付属資料

Long Term Transmission Development Plan (2004 LTTDS)

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
220kV	220/132kV Inter-bus Transformer				KOTMALE 1 x 250MVA						
	Augment & Rehabilitation of Transformer						RANTEMBE +1 x 105MVA				
	New Transmission Line / Equipment					KOTMALE - NEW ANURADHAPURA Zebra, 1cct 163km		RANDENIGALA - RANTEMBE 2xZebra, 1cct 3.1km			
132kV	132/33kV New Grid Substation	RATNAPURA 2 x 31.5MVA ATHURUGIRIYA 2 x 31.5MVA	HORANA 2 x 31.5MVA	HAVELOCK TOWN (Col A) 2 x 31.5MVA MARADANA (Col I) 2 x 31.5MVA DEHIWALA 2 x 31.5MVA SRI J'PURA 2 x 31.5MVA	NEW GALLE 2 x 31.5MVA MAHO 1 x 31.5MVA MEDAGAMA 1 x 31.5MVA POLONNARUWA 1 x 31.5MVA PANNALA 2 x 31.5MVA AMBALANGODA 2 x 31.5MVA ANIYAKANDA 2 x 31.5MVA KILINOCHCHI 1 x 31.5MVA CHUNNAKAM 2 x 31.5MVA	PALLEKELE 2 x 31.5MVA RAMTEMBE 1 x 31.5MVA NAULA 1 x 31.5MVA KOTAHENA (Col C) 2 x 31.5MVA KATANA 2 x 31.5MVA	PADIRIPPU 2 x 31.5MVA	KEGALLE 1 x 31.5MVA		Colombo Sub B 2 x 31.5MVA	Colombo Sub K 2 x 31.5MVA
	Augment & Rehabilitation of Grid Substation	THULHIRIYA +1 x 31.5MVA	AMPARA +1 x 31.5MVA	MADAMPE +1 x 31.5MVA	DENIYAYA +1 x 31.5MVA	KURUNEGALA +1 x 31.5MVA KOTUGODA +2 x 31.5MVA	HAVELOCK TOWN (Col A) +1 x 31.5MVA MARADANA (Col I) +1 x 31.5MVA VEYANGODA +1 x 31.5MVA	KOSGAMA +1 x 31.5MVA PANADURA +1 x 31.5MVA KELANIYA +1 x 31.5MVA WIMALASURENDRA +1 x 31.5MVA, -1 x 15MVA OLD ANURADHAPURA +1 x 31.5MVA -2 x 10MVA OLD GALLE +2 x 31.5MVA -2 x 30MVA	SRI J'PURA +1 x 31.5MVA VALACHCHENA +2 x 31.5MVA -2 x 10MVA	MATARA +1 x 31.5MVA MAHO +1 x 31.5MVA UKUWELA +1 x 31.5MVA NUWARA ELIYA +1 x 31.5MVA	PANNALA +1 x 31.5MVA HORANA +1 x 31.5MVA
	New Transmission Line / Equipment	KELANIYA - KHD - SAPUGASKANDA Zebra, 4cct 3.6km 2cct 1km BALANGODA - RATNAPURA Zebra, 2cct 40km ATURUGIRIYA GS Double in/out Lynx, 2cct 1.5km	HORANA GS Single in/out Zebra, 2cct 20km	SRI J'PURA GS T off Connection Zebra, 2cct 0.1km PANNIPITIYA - DEHIWALA CV1000, 1cct 9km Col I - KOLONNAWA CV1000, 1cct 4.6km Col A - Col I CV800, 1cct 6.3km DEHIWALA - HAVELOCK TOWN CV800, 1cct 8.5km	MATUGAMA - AMBALANGODA Zebra, 2cct 28km ANIYAKANDA GS Single in/out Zebra, 2cct 5km PANNALA GS Single in/out Zebra, 2cct 14km AMBALANGODA - NEW GALLE Zebra, 1cct 36km MATARA - NEW GALLE Zebra, 1cct 34km NEW GALLE GS Double in/out Lynx, 2x2cct 0.2km PUTTALAM - MAHO Zebra, 1cct 42km AMPARA - RANTEMBE Zebra, 2cct 130km MEDAGAMA GS Zebra, T off 1cct 0.1km HABARANA - VALACHCHENA Zebra, 1cct 99.7km	KELANITISSA - Col C CV500, 1cct 1.6km KOLONNAWA - Col C CV500, 1cct 6.2km UKUWELA - PALLEKELE Zebra, 2cct 18km NAULA GS Single in/out Lynx, 2cct 0.5km KATANA GS Double in/out BOLAWATTE GS _Double in/out	AMPARA - PADIRIPPU Zebra, 2cct 35km	THULHIRIYA - KEGALLE Zebra, 2cct 18.7km THULHIRIYA - VEYANGODA Zebra, 2cct 25km		Colombo B GS Single in/out PUTTALAM - MAHO Stringing 2nd	KOLONNAWA - Col K CV500, 1cct 5km or Col A - Col K CV500, 1cct 4km SRI J'PURA - Col K CV500, 1cct 5km
	Reconstruction of Transmission Line	KOLONNAWA - KELANIYA Coyote to Zebra KELANIYA - KOTUGODA Coyote to Zebra KELANITISSA - KOLONNAWA Invar, 2cct 2km			KOTHMALE - KIRIBATHKUMBURA Zebra, 2cct 22.5km KILINOCHCHI - VAVUNIYA Lynx, 2cct 74.1km KILINOCHCHI - CHUNNAKAM Zebra, 2cct 67.2km MADAMPE GS Double T-off to Single in/out		KOLONNAWA - J'PURA - PNNIPITIYA Zebra, 2cct 12.9km Double T-off to Single in/out	KOLONNAWA - ATHURUGIRIYA Zebra, 2cct 14km ATHURUGIRIYA - POLPITIYA Zebra, 2cct 52km			ANURADHAPURA - HABARANA Zebra, 2cct 49km NEW CHILAW - BOLAWATTA Zebra, 2cct 22.6km
Other Equipment		PNNIPITIYA GS BSC 10MVar ATHURUGIRIYA GS BSC 20MVar THULHIRIYA GS BSC 10MVar			MADAMPE GS BSC 30MVar AMBALANGODA GS BSC 2 x 5MVar ANIYAKANDA GS BSC 2 x 5MVar	PALLEKELE GS BSC 4 x 5MVar KATANA GS BSC 10MVar			VALACHCHENA GS BSC 20MVar		

Modified Point of Transmission Lines and Transformers Data

PSSE Original DATA from CEB　　Red letters: Data shold be changed to the standard value

Transmission Lines Data (100MVA base)

From			To			ID	Target Data to be checked R (pu/km)	X (pu/km)	B (pu/km)	capacity RateA	capacity RateB	capacity RateC	Standard Value Rate A (MVA)	Rate B	Rate C	R (pu)	X (pu)	B (pu)
1300	KELAN-1	132.00	1900	COL_C_1	132.00	1	0.00044	0.00167	0.01401	180	180	180	160	160	160	0.000354	0.001654	0.016305
1430	COL_I_1	132.00	1435	COL_A_1	132.00	1	0.00112	0.00597	0.06725	230	230	230	225	225	225	0.000621	0.004404	0.051482
1430	COL_I_1	132.00	1550	KOLON-1	132.00	1	0.00071	0.00417	0.05288	255	255	255	255	255	255	0.000501	0.004245	0.054407
1435	COL_A_1	132.00	1890	DEHIW_1	132.00	1	0.00151	0.00805	0.09073	230	230	230	225	225	225	0.000951	0.006741	0.078800
1550	KOLON-1	132.00	1750	COL_E-1	132.00	1	0.00158	0.00294	0.12119	120	120	120	120	120	120	0.001208	0.002285	0.094261
1550	KOLON-1	132.00	1920	COL_K132	132.00	1	0.00138	0.00522	0.04379	180	180	180	160	160	160	0.001105	0.005168	0.050954
1550	KOLON-1	132.00	1940	COL_B_13	132.00	1	0.00116	0.00439	0.03678	180	180	180	160	160	160	0.000928	0.004341	0.042801
1560	PANNI-1	132.00	1890	DEHIW_1	132.00	1	0.00139	0.00816	0.10346	255	255	255	255	255	255	0.000888	0.007518	0.096346
1690	HABAR-1	132.00	1705	NEWANU-1	132.00	2	0.02133	0.10861	0.02543	165	100	140	165	225	255	0.021329	0.108611	0.025429
1840	JPURA_1	132.00	1920	COL_K132	132.00	1	0.00138	0.00522	0.04379	180	180	180	160	160	160	0.001105	0.005168	0.050954
1900	COL_C_1	132.00	1940	COL_B_13	132.00	1	0.00055	0.00209	0.01752	180	180	180	160	160	160	0.000442	0.002067	0.020382

Transformers Data (100MVA base)

From			To			Standard Value X	Target Data to be checked X	RateA	RateB	RateC
1220	KOTMA-1	132.00	2220	KOTMA-2	220.00	0.056	0.04	250	250	250

GENROU (Round Roter Generator Model) Type

Type	Bus ID	Bus	Type	unit	T'do	T"do	T'qo	T"qo	Inertia	Speed Damping D	Xd	Xq	X'd	X'q	X"d=X"q	Xl	S(1.0)	S(1.2)	Remarks
GT	1300	KELAN-1 132.00	'GENROU'	1	5.568	0.03	1.09	0.16	7.23	0.5	2.38	1.72	0.231	1.2	0.17	0.1	0.03	0.4	Decomposition to 16MW×3
GT	1300	KELAN-1 132.00	'GENROU'	1A	5.568	0.03	1.09	0.16	7.23	0.5	2.38	1.72	0.231	1.2	0.17	0.1	0.03	0.4	
GT	1300	KELAN-1 132.00	'GENROU'	1B	5.568	0.03	1.09	0.16	7.23	0.5	2.38	1.72	0.231	1.2	0.17	0.1	0.03	0.4	
GT	1300	KELAN-1 132.00	'GENROU'	1C	5.568	0.03	1.09	0.16	7.23	0.5	2.38	1.72	0.231	1.2	0.17	0.1	0.03	0.4	
ST(retired)	1300	KELAN-1 132.00	'GENROU'	2	6.97	0.036	1.09	0.19	4	0.5	1.79	1.72	0.23	1.2	0.12	0.1	0.03	0.4	steam terbine's data No Existing
GT	1300	KELAN-1 132.00	'GENROU'	3	6.64	0.049	1.18	0.066	8	0.5	1.81	1.77	0.259	0.344	0.179	0.1	0.125	0.589	
CC(GT)	2300	KELAN-2 220.00	'GENROU'	1	6.85	0.032	1	0.16	4	0.5	1.75	1.68	0.2262	0.437	0.163	0.0875	0.1	0.4	
CC(ST)	2300	KELAN-2 220.00	'GENROU'	2	6.85	0.032	1	0.16	4	0.5	1.75	1.68	0.2262	0.437	0.153	0.0875	0.1	0.4	
CC(GT)	2300	KELAN-2 220.00	'GENROU'	3	7.55	0.032	1	0.16	8	0.5	2.16	1.68	0.283	0.437	0.163	0.0875	0.1	0.4	
CC(ST)	2300	KELAN-2 220.00	'GENROU'	4	5.53	0.032	1	0.16	4	0.5	1.68	1.68	0.219	0.437	0.204	0.0875	0.1	0.4	
CC(2007)	2305	KERAWAL2 220.00	'GENROU'	1	6.85	0.032	1	0.16	4	0.5	1.75	1.68	0.2262	0.437	0.163	0.0875	0.1	0.4	
CC(2007)	2305	KERAWAL2 220.00	'GENROU'	2	6.85	0.032	1	0.16	4	0.5	1.75	1.68	0.2262	0.437	0.153	0.0875	0.1	0.4	
CC(2007)	2305	KERAWAL2 220.00	'GENROU'	3	6.85	0.032	1	0.16	4	0.5	1.75	1.68	0.2262	0.437	0.163	0.0875	0.1	0.4	
CC(2007)	2305	KERAWAL2 220.00	'GENROU'	4	6.85	0.032	1	0.16	4	0.5	1.75	1.68	0.2262	0.437	0.153	0.0875	0.1	0.4	
GT(2013)	2305	KERAWAL2 220.00	'GENROU'	5	6.85	0.032	1	0.16	4.5	0.5	1.75	1.72	0.27	1.31	0.163	0.1	0.03	0.4	
Coal(2009)	2815	PUTTA-2 220.00	'GENROU'	1	6.85	0.032	1	0.16	4	0.5	1.75	1.68	0.2262	0.437	0.16	0.0875	0.1	0.4	
Coal(2009)	2815	PUTTA-2 220.00	'GENROU'	2	6.85	0.032	1	0.16	4	0.5	1.75	1.68	0.2262	0.437	0.16	0.0875	0.1	0.4	
	3301	KELAN-3A 33.000	'GENROU'	1	6.97	0.029	1.09	0.15	4.5	0.5	1.79	1.72	0.23	1.2	0.147	0.1	0.03	0.4	No existing
	3302	KELAN-3B 33.000	'GENROU'	1	6.97	0.029	1.09	0.15	4.5	0.5	1.79	1.72	0.23	1.2	0.149	0.1	0.03	0.4	No existing
Typical Value presented by PTI					6	0.05	1	0.05	3	0	1.4	1.35	0.3	0.6	0.2	0.1	0.03	0.4	

GENSAL (Salient Pole Generator Model) Type

Type	Bus ID	Bus		Type	unit	T'do	T''do	T''qo	Inertia	Speed Damping D	Xd	Xq	X'd	X''d	Xl	S(1.0)	S(1.2)	Remarks
Hydro	1100	LAX-1	132.00	'GENSAL'	1	5.2	0.068	0.12	3	0.5	1.15	0.66	0.255	0.16	0.1	0.03	0.25	Decomposition to 12.5MW×2
Hydro	1100	LAX-1	132.00	'GENSAL'	1A	5.2	0.068	0.12	3	0.5	1.15	0.66	0.255	0.16	0.1	0.03	0.25	
Hydro	1100	LAX-1	132.00	'GENSAL'	1B	5.2	0.068	0.12	3	0.5	1.15	0.66	0.255	0.16	0.1	0.03	0.25	
Hydro	1100	LAX-1	132.00	'GENSAL'	2	5.2	0.068	0.12	3	0.5	1.75	0.66	0.46	0.219	0.1	0.03	0.25	Decomposition to 8.33MW×3
Hydro	1110	LAX-1	132.00	'GENSAL'	2A	5.2	0.068	0.12	3	0.5	1.75	0.66	0.46	0.219	0.1	0.03	0.25	
Hydro	1110	LAX-1	132.00	'GENSAL'	2B	5.2	0.068	0.12	3	0.5	1.75	0.66	0.46	0.219	0.1	0.03	0.25	
Hydro	1110	LAX-1	132.00	'GENSAL'	2C	5.2	0.068	0.12	3	0.5	1.75	0.66	0.46	0.219	0.1	0.03	0.25	
Hydro	1110	N-LAX-1	132.00	'GENSAL'	1	8.6	0.056	0.12	3.32	0.5	0.9	0.55	0.23	0.15	0.1	0.03	0.25	
Hydro	1110	N-LAX-1	132.00	'GENSAL'	2	8.6	0.056	0.12	3.32	0.5	0.9	0.55	0.23	0.15	0.1	0.03	0.25	
Hydro	1120	WIMAL-1	132.00	'GENSAL'	1	5.2	0.074	0.13	3	0.5	1.28	0.66	0.27	0.147	0.1	0.03	0.25	
Hydro	1120	WIMAL-1	132.00	'GENSAL'	2	5.2	0.074	0.13	3	0.5	1.28	0.66	0.27	0.147	0.1	0.03	0.25	
Hydro	1130	POLPI-1	132.00	'GENSAL'	1	5.2	0.084	0.15	2.83	0.5	1.12	0.66	0.23	0.156	0.1	0.049	0.158	
Hydro	1130	POLPI-1	132.00	'GENSAL'	2	5.2	0.084	0.15	2.83	0.5	1.12	0.66	0.23	0.156	0.1	0.049	0.158	
Hydro	1140	CANYO-1	132.00	'GENSAL'	1	5.2	0.06	0.11	3.8	0.5	1.1	0.66	0.32	0.18	0.1	0.03	0.25	
Hydro	1140	CANYO-1	132.00	'GENSAL'	2	5.2	0.06	0.11	3.8	0.5	1.1	0.66	0.32	0.18	0.1	0.03	0.25	
Hydro	1170	SAMAN-1	132.00	'GENSAL'	1	7.58	0.07	0.15	3.18	0.5	1.03	0.57	0.288	0.135	0.1	0.057	0.256	
Hydro	1170	SAMAN-1	132.00	'GENSAL'	2	7.58	0.07	0.15	3.18	0.5	1.03	0.57	0.288	0.135	0.1	0.057	0.256	
Hydro	1200	UKUWE-1	132.00	'GENSAL'	1	8	0.055	0.03	3.2	0.5	1.1	0.58	0.28	0.22	0.09	0.179	0.5	
Hydro	1200	UKUWE-1	132.00	'GENSAL'	2	8	0.055	0.03	3.2	0.5	1.1	0.58	0.28	0.22	0.09	0.179	0.5	
Hydro	1210	BOWAT-1	132.00	'GENSAL'	1	5.2	0.073	0.13	4	0.5	0.87	0.66	0.157	0.148	0.1	0.259	0.625	
Hydro	1410	KUKULE-1	132.00	'GENSAL'	1	5	0.05	0.11	2.84	0	1.12	0.84	0.23	0.2	0.112	0.19	0.7	
Hydro	1410	KUKULE-1	132.00	'GENSAL'	2	5	0.05	0.11	2.84	0	1.12	0.84	0.23	0.2	0.112	0.19	0.7	
Hydro	2220	KOTMA-2	220.00	'GENSAL'	1	8	0.049	0.11	3.02	0.5	1	0.6	0.25	0.19	0.1	0.083	0.339	
Hydro	2220	KOTMA-2	220.00	'GENSAL'	2	8	0.049	0.11	3.02	0.5	1	0.6	0.25	0.19	0.1	0.083	0.339	
Hydro	2220	KOTMA-2	220.00	'GENSAL'	3	8	0.049	0.11	3.02	0.5	1	0.6	0.25	0.19	0.1	0.083	0.339	
Hydro	2225	UPKT-2	220.00	'GENSAL'	1	6.7	0.048	0.1	4.3	0.5	1.03	0.63	0.29	0.177	0.1	0.03	0.25	
Hydro	2225	UPKT-2	220.00	'GENSAL'	2	6.7	0.048	0.1	4.3	0.5	1.03	0.63	0.29	0.177	0.1	0.03	0.25	
Hydro	2230	VICTO-2	220.00	'GENSAL'	1	7.57	0.061	0.08	3.44	0.5	0.952	0.6	0.239	0.186	0.127	0.075	0.219	Decomposition to 70MW×3
Hydro	2230	VICTO-2	220.00	'GENSAL'	1A	7.57	0.061	0.08	3.44	0.5	0.952	0.6	0.239	0.186	0.127	0.075	0.219	
Hydro	2230	VICTO-2	220.00	'GENSAL'	1B	7.57	0.061	0.08	3.44	0.5	0.952	0.6	0.239	0.186	0.127	0.075	0.219	
Hydro	2230	VICTO-2	220.00	'GENSAL'	1C	7.57	0.061	0.08	3.44	0.5	0.952	0.6	0.239	0.186	0.127	0.075	0.219	
Hydro	2240	RANDE-2	220.00	'GENSAL'	1	6.2	0.04	0.09	3.65	0.5	1	0.63	0.32	0.21	0.153	0.064	0.211	
Hydro	2240	RANDE-2	220.00	'GENSAL'	2	6.2	0.04	0.09	3.65	0.5	1	0.63	0.32	0.21	0.153	0.064	0.211	
Diesel(2012retired)	3590	SAPUG-3A	33.000	'GENSAL'	1	3.6	0.021	0.09	0.53	0.5	2.2	1.06	0.358	0.241	0.173	0.075	0.26	Decomposition to 5.8MW×4
Diesel(2012retired)	3590	SAPUG-3A	33.000	'GENSAL'	1A	3.6	0.021	0.09	0.53	0.5	2.2	1.06	0.358	0.241	0.173	0.075	0.26	
Diesel(2012retired)	3590	SAPUG-3A	33.000	'GENSAL'	1B	3.6	0.021	0.09	0.53	0.5	2.2	1.06	0.358	0.241	0.173	0.075	0.26	
Diesel(2012retired)	3590	SAPUG-3A	33.000	'GENSAL'	1C	3.6	0.021	0.09	0.53	0.5	2.2	1.06	0.358	0.241	0.173	0.075	0.26	
Diesel(2012retired)	3590	SAPUG-3A	33.000	'GENSAL'	1D	3.6	0.021	0.09	0.53	0.5	2.2	1.06	0.358	0.241	0.173	0.075	0.26	
Diesel(2012retired)	3670	MATARA-3	33.000	'GENSAL'	1	3.8	0.027	0.09	0.83	0.5	2.34	1.13	0.381	0.258	0.1	0.093	0.242	Decomposition to 5MW×4
Diesel(2012retired)	3670	MATARA-3	33.000	'GENSAL'	1A	3.8	0.027	0.09	0.83	0.5	2.34	1.13	0.381	0.258	0.1	0.093	0.242	
Diesel(2012retired)	3670	MATARA-3	33.000	'GENSAL'	1B	3.8	0.027	0.09	0.83	0.5	2.34	1.13	0.381	0.258	0.1	0.093	0.242	
Diesel(2012retired)	3670	MATARA-3	33.000	'GENSAL'	1C	3.8	0.027	0.09	0.83	0.5	2.34	1.13	0.381	0.258	0.1	0.093	0.242	
Diesel(2012retired)	3670	MATARA-3	33.000	'GENSAL'	1D	3.8	0.027	0.09	0.83	0.5	2.34	1.13	0.381	0.258	0.1	0.093	0.242	
Diesel(2013retired)	4420	HORANA_G	11.000	'GENSAL'	1	3.8	0.027	0.09	0.83	0.5	2.34	1.13	0.381	0.258	0.1	0.093	0.242	Decomposition to 5MW×4
Diesel(2013retired)	4420	HORANA_G	11.000	'GENSAL'	1A	3.8	0.027	0.09	0.83	0.5	2.34	1.13	0.381	0.258	0.1	0.093	0.242	
Diesel(2013retired)	4420	HORANA_G	11.000	'GENSAL'	1B	3.8	0.027	0.09	0.83	0.5	2.34	1.13	0.381	0.258	0.1	0.093	0.242	
Diesel(2013retired)	4420	HORANA_G	11.000	'GENSAL'	1C	3.8	0.027	0.09	0.83	0.5	2.34	1.13	0.381	0.258	0.1	0.093	0.242	
Diesel(2013retired)	4420	HORANA_G	11.000	'GENSAL'	1D	3.8	0.027	0.09	0.83	0.5	2.34	1.13	0.381	0.258	0.1	0.093	0.242	
Hydro	4251	RANTE-G1	12.500	'GENSAL'	1	5.1	0.059	0.1	2.62	0.5	1.16	0.66	0.32	0.185	0.147	0.106	0.463	
Hydro	4252	RANTE-G2	12.500	'GENSAL'	1	5.1	0.059	0.1	2.62	0.5	1.16	0.66	0.32	0.185	0.147	0.106	0.463	
Diesel	1310	SAPUG-1P	132.00	'GENSAL'	1	3.92	0.05	0.19	3.2	0.5	2.4	1.9	0.42	0.215	0.099	0.1	0.246	
Diesel	1310	SAPUG-1P	132.00	'GENSAL'	2	3.92	0.05	0.19	3.2	0.5	2.4	1.9	0.42	0.215	0.099	0.1	0.246	
	Typical Value presented by PTI					5	0.05	0.06	5.084	1	1.5	1.2	0.4	0.25	0.12	0.03	0.25	

GENSAL (Salient Pole Generator Model) Type

Type	Bus ID	Bus	Type	unit	T'do	T''do	T''qo	Inertia	Speed Damping D	Xd	Xq	X'd	X''d	Xl	S(1.0)	S(1.2)	Remarks
Diesel(2013retired)	1310	SAPUG-1P 132.00	'GENSAL'	3	3.92	0.05	0.19	3.2	0.5	2.2	1.9	0.37	0.25	0.099	0.1	0.246	Decomposition to 18MW×4
Diesel(2013retired)	1310	SAPUG-1P 132.00	'GENSAL'	3A	3.92	0.05	0.19	3.2	0.5	2.2	1.9	0.37	0.25	0.099	0.1	0.246	
Diesel(2013retired)	1310	SAPUG-1P 132.00	'GENSAL'	3B	3.92	0.05	0.19	3.2	0.5	2.2	1.9	0.37	0.25	0.099	0.1	0.246	
Diesel(2013retired)	1310	SAPUG-1P 132.00	'GENSAL'	3C	3.92	0.05	0.19	3.2	0.5	2.2	1.9	0.37	0.25	0.099	0.1	0.246	
Diesel(2013retired)	1310	SAPUG-1P 132.00	'GENSAL'	3D	3.92	0.05	0.19	3.2	0.5	2.2	1.9	0.37	0.25	0.099	0.1	0.246	
	1310	SAPUG-1P 132.00	'GENSAL'	4	4.3	0.05	0.19	3.2	0.5	1.98	1.9	0.31	0.21	0.099	0.1	0.3	No exisiting
Diesel	4595	KHD-G 11.000	'GENSAL'	1	5.5	0.049	0.14	1	0.5	2.38	1.51	0.44	0.23	0.1	0.03	0.25	Decomposition to 6.375MW×8
Diesel	4595	KHD-G 11.000	'GENSAL'	1A	5.5	0.049	0.14	1	0.5	2.38	1.51	0.44	0.23	0.1	0.03	0.25	
Diesel	4595	KHD-G 11.000	'GENSAL'	1B	5.5	0.049	0.14	1	0.5	2.38	1.51	0.44	0.23	0.1	0.03	0.25	
Diesel	4595	KHD-G 11.000	'GENSAL'	1C	5.5	0.049	0.14	1	0.5	2.38	1.51	0.44	0.23	0.1	0.03	0.25	
Diesel	4595	KHD-G 11.000	'GENSAL'	1D	5.5	0.049	0.14	1	0.5	2.38	1.51	0.44	0.23	0.1	0.03	0.25	
Diesel	4595	KHD-G 11.000	'GENSAL'	1E	5.5	0.049	0.14	1	0.5	2.38	1.51	0.44	0.23	0.1	0.03	0.25	
Diesel	4595	KHD-G 11.000	'GENSAL'	1F	5.5	0.049	0.14	1	0.5	2.38	1.51	0.44	0.23	0.1	0.03	0.25	
Diesel	4595	KHD-G 11.000	'GENSAL'	1G	5.5	0.049	0.14	1	0.5	2.38	1.51	0.44	0.23	0.1	0.03	0.25	
Diesel	4595	KHD-G 11.000	'GENSAL'	1H	5.5	0.049	0.14	1	0.5	2.38	1.51	0.44	0.23	0.1	0.03	0.25	
Diesel	4444	BARGE-G1 11.000	'GENSAL'	1	4.9	0.056	0.1	1.62	0.1	1.35	0.77	0.39	0.29	0.18	0.111	0.436	
Diesel(2007)	3730	CHUNNA-3 33.000	'GENSAL'	1	4.3	0.05	0.06	3.2	0.5	1.98	1.9	0.31	0.21	0.099	0.1	0.3	
DG(2005)	1660	Embilipitiya	'GENSAL'	1	3.6	0.033	0.06	7.704	0.5	1.77	0.88	0.48	0.16	0.15	0.1	0.3	should be added
DG(2005)	1810	Ladanavi Puttlam	'GENSAL'	1	5.8	0.033	0.13	1.29	0.5	2.03	1.02	0.352	0.237	0.176	0.1	0.3	should be added
		Typical Value presented by PTI			5	0.05	0.06	5.084	1	1.5	1.2	0.4	0.25	0.12	0.03	0.25	

Excitors

	Type	Node	Name	Type	I	TA/TB	TB	K	TE	Emin	Emax	Remarks
				Checked Dynamic Data								
To 12.5MW×2	Hydro	1100	LAX-1 132.00	'SEXS'	1	0.1	10	300	0.05	0	3	
To 8.33MW×3	Hydro	1100	LAX-1 132.00	'SEXS'	2	0.1	10	300	0.05	0	3	
OK	Hydro	1110	N-LAX-1 132.00	'SEXS'	1	0.1	10	300	0.05	0	3	
OK	Hydro	1110	N-LAX-1 132.00	'SEXS'	2	0.1	10	300	0.05	0	3	
OK	Hydro	1120	WIMAL-1 132.00	'SEXS'	1	0.1	10	300	0.05	0	3	
OK	Hydro	1120	WIMAL-1 132.00	'SEXS'	2	0.1	10	300	0.05	0	3	
OK	Hydro	1130	POLPI-1 132.00	'SEXS'	1	0.1	10	300	0.05	0	3	
OK	Hydro	1130	POLPI-1 132.00	'SEXS'	2	0.1	10	300	0.05	0	3	
OK	Hydro	1140	CANYO-1 132.00	'SEXS'	1	0.1	10	300	0.05	0	3	
OK	Hydro	1140	CANYO-1 132.00	'SEXS'	2	0.1	10	300	0.05	0	3	
To 16MW×3	GT	1300	KELAN-1 132.00	'SEXS'	1	0.1	10	300	0.05	0	3.5	Initial condition NG
shold be removed	ST(retired)	1300	KELAN-1 132.00	'SEXS'	2	0.1	10	300	0.05	0	3	
OK	GT	1300	KELAN-1 132.00	'SEXS'	3	0.1	10	300	0.05	0	3.5	Initial condition NG
OK	Hydro	2220	KOTMA-2 220.00	'SEXS'	1	0.1	10	300	0.05	0	3	
OK	Hydro	2220	KOTMA-2 220.00	'SEXS'	2	0.1	10	300	0.05	0	3	
OK	Hydro	2220	KOTMA-2 220.00	'SEXS'	3	0.1	10	300	0.05	0	3	
OK	Hydro	2225	UPKT-2 220.00	'SEXS'	1	0.1	10	300	0.05	0	3	
OK	Hydro	2225	UPKT-2 220.00	'SEXS'	2	0.1	10	300	0.05	0	3	
To 70MW×3	Hydro	2230	VICTO-2 220.00	'SEXS'	1	0.1	10	300	0.05	0	3	
OK	Hydro	2240	RANDE-2 220.00	'SEXS'	1	0.1	10	300	0.05	0	3	
OK	Hydro	2240	RANDE-2 220.00	'SEXS'	2	0.1	10	300	0.05	0	3	
OK	CC	2300	KELAN-2 220.00	'SEXS'	1	0.1	10	200	0.05	0	3	
OK	CC	2300	KELAN-2 220.00	'SEXS'	2	0.1	10	200	0.05	0	4	
OK	CC	2300	KELAN-2 220.00	'SEXS'	3	0.1	10	200	0.05	0	3.5	Initial condition NG
OK	CC	2300	KELAN-2 220.00	'SEXS'	4	0.1	10	200	0.05	0	4	
To 5.6MW×4	Diesel(2012retired)	3590	SAPUG-3A 33.000	'SEXS'	1	0.1	10	300	0.05	0	6	
OK	Hydro	4251	RANTE-G1 12.500	'SEXS'	1	0.1	10	300	0.05	0	3	
OK	Hydro	4252	RANTE-G2 12.500	'SEXS'	1	0.1	10	300	0.05	0	3	
OK	Diesel	1310	SAPUG-1P 132.00	'SEXS'	1	0.1	10	300	0.05	0	5	
OK	Diesel	1310	SAPUG-1P 132.00	'SEXS'	2	0.1	10	300	0.05	0	6	Out of PTI range
To 18MW×4	Diesel(2013retired)	1310	SAPUG-1P 132.00	'SEXS'	3	0.1	10	300	0.05	0	6	Out of PTI range
No existing		1310	SAPUG-1P 132.00	'SEXS'	4	0.1	10	300	0.05	0	5	
OK	Diesel(2007)	3730	CHUNNA-3 33.000	'SEXS'	1	0.1	10	200	0.05	0	6	Out of PTI range
OK	CC(2007)	2305	KERAWAL2 220.00	'SEXS'	1	0.1	10	200	0.05	0	3	
OK	CC(2007)	2305	KERAWAL2 220.00	'SEXS'	2	0.1	10	200	0.05	0	3	
OK	CC(2007)	2305	KERAWAL2 220.00	'SEXS'	3	0.1	10	200	0.05	0	3	
OK	CC(2007)	2305	KERAWAL2 220.00	'SEXS'	4	0.1	10	200	0.05	0	3	
OK	GT(2013)	2305	KERAWAL2 220.00	'SEXS'	5	0.1	10	200	0.05	0	3	
OK	Coal(2009)	2815	PUTTA-2 220.00	'SEXS'	1	0.1	10	200	0.05	0	3	
OK	Coal(2009)	2815	PUTTA-2 220.00	'SEXS'	2	0.1	10	200	0.05	0	3	
OK	Diesel	4444	BARGE-G1 11.000	'SEXS'	1	0.1	10	200	0.05	0	3	
OK	Hydro	1210	BOWAT-1 132.00	'SEXS'	1	0.1	10	300	0.05	0	3	
should be added	DG(2005)	1660	Embilipitiya	'SEXS'	1	0.1	10	300	0.05	0	6	
should be added	DG(2005)	1810	Ladanavi Puttlam	'SEXS'	1	0.1	10	300	0.05	0	6	

Excitors

	Type	Node	Name	Type	I	TA/TB	TB	K	TE	Emin	Emax	Cswitch	re/rfd	Remarks
				Checked Dynamic Data										
OK	Hydro	1410	KUKULE-1 132.00	'SCRX'	1	0.1	10	200	0.05	0	4.5	0	10	
OK	Hydro	1410	KUKULE-1 132.00	'SCRX'	2	0.1	10	200	0.05	0	4.5	0	10	

Excitors

	Type	Node	Name	Checked Dynamic Data Type	I	TR	KA	TA	VRMAX	VRMIN	KE	TE	KF	TF		E1	SE(E1)	E2	SE(E2)	Remarks
To 6.375MW×8	Diesel	4595	KHD-G 11.000	'IEEET1'	1	0.03	40	0.001	4.5	0	1	0.35	0.04	0.32	0	3.38	0.01	4.5	0.05	

Governors

	Type	Node	Name	Checked Dynamic Data Type	I	R	r	Tr	Tf	Tg	VELM	Gmax	Gmin	TW	At	Dturb	QNL	Remarks
To 12.5MW×2	Hydro	1100	LAX-1 132.00	'HYGOV'	1	0.05	0.3	5.2	0.05	0.5	0.2	0.95	0	1.3	1.1	0.5	0.08	
To 8.33MW×3	Hydro	1100	LAX-1 132.00	'HYGOV'	2	0.05	0.3	5.2	0.05	0.5	0.2	0.95	0	1.3	1.1	0.5	0.08	
OK	Hydro	1110	N-LAX-1 132.00	'HYGOV'	1	0.05	0.3	5.2	0.05	0.5	0.2	0.95	0	1.3	1.1	0.5	0.08	
OK	Hydro	1110	N-LAX-1 132.00	'HYGOV'	2	0.05	0.3	5.2	0.05	0.5	0.2	0.95	0	1.3	1.1	0.5	0.08	
OK	Hydro	1120	WIMAL-1 132.00	'HYGOV'	1	0.05	0.43	5.2	0.05	0.5	0.2	1	0	1.3	1.1	0.5	0.08	
OK	Hydro	1120	WIMAL-1 132.00	'HYGOV'	2	0.05	0.43	5.2	0.05	0.5	0.2	1	0	1.3	1.1	0.5	0.08	
OK	Hydro	1130	POLPI-1 132.00	'HYGOV'	1	0.05	0.43	5.2	0.05	0.5	0.2	0.85	0	1.3	1.1	0.5	0.08	
OK	Hydro	1130	POLPI-1 132.00	'HYGOV'	2	0.05	0.43	5.2	0.05	0.5	0.2	0.85	0	1.3	1.1	0.5	0.08	
OK	Hydro	1140	CANYO-1 132.00	'HYGOV'	1	0.05	0.43	5.2	0.05	0.5	0.2	0.81	0	1.3	1.1	0.5	0.08	
OK	Hydro	1140	CANYO-1 132.00	'HYGOV'	2	0.05	0.43	5.2	0.05	0.5	0.2	0.81	0	1.3	1.1	0.5	0.08	
OK	Hydro	1210	BOWAT-1 132.00	'HYGOV'	1	0.05	0.43	5.2	0.05	0.5	0.2	1	0	1.3	1.1	0.5	0.08	
OK	Hydro	1410	KUKULE-1 132.00	'HYGOV'	1	0.05	0.46	8	0.05	0.5	0.2	0.86	0	1.3	1.1	0.5	0.08	
OK	Hydro	1410	KUKULE-1 132.00	'HYGOV'	2	0.05	0.46	8	0.05	0.5	0.2	0.86	0	1.3	1.1	0.5	0.08	
OK	Hydro	2220	KOTMA-2 220.00	'HYGOV'	1	0.05	0.3	5.2	0.05	0.5	0.2	0.85	0	1.3	1.1	0.5	0.08	
OK	Hydro	2220	KOTMA-2 220.00	'HYGOV'	2	0.05	0.3	5.2	0.05	0.5	0.2	0.85	0	1.3	1.1	0.5	0.08	
OK	Hydro	2220	KOTMA-2 220.00	'HYGOV'	3	0.05	0.3	5.2	0.05	0.5	0.2	0.85	0	1.3	1.1	0.5	0.08	
OK	Hydro	2225	UPKT-2 220.00	'HYGOV'	1	0.05	0.3	5.2	0.05	0.5	0.2	0.95	0	1.3	1.1	0.5	0.08	
OK	Hydro	2225	UPKT-2 220.00	'HYGOV'	2	0.05	0.3	5.2	0.05	0.5	0.2	0.95	0	1.3	1.1	0.5	0.08	
To 70MW×3	Hydro	2230	VICTO-2 220.00	'HYGOV'	1	0.05	0.3	5.2	0.05	0.5	0.2	0.85	0	1.3	1.1	0.5	0.08	
OK	Hydro	2240	RANDE-2 220.00	'HYGOV'	1	0.05	0.3	5.2	0.05	0.5	0.2	0.85	0	1.3	1.1	0.5	0.08	
OK	Hydro	2240	RANDE-2 220.00	'HYGOV'	2	0.05	0.3	5.2	0.05	0.5	0.2	0.85	0	1.3	1.1	0.5	0.08	
OK	Hydro	4251	RANTE-G1 12.500	'HYGOV'	1	0.05	0.43	5.2	0.05	0.5	0.2	0.8	0	1.3	1.1	0.5	0.08	
OK	Hydro	4252	RANTE-G2 12.500	'HYGOV'	1	0.05	0.43	5.2	0.05	0.5	0.2	0.8	0	1.3	1.1	0.5	0.08	

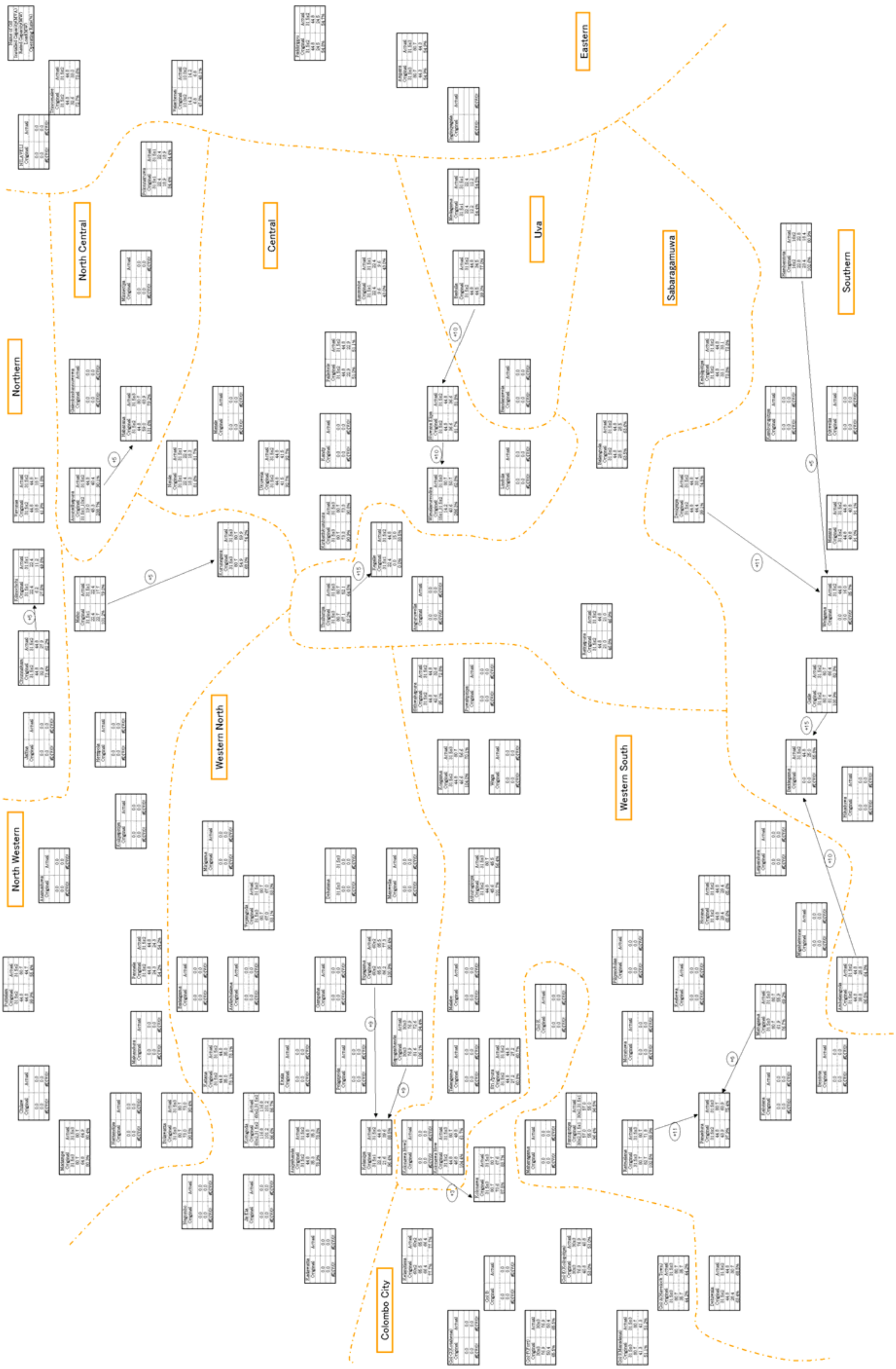
Governors

	Type	Node	Name	Checked Dynamic Data Type	I	R	T1	T2	T3	AT	KT	Vmax	Vmmin	Dturb	Remarks
To 16MW×3	GT	1300	KELAN-1 132.00	'GAST'	1	0.05	0.4	0.1	3	1	2	0.95	-0.05	0	Initial condition NG
OK	GT	1300	KELAN-1 132.00	'GAST'	3	0.05	0.4	0.1	3	1	2	0.95	-0.05	0	
OK	CC(2007)	2305	KERAWAL2 220.00	'GAST'	1	0.05	0.4	0.1	3	1	2	0.95	-0.05	0	
OK	CC(2007)	2305	KERAWAL2 220.00	'GAST'	3	0.05	0.4	0.1	3	1	2	0.95	-0.05	0	
OK	GT(2013)	2305	KERAWAL2 220.00	'GAST'	5	0.05	0.4	0.1	3	1	2	0.95	-0.05	0	
OK	CC	2300	KELAN-2 220.00	'GAST'	1	0.05	0.4	0.1	3	1	2	0.95	-0.05	0	
OK	CC	2300	KELAN-2 220.00	'GAST'	3	0.05	0.4	0.1	3	1	2	0.95	-0.05	0	

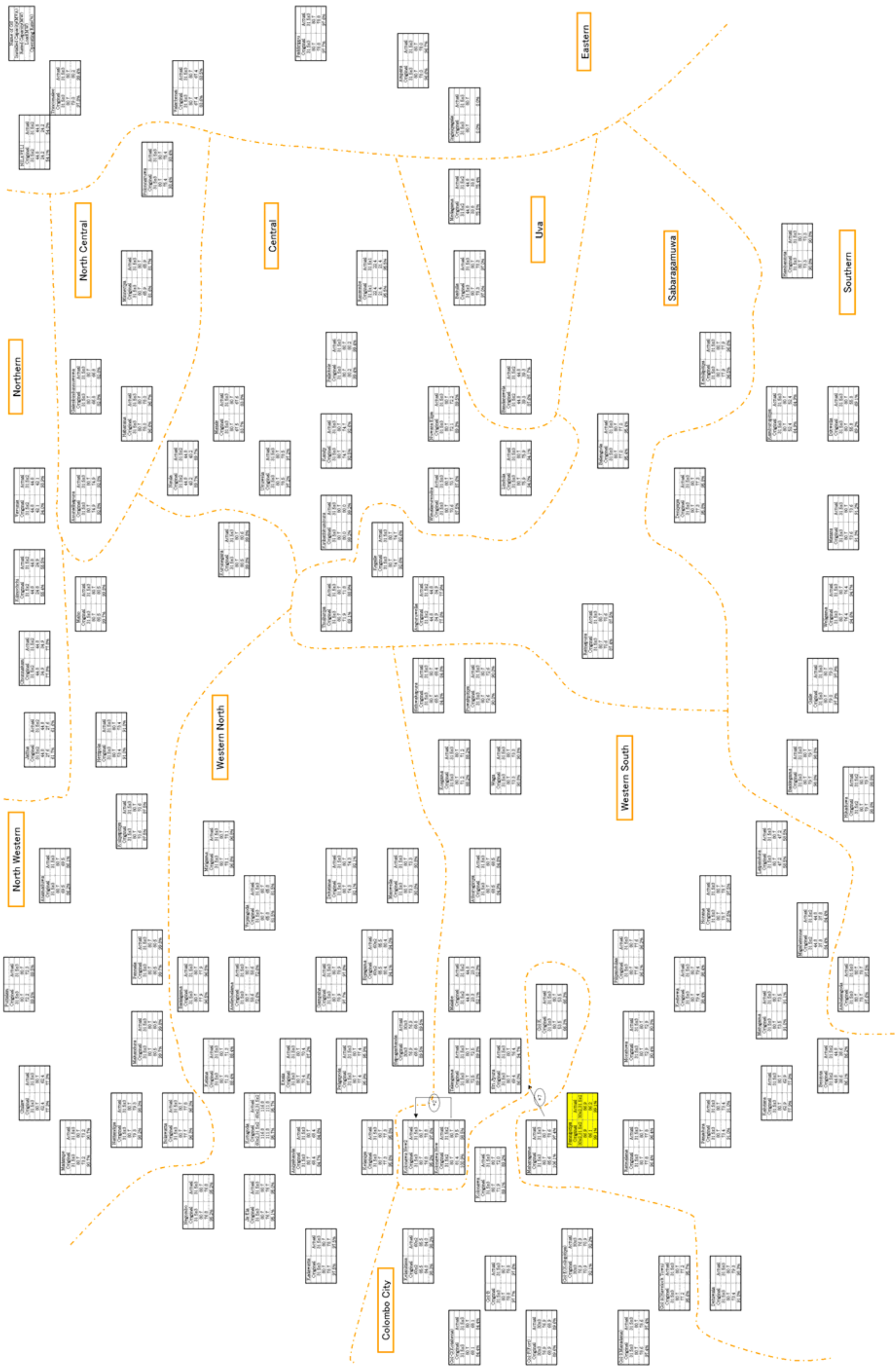
Governors

	Type	Node	Name	Checked Dynamic Data Type	I	R	T1	Vmax	Vmin	T2	T3	Dt	Remarks
shold be removed	ST(retired)	1300	KELAN-1 132.00	'TGOV1'	2	0.05	0.1	0.95	0	1.8	6	0	
To 5.6MW×4	Diesel(2012retired)	3590	SAPUG-3A 33.000	'TGOV1'	1	0.05	0.5	0.85	0.3	1.8	6	0	
OK	Diesel(2007)	3730	CHUNNA-3 33.000	'TGOV1'	1	0.05	0.5	1.08	0.3	1.8	6	0	
OK	CC(2007)	2305	KERAWAL2 220.00	'TGOV1'	2	0.05	0.1	0.95	0	1.8	6	0	
OK	CC(2007)	2305	KERAWAL2 220.00	'TGOV1'	4	0.05	0.1	0.95	0	1.8	6	0	
OK	CC	2300	KELAN-2 220.00	'TGOV1'	2	0.05	0.1	0.95	0	1.8	6	0	
OK	CC	2300	KELAN-2 220.00	'TGOV1'	4	0.05	0.1	0.95	0	1.8	6	0	
should be added	DG(2005)	1660	Embilipitiya	'TGOV1'	1	0.05	0.5	1.08	0.3	1.8	6	0	
should be added	DG(2005)	1810	Ladanavi Puttlam	'TGOV1'	1	0.05	0.5	1.08	0.3	1.8	6	0	

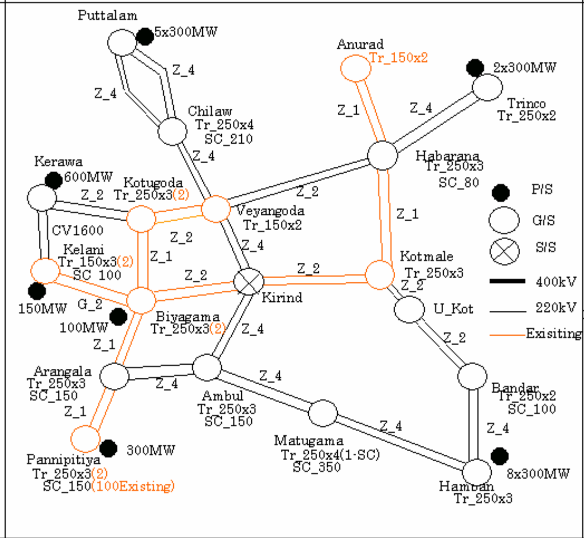
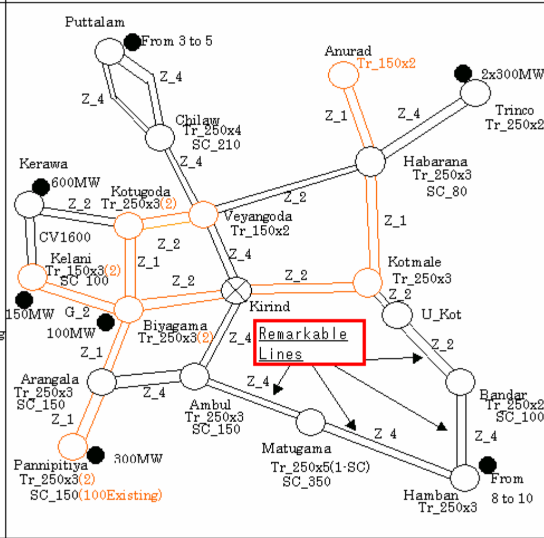
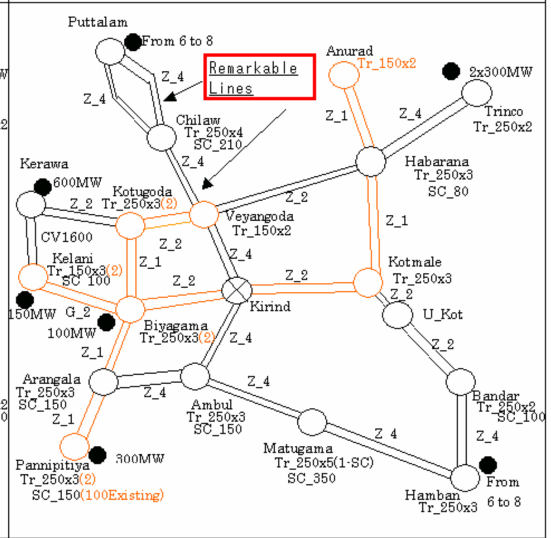
Load Transfer Forecast for Each Grid Substation (2010)



Load Transfer Forecast for Each Grid Substation (2025)



Outline for Power Concentration Case Study

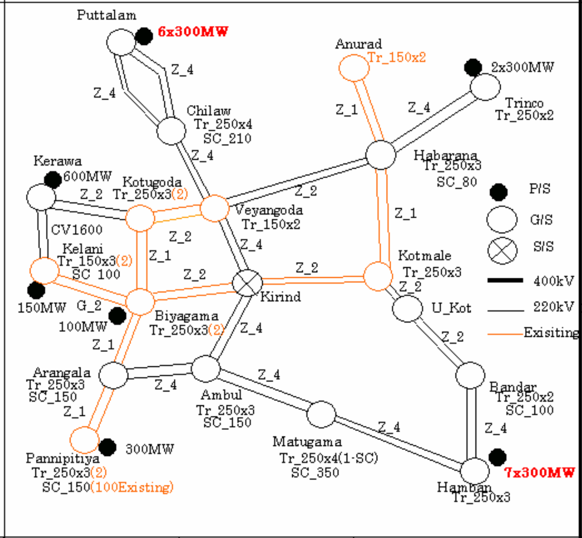
	Base Case	Power Concentration in Southern Area	Power Concentration in Northern Area
Single Line Diagram			

		Base Case Items	Base Case Volume	Base Case Cost (MLKR)	Southern Items	Southern Volume	Southern Cost (MLKR)	Northern Items	Northern Volume	Northern Cost (MLKR)
Cost	Lines	Chi - Vey Put - Chi Ham - Mat Tri - Hab Ban - Ham Vey - Kir Kir - Amb Ara - Amb Amb - Mat	45.km 140.km 135.6km 95.km 105.km 14.4km 22.2km 11.4km 58.2km	Zebra_4 2cct 16,434.7						
		Ham - Vey Kot - U_Kot U_Kot - Ban Kotu - Ker	145.km 18.5km 48.km 18.km	Zebra_2 2cct 4,720.8						
		Ker - Kel	14.4km	CV_1600mm2 2cct 2,717.6						
	Transformers	220 - 132 - 33 250MVA (Matu- 1units included)	31units	6,904.6						
		220 - 132 - 33 150MVA	1units	181.4						
	G/S	220kV-132kV	11places	4,168.0						
	S/S	220kV	1places	369.8						
	Phase Modifying Equipment (Trunk System)	SC (20MVR) Chi-210, Hab-80, Ban-100, Amb-150, Ara-150, Kel-100, Mat-150, Pan-50 ,Mat-200(SC)	59.5units	1,190.0						
	Others									
	Total Cost			36,687.0						
Remarks		A								

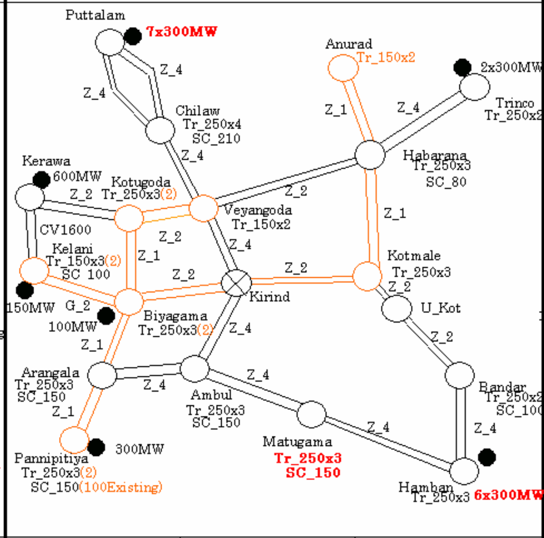
Best Allocation Checking for Generators

Single Line Diagram

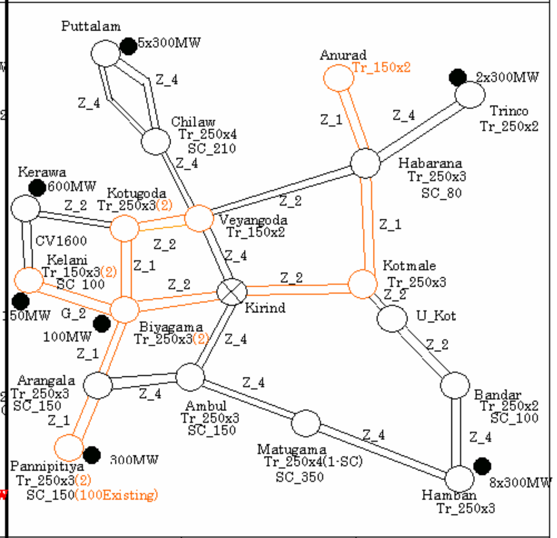
Alternative A



Alternative B



Base Case from Generation View Point



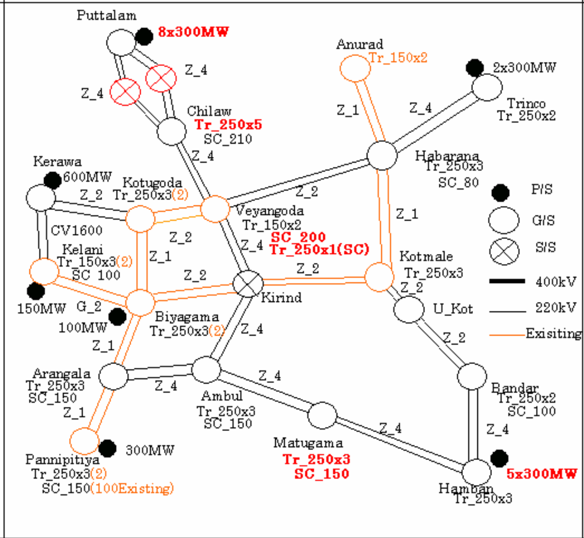
		Alternative A			Alternative B			Base Case from Generation View Point		
Cost		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
		Base Cost		36,687.0	Base Cost		36,687.0	Base Cost		36,687.0
	Lines			0.0			0.0			
	Transformers	220 - 132 - 33 250MVA	units	0.0	220 - 132 - 33 250MVA (Mat_-1unit)	-1units	-222.7			
			units	0.0		units	0.0			
	G/S		places	0.0		places	0.0			
	S/S	220kV	places	0.0	220kV	places	0.0			
	Phase Modifying Equipment	SC (20MVR)	units	0.0	SC (20MVR) Mat_-200MVAR	-10 units	-200.0			
	Others									
	Total Cost			36,687.0			36,264.3			36,687.0
Technical Assesment										
N-0		OK			OK			OK		
N-1 (SS is not considered)		OK			OK			OK		
Dynamic Stability		Put - Chi	Ham - Mat	Ham - Ban	Put - Chi	Ham - Mat	Ham - Ban	Put - Chi	Ham - Mat	Ham - Ban
		OK	OK	OK	OK	OK	OK	OK	OK	OK
Effect of S/S		-	-	-	-	-	-	-	-	-
Short Circuit		OK (Under 40kA)			OK (Under 40kA)			OK (Under 40kA)		
Assesment		A			S (In case that 6 units in South are operated at any time)			A		
Remarks					SC and Transformer for SC can be reduced					
Total Remarks		The maximum number of genarators in Northern area is 7. The number is can be 8 with extra high expence. The maximum number of genarators in Southern area is 8. The number is can be 9 with extra high expence.								

Red letters represent the difference between base case and the other's case

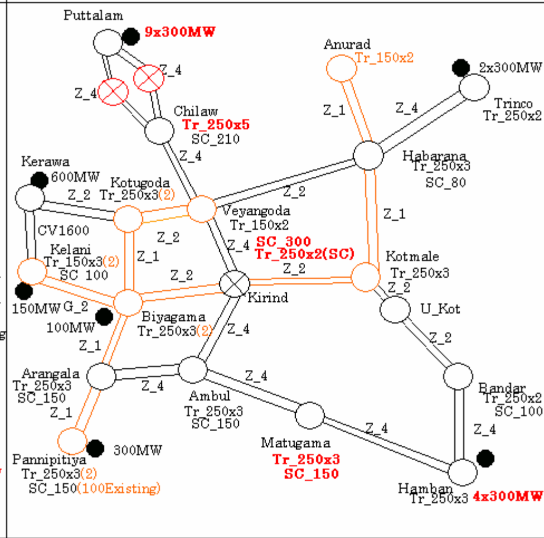
Case that Power Stations are Concentrated in North Area

Single Line Diagram

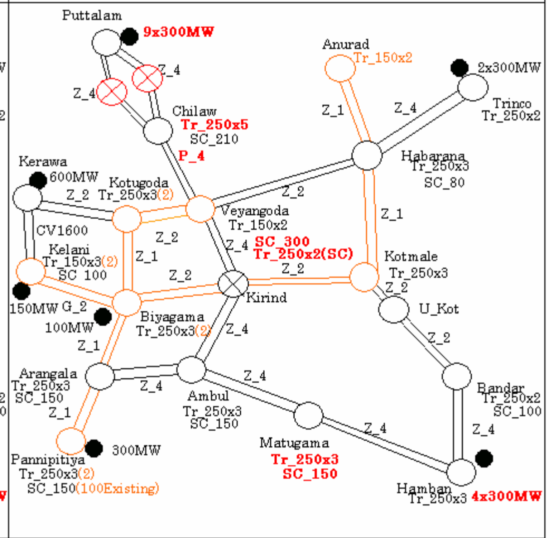
Alternative A-1



Alternative A-2



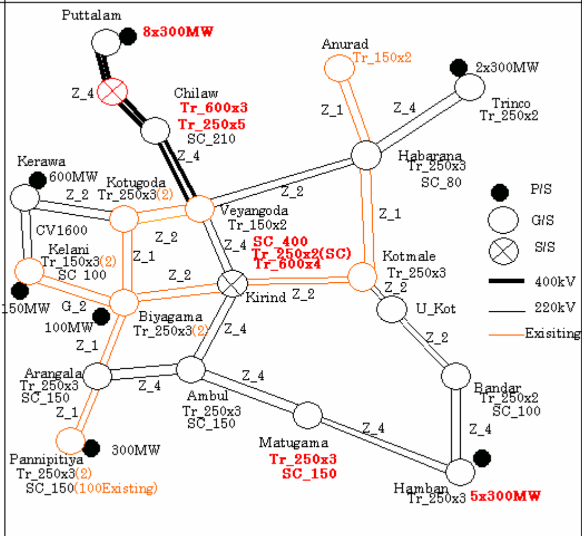
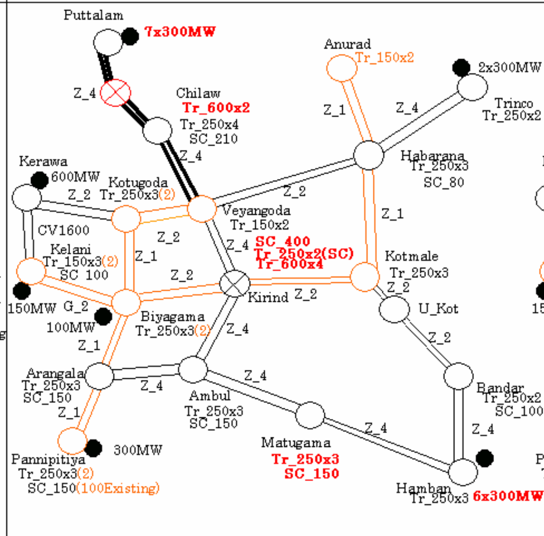
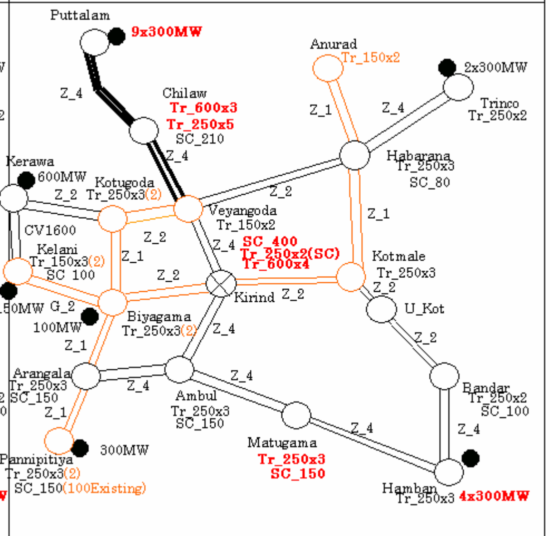
Alternative A-3



		A-1 Items	A-1 Volume	A-1 Cost (MLKR)	A-2 Items	A-2 Volume	A-2 Cost (MLKR)	A-3 Items	A-3 Volume	A-3 Cost (MLKR)
Cost		Base Cost		36,687.0	Base Cost		36,687.0	Base Cost		36,687.0
	Lines			0.0			0.0	Chi - Vey(Zebra_4) Chi - Vey(Parrot_4)	-45.km 45.km	-1,179.9 1,450.8
	Transformers	220 - 132 - 3326MVA (Chi_1 unit, Vey_1unit, Mat_-1unit)	1units	222.7	220 - 132 - 3326MVA (Chi_1 unit, Vey_2unit, Mat_-1unit)	2units	445.5	220 - 132 - 3326MVA (Chi_1 unit, Vey_2unit, Mat_-1unit)	2units	445.5
			units	0.0		units	0.0		units	0.0
	G/S		places	0.0		places	0.0		places	0.0
	S/S	220kV	2places	739.7	220kV	2places	739.7	220kV	2places	739.7
	Phase Modifying Equipment	SC (20MVR) Vey_200, Mat_-200	.units	0.0	SC (20MVR) Vey_300, Mat_-200	5.units	100.0	SC (20MVR) Vey_300, Mat_-200	5.units	100.0
	Others									
	Total Cost			37,649.4			37,972.1			38,243.0
Technical Assesment										
N-0		OK			OK			OK		
N-1 (SS is not considered)		OK			N.G. (In case of one line failure between Veyangoda and N_Chilaw, the other line is overloaded or transformers at N_Chilaw are overloaded with system configulation change.)			OK		
Dynamic Stability		Put220 - Chi	Chi220 - Vey		Put220 - Chi	Chi220 - Vey		Put220 - Chi	Chi220 - Vey	
		N.G	OK		-	-		N.G	OK	
Effect of S/S		OK	OK		-	-		N.G	OK	
Short Circuit		OK (Under 40kA)			OK (Under 40kA)			OK (Under 40kA)		
Assesment		B			N.G.			N.G.		
Remarks		One unit can be added with two S/Ss, however it costs a lot of money and is not so effective.								

Red letters represent the difference between base case and the other's case

Case that Power Stations are Concentrated in North Area

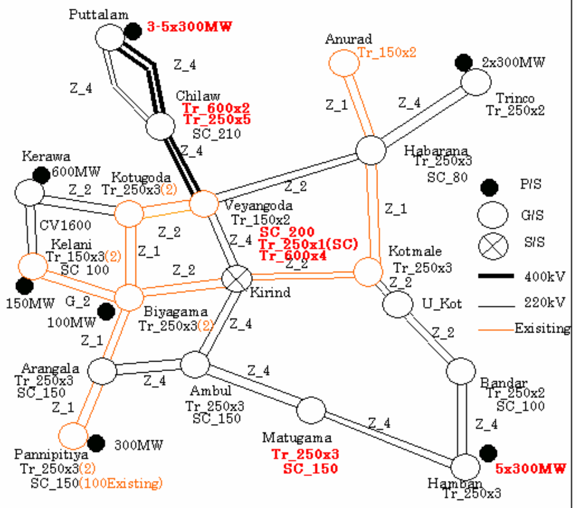
		Alternative B-1			Alternative B-2 (Just Confirmation)			Alternative B-3		
Single Line Diagram										
Cost		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
		Base Cost		36,687.0	Base Cost		36,687.0			
	Lines	Put - Chi	-140.km	Zebra_4 2cct -3670.8	Put - Chi	-140.km	Zebra_4 2cct -3670.8			
		Chi - Vey	-45.km	Zebra_4 2cct -1,179.9	Chi - Vey	-45.km	Zebra_4 2cct -1,179.9			
		Put - Chi Chi - Vey	70.km 45.km	Zebra_4 2cct(400kV) 7,855.7	Put - Chi Chi - Vey	70.km 45.km	Zebra_4 2cct(400kV) 7,855.7			
	Transformers	220 - 132 - 33 250MVA (Chi_1 unit, Vey_2unit, Mat_-1unit)	2units	445.5	220 - 132 - 33 250MVA (Vey_2unit, Mat_-1unit)	1units	222.7			
		440 - 220 600MVA	7units	6,853.0	440 - 220 600MVA	6units	5,874.0			
	G/S		places	0.0		places	0.0			
	S/S	400kV	1places	1,240.7	220kV	1places	369.8			
	Phase Modifying Equipment	SC (20MVR) Vey_400, Mat_-200	10.units	200.0	SC (20MVR) Vey_400, Mat_-200	10.units	200.0			
	Others									
	Total Cost			48,431.1			46,358.5			
Technical Assesment										
N-0		OK			OK			OK		
N-1 (SS is not considered)		OK			OK			N.G.(Capacity Over between Puttalam and New Chilaw)		
Dynamic Stability		Put400 - Chi N.G.			Put400 - Chi N.G.					
Effect of S/S		OK			OK					
Short Circuit		OK (Under 40kA)			OK (Under 40kA)					
Assesment		C			C					
Remarks		Very High Cost Thinking of route failure, 1 route is not good for reliability.			Very High Cost Thinking of route failure, 1 route is not good for reliability.					

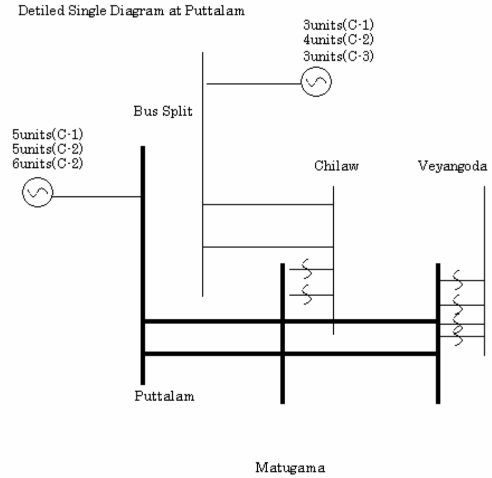
Red letters represent the difference between base case and the other's case

Case that Power Stations are Concentrated in North Area

Alternative C-1 (Bus Split)

Single Line Diagram

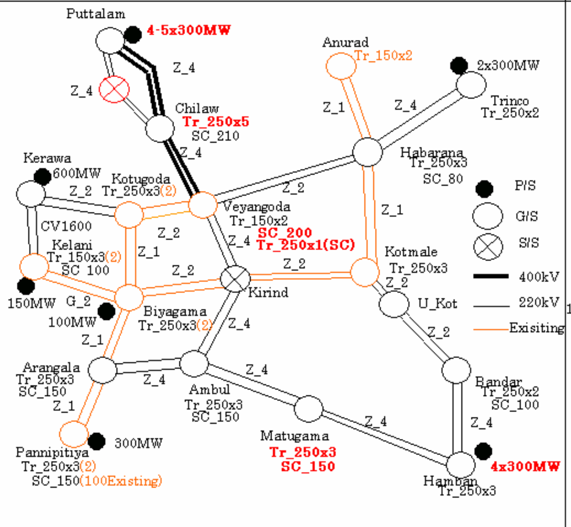
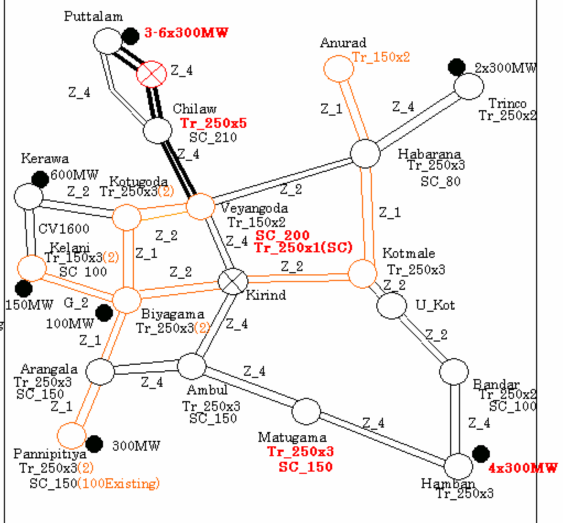




		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
Cost		Base Cost		36,687.0						
	Lines	Put - Chi	-70.km	Zebra_4 2cct -1835.4						
		Chi - Vey	-45.km	Zebra_4 2cct -1,179.9						
		Put - Chi Chi - Vey	70.km 45.km	Zebra_4 2cct(400kV) 7,855.7						
	Transformers	220 - 132 - 33 250MVA (Chi_1 unit, Vey_1unit, Mat_-1unit)	1units	222.7						
		440 - 220 600MVA	6units	5,874.0						
	G/S		places	0.0						
	S/S	220kV	places	0.0						
	Phase Modifying Equipment	SC (20MVR) Vey_200, Mat_-200	.units	0.0						
	Others									
	Total Cost			47,624.1						
Technical Assesment										
N-0		OK								
N-1 (SS is not considered)		OK								
Dynamic Stability		Put220 - Chi	Put400 - Chi							
		OK	OK							
Effect of S/S		-	-							
Short Circuit		OK (Under 40kA)								
Assesment		C								
Remarks										

Red letters represent the difference between base case and the other's case

Case that Power Stations are Concentrated in North Area

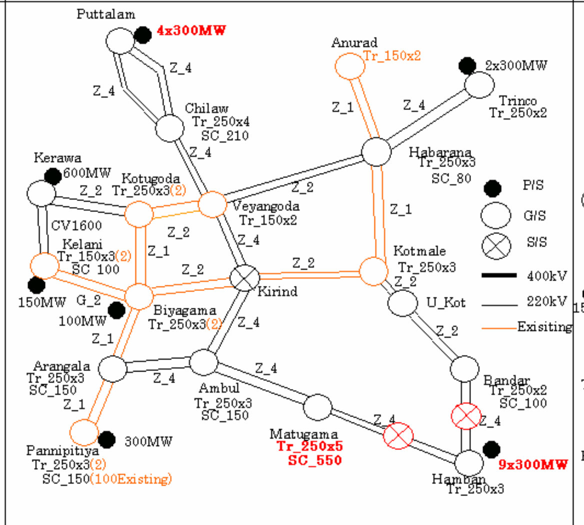
		Alternative C-2(Bus Split)			Alternative C-3(Bus Split)					
Single Line Diagram										
Cost		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
		Base Cost		36,687.0	Base Cost		36,687.0			
	Lines	Put - Chi	-70.km	Zebra_4 2cct -1835.4	Put - Chi	-70.km	Zebra_4 2cct -1835.4			
		Chi - Vey	-45.km	Zebra_4 2cct -1,179.9	Chi - Vey	-45.km	Zebra_4 2cct -1,179.9			
		Put - Chi Chi - Vey	70.km 45.km	Zebra_4 2cct(400kV) 7,855.7	Put - Chi Chi - Vey	70.km 45.km	Zebra_4 2cct(400kV) 7,855.7			
	Transformers	220 - 132 - 33 250MVA (Chi_1 unit, Vey_2unit, Mat_-1unit)	2units	445.5	220 - 132 - 33 250MVA (Chi_1 unit, Vey_2unit, Mat_-1unit)	2units	445.5			
		440 - 220 600MVA	6units	5,874.0	440 - 220 600MVA	6units	5,874.0			
	G/S		places	0.0		places	0.0			
	S/S	220kV	1places	369.8	400kV	1places	1,240.7			
	Phase Modifying Equipment	SC (20MVR) Vey_300, Mat_-200	5.units	100.0	SC (20MVR) Vey_300, Mat_-200	5.units	100.0			
	Others									
	Total Cost			48,316.6			49,187.5			
Technical Assesment										
N-0		OK			OK					
N-1 (SS is not considered)		OK			OK					
Dynamic Stability		Put220 - Chi	Put400 - Chi		Put220 - Chi	Put400 - Chi				
		N.G	OK		OK	N.G.				
Effrct of S/S		OK	-		-	OK				
Short Circuit		OK (Under 40kA)			OK (Under 40kA)					
Assesment		C			C					
Remarks		Very High Cost			Very High Cost					

Red letters represent the difference between base case and the other's case

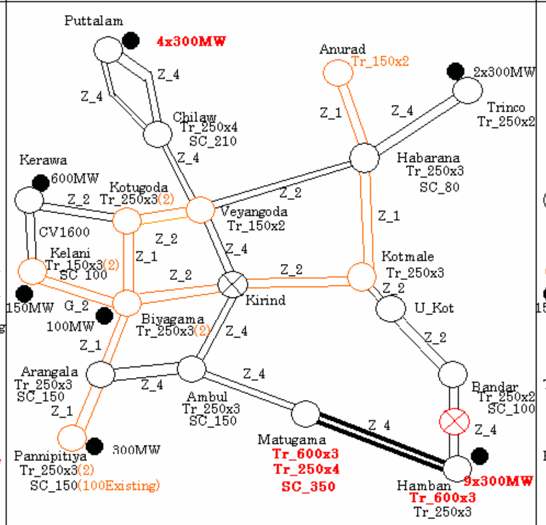
Case that Power Stations are Concentrated in South Area

Single Line Diagram

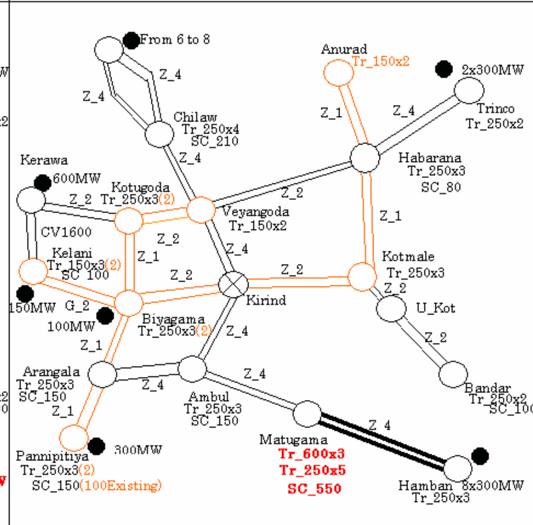
Alternative A-1



Alternative B-1



Alternative C



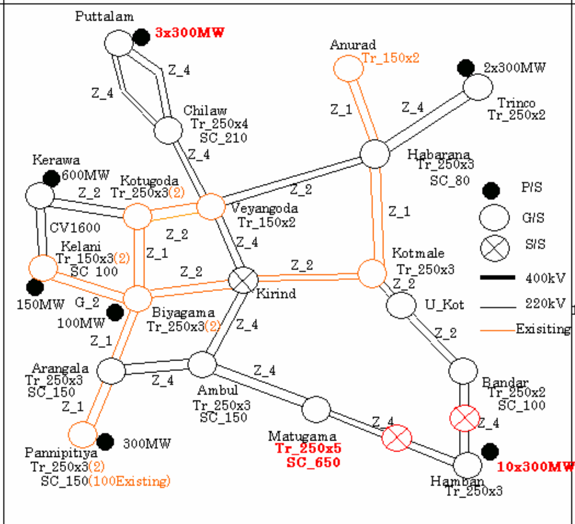
		Alternative A-1			Alternative B-1			Alternative C		
Cost		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
		Base Cost		36,687.0	Base Cost		36,687.0	Base Cost		36,687.0
	Lines			0.0	Ham - Mat(220 Z_4) Ham - Mat(400 Z_4)	-135.6km 135.6km	-3,555.4 9,262.8			
	Transformers	220 - 132 - 33 250MVA (Mat_1unit)	1units	222.7	220 - 132 - 33 250MVA	units	0.0			
			units	0.0	440 - 220 600MVA	6units	5,874.0			
	G/S		places	0.0		places	0.0			
	S/S	220kV	2places	739.7	220kV	1places	369.8			
	Phase Modifying Equipment	SC (20MVR) Mat_200	10.units	200.0	SC (20MVR)	.units	0.0			
	Others				Line Switch 400kV	4units	649.6			
	Total Cost			37,849.4			49,287.9			36,687.0
Technical Assesment										
N-0		OK			OK			N.G.		
N-1 (SS is not considered)		OK			OK					
Dynamic Stability		Mat - Ham	Ham - Ban		Mat - Ham	Ham - Ban	Ham Tr			
		N.G.	N.G.		OK	N.G.	OK			
Effect of S/S		OK	OK		-	OK	-			
Short Circuit		OK (Under 40kA)			OK (Under 40kA)					
Assesment		B			C			N.G.		
Remarks		One unit can be added with two S/Ss, however it costs a lot of money and is not so effective.			Very High Cost			1 route is not enough to supply power even if total power in Hambantota is 240MW(8 units)		

Red letters represent the difference between base case and the other's case

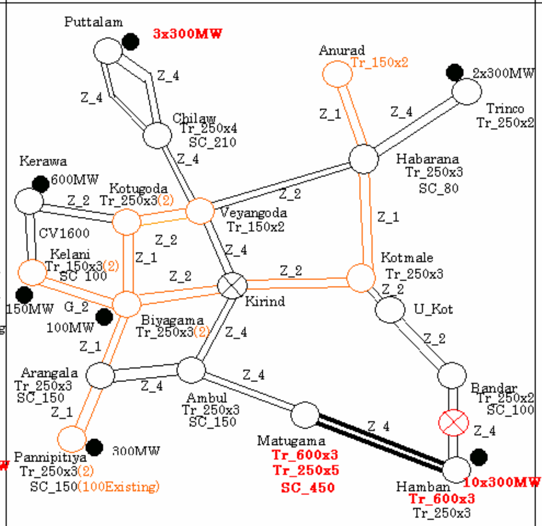
Case that Power Stations are Concentrated in South Area

Single Line Diagram

Alternative A-2



Alternative B-2



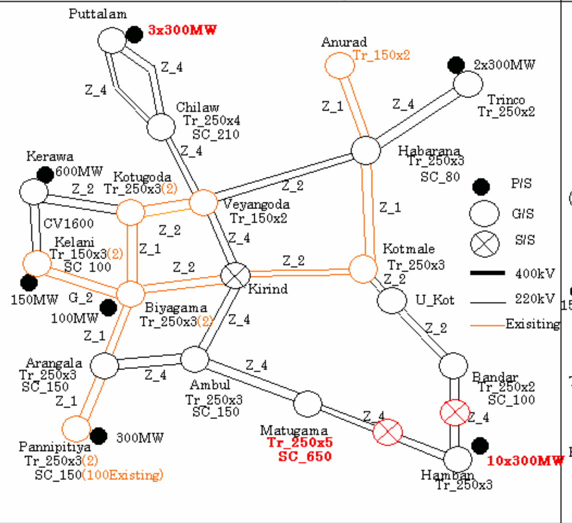
		A-2 Items	A-2 Volume	A-2 Cost (MLKR)	B-2 Items	B-2 Volume	B-2 Cost (MLKR)	Items	Volume	Cost (MLKR)
Cost	Base Cost			36,687.0			36,687.0			
	Lines			0.0	Ham - Mat(220 Z_4) Ham - Mat(400 Z_4)	-135.6km 135.6km	-3,555.4 9,262.8			
	Transformers	220 - 132 - 33 250MVA (Mat-1units)	1units	222.7	220 - 132 - 33 250MVA (Mat-1units)	1units	222.7			
			units	0.0	440 - 220 600MVA	6units	5,874.0			
	G/S		places	0.0		places	0.0			
	S/S	220kV	2places	739.7	220kV	1places	369.8			
	Phase Modifying Equipment	SC (20MVR) Mat-300	15.units	300.0	SC (20MVR) Mat-100	5.units	100.0			
	Others				Line Swith 400kV	4units	649.6			
	Total Cost			37,949.4			49,610.6			
Technical Assesment										
N-0		OK			OK					
N-1 (SS is not considered)		N.G. (In case of one line failure between Matugama and Hambantota, the system does not converge.)			OK					
Dynamic Stability		Mat - Ham	Ham - Ban		Mat - Ham	Ham - Ban	Ham Tr			
		N.G.	N.G.		OK	N.G.	N.G.			
Effect of S/S		N.G.	N.G.		-	N.G.				
Short Circuit		NG 41.8KA (Over 40kA)			NG 41.8KA (Over 40kA)					
Assesment		N.G.			N.G.					
Remarks					Very High Cost					

Red letters represent the difference between base case and the other's case

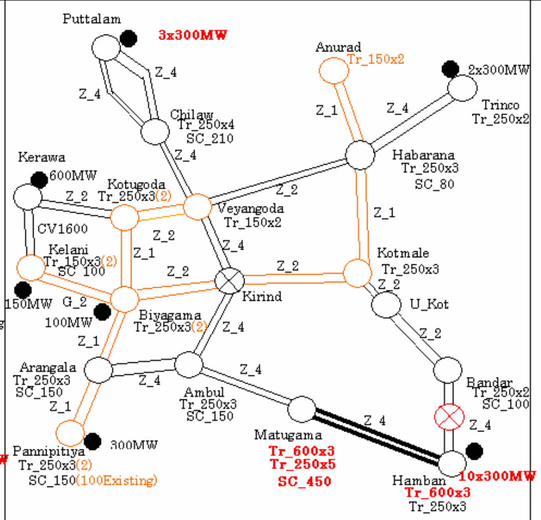
Case that Power Stations are Concentrated in South Area

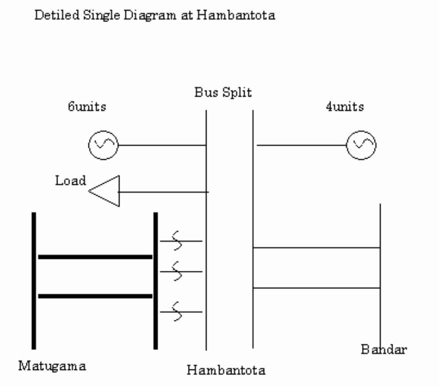
Single Line Diagram

Alternative A-2(Bus Split)



Alternative B-2(Bus Split)





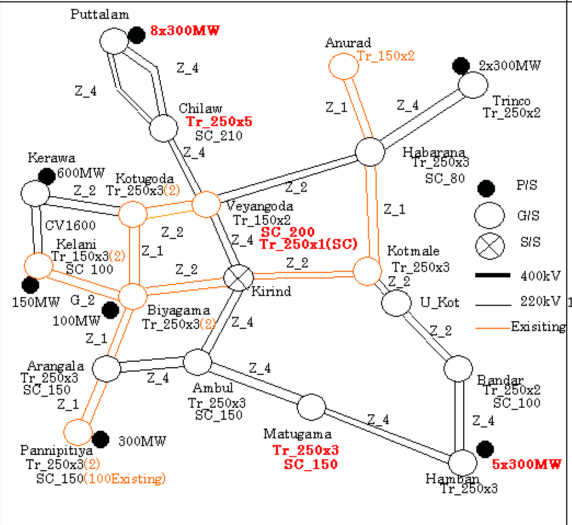
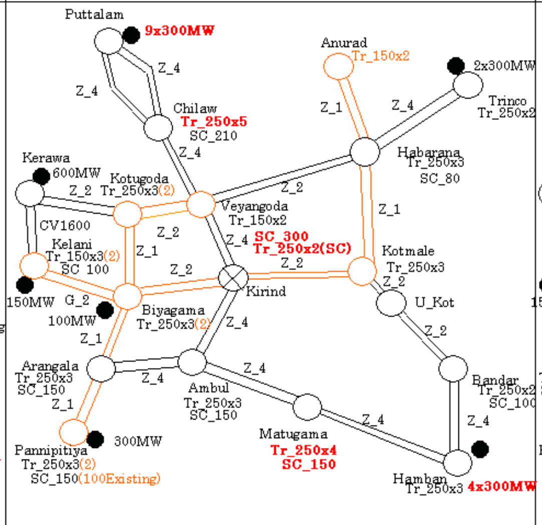
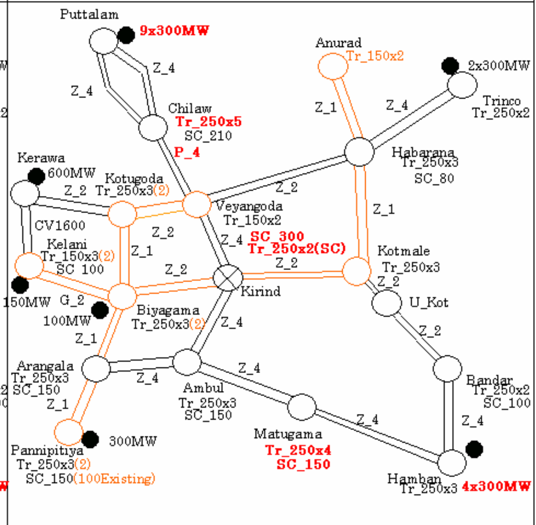
Cost

		Alternative A-2 Items	Volume	Cost (MLKR)	Alternative B-2 Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
Cost		Base Cost		36,687.0	Base Cost		36,687.0			
	Lines			0.0	Ham - Mat(220 Z_4) Ham - Mat(400 Z_4)	-135.6km 135.6km	-3,555.4 9,262.8			
	Transformers	220 - 132 - 33 250MVA (Mat-1units)	1units	222.7	220 - 132 - 33 250MVA (Mat-1units)	1units	222.7			
			units	0.0	440 - 220 600MVA	6units	5,874.0			
	G/S		places	0.0		places	0.0			
	S/S	220kV	2places	739.7	220kV	1places	369.8			
	Phase Modifying Equipment	SC (20MVR) Mat-300	15.units	300.0	SC (20MVR) Mat-100	5.units	100.0			
	Others				Line Swith 400kV	4units	649.6			
	Total Cost			37,949.4			49,610.6			

	Alternative A-2			Alternative B-2			
Technical Assesment							
N-0	OK			OK			
N-1 (SS is not considered)	N.G(Matugama to Hambantota line is bottleneck even if 500MVAR SC installed at Matugama)			OK			
Dynamic Stability	Mat - Ham	Ham - Ban		Mat - Ham	Ham - Ban	Ham Tr	
	N.G.	N.G.		OK	N.G.	N.G.	
Effect of S/S	OK	N.G.		-	N.G.		
Short Circuit	OK			OK			
Assesment	N.G.			N.G.			
Remarks				Very High Cost			

Red letters represent the difference between base case and the other's case

Case that Power Stations are Concentrated in North Area (Fault Clearance: 100ms)

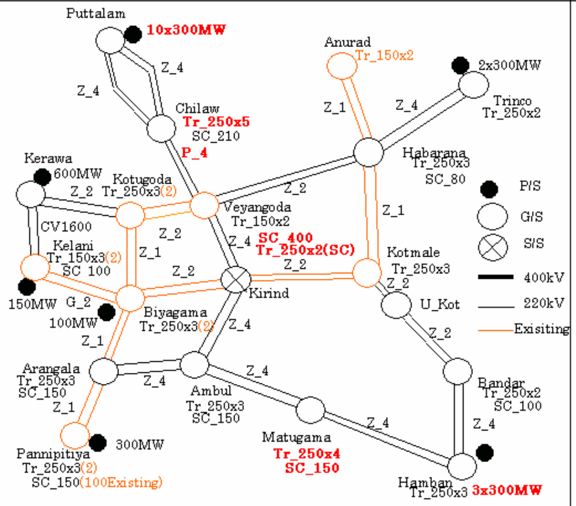
		Alternative A-1			Alternative A-2			Alternative B-1		
Single Line Diagram										
Cost		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
		Base Cost		36,687.0	Base Cost		36,687.0	Base Cost		36,687.0
	Lines			0.0			0.0	Chi - Vey(Zebra_4) Chi - Vey(Parrot_4)	-45 km 45 km	-1,179.9 1,450.8
	Transformers	220 - 132 - 33 250MVA (Chi_1 unit, Vey_1unit, Mat_-1unit)	1 units	222.7	220 - 132 - 33 250MVA (Chi_1 unit, Vey_2unit, Mat_-1unit)	2units	445.5	220 - 132 - 33 250MVA (Chi_1 unit, Vey_2unit, Mat_-1unit)	2units	445.5
			units	0.0		units	0.0		units	0.0
	G/S		places	0.0		places	0.0		places	0.0
	S/S	220kV	places	0.0	220kV	places	0.0	220kV	places	0.0
	Phase Modifying Equipment	SC (20MVR) Vey_200, Mat_-200	.units	0.0	SC (20MVR) Vey_300, Mat_-200	5.units	100.0	SC (20MVR) Vey_300, Mat_-200	5.units	100.0
	Others									
	Total Cost			36,909.7			37,232.4			37,503.3
Technical Assesment										
N-0		OK			OK			OK		
N-1 (SS is not considered)		OK			N.G. (In case of one line failure between Veyangoda and N_Chilaw, the other line is overloaded or transformers at N_Chilaw are overloaded with system configulation change.)			OK		
Dynamic Stability		Put220 - Chi	Chi220 - Vey		Put220 - Chi	Chi220 - Vey		Put220 - Chi	Chi220 - Vey	
		OK	OK		-	-		OK	OK	
Effect of S/S		OK	OK		-	-		OK	OK	
Short Circuit		OK (Under 40kA)			OK (Under 40kA)			OK (Under 40kA)		
Assesment		A			N.G			B		
Remarks		100 msec of the clearance time is effective. 8 is the marginal number of unit in the Northern area.						100 msec of the clearance time is effective. One unit can be added with Parrot.		

Red letters represent the difference between base case and the other's case

Case that Power Stations are Concentrated in North Area (Fault Clearance: 100ms)

Alternative B-2

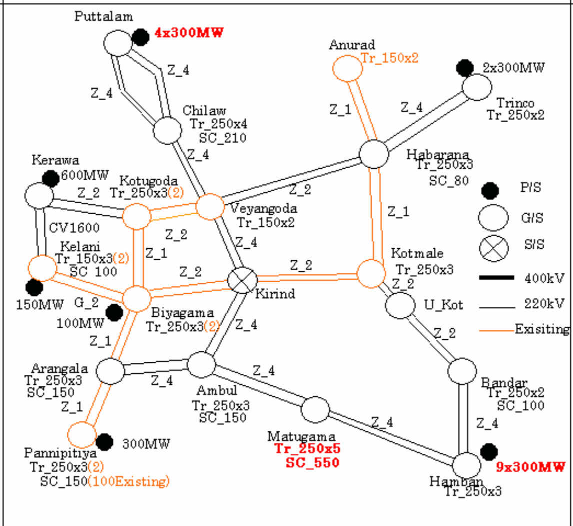
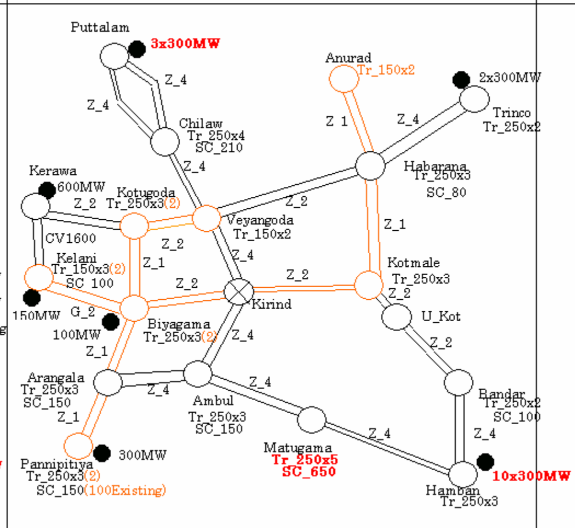
Single Line Diagram



		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
Cost		Base Cost		36,687.0						
	Lines	Chi - Vey(Zebra_4)	-45.km	-1,179.9						
		Chi - Vey(Parrot_4)	45.km	1,450.8						
	Transformers	220 · 132 · 33 250MVA (Chi_1 unit, Vey_2unit, Mat_1unit)	2units	445.5						
			units	0.0						
	G/S		places	0.0						
	S/S	220kV	places	0.0						
	Phase Modifying Equipment	SC (20MVR) Vey_400, Mat_-200	10.units	200.0						
	Others									
	Total Cost			37,603.3						
Technical Assesment										
N-0		OK								
N-1 (SS is not considered)		N.G. (In case of one line failure between Puttalam and N_Chilaw, the system does not converge. And line failure between N_Chilaw and Veyangoda is likewise.)								
Dynamic Stability		Put220 - Chi	Chi220 - Vey							
		-	-							
Effect of S/S		-	-							
Short Circuit		NG 40.8KA (Over 40kA)								
Assesment		N.G.								
Remarks		System can not be sustained even if there is 400MVAR SC at Veyangoda.								

Red letters represent the difference between base case and the other's case

Case that Power Stations are Concentrated in South Area (Fault Clearance: 100ms)

		Alternative A-1			Alternative A-2					
Single Line Diagram										
Cost		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
		Base Cost		36,687.0	Base Cost		36,687.0			
	Lines			0.0			0.0			
	Transformers	220 - 132 - 33 250MVA (Mat_1unit)	1units	222.7	220 - 132 - 33 250MVA (Mat-1units)	1units	222.7			
			units	0.0		units	0.0			
	G/S		places	0.0		places	0.0			
	S/S	220kV	places	0.0	220kV	places	0.0			
	Phase Modifying Equipment	SC (20MVR) Mat_200	10.units	200.0	SC (20MVR) Mat-300	15.units	300.0			
	Others									
	Total Cost			37,109.7			37,209.7			
Technical Assesment										
N-0		OK			OK					
N-1 (SS is not considered)		OK			OK					
Dynamic Stability		Mat - Ham	Ham - Ban		Mat - Ham	Ham - Ban				
		OK	OK		OK	OK				
Effect of S/S		OK	OK		OK	OK				
Short Circuit		OK (Under 40kA)			NG 41.7KA (Over 40kA)					
Assesment		A			N.G.(A)					
Remarks		100 msec of the clearance time is effective. 9 is the marginal number of unit in the Southern area.			10 units is acceptable with 50kA-Line switch.					

Red letters represent the difference between base case and the other's case

Result on Countermeasure for Power Supply to Northern Area

Interconnection Case

	Year	Construction Cost (M US$)	O&M of IPP (M US$)	O&M of CEB in Main Grid (M US$)	Cost for Producing Loss Energy (M US$)	Total (M US$)	P.V (M US$)	Remarks
	2004							
0	2005		15.3			15.3	15.3	Present Year
1	2006		16.1			16.1	14.7	
2	2007	22.93	0.0	6.1	0.06	29.1	24.0	LTTDS 2004
3	2008		0.0	6.4	0.07	6.5	4.9	
4	2009		0.0	6.8	0.08	6.9	4.7	
5	2010		0.0	7.2	0.08	7.2	4.5	
6	2011		0.0	7.5	0.09	7.6	4.3	
7	2012		0.0	8.0	0.10	8.1	4.1	
8	2013		0.0	8.4	0.12	8.5	4.0	
9	2014		0.0	8.9	0.13	9.0	3.8	
10	2015		0.0	9.4	0.14	9.5	3.7	
11	2016		0.0	9.9	0.16	10.0	3.5	
12	2017		0.0	10.4	0.18	10.6	3.4	
13	2018		0.0	11.0	0.20	11.2	3.2	
14	2019		0.0	11.6	0.22	11.8	3.1	
15	2020		0.0	12.2	0.24	12.5	3.0	
16	2021		0.0	12.9	0.27	13.2	2.9	
17	2022		0.0	13.6	0.30	13.9	2.8	
18	2023		0.0	14.4	0.34	14.7	2.6	
19	2024		0.0	15.2	0.38	15.6	2.5	
20	2025		0.0	16.0	0.42	16.4	2.4	
						Total Present Value	117.5	

After interconnection is installed, 100% of Total consumption in Jaffna area is supplied from CEB

Discount Rate = 10% Source: LTGEP2003

Generation Expantion Plan (CEB Only)

	Year	Power Plant Construction Cost (M US$)	O&M of IPP (M US$)	O&M of CEB in Jaffna (M US$)	Total (M US$)	P.V (M US$)	Remarks
	2004						
0	2005		15.3		15.3	15.3	Present Year
1	2006		16.1		16.1	14.7	
2	2007		17.0		17.0	14.1	
3	2008		18.0		18.0	13.5	
4	2009	44.8	0.0	14.9	59.7	40.8	
5	2010		0.0	15.8	15.8	9.8	
6	2011		0.0	16.6	16.6	9.4	
7	2012	22.4	0.0	17.6	40.0	20.5	
8	2013		0.0	18.5	18.5	8.6	
9	2014		0.0	19.6	19.6	8.3	
10	2015		0.0	20.6	20.6	8.0	
11	2016		0.0	21.8	21.8	7.6	
12	2017		0.0	23.0	23.0	7.3	
13	2018		0.0	24.2	24.2	7.0	
14	2019		0.0	25.6	25.6	6.7	
15	2020		0.0	27.0	27.0	6.5	
16	2021		0.0	28.5	28.5	6.2	
17	2022		0.0	30.1	30.1	5.9	
18	2023		0.0	31.7	31.7	5.7	
19	2024		0.0	33.5	33.5	5.5	
20	2025	22.4	0.0	35.3	57.7	8.6	
					Total Present Value	230.0	

Considering N-1 condition, the number of units includes back-up.

Discount Rate = 10% Source: LTGEP2003

Generation Expantion Plan (CEB and IPP as Back-up)

	Year	Power Plant Construction Cost (M US$)	O&M of IPP (M US$)	O&M of CEB in Jaffna (M US$)	Total (M US$)	P.V (M US$)	Remarks
	2004						
0	2005		15.3		15.3	15.3	Present Year
1	2006		16.1		16.1	14.7	
2	2007		17.0		17.0	14.1	
3	2008		18.0		18.0	13.5	
4	2009	22.4	3.8	12.0	38.1	26.1	
5	2010		4.0	12.6	16.6	10.3	
6	2011		4.2	13.3	17.5	9.9	
7	2012	22.4	4.5	14.0	40.9	21.0	
8	2013		4.7	14.8	19.5	9.1	
9	2014		5.0	15.6	20.6	8.7	
10	2015		5.2	16.5	21.7	8.4	
11	2016		5.5	17.4	22.9	8.0	
12	2017		5.8	18.4	24.2	7.7	
13	2018		6.1	19.4	25.5	7.4	
14	2019		6.5	20.5	27.0	7.1	
15	2020		6.8	21.6	28.4	6.8	
16	2021		7.2	22.8	30.0	6.5	
17	2022		7.6	24.0	31.7	6.3	
18	2023		8.0	25.4	33.4	6.0	
19	2024		8.5	26.8	35.3	5.8	
20	2025	22.4	9.0	28.2	59.6	8.9	
					Total Present Value	221.5	

80% of Total consumption in Jaffna area is supplied from CEB

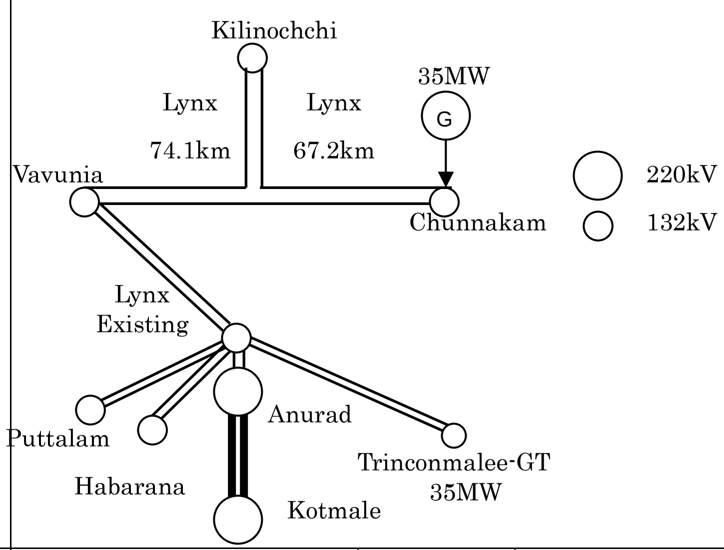
Discount Rate = 10% Source: LTGEP2003

Interconnection between North Area and Main Grid (Generator is installed from the beginning)

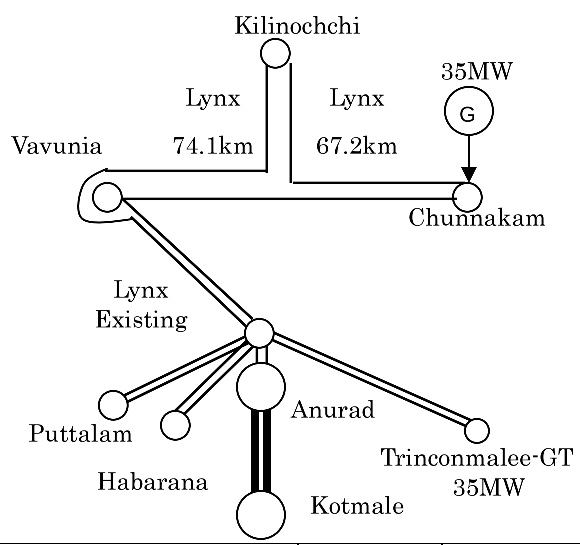
Base Data: 2010 Night Peak (New Demand and Generators are considered)

Single Line Diagram

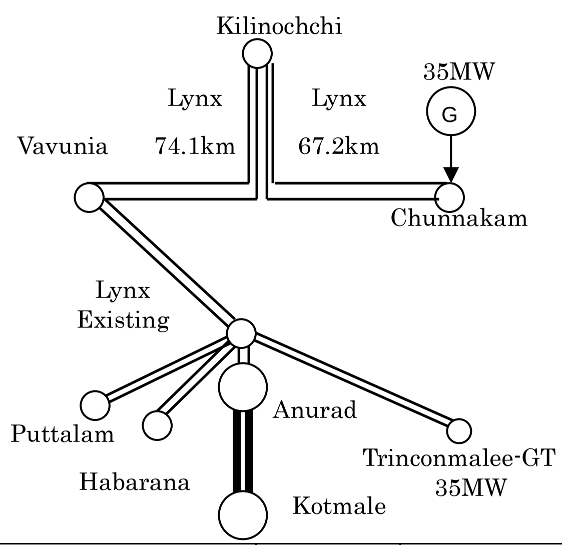
Alternative A



Alternative B



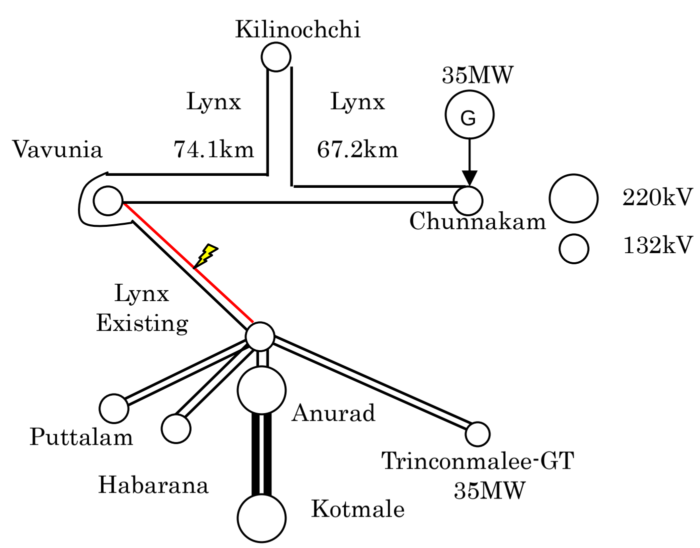
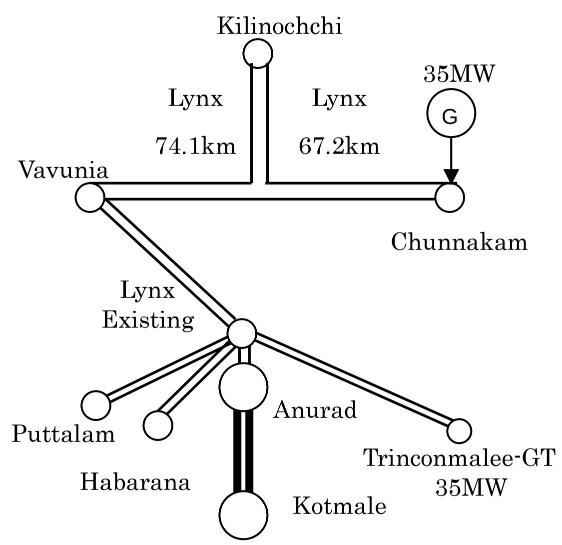
Alternative C



		Alternative A			Alternative B			Alternative C		
Cost		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
	Lines	Vav - Kil (Lynx 74.1km) Kil - Chu(Lynx 67.2km) Vav- Chu(Lynx 141.3km)	Lynx 2cct 141.3km	1,268.9	Vav - Kil (Lynx 74.1km) Kil - Chu(Lynx 67.2km) Vav- Chu(Lynx 141.3km)	Lynx 2cct 141.3km	1,268.9	Vav - Kil (Lynx 74.1km) Kil - Chu(Lynx 67.2km) Vav- Chu(Lynx 141.3km)	Lynx 2cct 141.3km	1,268.9
	Phase Modifying Equipment	SC (Chunnakam) 5MVAR	0units	0	SC (Chunnakam) 5MVAR	0units	0	SC (Chunnakam) 5MVAR	0units	0
	Others	132kV line bay	6 units	109.8	132kV line bay	4 units	73.2	132kV line bay	8 units	146.4
	Total Cost	Excluding Generator Construction Cost		1,378.7	Excluding Generator Construction Cost		1,342.1	Excluding Generator Construction Cost		1,415.3
Remarks										
Assessment on System Condition		B			A			C		

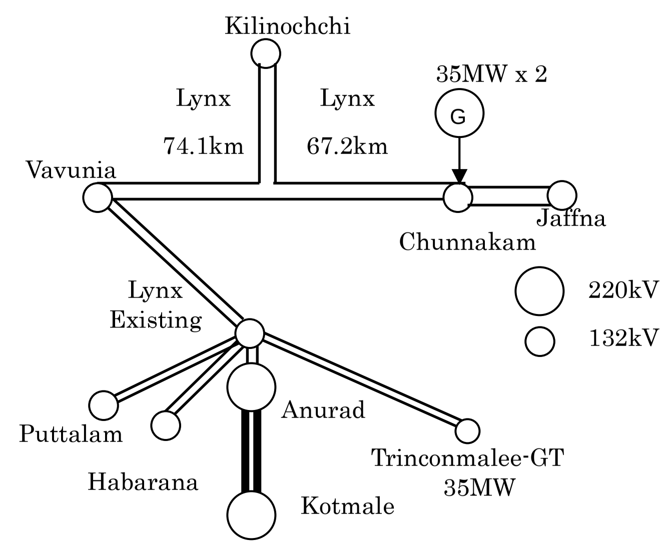
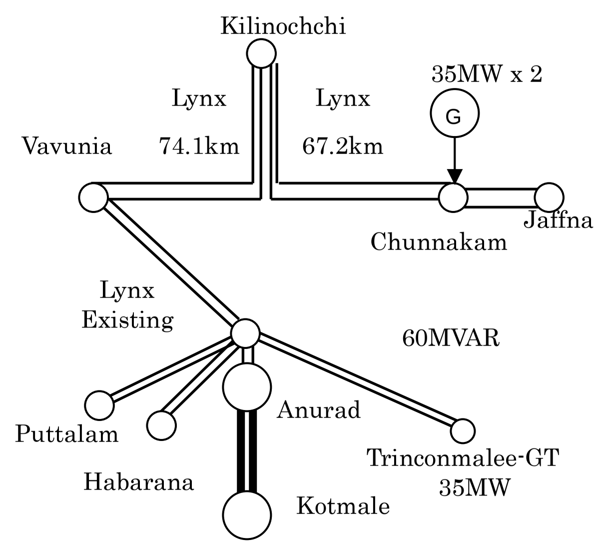
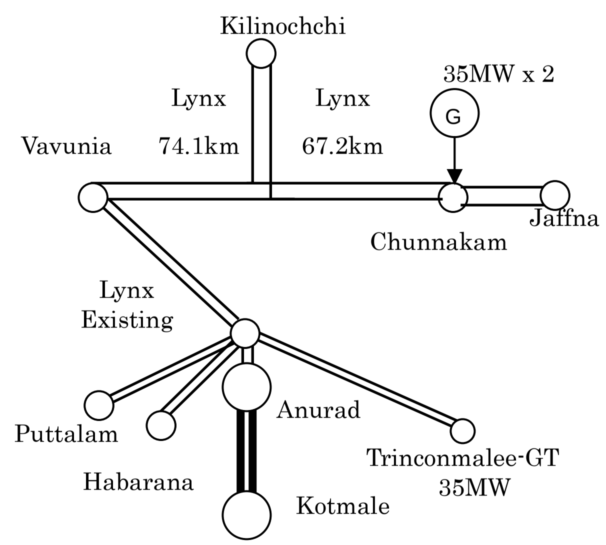
Interconnection between North Area and Main Grid (Generator is installed from the beginning)

Base Data: 2015 Night Peak (New Demand and Generators are considered)

		Alternative A			Alternative B					
Single Line Diagram										
Cost		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)			
	Lines	Vav - Kil (Lynx 74.1km) Kil - Chu(Lynx 67.2km) Vav- Chu(Lynx 141.3km)	Lynx 2cct 141.3km	1,268.9	Vav - Kil (Lynx 74.1km) Kil - Chu(Lynx 67.2km) Vav- Chu(Lynx 141.3km)	Lynx 2cct 141.3km	1,268.9			
	Phase Modifying Equipment	SC (Chunnakam) 5MVAR	units	0	SC (Chunnakam) 5MVAR	units	0			
	Others	132kV line bay	4 units	73.2	132kV line bay	6 units	109.8			
	Total Cost	Excluding Generator Construction Cost		1,342.1	Excluding Generator Construction Cost		1,378.7			
Remarks		If the line between Anuradhapura and Vavunia is failure, the system can not supply power to Vavunia. If the line between Anuradhapura and Kirinochchi is failure, the voltage at Kilinochchi is under 0.9 pu. (0.893)								
Assessment on System Condition		Not Good			A					

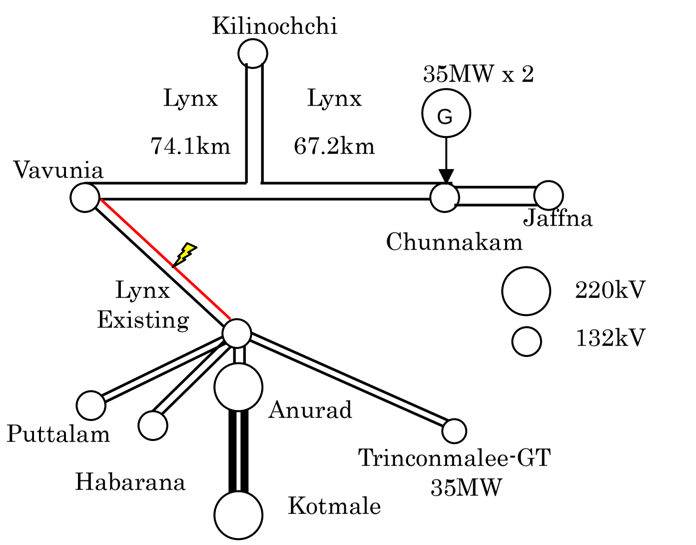
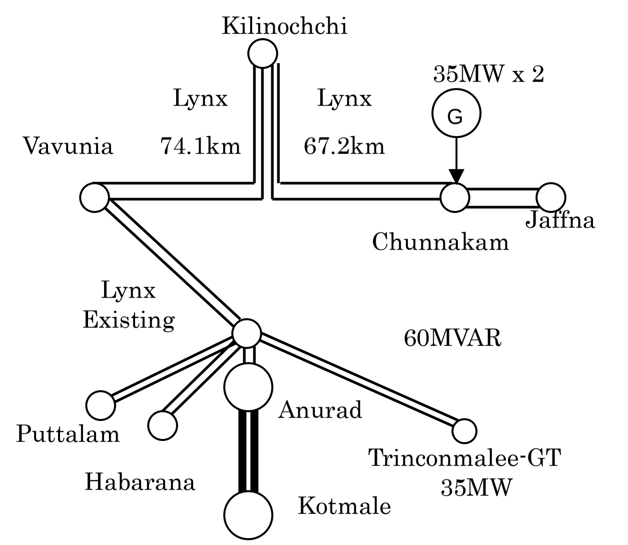
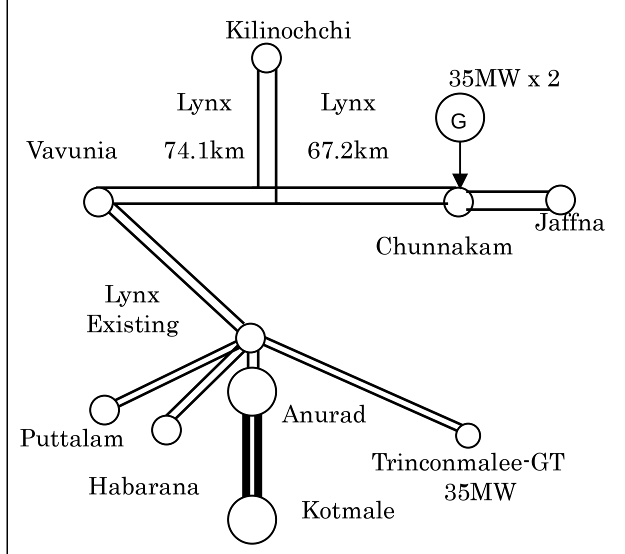
Interconnection between North Area and Main Grid (Generator is installed from the beginning)

Base Data: 2020 Night Peak (New Demand and Generators are considered)

		Alternative A			Alternative B			Alternative C		
Single Line Diagram										
Cost		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
	Lines	Vav - Kil (Lynx 74.1km) Kil - Chu(Lynx 67.2km) Vav- Chu(Lynx 141.3km) Chu - Jaf(Lynx 10.8km)	Lynx 2cct 152.1km	1,365.9	Vav - Kil (Lynx 74.1km) Kil - Chu(Lynx 67.2km) Vav- Chu(Lynx 141.3km) Chu - Jaf(Lynx 10.8km)	Lynx 2cct 152.1km	1,365.9	Vav - Kil (Lynx 74.1km) Kil - Chu(Lynx 67.2km) Vav- Chu(Lynx 141.3km) Chu - Jaf(Lynx 10.8km)	Lynx 2cct 152.1km	1,365.9
	Phase Modifying Equipment	SC (Chunnakam) 5MVAR	units	0	SC (Chunnakam) 5MVAR	units	0	SC (Chunnakam) 5MVAR	units	0
	Others	132kV line bay	6 units 4 units	183.0	132kV line bay	8 units 4 units	219.6	132kV line bay	6 units 4 units	183.0
	Total Cost	Excluding Generator Construction Cost		1,451.9	Excluding Generator Construction Cost		1,585.5	Excluding Generator Construction Cost		1,451.9
Remarks								Tower conversion cost (very small) is needed		
Assessment on System Condition		A			B			A^-		

Interconnection between North Area and Main Grid (Generator is installed from the beginning)

Base Data: 2025 (New Demand and Generators are considered)

		Alternative A			Alternative B			Alternative C		
Single Line Diagram										
Cost		Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)	Items	Volume	Cost (MLKR)
	Lines	Vav - Kil (Lynx 74.1km) Kil - Chu(Lynx 67.2km) Vav- Chu(Lynx 141.3km) Chu - Jaf(Lynx 10.8km)	Lynx 2cct 152.1km	1,365.9	Vav - Kil (Lynx 74.1km) Kil - Chu(Lynx 67.2km) Vav- Chu(Lynx 141.3km) Chu - Jaf(Lynx 10.8km)	Lynx 2cct 152.1km	1,365.9	Vav - Kil (Lynx 74.1km) Kil - Chu(Lynx 67.2km) Vav- Chu(Lynx 141.3km) Chu - Jaf(Lynx 10.8km)	Lynx 2cct 152.1km	1,365.9
	Phase Modifying Equipment	SC (Chunnakam) 5MVAR	units	0	SC (Chunnakam) 5MVAR	0units	0	SC (Chunnakam) 5MVAR	units	0
	Others	132kV line bay	6 units 4 units	183.0	132kV line bay	8 units 4 units	219.6	132kV line bay	6 units 4 units	183.0
	Total Cost	Excluding Generator Construction Cost		1,451.9	Excluding Generator Construction Cost		1,585.5	Excluding Generator Construction Cost		1,451.9
Remarks		If the line between Anuradhapura and Vavunia is failure, the system, the voltage at Kilinochchi is under 0.9 pu. (0.889)						Tower conversion cost (very small) is needed		
Assessment on System Condition		Not Good			B			A		

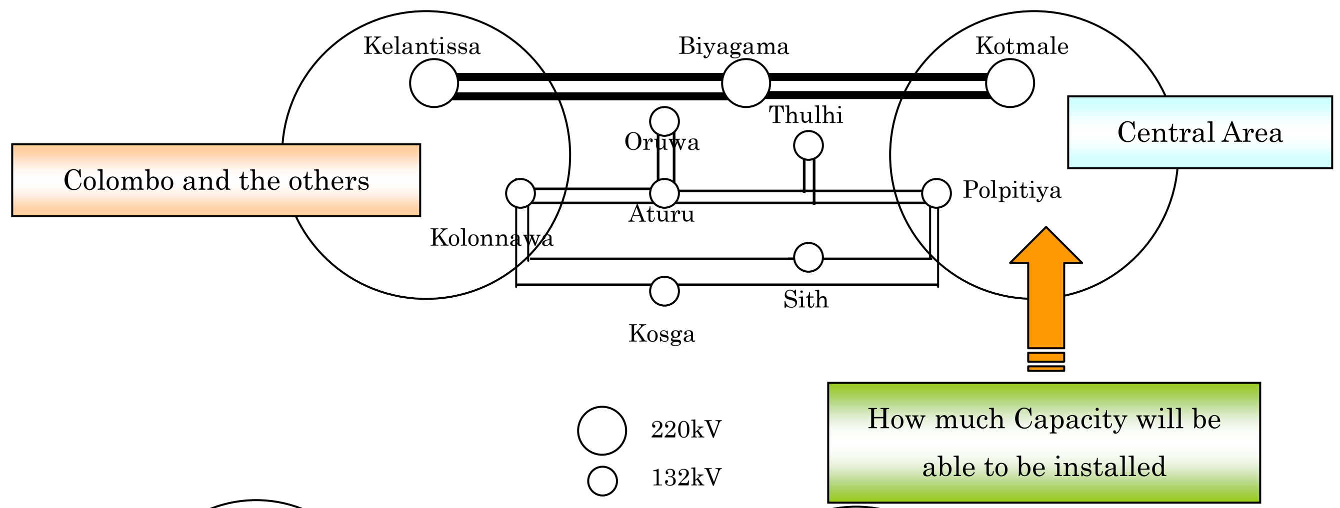
Affect to the Main Grid by Mini-Hydro Interconnection

Base Data: 2005 Hydro Maximum Case (New Demand and Generators are considered)

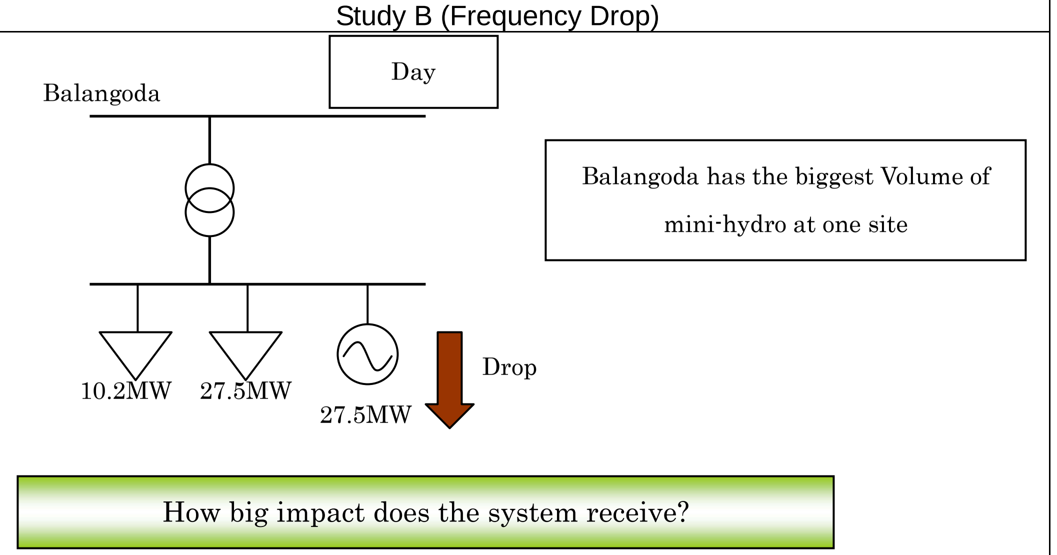
	Study A (N-0, N-1)	Study B (Frequency Drop)

Single Line Diagram

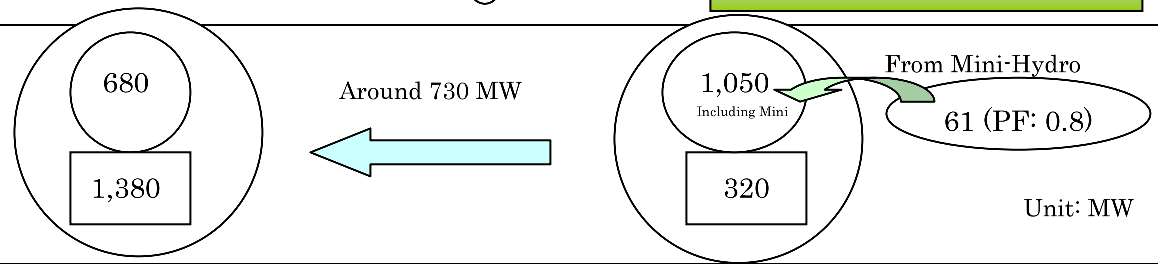
Study A (N-0, N-1)



Study B (Frequency Drop)



Pre Condition (Night)



Result (Night)

Study A

Bottle Neck	Marginal Volume (Normal state) (MW)	
Wimalsurendura Tr	308.9	
Deniyaya Tr	329.1	
Sithawaka - Kolonnawa	459.9	
Ratnapura Tr	461.6	
Bottle Neck	**Marginal Volume (N-1 State) (MW)**	**Causes (N-1)**
Wimalsurendura Tr	**198.7**	Wimalsurendura Tr 1unit failure
N-Laxapana - Polpitiya	223.0	N-Laxapana – Polpitiya 1cct Open
Deniyaya Tr	224.1	Deniyaya Tr 1unit failure
Ratnapura Tr	241.1	Ratnapura Tr 1unit failure

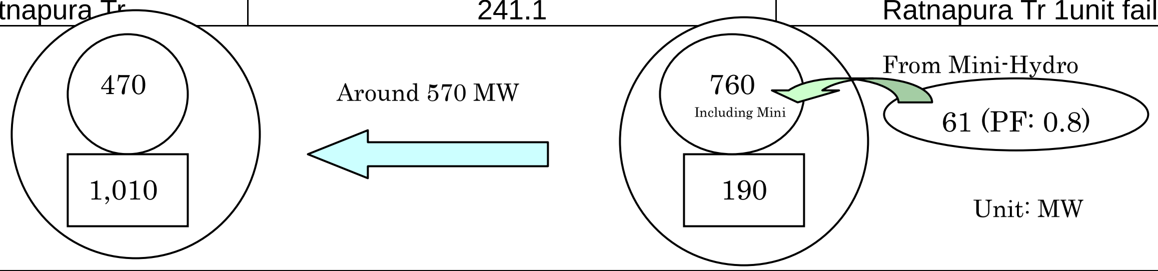
Study B

dF = 1/4.75 x100x (27.5 / 1700) = 0.34

49.66Hz > 48.75 Hz → No Load Shedding

49.66Hz > 49.5Hz (Grid Code) → No Problem

Pre Condition (Day)



Result (Day)

Study A

Bottle Neck	Marginal Volume (Normal state) (MW)	
Polpitiya - Kosgama	44.4	
Polpitiya - Thulhiriya	80.3	
Sithawaka - Kolonnawa	116.7	
N-Laxapana - Polpitiya	129.1	
Bottle Neck	**Marginal Volume (N-1 State) (MW)**	**Causes (N-1)**
Polpitiya - Thulhiriya	**0 (-42.6)**	Polpitiya - Thulhiriya 1cct Open
Polpitiya - Sithawaka	0 (-39.9)	Kosgama - Polpitiya 1cct Open
Polpitiya - Kosgama	0 (-27.1)	Polpitiya - Sithawaka 1cct Open
N-Laxapana - Polpitiya	17.2	N_Laxapana – Polpitiya 1cct Open

Study B

dF = 1/4.75 x100x (27.5 / 1200) = 0.48

49.52Hz > 48.75 Hz → No Load Shedding

49.52Hz > 49.5Hz (Grid Code) → No Problem

During Off Peak
Demand is 62% of Day Peak (Daily load curve as of Sep in 2004)

dF = 1/4.75 x100x (27.5 / 700) = 0.83

49.17Hz > 48.75 Hz → No Load Shedding

49.17Hz < 49.5Hz (Grid Code) → However, It can recover to the acceptable range after governor operating

Summary

Study A: Total around 20MW, 61MW as of existing working amount - 42.6 as of additional mini-hydro installed, is acceptable from the view point of thermal capacity.
All mini-hydro power plants can not be connected during day peak.

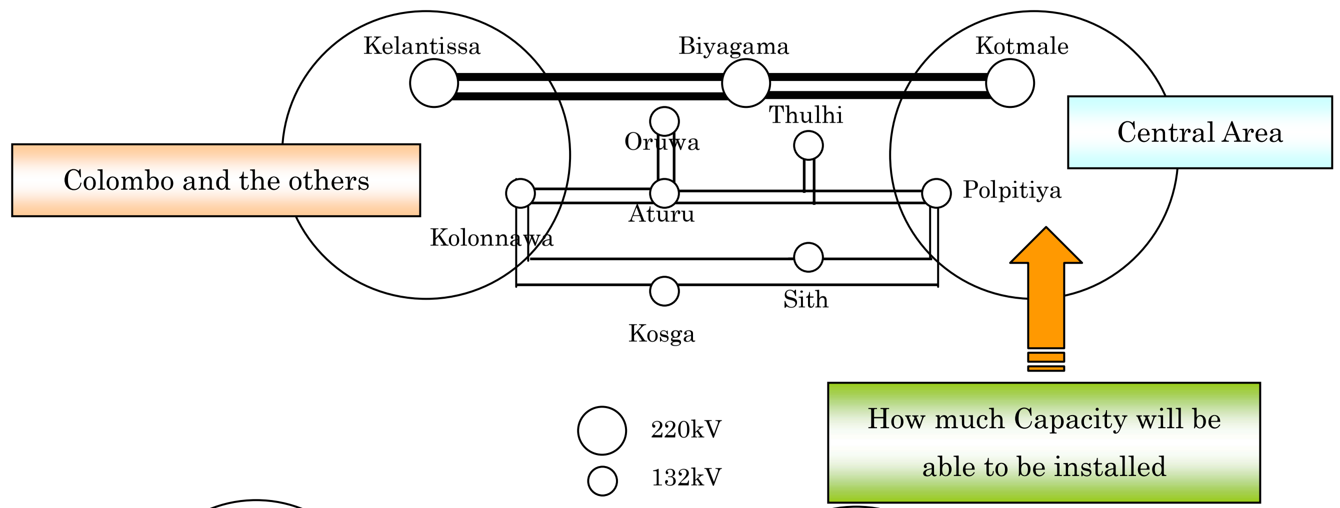
Study B: No Problem

Affect to the Main Grid by Mini-Hydro Interconnection

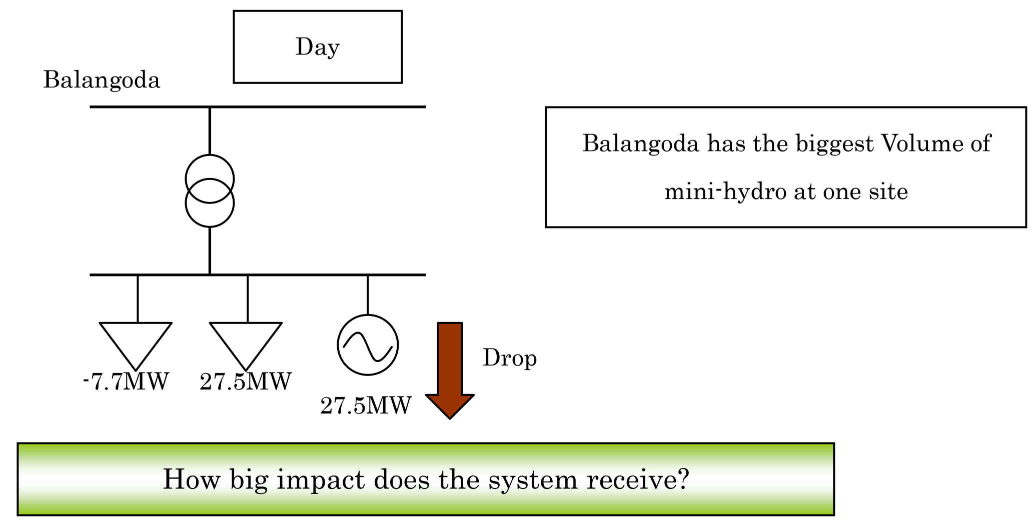
Base Data: 2010 Hydro and Thermal Maximum Case (New Demand and Generators are considered)

Single Line Diagram

Study A (N-0, N-1)

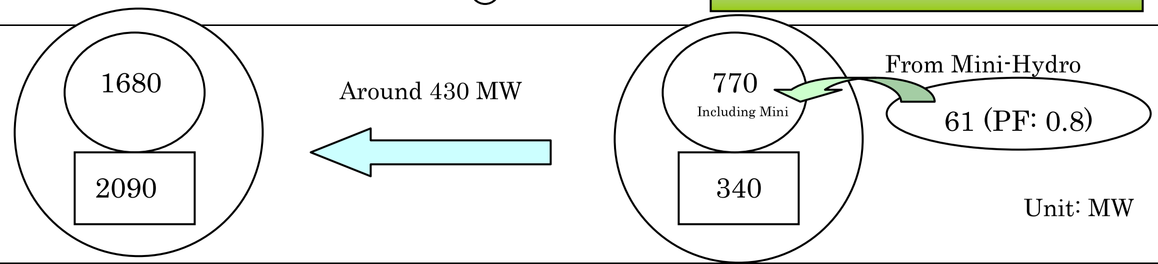


Study B (Frequency Drop)



Pre Condition (Night)

Study A



Study B

Out put of hydraulic power generation in central area declines, as compared with 2005. Because the excess capability of transmission lines in central area declines, as load increases. Out put of hydraulic power generation in central area is necessary to be reduced.

Result (Night)

Study A

Bottle Neck	Marginal Volume (Normal state) (MW)	
Balangoda Tr	486.5	
Ratnapura Tr	503.6	
N-Laxapana - Polpitiya	636.7	
Deniyaya Tr	639.2	
Bottle Neck	**Marginal Volume (N-1 State) (MW)**	**Causes (N-1)**
Balangoda Tr	**266.0**	Balangoda Tr 1unit failure
Ratnapura Tr	283.1	Ratnapura Tr 1unit failure
N-Laxapana - Polpitiya	361.8	N-Laxapana - Polpitiya 1cct Open
Polpitiya - Thulhiriya	407.1	Polpitiya - Thulhiriya 1cct Open

Study B

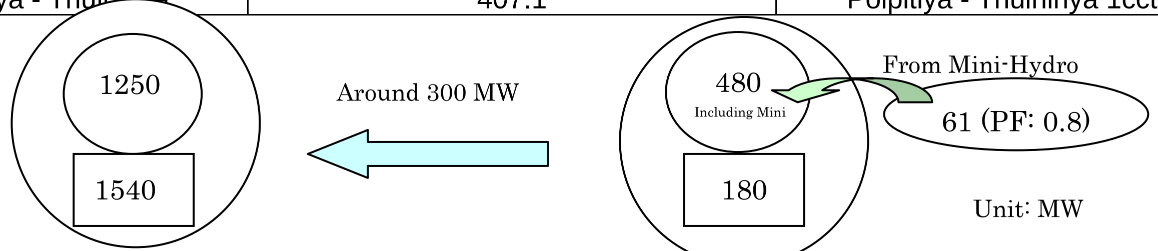
dF = 1/4.75 x100x (27.5 / 2430) = 0.24

49.76Hz > 48.75 Hz → No Load Shedding

49.76Hz > 49.5Hz (Grid Code) → No Problem

Pre Condition (Day)

Study A



Study B

Out put of hydraulic power generation in central area declines, as compared with 2005. Because the excess capability of transmission lines in central area declines, as load increases. Out put of hydraulic power generation in central area is necessary to be reduced.

Result (Day)

Study A

Bottle Neck	Marginal Volume (Normal state) (MW)	
Polpitiya - Kosgama	12.7	
Polpitiya - Thulhiriya	189.6	
Sithawaka - Kolonnawa	208.1	
N-Laxapana - Polpitiya	211.1	
Bottle Neck	**Marginal Volume (N-1 State) (MW)**	**Causes (N-1)**
Polpitiya - Kosgama	**0 (-84.3)**	Polpitiya - Sithawaka 1cct Open
Polpitiya - Sithawaka	4.1	Kosgama - Polpitiya 1cct Open
N-Laxapana - Polpitiya	74.4	Galle - Baddegama 1cct Open
Polpitiya - Thulhiriya	76.8	Polpitiya - Thulhiriya 1cct Open

Study B

dF = 1/4.75 x100x (27.5 / 1720) = 0.34

49.66Hz > 48.75 Hz → No Load Shedding

49.66Hz > 49.5Hz (Grid Code) → No Problem

During Off Peak

Demand is 62% of Day Peak (Daily load curve as of Sep in 2004)

dF = 1/4.75 x100x (27.5 / 700) = 0.54

49.46Hz > 48.75 Hz → No Load Shedding

49.46Hz < 49.5Hz (Grid Code) → However, It can recover to the acceptable range after governor operating

Summary

Study A

Total around 0MW(-23.3MW), 61MW as of existing working amount - 84.3 as of additional mini-hydro installed, is acceptable from the view point of thermal capacity.

Any mini-hydro power plants can not be connected during day peak.

Study B

No Problem

Mini-Hydro Impact Analysis (Operating Condition of Mini Hydro)

2005

Night Peak Case

80% Operation for Hydro_Maximum

		Pre P	Pre Q	Mini P	Mini P (80%)	Estimated P	Estimated Q
3770	KIRIB-3 33.000	69.1	37.3	9.65	7.72	61.38	33.1
3120	WIMAL-3 33.000	17	10.9	5.46	4.37	12.632	8.1
3520	NUWAR-3 33.000	38.2	17.4	4.41	3.53	34.672	15.8
3640	DENIY-3 33.000	22.1	14.8	6.35	5.08	17.02	11.4
3740	RATNAP-3 33.000	15	9.3	15.08	12.06	2.936	1.8
3510	SITHA-33 33.000	29	14.8	7.43	5.94	23.056	11.8
3630	BALAN-3 33.000	47.9	27	27.5	22.00	25.9	14.6
				75.88	60.70		

60% Operation for Thirmal Maximum

		Pre P	Pre Q	Mini P	Mini P (60%)	Estimated P	Estimated Q
3770	KIRIB-3 33.000	69.1	37.3	9.65	5.79	63.31	34.2
3120	WIMAL-3 33.000	17	10.9	5.46	3.28	13.724	8.8
3520	NUWAR-3 33.000	38.2	17.4	4.41	2.65	35.554	16.2
3640	DENIY-3 33.000	22.1	14.8	6.35	3.81	18.29	12.2
3740	RATNAP-3 33.000	15	9.3	15.08	9.05	5.952	3.7
3510	SITHA-33 33.000	29	14.8	7.43	4.46	24.542	12.5
3630	BALAN-3 33.000	47.9	27	27.5	16.50	31.4	17.7
				75.88	45.53		

Day Peak Case

80% Operation for Hydro_Maximum

		Pre P	Pre Q	Mini P	Mini P (80%)	Estimated P	Estimated Q
3770	KIRIB-3 33.000	34.6	18.6	9.65	7.72	26.88	14.4
3120	WIMAL-3 33.000	7.7	5	5.46	4.37	3.332	2.2
3520	NUWAR-3 33.000	19.1	8.7	4.41	3.53	15.572	7.1
3640	DENIY-3 33.000	11.7	7.9	6.35	5.08	6.62	4.5
3740	RATNAP-3 33.000	7.5	4.6	15.08	12.06	-4.564	-2.8
3510	SITHA-33 33.000	21.1	10.8	7.43	5.94	15.156	7.8
3630	BALAN-3 33.000	37.7	21.3	27.5	22.00	15.7	8.9
				75.88	60.70		

60% Operation for Thirmal Maximum

		Pre P	Pre Q	Mini P	Mini P (60%)	Estimated P	Estimated Q
3770	KIRIB-3 33.000	34.6	18.6	9.65	5.79	28.81	15.5
3120	WIMAL-3 33.000	7.7	5	5.46	3.28	4.424	2.9
3520	NUWAR-3 33.000	19.1	8.7	4.41	2.65	16.454	7.5
3640	DENIY-3 33.000	11.7	7.9	6.35	3.81	7.89	5.3
3740	RATNAP-3 33.000	7.5	4.6	15.08	9.05	-1.548	-0.9
3510	SITHA-33 33.000	21.1	10.8	7.43	4.46	16.642	8.5
3630	BALAN-3 33.000	37.7	21.3	27.5	16.50	21.2	12.0
				75.88	45.53		

Mini-Hydro Impact Analysis (Operating Condition of Mini Hydro)

2010

Night Peak Case

80% Operation for Hydro_Maximum

		Pre P	Pre Q	Mini P	Mini P (80%)	Estimated P	Estimated Q
3770	KIRIB-3 33.000	73.3	39.6	9.65	7.72	65.58	35.4
3120	WIMAL-3 33.000	50.7	32.7	5.46	4.37	46.332	29.9
3520	NUWAR-3 33.000	36.6	16.7	4.41	3.53	33.072	15.1
3640	DENIY-3 33.000	33.4	24.6	6.35	5.08	28.32	20.9
3740	RATNAP-3 33.000	21	13	15.08	12.06	8.936	5.5
3510	SITHA-33 33.000	32.6	16.7	7.43	5.94	26.656	13.7
3630	BALAN-3 33.000	28.5	16.2	27.5	22.00	6.5	3.7
				75.88	60.70		

60% Operation for Thirmal Maximum

		Pre P	Pre Q	Mini P	Mini P (60%)	Estimated P	Estimated Q
3770	KIRIB-3 33.000	73.3	39.6	9.65	5.79	67.51	36.5
3120	WIMAL-3 33.000	50.7	32.7	5.46	3.28	47.424	30.6
3520	NUWAR-3 33.000	36.6	16.7	4.41	2.65	33.954	15.5
3640	DENIY-3 33.000	33.4	24.6	6.35	3.81	29.59	21.8
3740	RATNAP-3 33.000	21	13	15.08	9.05	11.952	7.4
3510	SITHA-33 33.000	32.6	16.7	7.43	4.46	28.142	14.4
3630	BALAN-3 33.000	28.5	16.2	27.5	16.50	12	6.8
				75.88	45.53		

Day Peak Case

80% Operation for Hydro_Maximum

		Pre P	Pre Q	Mini P	Mini P (80%)	Estimated P	Estimated Q
3770	KIRIB-3 33.000	36.6	19.8	9.65	7.72	28.88	15.6
3120	WIMAL-3 33.000	25.3	16.4	5.46	4.37	20.932	13.6
3520	NUWAR-3 33.000	18.3	8.3	4.41	3.53	14.772	6.7
3640	DENIY-3 33.000	17.7	11.9	6.35	5.08	12.62	8.5
3740	RATNAP-3 33.000	10.5	6.5	15.08	12.06	−1.564	−1.0
3510	SITHA-33 33.000	23.8	12.2	7.43	5.94	17.856	9.2
3630	BALAN-3 33.000	14.3	8.1	27.5	22.00	−7.7	−4.4
				75.88	60.70		

60% Operation for Thirmal Maximum

		Pre P	Pre Q	Mini P	Mini P (60%)	Estimated P	Estimated Q
3770	KIRIB-3 33.000	36.6	19.8	9.65	5.79	30.81	16.7
3120	WIMAL-3 33.000	25.3	16.4	5.46	3.28	22.024	14.3
3520	NUWAR-3 33.000	18.3	8.3	4.41	2.65	15.654	7.1
3640	DENIY-3 33.000	17.7	11.9	6.35	3.81	13.89	9.3
3740	RATNAP-3 33.000	10.5	6.5	15.08	9.05	1.452	0.9
3510	SITHA-33 33.000	23.8	12.2	7.43	4.46	19.342	9.9
3630	BALAN-3 33.000	14.3	8.1	27.5	16.50	−2.2	−1.2
				75.88	45.53		

高調波・電圧変動問題対策（CEB へ２次調査時に報告）

I. スリランカにおける小水力連系現状および問題

スリランカでは CEB への電力売電契約を結び系統へ接続している小水力 IPP が 2005 年 2 月現在 41 件存在している。その大半が Nuwala Eliya, Wimalasurendra, Balangoda といった中部の水力地点に集中しており、規模としては、0.07MW 程度から最大で 9.9MW であり、総計で 75.63MW である。 またこれらの IPP はすべて 33kV 配電系統に接続されている。近年、こうした IPP が系統連系時また、系統離脱時において高調波・電圧低下の問題が発生している。

II. 小水力連系における問題

- CEB と小水力 IPP の間には電力規模についての契約はあるが、系統に連系する発電設備として具備すべき必要技術・制約等に関して取り決めがない。
- 系統への接続・離脱等を IPP 独自の意志で好きな時に行っている。なおその際 CEB への連絡がない。
- CEB の電力系統において SCADA が導入されている変電所は 70 のうち僅かに 17 である。さらに、IPP へも SCADA を導入したい意向はあるが、資金面の問題で進捗しておらず、IPP の発電状況連系状況等が把握しきれていない。

III. 制度面での対策

日本では、発電設備を商用電力系統に連系することを可能とするために必要となる技術要件が、分散型電源系統連系技術指針（JEAG 9701 (2001)）に取り纏められており、中部電力をはじめ日本のほとんどの電気事業者がこれに準じている。基本的に連系することによって生じる恐れのある高調波・電圧低下等の問題は、連系する IPP 側の問題として明示しており、こうした問題が発生しないよう IPP 側で対処していただくように指導している。

スリランカにおいても、早急に CEB として商用電力系統に連系する IPP に対して要求する技術的要件をまとめ、IPP と需給契約を結ぶ際確認すべきである。

以下に参考となるべく日本における、分散型電源系統連系技術指針について記載する。

1 背景・目的

小水力発電・ゴミ消却発電・燃料電池・太陽光発電等の分散型電源は、平成７年１０月の電気事業法改正により、一般電気事業者の入札制度の創設、発電部門の自由化が実現したことから、電気事業に参入する事業者が増えるに伴い増加傾向にある。こうした発電設備が系統連系することにより、系統における電力品質・保守運用面での影響が懸念されるようになった。また系統を介して他の需要家へ影響を与えることがないよう、系統へ連系する際は、系統連系に関わる情報の透明性および公平性が確保される必要性があることが確認された。このため系統連系に必要となる技術要件が本ガイドラインにとりまとめられている。

2　制約事項

2.1　高調波制約事項（全電圧階級）

電気共同研究会報告（第４６巻第２号　電力系統における高調波とその対策）を参考として、高調波流出電流を総合電流歪み率５％、各次電流歪み率３％以下とすることが望ましい。

2.2　電圧フリッカ制約事項（全電圧階級）

電圧フリッカの対策要否判定基準は以下のとおり、

ΔV10(発電設備設置者受電点における発電設備による単独の電圧フリッカ値)≦0.23V

風力発電設備の電圧フリッカとしては、風速の変化により並解列を繰り返し、突入電流等により電圧変動を生じる場合と風速の変化による出力変動により出力変動により生じる場合とがある。

2.2.1　頻繁な並解列による電圧フリッカによる電圧フリッカ

電圧フリッカは電圧変動値と変動頻度に左右されることから電圧変動値を抑制するか又は並解列頻度を低減する対策が必要。

電圧変動抑制対策としては、

- SVC（静止型無効電力補償装置）による無効電力の補償
- サイリスタ等によるソフトスタートの採用
- 配電線の太線化等による系統インピーダンスの採用

等があり、また並解列頻度低減対策としては、

- 並解列条件を瞬時風速から一定時間平均風速への変更

等がある。

2.2.2　出力変動による電圧フリッカ

この出力変動抑制対策としては、

- SVC（静止型無効電力補償装置）による無効電力の補償
- 配電線の太線化等による系統インピーダンスの採用

等がある。

2.3　電圧変動制約事項(特別高圧：22kV 以上)

2.3.1　発電設備の連系により、系統の電圧が適正値（常時電圧の概ね１～２％以内）を逸脱する恐れがあるときは、発電設備の設置者において自動的に電圧を調整するものとする。

2.3.2　同期発電機を用いる場合には、制動巻線付きのもの（制動巻線を有しているものと同等以上の乱調防止効果を有する制動巻線付きでない同期発電機を含む）とするとともに、自動同期検定装置を設置するものとする。誘導電動機を用いる場合であって、並列時の瞬時電圧低下により系統の電圧が適正値（常時電圧の２％を目安）を逸脱する恐れがあるときは、発電設備の設置者において源流リアクトル等を設置するものとする。なおこれにより対応できない場合は同期発電機を用いるものとする。

2.3.3　自励式の逆変換装置を用いる場合には、自動的に同期がとれる機能を有するもの

を用いるものとする。また他励式の逆変換装置を用いる場合であって、並列時の瞬時電圧低下により系統電圧が適正値（常時電圧の２％を目安）を逸脱する恐れがあるときは、発電設備の設置者において源流リアクトル等を設置するものとする。なおこれにより対応できない場合には自励式の逆変換装置を用いるものとする。

2.4　電圧変動制約事項(高圧：6.6kV 以下)

2.4.1　一般配電線との連系であって、発電設備の脱落等により低圧需要家の電圧が適正値（101±6V、202±20V）を逸脱する恐れがある時には、発電設備の設置者において自動的に負荷を制限する対策を行うものとする。なお、これにより対応できない場合には配電線の増強を行うか、専用線による連系とするものとする。

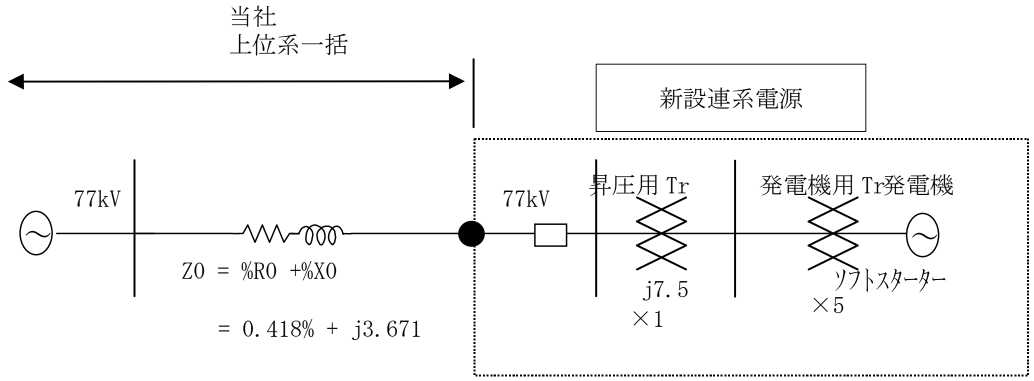
2.4.2　発電設備からの逆潮流により低圧需要家の電圧が適正値（101±6V、202±20V）を逸脱する恐れがある時には、発電設備の設置者において自動的に電圧を調整する対策を行うものとする。なお、これにより対応できない場合には配電線の増強を行うか、専用線による連系とするものとする。

2.4.3　同期発電機を用いる場合には、制動巻線付きのもの（制動巻線を有しているものと同等以上の乱調防止効果を有する制動巻線付きでない同期発電機を含む）とするとともに、自動同期検定装置を設置するものとする。誘導電動機を用いる場合であって、並列時の瞬時電圧低下により系統の電圧が適正値（常時電圧の１０％以内）を逸脱する恐れがあるときは、発電設備の設置者において源流リアクトルや起動補償用コンデンサの設置、ソフトスターター機能付き発電機を設置するものとする。なおこれにより対応できない場合は同期発電機を用いるものとする。

2.4.4　自励式の逆変換装置を用いる場合には、自動的に同期がとれる機能を有するものを用いるものとする。また他励式の逆変換装置を用いる場合であって、並列時の瞬時電圧低下により系統電圧が適正値（常時電圧の１０％以内）を逸脱する恐れがあるときは、発電設備の設置者において源流リアクトル等を設置するものとする。なおこれにより対応できない場合には自励式の逆変換装置を用いるものとする。

IV.　電圧変動対策検討（中部電力における実例）

1　**供給概要**



Step-up Transformers

定格容量	1,800kVA
リアクタンス	5.5%(自己容量ﾍﾞｰｽ) 30.555%(10MVA ﾍﾞｰｽ)
台数	5 台

Generators

種類	誘導機
定格容量	1,808kVA
定格出力	1,650kW
リアクタンス	17.6%(自己容量ﾍﾞｰｽ) 97.245%(10MVA ﾍﾞｰｽ)
台数	5 台

2　**現系統での検討結果**

2.1　系統連系時の電圧変動検討

77kV 系統であるため、2%以下とする。しかしながら本ケースでは、ソフトスターター採用のため問題なし。参考値である。

$$\Delta V = \sqrt{\frac{R0^2 + X0^2}{R0^2 + (X0 + Xt + XG)^2}} \times 100$$

$$2.73\% = \sqrt{\frac{0.418^2 + 3.671^2}{0.418^2 + (3.671 + 7.5 + 30.555 + 97.245)^2}}$$

2.2　系統脱落時の電圧変動検討

$$\Delta V = \%R0 \times P(p.u) + \%X0 \times Q(p.u)$$

$$\pm 2 \geq 0.418 \times \frac{8.3}{10} + 3.671 \times \frac{Q}{10}$$

$$901k\,\mathrm{var} \leq Q \leq -1{,}277k\,\mathrm{var}$$

運転力率許容範囲

遅れ 87.8%～進み 79.1%で運用する必要がある。これを満たせない場合は力率改善コンデンサを投入するか、指定力率で運転可能な自動力率調整装置を設置する必要がある。

V.　高調波抑制対策

ここでは高調波抑制として有益で実際に採用されている対策について列記する。

1.1　電力変換器のパルス数を増加して低次高調波電流を抑制

1.1.1　多パルス化

電力変換器のパルス数を増加して低次高調波電流を抑制する方法である。低次高調波電流を抑制することは高調波を抑えることになる。ここで電力変換装置のパルス数と高調波電流の次数との関係は以下の通りとなる。

発生する高調波電流の次数　　n＝k×P±1

k: 1,2,3....

P: パルス数

このように、例えば１２パルスの電力変換器の場合、理論的には５次及び７次の高調波電流を発生しないため（実際は回路の不平衡などにより若干の５次、7次の高調波電流を発生する)、１２パルスの変換器を採用することは高調波抑制対策として大変効果的である。

1.2　高調波電流吸収

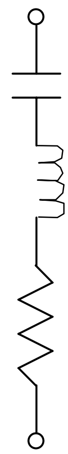
高調波電流を吸収して抑制する方法である。

1.2.1　受動フィルター

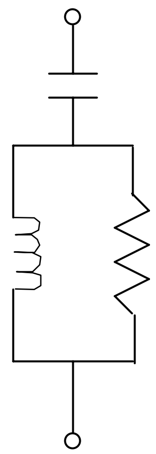
コンデンサ、リアクトルといった受動（Passive）素子を組み合わせて特定の周波数あるいは周波数領域で抵インピーダンスとなる分路を構成し、高調波電流を吸収するものである。受動フィルターには（単一）同調フィルタと高次フィルタの２種類がある。

同調フィルタとは、一つの高調波次数に共振したL-C-R直列回路で構成され、同調周波数で低抵抗となり効果を発揮する。先鋭度・共振の鋭さであるQを大きくすることで更に効果を高めることができるが、逆に同調ずれが起こりやすくなったり、フィルター過負荷を生じたりする可能性が高まる。

高次フィルターは広い周波数範囲で低抵抗となるので、高調波発生量の多い低次高調波を対象とした各次数の同調フィルターと組み合わせ高次高調波全体の吸収を分担するように構成される。



同調フィルター



高次フィルター

1.2.2　力率改善コンデンサ(需要家)

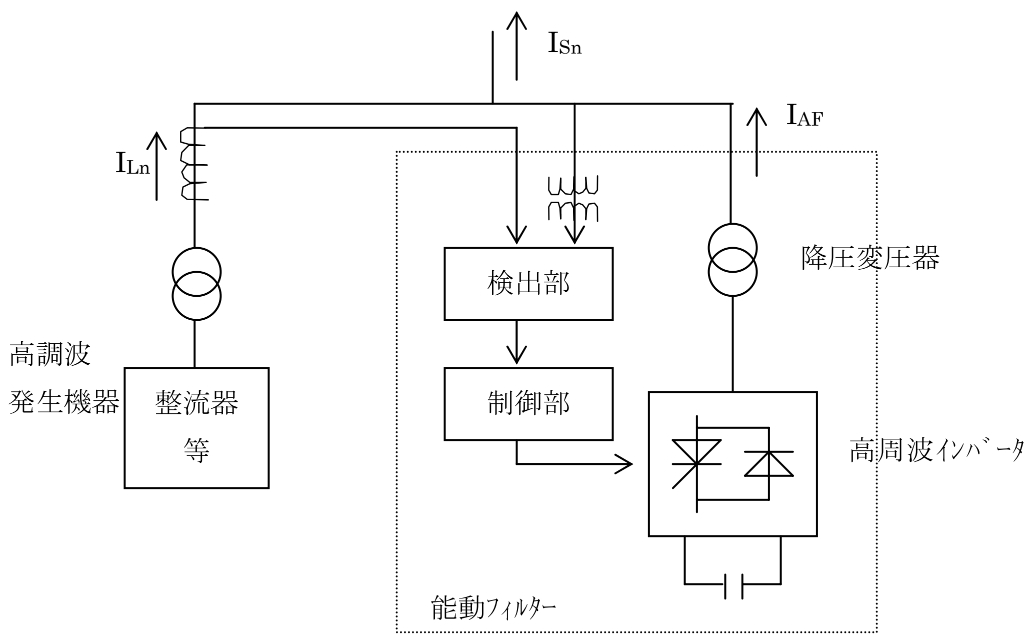
６％の直列リアクトル付き力率改善用コンデンサーは、高調波を吸収する効果があり、特に受電変圧器の抵圧側に設置すれば受電変圧器の漏れインダクタンスの大きさによっても異なるものの、第５高調波に対しては３０～５０％の流出電流を低減することができる。

1.3　高調波電流のキャンセル

高調波電流をキャンセルして抑制する方法である。

1.3.1　能動フィルター

発生する高調波電流を検出し、それを打ち消す極性の電流を能動的に（Active）に発生するものである。能動フィルターは下図のとおり、高周波インバータ、連系用変圧器、高周波検出部、電流制御部などからの基本構成されている。



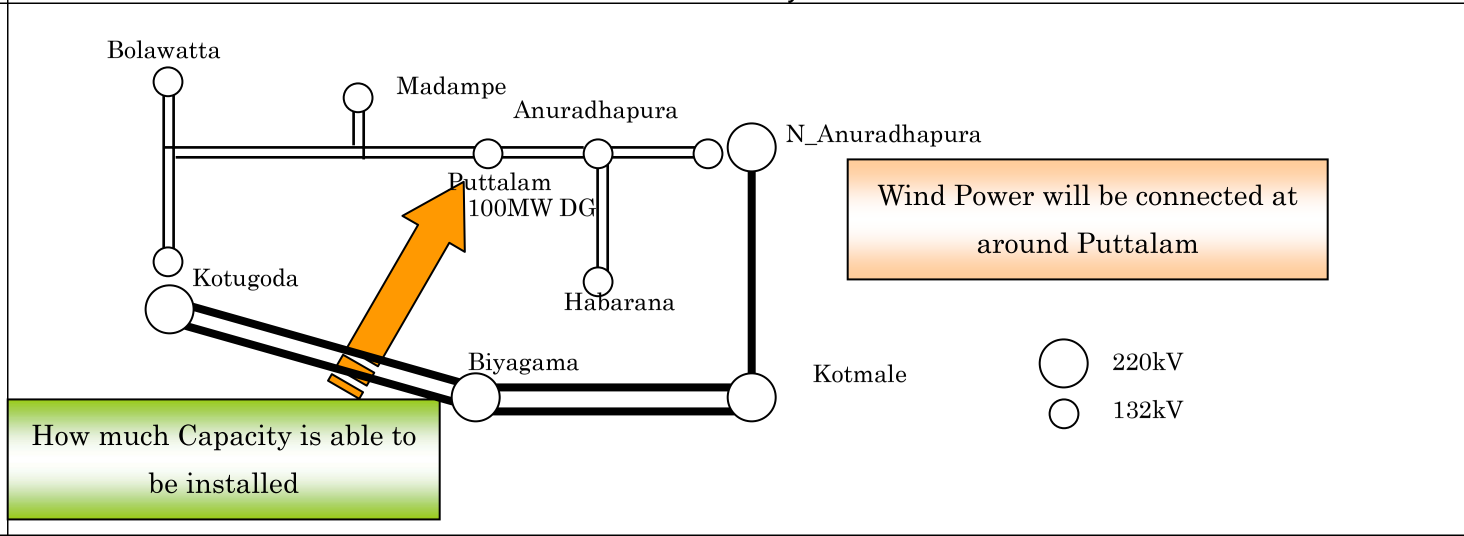
1.3.2　Δ－Δ、Δ－Ｙ巻線変圧器

一般に整流器などの電力変換装置には専用の変圧器が用いられる。三相変圧器の一次側と二次側巻線の結線方法にはΔ－Δ、Δ－Ｙ、Ｙ－Ｙ、Ｙ－Δの４方式がある。ここで同一母線に接続されたΔ－Δ、Δ－Ｙ結線の２変圧器を組み合わせた方式により、一次側に流れる５，７次高調波電流はお互いに１８０°の位相差となりキャンセルすることで高調波電流を低減できる。

Affect to the Main Grid by Wind-Power Interconnection

Base Data: 2005 Thermal Maximum Case (New Demand and Generators are considered)

Single Line Diagram (N-1 Study)



Result (Day)

Study Items	Marginal Volume (MW)	Bottle Neck	Frequency Drop Analysis
N-1	**55MW** (Puttalam - Madam_T - Bolaw_T - Kotugoda) 1cct is outage	Puttalam - Madam_T - Bolaw_T - Kotugoda	dF = 1/4.75 x100x (55 / 1200) = 0.96 49.04Hz > 48.75 Hz → No Load Shedding 49.04Hz < 49.5Hz (Grid Code) → However, It can recover to the acceptable range after governor operating

Result (Night)

Study Items	Marginal Volume (MW)	Bottle Neck	Frequency Drop Analysis
N-1	**210MW** In case that (Puttalam - Madam_T - Bolaw_T - Kotugoda) 1cct is outage	Puttalam - Madam_T - Bolaw_T - Kotugoda	dF = 1/4.75 x100x (210 / 1700) = 2.60 47.46Hz < 48.75 Hz → Load Shedding dF = 1/4.75 x100x (100 / 1700) = 1.24 48.76Hz > 48.75 Hz → No Load Shedding **100MW** is the marginal from the view point of no load shedding
			During Off Peak Demand is 62% of Day Peak (Daily load curve as of Sep in 2004) dF = 1/4.75 x100x (41 / 700) = 1.23 48.77Hz > 48.75 Hz → No Load Shedding **41MW** is the marginal from the view point of no load shedding

Summary

Classification	Marginal Volume (MW)	Causes	Remarks
Day	55MW	N-1 Problem	
Night	100MW	Frequency Drop Problem	
Off Peak	41MW	Frequency Drop Problem	

Remarks

Result on Transmission Loss Reduction

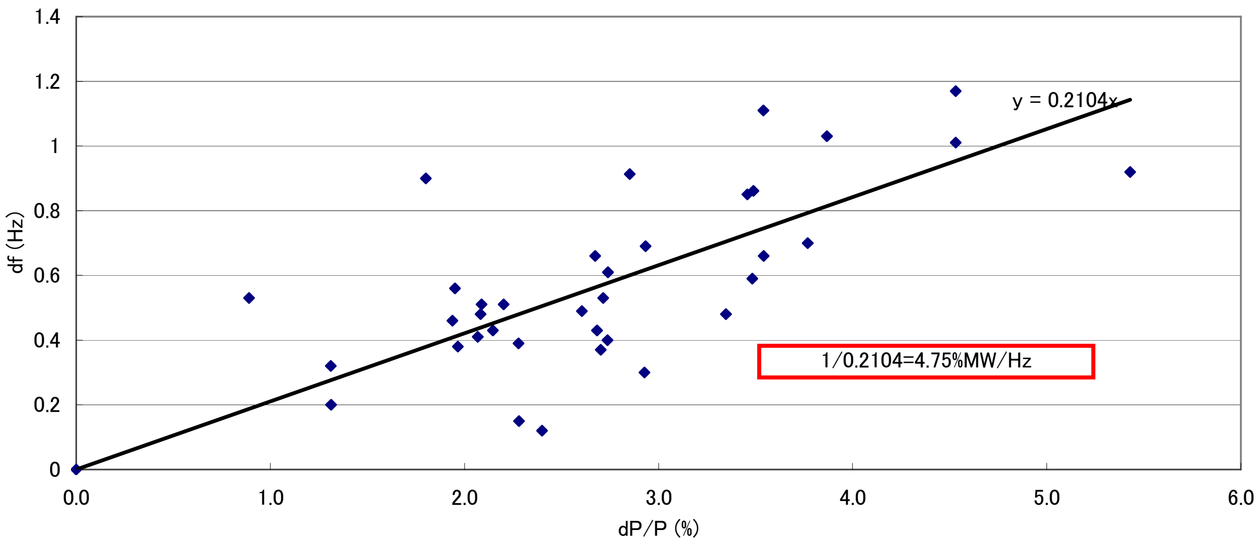
			Zebra_4		Zebra LL_4				Parrrot_4				
	Year	Power Flow (MW)	Zebra_4 TL Cost (M US$)	TL Loss (M US$)	TL Incremental Cost	Reduced TL Loss (M US$)	Total (M US$)	P.V (M US$)	TL Incremental Cost	Reduced TL Loss (M US$)	Total (M US$)	P.V (M US$)	Remarks
0	2011	600	19.712	2.523	-10.157	0.757	-9.400	-9.400	-7.901	1.211	-6.690	-6.690	Present Year
1	2012	600		2.523		0.757	0.757	0.688		1.211	1.211	1.101	
2	2013	600		2.523		0.757	0.757	0.626		1.211	1.211	1.001	
3	2014	600		2.523		0.757	0.757	0.569		1.211	1.211	0.910	
4	2015	600		2.523		0.757	0.757	0.517		1.211	1.211	0.827	
5	2016	600		2.523		0.757	0.757	0.470		1.211	1.211	0.752	
6	2017	600		2.523		0.757	0.757	0.427		1.211	1.211	0.684	
7	2018	600		2.523		0.757	0.757	0.388		1.211	1.211	0.621	
8	2019	600		2.523		0.757	0.757	0.353		1.211	1.211	0.565	
9	2020	900		1.388		0.404	0.404	0.171		0.656	0.656	0.278	2 route
10	2021	900		1.388		0.404	0.404	0.156		0.656	0.656	0.253	Break Even Poit for Parrot
11	2022	900		1.388		0.404	0.404	0.141		0.656	0.656	0.230	
12	2023	900		1.388		0.404	0.404	0.129		0.656	0.656	0.209	
13	2024	900		1.388		0.404	0.404	0.117		0.656	0.656	0.190	
14	2025	900		1.362		0.404	0.404	0.106		0.656	0.656	0.173	
15	2026	900		1.362		0.404	0.404	0.097		0.656	0.656	0.157	
16	2027	900		1.362		0.404	0.404	0.088		0.656	0.656	0.143	
17	2028	900		1.362		0.404	0.404	0.080		0.656	0.656	0.130	
18	2029	900		1.362		0.404	0.404	0.073		0.656	0.656	0.118	
19	2030	900		1.362		0.404	0.404	0.066		0.656	0.656	0.107	
20	2031	900		1.362		0.404	0.404	0.060		0.656	0.656	0.098	
					Total Present Value			-4.079				1.855	

Conversion Rate	10.74	USD/1000LKR	Source: LTGEP2003, 01st January 2002
Discount Rate =	10%		Source: LTGEP2003
Operation Cost	0.0000576	M US$/MWh	CEB Average Generation Cost Includng Fuel and O/M Cost

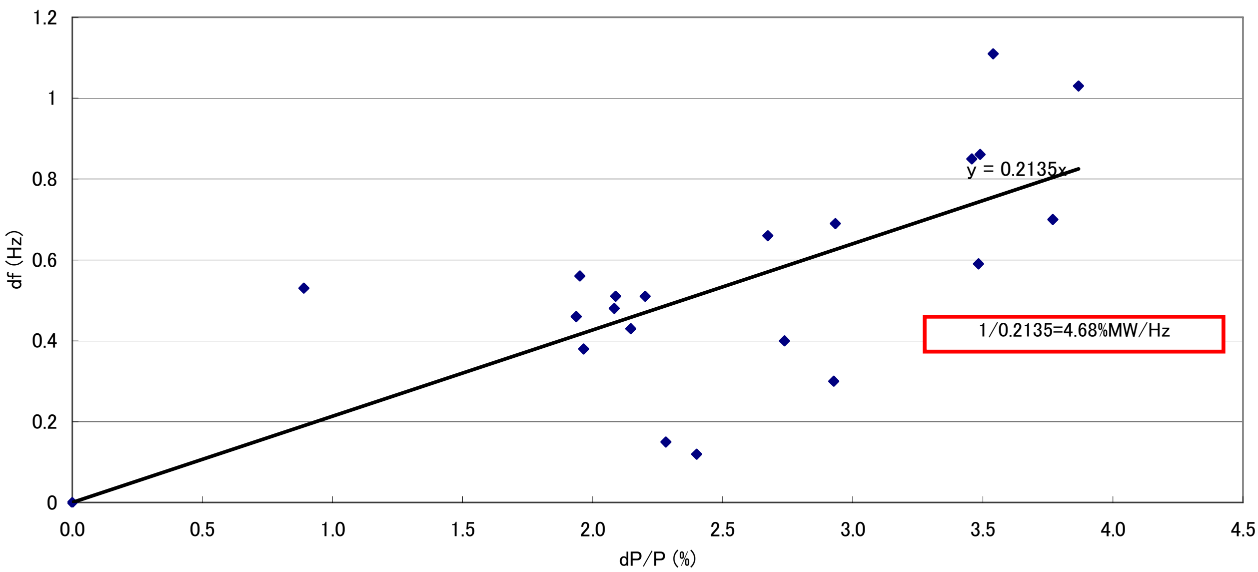
Puttalam - Chilaw: 70km

	Total	Only Conductor	
Zebra_4 2cct	1835.4 MLKR	1.52MLKR/km	
Parrot_4 2cct	2571.1 MLKR	2.89MLKR/km	Tower size is the same as that of the Zebra_4
Zebra LL_4 2cct	2781.1 MLKR	3.265MLKR/km	

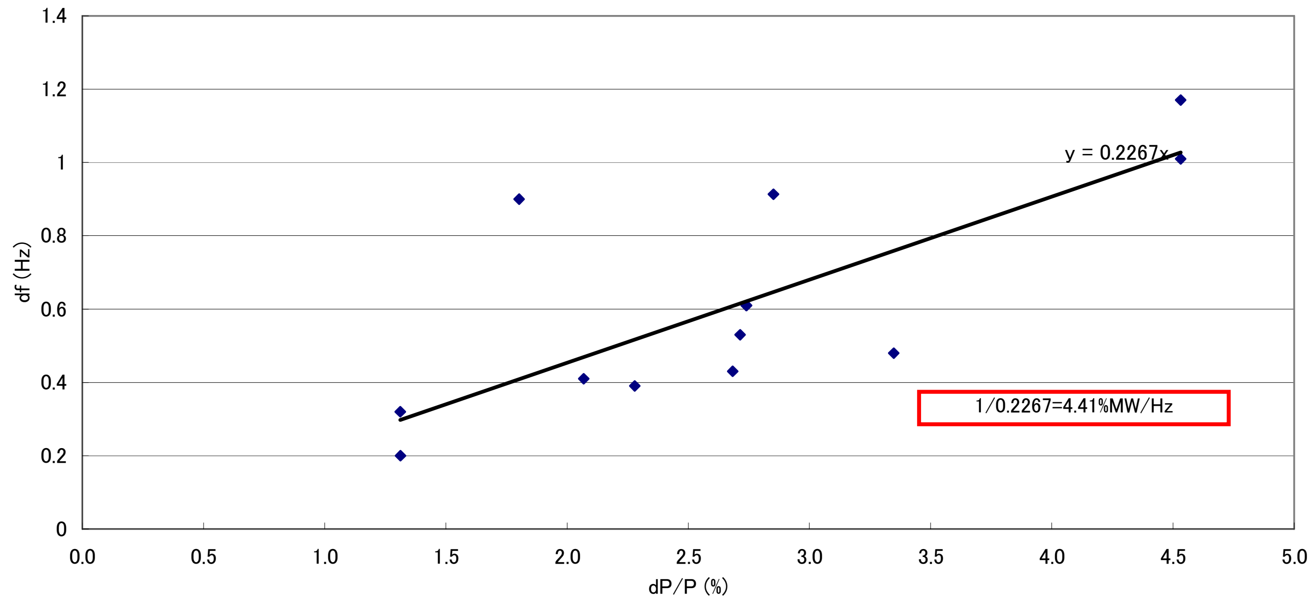
System Frequency Characteristic Constant (Whole Day)



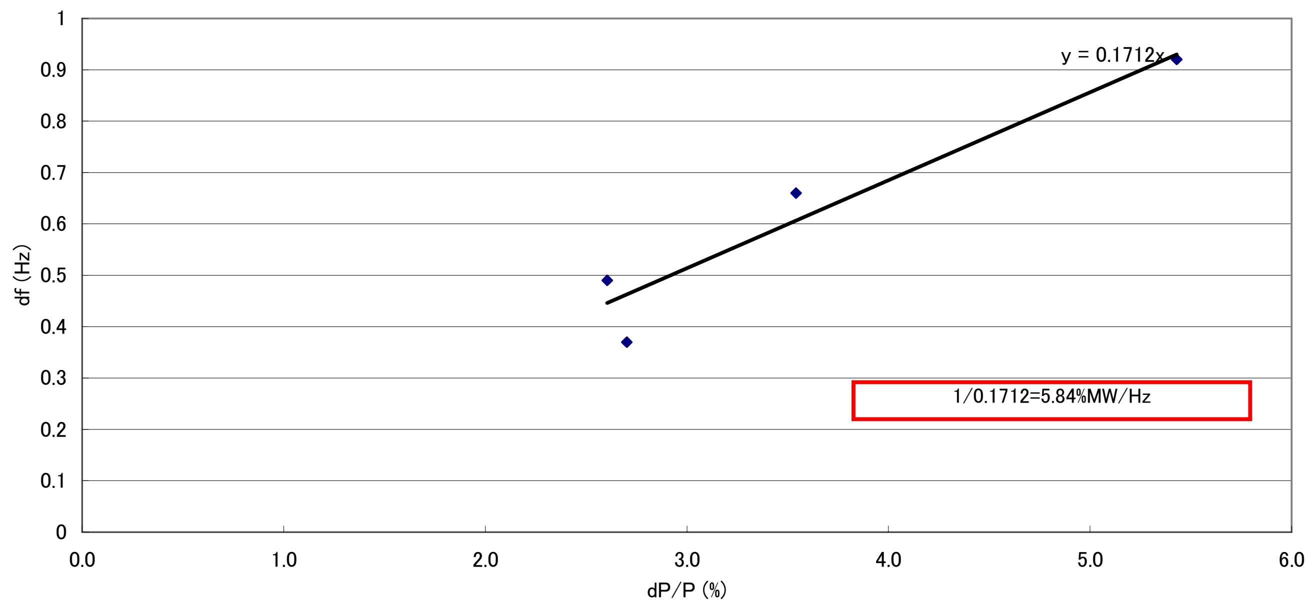
System Frequency Characteristic Constant (Day Peak)



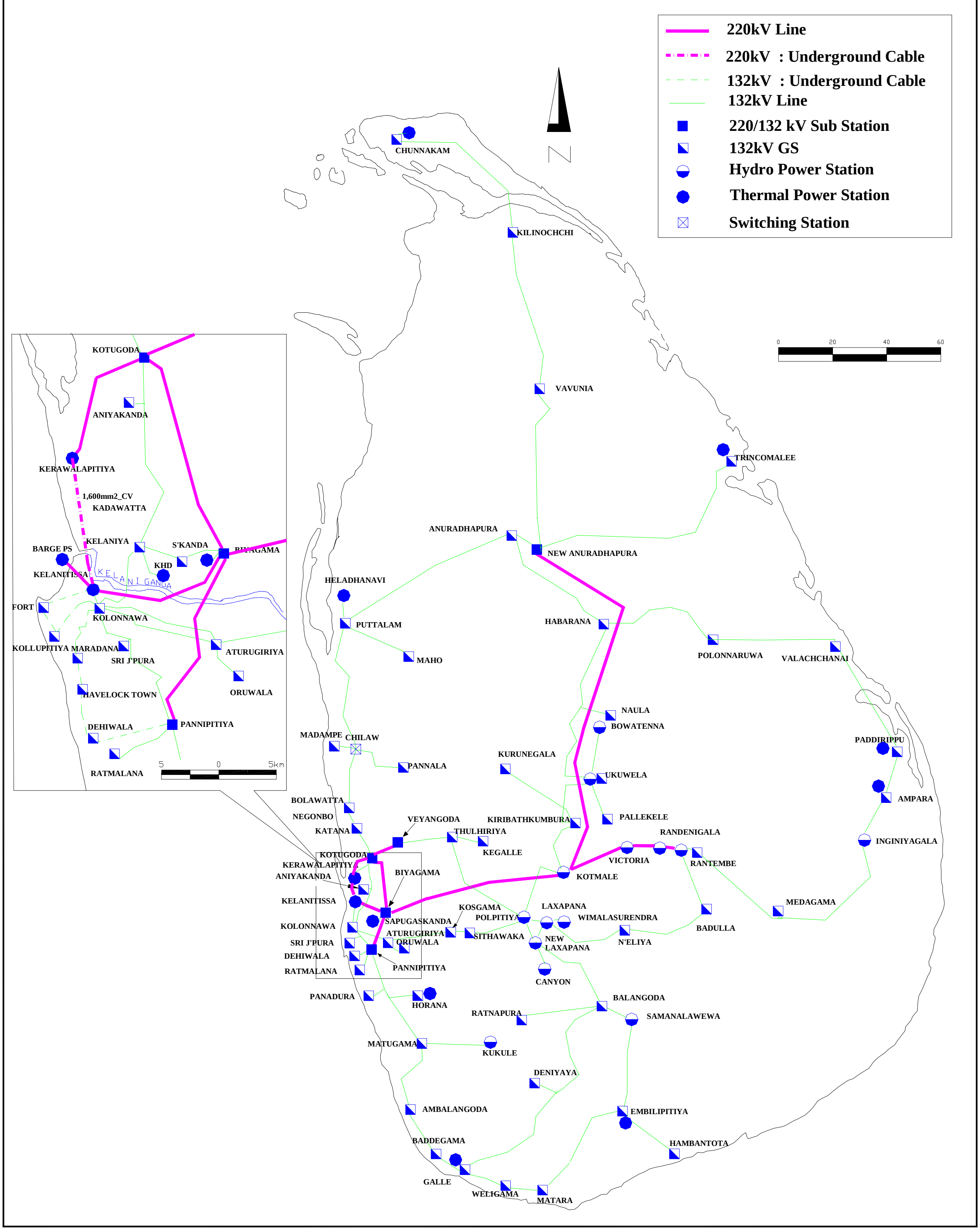
System Frequency Characteristic Constant (Night Peak)



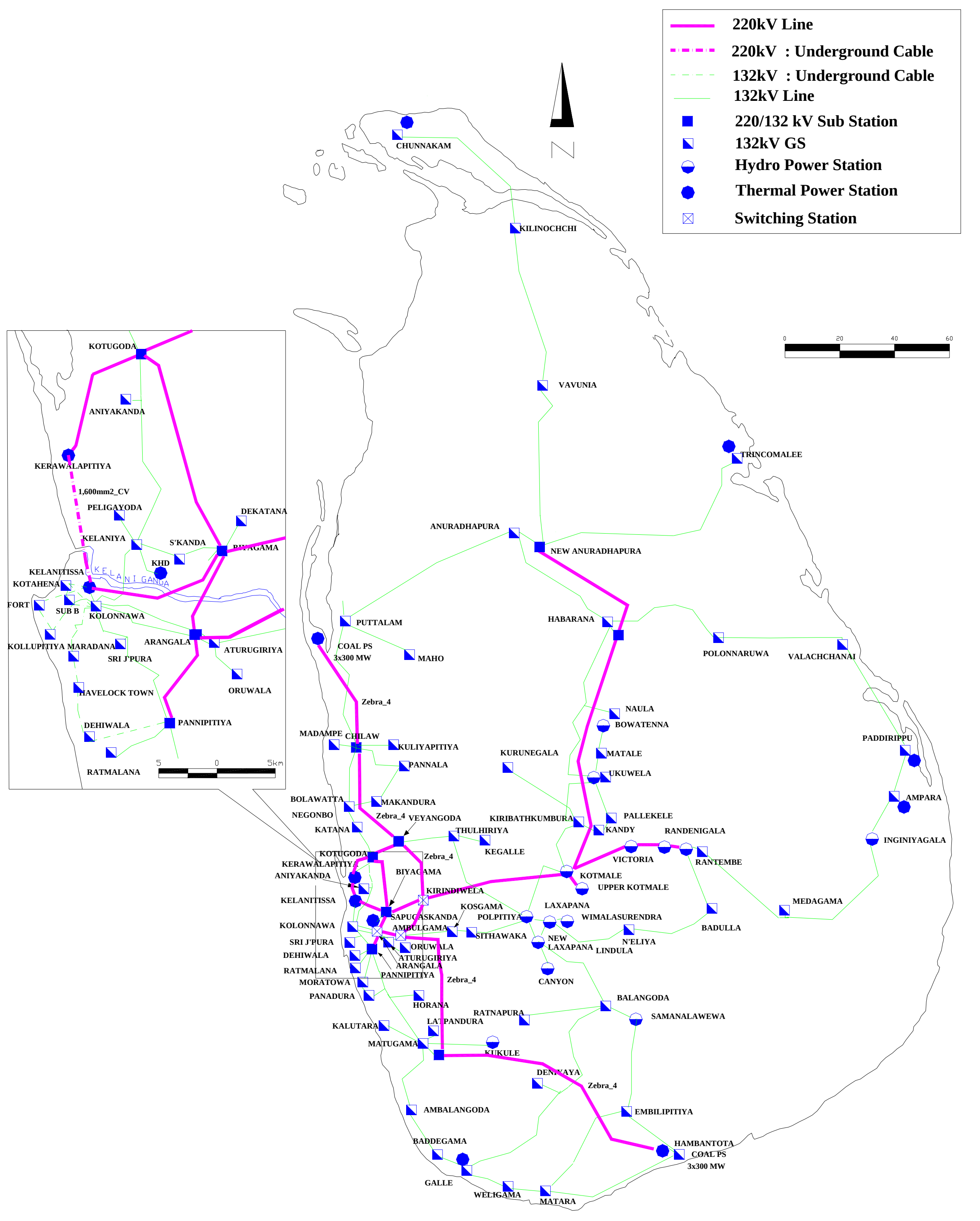
System Frequency Characteristic Constant (Off Peak)



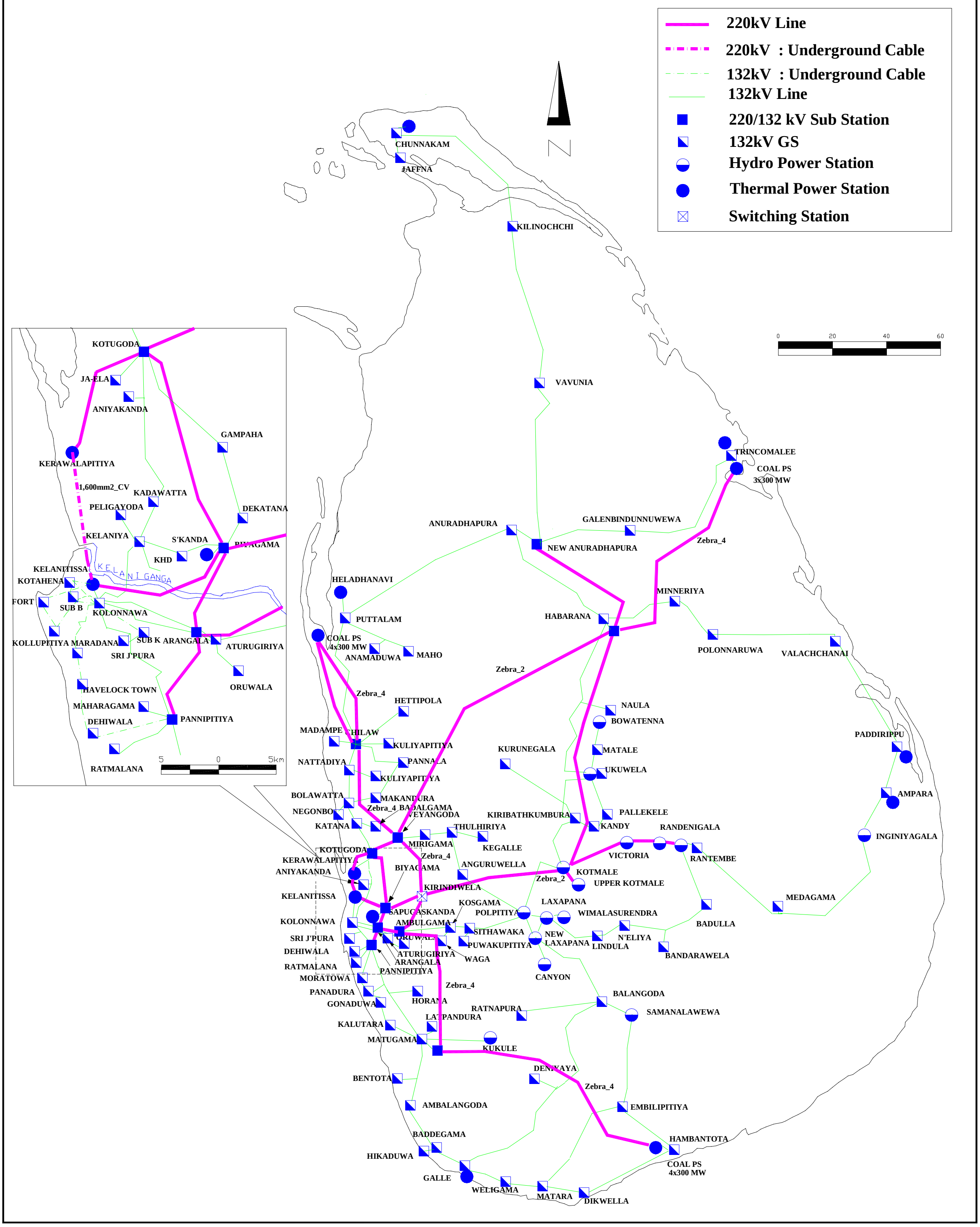
The Map of Sri Lanka Transmission System in Year 2010



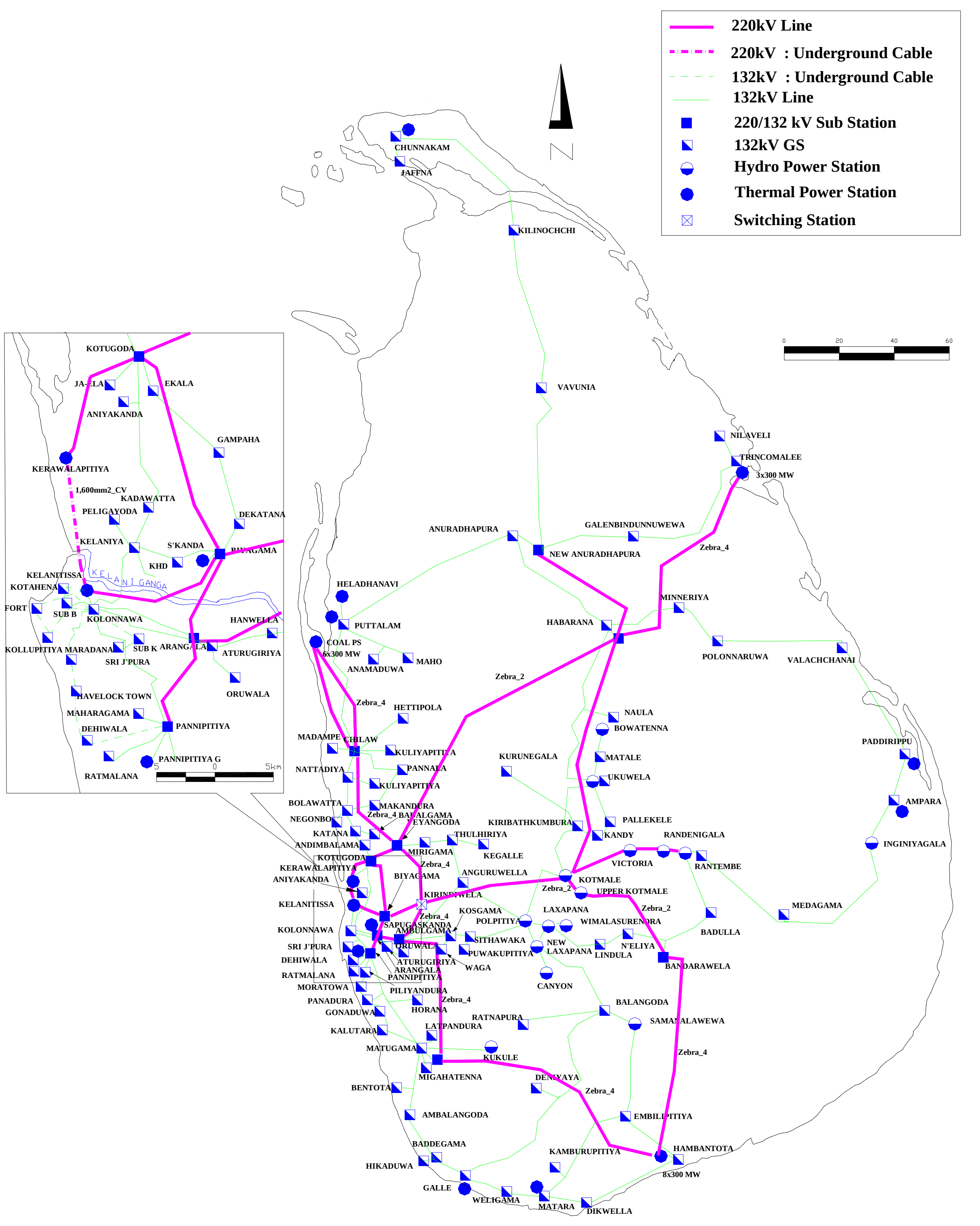
The Map of Sri Lanka Transmission System in Year 2015

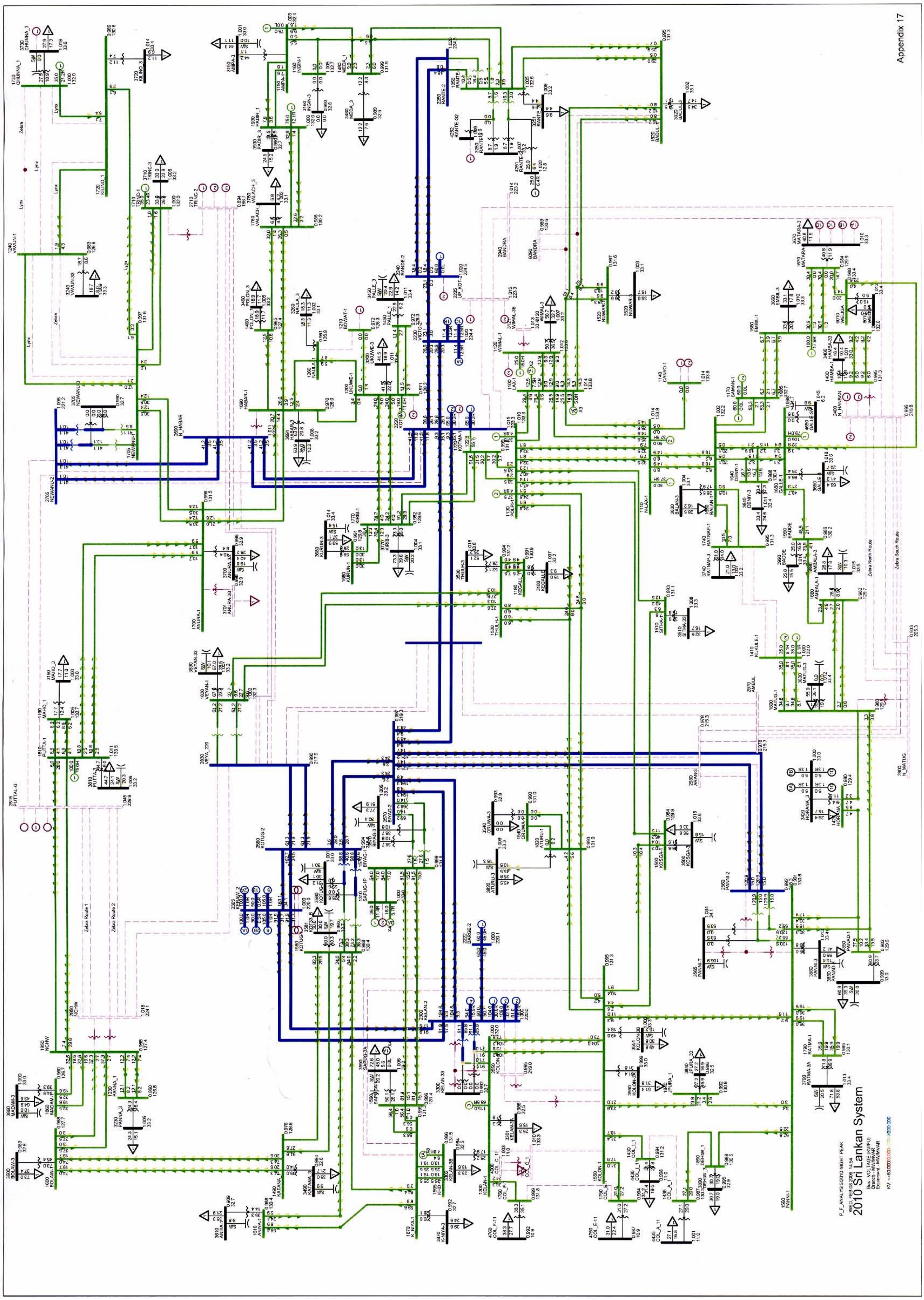


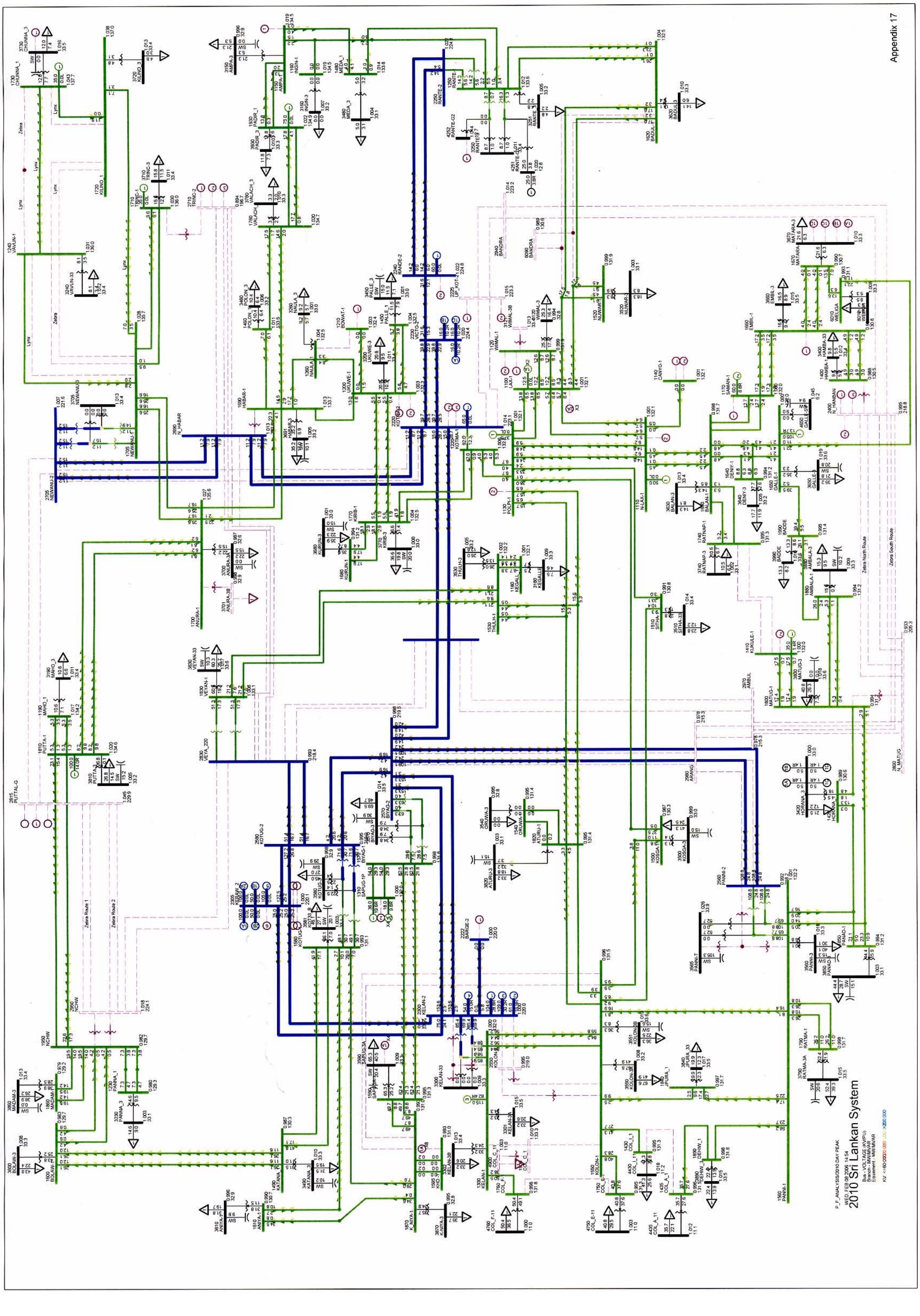
The Map of Sri Lanka Transmission System in Year 2020

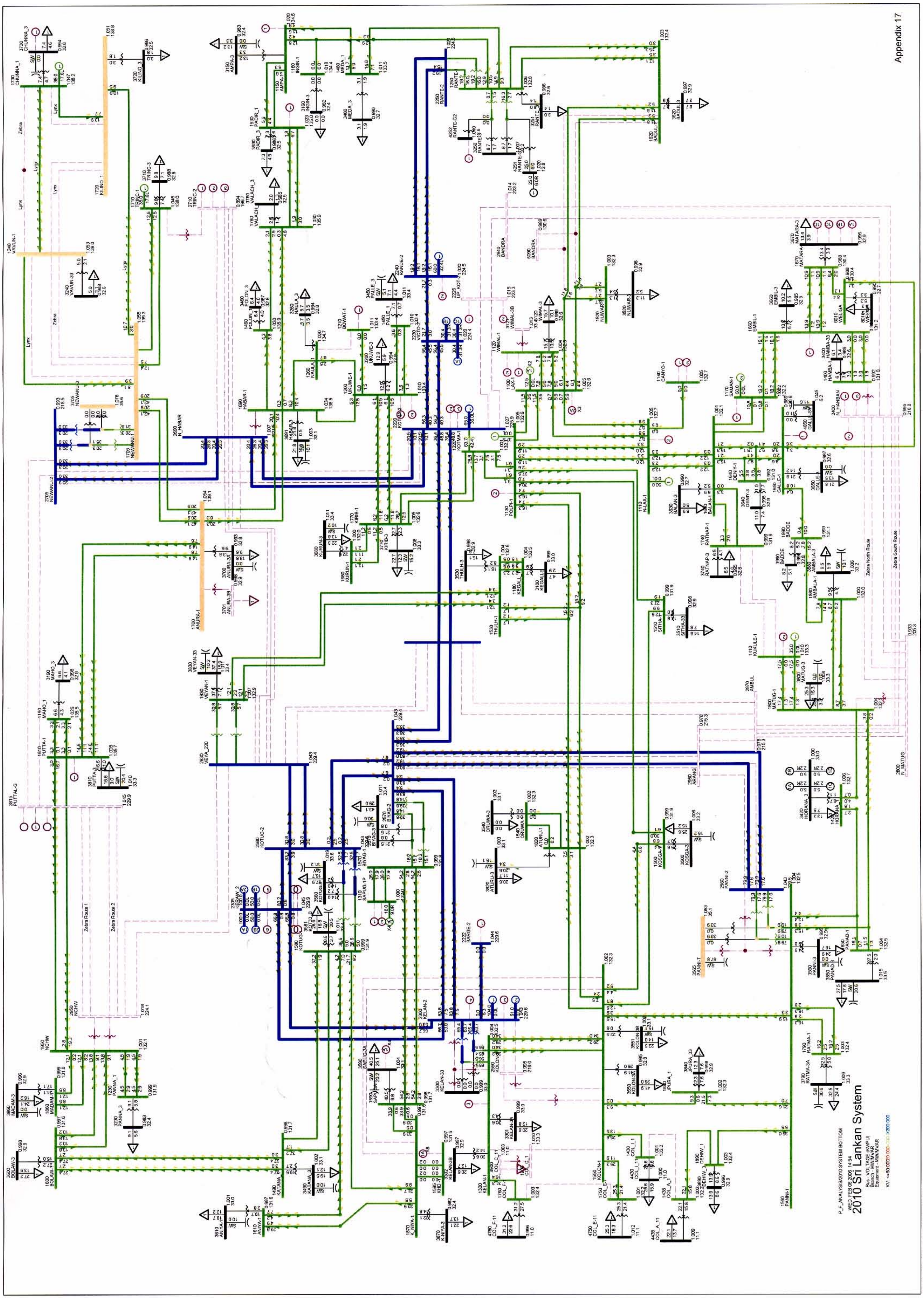


The Map of Sri Lanka Transmission System in Year 2025




Appendix 17
2010 Sri Lankan System


Appendix 17
2010 Sri Lankan System


Appendix 17
2010 Sri Lankan System

N-1 Checking based on 2010_Night_Peak

1. Branches and Tie Lines

Monitored Elements	Base Flow	Maximum Flow	Impact	Rate	%	Contingency	Countermeasures
Nothing							

2. Voltage

220kV

Bus	Voltage	Contingency	Countermeasures
Nothing			

132kV

Bus	Voltage	Contingency	Countermeasures
Nothing			

N-1 Checking based on 2010_Day_Peak

1. Branches and Tie Lines

Monitored Elements	Base Flow	Maximum Flow	Impact	Rate	%	Contingency	Countermeasures
Nothing							

2. Voltage

220kV

Bus	Voltage	Contingency	Countermeasures
Nothing			

132kV

Bus	Voltage	Contingency	Countermeasures
Nothing			