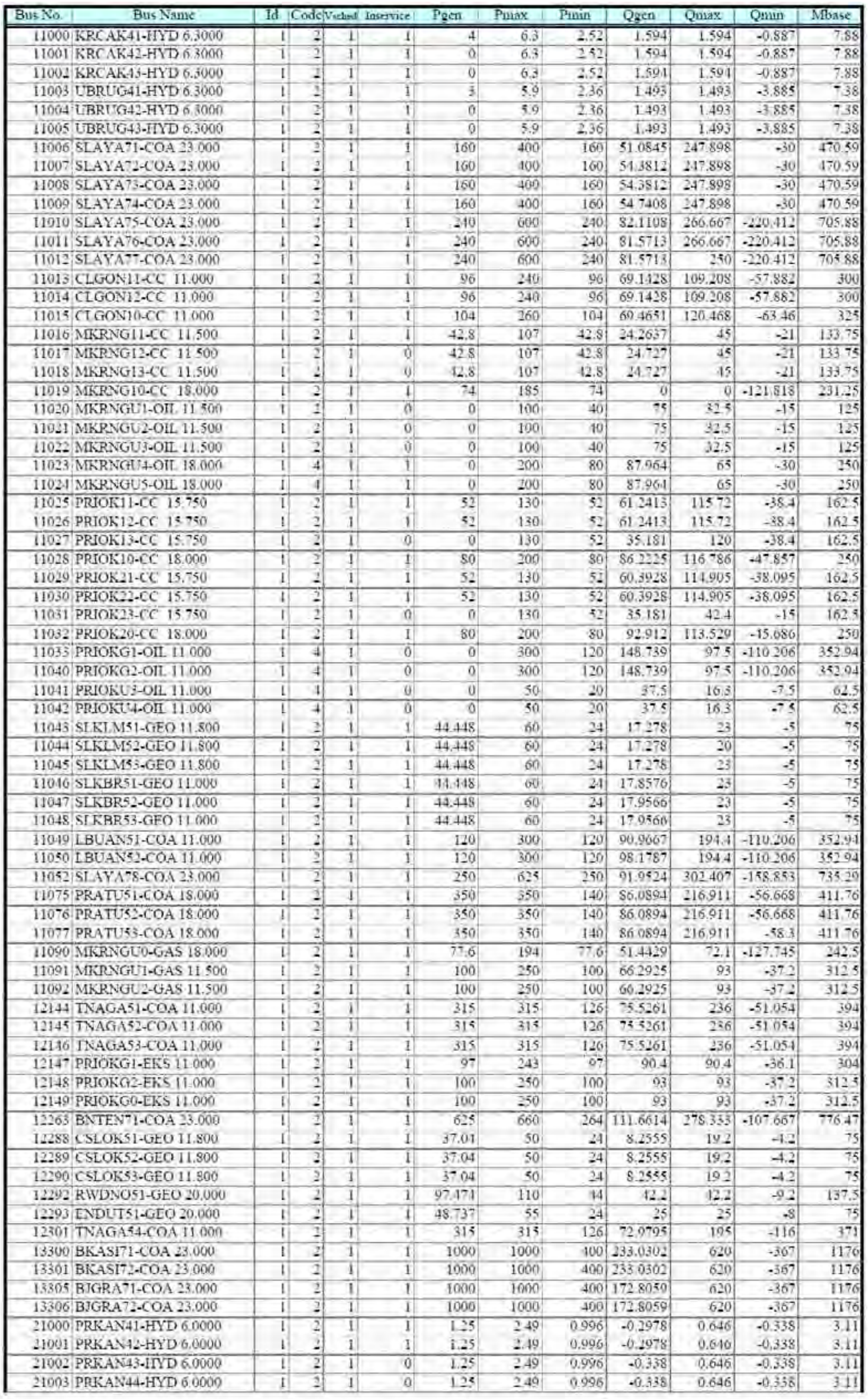
Table.13 Active and Reactive Power Outputs of Generators in 2021 (1/5)

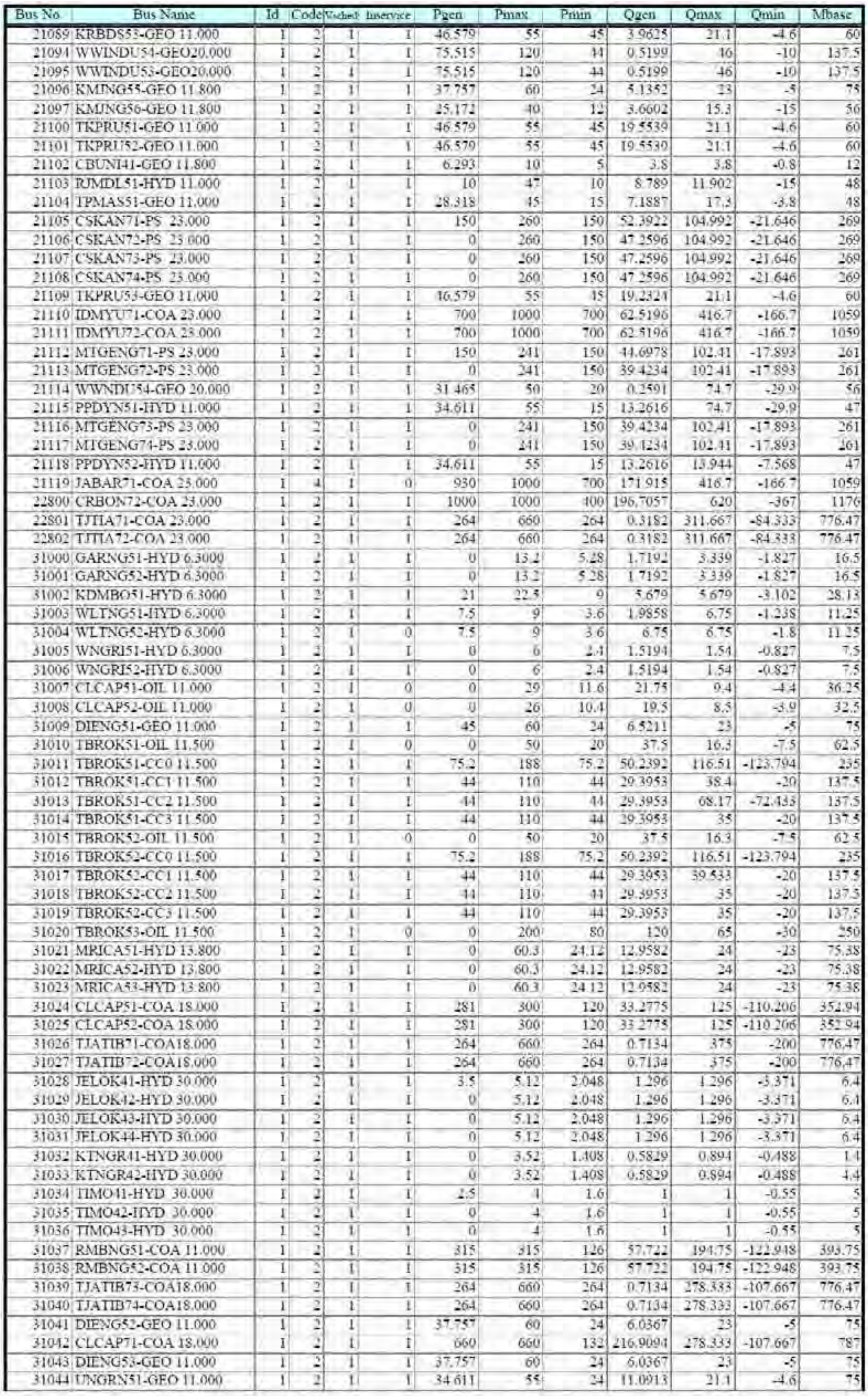


Bus No.	Bus Name	Id	Code	Vsched	Inservice	Pgen	Pmax	Pmin	Qgen	Qmax	Qmin	Mbase
11000	KRCAK41-HYD 6.3000	1	2	1	1	4	6.3	2.52	1.594	1.594	-0.887	7.88
11001	KRCAK42-HYD 6.3000	1	2	1	1	0	6.3	2.52	1.594	1.594	-0.887	7.88
11002	KRCAK43-HYD 6.3000	1	2	1	1	0	6.3	2.52	1.594	1.594	-0.887	7.88
11003	UBRUG41-HYD 6.3000	1	2	1	1	3	5.9	2.36	1.493	1.493	-3.885	7.38
11004	UBRUG42-HYD 6.3000	1	2	1	1	0	5.9	2.36	1.493	1.493	-3.885	7.38
11005	UBRUG43-HYD 6.3000	1	2	1	1	0	5.9	2.36	1.493	1.493	-3.885	7.38
11006	SLAYA71-COA 23.000	1	2	1	1	160	400	160	51.0845	247.898	-30	470.59
11007	SLAYA72-COA 23.000	1	2	1	1	160	400	160	54.3812	247.898	-30	470.59
11008	SLAYA73-COA 23.000	1	2	1	1	160	400	160	54.3812	247.898	-30	470.59
11009	SLAYA74-COA 23.000	1	2	1	1	160	400	160	54.7408	247.898	-30	470.59
11010	SLAYA75-COA 23.000	1	2	1	1	240	600	240	82.1108	266.667	-220.412	705.88
11011	SLAYA76-COA 23.000	1	2	1	1	240	600	240	81.5713	266.667	-220.412	705.88
11012	SLAYA77-COA 23.000	1	2	1	1	240	600	240	81.5713	250	-220.412	705.88
11013	CLGON11-CC 11.000	1	2	1	1	96	240	96	69.1428	109.208	-57.882	300
11014	CLGON12-CC 11.000	1	2	1	1	96	240	96	69.1428	109.208	-57.882	300
11015	CLGON10-CC 11.000	1	2	1	1	104	260	104	69.4651	120.468	-63.46	325
11016	MKRNG11-CC 11.500	1	2	1	1	42.8	107	42.8	24.2637	45	-21	133.75
11017	MKRNG12-CC 11.500	1	2	1	0	42.8	107	42.8	24.727	45	-21	133.75
11018	MKRNG13-CC 11.500	1	2	1	0	42.8	107	42.8	24.727	45	-21	133.75
11019	MKRNG10-CC 18.000	1	2	1	1	74	185	74	0	0	-121.818	231.25
11020	MKRNGU1-OIL 11.500	1	2	1	0	0	100	40	75	32.5	-15	125
11021	MKRNGU2-OIL 11.500	1	2	1	0	0	100	40	75	32.5	-15	125
11022	MKRNGU3-OIL 11.500	1	2	1	0	0	100	40	75	32.5	-15	125
11023	MKRNGU4-OIL 18.000	1	4	1	1	0	200	80	87.964	65	-30	250
11024	MKRNGU5-OIL 18.000	1	4	1	1	0	200	80	87.964	65	-30	250
11025	PRIOK11-CC 15.750	1	2	1	1	52	130	52	61.2413	115.72	-38.4	162.5
11026	PRIOK12-CC 15.750	1	2	1	1	52	130	52	61.2413	115.72	-38.4	162.5
11027	PRIOK13-CC 15.750	1	2	1	0	0	130	52	35.181	120	-38.4	162.5
11028	PRIOK10-CC 18.000	1	2	1	1	80	200	80	86.2225	116.786	-47.857	250
11029	PRIOK21-CC 15.750	1	2	1	1	52	130	52	60.3928	114.905	-38.095	162.5
11030	PRIOK22-CC 15.750	1	2	1	1	52	130	52	60.3928	114.905	-38.095	162.5
11031	PRIOK23-CC 15.750	1	2	1	0	0	130	52	35.181	42.4	-15	162.5
11032	PRIOK20-CC 18.000	1	2	1	1	80	200	80	92.912	113.529	-15.686	250
11033	PRIOKG1-OIL 11.000	1	4	1	0	0	300	120	148.739	97.5	-110.206	352.94
11040	PRIOKG2-OIL 11.000	1	4	1	0	0	300	120	148.739	97.5	-110.206	352.94
11041	PRIOKU3-OIL 11.000	1	4	1	0	0	50	20	37.5	16.3	-7.5	62.5
11042	PRIOKU4-OIL 11.000	1	4	1	0	0	50	20	37.5	16.3	-7.5	62.5
11043	SLKLM51-GEO 11.800	1	2	1	1	44.448	60	24	17.278	23	-5	75
11044	SLKLM52-GEO 11.800	1	2	1	1	44.448	60	24	17.278	20	-5	75
11045	SLKLM53-GEO 11.800	1	2	1	1	44.448	60	24	17.278	23	-5	75
11046	SLKBR51-GEO 11.000	1	2	1	1	44.448	60	24	17.8576	23	-5	75
11047	SLKBR52-GEO 11.000	1	2	1	1	44.448	60	24	17.9566	23	-5	75
11048	SLKBR53-GEO 11.000	1	2	1	1	44.448	60	24	17.9566	23	-5	75
11049	LBUAN51-COA 11.000	1	2	1	1	120	300	120	90.9667	194.4	-110.206	352.94
11050	LBUAN52-COA 11.000	1	2	1	1	120	300	120	98.1787	194.4	-110.206	352.94
11052	SLAYA78-COA 23.000	1	2	1	1	250	625	250	91.9524	302.407	-158.853	735.29
11075	PRATU51-COA 18.000	1	2	1	1	350	350	140	86.0894	216.911	-56.668	411.76
11076	PRATU52-COA 18.000	1	2	1	1	350	350	140	86.0894	216.911	-56.668	411.76
11077	PRATU53-COA 18.000	1	2	1	1	350	350	140	86.0894	216.911	-58.3	411.76
11090	MKRNGU0-GAS 18.000	1	2	1	1	77.6	194	77.6	51.4429	72.1	-127.745	242.5
11091	MKRNGU1-GAS 11.500	1	2	1	1	100	250	100	66.2925	93	-37.2	312.5
11092	MKRNGU2-GAS 11.500	1	2	1	1	100	250	100	66.2925	93	-37.2	312.5
12144	TNAGA51-COA 11.000	1	2	1	1	315	315	126	75.5261	236	-51.054	394
12145	TNAGA52-COA 11.000	1	2	1	1	315	315	126	75.5261	236	-51.054	394
12146	TNAGA53-COA 11.000	1	2	1	1	315	315	126	75.5261	236	-51.054	394
12147	PRIOKG1-EKS 11.000	1	2	1	1	97	243	97	90.4	90.4	-36.1	304
12148	PRIOKG2-EKS 11.000	1	2	1	1	100	250	100	93	93	-37.2	312.5
12149	PRIOKG0-EKS 11.000	1	2	1	1	100	250	100	93	93	-37.2	312.5
12263	BNTEN71-COA 23.000	1	2	1	1	625	660	264	111.6614	278.333	-107.667	776.47
12288	CSLOK51-GEO 11.800	1	2	1	1	37.04	50	24	8.2555	19.2	-4.2	75
12289	CSLOK52-GEO 11.800	1	2	1	1	37.04	50	24	8.2555	19.2	-4.2	75
12290	CSLOK53-GEO 11.800	1	2	1	1	37.04	50	24	8.2555	19.2	-4.2	75
12292	RWDNO51-GEO 20.000	1	2	1	1	97.471	110	44	42.2	42.2	-9.2	137.5
12293	ENDUT51-GEO 20.000	1	2	1	1	48.737	55	24	25	25	-8	75
12301	TNAGA54-COA 11.000	1	2	1	1	315	315	126	72.9795	195	-116	371
13300	BKASI71-COA 23.000	1	2	1	1	1000	1000	400	233.0302	620	-367	1176
13301	BKASI72-COA 23.000	1	2	1	1	1000	1000	400	233.0302	620	-367	1176
13305	BJGRA71-COA 23.000	1	2	1	1	1000	1000	400	172.8059	620	-367	1176
13306	BJGRA72-COA 23.000	1	2	1	1	1000	1000	400	172.8059	620	-367	1176
21000	PRKAN41-HYD 6.0000	1	2	1	1	1.25	2.49	0.996	-0.2978	0.646	-0.338	3.11
21001	PRKAN42-HYD 6.0000	1	2	1	1	1.25	2.49	0.996	-0.2978	0.646	-0.338	3.11
21002	PRKAN43-HYD 6.0000	1	2	1	0	1.25	2.49	0.996	-0.338	0.646	-0.338	3.11
21003	PRKAN44-HYD 6.0000	1	2	1	0	1.25	2.49	0.996	-0.338	0.646	-0.338	3.11

Table.14 Active and Reactive Power Outputs of Generators in 2021 (2/5)

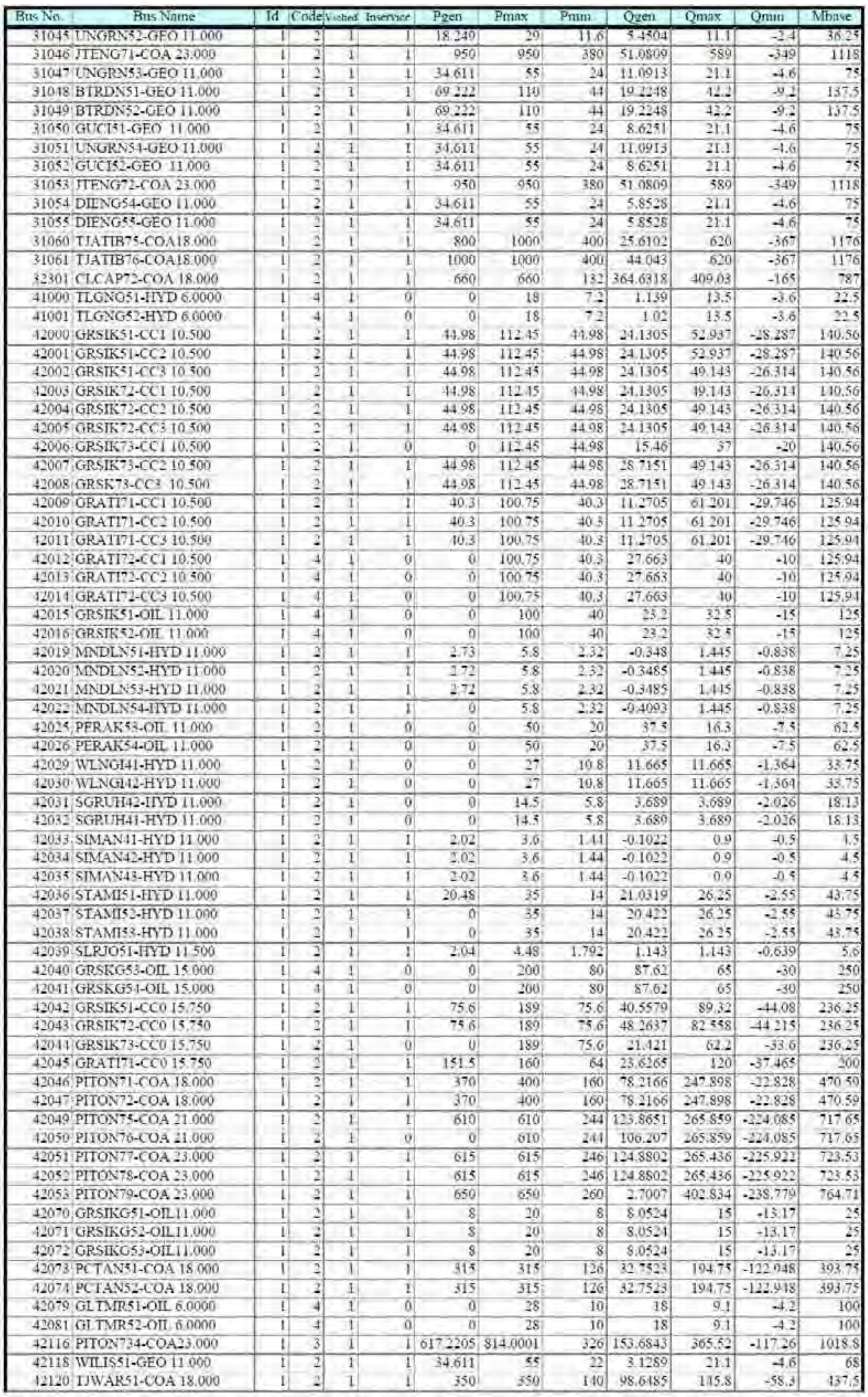
Bus No.	Bus Name	Id	Code	Vsched	Inservice	Pgen	Pmax	Pmin	Qgen	Qmax	Qmin	Mbase
21008	CKLNG41-HYD 6.3000	1	2	1	1	0	6.4	2.56	-0.875	1.641	-0.875	8
21009	CKLNG42-HYD 6.3000	1	2	1	0	0	6.4	2.56	1.315	1.641	-0.875	8
21010	CKLNG43-HYD 6.3000	1	2	1	0	0	6.4	2.56	1.315	1.641	-0.875	8
21011	LMJAN41-HYD 6.3000	1	2	1	1	3	6.5	2.6	-0.9	1.65	-0.9	8.13
21012	LMJAN42-HYD 6.3000	1	2	1	0	0	6.5	2.6	1.65	1.65	-0.9	8.13
21013	LMJAN43-HYD 6.3000	1	2	1	0	0	6.5	2.6	1.65	1.65	-0.9	8.13
21014	SRAGI51-GAS 11.000	1	2	1	1	0	20	8	-0.5581	15	-13.17	25
21015	SRAGI52-GAS 11.000	1	2	1	1	0	20	8	-0.6889	15	-13.17	25
21016	SRAGI53-GAS 11.000	1	2	1	1	0	20	8	-0.5581	15	-13.17	25
21017	SRAGI54-GAS 11.000	1	2	1	1	0	20	8	-0.6889	15	-13.17	25
21021	PLNGN41-HYD 30.000	1	2	1	1	1.3	4	1.6	-0.55	1	-0.55	5
21022	PLNGN42-HYD 30.000	1	2	1	1	0	4	1.6	-0.55	1	-0.55	5
21023	PLNGN43-HYD 30.000	1	2	1	1	0	4	1.6	-0.55	1	-0.55	5
21024	PLNGN44-HYD 30.000	1	2	1	1	0	4	1.6	-0.55	1	-0.55	5
21025	MTWR711-CC 16.000	1	2	1	1	58.4	146	58.4	32.6915	75.638	-17.34	182.5
21026	MTWR712-CC 16.000	1	2	1	1	58.4	146	58.4	32.6915	75.638	-17.34	182.5
21027	MTWR713-CC 16.000	1	2	1	1	58.4	146	58.4	32.6915	75.638	-17.34	182.5
21028	MTWR710-CC 16.000	1	2	1	1	89.6	224	89.6	50.1569	101.333	-15	280
21029	MTWR721-CC 16.000	1	2	1	1	58.4	146	58.4	32.6915	75.638	-17.34	182.5
21030	MTWR722-CC 16.000	1	2	1	1	58.4	146	58.4	32.6915	75.638	-17.34	182.5
21031	MTWR723-CC 16.000	1	2	1	1	60	150	60	33.5872	74.167	-17.917	187.5
21032	MTWR720-CC 16.000	1	2	1	1	140	350	140	78.3701	156.265	-83.577	437.5
21033	MTWR731-CC 11.000	1	2	1	1	58.4	146	58.4	32.6915	76	-17.5	182.5
21034	MTWR732-CC 11.000	1	2	1	1	58.4	146	58.4	32.6915	76	-17.5	182.5
21035	MTWR733-CC 11.000	1	2	1	1	58.4	146	58.4	32.6915	76	-17.5	182.5
21036	MTWR730-CC 16.000	1	2	1	0	0	350	140	44.991	115.2	-62.2	437.5
21037	MTWR741-CC 11.000	1	2	1	1	58.4	146	58.4	32.6915	76	-17.5	182.5
21038	MTWR742-CC 11.000	1	2	1	1	58.4	146	58.4	32.6915	76	-17.5	182.5
21039	MTWR743-CC 11.000	1	2	1	1	58.4	146	58.4	32.6915	76	-17.5	182.5
21040	MTWR740-CC 16.000	1	2	1	0	0	350	140	44.991	115.2	-62.2	437.5
21041	MTWR751-CC 16.000	1	2	1	1	58.4	146	58.4	32.6915	76	-17.5	182.5
21042	MTWR750-CC 16.000	1	2	1	1	30	75	30	16.7936	33.289	-17.774	93.75
21043	DRJAT51-GEO 13.800	1	2	1	1	52	60	30	3.0395	23	-5	70
21044	DRJAT52-GEO 13.800	1	2	1	1	70	110	55	3.546	42.2	-9.2	137.5
21045	DRJAT53-GEO 13.800	1	2	1	1	105.8	110	55	6.3041	42.2	-9.2	137.5
21046	CRATA71-HYD 16.500	1	2	1	1	98	126	50.4	34.6593	43.419	-40	157.5
21047	CRATA72-HYD 16.500	1	2	1	1	98	126	50.4	34.6593	43.419	-40	157.5
21048	CRATA73-HYD 16.500	1	2	1	0	0	126	50.4	25.217	43.419	-40	157.5
21049	CRATA74-HYD 16.500	1	2	1	0	0	126	50.4	25.217	43.419	-40	157.5
21050	CRATA75-HYD 16.500	1	2	1	0	0	126	50.4	25.217	43.419	-40	157.5
21051	CRATA76-HYD 16.500	1	2	1	0	0	126	50.4	25.217	43.419	-40	157.5
21052	CRATA77-HYD 16.500	1	2	1	0	0	126	50.4	25.217	43.419	-40	157.5
21053	CRATA78-HYD 16.500	1	2	1	0	0	126	50.4	25.217	43.419	-40	157.5
21054	SGLNG71-HYD 16.500	1	2	1	1	147	175	70	42.542	42.542	-115.234	218.75
21055	SGLNG72-HYD 16.500	1	2	1	1	147	175	70	42.542	42.542	-115.234	218.75
21056	SGLNG73-HYD 16.500	1	2	1	0	0	175	70	32.877	42.542	-115.234	218.75
21057	SGLNG74-HYD 16.500	1	2	1	0	0	175	70	32.877	42.542	-115.234	218.75
21058	WWNDU51-GEO 20.000	1	2	1	1	109.2	110	44	3.2395	42.2	-9.2	137.5
21059	WWNDU52-GEO 20.000	1	2	1	1	110	110	44	3.3162	42.2	-9.2	137.5
21060	LSTDO51-GAS 11.000	1	2	1	1	34	49	19.6	20.389	20.389	-5.35	61.25
21061	LSTDO52-GAS 11.000	1	2	1	1	34	49	19.6	20.389	20.389	-5.35	61.25
21062	LSTDO53-GAS 11.000	1	2	1	1	41	49	19.6	20.389	20.389	-5.35	61.25
21063	LSTDO54-GAS 11.000	1	2	1	1	150	150	60	62.56	62.56	-16.3	187.5
21065	JTLHR51-HYD 11.000	1	2	1	1	15	25	10	6.324	6.324	-3.44	31.25
21066	JTLHR52-HYD 11.000	1	2	1	1	0	25	10	6.324	6.324	-3.44	31.25
21067	JTLHR53-HYD 11.000	1	2	1	1	15	25	10	6.324	6.324	-3.44	31.25
21068	JTLHR54-HYD 11.000	1	2	1	1	0	25	10	6.324	6.324	-3.44	31.25
21069	JTLHR55-HYD 11.000	1	2	1	1	0	25	10	6.324	6.324	-3.44	31.25
21070	JTLHR56-HYD 11.000	1	2	1	1	0	25	10	6.324	6.324	-3.44	31.25
21071	KMJNG51-GEO 11.800	1	2	1	1	27.4	30	12	3.2727	15	-5	37.5
21072	KMJNG52-GEO 11.800	1	2	1	1	52.3	60	24	6.3289	25	-8	75
21073	KMJNG53-GEO 11.800	1	2	1	1	52.3	60	24	6.3289	25	-8	75
21074	KMJNG54-GEO 11.800	1	2	1	1	60	60	24	6.8916	25	-8	75
21076	IDMYU51-COA 11.000	1	2	1	1	200	330	200	92.8146	120	-100.047	412
21077	IDMYU52-COA 11.000	1	2	1	1	200	330	200	81.0002	120	-100.047	351
21078	IDMYU53-COA 11.000	1	2	1	1	200	330	200	81.0002	120	-100.047	351
21080	CRBON21-COA 11.000	1	2	1	1	660	660	400	106.3029	278.333	-107.667	825
21082	PTUHA51-GEO 11.000	1	2	1	1	46.579	60	45	21.5934	23	-5	65
21083	PTUHA52-GEO 11.000	1	2	1	1	46.579	60	45	21.5934	23	-5	65
21084	PTUHA53-GEO 11.000	1	2	1	1	46.579	60	45	21.5934	23	-5	65
21085	DRAJAT54-GEO13.800	1	2	1	1	46.579	55	45	2.7893	23	-2	60
21087	KRBDS51-GEO 13.800	1	2	1	1	18.879	30	5	1.6408	15	-15	34
21088	KRBDS52-GEO 11.000	1	2	1	1	46.579	55	45	3.9625	21.1	-4.6	60

Table.15 Active and Reactive Power Outputs of Generators in 2021 (3/5)



Bus No	Bus Name	Id	Code	Vsched	Inservice	Pgen	Pmax	Pmin	Qgen	Qmax	Qmin	Mbase
21089	KRBDS53-GEO 11.000	1	2	1	1	46.579	55	45	3.9625	21.1	-4.6	60
21094	WWINDU54-GEO20.000	1	2	1	1	75.515	120	44	0.5199	46	-10	137.5
21095	WWINDU53-GEO20.000	1	2	1	1	75.515	120	44	0.5199	46	-10	137.5
21096	KMJNG55-GEO 11.800	1	2	1	1	37.757	60	24	5.1352	23	-5	75
21097	KMJNG56-GEO 11.800	1	2	1	1	25.172	40	12	3.6602	15.3	-15	56
21100	TKPRU51-GEO 11.000	1	2	1	1	46.579	55	45	19.5539	21.1	-4.6	60
21101	TKPRU52-GEO 11.000	1	2	1	1	46.579	55	45	19.5539	21.1	-4.6	60
21102	CBUNI41-GEO 11.800	1	2	1	1	6.293	10	5	3.8	3.8	-0.8	12
21103	RJMDL51-HYD 11.000	1	2	1	1	10	47	10	8.789	11.902	-15	48
21104	TPMAS51-GEO 11.000	1	2	1	1	28.318	45	15	7.1887	17.3	-3.8	48
21105	CSKAN71-PS 23.000	1	2	1	1	150	260	150	52.3922	104.992	-21.646	269
21106	CSKAN72-PS 23.000	1	2	1	1	0	260	150	47.2596	104.992	-21.646	269
21107	CSKAN73-PS 23.000	1	2	1	1	0	260	150	47.2596	104.992	-21.646	269
21108	CSKAN74-PS 23.000	1	2	1	1	0	260	150	47.2596	104.992	-21.646	269
21109	TKPRU53-GEO 11.000	1	2	1	1	46.579	55	45	19.2324	21.1	-4.6	60
21110	IDMYU71-COA 23.000	1	2	1	1	700	1000	700	62.5196	416.7	-166.7	1059
21111	IDMYU72-COA 23.000	1	2	1	1	700	1000	700	62.5196	416.7	-166.7	1059
21112	MTGENG71-PS 23.000	1	2	1	1	150	241	150	44.6978	102.41	-17.893	261
21113	MTGENG72-PS 23.000	1	2	1	1	0	241	150	39.4234	102.41	-17.893	261
21114	WWNDU54-GEO 20.000	1	2	1	1	31.465	50	20	0.2591	74.7	-29.9	56
21115	PPDYN51-HYD 11.000	1	2	1	1	34.611	55	15	13.2616	74.7	-29.9	47
21116	MTGENG73-PS 23.000	1	2	1	1	0	241	150	39.4234	102.41	-17.893	261
21117	MTGENG74-PS 23.000	1	2	1	1	0	241	150	39.4234	102.41	-17.893	261
21118	PPDYN52-HYD 11.000	1	2	1	1	34.611	55	15	13.2616	13.944	-7.568	47
21119	JABAR71-COA 23.000	1	4	1	0	930	1000	700	171.915	416.7	-166.7	1059
22800	CRBON72-COA 23.000	1	2	1	1	1000	1000	400	196.7057	620	-367	1176
22801	TJTIA71-COA 23.000	1	2	1	1	264	660	264	0.3182	311.667	-84.333	776.47
22802	TJTIA72-COA 23.000	1	2	1	1	264	660	264	0.3182	311.667	-84.333	776.47
31000	GARNG51-HYD 6.3000	1	2	1	1	0	13.2	5.28	1.7192	3.339	-1.827	16.5
31001	GARNG52-HYD 6.3000	1	2	1	1	0	13.2	5.28	1.7192	3.339	-1.827	16.5
31002	KDMBO51-HYD 6.3000	1	2	1	1	21	22.5	9	5.679	5.679	-3.102	28.13
31003	WLTNG51-HYD 6.3000	1	2	1	1	7.5	9	3.6	1.9858	6.75	-1.238	11.25
31004	WLTNG52-HYD 6.3000	1	2	1	0	7.5	9	3.6	6.75	6.75	-1.8	11.25
31005	WNGRI51-HYD 6.3000	1	2	1	1	0	6	2.4	1.5194	1.54	-0.827	7.5
31006	WNGRI52-HYD 6.3000	1	2	1	1	0	6	2.4	1.5194	1.54	-0.827	7.5
31007	CLCAP51-OIL 11.000	1	2	1	0	0	29	11.6	21.75	9.4	-4.4	36.25
31008	CLCAP52-OIL 11.000	1	2	1	0	0	26	10.4	19.5	8.5	-3.9	32.5
31009	DIENG51-GEO 11.000	1	2	1	1	45	60	24	6.5211	23	-5	75
31010	TBROK51-OIL 11.500	1	2	1	0	0	50	20	37.5	16.3	-7.5	62.5
31011	TBROK51-CC0 11.500	1	2	1	1	75.2	188	75.2	50.2392	116.51	-123.794	235
31012	TBROK51-CC1 11.500	1	2	1	1	44	110	44	29.3953	38.4	-20	137.5
31013	TBROK51-CC2 11.500	1	2	1	1	44	110	44	29.3953	68.17	-72.433	137.5
31014	TBROK51-CC3 11.500	1	2	1	1	44	110	44	29.3953	35	-20	137.5
31015	TBROK52-OIL 11.500	1	2	1	0	0	50	20	37.5	16.3	-7.5	62.5
31016	TBROK52-CC0 11.500	1	2	1	1	75.2	188	75.2	50.2392	116.51	-123.794	235
31017	TBROK52-CC1 11.500	1	2	1	1	44	110	44	29.3953	39.533	-20	137.5
31018	TBROK52-CC2 11.500	1	2	1	1	44	110	44	29.3953	35	-20	137.5
31019	TBROK52-CC3 11.500	1	2	1	1	44	110	44	29.3953	35	-20	137.5
31020	TBROK53-OIL 11.500	1	2	1	0	0	200	80	120	65	-30	250
31021	MRICA51-HYD 13.800	1	2	1	1	0	60.3	24.12	12.9582	24	-23	75.38
31022	MRICA52-HYD 13.800	1	2	1	1	0	60.3	24.12	12.9582	24	-23	75.38
31023	MRICA53-HYD 13.800	1	2	1	1	0	60.3	24.12	12.9582	24	-23	75.38
31024	CLCAP51-COA 18.000	1	2	1	1	281	300	120	33.2775	125	-110.206	352.94
31025	CLCAP52-COA 18.000	1	2	1	1	281	300	120	33.2775	125	-110.206	352.94
31026	TJATIB71-COA18.000	1	2	1	1	264	660	264	0.7134	375	-200	776.47
31027	TJATIB72-COA18.000	1	2	1	1	264	660	264	0.7134	375	-200	776.47
31028	JELOK41-HYD 30.000	1	2	1	1	3.5	5.12	2.048	1.296	1.296	-3.371	6.4
31029	JELOK42-HYD 30.000	1	2	1	1	0	5.12	2.048	1.296	1.296	-3.371	6.4
31030	JELOK43-HYD 30.000	1	2	1	1	0	5.12	2.048	1.296	1.296	-3.371	6.4
31031	JELOK44-HYD 30.000	1	2	1	1	0	5.12	2.048	1.296	1.296	-3.371	6.4
31032	KTNGR41-HYD 30.000	1	2	1	1	0	3.52	1.408	0.5829	0.894	-0.488	4.4
31033	KTNGR42-HYD 30.000	1	2	1	1	0	3.52	1.408	0.5829	0.894	-0.488	4.4
31034	TIMO41-HYD 30.000	1	2	1	1	2.5	4	1.6	1	1	-0.55	5
31035	TIMO42-HYD 30.000	1	2	1	1	0	4	1.6	1	1	-0.55	5
31036	TIMO43-HYD 30.000	1	2	1	1	0	4	1.6	1	1	-0.55	5
31037	RMBNG51-COA 11.000	1	2	1	1	315	315	126	57.722	194.75	-122.948	393.75
31038	RMBNG52-COA 11.000	1	2	1	1	315	315	126	57.722	194.75	-122.948	393.75
31039	TJATIB73-COA18.000	1	2	1	1	264	660	264	0.7134	278.333	-107.667	776.47
31040	TJATIB74-COA18.000	1	2	1	1	264	660	264	0.7134	278.333	-107.667	776.47
31041	DIENG52-GEO 11.000	1	2	1	1	37.757	60	24	6.0367	23	-5	75
31042	CLCAP71-COA 18.000	1	2	1	1	660	660	132	216.9094	278.333	-107.667	787
31043	DIENG53-GEO 11.000	1	2	1	1	37.757	60	24	6.0367	23	-5	75
31044	UNGRN51-GEO 11.000	1	2	1	1	34.611	55	24	11.0913	21.1	-4.6	75

Table.16 Active and Reactive Power Outputs of Generators in 2021 (4/5)



Bus No.	Bus Name	Id	Code	Visited	Inservice	Pgen	Pmax	Pmin	Qgen	Qmax	Qmin	Mbase
31045	UNGRN52-GEO 11.000	1	2	1	1	18.240	29	11.6	5.4504	11.1	-2.4	36.25
31046	JTENG71-COA 23.000	1	2	1	1	950	950	380	51.0809	589	-349	1118
31047	UNGRN53-GEO 11.000	1	2	1	1	34.611	55	24	11.0913	21.1	-4.6	75
31048	BTRDN51-GEO 11.000	1	2	1	1	69.222	110	44	19.2248	42.2	-9.2	137.5
31049	BTRDN52-GEO 11.000	1	2	1	1	69.222	110	44	19.2248	42.2	-9.2	137.5
31050	GUCI51-GEO 11.000	1	2	1	1	34.611	55	24	8.6251	21.1	-4.6	75
31051	UNGRN54-GEO 11.000	1	2	1	1	34.611	55	24	11.0913	21.1	-4.6	75
31052	GUCI52-GEO 11.000	1	2	1	1	34.611	55	24	8.6251	21.1	-4.6	75
31053	JTENG72-COA 23.000	1	2	1	1	950	950	380	51.0809	589	-349	1118
31054	DIENG54-GEO 11.000	1	2	1	1	34.611	55	24	5.8528	21.1	-4.6	75
31055	DIENG55-GEO 11.000	1	2	1	1	34.611	55	24	5.8528	21.1	-4.6	75
31060	TJATIB75-COA18.000	1	2	1	1	800	1000	400	25.6102	620	-367	1176
31061	TJATIB76-COA18.000	1	2	1	1	1000	1000	400	44.043	620	-367	1176
32301	CLCAP72-COA 18.000	1	2	1	1	660	660	132	364.6318	409.03	-165	787
41000	TLGNG51-HYD 6.0000	1	4	1	0	0	18	7.2	1.139	13.5	-3.6	22.5
41001	TLGNG52-HYD 6.0000	1	4	1	0	0	18	7.2	1.02	13.5	-3.6	22.5
42000	GRSIK51-CC1 10.500	1	2	1	1	44.98	112.45	44.98	24.1305	52.937	-28.287	140.56
42001	GRSIK51-CC2 10.500	1	2	1	1	44.98	112.45	44.98	24.1305	52.937	-28.287	140.56
42002	GRSIK51-CC3 10.500	1	2	1	1	44.98	112.45	44.98	24.1305	49.143	-26.314	140.56
42003	GRSIK72-CC1 10.500	1	2	1	1	44.98	112.45	44.98	24.1305	49.143	-26.314	140.56
42004	GRSIK72-CC2 10.500	1	2	1	1	44.98	112.45	44.98	24.1305	49.143	-26.314	140.56
42005	GRSIK72-CC3 10.500	1	2	1	1	44.98	112.45	44.98	24.1305	49.143	-26.314	140.56
42006	GRSIK73-CC1 10.500	1	2	1	0	0	112.45	44.98	15.46	37	-20	140.56
42007	GRSIK73-CC2 10.500	1	2	1	1	44.98	112.45	44.98	28.7151	49.143	-26.314	140.56
42008	GRSK73-CC3 10.500	1	2	1	1	44.98	112.45	44.98	28.7151	49.143	-26.314	140.56
42009	GRATI71-CC1 10.500	1	2	1	1	40.3	100.75	40.3	11.2705	61.201	-29.746	125.94
42010	GRATI71-CC2 10.500	1	2	1	1	40.3	100.75	40.3	11.2705	61.201	-29.746	125.94
42011	GRATI71-CC3 10.500	1	2	1	1	40.3	100.75	40.3	11.2705	61.201	-29.746	125.94
42012	GRATI72-CC1 10.500	1	4	1	0	0	100.75	40.3	27.663	40	-10	125.94
42013	GRATI72-CC2 10.500	1	4	1	0	0	100.75	40.3	27.663	40	-10	125.94
42014	GRATI72-CC3 10.500	1	4	1	0	0	100.75	40.3	27.663	40	-10	125.94
42015	GRSIK51-OIL 11.000	1	4	1	0	0	100	40	23.2	32.5	-15	125
42016	GRSIK52-OIL 11.000	1	4	1	0	0	100	40	23.2	32.5	-15	125
42019	MNDLN51-HYD 11.000	1	2	1	1	2.73	5.8	2.32	-0.348	1.445	-0.838	7.25
42020	MNDLN52-HYD 11.000	1	2	1	1	2.72	5.8	2.32	-0.3485	1.445	-0.838	7.25
42021	MNDLN53-HYD 11.000	1	2	1	1	2.72	5.8	2.32	-0.3485	1.445	-0.838	7.25
42022	MNDLN54-HYD 11.000	1	2	1	1	0	5.8	2.32	-0.4093	1.445	-0.838	7.25
42025	PERAK53-OIL 11.000	1	2	1	0	0	50	20	37.5	16.3	-7.5	62.5
42026	PERAK54-OIL 11.000	1	2	1	0	0	50	20	37.5	16.3	-7.5	62.5
42029	WLNGI41-HYD 11.000	1	2	1	0	0	27	10.8	11.665	11.665	-1.364	33.75
42030	WLNGI42-HYD 11.000	1	2	1	0	0	27	10.8	11.665	11.665	-1.364	33.75
42031	SGRUH42-HYD 11.000	1	2	1	0	0	14.5	5.8	3.689	3.689	-2.026	18.13
42032	SGRUH41-HYD 11.000	1	2	1	0	0	14.5	5.8	3.689	3.689	-2.026	18.13
42033	SIMAN41-HYD 11.000	1	2	1	1	2.02	3.6	1.44	-0.1022	0.9	-0.5	4.5
42034	SIMAN42-HYD 11.000	1	2	1	1	2.02	3.6	1.44	-0.1022	0.9	-0.5	4.5
42035	SIMAN43-HYD 11.000	1	2	1	1	2.02	3.6	1.44	-0.1022	0.9	-0.5	4.5
42036	STAMI51-HYD 11.000	1	2	1	1	20.48	35	14	21.0319	26.25	-2.55	43.75
42037	STAMI52-HYD 11.000	1	2	1	1	0	35	14	20.422	26.25	-2.55	43.75
42038	STAMI53-HYD 11.000	1	2	1	1	0	35	14	20.422	26.25	-2.55	43.75
42039	SLRJO51-HYD 11.500	1	2	1	1	2.04	4.48	1.792	1.143	1.143	-0.639	5.6
42040	GRSKG53-OIL 15.000	1	4	1	0	0	200	80	87.62	65	-30	250
42041	GRSKG54-OIL 15.000	1	4	1	0	0	200	80	87.62	65	-30	250
42042	GRSIK51-CC0 15.750	1	2	1	1	75.6	189	75.6	40.5579	89.32	-44.08	236.25
42043	GRSIK72-CC0 15.750	1	2	1	1	75.6	189	75.6	48.2637	82.558	-44.215	236.25
42044	GRSIK73-CC0 15.750	1	2	1	0	0	189	75.6	21.421	62.2	-33.6	236.25
42045	GRATI71-CC0 15.750	1	2	1	1	151.5	160	64	23.6265	120	-37.465	200
42046	PITON71-COA 18.000	1	2	1	1	370	400	160	78.2166	247.898	-22.828	470.59
42047	PITON72-COA 18.000	1	2	1	1	370	400	160	78.2166	247.898	-22.828	470.59
42049	PITON75-COA 21.000	1	2	1	1	610	610	244	123.8651	265.859	-224.085	717.65
42050	PITON76-COA 21.000	1	2	1	0	0	610	244	106.207	265.859	-224.085	717.65
42051	PITON77-COA 23.000	1	2	1	1	615	615	246	124.8802	265.436	-225.922	723.53
42052	PITON78-COA 23.000	1	2	1	1	615	615	246	124.8802	265.436	-225.922	723.53
42053	PITON79-COA 23.000	1	2	1	1	650	650	260	2.7007	402.834	-238.779	764.71
42070	GRSIKG51-OIL11.000	1	2	1	1	8	20	8	8.0524	15	-13.17	25
42071	GRSIKG52-OIL11.000	1	2	1	1	8	20	8	8.0524	15	-13.17	25
42072	GRSIKG53-OIL11.000	1	2	1	1	8	20	8	8.0524	15	-13.17	25
42073	PCTAN51-COA 18.000	1	2	1	1	315	315	126	32.7523	194.75	-122.948	393.75
42074	PCTAN52-COA 18.000	1	2	1	1	315	315	126	32.7523	194.75	-122.948	393.75
42079	GLTMR51-OIL 6.0000	1	4	1	0	0	28	10	18	9.1	-4.2	100
42081	GLTMR52-OIL 6.0000	1	4	1	0	0	28	10	18	9.1	-4.2	100
42116	PITON734-COA23.000	1	3	1	1	617.2205	814.0001	326	153.6843	365.52	-117.26	1018.8
42118	WILIS51-GEO 11.000	1	2	1	1	34.611	55	22	3.1289	21.1	-4.6	68
42120	TJWAR51-COA 18.000	1	2	1	1	350	350	140	98.6485	115.8	-58.3	437.5

Table.17 Active and Reactive Power Outputs of Generators in 2021 (5/5)

Bus No.	Bus Name	Id	Code	Vsched	Inservice	Pgen	Pmax	Pmin	Qgen	Qmax	Qmin	Mbase
42121	WILIS52-GEO 11.000	1	2	1	1	34.611	55	22	3.1289	21.1	-4.6	68
42123	WILIS53-GEO 11.000	1	2	1	1	34.611	55	22	3.1289	21.1	-4.6	68
42124	IJEN51-GEO 11.000	1	2	1	1	34.611	55	22	7.2548	21.1	-4.6	68
42125	IJEN52-GEO 11.000	1	2	1	1	34.611	55	22	7.2548	21.1	-4.6	68
42126	TJWAR52-COA 18.000	1	2	1	1	350	350	140	98.6485	145.8	-58.3	437.5
42127	IYANG51-GEO 11.000	1	2	1	1	34.611	55	22	13.3105	21.1	-4.6	68
42128	MDURA51-COA 11.000	1	2	1	1	200	200	80	32.5075	123.9	-32.368	235.3
42129	MDURA52-COA111.000	1	2	1	1	200	200	80	32.5075	123.9	-32.368	235.3
42135	IYANG52-GEO 11.000	1	2	1	1	34.611	55	22	13.3105	21.1	-4.6	68
42136	IYANG53-GEO 11.000	1	2	1	1	34.611	55	22	13.3105	21.1	-4.6	68
42137	IYANG54-GEO 11.000	1	2	1	1	34.611	55	22	13.3105	21.1	-4.6	68
42138	IYANG55-GEO 11.000	1	2	1	1	34.611	55	22	13.3105	21.1	-4.6	68
42139	GRDLU71-HYD 11.000	1	2	1	0	0	250	100	62.26	62.26	-32	312.5
42140	GRDLU72-HYD 11.000	1	2	1	0	0	250	100	62.26	62.26	-32	312.5
42147	GRDLU73-HYD 11.000	1	2	1	0	0	250	100	62.26	62.26	-32	312.5
42148	GRDLU74-HYD 11.000	1	2	1	0	0	250	100	62.26	62.26	-32	312.5
42300	GRATI73-CC0 10.500	1	2	1	1	104	260	104	27.6276	161	-96	306
42301	GRATI73-CC1 10.500	1	2	1	1	98	245	98	26.0073	152	-90	288
42302	GRATI73-CC2 10.500	1	2	1	1	98	245	98	26.0073	152	-90	288
42400	GRSIK740-CC 10.500	1	2	1	1	100	250	100	64.3202	93	-37.2	312.5
42401	GRSIK741-CC 10.500	1	2	1	1	100	250	100	64.3202	93	-37.2	312.5
42402	GRSIK742-CC 10.500	1	2	1	1	100	250	100	64.3202	93	-37.2	312.5
51000	PSGRN51-DIE 6.3000	1	2	1	1	7.551	12	4.8	1.786	5.302	-1.087	15
51001	PSGRN52-DIE 6.3000	1	2	1	1	7.551	12	4.8	1.786	5.302	-1.087	15
51011	PSGRN53-DIE 20.000	1	2	1	0	3.924	5	2	0.155	3.75	-3.292	6.25
52002	CLKBW11 11.000	1	2	1	1	81.807	130	52	8.873	57.668	-11.576	162.5
52003	CLKBW12 11.000	1	2	1	1	78.661	125	50	8.5257	55.392	-11.132	156
52004	CLKBW13 11.000	1	2	1	1	78.661	125	50	8.5257	55.392	-11.132	156
52006	PMRON51-GAS 11.000	1	2	1	1	30.835	49	19.6	2.9941	16.627	-9.067	61.25
52008	PMRON52-GAS 11.000	1	2	1	1	30.835	49	19.6	2.9941	16.627	-9.067	61.25
52009	PSGRN51-GAS 11.500	1	2	1	1	13.215	21	8.4	3.1256	8.771	-2.25	26.25
52010	PSGRN52-GAS 11.500	1	2	1	1	12.586	20	8	2.9768	15	-13.17	25
52011	PSGRN53-GAS 11.500	1	2	1	1	26.43	42	16.8	6.2512	17.514	-4.525	52.5
52012	PSGRN54-GAS 11.500	1	2	1	1	26.43	42	16.8	6.2512	17.514	-4.525	52.5
52014	GLMNK51-GAS 16.000	1	2	1	1	91.876	146	58.4	32.3668	62.302	-34.996	182.5
52020	BALIT51 11.000	1	2	1	1	62.929	100	40	1.2731	42.948	-8.808	125
52021	BALIT52 11.000	1	2	1	1	62.929	100	40	1.2731	42.948	-8.808	125
52900	PMRON-BOO1 11.000	1	2	1	1	29.487	45	18	2.914	27.889	-16.531	52.94
52901	PMRON-BOO2 11.000	1	2	1	1	29.487	45	18	2.914	27.880	-16.531	52.94
52902	PMRON-BOO3 11.000	1	4	1	1	30	45	18	14.046	27.889	-16.531	52.94
52904	PSRAN-BOT 20.000	1	2	1	1	44.23	50	20	8.2933	30.987	-18.368	58.82
52905	PSRAN-BOO1 11.000	1	2	1	1	8.846	10	4	1.8722	6.197	-3.674	11.76
52906	PSRAN-BOO2 11.000	1	2	1	1	8.846	10	4	1.8722	6.197	-3.674	11.76
52907	PSRAN-BOO3 11.000	1	2	1	1	8.846	10	4	1.8722	6.197	-3.674	11.76
52910	PSRAN-PEAKR120.000	1	2	1	1	44.23	50	20	8.2933	30.987	-18.368	58.82
52911	PSRAN-PEAKR220.000	1	2	1	1	44.23	50	20	8.2933	30.987	-18.368	58.82

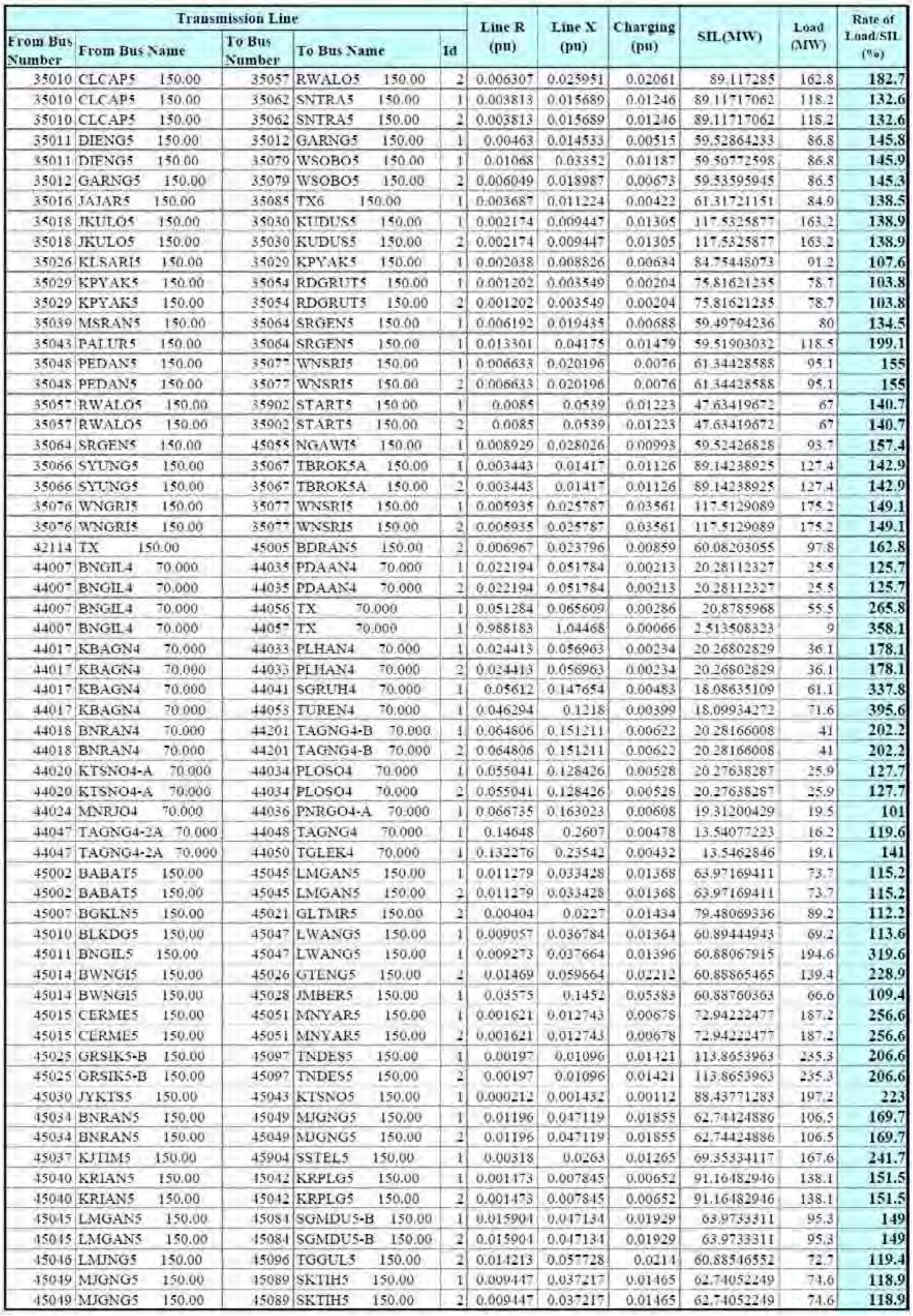
Table.18 Comparison of Load Flow and SIL Value of Transmission Lines in 2021 (1/4)

Transmission Line					Line R (pu)	Line X (pu)	Charging (pu)	SIL(MW)	Load (MW)	Rate of Load/SIL (%)
From Bus Number	From Bus Name	To Bus Number	To Bus Name	Id						
14003	CBDAK4 70.000	14021	UBRUG4 70.000	1	0.043944	0.075864	0.00148	13.96731697	15.4	**110.3**
14003	CBDAK4 70.000	14021	UBRUG4 70.000	2	0.043944	0.075864	0.00148	13.96731697	15.4	**110.3**
14005	CIBNG4 70.000	14006	CLGSI4 70.000	1	0.024763	0.045795	0.00078	13.05083412	16.2	**124.1**
14005	CIBNG4 70.000	14006	CLGSI4 70.000	2	0.024763	0.045795	0.00078	13.05083412	16.2	**124.1**
14005	CIBNG4 70.000	14025	GDRIA4 70.000	1	0.052378	0.090423	0.00176	13.95137069	18.2	**130.5**
14005	CIBNG4 70.000	14025	GDRIA4 70.000	2	0.052378	0.090423	0.00176	13.95137069	18.2	**130.5**
15005	ANGKE5A 150.00	15042	KARET5A 150.00	1	0.001488	0.006467	0.00893	117.5098573	241.8	**205.8**
15005	ANGKE5A 150.00	15042	KARET5A 150.00	2	0.001488	0.006467	0.00893	117.5098573	241.8	**205.8**
15009	BGBRU5 150.00	15089	SNTUL5 150.00	1	0.005041	0.017576	0.00678	62.10904121	71.5	**115.1**
15009	BGBRU5 150.00	15089	SNTUL5 150.00	2	0.005041	0.017576	0.00678	62.10904121	71.5	**115.1**
15009	BGBRU5 150.00	15156	KDBDK5 150.00	1	0.00094	0.00409	0.00565	117.5337438	175.3	**149.1**
15009	BGBRU5 150.00	15156	KDBDK5 150.00	2	0.00094	0.00409	0.00565	117.5337438	175.3	**149.1**
15010	BKASI5A 150.00	15064	MRNDA5 150.00	1	0.002431	0.010003	0.00795	89.14940109	176.7	**198.2**
15010	BKASI5A 150.00	25171	BKASI5-2 150.00	1	0.000377	0.002417	0.00208	92.76696372	133.5	**143.9**
15010	BKASI5A 150.00	25174	BKASI5-2 150.00	2	0.000377	0.002417	0.00208	92.76696372	133.5	**143.9**
15011	BLRJA5 150.00	15115	CKUPA5B 150.00	1	0.001994	0.053886	0.01103	45.24283209	135.7	**299.9**
15011	BLRJA5 150.00	15115	CKUPA5B 150.00	2	0.001994	0.053886	0.01103	45.24283209	135.7	**299.9**
15013	CBDAK5 150.00	15141	CIAWI5 150.00	1	0.00221	0.02102	0.0342	127.554768	210.4	**164.9**
15013	CBDAK5 150.00	15141	CIAWI5 150.00	2	0.00221	0.02102	0.0342	127.554768	210.4	**164.9**
15017	CKNDE5 150.00	15067	PCADM5 150.00	1	0.000578	0.003715	0.0032	92.81017255	99.8	**107.5**
15017	CKNDE5 150.00	15067	PCADM5 150.00	2	0.000578	0.003715	0.0032	92.81017255	99.8	**107.5**
15018	CKUPA5A 150.00	15108	LIPPO5 150.00	2	0.00124	0.01152	0.01394	110.0031565	146.8	**133.5**
15020	CLGBR5 150.00	15052	KSTEL5 150.00	1	0.000723	0.004646	0.004	92.78769642	114.1	**123**
15020	CLGBR5 150.00	15052	KSTEL5 150.00	2	0.000723	0.004646	0.004	92.78769642	114.1	**123**
15020	CLGBR5 150.00	15092	SRANG5 150.00	1	0.0039	0.02547	0.02199	92.9176339	229.1	**246.6**
15020	CLGBR5 150.00	15092	SRANG5 150.00	2	0.0039	0.02547	0.02199	92.9176339	229.1	**246.6**
15020	CLGBR5 150.00	15904	INFRO5 150.00	1	0.000463	0.002973	0.00256	92.7945624	133	**143.3**
15020	CLGBR5 150.00	15904	INFRO5 150.00	2	0.000463	0.002973	0.00256	92.7945624	133	**143.3**
15022	CLGON5B 150.00	15907	SMTRKIEC5 150.00	1	0.00145	0.00519	0.00199	61.92169833	68.5	**110.6**
15025	CNKNG5 150.00	15098	TGRNG5 150.00	1	0.003204	0.015471	0.00632	63.91449268	70.4	**110.1**
15025	CNKNG5 150.00	15098	TGRNG5 150.00	2	0.003204	0.015471	0.00632	63.91449268	70.4	**110.1**
15028	CWGBR5 150.00	15031	DTIGA5 150.00	1	0.000301	0.002862	0.00466	127.6021946	193.3	**151.5**
15028	CWGBR5 150.00	15031	DTIGA5 150.00	2	0.000301	0.002862	0.00466	127.6021946	193.3	**151.5**
15033	DUKSB5B 150.00	15172	TX 150.00	1	0.00112	0.007305	0.0063	92.86673236	109.1	**117.5**
15033	DUKSB5B 150.00	15173	TX 150.00	1	0.001119	0.007306	0.00631	92.93404612	109	**117.3**
15043	KARET5B 150.00	15116	SMNGIB-1 150.00	1	0.00109	0.00351	0.0023	80.94878969	102.3	**126.4**
15043	KARET5B 150.00	15117	SMNGIB-2 150.00	2	0.00109	0.00351	0.0023	80.94878969	102.3	**126.4**
15048	KMBNG5 150.00	15164	ALAM5 150.00	1	0.000925	0.008645	0.01046	109.9976339	152.7	**138.8**
15066	DEPOK5 150.00	15203	DEPOK5-2 150.00	1	0.00106	0.0068	0.00585	92.75204136	97.4	**105**
15066	DEPOK5 150.00	15203	DEPOK5-2 150.00	2	0.00106	0.0068	0.00585	92.75204136	97.4	**105**
15068	PDKLP5A 150.00	15127	TX 150.00	1	0.001041	0.006796	0.00587	92.93779524	267.9	**288.3**
15068	PDKLP5A 150.00	15129	TX 150.00	1	0.000908	0.005924	0.00511	92.87587645	279.8	**301.3**
15071	PGSAN5 150.00	15073	PLGDG5A 150.00	1	0.000746	0.004871	0.0042	92.85719926	221.2	**238.2**
15071	PGSAN5 150.00	15075	PLMAS5 150.00	1	0.001323	0.0085	0.00732	92.79959432	226.5	**244.1**
15071	PGSAN5 150.00	15075	PLMAS5 150.00	2	0.001323	0.0085	0.00732	92.79959432	226.5	**244.1**
15073	PLGDG5A 150.00	15074	PLGDG5B 150.00	1	0.000043	0.000283	0.00024	92.08998518	96.8	**105.1**
15075	PLMAS5 150.00	15133	TX 150.00	1	0.000258	0.002453	0.00399	127.5374337	155	**121.5**
15075	PLMAS5 150.00	15134	TX 150.00	2	0.000258	0.002453	0.00399	127.5374337	155	**121.5**
15077	PLPNG5-40 150.00	15110	KLPGD5 150.00	1	0.00052	0.0034	0.00293	92.83128276	132.7	**142.9**
15077	PLPNG5-40 150.00	15110	KLPGD5 150.00	2	0.00052	0.0034	0.00293	92.83128276	132.7	**142.9**
15078	PRBRT5 150.00	15910	PELINDOB 150.00	1	0.0013	0.00565	0.0078	117.4959988	292.4	**248.9**
15078	PRBRT5 150.00	15910	PELINDOB 150.00	2	0.0013	0.00565	0.0078	117.4959988	292.4	**248.9**
15092	SRANG5 150.00	15905	IKIAT5 150.00	1	0.001067	0.006855	0.0059	92.77314433	167.4	**180.4**
15095	SRPNG5A 150.00	15255	TX 150.00	1	0.001345	0.00976	0.00709	85.23112262	190.7	**223.7**
15104	LBUAN5 150.00	15105	SKETI5 150.00	1	0.00406	0.02607	0.02244	92.77712507	118.8	**128**
15104	LBUAN5 150.00	15105	SKETI5 150.00	2	0.00406	0.02607	0.02244	92.77712507	118.8	**128**
15106	BLRJA5-N 150.00	15140	LSTEL5 150.00	1	0.00245	0.01064	0.0147	117.5405865	264.1	**224.7**
15106	BLRJA5-N 150.00	15140	LSTEL5 150.00	2	0.00245	0.01064	0.0147	117.5405865	264.1	**224.7**
15112	LBSTU5 150.00	25023	CNJUR5B 150.00	1	0.00565	0.03627	0.03122	92.77750124	121.5	**131**
15112	LBSTU5 150.00	25023	CNJUR5B 150.00	2	0.00565	0.03627	0.03122	92.77750124	121.5	**131**
15114	PRATU5 150.00	15220	CBDAK5-2 150.00	2	0.00706	0.04533	0.03903	92.79111987	344.8	**371.6**

Table.19 Comparison of Load Flow and SIL Value of Transmission Lines in 2021 (2/4)

Transmission Line					Line R (pu)	Line X (pu)	Charging (pu)	SIL(MW)	Load (MW)	Rate of Load/SIL (%)
From Bus Number	From Bus Name	To Bus Number	To Bus Name	Id						
15127	TX 150.00	15130	JTWRG5 150.00	1	0.00212	0.0136	0.01171	92.79167052	267	**287.7**
15129	TX 150.00	15130	JTWRG5 150.00	1	0.00212	0.0136	0.01171	92.79167052	279.1	**300.8**
15143	TNAGA5-2 150.00	15277	TNAGA5-2 150.00	1	0.00019	0.00082	0.00113	117.3903224	127.1	**108.3**
15143	TNAGA5-2 150.00	15277	TNAGA5-2 150.00	2	0.00019	0.00082	0.00113	117.3903224	127.1	**108.3**
15172	TX 150.00	15174	DMGOT5 150.00	1	0.00018	0.00113	0.00098	93.12661473	108.9	**116.9**
15173	TX 150.00	15174	DMGOT5 150.00	1	0.00018	0.00113	0.00098	93.12661473	108.9	**116.9**
15226	BOGORX7-HVDC500	17004	CIBNG7 500.00	1	0.000132	0.001635	0.156098	87.93915745	1598.7	**1818**
15226	BOGORX7-HVDC500	17005	CLGON7 500.00	1	0.000132	0.001635	0.156098	87.93915745	411.9	**468.4**
15226	BOGORX7-HVDC500	17008	DEPOK7 500.00	1	0.001186	0.014717	1.404884	87.93324449	279.8	**318.2**
15226	BOGORX7-HVDC500	17008	DEPOK7 500.00	2	0.001186	0.014717	1.404884	87.93324449	279.8	**318.2**
17300	BKASI-3 500.00	27009	MTWAR7 500.00	1	0.000088	0.00109	0.104066	977.1048792	1000	**102.3**
17300	BKASI-3 500.00	27009	MTWAR7 500.00	2	0.000088	0.00109	0.104066	977.1048792	1000	**102.3**
22226	TX 150.00	25110	CBBAT5-2 150.00	1	0.00212	0.01006	0.0041	63.84000877	70.1	**109.8**
22228	TX 150.00	25118	DKLOT5 150.00	1	0.00026	0.0017	0.00146	92.6727322	138.7	**149.7**
24001	ARJWN4B 70.000	24048	PLMNN4 70.000	1	0.01316	0.04008	0.00071	13.30960963	35.9	**269.7**
24001	ARJWN4B 70.000	24048	PLMNN4 70.000	2	0.01185	0.03607	0.00064	13.32038924	39.9	**299.5**
24006	BNJAR4 70.000	24046	PGDRN4 70.000	1	0.196194	0.338705	0.00659	13.94864121	16.9	**121.2**
24006	BNJAR4 70.000	24046	PGDRN4 70.000	2	0.196194	0.338705	0.00659	13.94864121	16.9	**121.2**
24038	LMJAN4 70.000	24062	SMDRA4 70.000	1	0.079898	0.137934	0.00269	13.96498504	29.9	**214.1**
24057	PWKTA4B 70.000	24901	SPFVI4 70,000	1	0.028874	0.049579	0.00097	13.98739971	40.8	**291.7**
25000	BDSLN5 150.00	25015	CGRLG5B 150.00	1	0.00372	0.01491	0.01288	92.94351862	119.6	**128.7**
25003	BDUTR5B 150.00	25720	PDLRG5-B 150.00	1	0.007339	0.022343	0.0084	61.31530604	191.3	**312**
25003	BDUTR5B 150.00	25720	PDLRG5-B 150.00	2	0.007339	0.022343	0.0084	61.31530604	191.3	**312**
25008	CBATU5A 150.00	25062	MKSRI5 150.00	1	0.000865	0.005553	0.00478	92.77909065	244.6	**263.6**
25008	CBATU5A 150.00	25062	MKSRI5 150.00	2	0.000865	0.005553	0.00478	92.77909065	244.6	**263.6**
25009	CBATU5B 150.00	25134	CLIPO5 150.00	1	0.00203	0.01303	0.01122	92.79492404	106.3	**114.6**
25009	CBATU5B 150.00	25134	CLIPO5 150.00	2	0.00203	0.01303	0.01122	92.79492404	106.3	**114.6**
25009	CBATU5B 150.00	25190	JBBKA5-2 150.00	1	0.00306	0.01962	0.01689	92.78234041	128.5	**138.5**
25009	CBATU5B 150.00	25190	JBBKA5-2 150.00	2	0.00306	0.01962	0.01689	92.78234041	128.5	**138.5**
25015	CGRLG5B 150.00	25194	CGRLG5-2 150.00	1	0.001708	0.008046	0.00656	90.29462643	110.2	**122**
25015	CGRLG5B 150.00	25194	CGRLG5-2 150.00	2	0.001708	0.008046	0.00656	90.29462643	110.2	**122**
25017	CIKRG5B 150.00	25903	GNRJP5 150.00	1	0.00104	0.00669	0.00576	92.78936076	105	**113.2**
25017	CIKRG5B 150.00	25903	GNRJP5 150.00	2	0.00104	0.00669	0.00576	92.78936076	105	**113.2**
25020	CKSKA5 150.00	25088	RCKSB5 150.00	1	0.003158	0.011011	0.00425	62.12710026	127.7	**205.5**
25020	CKSKA5 150.00	25088	RCKSB5 150.00	2	0.003158	0.011011	0.00425	62.12710026	127.7	**205.5**
25024	CRATA5 150.00	25072	PDLRG5 150.00	1	0.012434	0.039977	0.02614	80.8625982	104.9	**129.7**
25024	CRATA5 150.00	25072	PDLRG5 150.00	2	0.012434	0.039977	0.02614	80.8625982	104.9	**129.7**
25038	IDMYU5 150.00	25913	IDMLY5 150.00	1	0.00113	0.00491	0.00678	117.5098037	220.4	**187.6**
25038	IDMYU5 150.00	25913	IDMLY5 150.00	2	0.00113	0.00491	0.00678	117.5098037	220.4	**187.6**
25042	JTBRG5 150.00	25158	CKRNG5 150.00	1	0.001172	0.00753	0.00648	92.76625297	98.8	**106.5**
25042	JTBRG5 150.00	25158	CKRNG5 150.00	2	0.001172	0.00753	0.00648	92.76625297	98.8	**106.5**
25052	KSBRU5A 150.00	25054	KTMKR5 150.00	1	0.00132	0.008477	0.0073	92.79836798	101.3	**109.2**
25052	KSBRU5A 150.00	25064	MLIGI5 150.00	1	0.001182	0.007593	0.00654	92.80730771	180.3	**194.3**
25053	KSBRU5B 150.00	25901	TTJBR5 150.00	1	0.00229	0.01473	0.01268	92.78083001	111.7	**120.4**
25053	KSBRU5B 150.00	25901	TTJBR5 150.00	2	0.00229	0.01473	0.01268	92.78083001	111.7	**120.4**
25054	KTMKR5 150.00	25080	PRMYA5 150.00	1	0.000902	0.005791	0.00499	92.82682372	100.5	**108.3**
25060	MDRCN5 150.00	25140	KDPTN5 150.00	1	0.00159	0.01022	0.0088	92.79314368	160.4	**172.9**
25060	MDRCN5 150.00	25140	KDPTN5 150.00	2	0.00159	0.01022	0.0088	92.79314368	160.4	**172.9**
25062	MKSRI5 150.00	25078	PNYNG5 150.00	1	0.000759	0.004873	0.0042	92.83814185	222.9	**240.1**
25062	MKSRI5 150.00	25078	PNYNG5 150.00	2	0.000759	0.004873	0.0042	92.83814185	222.9	**240.1**
25072	PDLRG5 150.00	25204	LGDAR5-2 150.00	1	0.003153	0.009378	0.00357	61.69912341	71.8	**116.4**
25072	PDLRG5 150.00	25204	LGDAR5-2 150.00	2	0.003153	0.009378	0.00357	61.69912341	71.8	**116.4**
25078	PNYNG5 150.00	25082	PRURI5 150.00	1	0.000796	0.005111	0.0044	92.78406545	93.8	**101.1**
25086	RCKEK5 150.00	25102	UBRNG5 150.00	1	0.00221	0.01417	0.0122	92.78867865	299.3	**322.6**
25098	TMBUN5 150.00	25200	PNCOL5-2 150.00	1	0.00203	0.01303	0.01122	92.79492404	128.3	**138.3**
25098	TMBUN5 150.00	25200	PNCOL5-2 150.00	2	0.00203	0.01303	0.01122	92.79492404	128.3	**138.3**
25140	KDPTN5 150.00	25202	PRKAN5 150.00	1	0.00147	0.009444	0.00813	92.78275921	100.6	**108.4**
25140	KDPTN5 150.00	25202	PRKAN5 150.00	2	0.00147	0.009444	0.00813	92.78275921	100.6	**108.4**
35003	BNTUL5 150.00	35013	GDEAN5 150.00	1	0.007023	0.022043	0.00781	59.52373391	76	**127.7**
35003	BNTUL5 150.00	35028	KNTGN5 150.00	1	0.011441	0.035912	0.01272	59.51463295	59.5	**100**
35010	CLCAP5 150.00	35057	RWALO5 150.00	1	0.006307	0.025951	0.02061	89.117285	162.8	**182.7**

Table.20 Comparison of Load Flow and SIL Value of Transmission Lines in 2021 (3/4)



Transmission Line					Line R (pu)	Line X (pu)	Charging (pu)	SIL(MW)	Load (MW)	Rate of Load/SIL (%)
From Bus Number	From Bus Name	To Bus Number	To Bus Name	Id						
35010	CLCAP5 150.00	35057	RWALO5 150.00	2	0.006307	0.025951	0.02061	89.117285	162.8	**182.7**
35010	CLCAP5 150.00	35062	SNTRA5 150.00	1	0.003813	0.015689	0.01246	89.11717062	118.2	**132.6**
35010	CLCAP5 150.00	35062	SNTRA5 150.00	2	0.003813	0.015689	0.01246	89.11717062	118.2	**132.6**
35011	DIENG5 150.00	35012	GARNG5 150.00	1	0.00463	0.014533	0.00515	59.52864233	86.8	**145.8**
35011	DIENG5 150.00	35079	WSOBO5 150.00	1	0.01068	0.03352	0.01187	59.50772598	86.8	**145.9**
35012	GARNG5 150.00	35079	WSOBO5 150.00	2	0.006049	0.018987	0.00673	59.53595945	86.5	**145.3**
35016	JAJAR5 150.00	35085	TX6 150.00	1	0.003687	0.011224	0.00422	61.31721151	84.9	**138.5**
35018	JKULO5 150.00	35030	KUDUS5 150.00	1	0.002174	0.009447	0.01305	117.5325877	163.2	**138.9**
35018	JKULO5 150.00	35030	KUDUS5 150.00	2	0.002174	0.009447	0.01305	117.5325877	163.2	**138.9**
35026	KLSARI5 150.00	35029	KPYAK5 150.00	1	0.002038	0.008826	0.00634	84.75448073	91.2	**107.6**
35029	KPYAK5 150.00	35054	RDGRUT5 150.00	1	0.001202	0.003549	0.00204	75.81621235	78.7	**103.8**
35029	KPYAK5 150.00	35054	RDGRUT5 150.00	2	0.001202	0.003549	0.00204	75.81621235	78.7	**103.8**
35039	MSRAN5 150.00	35064	SRGEN5 150.00	1	0.006192	0.019435	0.00688	59.49794236	80	**134.5**
35043	PALUR5 150.00	35064	SRGEN5 150.00	1	0.013301	0.04175	0.01479	59.51903032	118.5	**199.1**
35048	PEDAN5 150.00	35077	WNSRI5 150.00	1	0.006633	0.020196	0.0076	61.34428588	95.1	**155**
35048	PEDAN5 150.00	35077	WNSRI5 150.00	2	0.006633	0.020196	0.0076	61.34428588	95.1	**155**
35057	RWALO5 150.00	35902	START5 150.00	1	0.0085	0.0539	0.01223	47.63419672	67	**140.7**
35057	RWALO5 150.00	35902	START5 150.00	2	0.0085	0.0539	0.01223	47.63419672	67	**140.7**
35064	SRGEN5 150.00	45055	NGAWI5 150.00	1	0.008929	0.028026	0.00993	59.52426828	93.7	**157.4**
35066	SYUNG5 150.00	35067	TBROK5A 150.00	1	0.003443	0.01417	0.01126	89.14238925	127.4	**142.9**
35066	SYUNG5 150.00	35067	TBROK5A 150.00	2	0.003443	0.01417	0.01126	89.14238925	127.4	**142.9**
35076	WNGRI5 150.00	35077	WNSRI5 150.00	1	0.005935	0.025787	0.03561	117.5129089	175.2	**149.1**
35076	WNGRI5 150.00	35077	WNSRI5 150.00	2	0.005935	0.025787	0.03561	117.5129089	175.2	**149.1**
42114	TX 150.00	45005	BDRAN5 150.00	2	0.006967	0.023796	0.00859	60.08203055	97.8	**162.8**
44007	BNGIL4 70.000	44035	PDAAN4 70.000	1	0.022194	0.051784	0.00213	20.28112327	25.5	**125.7**
44007	BNGIL4 70.000	44035	PDAAN4 70.000	2	0.022194	0.051784	0.00213	20.28112327	25.5	**125.7**
44007	BNGIL4 70.000	44056	TX 70.000	1	0.051284	0.065609	0.00286	20.8785968	55.5	**265.8**
44007	BNGIL4 70.000	44057	TX 70.000	1	0.988183	1.04468	0.00066	2.513508323	9	**358.1**
44017	KBAGN4 70.000	44033	PLHAN4 70.000	1	0.024413	0.056963	0.00234	20.26802829	36.1	**178.1**
44017	KBAGN4 70.000	44033	PLHAN4 70.000	2	0.024413	0.056963	0.00234	20.26802829	36.1	**178.1**
44017	KBAGN4 70.000	44041	SGRUH4 70.000	1	0.05612	0.147654	0.00483	18.08635109	61.1	**337.8**
44017	KBAGN4 70.000	44053	TUREN4 70.000	1	0.046294	0.1218	0.00399	18.09934272	71.6	**395.6**
44018	BNRAN4 70.000	44201	TAGNG4-B 70.000	1	0.064806	0.151211	0.00622	20.28166008	41	**202.2**
44018	BNRAN4 70.000	44201	TAGNG4-B 70.000	2	0.064806	0.151211	0.00622	20.28166008	41	**202.2**
44020	KTSNO4-A 70.000	44034	PLOSO4 70.000	1	0.055041	0.128426	0.00528	20.27638287	25.9	**127.7**
44020	KTSNO4-A 70.000	44034	PLOSO4 70.000	2	0.055041	0.128426	0.00528	20.27638287	25.9	**127.7**
44024	MNRJO4 70.000	44036	PNRGO4-A 70.000	1	0.066735	0.163023	0.00608	19.31200429	19.5	**101**
44047	TAGNG4-2A 70.000	44048	TAGNG4 70.000	1	0.14648	0.2607	0.00478	13.54077223	16.2	**119.6**
44047	TAGNG4-2A 70.000	44050	TGLEK4 70.000	1	0.132276	0.23542	0.00432	13.5462846	19.1	**141**
45002	BABAT5 150.00	45045	LMGAN5 150.00	1	0.011279	0.033428	0.01368	63.97169411	73.7	**115.2**
45002	BABAT5 150.00	45045	LMGAN5 150.00	2	0.011279	0.033428	0.01368	63.97169411	73.7	**115.2**
45007	BGKLN5 150.00	45021	GLTMR5 150.00	2	0.00404	0.0227	0.01434	79.48069336	89.2	**112.2**
45010	BLKDG5 150.00	45047	LWANG5 150.00	1	0.009057	0.036784	0.01364	60.89444943	69.2	**113.6**
45011	BNGIL5 150.00	45047	LWANG5 150.00	1	0.009273	0.037664	0.01396	60.88067915	194.6	**319.6**
45014	BWNGI5 150.00	45026	GTENG5 150.00	2	0.01469	0.059664	0.02212	60.88865465	139.4	**228.9**
45014	BWNGI5 150.00	45028	JMBER5 150.00	1	0.03575	0.1452	0.05383	60.88760363	66.6	**109.4**
45015	CERME5 150.00	45051	MNYAR5 150.00	1	0.001621	0.012743	0.00678	72.94222477	187.2	**256.6**
45015	CERME5 150.00	45051	MNYAR5 150.00	2	0.001621	0.012743	0.00678	72.94222477	187.2	**256.6**
45025	GRSIK5-B 150.00	45097	TNDES5 150.00	1	0.00197	0.01096	0.01421	113.8653963	235.3	**206.6**
45025	GRSIK5-B 150.00	45097	TNDES5 150.00	2	0.00197	0.01096	0.01421	113.8653963	235.3	**206.6**
45030	JYKTS5 150.00	45043	KTSNO5 150.00	1	0.000212	0.001432	0.00112	88.43771283	197.2	**223**
45034	BNRAN5 150.00	45049	MJGNG5 150.00	1	0.01196	0.047119	0.01855	62.74424886	106.5	**169.7**
45034	BNRAN5 150.00	45049	MJGNG5 150.00	2	0.01196	0.047119	0.01855	62.74424886	106.5	**169.7**
45037	KJTIM5 150.00	45904	SSTEL5 150.00	1	0.00318	0.0263	0.01265	69.35334117	167.6	**241.7**
45040	KRIAN5 150.00	45042	KRPLG5 150.00	1	0.001473	0.007845	0.00652	91.16482946	138.1	**151.5**
45040	KRIAN5 150.00	45042	KRPLG5 150.00	2	0.001473	0.007845	0.00652	91.16482946	138.1	**151.5**
45045	LMGAN5 150.00	45084	SGMDU5-B 150.00	1	0.015904	0.047134	0.01929	63.9733311	95.3	**149**
45045	LMGAN5 150.00	45084	SGMDU5-B 150.00	2	0.015904	0.047134	0.01929	63.9733311	95.3	**149**
45046	LMJNG5 150.00	45096	TGGUL5 150.00	2	0.014213	0.057728	0.0214	60.88546552	72.7	**119.4**
45049	MJGNG5 150.00	45089	SKTIH5 150.00	1	0.009447	0.037217	0.01465	62.74052249	74.6	**118.9**
45049	MJGNG5 150.00	45089	SKTIH5 150.00	2	0.009447	0.037217	0.01465	62.74052249	74.6	**118.9**

Table.21 Comparison of Load Flow and SIL Value of Transmission Lines in 2021 (4/4)

Transmission Line					Line R (pu)	Line X (pu)	Charging (pu)	SIL(MW)	Load (MW)	Rate of Load/SIL (%)
From Bus Number	From Bus Name	To Bus Number	To Bus Name	Id						
45069	PAKIS5 150.00	45201	KBAGN5-B 150.00	2	0.002276	0.014619	0.01259	92.80129401	116.4	**125.4**
45069	PAKIS5 150.00	45201	KBAGN5-B 150.00	3	0.002276	0.014619	0.01259	92.80129401	116.4	**125.4**
45073	PIER5 150.00	45221	PSARI5 150.00	1	0.001057	0.00679	0.00585	92.8203167	178.1	**191.9**
45083	WNRJO5 150.00	45228	KLSRI5 150.00	2	0.00081	0.00521	0.00449	92.83341115	210.1	**226.3**
45083	WNRJO5 150.00	45228	KLSRI5 150.00	3	0.00081	0.00521	0.00449	92.83341115	210.1	**226.3**
45095	SWHAN5 150.00	45102	WARU5 150.00	2	0.002318	0.012344	0.01026	91.16869197	129	**141.5**
45095	SWHAN5 150.00	45220	SMGNG5 150.00	1	0.001159	0.006172	0.00513	91.16869197	129	**141.5**
47007	PITON7 500.00	47011	BNGIL7 500.00	2	0.000009	0.000109	0.010407	977.1236576	1015.8	**104**
47007	PITON7 500.00	47011	BNGIL7 500.00	3	0.000009	0.000109	0.010407	977.1236576	1015.8	**104**

Glossary

Words	Term Meanings
positive phase voltage	The positive sequence of balanced voltage analyzed by the use of the techniques of symmetric components.
negative phase voltage	The negative sequence of balanced voltage analyzed by the use of the techniques of symmetric components.
surge voltage	The surge voltages appear in electric equipment when abrupt changes occur in operating conditions.
Over Current	The over current is a situation where a larger than intended electric current exists through a conductor
Under Voltage	Under Voltage is the level to keep machinery from starting automatically
Unbalance	The case is called unbalance that three phases in practice three-phase circuits have unbalanced voltages, frequencies and phases.
AVR	The automatic voltage regulator or AVR, as the name implies, is a device intended to regulate voltage automatically: that is to take a varying voltage level and turn it into a constant voltage level.
AQR	AQR changes exciting current automatically to control reactive power of generators.
On-load Tap-changer	More expensive and complex equipment that fits transformers to avoid a supply interruption during a tap change
Off-load Tap-changer	Equipment to change a tap position during its off-load
Nominal Voltage	Standard voltage for the system
Telemeter	Equipment to measure the data from remote location
bank down power flow	Power flow from primarily winding to secondary winding.
Interface Flow	The active and reactive power flows of interconnected power system
Surge Resistance	Resistance of electric equipment when abrupt changes occur in operating conditions.
Speed Regulation	The rate of the speed for the changes of generating outputs with the governor under normal operation.
Digsilent	A tool to analyze power flows
Economic Load Dispatch Function	The function to dispatch loads economically
N-1 contingency	One-circuit under an accident
LFC function	The function of load - frequency control

Workshop and Seminar Materials

AGENDA

The Workshop on the Study on Power Supply Reliability Improvement in Jakarta

Date: 18, Apr 2013
Venue: Ambhara Hotel, JI. Iskandarsyah Raya 1, Blok M 12160
Attendants : PLN, P3B, Indonesia Power, PJB

Time table:

8:15 – 8:45	Registration	
8:45 – 9:00	Opening remarks	**Representative of JICA Indonesia** **PLN Head of System Planning Division Djoko Prasetyo**
9:00 – 9:20	Outlines	**Mr. Masaharu YOGO** Team Leader/Power Supply Planner
9:20 – 9:50	Study of the System of 2012	**Mr. Atsumasa SAKAI** Power System Operation Analyst
9:50– 10:20	Study of the System of 2015	**Mr. Masaya OTSUKI** Power Supply System Planner
10:20 – 10:35	(Coffee break)	
10:35– 11:05	Study of the System of 2021	**Mr. Masaharu YOGO** Team Leader/Power Supply Planner
11:05 – 11:35	Voltage & Frequency Control	**Mr. Hitoshi OMATA** Power Generation Facility Planner
11:35 – 12:05	Capacitor Installation	**Mr. Takashi WAKABAYASHI** **Mr. Eiji MATSUDA** Substation Facility Operation Planner
12:05– 12:15	Q&A	
12:15 – 12:25	Closing Remarks	**PLN**
12:25– 13:25	(Lunch)	

Outlines of the Study

The Workshop
on
The Study on Power Supply Reliability Improvement in Jakarta

Jakarta, April 18, 2013

PT.PLN (Persero)

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Company Inc.

Nippon Koei Co., LTD

Schedule of the Study

- 1st mission (Dec. 2012), 2nd (Jan.-Feb.2013) & 3rd (Apr. 2013)
- Review Power Supply and System Operation Plan
- Confirm the Current Situation of System Operation
- Develop Voltage Stabilization Plan

Contents of Draft Final Report

- Chapter 1 Introduction
- Chapter 2 Laws and Regulations related to the Grid Operation in Indonesia
- Chapter 3 Current Voltage Control in Jakarta System
- Chapter 4 Current Jakarta System Model and Analysis
- Chapter 5 Modeling and Analysis of Jakarta system in the Near Future (Year 2015)
- Chapter 6 Analysis and Countermeasures of Voltage in the Future Jakarta System (in 2021)
- Chapter 7 Countermeasures against Low Voltage
- Chapter 8 Impact of the Blackout in the Economic and Industrial Activities in the Jakarta Metropolitan Area
- Chapter 9 Technical and Economic Comparison of Implementation of Countermeasures against Voltage Drops
- Chapter 10 Recommendations

Recommendations
-Installation of Shunt Capacitors

		Incremental (MVar)	Total (MVar)
	Existing	950	950
P3B's	On-going	475	1,425
	Planned	1,070	2,495
	Recommended additional shunt capacitors		
	2015	1,445	3,940
	(HVDC)	(1,800)	(5,740)
	2021	315	6,055

- Selecting locations for shunt capacitors through utilizing power cables for spaces viewing the future system configuration
- Confirming specifications of circuit breakers
- Selecting shunt capacitors with high endurable performance for electric surges

Recommendations
-Voltage Control Scheme

- Change rules to make P3B possible to decide tap positions of step-up transformers including IPP
- Study the effects of replacing large generators AQR to AVR
  - for more contribution to voltage stability
- Apply local voltage/ reactive power control scheme (Local VQC) with speedy voltage recovery against disturbances
  - On/off switching of shunt reactors and tap changing according to demand fluctuation will be further required due to increase in number of shunt capacitors.
  - Prerequisite for Centralized control scheme (Central VQC) or PMU
    - ✓ Appropriate maintenance of online data and network data
    - ✓ Achieving an accurate state estimation in EMS
    - ✓ Completion of telecommunication facilities between a Control Center and power stations/ substations

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Recommendations
- Data for System Monitoring

- Enhance network data maintenance for SCADA system on State Estimator and Security Analysis Function
  - State Estimator becomes not accurate while maintenance of network data is not sufficient. As a result, security analysis does not work well.
    - ✓ Parameters for the step-up transformers and transmission lines
  - SCADA online data seems to have some errors including missing data, error of positive/negative signs and the multiplying factor.
  - The maintenance of online data can offer more accurate state estimator results.
- P3B should allocate more human resources and financial resources to maintain network data and online data.

Recommendations
- Management of Facility and Analysis Data

- Prepare a data book of facilities including generators, transmission lines, transformers, the shunt reactor/capacitor, etc
- Establish a work-flow for the appropriate maintenance of analysis data
  - P3B Operation System Division should prepare a data book of facilities in order to manage facility data appropriately with Facility Management Division, Protective Relay Division and System Planning Division
    - ✓ Transmission lines, transformers, shunt reactor / capacitor, etc.
  - P3B should establish a work-flow so that analysis data can be modified based on the actual parameters when new and additional facilities start operations.

Recommendations
- Plan of Reactive Power Sources / Installation of Power Plants and Transmission Lines in around Jakarta

- Carry out annual periodical planning of reactive power sources and its review
- Promote to install generators directly connected to Jakarta metropolitan area
- Install 500 kV T/L Muara Tawar- Priok-Muara Karang- Duri Kosambi, and 500 kV substations located on its route, 500 kV Duri Kosambi - Kembangan– Balaraja
  - They have a large impact on voltage maintenance.

Menus of Countermeasures

A	In addition to the existing and planed shunt capacitors in Java Bali system, the following shunt capacitors are to be installed: ·By 2015, 1,445 MVar in Java system (Total in 2015: 3,940 MVar) ·By 2021, Total: 6,055 MVar in Java system (Incremental amount from 2015 is 315 MVar excluding 1,800 MVar for Java-Sumatra 3,000 MW HVDC transmission line)
B	Installation of Local VQC in addition to the countermeasure A
C	Installation of Central VQC in addition to the countermeasure A

Rough Cost Estimation of Menus

Menus	A	B	C
Shunt Capacitors	38.0 million USD in 2015 8.2 million USD in 2021	38.0 million USD in 2015 8.2 million USD in 2021	38.0 million USD in 2015 8.2 million USD in 2021
VQC		Local VQC 34.1 million USD	Central VQC 2.19 million USD
Total	46.2 million USD	80.3 million USD	48.39 million USD

Technical Comparison among Menus

	A (Capacitors)	B (+ Local VQC)	C (+ Central VQC)
Installation			Requirerng telecommunication JCC-ACC
Operation	Operators have to control manually. System complication increases operation works. ⇩ Quality of voltage or regulation response might be late depending on operators experience.	VQC can respond quickly to large disturbance. Setting values for substations/ power station has to be determined in coordination with each other.	Recovery from voltage fluctuation in large disturbance takes a certain extent of time (Control interval 30 sec. to 2 minutes). Setting values for substations/ power station has to be determined in coordination with each other. Possible to control considering of minimization of active power loss. Requiring central control state estimation has to be converged. Deficiency of telemetering or input data may cause inadequate control.

Benefits obtained by Improvement of Voltage

- Normal operation of power system user's electric machines and power generators and securing their long life time
- Avoiding a black-out caused by voltage collapse
- Transmission line loss reduction

⇩

- Only loss reduction is quantitatively evaluated
- 135 million USD saved by loss reduction
  - Evaluation period 15 years from 2015
  - Transmission line loss reduction : 84 MW at peak in 2015
  - Load Factor: 70%
  - Loss Factor: 0.52
  - Discount rate: 10%
  - 0.06 USD/kWh

JICA
The Study on Power Supply Reliability Improvement in Jakarta

- Study of the System of 2012 -

Final Workshop

18th Apr. 2013

Tokyo Electric Power Company Inc.

Nippon Koei Co., LTD

Agenda

- Review the Current Status of Voltage Operation
  - Voltage drop situation
  - Possible causes
  - Current countermeasures
- Assess the Margin to critical status
  - Modeling
  - PV Curve analysis
  - Finding

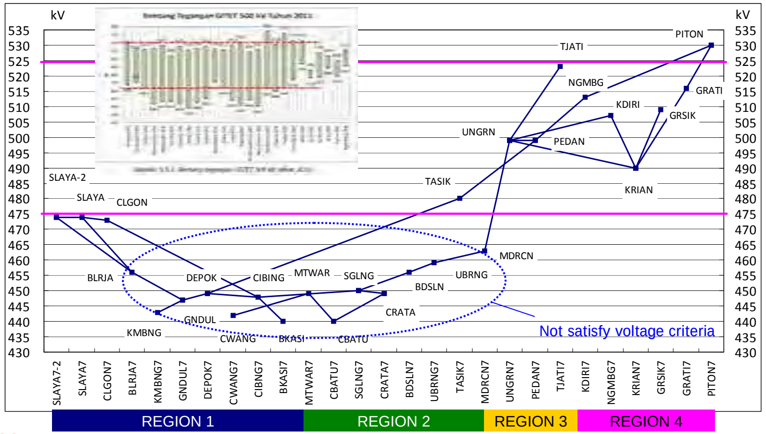
Part 1: Review Current Status of Voltage Operation

Objective

- To review the current situation of voltage operation of Java Bali System.
- To review the current countermeasures against low-voltage issue.

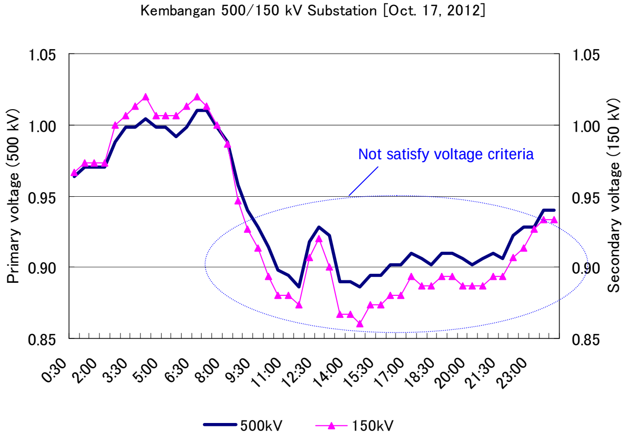
Review Current Status of Voltage Operation (1)

- Geographical phase: Lower in the west side of the Java Bali System



Review Current Status of Voltage Operation (2)

- Time phase: Lowest in the afternoon.



Possible Causes of Voltage Drop

a. **Heavy Loading of Transmission Lines and Transformers**

More than 80%-loaded transformers in Region1.

Correlation between Demand and Voltage in Region 1.

b. **Load of Low Power Factor**

Weak correlation between voltage and power factor of load by Region 1's subsystem.

c. **Lack of Reactive Power Supplier**

Shortage of shunt capacitors at substations.

d. **Insufficient voltage control**

Operated at the limit: [1] Tap at substations, [2] Q supply at power stations.

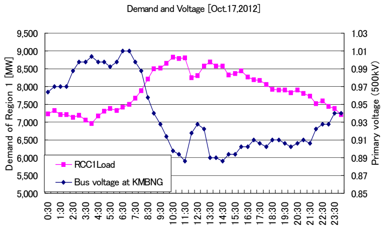
Manual (phone) dispatch command: tap position change at substations (excl. 150/20 kV Tr.), Q supply at power stations.

Little coordination on voltage control between substations and power stations.

CAUSE: a. Heavy Loading of Transmission Lines and Transformers

Loading during peak time	150/20V		500/150kV	
	Unit	MVA	Unit	MVA
0<<20%	14	666	1	500
20%<<40%	44	2,430	1	250
40%<<60%	117	5,839	7	3,500
60%<<80%	197	9,727	12	6,000
80%<<100%	229	11,894	30	14,500
100&<	6	320	2	1,000
Total	607	308,876	53	25,750

Performance of Transformers of Java Bali System (2012)



Hourly shift of Voltage and Demand of Region 1 (Oct. 17, 2012)

- Majority of transformers are heavily loaded.
- Clear correlation between Voltage drop and Demand in Region 1.

=> Well correlation between voltage drop and heavy loading

CAUSE: b. Load of Low Power Factor

REGION 1

Subsystem	p.f. [%]	500kV [p.u.]	150kV [p.u]
Suralaya	71	0.94	0.93
Cilegon	99	0.94	0.93
Balaraja	94	0.88	0.81
Kembangan	95	0.89	0.85
Gandul	99	0.89	0.87
Depok	99	0.90	0.87
Bekasi	99	0.88	0.87
Cawang	93	0.88	0.91
Cibinong	95	0.90	0.88
Total	97		

REGION 2

Subsystem	p.f. [%]	500kV [p.u.]	150kV [p.u]
Cibatu	96	0.88	0.93
Cirata	97	0.89	0.99
Bandung Seltan	93	0.91	0.99
Mandirancan	93	0.92	0.95
Tasikbaru	91	0.96	0.97
Total			

▭ :strongly correlated.

▭ :weakly correlated.

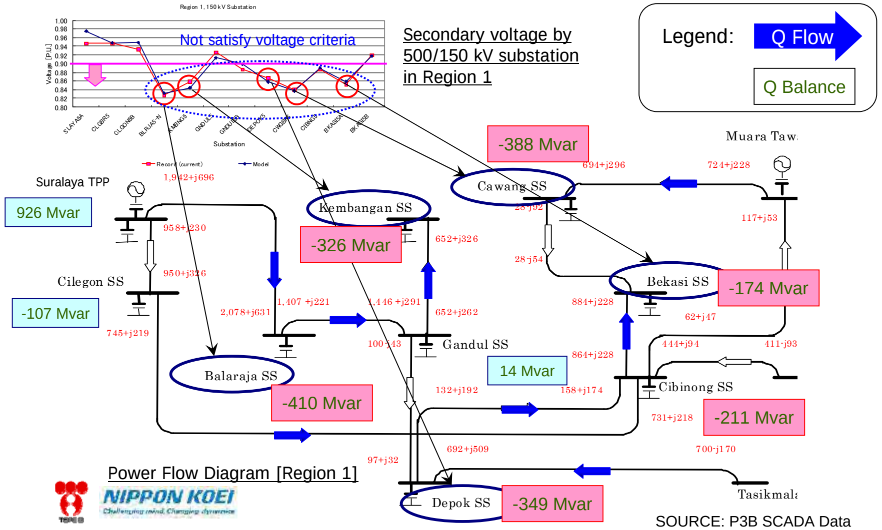
TOTAL

Region	P [MW]	Q [Mvar]	p.f. [%]
Region 1	8,178	1,996	97
Region 2	3,686	1,247	95
Region 3	2,463	1,037	92
Region 4	3,081	1,135	94
Region 5	468	168	94
Total	17,877	5,583	95

- **Weak correlation between voltage and power factor of load.**

CAUSE: c. Lack of Reactive Power Supplier

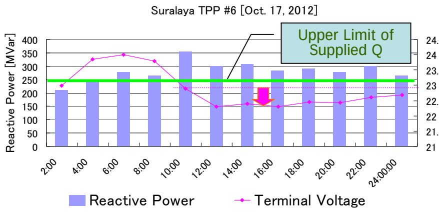
- **Q balance and low voltage correlate well by subsystem.**



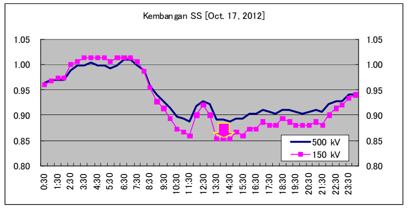
Power Flow Diagram [Region 1]

SOURCE: P3B SCADA Data

CAUSE: d. Insufficient Voltage Control



Terminal voltage v.s Q supply at Suralaya Power Station



Bus-bar voltage at 500/150 kV SS

- **Almost upper limit: Supplied reactive power from power plants**
- **Operated almost at the limit: Tap position at substations.**

Summary: Possible causes

- **Current low-voltage issue is mainly caused by,**
  - **Heavily loaded transformers during Jakarta peak time,**
  - **Shortage of reactive power suppliers, and**
  - **Similarly, limit of voltage control employing current measures.**

Current Countermeasures

a. Heavy Loading of Transmission Lines and Transformers

=> Short Term: Request to power stations to lower their output (e.g. TJJ B PS, Paiton PS).

=> Long Term: Expand the capacity at substations.

b. Load of Low Power Factor

=> Penalty paid by customers for not satisfying the aimed power factor of 0.85.

c. Lack of Reactive Power Supplier

=> **Substations: The project to place shunt capacitors is under way.**

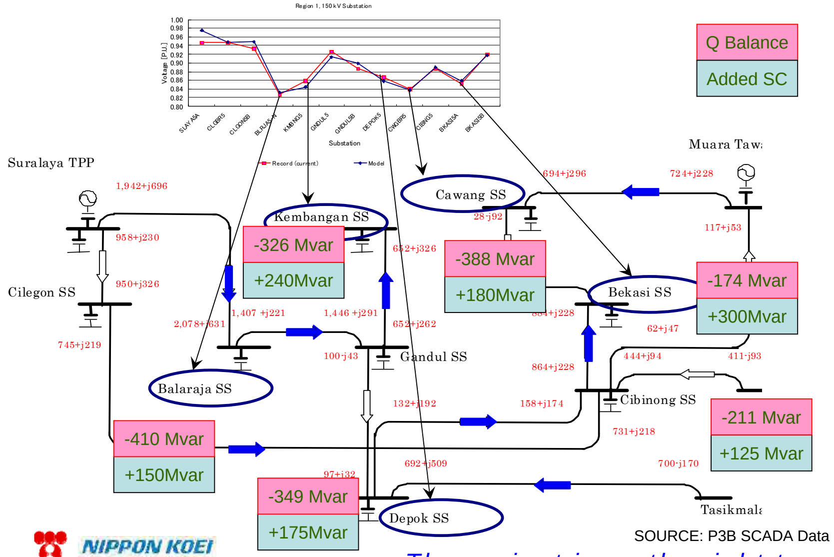
=> Power stations: Discussion needs to be held between P3B JB and generation companies regarding the shift of tap positions of step-up transformers.

d. Insufficient voltage control

=> Due to the limit of current facilities, few good measures.

=> In future after installing more shunt capacitors, the activity of connecting / disconnecting SCs will be need to be implemented automatically.

Project to place shunt capacitors (Region 1)



SOURCE: P3B SCADA Data

The project is on the right track.

Part 2: Margin to critical status

Overview

- ***Objective***

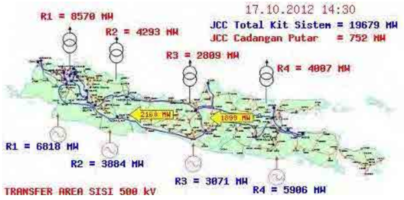
  Assess how much margin is left for the current Java Bali System before reaching widespread blackout triggered by voltage collapse.

- ***Methodology***

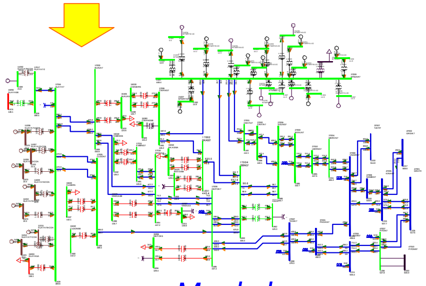
  1. **Employ the power system model emulating the current Java Bali system.**
  2. **Conduct PV curve analysis under Jakarta peak demand in 2012 to examine the voltage stability and to calculate the upper limit of the power transfer to Jakarta metropolitan area limited by voltage stability.**

Modeling (1)

- ***APPROACH***
  - **Utilized the P3B's PSS/E model.**
  - **Dataset: Updated the values with actual values as of the peak time based on the survey.**
  - **OBJECTIVE: Emulate the condition recording the lowest voltage – during Jakarta Peak time (Oct. 17, 2012, 14:30).**



Real data



Model

Modeling (2)

- ***Data update***
  - **Entered actual values.**
  - **Adjusted values to emulate the voltage status.**

Component	Input item	Source
Generator	➢Active power ➢Reactive power ➢Terminal voltage	SCADA data. Operation record.
Load	➢Active power ➢Reactive power	SCADA data.
Transmission line	➢Line constants ➢Distance	PSS/E data. DigSilent.
Transformer	➢Capacity ➢Reactance ➢Winding ratio	PSS/E data. DigSilent.
Network topology	➢Connection points	SCADA data. Operation record.
Reactive power supplier	➢Capacity	P3B Study.

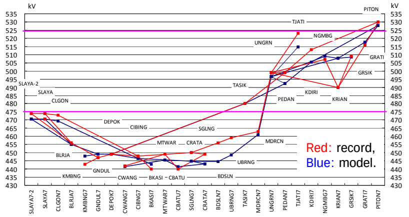
SCADA data

Operation record

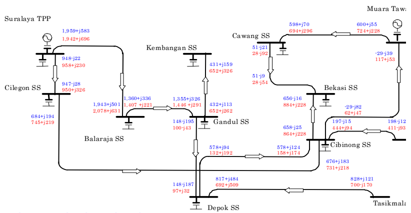
P3B study on SC

Modeling (3)

- ***Result***
  - **System voltage within +/- 1 % of actual record in Region 1.**
  - **Power flow (500 kV) of major sections within 10% range of actual value.**



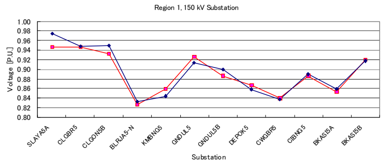
Voltage of Java Bali System (500kV)



Blue: Calculated values

Red: Actual record

Power flow of Region 1



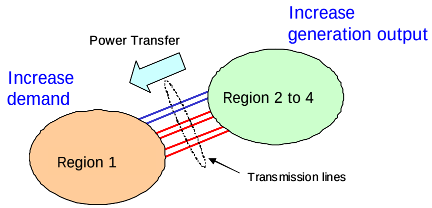
Red: record, Blue: model.

Voltage of Region 1 (150kV)

The model is confirmed to be valid.

PV Curve Analysis

- ***In Theory,***
  - **PV curve was drawn by simulating the increase in the load of Jakarta (load of Region1) from its peak power demand. In this case, the upper limit of Jakarta power demand was taken as an evaluating value by increasing the power outputs of the generators that are located in the region other than Jakarta area (Region 2, 3, 4, 5) among the operating generators.**



Analyzed system

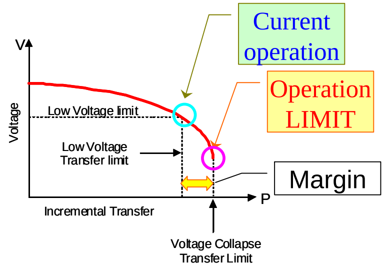
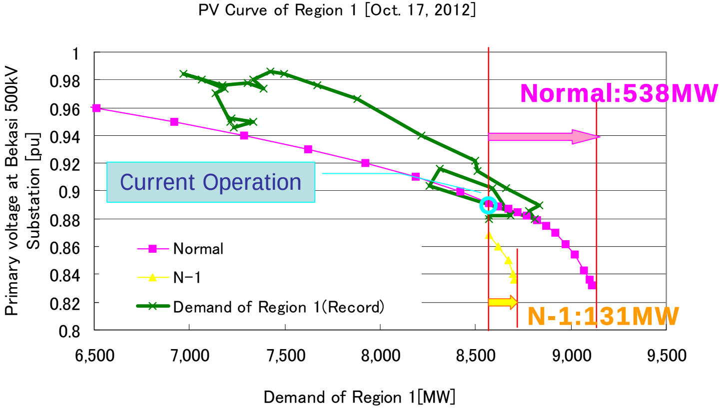


Image of PV Curve

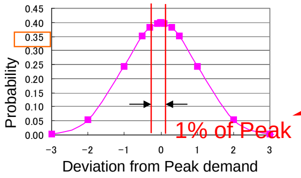
Assessment of Margin to Critical Status

- **Result**
  - **Normal time: 538MW margin is secured.**
  - **N-1: 131 MW margin is estimated.**

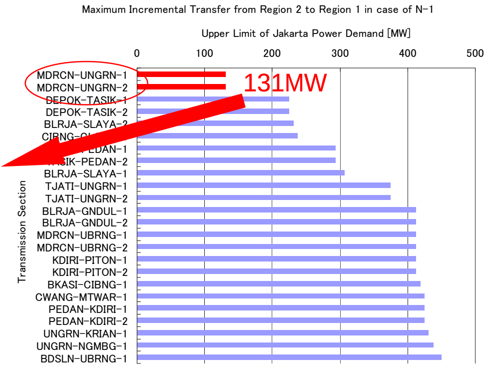


PV Curve of Region 1 [Oct. 17, 2012]

Assessment of Margin to Critical Status



Demand distribution



N-1 section vs. Upper limit

- **Finding**
  - **In case of N-1 at the 500 kV line between R3 and R2 could cause the most critical situation to Jakarta Metropolitan Area, leaving only 1％ of Jakarta's peak demand as demand margin.＝＞Urgent countermeasure is preferred.**

Conclusion

- **While Jakarta and the surrounding regions suffer low-voltage issue, its countermeasure – placing shunt capacitors – is now on right track: immediate & efficient effect is expected.**

- **Until the completion of the countermeasure, however, it is recommended to pay attention to the whole system in case of N-1 condition, during daily operation of Java Bali system.**

JICA
The Study on Power Supply Reliability Improvement in Jakarta

- Study of the System of 2015 -

Final Workshop

18th Apr. 2013

Tokyo Electric Power Company Inc.

Nippon Koei Co., LTD

Contents

- Estimation of reactive power load based on measured P&Q values
- Study on required amount of additional shunt capacitors for west Java area in 2015
- Examination of the effect of additional shunt capacitors on system voltage, voltage stability and transmission loss
- Study on system voltage under off-peak demand with additional shunt capacitors

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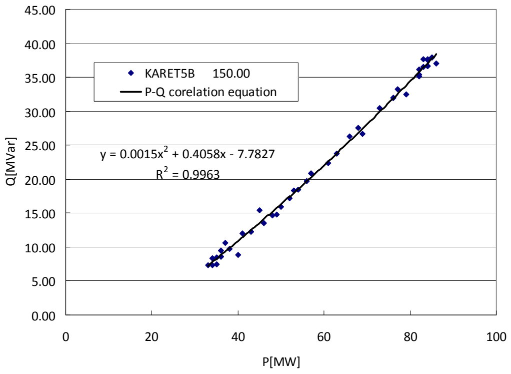
Estimation of Reactive Power Load

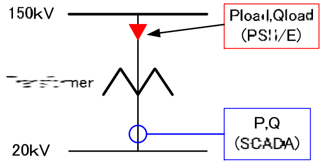
For the voltage analysis, it is important to precisely estimate the reactive power load. In this study, a quadratic regression analysis was performed using the P&Q values measured at 17th October 2012.



Example of P-Q correlation equation (KARET5B)

Estimation of Reactive Power Load

In consideration of reactive power loss through transformer, reactive power is corrected using calculation below.



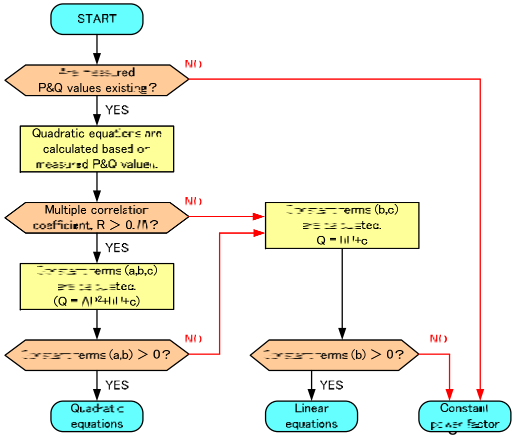
$$Q_{loss} \cong x_t \cdot (p^2 + q^2) \cdot P_0 [MVar]$$

$$Q_{load} = Q_{loss} + Q$$

$$Q_{loss} \cong x_t \cdot (p^2 + q^2) \cdot P_0 [MVar]$$

(Assuming that V=1.0 pu)

P-Q correlation equations were calculated using quadratic equations, linear equations or constant power factor based on a flow chart and the calculated constant terms. (a and b)



Condition of Analysis for
Required Amount of Additional Shunt Capacitors in 2015 (1)

Total Load in Each Region under Jakarta Peak Demand in 2015

	Total	Region 1	Region 2	Region 3	Region 4	Region 5
Jakarta peak at 13:00	24,653	9,869	6,052	3,143	4,964	625

Generation Dispatching Scenario under Jakarta Peak Demand in 2015

Fuel type	Setting
Coal	Maximum output
Gas	Output is adjusted for demand-supply balance
LNG	Output is adjusted for demand-supply balance
Oil	Minimum output
Hydro	Output is set based on actual record on 17 Oct 2012. Following reservoir type hydro power plants were set based on information from P3B: • Cirata: 2╳98 MW • Saguling: 2╳147 MW • Jatiluhur: 2╳15 MW
Geothermal	Maximum output

Condition of Analysis for
Required Amount of Additional Shunt Capacitors in 2015 (2)

Shunt reactors and shunt capacitors shown in tables below were assumed to be in-service in 2015. These tables were made based on P3B:"Program Peningkatan Kuakitas Tegangan" and analysis data (Digsilent data) received from P3B operation system division.

In service Shunt Capacitor in 2015

Area	Voltage [kV]	Unit size [MVar]	No. of units	Capacity [MVar]
Region 1	150	50	22	1,100
	150	25	15	375
	70	10	1	10
	20	20	11	220
Region 2	150	50	2	100
	150	25	2	50
	70	10	2	20
Region 3	150	25	3	75
Region 4	150	25	10	250
	150	10	5	50
	70	10	7	70
	150	25	7	175
Total				2,495

In-service Shunt Reactor in 2015

Area	Voltage [kV]	Unit size [MVar]	No. of units	Capacity [MVar]
Region 1	500	100	1	100
Region 2	500	100	2	200
Region 3	500	100	2	200
Region 4	500	100	2	200
		50	2	100
Total				800

Condition of Analysis for
Required Amount of Additional Shunt Capacitors in 2015 (3)

- As for Region 1 and Region 2 including Jakarta area, required amount of additional shunt capacitors were studied in order to satisfy the voltage criteria under normal and N-1 contingencies.
- As for Region 3, 4 and 5, required amount of additional shunt capacitors were studied in order to satisfy the voltage criteria only under normal condition since Region 3, 4 and 5 are outside the scope of this study.
- Unit sizes of shunt capacitor shown in the table below were applied based on the unit sizes of existing minimum shunt capacitors for each nominal voltage.
- Further study of unit size selection is recommended in consideration of acceptable voltage deviation.

Voltage Criteria under Normal and Contingency Condition

Nominal voltage	Normal condition
500 kV	95% - 105%
150 kV	90% - 105%
70 kV	90% - 105%
20 kV	90% - 105%

Source: "PLN PLANNING AND OPERATION CRITERIA"

Unit size of Additional Shunt Capacitor

Nominal voltage	Unit size [MVar]
150 kV	25
70 kV	10

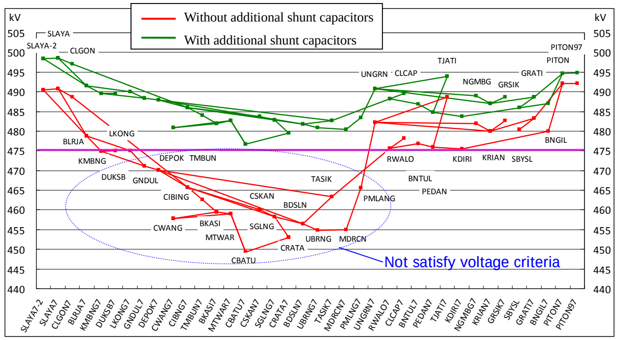
Required Amount of Additional Shunt Capacitors in 2015

The list of required additional shunt capacitors for each Region under Jakarta peak demand in 2015 are shown below.

Area	kV	Unit size [MVar]	No. of units	Subtotal [MVar]	Total [MVar]
Region 1	150	25	7	175	245
	70	10	7	70	
Region 2	150	25	28	700	910
	70	10	21	210	
Region 3	150	25	1	25	25
Region 4	150	25	7	175	265
	70	10	9	90	
Grand total					1,445

Voltage Profile of 500kV System in 2015

- ➢ System voltage is improved by additional shunt capacitors.
- ➢ All the 500kV system voltage with additional shunt capacitors satisfy the voltage criteria.



- ➢ In the case of no additional shunt capacitors, 500kV system voltages around Region 1 and Region 2 do not satisfy the voltage criteria.

System Voltage at 150kV Network with and without Additional Shunt Capacitors

- ➢ For example, parts of the system voltages in Cibatu 150kV subsystem with or without additional shunt capacitors are shown below.
- ➢ The system voltages without additional shunt capacitors fall below 0.90pu and those with additional shunt capacitors are maintained above 0.90pu.

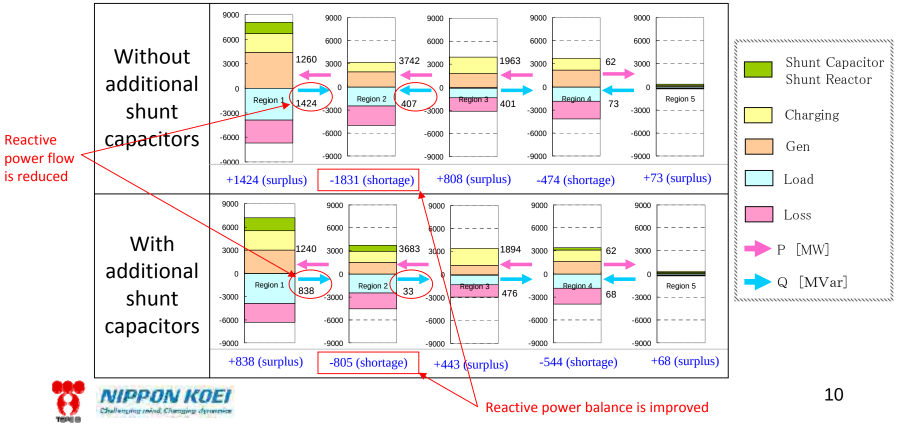
Bus Number	Bus Name	Without additional shunt capacitors		With additional shunt capacitors	
		Voltage [pu]	Voltage[kV]	Voltage [pu]	Voltage[kV]
25009	CBATU5B	0.8987	134.8	0.9832	147.5
25017	CIKRG5B	0.8697	130.5	0.9738	146.1
25034	GDMKR5	0.8648	129.7	0.9718	145.8
25058	LSTDO5	0.8705	130.6	0.9743	146.1
25074	PNCOL5	0.8557	128.4	0.9735	146.0
25096	TLJMB5	0.8586	128.8	0.9370	140.6
25134	CLIPO5	0.8803	132.0	0.9763	146.4
25903	GNRJP5	0.8656	129.8	0.9712	145.7
25904	ALIQCKRG5	0.8631	129.5	0.9712	145.7
25905	SMTRCKRG5	0.8631	129.5	0.9712	145.7
15121	PDKLP5B	0.8538	128.1	0.9720	145.8

Not satisfy voltage criteria

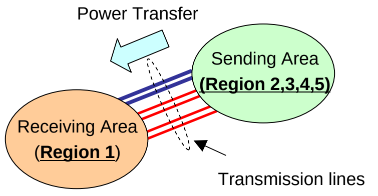
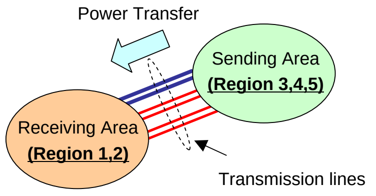
Satisfy voltage criteria

Reactive Power Balance in Each Region

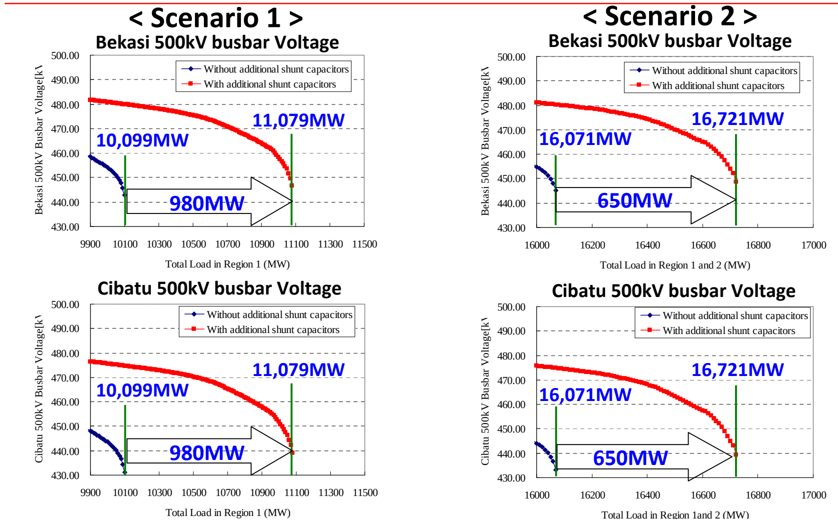
- ➢ Reactive power flows between Region 1 and Region 2 and between Region 2 and Region 3 are reduced since the reactive power balance in Region 2 was improved due to the additional shunt capacitors.



Condition of PV Analysis

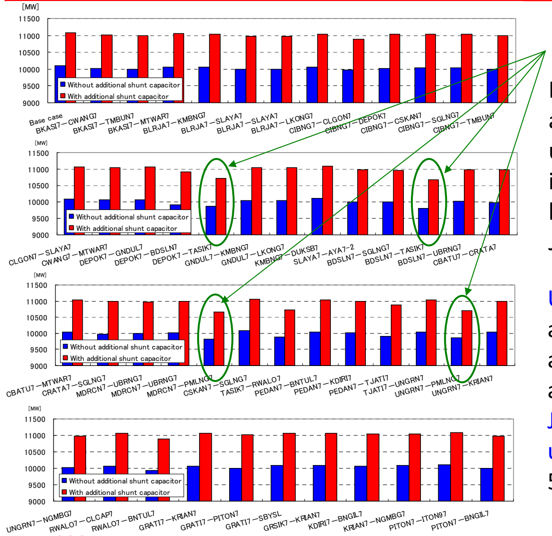
Scenario 1	Scenario 2
(Receiving Area) Increase in the load of Jakarta (load of Region1) from its peak power demand. (Sending Area) Increasing the outputs of the generators located in the region other than Jakarta area. (Region 2, 3, 4, 5)	(Receiving Area) Increase in the load of west Java (loads of Region1 and 2) from its peak power demand. (Sending Area) Increasing the outputs of the generators located in the region other than west Java area. (Region 3, 4, 5)
	

PV Curves under Normal Condition



Scenario 2 is considered to be more severe condition than Scenario 1 since the incremental power transfer in Scenario 2 is smaller than that in Scenario 1.

Upper limits of Power Demand under N-1 Contingencies in 500kV Transmission line (Scenario 1)

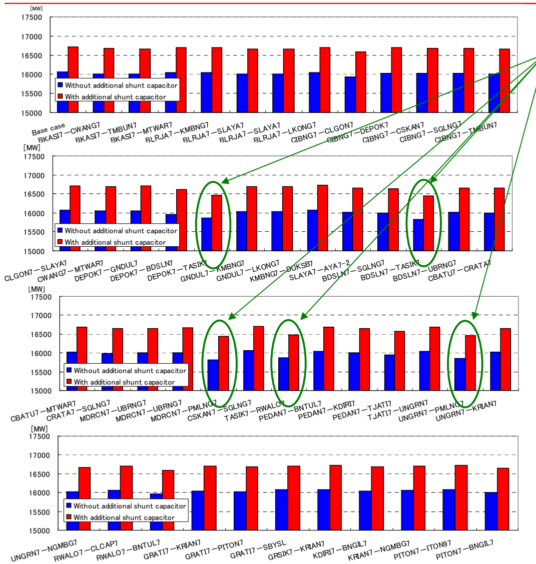


Severe contingencies

Limits of power demand without additional shunt capacitors under N-1 contingencies indicated by green circle are lower than the estimated Jakarta peak demand in 2015.

Upper limits of power demand are increased due to additional shunt capacitors and achieved estimated Jakarta peak demand in 2015 under all N-1 contingencies in 500kV transmission lines.

Upper limits of Power Demand under N-1 Contingencies in 500kV Transmission line (Scenario 2)



Severe contingencies

Limits of power demand without additional shunt capacitors under N-1 contingencies indicated by green circle are lower than the estimated Jakarta peak demand in 2015.

Upper limits of power demand are increased due to additional shunt capacitors and achieved estimated Jakarta peak demand in 2015 under all N-1 contingencies in 500kV transmission lines.

Severe Cases among N-1 Contingencies without Additional Shunt Capacitors

From	To	Jakarta Peak demand in 2015 [MW]		Transfer limit [MW]	
		Total load In Region 1	Total load In Region 1&2	Scenario 1	Scenario 2
				Total load in Region 1	Total load in Region 1&2
Cibinong	Cilegon	9,869	15,921	9,969	15,931
Depok	Tasikmalaya			9,859	15,861
Bandung selatan	Tasikmalaya			9,799	15,821
Mandirancan	Pemalang			9,819	15,821
Tasikmalaya	Rawalo			9,879	15,871
Ungaran	Pemalang			9,869	15,861

It was confirmed that the limits of power demand under N-1 contingencies in above transmission lines were not achieve the demand estimated for Jakarta peak in 2015 in the case of no additional shunt capacitors.

Voltage Stability Limit and Interconnection Power Flow

(Objective)

To examine the relationship between voltage stability limits and interconnection power flow

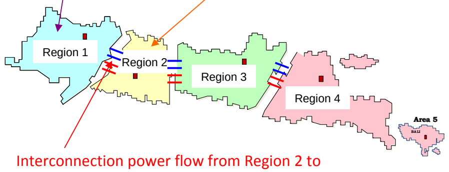
(Methodology)

Interconnection power flows under the initial condition and in the process of PV analysis were changed by different generation dispatching patterns and different load increasing scenarios.

Different Pattern of Generator Dispatching under the Initial Condition

Pattern	Generation dispatch at initial condition			
	Area	Generator output	Area	Generator output
1	Region 1	Reduced by 300MW	Region 2	Increased by 300MW
2	Region 1		Region 3	
3	Region 1		Region 4	
4	Region 2		Region 3	
5	Region 2		Region 4	
6	Region 3		Region 4	
7	Region 1	Increased by 300MW	Region 2	Reduced by 300MW
8	Region 1		Region 3	
9	Region 1		Region 4	
10	Region 2		Region 3	
11	Region 2		Region 4	
12	Region 3		Region 4	

Taking Patten 1 for the example,



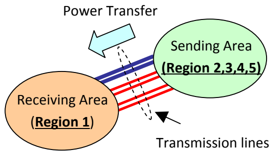
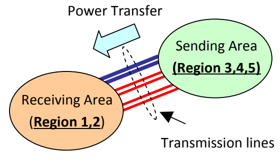
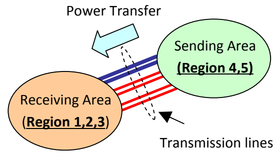
Outputs of generators in Region 1 were reduced by 300MW, totally.

Outputs of generators in Region 2 was increased by 300MW,totally.

Interconnection power flow from Region 2 to Region 1 was increased by 300MW.

Voltage Stability Limit and Interconnection Power Flow

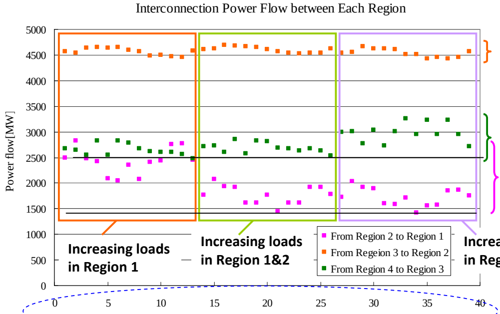
Scenarios for Increase in Load and Generation Output in the Process of PV Analysis

Scenario 1	Scenario 2	Scenario 3(for comparison)
(Receiving Area) Increase in the load of Jakarta (load of Region1) from its peak power demand. (Sending Area) Increasing the outputs of the generators located in Region 2, 3, 4, 5	(Receiving Area) Increase in the load of west Java (load of Region1&2) from its peak power demand. (Sending Area) Increasing the outputs of the generators located in Region 3, 4, 5	(Receiving Area) Increase in the load Region1, 2 &3 from its peak power demand. (Sending Area) Increasing the outputs of the generators located in Region 4, 5
		

- PV analysis performed under 39 cases with a combination of 13 patterns (base pattern and 12 patterns shown in the previous slide) and above 3 scenarios.

Voltage Stability Limit and Interconnection Power Flow

- Power flows between Region 2 and Region 3 at the voltage stability limits fall within a certain range. On the other hand, power flows between Region 1 and Region 2 and those between Region 3 and Region 4 show large variations.
- Interconnection power flows between Region 2 and Region 3 show correlation with voltage stability limits.
- Consequently, monitoring power flow between Region 2 and Region 3 is considered to be effective for monitoring voltage stability.



Power flows between Region 2 and Region 3 at the voltage stability limits fall within a certain range.

power flows between Region 1 and Region 2 and those between Region 3 and Region 4 show large variations.

Horizontal axis of the figure shows 39 cases with a combination of 13 patterns and 3 scenarios.

Transmission Loss Reduction due to Additional Shunt Capacitors

Transmission loss in Java-Bali system with and without additional shunt capacitors at Jakarta peak demand in 2015

	Amount of in-service shunt capacitors [MVar]	Transmission Losses [MW]
Without additional shunt capacitors	2,495	716.9
With additional shunt capacitors	3,940	632.9
Difference	1,445	84.0

Total transmission losses in Java-Bali system modeled in PSS/E file (including 500kV, 150kV and 70kV networks) were calculated.

Transmission loss is reduced due to installation of additional shunt capacitors since system voltages are maintained at higher voltages and power factor are improved.

Condition of Study on System Voltage under Off-peak Demand

Percentage of off-peak load (at 3:00) against Java-Bali peak load (19:00) is assumed to be 73%.

Percentage of Load in each Region under Off-peak Demand

	Total	Region 1	Region 2	Region 3	Region 4&5
Off peak at 3:00	100%	42.1%	21.2%	14.0%	22.7%

Active Power Load in Each Region under Off-peak Demand [MW]

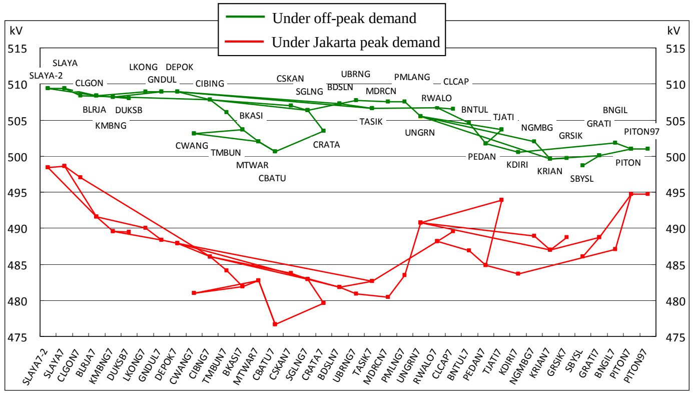
	Total	Region 1	Region 2	Region 3	Region 4	Region 5
Off peak at 3:00	19,454	8,190	4,124	2,724	3,922	494

Generation Dispatching Scenario under Off- peak Demand in 2015

Fuel type	Setting
Coal	Output is adjusted for demand-supply balance
Gas	Minimum output
LNG	Minimum output
Oil	Minimum output
Hydro	Output is set based on actual record on 17 Oct 2012. Following reservoir type hydro power plants were set based on information from P3B: Cirata: 1×50 MW, Saguling: 1×60 MW, Jatiluhur: 1×19 MW
Geothermal	Maximum output

System Voltage under Off-peak Demand

500kV system voltages under off-peak demand are maintained appropriately, even if all additional shunt capacitors are in-service.



Voltage Profile at 500kV System under Jakarta Peak Demand and Off-peak Demand

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System Voltage under Off-peak Demand

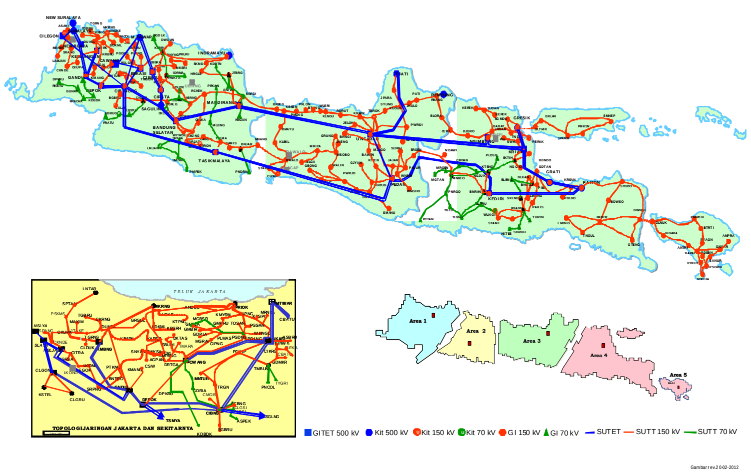
- Some voltages at 150kV and 70kV system exceed the acceptable range from 0.90pu to 1.05pu under normal or N-1 contingencies.
- In Jakarta and Java-Bali peak season in 2015, it is expected that the switching operations of amount of shunt capacitors shown in below table are necessary to maintain the system voltage appropriately.

Area	kV	Unit size [MVar]	No. of units	Total
Region 1	150	50	2	100
		25	1	25
	70	10	2	20
Region 2	150	25	1	25
	70	10	11	110
Total			17	280

Shunt capacitors are necessary to be switched on to meet the increasing demand in the morning and to be switched off after peak demand.

System Diagram in Java-Bali System

TOPOLOGI JARINGAN JAWA BALI



Study of the System of 2021

The Workshop
on
The Study on Power Supply Reliability Improvement
in Jakarta

Jakarta, April 18, 2013

PT.PLN (Persero)

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Company Inc.

Nippon Koei Co., LTD

Active Load and Generator Output Settings

	Total	Region 1	Region 2	Region 3	Region 4	Region 5
Jakarta Peak at 13:00	36,700	14,674	9,062	4,812	7,217	935

Fuel type	Settings
Coal	Maximum output, if possible. Otherwise, Adjusted to the demand.
Gas	Output is adjusted for demand-supply balance
LNG	Output is adjusted for demand-supply balance
Oil	Minimum output
Hydro	Output is set based on actual record on 17 Oct 2012. Following reservoir type hydro power plants were set based on information from P3B: Cirata: 2×98 MW Saguling: 2×147 MW Jatiluhur: 2×15 MW
Geothermal	Maximum output

Additional Shunt Capacitors in 2021

	Type of Equipment	Installed Capacity
Base Case Capacitors	Capacitor	4,295 MVA
	Reactor	-800 MVA
With Additional capacitors	Capacitor	6,055 MVA
	Reactor	-800 MVA
Increment	Capacity	1,760 MVA

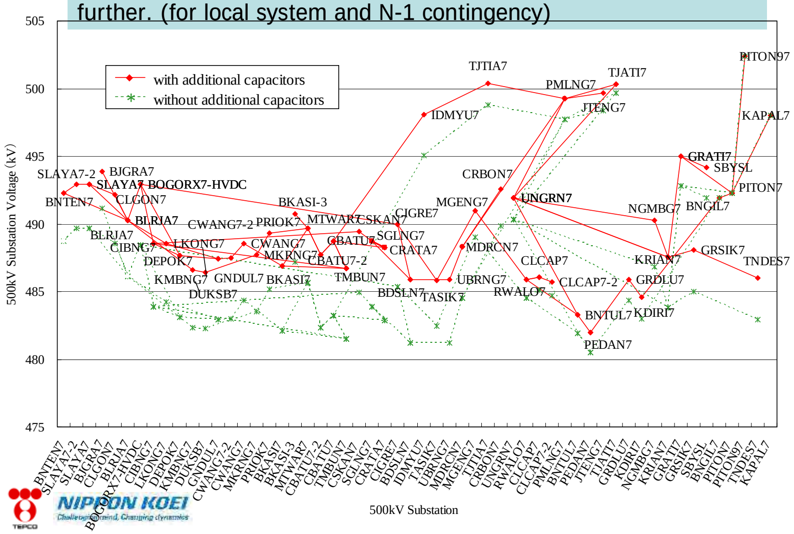
PLN/P3B's Existing, on-going, planned + HVDC1800MVar

Involves 1800MVA of XBogor HVDC

+
1,445 MVar 2015
315 MVar 2021

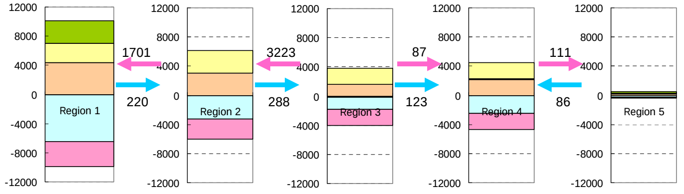
Voltage Profile with / without Capacitors Installed in 2021

Base Case Without additional capacitors 500 kV Voltage meets the Grid Code. But installation of capacitors improves system voltage further. (for local system and N-1 contingency)

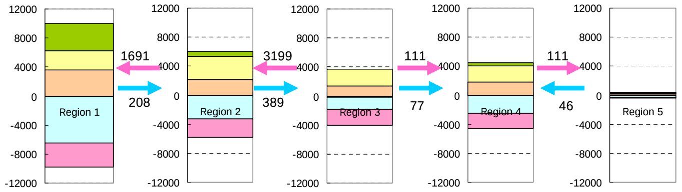


Regional Balance of Reactive Power

Regional Reactive Power Balance without Additional Capacitors in 2021

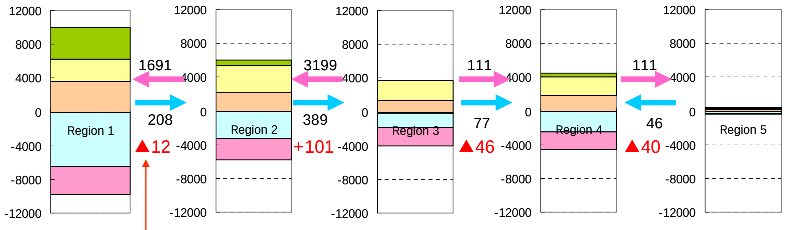


Regional Reactive Power Balance with Additional Capacitors in 2021



🟧 Gen	🟩 Shunt Capacitor/Reactor	🟨 Charging
⬜ Load	🟪 Loss	→ P
→ Q [MW, MVar]		

Regional Balance of Reactive Power



with Additional Capacitors in 2021

Because capacitors are installed to meet the Grid Code under N-1 contingency condition, reactive power is too much to balance under normal condition in Region 1 and 2.

Remaining reactive power of Region 1 and 2 improve the voltage of Region 3 (no additional capacitors installed) under normal condition.

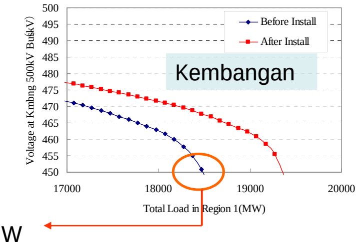
The capacitor banks are installed in effective point to raise the voltage to minimize the amount of capacitors.

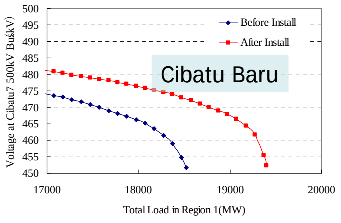
The Upper Limit of Jakarta demand

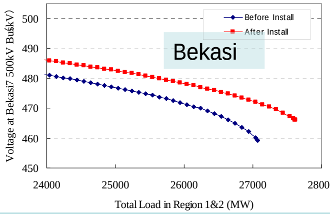
Concerning to Voltage Stability

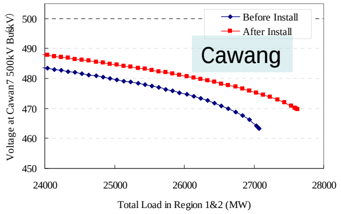
Already much higher than Region 1 Peak

Load 14,674 MW









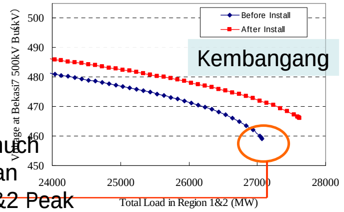
The Upper Limit of Jakarta Power Demand increases by 856MW or 6% of Region 1 demand (14,674MW).

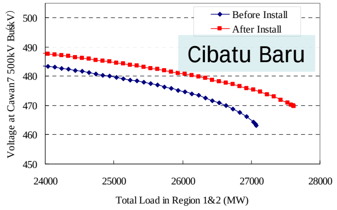
The Upper Limit of Jakarta & Western Jawa demand

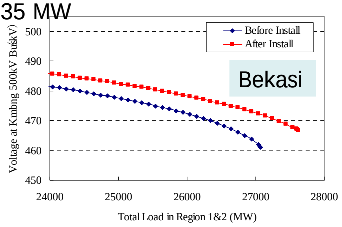
Concerning to Voltage Stability

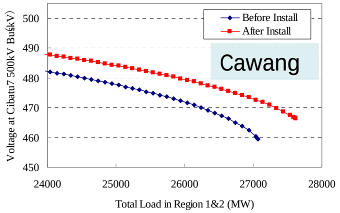
Already much higher than Region 1&2 Peak

Load 23,735 MW



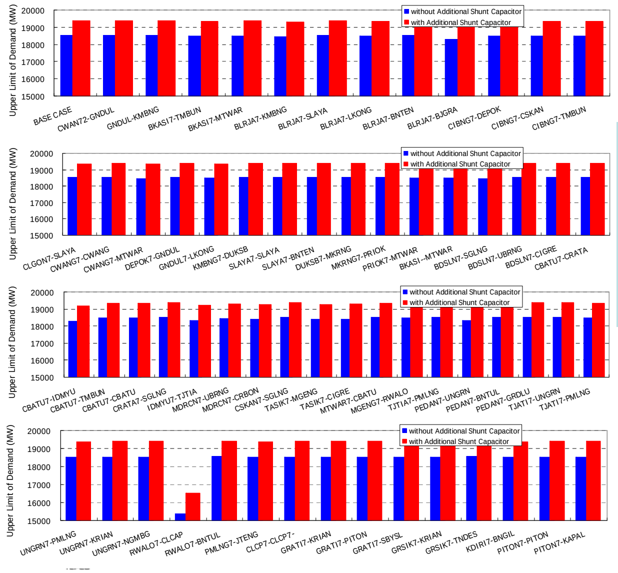






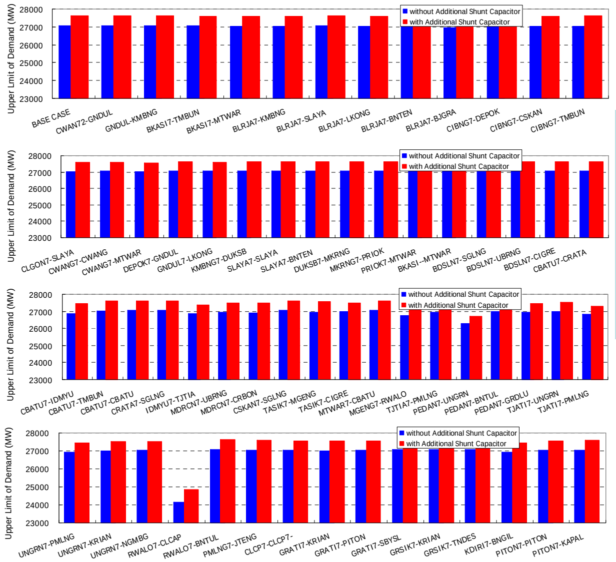
Installing the Capacitors makes the upper limit of Western Jawa power demand increase by 544MW.or 2% of Region 1 and 2 demand (23,735MW).

Validation of Scenario 1 under N-1 Contingency

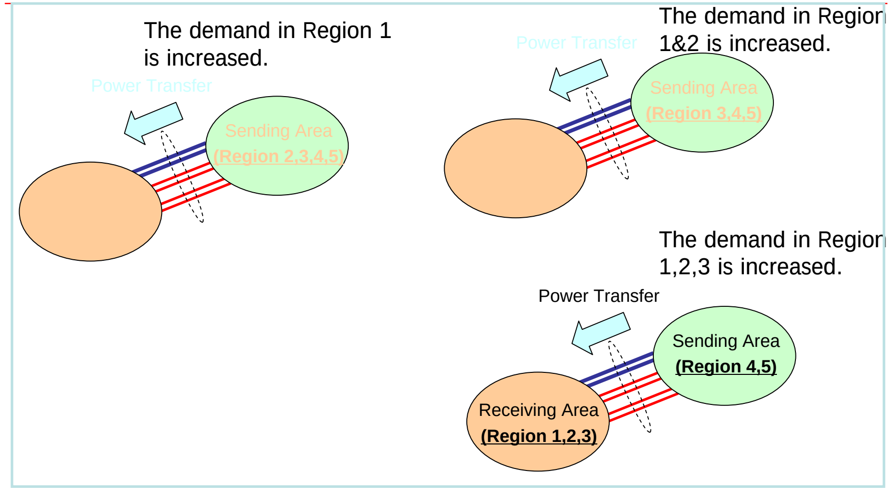


Under normal or N-1 contingency condition, installing the capacitors makes the upper limit of Jakarta Power Demand increases by 864MW or 6% of Region 1 demand (14,674MW)

Validation of Scenario 2 under N-1 Contingency



Under normal or N-1 contingency condition, installing the capacitors makes the upper limit of Jakarta and Western Jawa Power Demand increase by 544MW or 2.3% of demand in Region 1 and 2 (23,735MW).



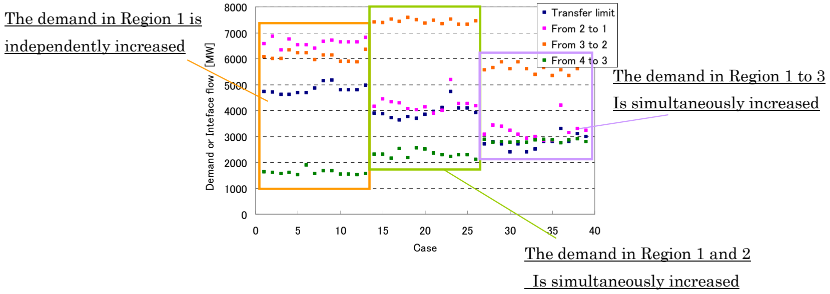
The demand in Region 1 is increased.

The demand in Region 1&2 is increased.

The demand in Region 1,2,3 is increased.

+ Application of Various Initial Patterns of Generation and Demand

Validation upon Voltage Stability Limit of Interface Flows between Two Regions



The demand in Region 1 is independently increased

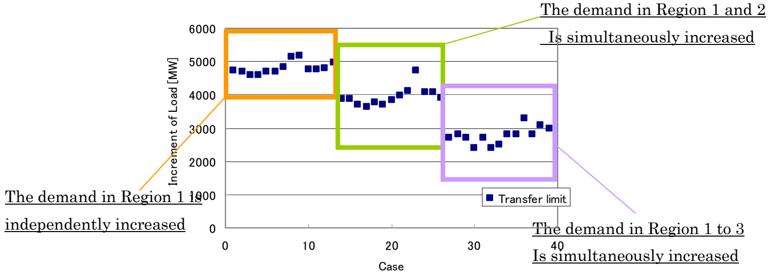
The demand in Region 1 to 3 Is simultaneously increased

The demand in Region 1 and 2 Is simultaneously increased

The Upper Limits of Interface Flow between Two Regions
Applied Various Patterns of Generation and Demand

The upper limits under three scenarios of demand-increase differ from each other, but the upper limits under different setting of initial generation dispatching are almost the same.

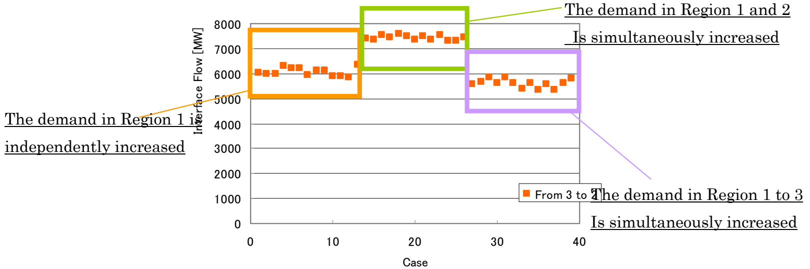
Validation upon Voltage Stability Limit of Demand under Various Scenarios of Generation and Demand



The Upper Limits of Demand under Various Scenarios of Generation and Demand

When the demand in Region 1&2 increased, the increment of upper limit of demand becomes smaller than in case with increasing only Region 1.
This means the demand of Region 2 has more influence over voltage limitation than in Region 1.
For the same reason Region 3 has more influence on the voltage stability than Region 2.

Validation upon Voltage Stability Limit of Interface Flow between Region 3 and 2



The Upper Limits of Interface Flow between Region 3 and 2 under Various Scenarios of Generation and Demand

When the demand in Region 1,2,3 increase, upper limit of the demand in Region 1,2,3 becomes smaller than in case with increasing Region 1 & 2.
So the demand in Region 3 has more influence.

Effects of Main Power Generators in around Jakarta on Voltage Maintenance (Scenario 1)

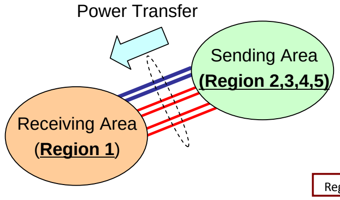
	Power Reduction (MW)	Upper Limit of Jakarta Demand	Reduction from Base Case	Upper Limit Reduction (MW)/Power Reduction (MW)
Base Case	-	19,400.96	0	-
Without Banten TPP	625	19,179.71	▲ 221	▲ 0.35
Without Bekasi TPP	2,000	17,982.84	▲ 1,418	▲ 0.71
Without Lontar TPP	315	18,883.46	▲ 518	▲ 1.6
Without Upper Cisokan PSPP	150	19,299.09	▲ 102	▲ 0.68

Effects of Main T/L in around Jakarta on Voltage Maintenance (Scenario 1)

	Upper Limit of Jakarta Demand	Reduction from Base Case	Upper Limit Reduction (MW)/Power Reduction (MW)
Base Case	19,401	0	-
W/o 500 kV T/L Muara Tawar- Priok-Muara Karang - Duri Kosambi	18,336	▲ 1,064	-
W/o 500 kV Muara Tawar S/S & Priok S/S	18,405	▲ 996	
W/o 500 kV T/L Muara Tawar - Priok	19,030	▲ 371	-
W/o 500 kV T/L Cawang – Gandul	19,347	▲ 54	-
W/o 500 kV T/L Cibatu – Tambun	19,240	▲ 161	-
W/o 500 kV T/L Duri Kosambi – Kembangan - Balaraja	18,928	▲ 473	-
W/o HVDC Smatra - Bogor (2,500 MW)	18,630	▲ 771	▲ 0.30825

Effect of Installation of Shunt Capacitor by Its Location

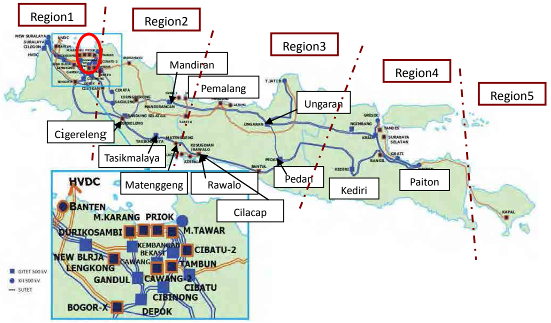
Scenario 1 in 2021



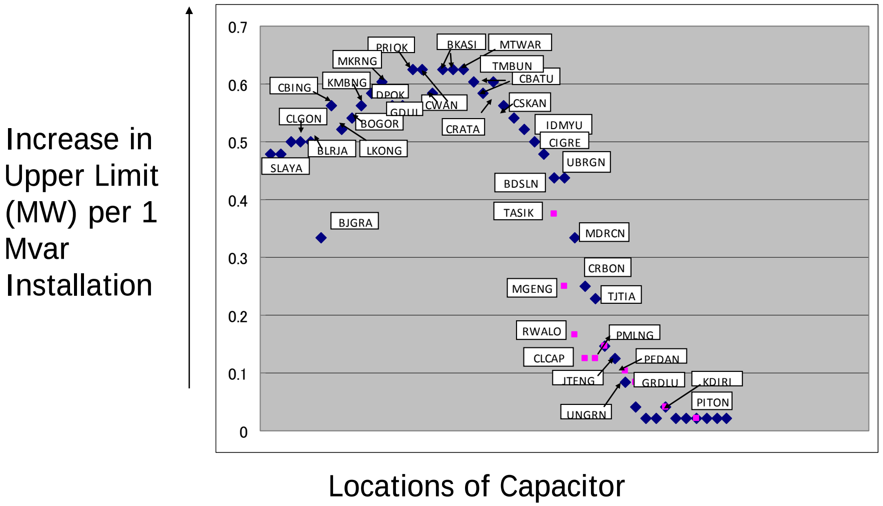
Power Transfer

Sending Area
(Region 2,3,4,5)

Receiving Area
(Region 1)

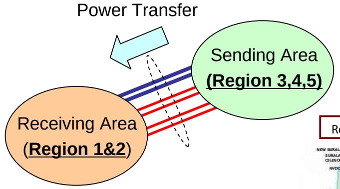


Increase in Upper limit of Jakarta Demand (MW) per 1MVar Capacitor



Effect of Installation of Shunt Capacitor by Its Location

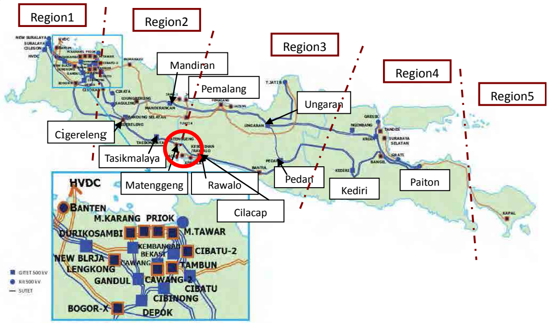
Scenario 2 in 2021

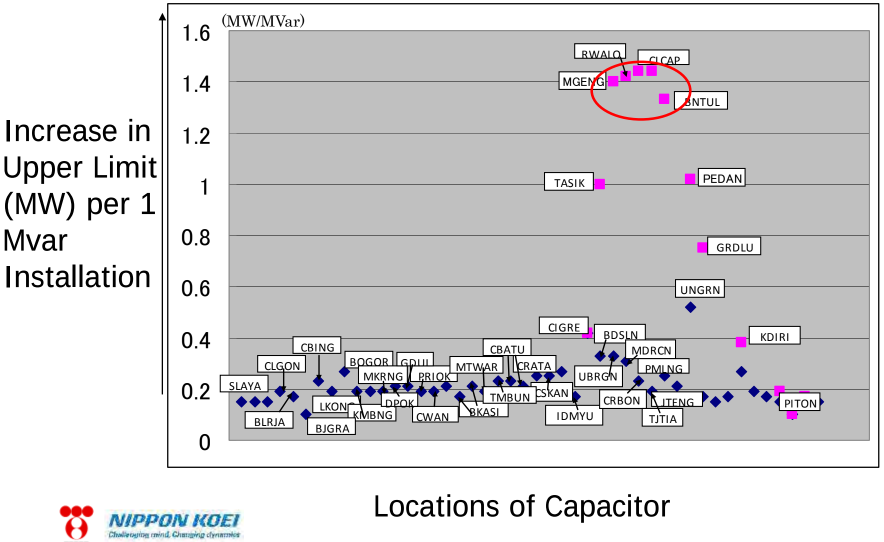


Power Transfer

Sending Area
(Region 3,4,5)

Receiving Area
(Region 1&2)





Voltage & Frequency Control

Apr.18,2013

JICA Study Team

Contents

- New methodologies of system voltage control that can be applied to the Jakarta metropolitan area in addition to the installation of shunt capacitors
- Basic study of Phase Measurement Unit (PMU) in the future
- Recommendation for better frequency control

Growing Amount of Shunt Capacitors

Area	Result of P3B study		Year 2015	Year 2021
	Existing	On-going & planned		
Region 1	260	1,445	1,950	4,255 (6,055※)
Region 2	70	100	1,080	
Region 3	75	0	100	
Region 4	370	0	635	
Region 5	175	0	175	
Total	950	1,545	3,940	
Increase			**1,445**	**315 (2,115※)**

(MVA)

※ Including Shunt capacitors (1,800MVar) for Java-Sumatra 3,000MW HVDC transmission system

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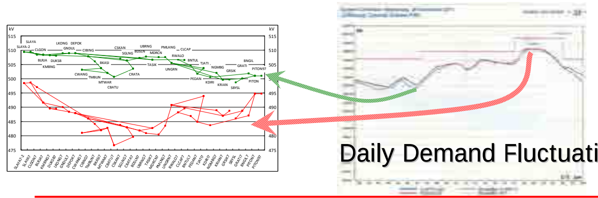
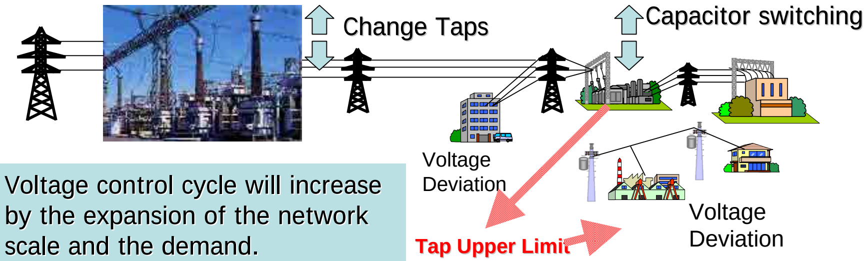
Increase of Voltage Control Cycle



Needs Daily on /off of Shunt Capacitors



Voltage control cycle will increase by the expansion of the network scale and the demand.

Automatic voltage regulation may be essencial.

Control of Transformer Tap & Shunt Capacitors

Option	Countermeasures
A	In addition to the existing and planed shunt capacitors in Java Bali system, the following shunt capacitors are to be installed: ・By 2015；1,445MVar（Total:3,940 MVar） ・By 2021；315MVar ＋ 1,800MVar for HVDC（Total:6,055 MVar） (HVDC means Java-Sumatera 3,000 MW HVDC transmission line.) Without additional Voltage Controller（Manually）
B	Countermeasure A（Additional Shunt Capacitors） + Installation of Local VQC to regulate voltage automatically
C	Countermeasure A（Additional Shunt Capacitors） + Installation of Centralized VQC to regulate voltage automatically

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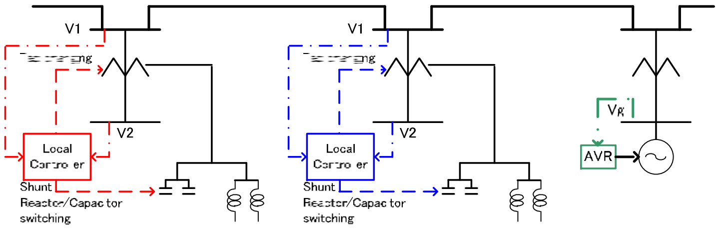
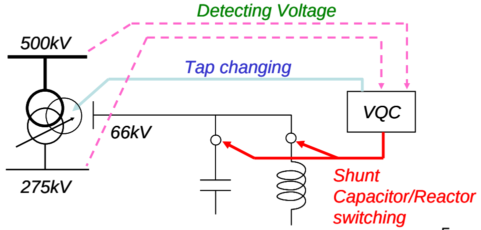
Local VQC Scheme



Control individually in each substation

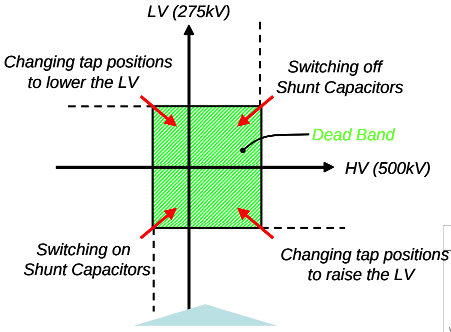
Regulate primary side with capacitors

Regulate secondary side with taps of transformer



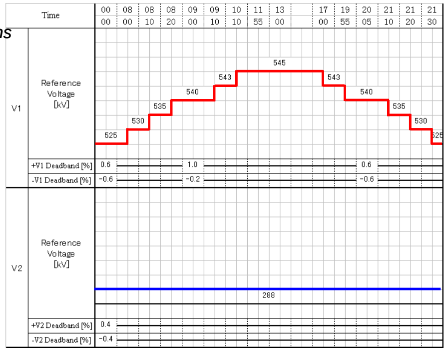
VQC;voltage reactive power controller

Operating characteristics of Local VQC



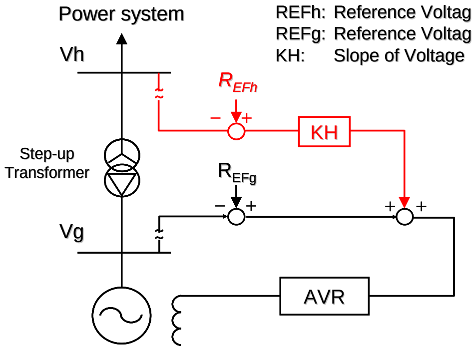
Within the dead band (green area), switching of shunt capacitors or changing tap positions does not work. If the voltages are out of range, they are controlled into the dead band.

An example of voltage control pattern is shown in this figure. In this example, the primary voltage is varied up and down according to the demand fluctuation.



PSVR control scheme

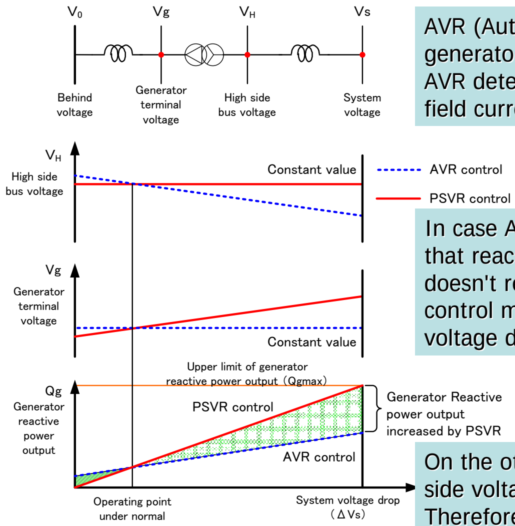
REFh: Reference Voltage of High-side Bus
REFg: Reference Voltage of Terminal Voltage
KH: Slope of Voltage



AVR (Automatic Voltage controller) controls generator's terminal voltage.
AVR detects the terminal voltage and control field current of exciter.

On the other hand, PSVR controls the high side voltage of step-up transformer.
Therefore reactive power of generator can be fully utilized.

Control Characteristics of PSVR and AVR

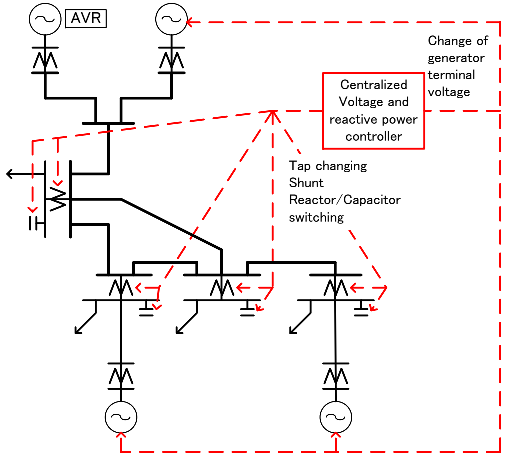


AVR (Automatic Voltage controller) controls generators' terminal voltage.
AVR detects the terminal voltage and control field current of exciter.

In case AVR is applied, it is often the case that reactive power output of the generator doesn't reach its upper limit and voltage control margin is remained even if system voltage drops.

On the other hand, PSVR controls the high side voltage of step-up transformer. Therefore reactive power of generator can be fully utilized.

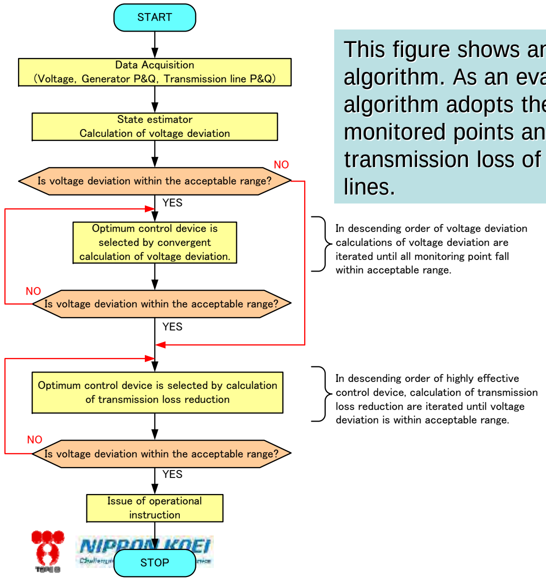
Centralized VQC Scheme



The conceptual diagram of Central VQC is shown in This Figure.

Based on the monitored online data, voltage control signal is sent out to the power stations and substations from central load dispatching center etc.

Example of the algorithm of Centralized VQC



START

Data Acquisition
(Voltage, Generator P&Q, Transmission line P&Q)

State estimator
Calculation of voltage deviation

Is voltage deviation within the acceptable range?

NO

YES

Optimum control device is selected by convergent calculation of voltage deviation.

In descending order of voltage deviation calculations of voltage deviation are iterated until all monitoring point fall within acceptable range.

Is voltage deviation within the acceptable range?

NO

YES

Optimum control device is selected by calculation of transmission loss reduction

In descending order of highly effective control device, calculation of transmission loss reduction are iterated until voltage deviation is within acceptable range.

Is voltage deviation within the acceptable range?

NO

YES

Issue of operational instruction

STOP

This figure shows an example of Centralized VQC algorithm. As an evaluation function, this algorithm adopts the voltage deviation at the monitored points and minimization of transmission loss of the monitored transmission lines.

Making Rule of Calibration

- Calibration of the input value to voltage controller
  - Voltage drop along the wiring from potential transformer should be calibrated.
- Making rules of calibration of detected voltage
  - Accuracy of potential transformer is not necessarily maintained because characteristics changes across the ages or under changing temperature.
  - Calibration rule is needed such as "If the detected value continuously differs more than 2 kV between neighboring busses in a substation, research and countermeasure should be taken."

Trend of PMU technology

- “PMU” is short for “ Phaser Measurement Unit”

  can widely measure time synchronized voltage phase angle by using GPS (Global Positioning System) etc.

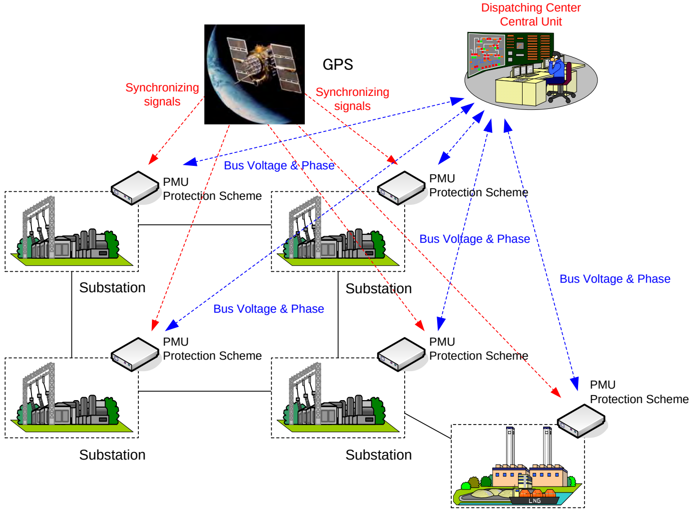
- At present ;WAMS (Wide Area Monitoring System)

  which PMU technology is based on is applied in many countries including Europe and the US and is utilized for real-time power system monitoring.

- Further more;WAMPAC (Wide Area Monitoring, Protection and Control)

  is being developed, which uses the monitored system information acquired by PMU.

Conceptual Structure of Developed PMU System



WAMPAC (Wide Area Monitoring, Protection and Control)

Synchrophasor Technology Roadmap (March 13, 2009)

By NASPI (North American Synchrophasor Initiative)

- By the year 2014 (WAMS)
  - Analysis after grid disturbances
  - Monitoring and visualization of angle differences, voltage stability, frequency, and thermal overloads
  - Power plant monitoring including windfarm, solar power and other dispersed generation
  - Power system restoration
  - Static model benchmarking
  - State estimation

“Monitor by PMU”

Synchrophasor Technology Roadmap (March 13, 2009)

By NASPI (North American Synchrophasor Initiative)

- By the year 2019 (WAMPAC)
  - Alarming for situational awareness tools
  - Day- and hour-ahead operations planning
  - Real-time automated grid controls and adaptive protection on a wide-area basis
  - Congestion management
  - Inter-area oscillation damping modulation controls
  - System integrity protection schemes
  - Dynamic model benchmarking
  - Dynamic line ratings and VAR support
  - Automatically manage frequency and voltage response from load
  - Distribution network monitoring, restoration and self-healing

“Control by PMU”

Accuracy improvement of State Estimation

EMS (Energy Management System) installed in JCC has the function of periodical Security Analysis on a real-time basis.

Introduction of PMU improve the accuracy as follows.

- State Estimation
- Contingency Screening

However, the following measures will be necessary along with the feasibility study on the introduction of PMU:

- To collect accurate network parameters
- To reduce missing data by the improvement of telecommunication facility

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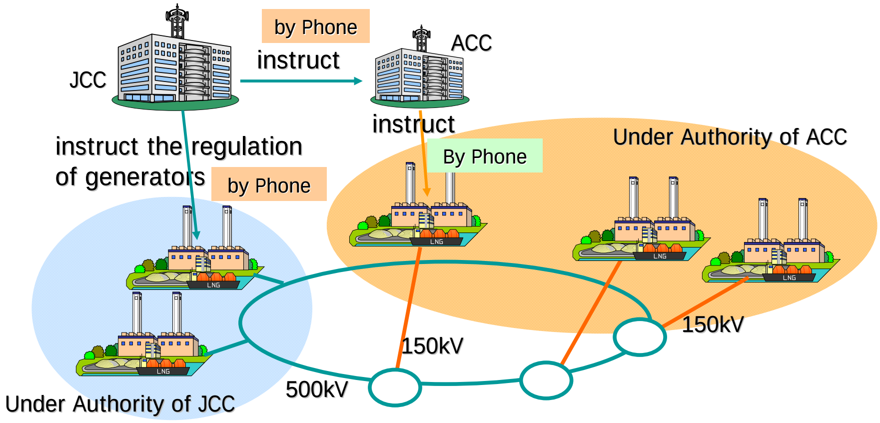
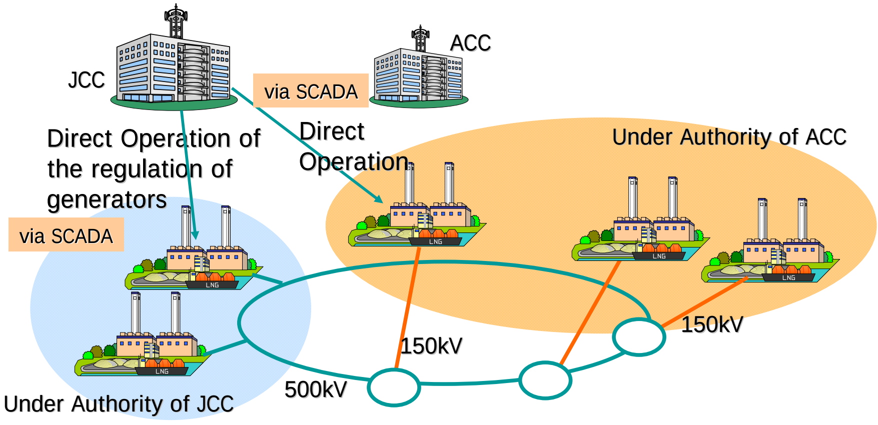
Present Conditions of Frequency Control



JCC operators instruct the regulation of generators directly by phone to the power stations connected to 500kV system, but instruct the p.s. connected 150 or 70 kV through ACCs.

Recommendation for Frequency Control



Study Team recommends direct dispatching of generators via SCADA of JCC, for quick response to the demand fluctuation.

Sharing The Knowledge for Frequency Control

Power Regulation is inhibited.

- When the number of mills is changed
- When the number of boiler feed pump changed
- During the hammering of Electrostatic Precipitator
- Valve Test etc.

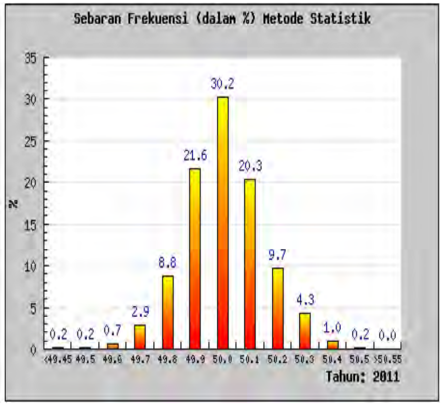
Minimum output is raised.

- LNG equipment has Boil-Off gas
- When the LNG carrier arrives etc.

Conservative and Quiet Way

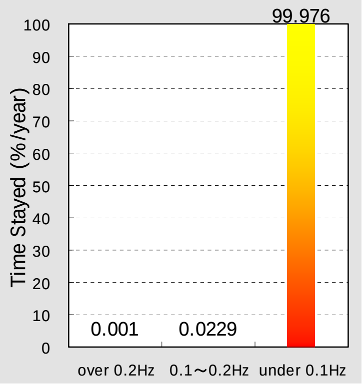
For Strategic Dispatching

【information】Frequency Distribution of Java Bali System



(SOURCE: Evaluasi Operasi Sistem Jawa Bali 2011)

Frequency Distribution of Jawa Bali System
on 2011 1.1-12.31



(SOURCE: Tokyo Electric Power Company)

Frequency Distribution of TEPCO
on 2010.4.1-2011.3.31

Involves on 2011.3.11 ; 221 sec.out of 0.2Hz

Capacitor Bank Design Considerations

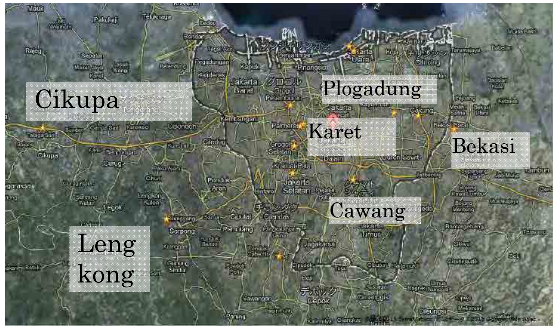
April. 18, 2013

JICA Study Team (Substation Design)
Takashi Wakabayashi
Eiji Matsuda

Capacitor Bank Installation

Objective: To develop a plan for capacitor bank installation, evaluate relevant designs and specifications, and review construction costs.

Photos: 500/150kV Kenbangan Substation



Capacitor Bank Installation Plan in near future

475 (on-going) +1070 (future) MVAR

= (approx.) 30 x 50MVAR Capacitor Banks

Japanese Typical Design for Capacitor Banks

Use of Power Cable for the flexibility of equipment location, because some substations was not designed to accommodate capacitor banks within.

Example of Direct Wiring

Cubicle for Capacitor Banks (22kV) And Its Cable heads

Cable Head For Cirbuit Breakers to capacitors

Cable Head For Capacitor Banks (66kV 40MVA)

Typical Practices for Capacitor Banks

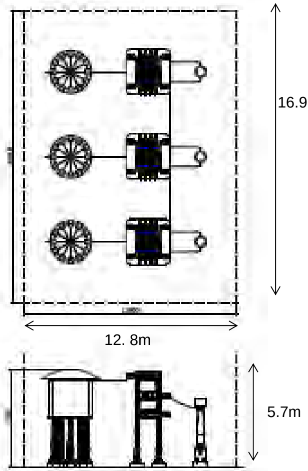
(Reference) TEPCO's Substation Design Philosophy:

- Securing areas for marshalling spaces, future substation expansion, rehabilitation, and renovations.
- Employing compact–type oil–immersed capacitor banks
- Enhanced seismic strength of facilities (0.3G with resonant sinusoidal three waves) = 0.2G in PLN
- Employing power cables for the flexibility for the equipment location
- Voltage control relay operates the OLTC tap and on/off of SCs and ShRs

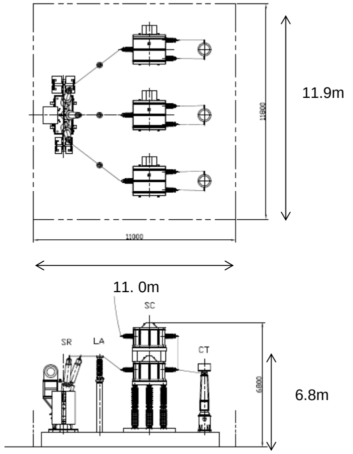
Japanese Typical Design for Capacitor Banks

Use of the Compact Type Capacitor Banks (154kV,25MVA)

Example of Condensor Banks (can type to oil-immersed type)



Expected Life of the Eelement: 10 yrs



Expected Life of the Eelement: 30 yrs

Transportation and Replacement in Substation

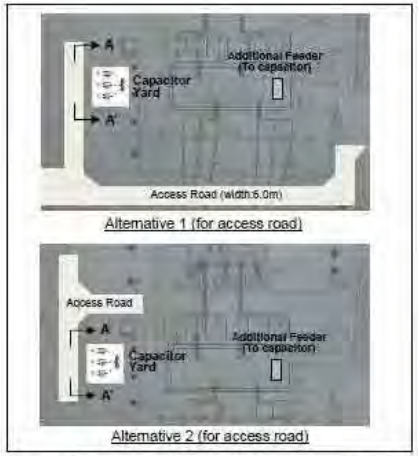


Figure Layout Plan of Additional Works for Capacitor Bank

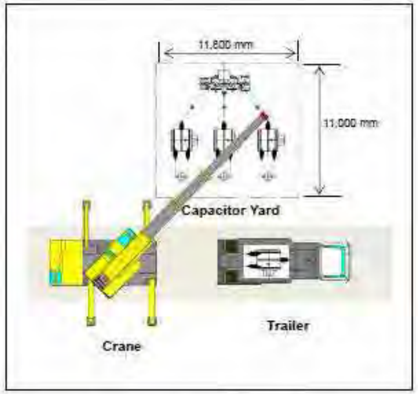
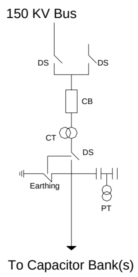


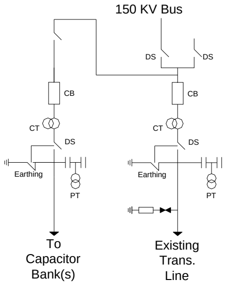
Figure Installation Method (Plan View A-A')

We should make sure that capacitor banks never become obstructions for future construction work

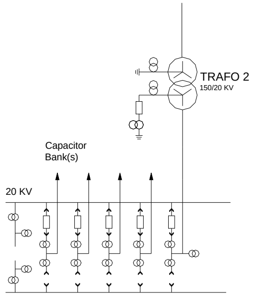
Capacitor Bank Connection



Feeder Addition



Modification of existing Feeder



in Case of GIS SS

Tertiary side connection could be possible in Transmission Substation if 66kV Tertiary side can be used.

Specifications for Reactive Power Source CBs

Circuit breakers for Capacitor Banks has typical operational requirements

- Frequent Operation during its lifetime
- Interruption of capacitive current : TRV specification

PLN already has a good equipment specification for Capacitor bank CB:

⇨ IEC M2 class circuit breaker with operation controller

The mechanical trouble in CB (M2+) for a Capacitor Bank in Bali system (6years after commissioning, operation 3 times a day)

Comparison of the specifications for capacitor CB

	PLN	TEPCO
Nominal Voltage,Capacity	154kV 50MVA (max.)	66kV 60MVA (max.)
CB Operation Duty	M2 Class (10,000+)	M2 Class (10,000+)
CB Controller	Necessary	Not for capacitive interruption. (only for inductive interruption)
Testing History for capacitive interruption	(Not specified)	Specified as a type test item

Environmental Change in Substation's Lifetime

TEPCO's expected Lifespan of the Substation's Equipment

65 years for 150kV+ transformers, Circuit breakers

Substation sites should be secured as long as it's possible

<u>What'll happen in 40-60 years around substation ?</u>

Ikebukuro, 45Years Ago

Ikebukuro, 2010

Future expansion of Substation (needs for land)

TEPCO is replacing the equipment installed 60+ years ago.

Conventional Air Insulated Substation

Gas Insulated Substation

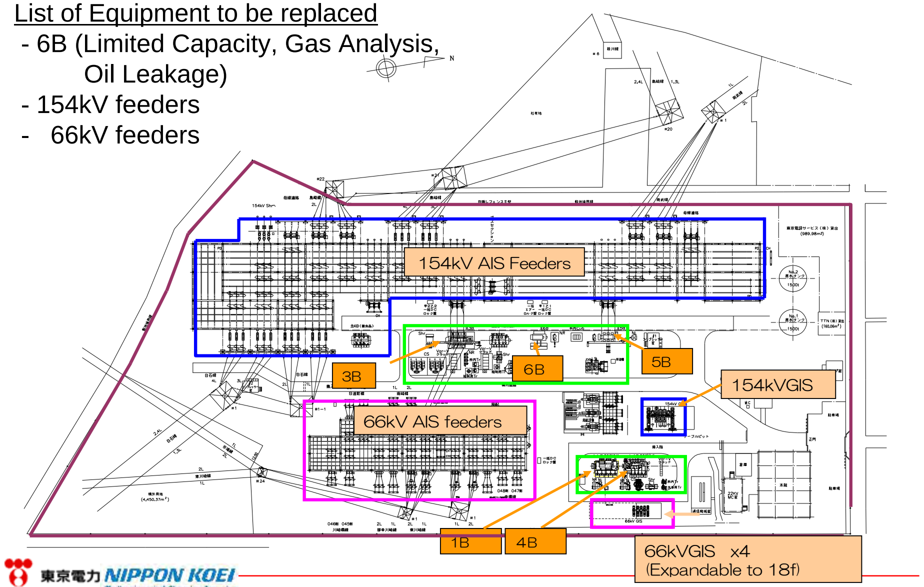
Substation Example:
154/66/22kV Substaton originally built in 1950s
With 12x 154kV ,17x 66kV ,13x 22kV Feeders.
Transformer: 200MVAx3, 45MVAx2

<u>Next Page, We' ll see the struggle for acquiring necessary land for the equipment replacements</u>

(EX.)Replacement Procedure in a Limited Space

<u>List of Equipment to be replaced</u>

- 6B (Limited Capacity, Gas Analysis, Oil Leakage)
- 154kV feeders
- 66kV feeders



154kV AIS Feeders

3B

6B

5B

154kVGIS

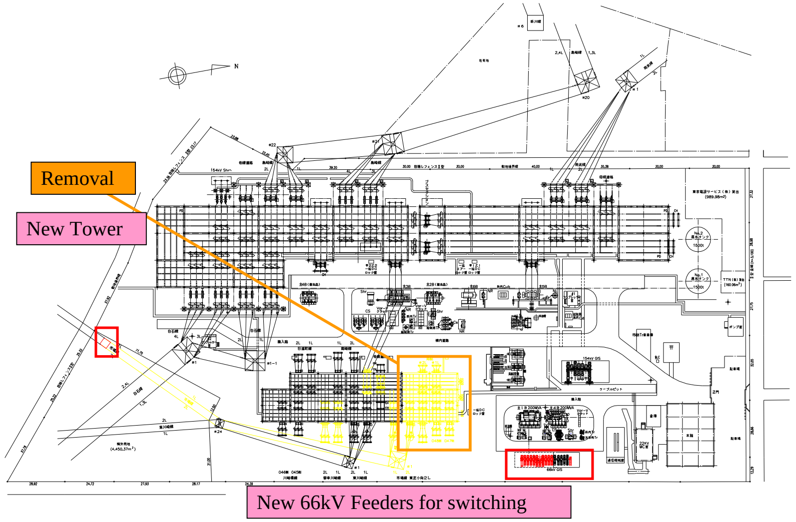
66kV AIS feeders

1B

4B

66kVGIS x4 (Expandable to 18f)

(EX.) Replacement Procedure in a Limited Space

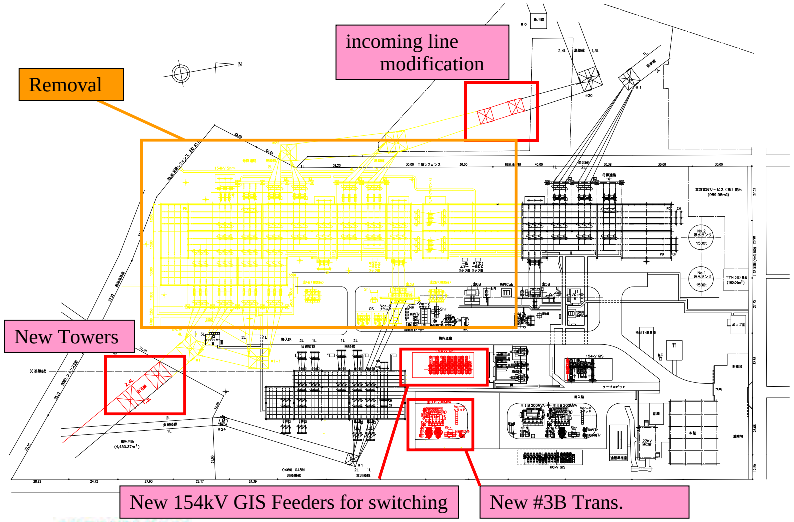


Removal

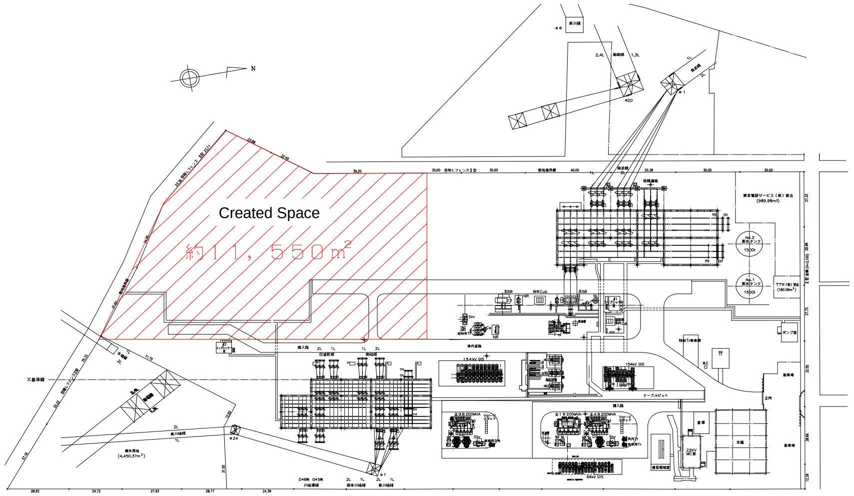
New Tower

New 66kV Feeders for switching

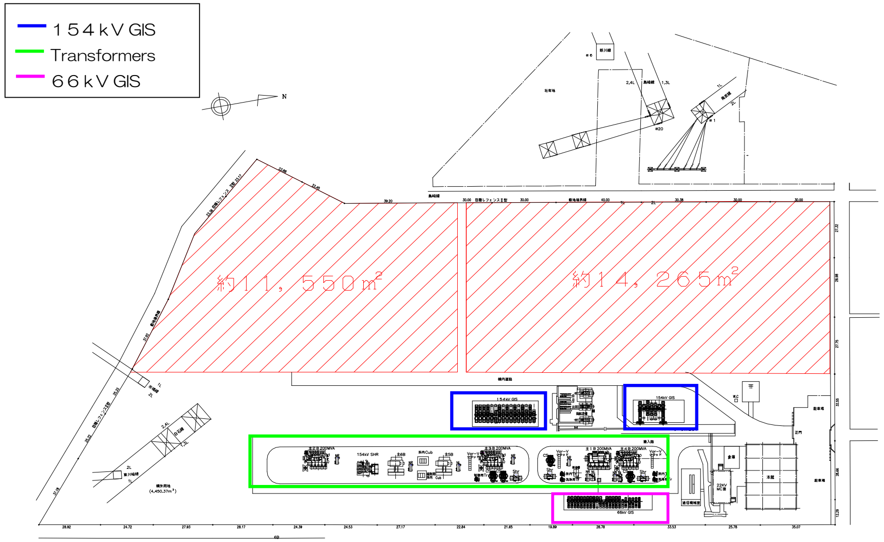
(EX.) Replacement Procedure in a Limited Space



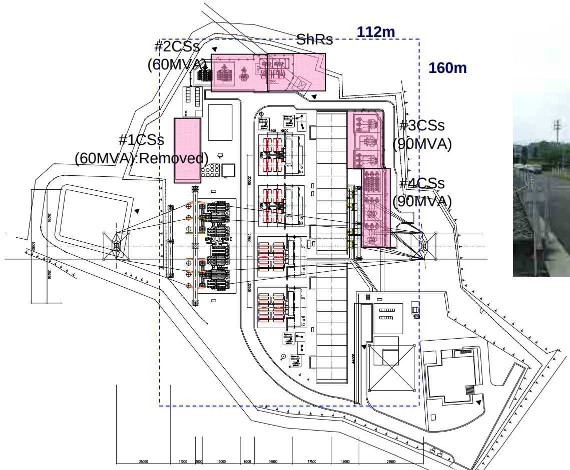
(EX.) Replacement Procedure in a Limited Space



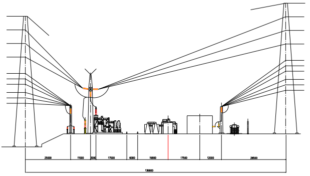
(EX.) Final Form of the Replacement Plan



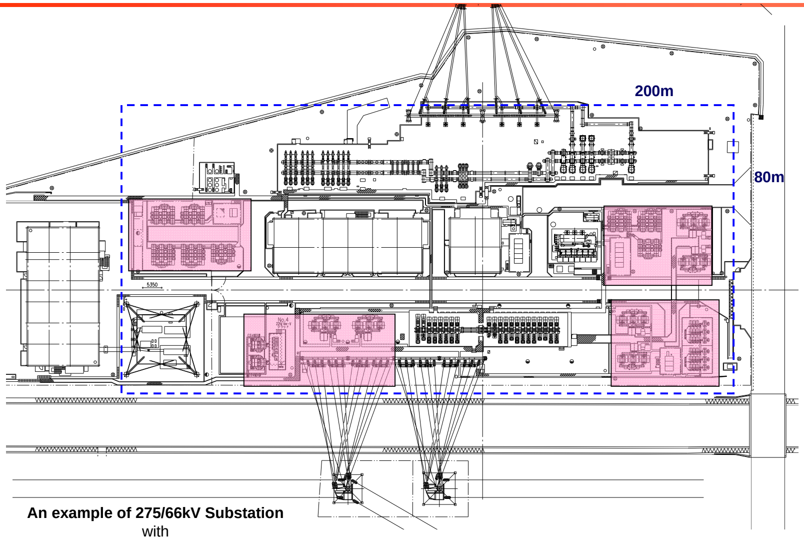
How much is the minimum land area for Substation ?



An example of 275/66kV Substation
with
200MVA x 2 banks & 300MVA x 2 banks,
6x275kV GIS feeders, 20x66kV GIS and AIS Feeders

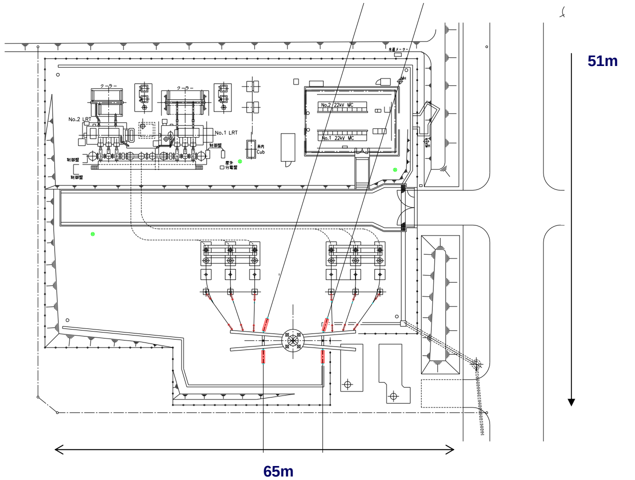


How much is the minimum land area for GIS Substation ?



An example of 275/66kV Substation
with
300MVA x 4 Main Tr Bank, 500MVar SCs
7x275kV GIS feeders, 20x66kV GISFeeders

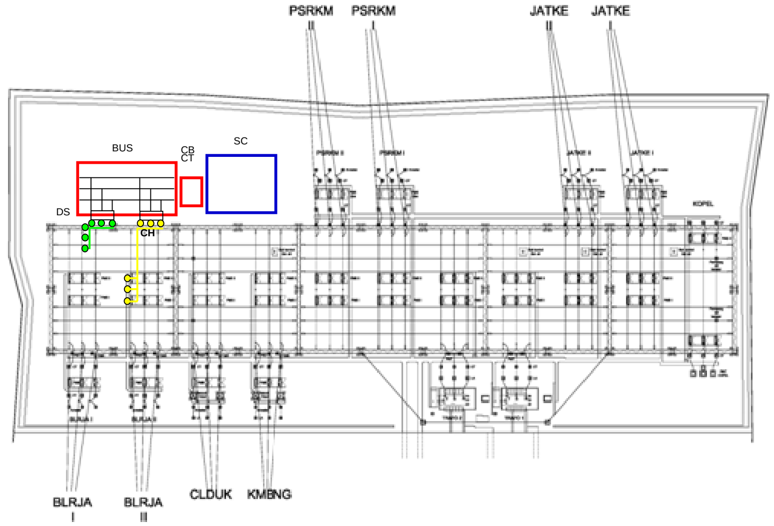
How much is the minimum land area for GIS Substation ?



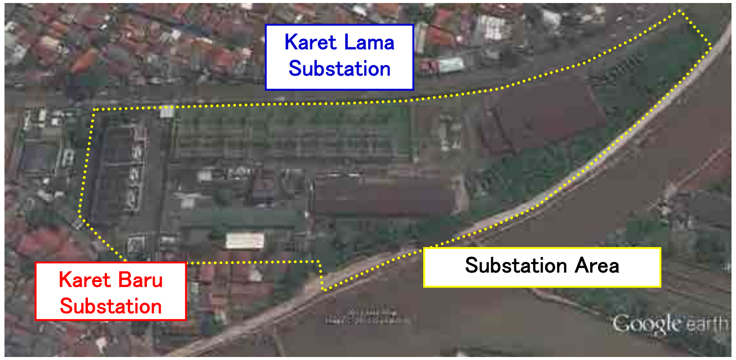
An example of 154/22kV Distribution Substation
with
30MVA x 2 banks, 2x154kV GIS feeders, 12x22kV Dist. Feeders

Discussion : Chikupa Substation

Yellow:
Substation
Area



Discussion : Karet Lama&Baru Future Expansion

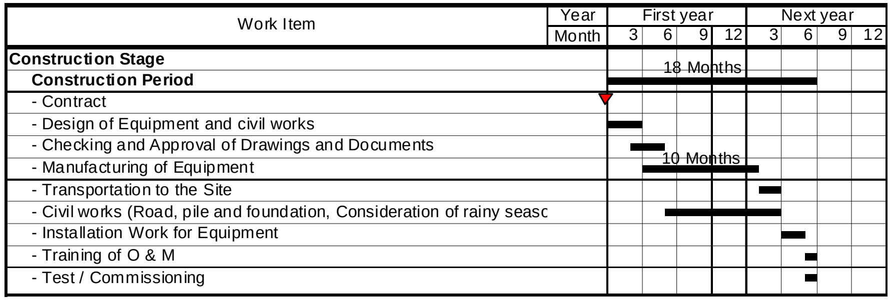


Consideration:

- Future expansion for 230 kV Substation ?
- Expansion of transformers ?
- New Office Building in City Center ?

Construction Work Planning

Implementation Schedule



Construction Stage

Construction Period

- Contract
- Design of Equipment and civil works
- Checking and Approval of Drawings and Documents
- Manufacturing of Equipment
- Transportation to the Site
- Civil works (Road, pile and foundation, Consideration of rainy seasc
- Installation Work for Equipment
- Training of O & M
- Test / Commissioning

Assumed Project Period : 18 month

including

Equipment Manufacturing : 10 months

On-site Construction Work : 5 months

Cost Comparison

kV	Unit size [MVar]	Electrical Works (Rp.)	Civil Works (Rp.)	Total (Rp.)
150	50	7,650,000,000	2,220,000 ,000	9,870,000 ,000
150	25	5,970,000,000	1,100,000,000	7,070,000,000
70	10	3,200,000,000	700,000,000	3,900,000,000
(22)	10	1,850,000,000	200,000,000	2,050,000,000

These cost estimation assumes

- Air insulated switchgears on 150kV
- Conventional Capacitor Bank (not compact)
- 22kV 10MVAR consists 5 x 2MVAR banks

If Compact type capacitor bank is selected, the equipment cost almost triples, but the expected lifetime will be also tripled (According to IEC) and has improved TRV.

Thus, in special case such as limited site availability, frequent operation of capactor banks, corrosive atmosphere, lifecycle cost of the compact capacitor bank will be beneficial to select the best form.