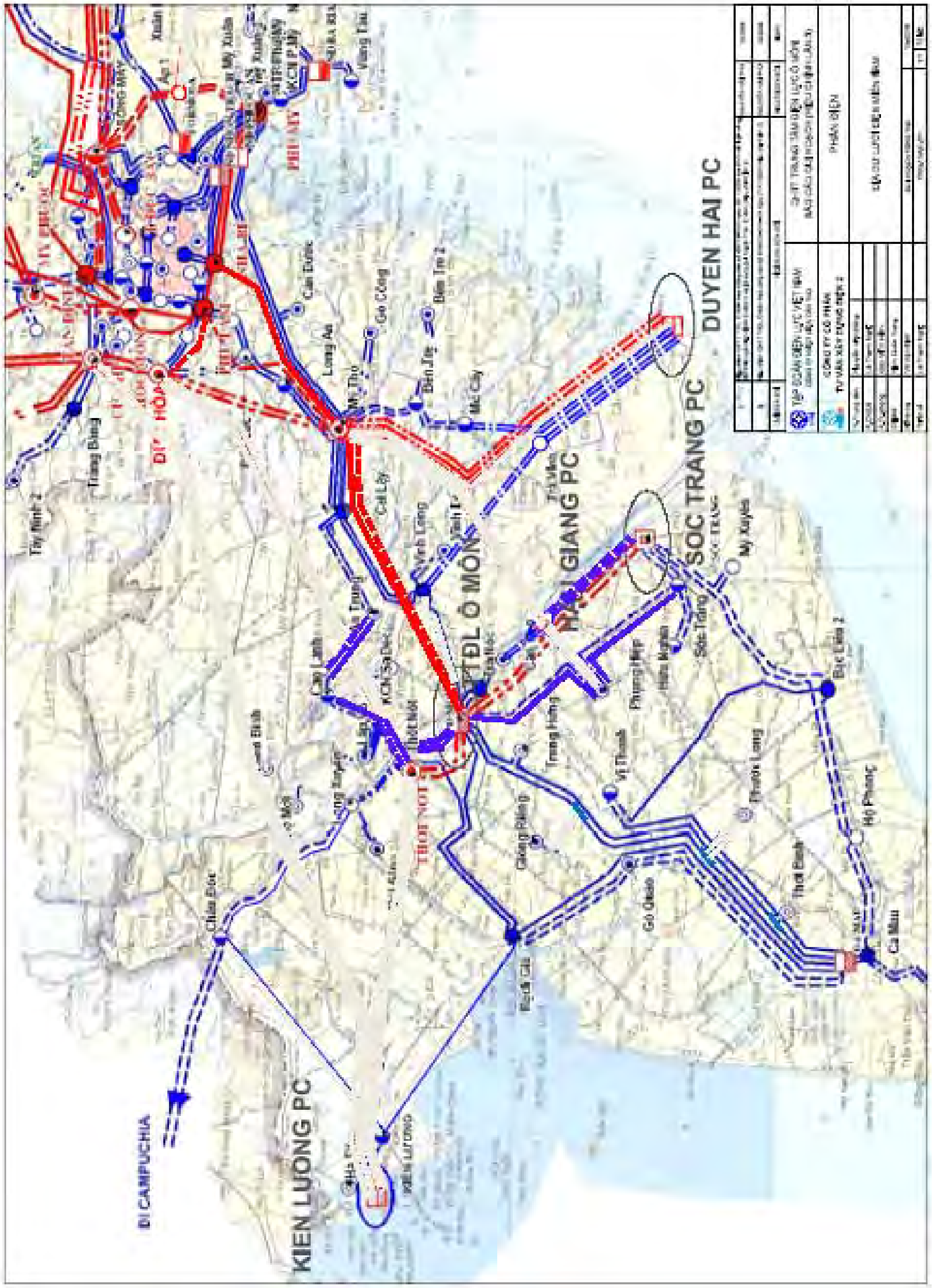


Fig. 4.5-7 Transmission System around O Mon Power Complex in 2016

Source: The Study team created from Fig. 4.5-2 and various data

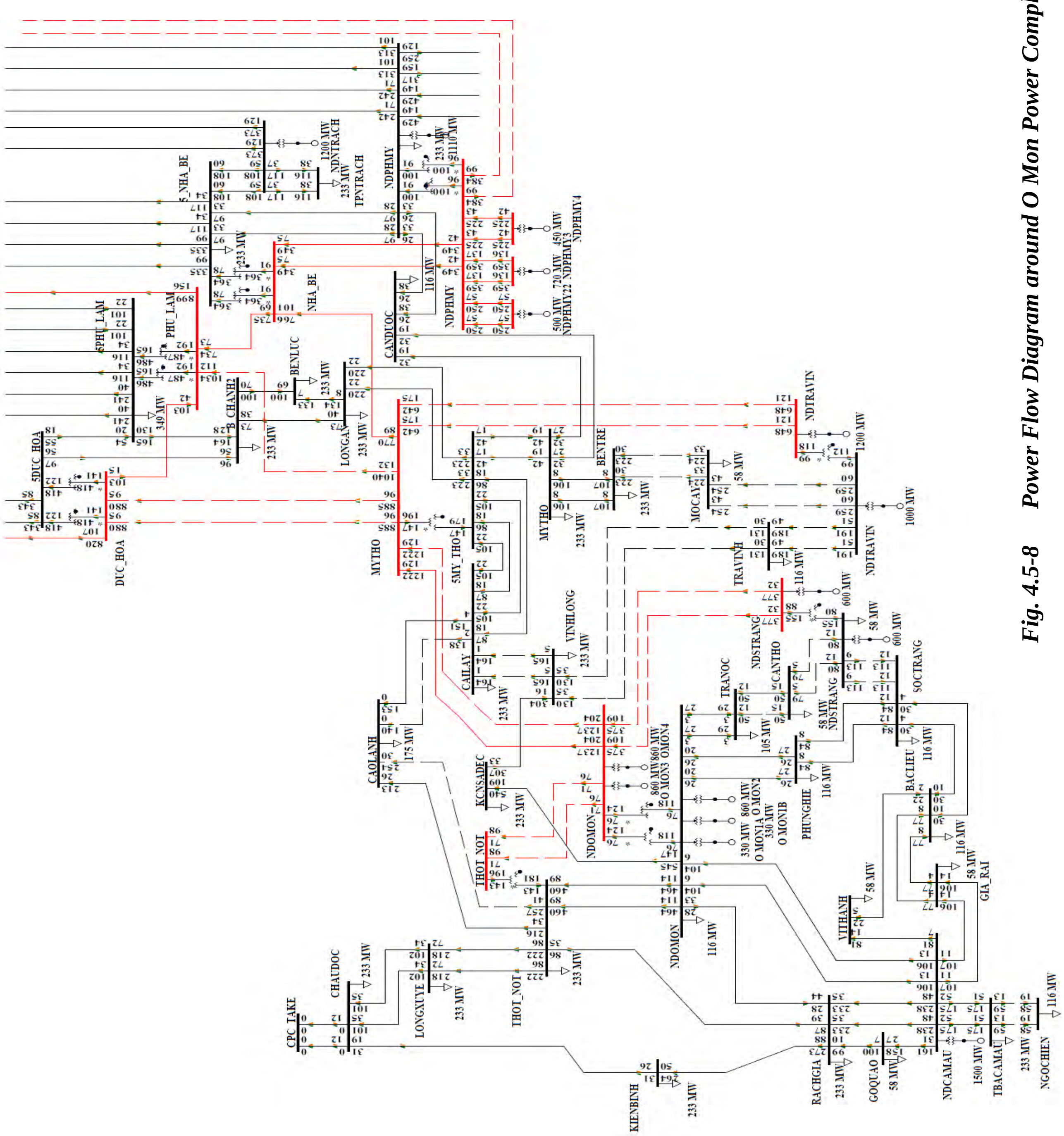


Fig. 4.5-8 Power Flow Diagram around O Mon Power Complex in 2016

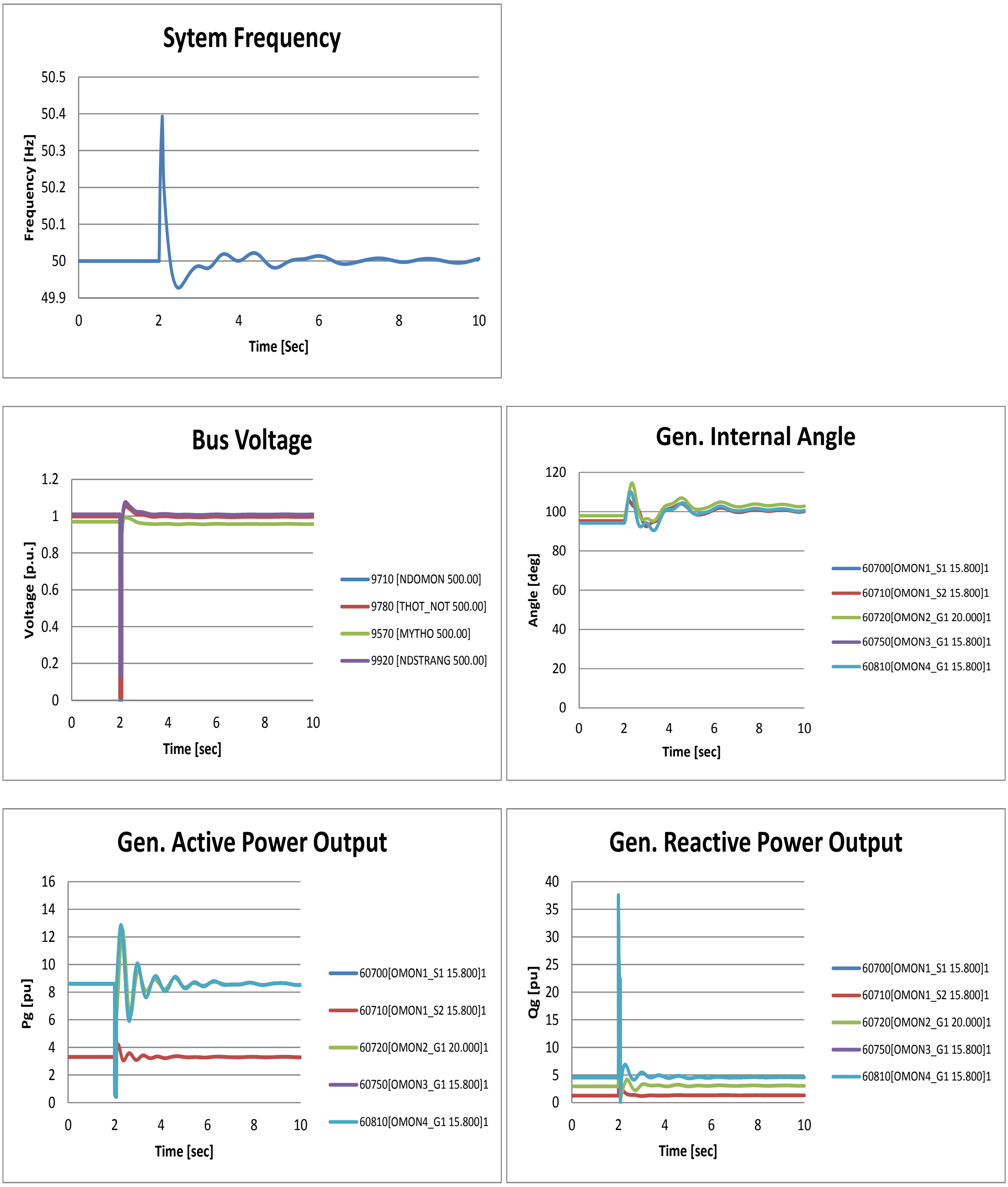


Fig. 4.5-9 Case 1 (O Mon – My Tho 500kV)

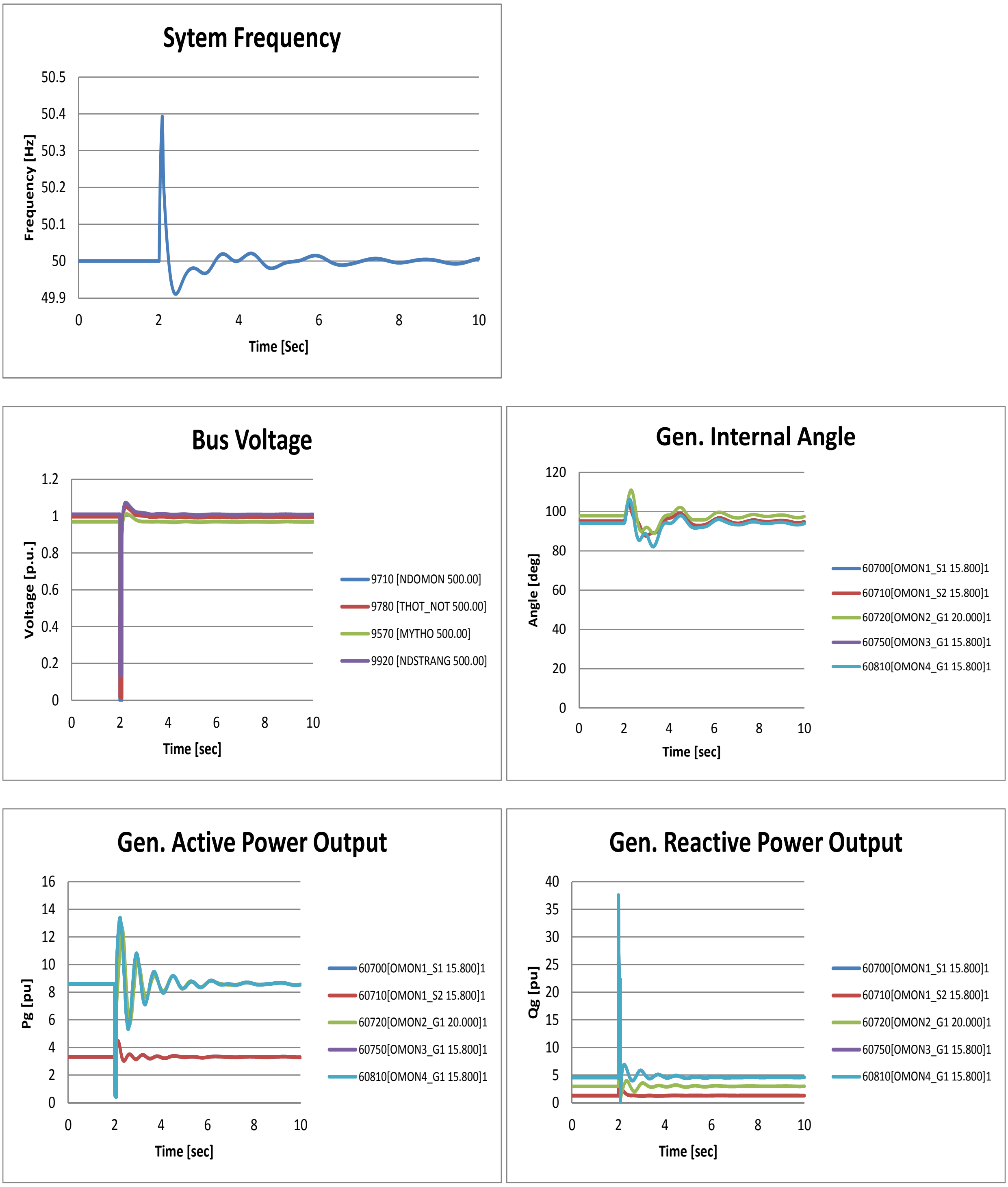


Fig. 4.5-10 Case 2 (O Mon – Thot Not 500kV)

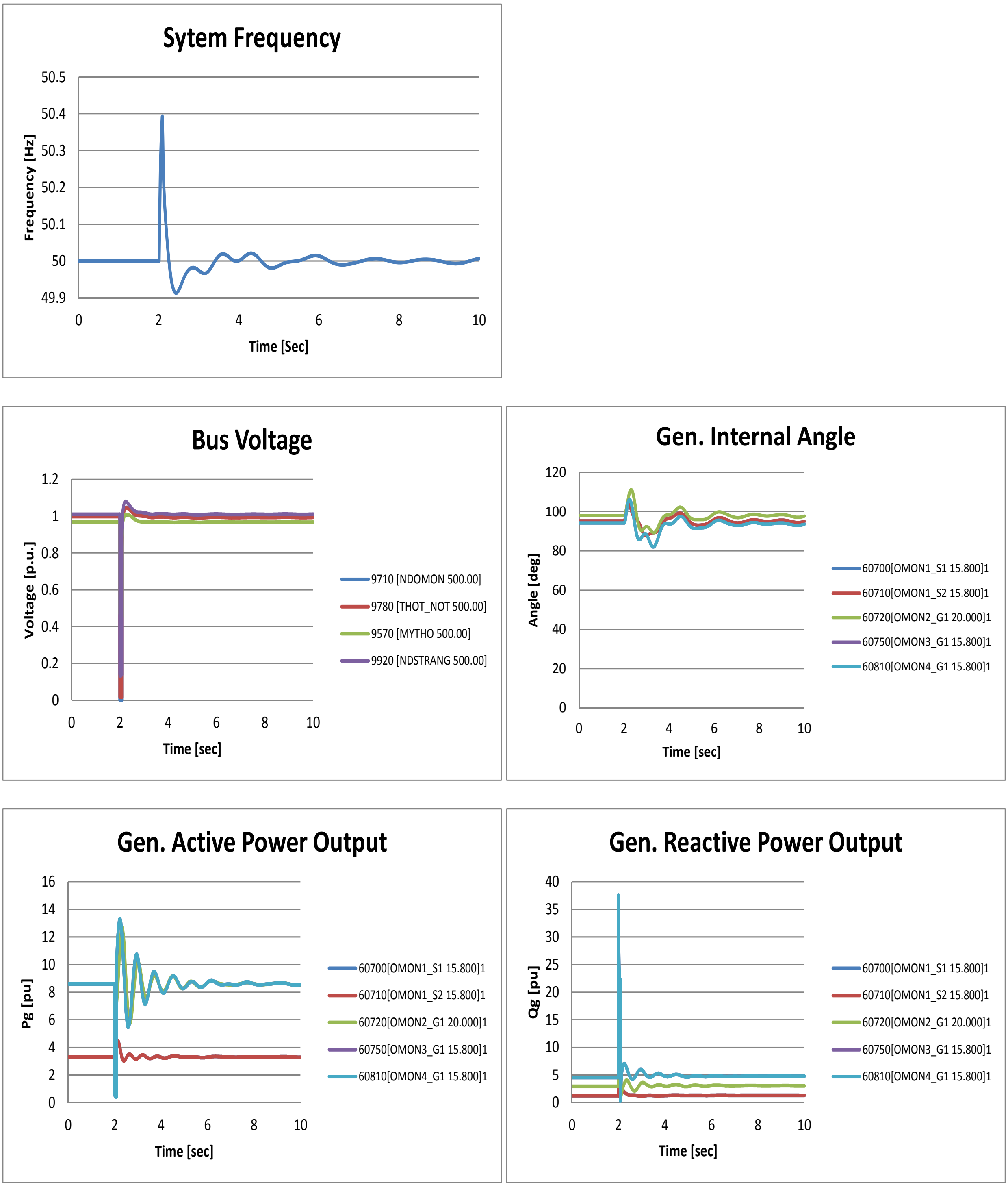


Fig. 4.5-11 Case 3 (O Mon – Soc Trang 500kV)

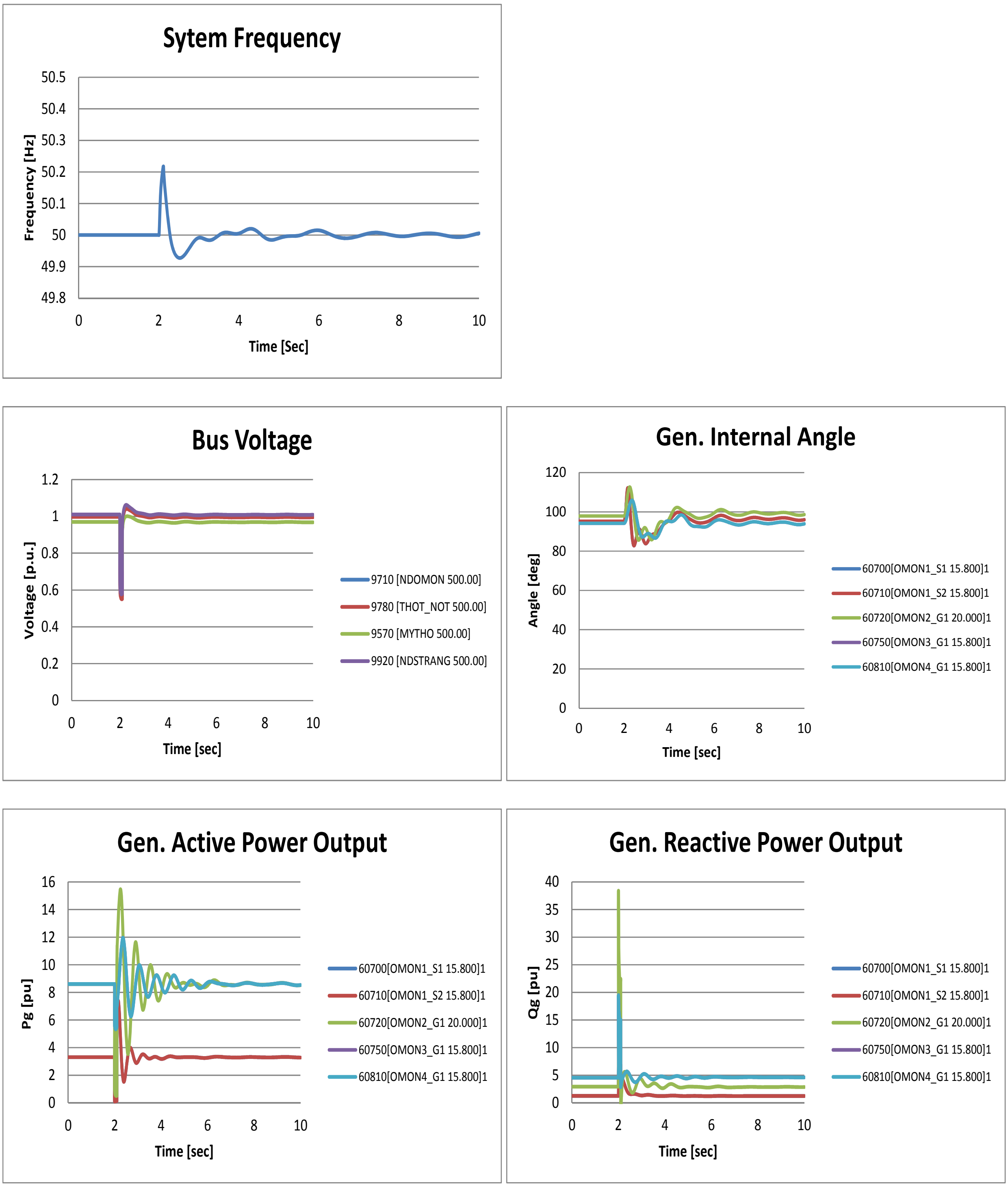


Fig. 4.5-12 Case 4 (O Mon – Thot Not 220kV)

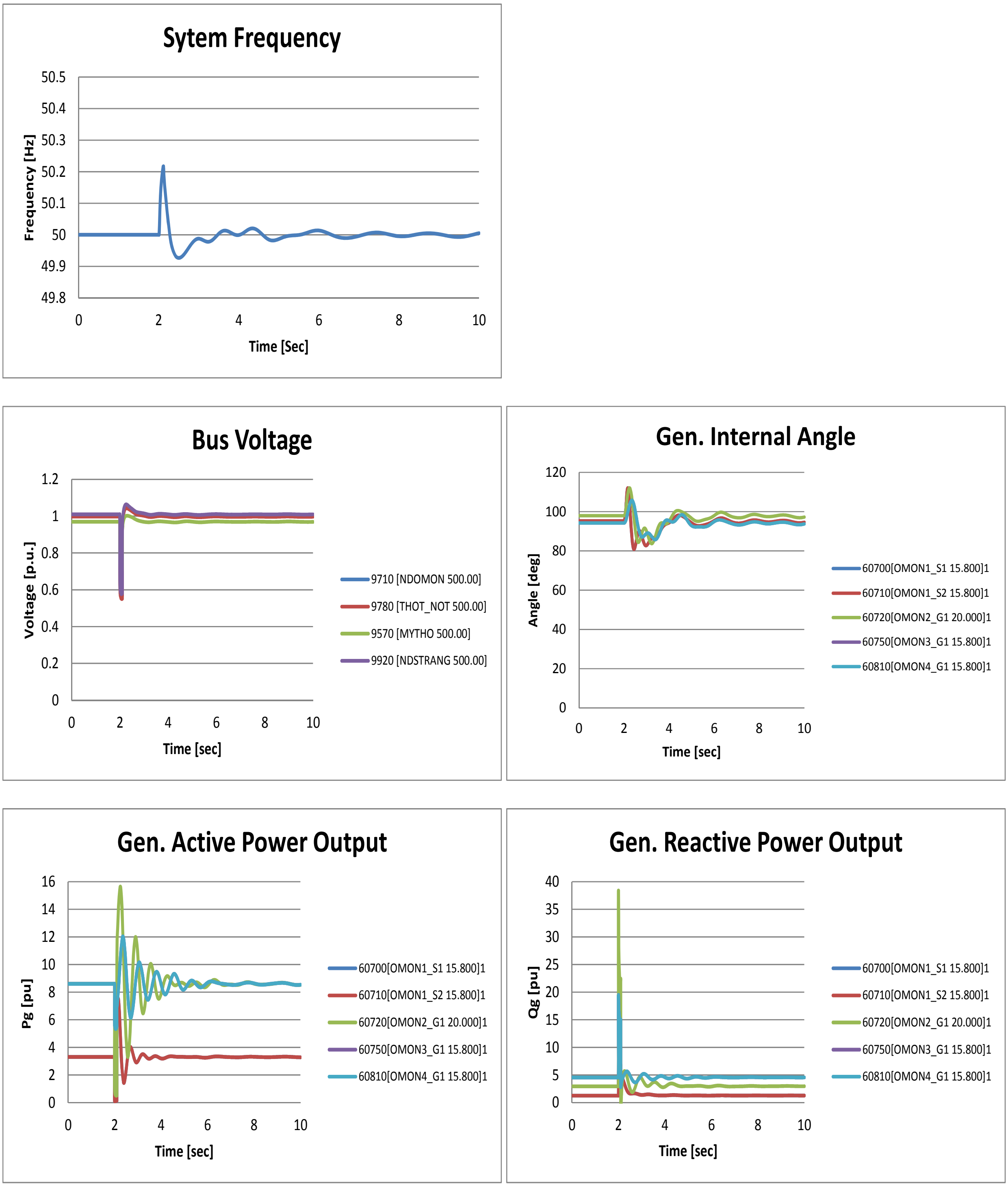


Fig. 4.5-13 Case 5 (O Mon – Ca Mau 220kV)

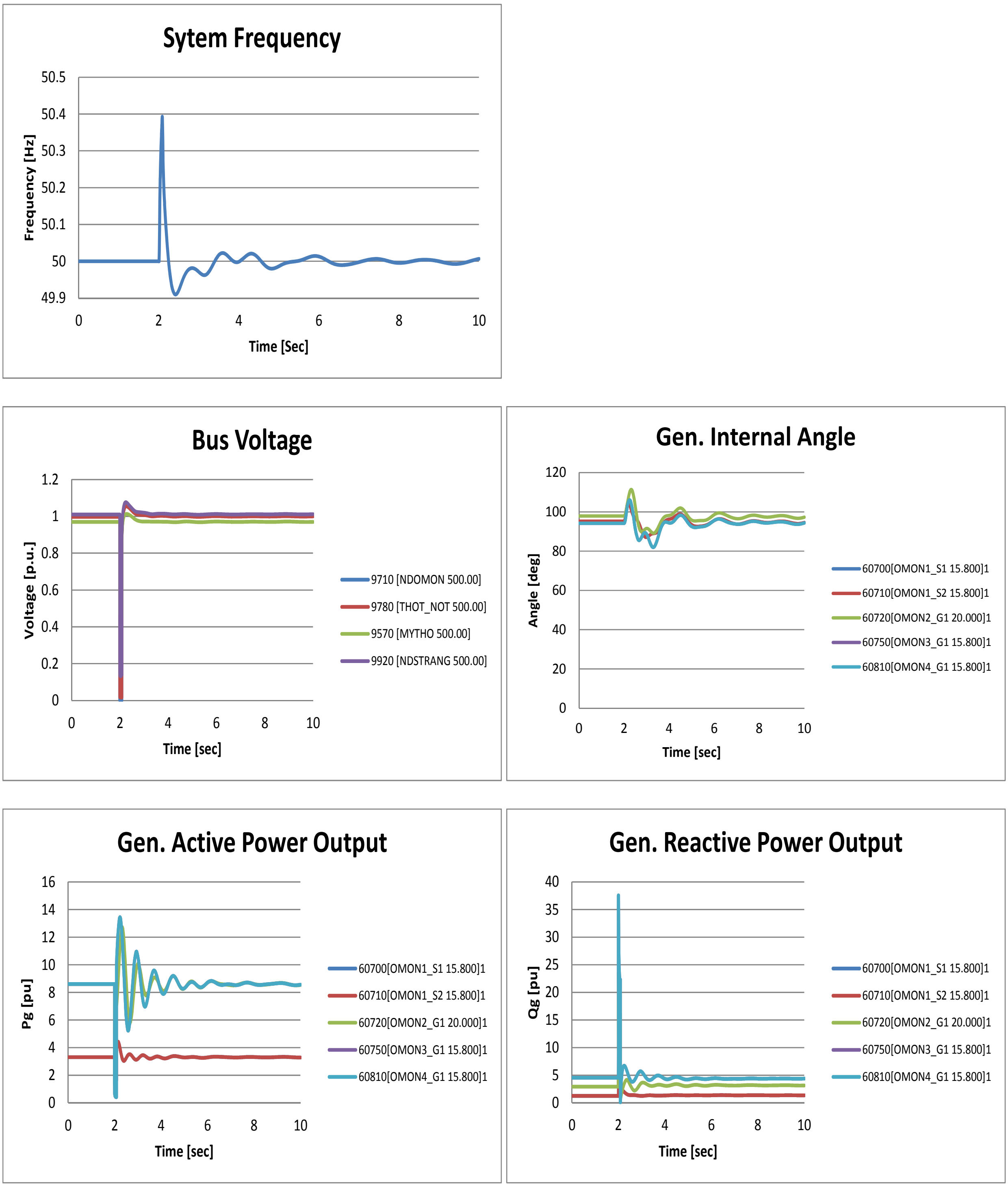


Fig. 4.5-14 Case 6 (Interchange Transformer at O Mon 500kV)

4.6 ARCHITECTURAL AND CIVIL FACILITY

4.6.1 Outline of Facility

(1) Facility Plan of O Mon 3 Thermal Power Plant

The main architectural and civil facilities for O Mon 3 power plant are shown as follows.

1) Turbine and generator buildings
2) Administration Building
3) Warehouse and other buildings
4) CW intake channel and discharge channel (Common facilities between O Mon 3 and 4 out of intake structure and discharge channel are constructed in the O Mon 4 project.)
5) Foundation Works
6) Road Works

(2) Architectural and Civil Works in O Mon 1A Power Plant

The construction works for the O Mon 1A power plant were implemented from January, 2006 to February, 2009, for 38 months. The major works are summarized below.

Table 4.6-1 Major Architectural and Civil Works in O Mon 1A Power Plant

No.	Name	Quantity	Length (m)	Width (m)	Height (m)
1	Steam Turbine Building	1	70	33	29
2	Center Control Building	1	53	24	24
3	Administration Building	1	45	19	19
4	Stuck	1	Dia D=16-13 m		140
5	Gypsum Storage Tank		73	27	33
6	Warehouse	1	64	32	10
7	Pump Pit		45	24	13
8	CW Discharge Culvert	1	300	5	5
9	CW Discharge Channel	1	800	34	8.6
10	CW Intake Tower (in the River)	1	Dia D = 20m		10.5
11	CW Intake Pipe (in the River)	1	Dia D = 3.6m		120
12	Fuel Oil Port	1	For 10,000 DWT		
13	River Bank Protection	1			800
14	Foundation for Boiler, Electric Precipitator, Flue Gas Desulfurization Device, etc.	1			

Note) DWT means Dead Weight Tonnage

A main feature for the construction works in O Mon 1A power plant is that the cement deep mixing method to build foundation for the pump pits, discharge channel (culvert and open channel) and river revetment was applied to improve soft ground in the Mekong delta and ensure the required safety. Although the construction materials for the cement deep mixing method and few appurtenant facilities were procured in Vietnam, main facilities and construction management system were from Japan. The foundation improvement works by the cement deep mixing method were completed within the planned schedule for 7 months.

The intake tower (Dia. 20m, Height 15.5m, total weight 300t) and conduit (Dia. 4.6m, Length

120m) were planned to be installed as intake structures in the Hau River. The diving works were required for this work, therefore the construction works were implemented immediately before the coming rainy season. It was planned to utilize the floating crane with hoisting capacity of 400t, however it was difficult to procure it in Vietnam. Therefore, the intake tower was divided into two parts and installed with the floating crane with hoisting capacity of 150t.

Source: Civil and Architectural Works of O Mon Power Plant in Vietnam, Electric Power Civil Engineering, Sep., 2009

4.6.2 Natural and Design Conditions

(1) Topography and Geology

The site of O Mon Power Complex is 18 km away from the center of Can Tho City in the direction of south west. The coordination of the plant is 10°07’07”N and 105°40’00”E.

The north-east boundary of the power complex faces the Hau River whose width is about 900m and maximum depth is 22m at the power complex and the plant site is about 90km far from the river mouth. In addition, Vau canal and Chanh canal run in south west and south east of the power complex, respectively. Both canals have a river width of about 50m and depth of about 6 to 7 m.

O Mon Power Complex is located in the downstream area of the Mekong River (Mekong Delta), therefore the plant site is quite flat and its elevation is about EL. 0.3 ~ 1.5m. Land use around the power complex is mainly for paddy field and residences are found along the river and canals.

The geology of Vietnam is generally classified into two as the boundary of 16°N, and many major faults have been found and geological structures are complex in its northern part.

O Mon thermal power plant is located on the broad Mekong delta formed by deposition of soft clays in the southern part of Vietnam. The surface geology of the Mekong delta is alluvium deposit in Cainozoic era. These geological structures belong to Dalat Strungtreng which is the same as those in most areas of Cambodia.

PEEC2 conducted the geological survey at site in 2009. The main items of the geological survey were drilling survey with core sampling, penetration test, grain size analysis, physical characteristics test, direct shear test, compressive test and so on. Total number of drilling surveys was 24.

Based on the survey results, the soil layers are composed of clay which is main, clayey sand, clayey mud and sand, the layers are generally classified 6 ones as shown in Table 4.6-3. These layers accumulate horizontally, Layer 6 is found below EL-70m. According to Table 4.6-3, Layer 1 and 2 and minimum N values from Layer 1 to Layer 5 are not expected as a supporting layer of power plant facilities

Generally, N values of 30 or more for sandy soil and those of 20 or more for clay soil are expected as a supporting layer.

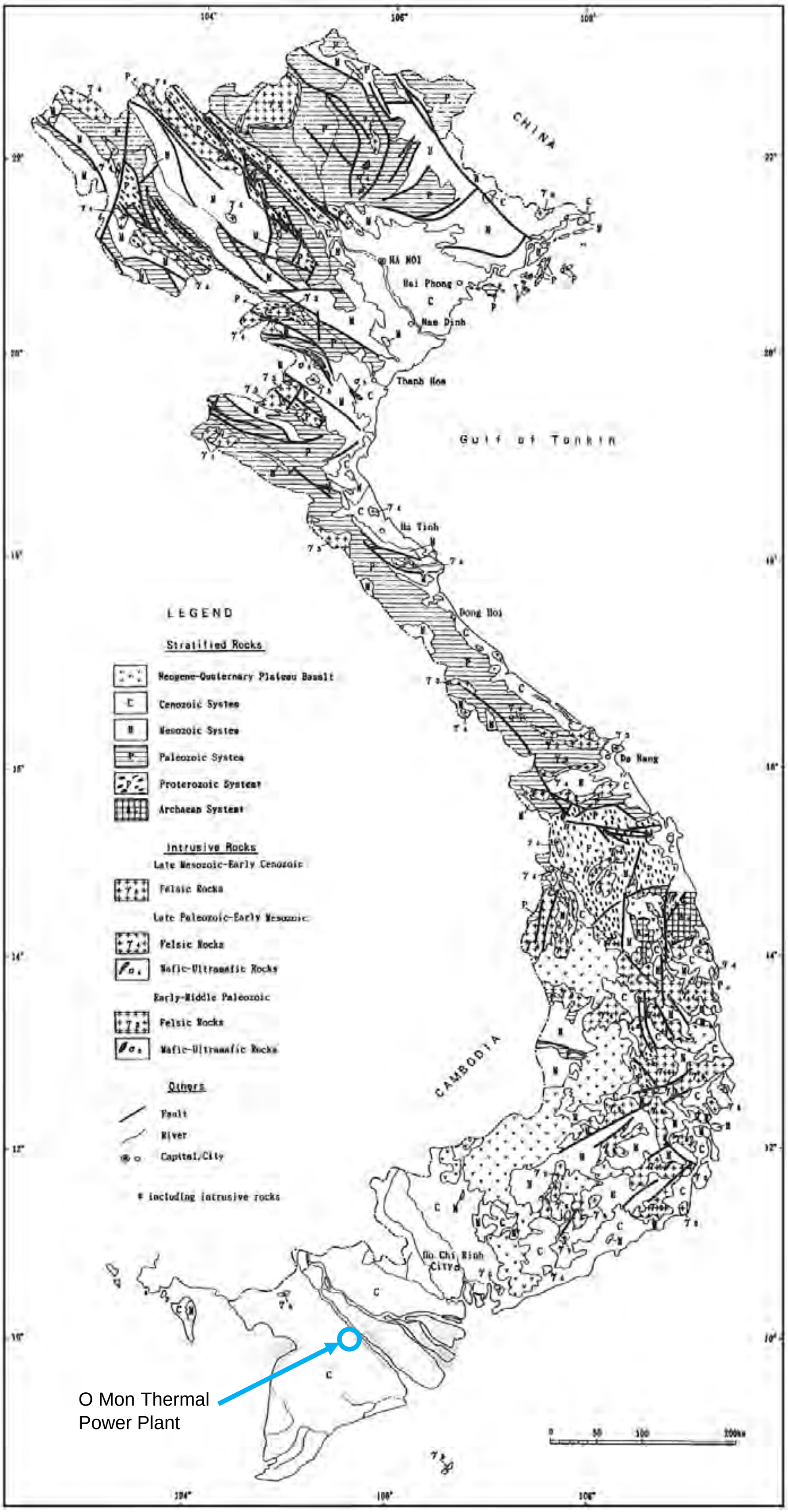


Fig. 4.6-1 Geological Map of Vietnam

Source: Resources Development Environment Research in Vietnam, Japan Oil, Gas and Metals National Corporation

Table 4.6-2 Geological Survey for O Mon 3 Power Plant

No.	Location	Depth (m)	Test Items: In-situ Test: Core Sampling	Standard Penetration Test	Cone Penetration Test	Physical Test: Grain Size Distribution	Physical Property Test	Mechanical Test: Direct Share Test	Unconfined Stress Test	Triaxial Test	Consoli-dation Test
BH- 01	GT System	100	☑	☑							
BH- 02	GT System	73	☑	☑							
BH- 03	Water Treatment Facility	72	☑	☑							
BH- 04	Fuel Tank	71	☑	☑							
BH- 05	Intake (Old)	70	☑	☑							
BH- 06	Road between No.2 and 3	20	☑	☑							
BH- 07	Discharge Channel (Culvert)	20	☑	☑							
BH- 08	Discharge Channel (Culvert)	20	☑	☑							
BH- 09	Discharge Channel (Open)	20	☑	☑							
BH- 10	Discharge Channel (Open)	20	☑	☑							
BH- 11	Discharge Channel (Open)	20	☑	☑							
BH- 12	Discharge Channel (Open)	20	☑	☑							
OM- 01	Intake (Old) In the Hau River	50	☑	☑		☑	☑	☑	☑	☑	☑
OM- 02	Intake (Old)	50	☑	☑		☑	☑	☑	☑	☑	☑
OM- 03	GT System	100	☑	☑		☑	☑	☑	☑	☑	☑
OM- 04	GT System	100	☑	☑		☑	☑	☑	☑	☑	☑
OM- 05	GT System	100	☑	☑		☑	☑	☑	☑	☑	☑
OM- 06	Discharge Channel (Culvert)	50	☑	☑		☑	☑	☑	☑	☑	☑
OM- 07	Discharge Channel (Open)	50	☑	☑		☑	☑	☑	☑	☑	☑
OM- 08	Discharge Channel (Open)	50	☑	☑		☑	☑	☑	☑	☑	☑
C- 01	Fuel Tank	50	☑		☑						
C- 02	GT System	60	☑		☑						
C- 03	GT System	60	☑		☑						
C- 04	Discharge Channel (Culvert)	50	☑		☑						

Source: NHA MAY DIEN CTHH OMON III、PECC 2, 2009

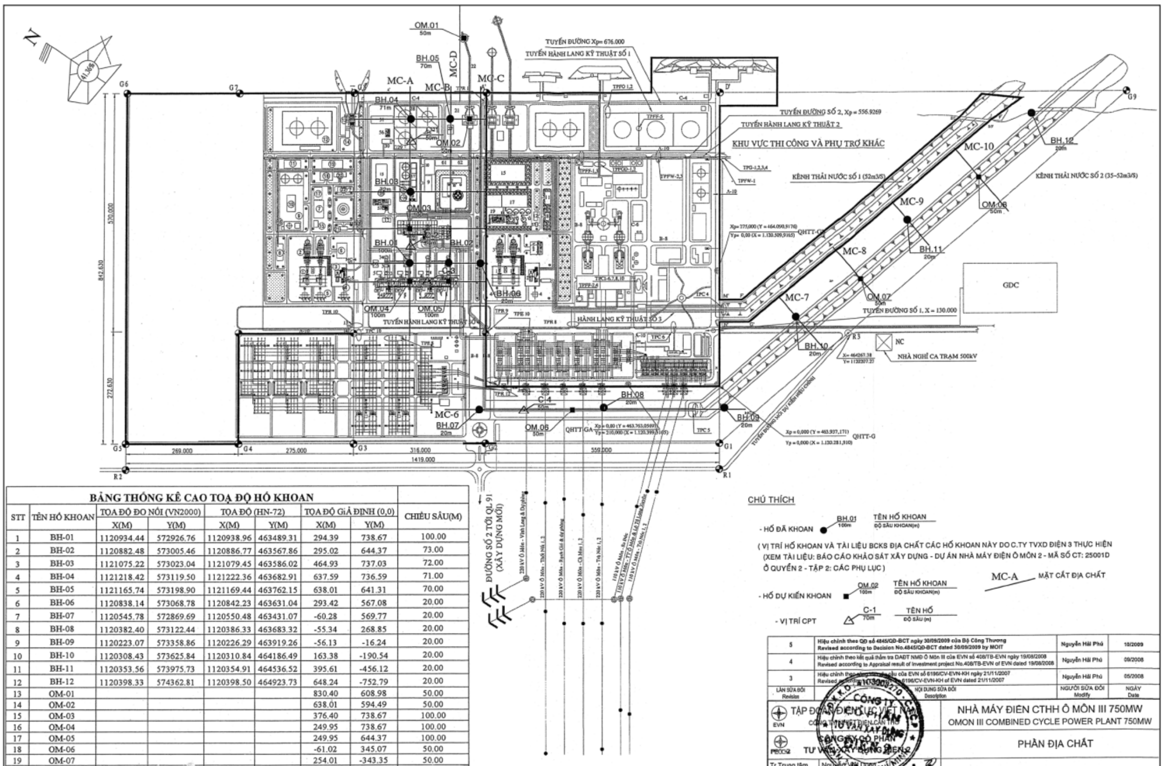


Fig. 4.6-2 Location of Drilling Survey

Source: NHA MAY DIEN CTHH OMON III, PECC 2, 2009

Table 4.6-3 Soil Layer at O Mon Power Complex

Layer	Category	Thickness	Material	Color	N-Value	Remarks
1	CH	2.5m (1.3-5.6m)	Clay	Yellow-spotted Gray-brown	5 (2-10)	Surface
2	CL/CH	10.4m (3.5-13.7m)	Liquid Clay	Dark-gray	0	Physico-mechanical properties are low.
2a	CL	2m (0.5-5.5m)	Clayed sand mud	Dark-gray	0	Liquidity, Mixed with shell and organic impurities
2b	CH	1.1m (0.5-6.0m)	Clay mud	-	0	Distributed under or above Layer 2
3	CL	10.3m (3-37m)	Clay	Gray-brown	16 (3-37)	Medium dense, mixing with 5% hard lacerit curdles
3a	CL	2.1m (0.7-5m)	Clayed loam	Yellowish brown	18 (13-28)	Mixed with thin lenses of fine sand
4	SP/SM	10.4m (4.5-15m)	Fine sand	Yellowish brown	17 (9-58)	Medium dense to dense
4a	CL/CH	2m (0.5-5m)	Clay	Greenish Brown (Yellowish and Red brown Spot)	17 (11-33)	Among and below layer 4, 5% organic impurities
5	CL/CH	29.9m (23-34.2m)	Loam	Purple brown (Black gray spot)	17 (11-48)	Semi-hard to hard
5a	CL/ML	> 26m	Loam dust	Light gray	19 (16-28)	Distributed in Layer 5
6	SP/SC	10.4m (4.5-15m)	Fine sand	Yellowish grey	60 (32-103)	Dense to very dense
6a	CL/ML	1.4m (0.5-2.5m)	Loam dust	Black spotted Purple gray	58 (54-61)	There are thin lenses in Layer 6.

Source: O Mon Combined Cycle Power Project Feasibility Study Report, Sep., 2010, PECC2, P4-5 -

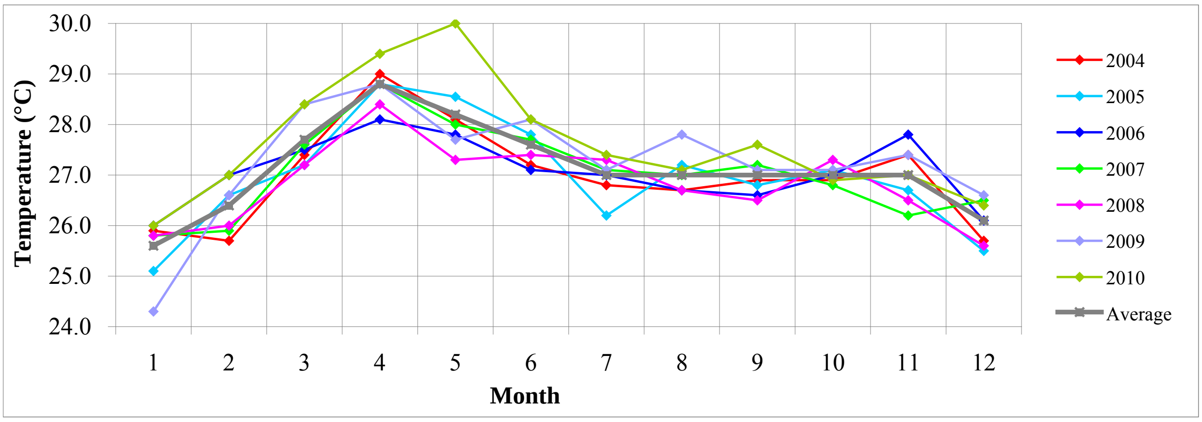
(2) Meteorology

The O Mon Thermal Power Plant site belongs to a tropical monsoon climate region in which annual air temperature change is small and rainy season and dry season are clearly distinguished. The dry season starts from November and the rainy season does from May.

1) Ambient temperature

Monthly average ambient temperature at Can Tho station is shown in Fig.4.6-3. According the monthly average temperature in the figure, the air temperature varies by 3 to 4°C through a year and air temperatures in December and January are low and those in April and May are high.

Name of Station:	***Can Tho***	
Location:	10°02' N	105°45' E
Altitude:	EL.2m	



(in °C)

Season		Dry Season				Rainy Season						Dry Season		
Month		1	2	3	4	5	6	7	8	9	10	11	12	Average
Year	2004	25.9	25.7	27.4	29.0	28.1	27.2	26.8	26.7	26.9	26.9	27.4	25.7	27.0
	2005	25.1	26.6	27.2	28.8	28.6	27.8	26.2	27.2	26.8	27.1	26.7	25.5	27.0
	2006	26.0	27.0	27.5	28.1	27.8	27.1	27.0	26.7	26.6	27.0	27.8	26.1	27.1
	2007	25.8	25.9	27.6	28.8	28.0	27.7	27.1	27.0	27.2	26.8	26.2	26.5	27.1
	2008	25.8	26.0	27.2	28.4	27.3	27.4	27.3	26.7	26.5	27.3	26.5	25.6	26.8
	2009	24.3	26.6	28.4	28.8	27.7	28.1	27.1	27.8	27.1	27.1	27.4	26.6	27.3
	2010	26.0	27.0	28.4	29.4	30.0	28.1	27.4	27.1	27.6	26.9	27.0	26.4	27.6
Average		25.6	26.4	27.7	28.8	28.2	27.6	27.0	27.0	27.0	27.0	27.0	26.1	27.1

Fig. 4.6-3 Monthly Average Temperature

Source: Statistical Annual of Can Tho City

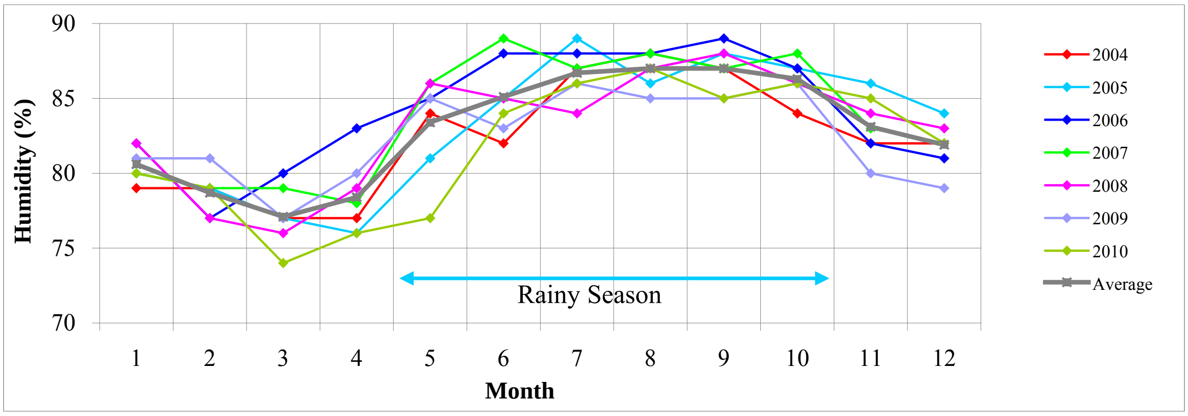
The historical observed data in ambient temperature at Can Tho station are summarized below.

- Yearly averaged temperature : 27.1°C (25.6 - 28.8°C)
- Maximum Temperature : 40°C
- Minimum Temperature : 14.8°C

2) Humidity

Humidity at O Mon Thermal Power Plant is high through a year and not less than 75%. Monthly average relative humidity from June to October during rainy season is high and exceeds 85%.

Name of Station:	***Can Tho***	
Location:	10°02' N	105°45' E
Altitude:	EL.2m	



(in %)

Season		Dry Season				Rainy Season						Dry Season		
Month		1	2	3	4	5	6	7	8	9	10	11	12	Average
Year	2004	79	79	77	77	84	82	87	88	87	84	82	82	82.3
	2005	80	79	77	76	81	85	89	86	88	87	86	84	83.2
	2006	82	77	80	83	85	88	88	88	89	87	82	81	84.2
	2007	80	79	79	78	86	89	87	88	87	88	83	82	83.8
	2008	82	77	76	79	86	85	84	87	88	86	84	83	83.1
	2009	81	81	77	80	85	83	86	85	85	86	80	79	82.3
	2010	80	79	74	76	77	84	86	87	85	86	85	82	81.8
Average		80.6	78.7	77.1	78.4	83.4	85.1	86.7	87.0	87.0	86.3	83.1	81.9	83.0

Fig. 4.6-4 Average Humidity

Source 1: Statistical Annual of Can Tho City, 2006
Source 2: Can Tho Statistic Bureau, 2011

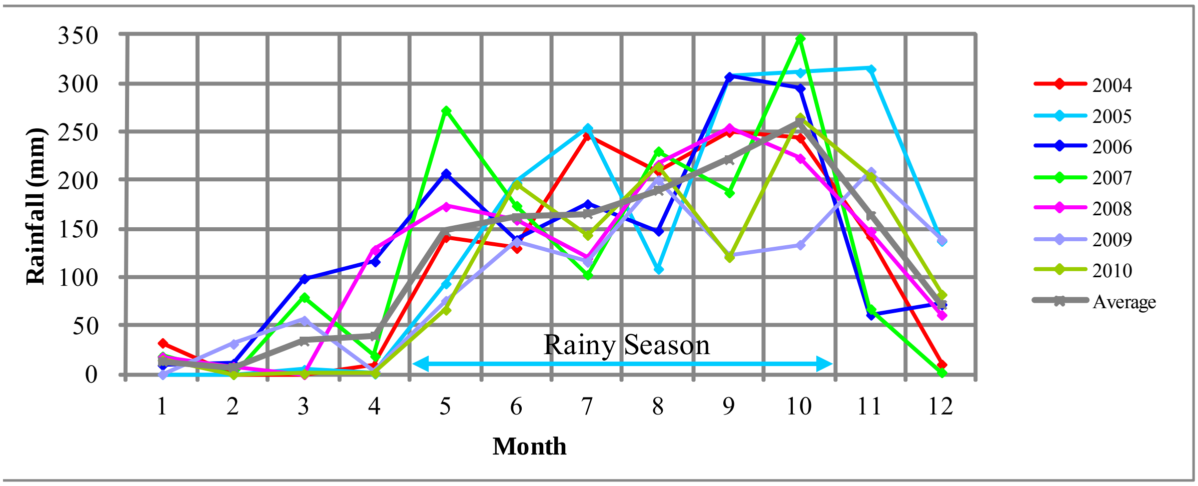
3) Rainfall

Monthly rainfall at Can Tho station is shown in Fig. 4.6-5.

Annual rainfall at Can Tho station reaches about 1,500 mm and more than 80% of the rainfall is observed in rainy season.

- Maximum Annual Rainfall : 1,878 mm
- Minimum Annual Rainfall : 1,257 mm
- Average Rainfall Days : 130 days/year
- Maximum Rainfall Days : 172 days/year
- Minimum Rainfall Days : 111 days/year
- Maximum Monthly Rainfall : 439 mm/month (August, 1988)
- Maximum Daily Rainfall : 198 mm/day
- Maximum Hourly Rainfall : 79.3 mm/hour

Name of Station:	***Can Tho***	
Location:	10°02' N	105°45' E
Altitude:	EL.2m	



(in mm)

Season		Dry Season				Rainy Season						Dry Season		
Month		1	2	3	4	5	6	7	8	9	10	11	12	Total
Year	2004	32.5	0.0	0.0	8.3	141.5	130.3	246.8	209.8	250.1	244.2	141.9	10.3	1,415.7
	2005	0.0	0.0	4.8	0.5	93.7	197.8	254.6	108.8	307.4	311.5	315.1	137.7	1,731.9
	2006	9.5	11.1	98.8	116.3	207.6	138.7	175.8	148.1	307.3	295.4	61.4	72.2	1,642.2
	2007	18.6	0.0	79.7	18.7	272.6	174.1	102.8	230.4	187.6	347.2	67.4	2.0	1,501.1
	2008	17.8	8.0	0.0	128.4	173.2	159.5	119.8	216.5	254.5	223.1	147.6	61.3	1,509.7
	2009	0.0	31.3	55.6	2.9	76.0	136.6	116.0	200.6	122.5	133.8	209.5	138.8	1,223.6
	2010	14.7	0.0	0.6	1.1	66.5	195.9	143.8	214.5	120.9	265.4	204.0	82.4	1,309.8
Average		13.3	7.2	34.2	39.5	147.3	161.8	165.7	189.8	221.5	260.1	163.8	72.1	1,476.3
Percentage		0.9	0.5	2.3	2.7	10.0	11.0	11.2	12.9	15.0	17.6	11.1	4.9	100

Fig. 4.6-5 Monthly Rainfall

Source 1: Statistical Annual of Can Tho City, 2006
Source 2: Can Tho Statistic Bureau, 2011

4) Wind Speed

Wind observed around O Mon Power Complex is affected by the seasonal wind. The wind from June to October is from southwest, which cause much amount of rainfall, the wind from November to February is from Northeast, and the wind from March to May is from southeast. Annual average wind speed is about 3.5 m/s and the wind speed varies seasonally from 3.2 to 4.0m/s.

The wind direction at O Mon Power Complex changes remarkably because the site faces the big river and is topographically flat.

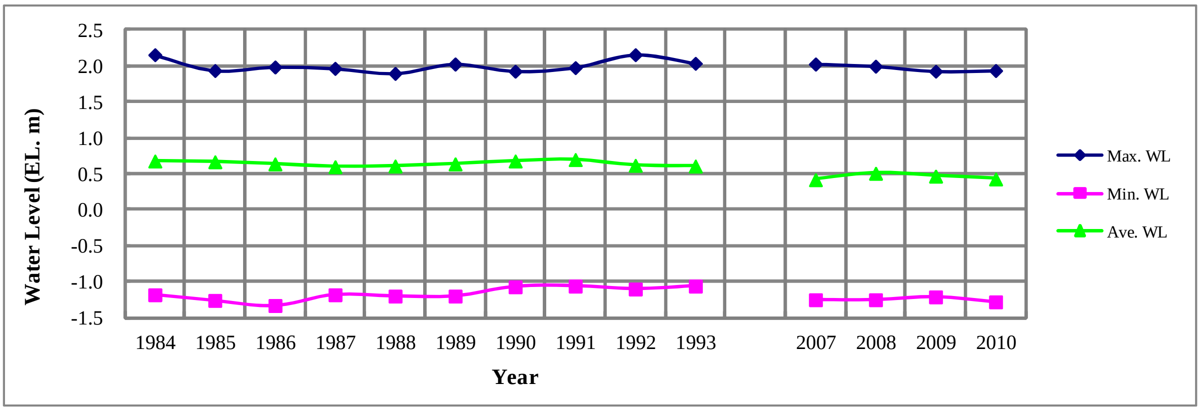
5) Water level

The Mekong River branches at the most downstream area, one is the Mekong main river and the other is the Hau River. The O Mon Power Complex site along the Hau River is located at about 90 km upstream from the river mouth of the Hau River. The river discharge of the Hau River is quite large and its annual average discharge reaches about 2,440m^3/s.

The water level from March to June is lower and that from September to October is higher. The historical highest water level at the Can Tho water level observation station reached at EL.2.16 m on October 26, 1984 and the historical lowest water level reached at EL.-1.33 m on May 18, 1986.

- Maximum Water Level : EL. 2.16 m
- Minimum Water Level : EL. -1.33 m
- Average Water Level : EL. 0.59 m

Name of Station: Can Tho



(in m)

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993		2007	2008	2009	2010	Average
Max. WL	2.16	1.94	1.99	1.97	1.90	2.03	1.93	1.98	2.16	2.04		2.03	2.00	1.93	1.94	2.00
Month	10	9	11	10	10	10	10	10	9	10		10	10	11	11	
Min. WL	-1.18	-1.26	-1.33	-1.18	-1.20	-1.20	-1.07	-1.06	-1.10	-1.06		-1.25	-1.25	-1.21	-1.28	-1.19
Month	5	6	5	6	5	5	3	3	6	6		6	5	4	5	
Ave. WL	0.68	0.67	0.64	0.60	0.61	0.64	0.68	0.70	0.62	0.61		0.42	0.51	0.47	0.43	0.59
Difference (m)	3.34	3.20	3.32	3.15	3.10	3.23	3.00	3.04	3.26	3.10						3.19

Fig. 4.6-6 Annual Maximum, Minimum and Average Water Level at Can Tho Station

Source 1: Resource and Environment Department of Can Tho City
Source 2: Can Tho Statistic Bureau, 2011

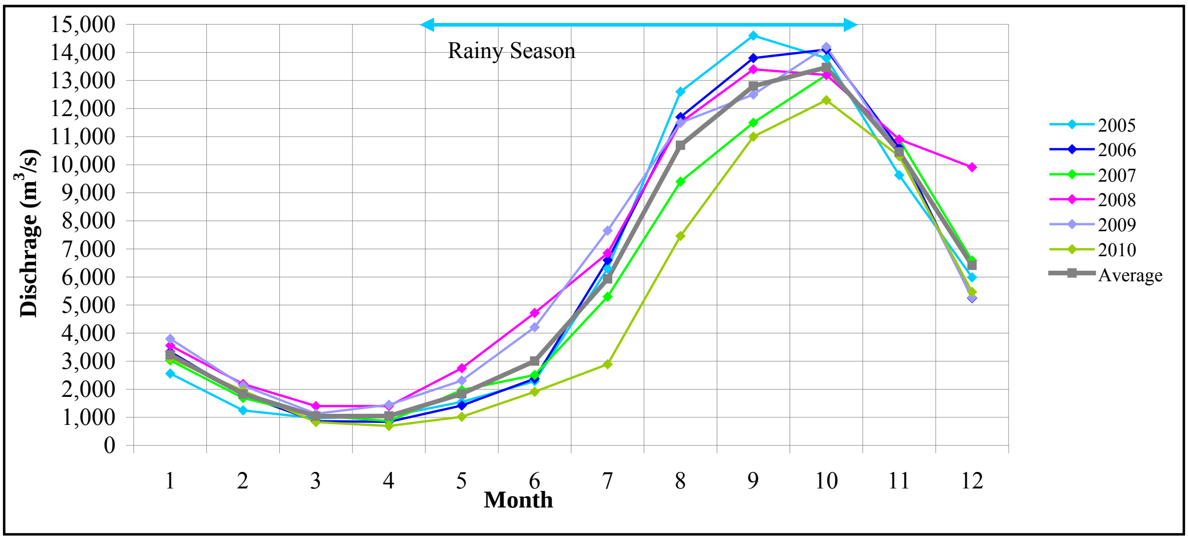
The water level records at the Can Tho station are shown in Fig. 4.6-6. According to Fig. 4.6-6, annual maximum water level reaches at about EL. 2 m, annual minimum water level reached at about EL. -1.2 m and annual average water level reached at about EL. 0.6 m.

6) River discharge

The river discharge of the Hau River at the Can Tho station is summarized in Fig. 4.6-7.

The river discharge of the Hau River seasonally varies from 800 to 15,000m^3/s and annual average river discharge is about 6,000m^3/s. The fluctuation of the water level is smaller comparing to that of the water discharge because it is supposed that water level at Can Tho is affected by sea water level.

Name of Station:	***Can Tho***	
Location:	10°02' N	105°45' E
Altitude:	EL.2m	



(in m^3/s)

Season		Dry Season				Rainy Season						Dry Season		
Month		1	2	3	4	5	6	7	8	9	10	11	12	Average
Year	2005	2,560	1,250	972	1,040	1,550	2,290	6,300	12,600	14,600	13,800	9,630	5,990	6,049
	2006	3,340	1,800	864	844	1,420	2,380	6,600	11,700	13,800	14,100	10,600	5,250	6,058
	2007	3,030	1,690	1,070	867	1,970	2,510	5,300	9,400	11,500	13,200	10,900	6,590	5,669
	2008	3,560	2,190	1,400	1,400	2,750	4,720	6,850	11,500	13,400	13,200	10,900	9,910	6,815
	2009	3,800	2,130	1,130	1,450	2,310	4,210	7,650	11,500	12,500	14,200	10,400	5,270	6,379
	2010	3,100	1,950	831	691	1,020	1,910	2,890	7,460	11,000	12,300	10,300	5,470	4,910
Average		3,232	1,835	1,045	1,049	1,837	3,003	5,932	10,693	12,800	13,467	10,455	6,413	5,980

Fig. 4.6-7 Monthly Average River Discharge

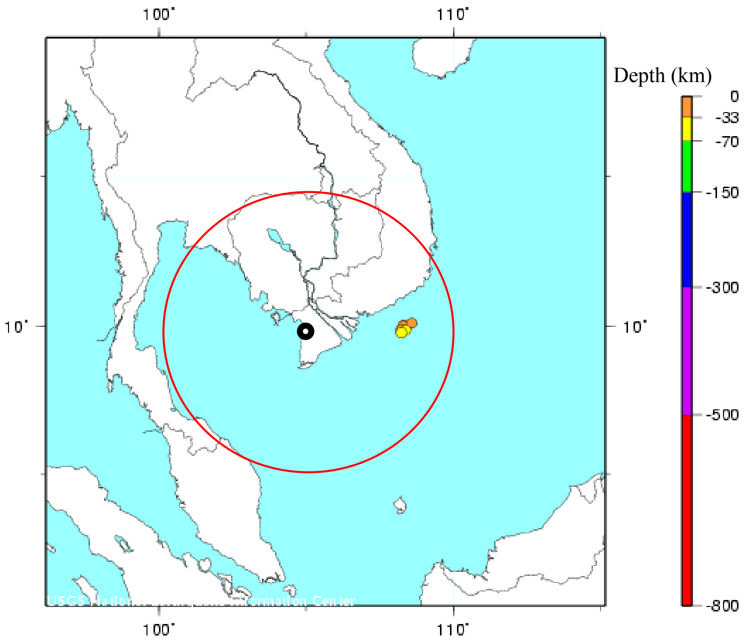
Source: Cuu Long Hydrographic Center

(3) Earthquake

1) Historical earthquake and earthquake risk

Historical earthquakes occurred around O Mon Power Complex are investigated below.

Historical earthquakes within the radius of 500 km from O Mon Power Complex and its intensity of not less than Magnitude 4.0 are extracted from earthquake database operated by United States Geological Survey (USGS) as shown in Fig. 4.6-8. The 10 earthquakes are observed and all of them are about 300 km away from the site.



No.	Date			Depth (km)	Magnitude	Distance (km)
	Year	Month	Day			
1	2005	8	5	16	4.4	295
2	2005	8	5	10	4.5	296
3	2005	11	7	10	4.0	288
4	2005	11	7	10	5.2	297
5	2005	11	8	10	5.3	286
6	2006	07	3	55	4.3	297
7	2007	11	28	10	5.2	287
8	2010	6	23	42	4.4	282
9	2010	11	6	10	4.1	320
10	2011	1	26	10	4.7	281

Fig. 4.6-8 Depth and Distance of Earthquake Source (R=500km, 1973-2011)

Source : UPGS Website

Based on the above results, major earthquakes have not occurred for the past 40 years around the site and the earthquake intensity even observed in 300 km far from the site is nearly magnitude 5.0 which is moderate scale.

Moreover, earthquake epicenter map prepared by earthquake records observed in Vietnam is shown in Fig. 4.6-9. According to Fig. 4.6-9, it is found that the small scale earthquakes at the boundary of Cambodia occurred and no large scale earthquake has been observed.

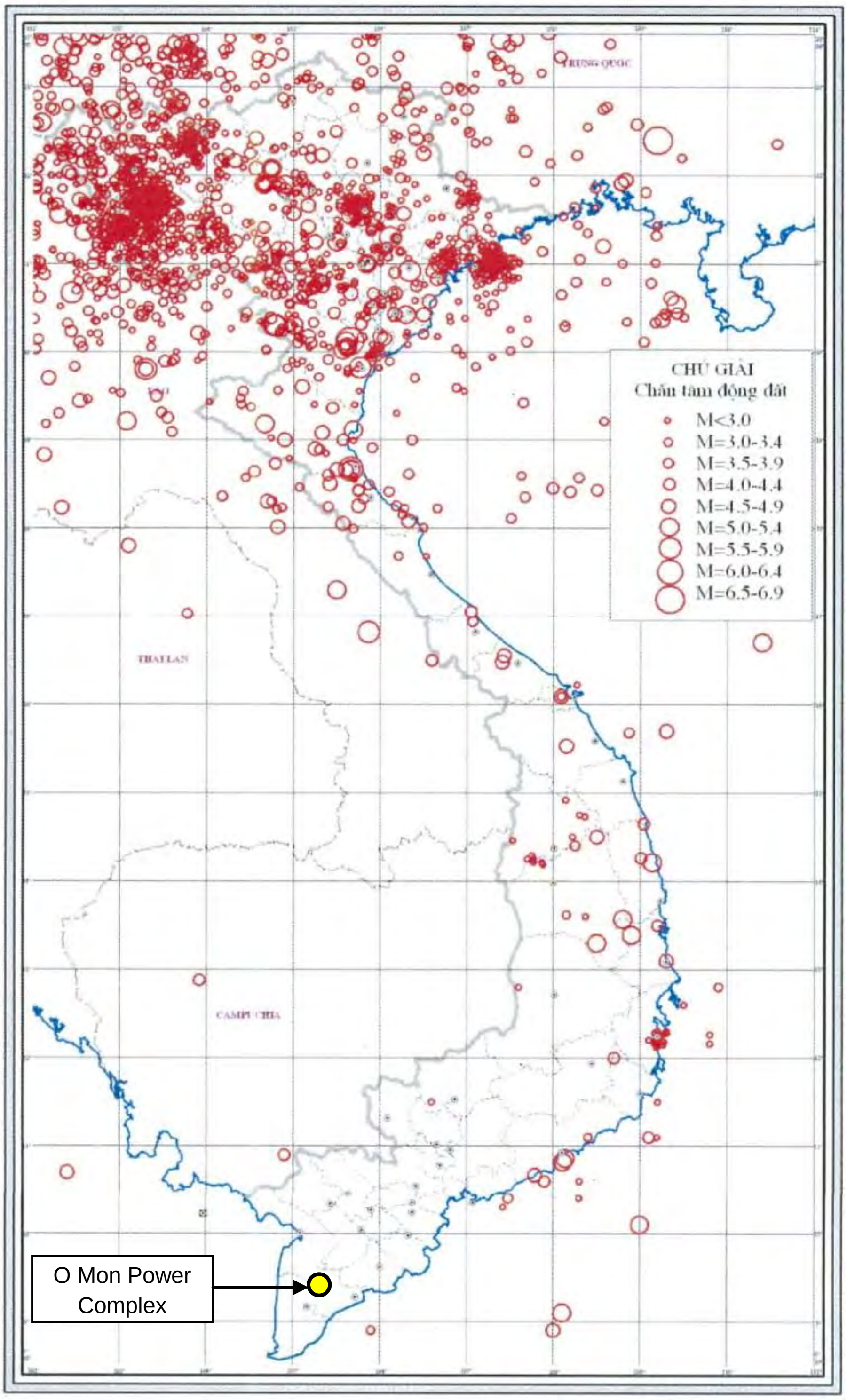


Fig. 4.6-9 Historical Earthquake in and around Vietnam (till year of 2005)

Source : Seismic Hazard of the Territory of Vietnam, Vietnamese Academy of Science and Technology Institute of Geophysics

The expected peak ground acceleration due to earthquake which might occur with the possibility of 10% for 50 years is shown in Fig. 4.6-10. The O Mon Power Complex belongs to the area classified as the lower peak ground acceleration range, therefore the earthquake risk is minor in the area.

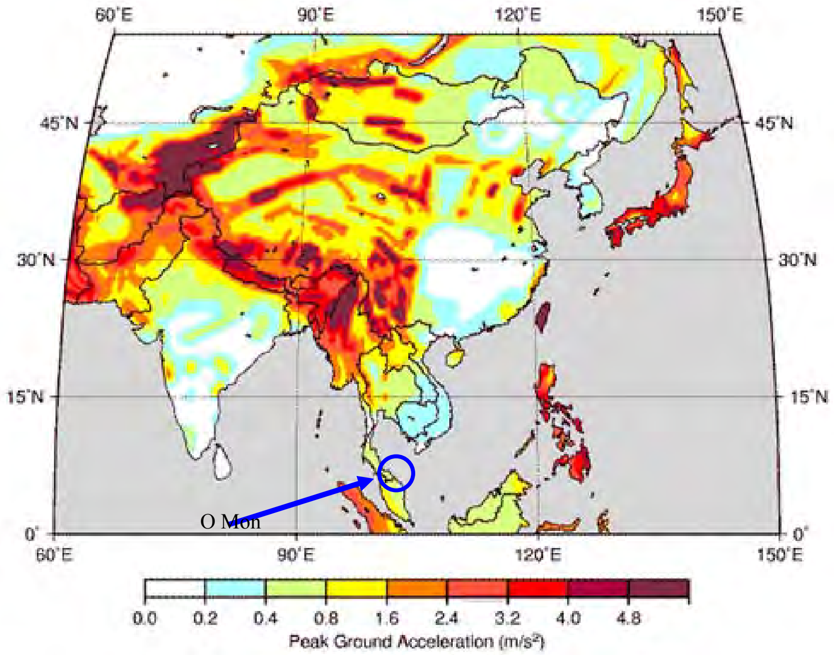


Fig. 4.6-10 Expected Peak Ground Acceleration in East Asia (Occurrence Probability: 10% for 50 years)

Source: Global Seismic Hazard Assessment Program

2) Fault

The Hau River, which O Mon Power Complex is facing, flows on the Hau River fault. It is identified by satellite image that this fault is running from eastside of Myanmar and its length is about 1,600 km. It is said that the activity started from Cretaceous or Cainozoic era and the fault is still active.

The active fault map in Vietnam is shown in Fig. 4.6-11. The Hau River fault is clearly shown on the active fault map.

In addition to the Hau River fault, the three faults, namely Vung Tau Fault, Rach Fault, and Thuan Hai Fault are cited as existing adjacent faults in the F/S Report.

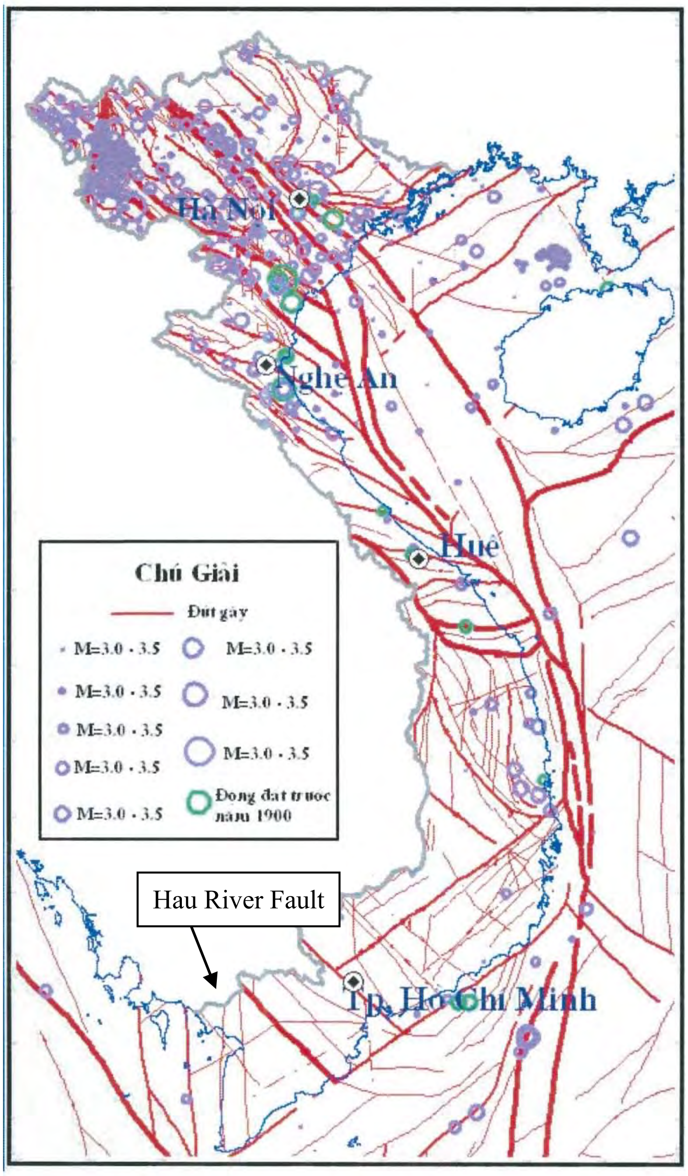


Fig. 4.6-11 Location of Active Faults and Source of Earthquakes in Vietnam

Source: Seismic Hazard of the Territory of Vietnam, Vietnamese Academy of Science and Technology Institute of Geophysics

3) Earthquake Risks and Seismic Design in Vietnam

The horizontal acceleration with occurrence probability of 10% in 50 years (once 475 years) in sound rocks, which is fundamental of seismic design in Vietnam, is shown in Fig. 4.6-12. According to Fig. 4.6-12, the horizontal acceleration of 0.04g to 0.08g is expected at O Mon Power Complex.

In addition, the earthquake risk map in Vietnam is shown in Fig. 4.6-13. Fig. 4.6-13 shows that the O Mon 3 is classified into Level 7 in Medvedev-Sponheur-Karnik (MSK-64) seismic intension scale, the intensity corresponds to Level 4 to 5 in Japan Meteorological Agency's seismic intensity scale.

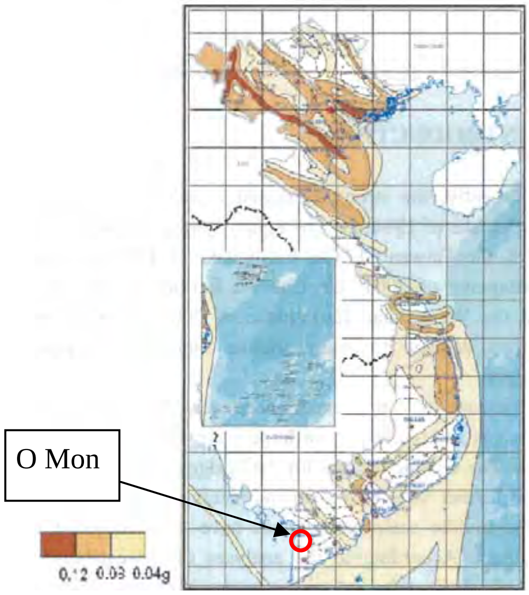


Fig. 4.6-12 Expected Ground Acceleration (Probability: 10% in 50 years, once 475 years)

Source: Assessment of Seismic Design for Bridge in Vietnam、30th Seismic Engineering Research Paper of Civil Engineering Association

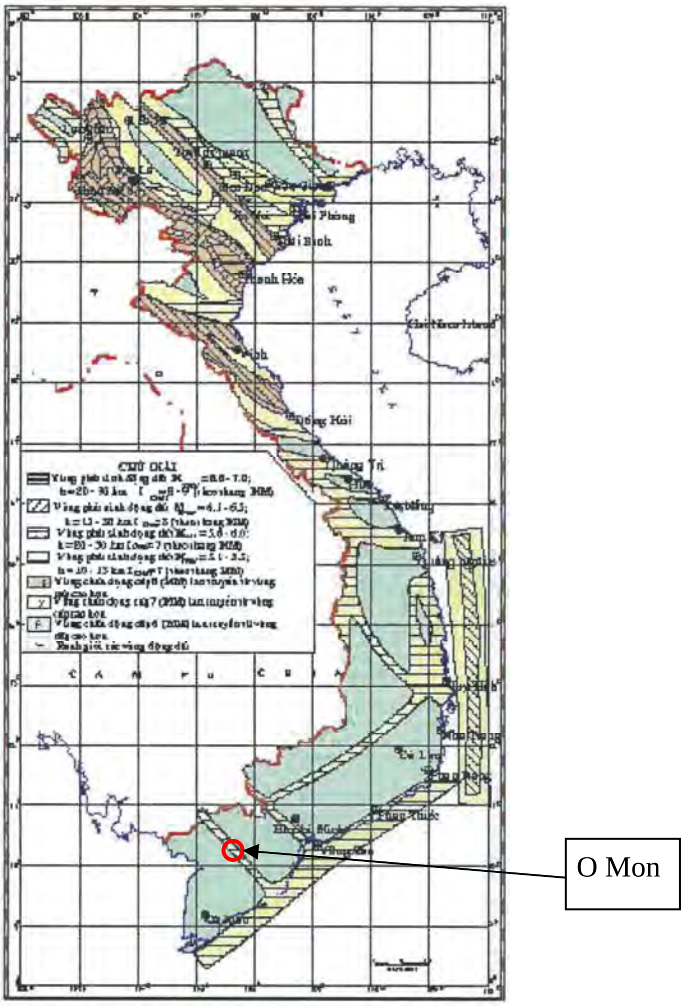


Fig. 4.6-13 Seismic Zoning Map of Vietnam

Source: Seismic Hazard in Vietnam、Institute of Geographic

(4) Design Conditions

1) Design conditions in the F/S Report

(a) River water level

The high water level (WL) of 100-year-probability is applied for the design water level for the O Mon Power Complex. The ground elevation of the O Mon 3 power plant is determined by the high water level plus freeboard. The high water level is EL. +2.28m estimated by Resource and Environment Department of Can Tho City,

Table 4.6-4 Probable High Water at O Mon Power Complex

P (%)	1	3	5	10	25	50
P (Year)	100	33.3	20	10	4	2
WL (cm)	228	247	212	203	191	180

Source: O Mon Combined Cycle Power Project Feasibility Study Report, Sep., 2010, PECC2, P8-10

The ground level of the O Mon power plant has been determined as follows in consideration of layout and elevation of CW discharge system, drainage, high tide, flood, waves caused by wind or ship, and topography and geology.

Ground Level = Flood Water Level (P=1%) + Freeboard
= 2.28m + 0.4m = 2.68 m → EL.+2.7m

In addition, damages to the O Mon Complex due to flood have never occurred from time of construction to now.

(b) Seismic coefficient

In the F/S Report, the seismic coefficient was set as follows based on Vietnamese Standard of TCXDVN375-2006.

$$a_g = a_{gR} \times I$$

where, a_g : Design Acceleration
a_{gR} : Basic Acceleration
I : Important Factor of Structures (=1.25)

The regional basic acceleration is given as shown in Table 4.6-5. According to the regional basic acceleration, O Mon district has the value of 0.0546g and its surrounding districts have the values from 0.05 to 0.07g.

Therefore, the design acceleration for the O Mon Power plants become 0.068g (m/s^2).

The design acceleration of each level in MSK-64 seismic intension scale is specified as shown in Table 4.6-6 and the calculated design acceleration corresponds to Level 7.

Table 4.6-5 Expected Acceleration around O Mon Power Complex

No.	District	Expected Acceleration (a_{gR})
<u>1</u>	**<u>O Mon</u>**	**<u>0.0546g</u>**
2	Binh Thuy	0.0685g
3	Ninh Kieu	0.0662g
4	Cai Rang	0.0515g

Table 4.6-6 Design Acceleration of Each Level in MSK-64 Seismic Intension Scale

Level	Design Acceleration (a_g)
5	0.012 - 0.03
6	> 0.03 - 0.06
<u>7</u>	**<u>> 0.06 - 0.12</u>**
8	> 0.12 - 0.24
9	> 0.24 - 0.48
10	> 0.48

2) Design condition

(a) Ground level

The design philosophy in the F/S Report is widely applied for the design of the thermal power plant in Vietnam as well as for that in O Mon 1A Power Plant. In addition, damages caused by high tides have never occurred

Therefore, it can be judged that the design condition to determine the ground level showing in the F/S Report is applicable.

(b) Design wind

Wind loads in Vietnam are stipulated in TCVN 2737 (Loads and Actions - Design Code). Map of wind speed as shown in Fig.4.6-14 shows that the O Mon Power Complex is classified into II-A zone and the design wind speed in the zone is about 37m/s. TVCN regulates that the design wind roads should be determined with the wind pressures from the classified design wind speed and coefficient taking lifetime, surrounding conditions and shape of facility into account

(c) Design seismic coefficient

The design seismic coefficient is based on the Vietnamese Standards. This corresponds to the seismic hazard of 10% in 50 years.

Fig. 4.6-14 Design Wind Speed in Vietnam

Source: Damage Cause by Strong Wind & Wind Loads

4.6.3 CW Intake Channel

(1) Required Water Volume

The required water discharge for the O Mon power plants are planned as follows.

Table 4.6-7 Required Water Discharge for O Mon Power Plants

No.	Plant	Plant Type	Capacity (MW)	Owner	Year in Operation	Total Demand for CW $(m^3/s)^{*1}$
1	O Mon 1	Conventional Steam Power Plant	660 (330+330)	EVN	2009(#1) 2014(#2)	32.0
2	O Mon 2	Combined Cycle	750	BOT		18
1 & 2	-	-	1,410	-	-	50.0
3	O Mon 3	Combined Cycle	750	EVN	2017	18
4	O Mon 4	Combined Cycle	750	EVN	2016	18
3 & 4	-	-	1,500	-	-	36.0
Total	-	-	2,910	-	-	86.0

Source: Information by CTTP

(2) Intake

Intake structure is a common facility between O Mon 3 and 4, therefore it should be installed between both plants. The intake structure will be constructed in the O Mon 4 project.

The water way from the intake to the power house should be constructed by each project respectively. The water way is to be constructed with a steel pipe.

4.6.4 CW Discharge Channel

(1) Existing Channel

The CW discharge channel for the O Mon 1 and 2 power plants is composed of culvert and channel.

The design in the CW discharge channel for the O Mon 1 and 2 was made as follows.

Structure	:	Open Channel (1 No.) and Culvert (2 Nos. for O Mon 1 and O Mon2) *
Power Generation Facility	:	Conventional Type in both 1 and 2 (4 units of 1A, 1B, 2A, and 2-B)
Power Output	:	300MW × 4 Units
Design Discharge	:	Open Channel (52 m^3/s, 13m^3/s × 4), Culvert (26m^3/s × 2)
Dimension of Channel	:	Shown in Fig. 4.6-15

*The design concept of CW discharge channel has been changed as follows.

Stage		O Mon 1 F/S	Construction of O Mon 1A	Planning of O Mon 3 & 4
Output		1,200MW	1,410MW	2,910MW
		(300MW × 4 Units) for O Mon 1&2	O Mon 1: 660MW (330MW × 2) O Mon 2: 750MW	O Mon 1: 660MW O Mon 2-4: 750MW
CW Discharge		52m^3/s: 13 × 4 Units	50m^3/s: O Mon 1: 16 m^3/s × 2 O Mon 2: 18m^3/s	86m^3/s O Mon 1: 32 m^3/s O Mon 2-4: 18 × 3 m^3/s
Water Channel	Open	1 Nos (Q=52m^3/s)	1 Nos (Q=52m^3/s)	2 Nos No.1: O Mon 1 & 2 (Q=52m^3/s) No.2: O Mon 3 & 4 (Q=36m^3/s)
	Culvert (Common)	1 Nos (Q=52m^3/s) for O Mon 1&2	2 Nos No.1: O Mon 1 (Q=32m^3/s) No.2: O Mon 2	3 Nos No.1: O Mon 1 (Q=32m^3/s) No.2: O Mon 2 No.3: O Mon 3 & 4 (Q=36m^3/s)

Discharge Channel No.1

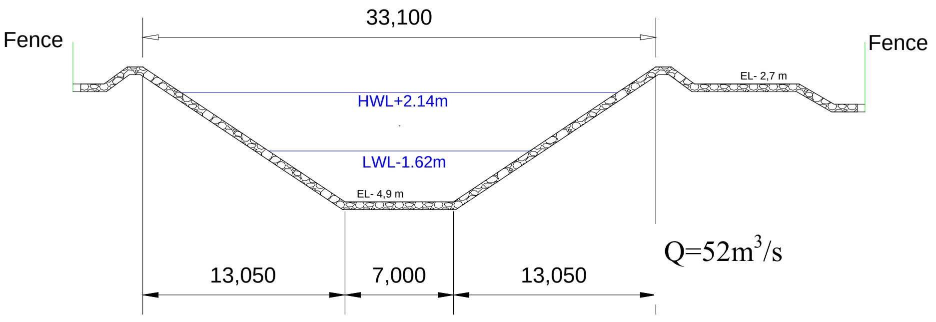
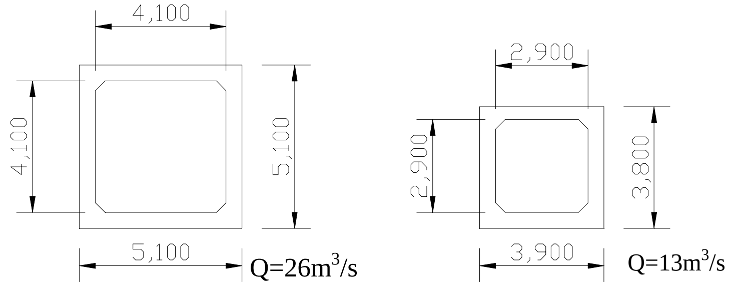


Fig. 4.6-15 No.1 Section of the CW Discharge Channel



(1A, 1B Junction to Channel) (1A(B) Culvert)

Fig. 4.6-16 No.1 Section of CW Discharge Culvert at the Construction of O Mon 1A

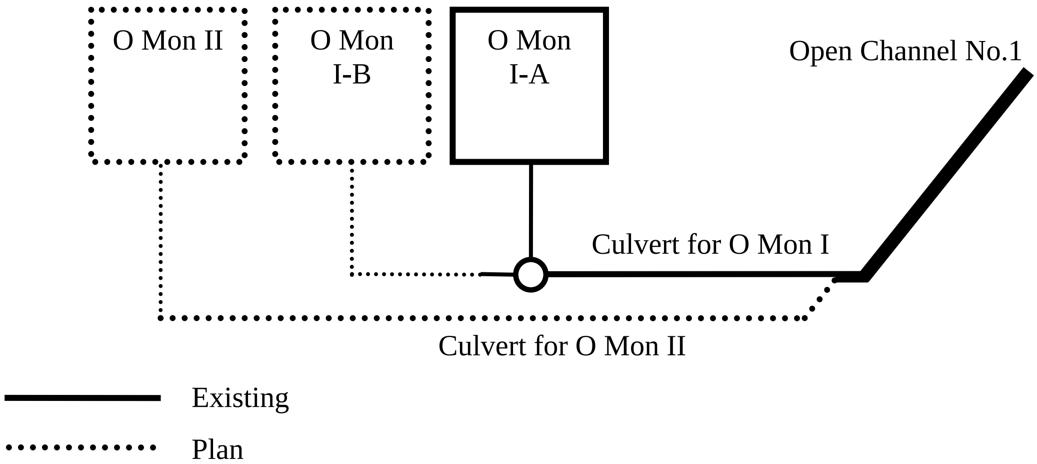


Fig. 4.6-17 Layout Plan of CW Discharge Channel

In the F/S Report of O Mon 1, the CW discharge channel is designed to meet the criterion that water level is not more than 2.7m at the upstream end of the culvert. (Calculation results; 2.659m)

The water level of O Mon 1 has a margin and the design of CW discharge channel for O Mon 2 Power Plant has not made yet. Therefore, the CW of O Mon 3 can be flown through the CW culvert No.2 (Common use between O Mon 2 and 3) and the open channel (Common use among O Mon 1, 2 and 3).

In addition, the foundation of the CW discharge channels has been improved by means of the cement deep mixing method. The cement deep mixing method is a method to improve the ground strength up to designed one by mixing soft ground and cement water mixture at site. The mixing machine was procured from Japan, because it could not be gotten in Vietnam.

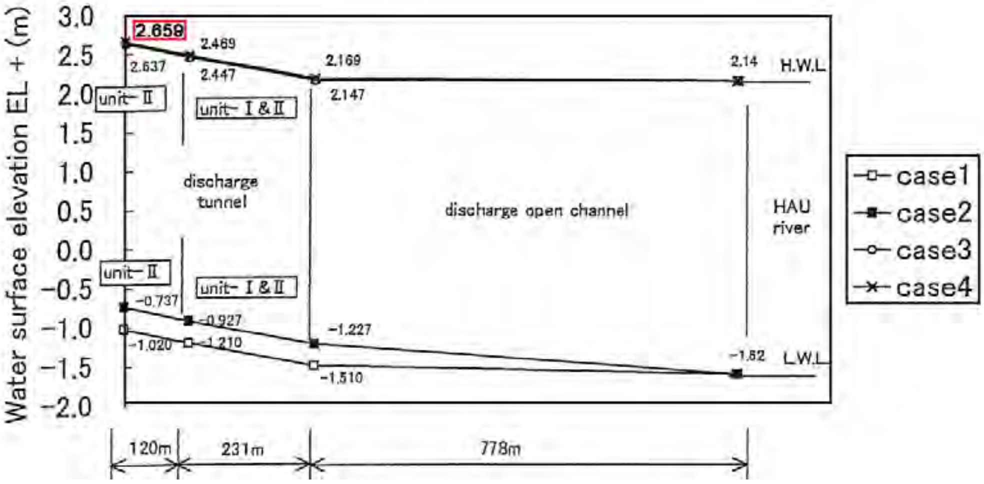


Fig. 4.6-18 Results of Hydraulic Analysis in the F/S Report of O Mon 1

Note: Unit-I and II in Fig. 4.6-18 correspond to 1A and 1B at present. Source: Design on O Mon Thermal Power Plant

(2) New Discharge Channel

Based on the present design such as the F/S Reports of O Mon 3 and O Mon 4, a new discharge channel for O Mon 3 and O Mon 4 is to be constructed and the siphon type discharge channel has been designed in the F/S Report of O Mon 3.

As mentioned above, the O Mon 4 project is responsible for most of newly constructed CW discharge channel and the culvert from powerhouse to connection points to common culvert, which is 80m long, shall be constructed in the project of the O Mon 3 development. The pipe water way from the turbine to the siphon, about 40m long, and the rectangular culvert from the siphon to the connection point, about 40m long, are planned.

On the other hand, the culvert shall pass under the existing transmission lines (220kV/110kV). The clearance between the transmission line to the ground is less than 10m, which is lower than the height of pile driver and mixing machine. Therefore, the power transmission should be suspended in the construction area and the special attention should be paid during the construction. The power generation of the O Mon 1A Power Plant is suspended in rainy season having enough water discharge, because hydropower plants are prior to thermal power plants in such season due to their lower generation cost comparing to that of thermal power plants. Therefore, the social impacts due to the suspension of the power generation during construction works can be minimized, if the construction works under the transmission line are done in such season. Moreover, CTTP has already understood the suspension of the power generation during the construction works and intends to cooperate such construction works.

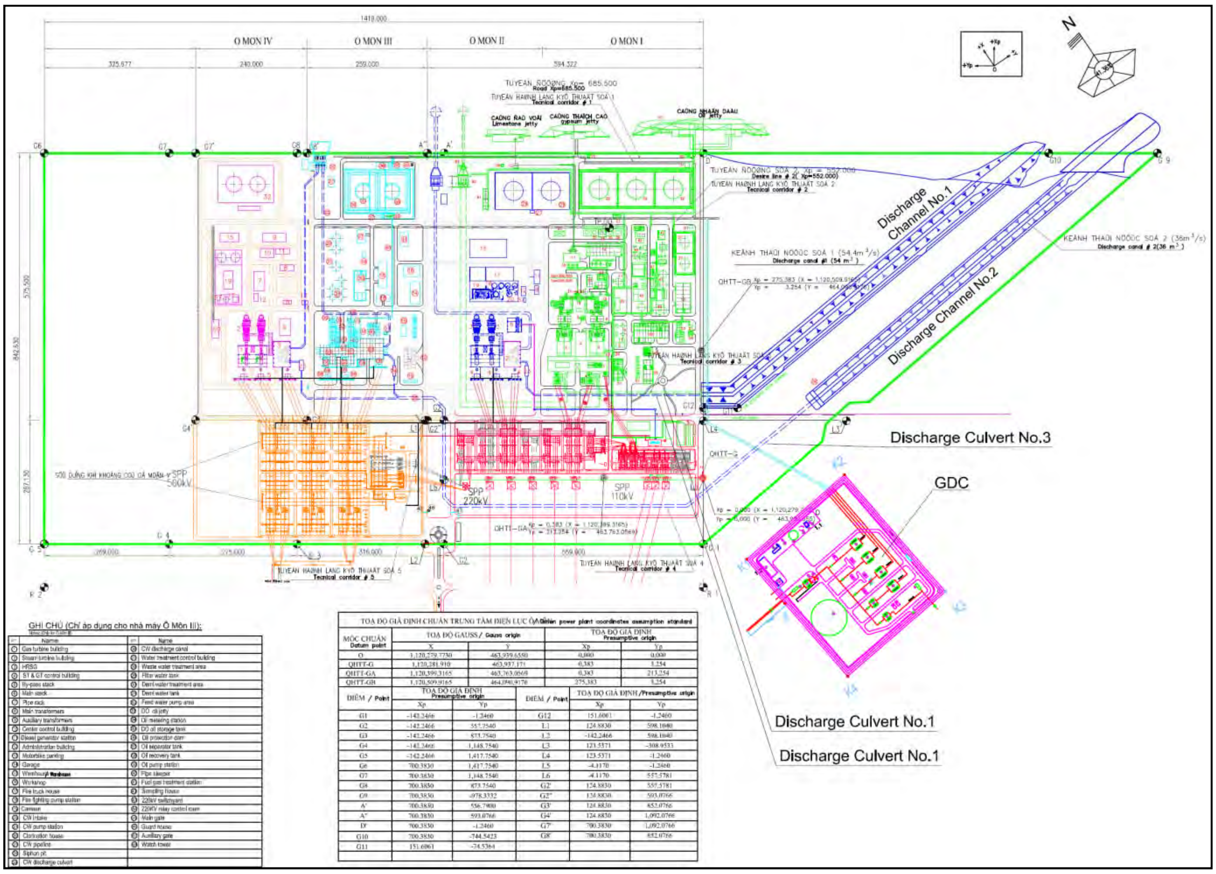


Fig. 4.6-19 Layout of CW Discharge Channel

Photo 4.6-1 Route of CW Discharge Cannel for O Mon 3 and 4

(3) Plan of CW Discharge Channel

As mentioned above, there are 2 possibilities for the plan of CW discharge channel.

1) The culvert is commonly used with O Mon 2 and the open channel is commonly used with O Non 1 and 2. The open channel No.2 and culvert No.3 are solely used by O Mon 4.
2) The open channel No.2 and culvert No.3 are commonly used with O Mon 4.

For these two plans, the rough hydraulic analysis is carried out and the results are summarized in Table 4.6-8. Based on the results, it is identified that the common culvert No.3 can be lessen by 1 m in width and height when the CW culvert of O Mon 2 is commonly used with O Mon 3.

Herein, it is recommended that the CW discharge channel of O Mon 4 should be commonly used with O Mon 3.

1) It would be difficult to construct the culvert under the transmission line, however it can be done in consideration with appropriate construction method applying not continuous cement deep mixing method but piling works and so on.

2) In the advanced O Mon 4 Project, the CW discharge channel with the dimensions for O Mon 2 as well as O Mon 4 will be constructed and the plan is approved by ADB. In addition, the intake structure for both O Mon 4 and 3 will be constructed in the O Mon 4 Project.

3) When being commonly used with the O Mon 2 Plant, the O Mon 3 should construct the CW discharge culvert. The O Mon 2 Plant will be developed by IPP, therefore EVN doesn't want to take more responsibility than the present status.

Table 4.6-8 Results of Hydraulic Analysis for CW Discharge Culvert

Culvert of O Mon 3		Common use with O Mon 2			Common use with O Mon 4		
Culvert (Conditions)	No.	No.1	No.2	No.3	No.1	No.2	No.3
	Used by	O Mon 1	O Mon 2 & 3	O Mon 4	O Mon 1	O Mon 2	O Mon 3 & 4
	Discharge (m^3/s)	32	36	18	32	18	36
Open Channel (Conditions)	No.	1		2	1		2
	Discharge (m^3/s)	68		18	50		36
Open Channel	Water Level at Upstream End (EL.m)	2.17 (V=0.5m/s at HWL)		2.14	2.16 (V=0.4m/s at HWL)		2.15
Culvert	Water Level at Pond or Siphon (EL.m)	O Mon 1A:2.6 O Mon 1B: 2.7	O Mon 2: - O Mon 3: 3.4	3.8	O Mon 1A:2.6 O Mon 1B: 2.7	3.9	O Mon 3: 3.9 O Mon 4: 4.3
Dimension of Culvert (B × H × L)	Common	4.1m × 4.1m	4.1m × 4.1m	-	4.1m × 4.1m	-	4.1m × 4.1m
		210m	360 m	-	210 m		1,200 m
	To each plant	2.9m × 2.9m	2.9m × 2.9m	3.2m × 3.2m	2.9m × 2.9m	2.8m × 2.8m	2.9m × 2.9m
		O Mon 1A:26m O Mon 1B: 100m	O Mon 2:50m O Mon 3: 340m	1,460 m	O Mon 1A:26 m O Mon 1B: 100 m	410 m	O Mon 3: 50 m O Mon 4: 260 m
Remarks		Existing	Common Culvert is done by O Mon 3		Existing		Common Culvert is done by O Mon 4

4.6.5 Architectural Structures

The main specifications required for the O Mon 3 power plant are summarized in Table 4.6-9. In addition, the common facilities of the O Mon 3 and 4 power plants are cited and those allotments are also mentioned.

Table 4.6-9 Architectural Structures for the O Mon 3 Power Plant

Structure	Specification	Allotment
Powerhouse(including Gas & Steam Turbine Building)	- Steel structure equipping with cranes of 140t and 10t class - Side walls are constructed with corrugated plates and steel plates and roof structures are constructed with steel truss. - Structures are designed in consideration with the life time for 20 to 30 years.	O Mon 3
HRSG, Bypass Stack and Main Stack	- Support structures for HRSG and air cooling tower are constructed with steel. - The required height of bypass stack and main stack will be 40m and 60m, respectively. They shall take EIA into account.	O Mon 3
Control Building	- Reinforced concrete structure (25MPa) with three floors. The grade of the reinforcement is CII-CIII. - The walls are constructed with bricks with holes, cement block or concrete.	O Mon 3
Administration Building	- It is desirable to be column structures with reinforced concrete (25MPa). Walls are constructed with cement block. - For fire prevention, exit shall be installed by the stairs. - It is expected to be of 3 stories.	O Mon 4
Auxiliary Building		
Workshop	- The structure is normally of one span and one story. - Steel structure equipping with a crane of 10t class.	O Mon 3
Warehouse	- The same structure as the workshop is applied. - It equips with a crane of 10t class.	O Mon 3
Vehicle Maintenance and Garage Building	- The structure of one span and one story is constructed with steel. It is expected that the insulation roof is installed and the walls are constructed with bricks - It is required to have areas for parking lot of bus and cars, washing and repair works, rest room, tool storage and so on.	O Mon 4
Motorbike Parking	- It is constructed with steel and of one span and one story. - The roof is composed of an insulation material and it has no walls.	O Mon 4
Foundation of DO Tanks and Dike	- The embankment (boundary walls) to protect concrete surface due to outflow of oil is installed around the tanks.	O Mon 3
Fuel Oil Measurement Station	- Outdoor type of the fuel oil counter station is applied.	O Mon 3
Fuel Oil Pump House	- It is planned to be installed along the fuel oil pipeline. - It has two types, namely outdoor type and indoor type. The type will be proposed by the Contractor.	O Mon 3
Fuel Gas Treatment and Fuel Gas Distribution Center	- They are installed along the gas supply pipeline and those structures are constructed with steel. The necessity of walls will be proposed by the Contractor. - The steel roof is installed to prevent from infiltration of rain water.	O Mon 3
Pre-Treatment Water Plant	- It is required to install raw water tanks, water tanks during filtration, storage tanks including sedimentation tanks, filtration ponds, and water treatment system for sewage from offices and so on for Pre-Treatment Water Plant.	O Mon 3
Raw Water Tank	- Two tanks are necessary. - It is constructed with reinforced concrete and equips stairs for maintenance works.	O Mon 3
Sediment Basin	- The structure is the same as the raw water tank.	O Mon 3
Emergency Diesel Generator Building	- It is of one story and flat roof and constructed with reinforced concrete. - Main materials are of concrete (25MPa) and reinforcement (CII-CIII).	O Mon 3

Structure	Specification	Allotment
Main Transformer	- In architectural works, there are foundation works for transformer and oil separator, and construction works for fire division walls (6 to 12m), oil tank, oil separator, oil pipes, fence and so on. - Oil separator and oil pipeline are constructed with reinforced concrete. - Main materials are of concrete (25MPa) and reinforcement (CII-CIII).	O Mon 3
Auxiliary Transformer	- The structure is the same as the main transformer.	O Mon 3
Cable Trench and Cable Duct System	- The cable trench is constructed with reinforce concrete and equips removable concrete cover. - In case that the cable trench is installed across roads, the trench is of underground culvert and PVC pipes are installed in the culvert. - Main materials are of concrete (25MPa) and reinforcement (CII-CIII).	O Mon 3
Fire Fighting System	- The fire fighting system includes fire pump area and fire water pipes for fire fighting.	O Mon 3
Transportation Road System (Internal Road)	- Roads are classified into four (A-10, B-8, C-6, C-4). - All roads shall be paved and equip sidewalks with 1.5m wide for A-10 and 1.0m wide for the others. - The A-10 road is classified into the Grade III whose design transportation capacity is 300-1000 cars/day and design speed is 80km/h, and the others are classified into the Grade V whose design transportation capacity is 50-300 cars/day and design speed is 40km/h.	O Mon 3
Security Facility		
Fence	- Fences are constructed with concrete walls or wire nets. - Outside fences is more than 3m high and take impulse and eyes from outside into account. - Fence at gates is 2 to 3 m high. - Main materials are of concrete (25MPa), reinforcement (CII-CIII) and steel (CT3 or B40).	O Mon 4
Guard House	- It is of one story and flat roof, constructed with reinforced concrete and located around the gates of the complex. - It equips an office, a watch room, a kitchen, toilets, etc.	O Mon 4
Gate of Power Plant	- It is desirable to install two gate, main and sub gates. - The main gate is for vehicles and is expected to be electric movable steel frame structure. - The sub gate is for bikes and pedestrians.	O Mon 4
Security Tower	- It is desirable that the security tower is installed at the center of the complex and around the outside fences - It is constructed with reinforced concrete and has a watch room at the height of 6-9m.	O Mon 4
CW System		
CW Head Intake and CW Pump Station	- The CW is taken from the Hau River. - The capacity of pump for the CW is 18m^3/s. - It is desirable that the building for the CW pump station should be of steel structure and insulation steel roof and equips 20t class crane. - It is necessary to install 10t class gantry crane for outdoor apparatus such as screen and so on. - The CW pump station should have an enough space for 4 units of pumps and other required facilities.	O Mon 4 However, pump and screen should also be installed in O Mon 3.
Pipeline from CW Pump Station to Condenser and from Condenser to Siphon Pit	- Pipe diameter will be about 2.2m and its material is to be steel, Glassfiber Reinforced Plastic GRP), or High-density Polyethylene (HDPE). On the other hand, the steel pipes shall be utilized after condenser taking into consideration of water temperature. - Manholes for maintenance works should be installed.	O Mon 3

Structure	Specification	Allotment
Siphon Pit	- It is constructed with reinforced concrete (25MPa) and its reinforcement is CII-CIII class.	O Mon 3
CW Discharge Culvert	- It is desirable for the culvert to be reinforced concrete (25MPa) structures. - Joints every 12 to 20m and manholes every 50 -70 m should be installed in the culvert.	O Mon 4
CW Open Discharge Cannel	- The capacity of the channel is 36m^3/s for O Mon 3 and 4 plants.	O Mon 4
Chlorination Building	- It equips facilities required to store chlorite and put it into the pump station. - The building is of one story and flat roof and constructed by reinforced concrete. The sidewalls are constructed with bricks with holes.	O Mon 3

Reference: O Mon Combined Cycle Power Project Feasibility Study Report, Sep., 2009, PECC2

4.6.6 Foundation Work

The geological conditions in the O Mon complex are very loose and its bearing capacity is expected to be 50 ~ 150 kN/m^2 (0.5 ~ 1.5kgf/cm^2), therefore the improvement of foundation is necessary. The survey results in geology are summarized in Table 4.6-10.

Table 4.6-10 Geology in the O Mon 3 Site

No.		OM-01	OM-02	OM-03	OM-04	OM-05	OM-06	OM-07	OM-08	Soil Classification	N Value	
Location		Hau River	Intake (Old)	GT System			Discharge Channel (Culvert)	Discharge Channel (Open Channel)				
Length		50	50	100	100	100	50	50	50			
Ground Level		-20.6	0.21	1.08	1.01	1.71	-0.10	1.53	1.30			
WL		-2.60	-1.29	-1.85	-1.49	-1.09	-0.40	1.03	0.80			
Elevation (EL.m)	Layer- 1		0.2	1.1	1.0	1.7	-0.1	1.5	1.3	Clay	5	(2-10)
	Layer- 2		-1.6	-1.1	-1.0	-0.1	-1.7	-1.7	-0.7	Clay	0	(0)
	Layer- 3	-20.6	-13.7	-10.4	-11.5	-11.2	-12.1	-16.1	-16.9	Clay	16	(3-37)
	Layer- 4	-26.6	-26.0	-29.1	-29.7	-27.0	-27.8	-27.2	-27.5	Sand	17	(9-58)
	Layer- 5	-37.2	-33.2	-33.2	-34.4	-32.0	-38.1	-39.0	-39.7	Clay	17	(11-48)
	Layer- 6	-57.7	-76.8	-75.9	-73.0	-70.8				Sand	60	(32-103)

In general, foundation with more than 30 of N-Value for sand or more than 20 of N-Value for clay is defined to have enough strength. From this viewpoint, supporting layer will be Layer-3 or deeper. In the construction works in the O Mon 1A, the supporting layer for light structure was Layer-3 or 4 and that for heavy equipment/structure was Layer-5. Because the geological conditions of the O Mon 3 site are very similar to those of the O Mon 1A site and the problems in foundation have not occurred, it is desirable that the design philosophy of the O Mon 3 should be the same as that of the O Mon 1A.

The minor settlement can be allowed for the main structure, therefore the Pre-stressed High Strength Concrete (PHC) Pile is normally applied for the main heavy structures. The following types of foundation works are expected in the plant.

1) PHC Pile Foundation (L=42~48m)
2) PHC Pile Foundation or RC Pile Foundation (L=24~30m)
3) Direct Foundation

The expected specifications for foundation works are shown in Table 4.6-11.

Table 4.6-11 Foundation of Main Structures for O Mon 3

No.	Structure	Foundation
1	Gas turbine, Steam turbine, HRSG, By pass Stack, Stack, Transformer	Reinforces Concrete PHC Pile, D600, L=42m
2	Oil tank foundation, Pure water tank, Dematerialize water tank	Reinforces Concrete PHC Pile, D600, L=42m
3	Siphon pit	Reinforces Concrete PHC Pile, D600, L=42m
4	Dematerialize water plant	Reinforces Concrete PHC or RC Pile, D400, L=24m
5	Gas treatment and supply station, Oil pump station, Oil recovery pit	Reinforces Concrete PHC or RC Pile, D400, L=24m
6	Oil metering station	Reinforces Concrete PHC or RC Pile, D300, L=24m
7	Workshop, Warehouse	Reinforces Concrete PHC or RC Pile, D400, L=24m
8	Cable trench, Road, Side ditch	Direct foundation

In addition, it was reported that the cement deep mixing Method applied for the foundation improvement works of pump pits, discharge channel (both open channel and culvert) and river revetment in O Mon 1A plant was effective way. The cement deep mixing method can improve the foundation to 400 to 750 kN/m^2 in baring capacity without piling works.

4.6.7 Plan for Material Transportation and Temporary Facility

(1) Plan for Material Procurement and Transportation

1) Construction materials

Construction materials for architectural and civil works are basically procured in Vietnam, except main steel materials for structures.
The steel for O Mon 1A and Non Trach Thermal Power Plant were procured out of Vietnam, because required quality and quantity were not satisfied. Therefore, the steels are to be procured from out of Vietnam.

2) Construction equipment

The main construction equipment used in O Mon 3 Thermal Power Plant is expected as follows.

- Dump Truck
- Bulldozer
- Backhaus
- Compaction Roller
- Crane (Truck Crane, Cruller Crane, barge with crane, etc)
- Pile drivers with excavation/drilling equipment
- Concrete mixing plant, etc.

They can be procured in Vietnam. As mentioned above, the EPC contractor for O Mon 1A procured the mixing machine for the cement deep mixing method from Japan.

3) Plan for material transportation

Much amount of construction materials will be necessary for the O Mon No.3 construction works. Therefore, the proper transportation plan will be a key to finalize construction works within the given deadline.

Under the site conditions such as the O Mon, the material will be generally transported with a barge for heavy equipment and materials and with a load for light materials procured nearby.

The temporary jetty, which was used for the construction works in the O Mon 1A, has been constructed in the northeast side of O Mon 1A power plant. Therefore, the temporary jetty is available for the transportation for construction works in the O Mon 3, including heavy equipment such as a gas turbine and a generator. In addition, the broad area in the southwest of the O Mon 4 planned area has been acquired and the temporary jetty for the construction works of the O Mon 3 can be newly constructed here.

Using a road, the way to the O Mon 3 will be through National Road No.91 and O Mon 1A Road (Access road to O Mon 1A) or No.2 Road (Access road to center of the O Mon power complex whose construction will be completed in March, 2012.

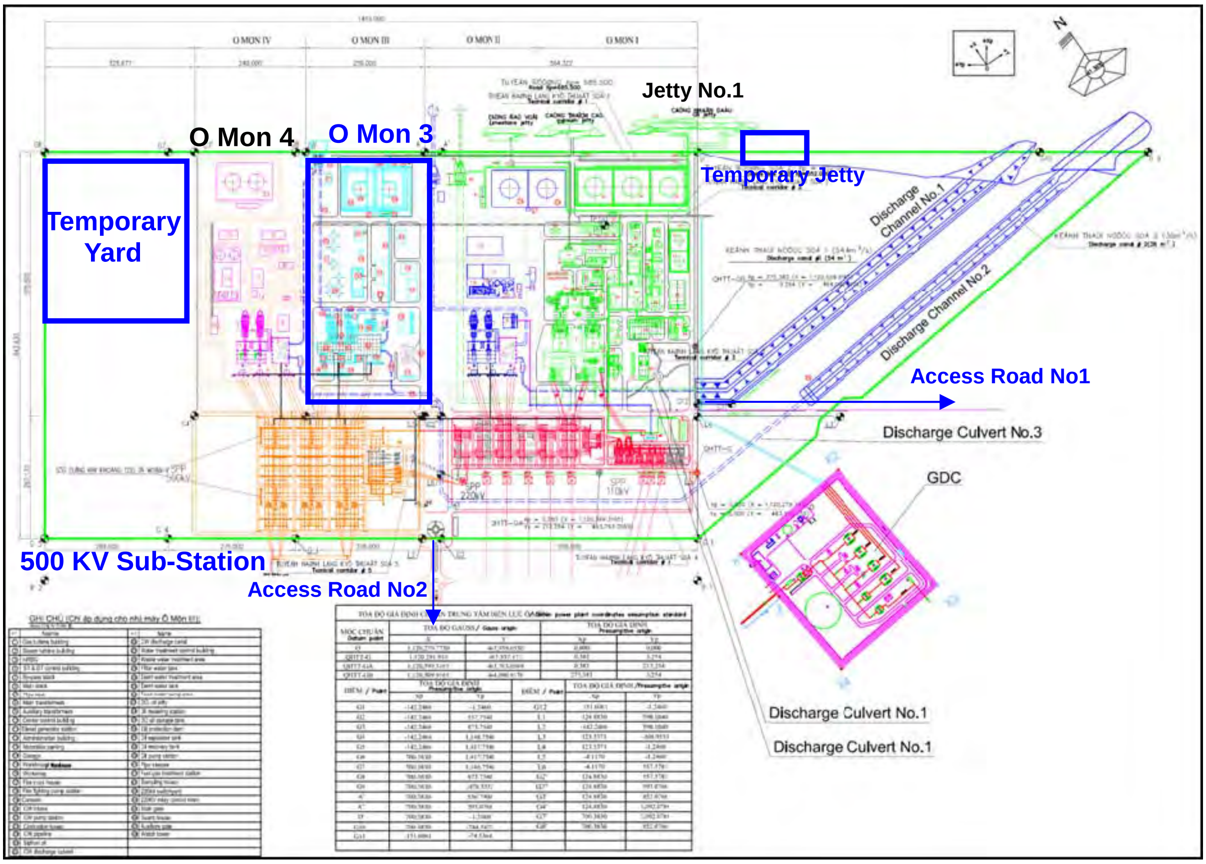


Fig. 4.6-20 Location Map of Temporary Yard

(2) Plan of Temporary Yard

The planned temporary yard is located in the area in the river side of north-eastern area of O Mon 4 power plant site, whose land acquisition has been completed. The location is shown in Fig. 4.6-20.

The area of the temporary yard is about 147,000m^2 (350m × 420 m).

The main advanced and temporary works are summarized in Table 4.6-12.

Table 4.6-12 Main Advanced and Temporary Works

Structure	Explanation
Temporary Works for Construction	
Site Preparation Works	
Sand filling and Leveling	- To carry out filling and smoothing to secure required elevation for the power plant. The landfill works has been finished.
Sheet Pile Revetment Work	- The riverbank protection works such as riprap works is necessary, because the power plant faces the Hau River. The riverbank protection is to protect any damages caused by river flow, land slide, infiltration of river water and construction works. - Based on the results of the geological investigations, geological structures at the site are very loose and the layer with the N-value of 0 widely exists upto 10 to 20m depth from the surface. - To ensure stability of the protection works, the sheet pile can be utilized.
Temporary Unloading Jetty	- The temporary jetty used in construction works of O Mon 1 is available. - When it is desirable that the temporary jetty should be constructed nearby the plant site, it can be installed in the upstream area of the O Mon 4 plant site - The above mentioned 2 options are selected by a contractor.
Power for Construction	- The expected power for construction will be about 20kW × 40 for welding machine, 100kW × 2 for concrete plants, 300kV × 1 for workshop, 1,500kW × 1 for water and power supply for contractor, consultant and owner and so on. The total power will be about 2,800kW. For this power demand, the power supply facilities of 2,500kVA are required.
Water for Construction	- The expected water demand will be about 5.72m^3/h for concrete plant, 0.06m^3/h for architectural works, 0.6m^3/h for plastering, 20m^3/h for material wash, 8.34m^3/h for office use and so on, total required water will be about 40m^3/h. - Water source will be the Hau River, the water for the office will be filtered and sterilized, The water supply facilities will be raw water tank of 60m3, slow filtration equipment, pump of 40-50m^3/h, water supply facilities in offices and so on.
Site Office	
Site Office for Owner and Consultant	- Site office for Owner will be utilized by Project Management Board and consultant. - The insulation roof and brick wall will be applied for the office.
Site Office for Constructor	- The size of the site office for the Contractor depends on the number of the EPC Contractor's staff.

Source: O Mon Combined Cycle Power Project Feasibility Study Report, Sep., 2009, PECC2

In addition, the required area for the temporary yard is summarized in Table 4.6-13.

The area of the available temporary yard in Table 4.6-13 is now two times as large as that of the required temporary yard due to the cancellation of construction of O Mon 5 power plant, and it is broad enough.

Table 4.6-13 Temporary Yard Plan

No.	Items	Dimension
1	Equipment Gathering Yard	200m × 100m
2	Trial Assembling Yard	150m × 100m
3	Equipment Warehouse	100m × 50m
4	Steel Warehouse	25m × 50m
5	Cement Warehouse	25m × 50m
6	Sand Storage	50m × 60m
7	Rock Pile of 1 × 2, 4 × 6 in size	50m × 60m
8	Reinforcement Warehouse	25m × 50m
9	Steel Processing Workshop	50m × 50m
10	Reinforced Concrete Placing Area	100m × 50m
11	Site for Prefabricated Reinforced Concrete Component	75m × 50m
12	Wood Processing Workshop	25m × 25m
13	Vehicle Garage	75m × 50m
14	Construction Equipment Repairing Workshop	25m × 25m
15	Construction Site Steering Committee	50m × 50m
16	Camps for Construction Workers	50m × 100m
17	$200m^3$ Raw Water Tank	-
18	Domestic Water Tank of $10m^3$/tank	-
Total Area of Construction Site (Larger than the total area of above items)		$73,500m^3$

Source: O Mon Combined Cycle Power Project Feasibility Study Report, Sep., 2009, PECC2

4.7 CURRENT STATUS OF COMMON FACILITIES AND THEIR AVAILABILITY

Change of Surroundings of the Project

(1) Construction of par of common facilities for O Mon 3 power plant has been already done.

(2) Commencement of commercial operation and construction of O Mon 4 power plant becomes earlier than those of O Mon 3 power plant.

Based on the above change of surroundings of the Project, availability of common facilities for O Mon 3 power plant was discussed and confirmed between CTTP, ADB and the Study Team.

4.7.1 Current Status of Common Facilities and their Availability

(1) Current Status of Common Facilities

17 common facilities are available for O Mon 3 power plant as shown in Table 4.7-1, and out of 17 facilities, 6 facilities has been already constructed and the remaining 11 facilities are newly constructed.

(2) Allocation of Construction Cost for Common Facilities

As shown in Table 4.7-1, the construction cost for two common facilities is allocated to O Mon 3 project, although the construction cost for the remaining fifteen common facilities are out of expense of O Mon 3 project.

Table 4.7-1 Allocation of Construction Cost for Common Facilities

No.	Common facilities for O Mon 3 and O Mon 4 of which construction cost of 100 % is allocated to O Mon 4 project	No.	Common facilities for O Mon 3 and O Mon 4 of which construction cost of 100 % is allocated to EVN
1	Administration Building	1	Construction Power
2	500KV Switchyards(Common Civil Work)	2	Land leveling for operating Staff Quarter
3	CW Intake & CW Pump Station	3	Road for common use between O Mon 3 & 4
4	CW Discharge Channel No.2	4	Disarming the explosion and bomb
5	CW Discharge Culvert (to Tie-Point)	5	Compensation and clearance for site layout, operation and management compound infrastructure
6	Fire Fighting Trucks		
7	Piping Rack & Sleeper for DO/Gas		
No.	Common facilities for of which construction cost of 100 % is allocated to O Mon 3 project	No.	Other Common facilities
1	Guard House & Gate (main & sub): for O Mon 3 and O Mon 4	1	DFO Unloading Jetty: 100% allocated to O Mon 1
2	Watch Tower：for O Mon 1 ~ O Mon 4	2	500kV Station (including Switchyards Control House): Constructed by National Transmission Co.
		3	200kV Relay Control Room：Constructed by O Mon1

In addition to the above, Table 4.7-2 shows the cost allocation relating to the common facilities in the O Mon Power Complex.

Table 4.7-2 Cost Allocation of Common Facilities in O Mon Power Complex

No.	Common facilities	Related power plants	New	Existing	Cost Allocation (%)			
					O Mon 1	O Mon 2	O Mon 3	O Mon 4
1	Administration Building	O Mon 3 & O Mon 4	○		0	0	0	100
2	500kV Switchyard (Common Civil Work)	O Mon 3 & O Mon 4	○		0	0	0	100
3	CW Intake and CW pump Station	O Mon 3 & O Mon 4	○		0	0	0	100
4	CW Discharge Culvert	O Mon 3 & O Mon 4	○		0	0	0	100
5	CW Discharge Channel No.1	O Mon 1 & O Mon 2		○	50	50	0	0
6	CW Discharge Channel No.2	O Mon 3 & O Mon 4	○		0	0	0	100
7	Construction Power	O Mon 3 & O Mon 4	○		EVN to be invested			
8	Land leveling for operating staff Quarter	O Mon 2、3 & 4	○		EVN to be invested			
9	Road for common use between O Mon 3 & O Mon 4	O Mon 3 & O Mon 4	○		EVN to be invested			
10	Disarming the explosion and bomb	O Mon 3 & O Mon 4		○	Completed by EVN			
11	DFO unloading Jetty	O Mon 1 ~ O Mon 4		○	100	0	0	0
12	Compensation and clearance for site layout area, operation and management compound infrastructure	O Mon 3 & O Mon 4		○	Completed by EVN			
13	Switchyard 220kV & 110kV (including switchyard control house)	O Mon 1 & O Mon 2		○	50	50	0	0
14	500kV station (including switchyard control house)	O Mon 3 & O Mon 4	○		Constructed by National Transmission Company			
15	Fire fighting trucks	O Mon 3 & O Mon 4	○		0	0	0	100
16	200kV Relay Control Room	O Mon 1 ~ O Mon 4		○	100	0	0	0
17	Piping Rack & Sleeper for DO/Gas	O Mon 1 ~ O Mon 4	○					100
18	Guard House & Gate (main & sub)	O Mon 3 & O Mon 4	○				100	0
19	Watch Tower	O Mon 1 ~ O Mon 4	○		0	0	100	0

4.7.2 Other Equipment and Facilities

CTTP informed that the following equipment and facilities were not common use and to be constructed by each project.

No.	Equipment and Facilities	No.	Equipment and Facilities
1	Warehouse	5	Canteen
2	Workshop	6	Fire fighting pump Station
3	Vehicle maintenance Garage Building	7	Fire fighting water Pipeline
4	Motorbike shed		

Note) - Electric fire water will be installed by O Mon 4 project.
- Outer fence will be installed by CTTP by his own finance.