Appendix I

Test Systems Data

Table A.I.1 Bus Data of IEEE-30 bus system

Bus	Voltage		Generation		Load	
	Mag(pu)	Ang(deg)	P (MW)	Q (MVAr)	P (MW)	Q (MVAr)
1	1.100	0.000	98.90	-24.11		-
2	1.100	-1.835	80.00	10.80	21.70	12.70
3	1.088	-3.744	-	-	2.40	1.20
4	1.087	-4.493	-	-	7.60	1.60
5	1.100	-6.437	50.00	43.23	94.50	19.00
6	1.089	-5.263	-	-	-	-
7	1.085	-6.167	-	-	22.80	10.90
8	1.100	-5.654	20.00	67.83	30.00	30.00
9	1.076	-6.546	-	-	-	-
10	1.058	-8.346	-	-	5.80	2.00
11	1.100	-4.513	20.00	12.83	-	-
12	1.076	-7.682	-	-	11.20	7.50
13	1.100	-6.326	20.00	19.31	-	-
14	1.060	-8.558	-	-	6.20	1.60
15	1.055	-8.617	-	-	8.20	2.50
16	1.061	-8.229	-	-	3.50	1.80
17	1.054	-8.506	-	-	9.00	5.80
18	1.044	-9.203	-	-	3.20	0.90
19	1.041	-9.369	-	-	9.50	3.40
20	1.044	-9.163	-	-	2.20	0.70
21	1.046	-8.781	-	-	17.50	11.20
22	1.047	-8.774	-	-	-	-
23	1.043	-8.997	-	-	3.20	1.60
24	1.035	-9.182	-	-	8.70	6.70
25	1.042	-9.316	-	-	-	-
26	1.025	-9.721	-	-	3.50	2.30
27	1.055	-9.137	-	-	-	-
28	1.086	-5.689	-	-	-	-
29	1.036	-10.302	-	-	2.40	0.90
30	1.025	-11.118	-	-	10.60	1.90

Table A.I.2 Branch Data of IEEE-30 bus system

Lines	From bus	To bus	Max. Limit	r	x	b	Tap
1	**1**	**2**	**130**	0.02	0.06	0.03	1
2	**1**	**3**	**130**	0.05	0.19	0.02	1
3	**2**	**4**	**65**	0.06	0.17	0.02	1
4	**3**	**4**	**130**	0.01	0.04	0	1
5	**2**	**5**	**10**	0.05	0.2	0.02	1
6	**2**	**6**	**65**	0.06	0.18	0.02	1
7	**4**	**6**	**90**	0.01	0.04	0	1
8	**5**	**7**	**70**	0.05	0.12	0.01	1
9	**6**	**7**	**10**	0.03	0.08	0.01	1
10	**6**	**8**	**32**	0.01	0.04	0	1
11	**6**	**9**	**65**	0	0.21	0	1
12	**6**	**10**	**32**	0	0.56	0	1
13	**9**	**11**	**65**	0	0.21	0	1
14	**9**	**10**	**65**	0	0.11	0	1
15	**4**	**12**	**30**	0	0.26	0	1
16	**12**	**13**	**65**	0	0.14	0	1
17	**12**	**14**	**32**	0.12	0.26	0	1
18	**12**	**15**	**32**	0.07	0.13	0	1
19	**12**	**16**	**32**	0.09	0.2	0	1
20	**14**	**15**	**16**	0.22	0.2	0	1
21	**16**	**17**	**16**	0.08	0.19	0	1
22	**15**	**18**	**16**	0.11	0.22	0	1
23	**18**	**19**	**16**	0.06	0.13	0	1
24	**19**	**20**	**32**	0.03	0.07	0	1
25	**10**	**20**	**32**	0.09	0.21	0	1
26	**10**	**17**	**32**	0.03	0.08	0	1
27	**10**	**21**	**32**	0.03	0.07	0	1
28	**10**	**22**	**32**	0.07	0.15	0	1
29	**21**	**22**	**32**	0.01	0.02	0	1
30	**15**	**23**	**16**	0.1	0.2	0	1
31	**22**	**24**	**16**	0.12	0.18	0	1
32	**23**	**24**	**16**	0.13	0.27	0	1
33	**24**	**25**	**16**	0.19	0.33	0	1
34	**25**	**26**	**16**	0.25	0.38	0	1
35	**25**	**27**	**10**	0.11	0.21	0	1
36	**28**	**27**	**65**	0	0.4	0	1
37	**27**	**29**	**16**	0.22	0.42	0	1
38	**27**	**30**	**16**	0.32	0.6	0	1
39	**29**	**30**	**16**	0.24	0.45	0	1
40	**8**	**28**	**32**	0.06	0.2	0.02	1
41	**6**	**28**	**32**	0.02	0.06	0.01	1

Table A.I.3 Bus Data of IEEE-118 bus system

Bus	Voltagc		Gcncration		Load	
	Mag(pu)	Ang(deg)	P (MW)	Q (MVAr)	P (MW)	Q (MVAr)
1	0.955	10.973	0.00	-3.10	51.00	27.00
2	0.971	11.513	-	-	20.00	9.00
3	0.968	11.856	-	-	39.00	10.00
4	0.998	15.574	0.00	-15.01	39.00	12.00
5	1.002	16.019	-	-	-	-
6	0.990	13.292	0.00	15.93	52.00	22.00
7	0.989	12.847	-	-	19.00	2.00
8	1.015	21.041	0.00	63.14	28.00	0.00
9	1.043	28.295	-	-	-	-
10	1.050	35.876	450.00	-51.04	-	-
11	0.985	13.006	-	-	70.00	23.00
12	0.990	12.489	85.00	91.29	47.00	10.00
13	0.968	11.630	-	-	34.00	16.00
14	0.984	11.771	-	-	14.00	1.00
15	0.970	11.474	0.00	7.16	90.00	30.00
16	0.984	12.187	-	-	25.00	10.00
17	0.995	13.995	-	-	11.00	3.00
18	0.973	11.781	0.00	28.43	60.00	34.00
19	0.962	11.315	0.00	-14.27	45.00	25.00
20	0.957	12.191	-	-	18.00	3.00
21	0.958	13.778	-	-	14.00	8.00
22	0.969	16.332	-	-	10.00	5.00
23	0.999	21.249	-	-	7.00	3.00
24	0.992	21.114	0.00	-14.91	13.00	0.00
25	1.050	28.180	220.00	50.04	-	-
26	1.015	29.960	314.00	10.12	-	-
27	0.968	15.604	0.00	3.98	71.00	13.00
28	0.962	13.879	-	-	17.00	7.00
29	0.963	12.885	-	-	24.00	4.00
30	0.985	19.034	-	-	-	-
31	0.967	13.002	7.00	32.59	43.00	27.00
32	0.963	15.061	0.00	-16.28	59.00	23.00
33	0.971	10.854	-	-	23.00	9.00
34	0.984	11.511	0.00	-20.83	59.00	26.00
35	0.980	11.055	-	-	33.00	9.00
36	0.980	11.056	0.00	7.73	31.00	17.00
37	0.991	11.967	-	-	-	-
38	0.961	17.108	-	-	-	-
39	0.970	8.577	-	-	27.00	11.00
40	0.970	7.496	0.00	28.45	66.00	23.00
41	0.967	7.052	-	-	37.00	10.00
42	0.985	8.653	0.00	41.03	96.00	23.00
43	0.977	11.460	-	-	18.00	7.00
44	0.984	13.943	-	-	16.00	8.00
45	0.986	15.773	-	-	53.00	22.00
46	1.005	18.576	19.00	-5.03	28.00	10.00
47	1.017	20.799	-	-	34.00	0.00
48	1.021	20.019	-	-	20.00	11.00
49	1.025	21.022	204.00	115.85	87.00	30.00
50	1.001	18.983	-	-	17.00	4.00
51	0.967	16.364	-	-	17.00	8.00
52	0.957	15.411	-	-	18.00	5.00
53	0.946	14.436	-	-	23.00	11.00
54	0.955	15.348	48.00	3.90	113.00	32.00
55	0.952	15.058	0.00	4.66	63.00	22.00
56	0.954	15.245	0.00	-2.29	84.00	18.00
57	0.971	16.449	-	-	12.00	3.00
58	0.959	15.592	-	-	12.00	3.00
59	0.985	19.448	155.00	76.83	277.00	113.00

60	0.993	23.230	-	-	78.00	3.00
61	0.995	24.121	160.00	-40.39	-	-
62	0.998	23.505	0.00	1.26	77.00	14.00
63	0.969	22.827	-	-	-	-
64	0.984	24.593	-	-	-	-
65	1.005	27.719	391.00	81.51	-	-
66	1.050	27.559	392.00	-1.96	39.00	18.00
67	1.020	24.919	-	-	28.00	7.00
68	1.003	27.598	-	-	-	-
69	1.035	30.000	513.86	-82.42	-	-
70	0.984	22.618	0.00	9.67	66.00	20.00
71	0.987	22.207	-	-	-	-
72	0.980	21.109	0.00	-11.13	12.00	0.00
73	0.991	21.995	0.00	9.65	6.00	0.00
74	0.958	21.669	0.00	-5.63	68.00	27.00
75	0.967	22.930	-	-	47.00	11.00
76	0.943	21.799	0.00	5.27	68.00	36.00
77	1.006	26.751	0.00	12.17	61.00	28.00
78	1.003	26.447	-	-	71.00	26.00
79	1.009	26.745	-	-	39.00	32.00
80	1.040	28.990	477.00	105.47	130.00	26.00
81	0.997	28.145	-	-	-	-
82	0.989	27.272	-	-	54.00	27.00
83	0.984	28.464	-	-	20.00	10.00
84	0.980	31.000	-	-	11.00	7.00
85	0.985	32.556	0.00	-5.61	24.00	15.00
86	0.987	31.186	-	-	21.00	10.00
87	1.015	31.445	4.00	11.02	-	-
88	0.987	35.690	-	-	48.00	10.00
89	1.005	39.748	607.00	-5.90	-	-
90	0.985	33.338	0.00	59.31	163.00	42.00
91	0.980	33.351	0.00	-13.09	10.00	0.00
92	0.990	33.881	0.00	-13.96	65.00	10.00
93	0.985	30.849	-	-	12.00	7.00
94	0.990	28.682	-	-	30.00	16.00
95	0.980	27.710	-	-	42.00	31.00
96	0.992	27.543	-	-	38.00	15.00
97	1.011	27.916	-	-	15.00	9.00
98	1.024	27.433	-	-	34.00	8.00
99	1.010	27.067	0.00	-17.54	42.00	0.00
100	1.017	28.059	252.00	95.55	37.00	18.00
101	0.991	29.647	-	-	22.00	15.00
102	0.989	32.365	-	-	5.00	3.00
103	1.010	24.318	40.00	75.42	23.00	16.00
104	0.971	21.748	0.00	2.39	38.00	25.00
105	0.965	20.644	0.00	-18.33	31.00	26.00
106	0.961	20.383	-	-	43.00	16.00
107	0.952	17.583	0.00	6.56	50.00	12.00
108	0.966	19.443	-	-	2.00	1.00
109	0.967	18.991	-	-	8.00	3.00
110	0.973	18.144	0.00	0.28	39.00	30.00
111	0.980	19.789	36.00	-1.84	-	-
112	0.975	15.045	0.00	41.51	68.00	13.00
113	0.993	13.993	0.00	6.75	6.00	0.00
114	0.960	14.726	-	-	8.00	3.00
115	0.960	14.718	-	-	22.00	7.00
116	1.005	27.163	0.00	51.32	184.00	0.00
117	0.974	10.948	-	-	20.00	8.00
118	0.949	21.942	-	-	33.00	15.00

Table A.I.4 Branch Data of IEEE-118 bus system

Lines Nos.	From bus	To bus	r	x	b	Tap
1	1	2	0.0303	0.0999	0.0254	1
2	1	3	0.0129	0.0424	0.01082	1
3	4	5	0.00176	0.00798	0.0021	1
4	3	5	0.0241	0.108	0.0284	1
5	5	6	0.0119	0.054	0.01426	1
6	6	7	0.00459	0.0208	0.0055	1
7	8	9	0.00244	0.0305	1.162	1
8	8	5	0	0.0267	0	1
9	9	10	0.00258	0.0322	1.23	1
10	4	11	0.0209	0.0688	0.01748	1
11	5	11	0.0203	0.0682	0.01738	1
12	11	12	0.00595	0.0196	0.00502	1
13	2	12	0.0187	0.0616	0.01572	1
14	3	12	0.0484	0.16	0.0406	1
15	7	12	0.00862	0.034	0.00874	1
16	11	13	0.02225	0.0731	0.01876	1
17	12	14	0.0215	0.0707	0.01816	1
18	13	15	0.0744	0.2444	0.06268	1
19	14	15	0.0595	0.195	0.0502	1
20	12	16	0.0212	0.0834	0.0214	1
21	15	17	0.0132	0.0437	0.0444	1
22	16	17	0.0454	0.1801	0.0466	1
23	17	18	0.0123	0.0505	0.01298	1
24	18	19	0.01119	0.0493	0.01142	1
25	19	20	0.0252	0.117	0.0298	1
26	15	19	0.012	0.0394	0.0101	1
27	20	21	0.0183	0.0849	0.0216	1
28	21	22	0.0209	0.097	0.0246	1
29	22	23	0.0342	0.159	0.0404	1
30	23	24	0.01	0.05	0.05	1
31	23	25	0.02	0.08	0.09	1
32	26	25	0.00	0.04	0	1
33	25	27	0.0318	0.163	0.1764	1
34	27	28	0.01913	0.0855	0.0216	1
35	28	29	0.0237	0.0943	0.0238	1
36	30	17	0	0.0388	0	1
37	8	30	0.00431	0.0504	0.514	1
38	26	30	0.00799	0.086	0.908	1
39	17	31	0.0474	0.1563	0.0399	1
40	29	31	0.0108	0.0331	0.0083	1
41	23	32	0.0317	0.1153	0.1173	1
42	31	32	0.0298	0.0985	0.0251	1
43	27	32	0.0229	0.0755	0.01926	1
44	15	33	0.038	0.1244	0.03194	1
45	19	34	0.0752	0.247	0.0632	1
46	35	36	0.00224	0.0102	0.00268	1
47	35	37	0.011	0.0497	0.01318	1
48	33	37	0.0415	0.142	0.0366	1
49	34	36	0.00871	0.0268	0.00568	1
50	34	37	0.00256	0.0094	0.00984	1
51	38	37	0	0.0375	0	1
52	37	39	0.0321	0.106	0.027	1
53	37	40	0.0593	0.168	0.042	1
54	30	38	0.00464	0.054	0.422	1
55	39	40	0.0184	0.0605	0.01552	1
56	40	41	0.0145	0.0487	0.01222	1
57	40	42	0.0555	0.183	0.0466	1
58	41	42	0.041	0.135	0.0344	1
59	43	44	0.0608	0.2454	0.06068	1
60	34	43	0.0413	0.1681	0.04226	1
61	44	45	0.0224	0.0901	0.0224	1

62	45	46	0.04	0.1356	0.0332	1
63	46	47	0.038	0.127	0.0316	1
64	46	48	0.0601	0.189	0.0472	1
65	47	49	0.0191	0.0625	0.01604	1
66	42	49	0.0715	0.323	0.086	1
67	42	49	0.0715	0.323	0.086	1
68	45	49	0.0684	0.186	0.0444	1
69	48	49	0.0179	0.0505	0.01258	1
70	49	50	0.0267	0.0752	0.01874	1
71	49	51	0.0486	0.137	0.0342	1
72	51	52	0.0203	0.0588	0.01396	1
73	52	53	0.0405	0.1635	0.04058	1
74	53	54	0.0263	0.122	0.031	1
75	49	54	0.073	0.289	0.0738	1
76	49	54	0.0869	0.291	0.073	1
77	54	55	0.0169	0.0707	0.0202	1
78	54	56	0.00275	0.00955	0.00732	1
79	55	56	0.00488	0.0151	0.00374	1
80	56	57	0.0343	0.0966	0.0242	1
81	50	57	0.0474	0.134	0.0332	1
82	56	58	0.0343	0.0966	0.0242	1
83	51	58	0.0255	0.0719	0.01788	1
84	54	59	0.0503	0.2293	0.0598	1
85	56	59	0.0825	0.251	0.0569	1
86	56	59	0.0803	0.239	0.0536	1
87	55	59	0.04739	0.2158	0.05646	1
88	59	60	0.0317	0.145	0.0376	1
89	59	61	0.0328	0.15	0.0388	1
90	60	61	0.00264	0.0135	0.01456	1
91	60	62	0.0123	0.0561	0.01468	1
92	61	62	0.00824	0.0376	0.0098	1
93	63	59	0	0.0386	0	1
94	63	64	0.00172	0.02	0.216	1
95	64	61	0	0.0268	0	1
96	38	65	0.00901	0.0986	1.046	1
97	64	65	0.00269	0.0302	0.38	1
98	49	66	0.018	0.0919	0.0248	1
99	49	66	0.018	0.0919	0.0248	1
100	62	66	0.0482	0.218	0.0578	1
101	62	67	0.0258	0.117	0.031	1
102	65	66	0	0.037	0	1
103	66	67	0.0224	0.1015	0.02682	1
104	65	68	0.00138	0.016	0.638	1
105	47	69	0.0844	0.2778	0.07092	1
106	49	69	0.0985	0.324	0.0828	1
107	68	69	0	0.037	0	1
108	69	70	0.03	0.127	0.122	1
109	24	70	0.00221	0.4115	0.10198	1
110	70	71	0.00882	0.0355	0.00878	1
111	24	72	0.0488	0.196	0.0488	1
112	71	72	0.0446	0.18	0.04444	1
113	71	73	0.00866	0.0454	0.01178	1
114	70	74	0.0401	0.1323	0.03368	1
115	70	75	0.0428	0.141	0.036	1
116	69	75	0.0405	0.122	0.124	1
117	74	75	0.0123	0.0406	0.01034	1
118	76	77	0.0444	0.148	0.0368	1
119	69	77	0.0309	0.101	0.1038	1
120	75	77	0.0601	0.1999	0.04978	1
121	77	78	0.00376	0.0124	0.01264	1
122	78	79	0.00546	0.0244	0.00648	1
123	77	80	0.017	0.0485	0.0472	1
124	77	80	0.0294	0.105	0.0228	1

125	79	80	0.0156	0.0704	0.0187	1
126	68	81	0.00175	0.0202	0.808	1
127	81	80	0	0.037	0	1
128	77	82	0.0298	0.0853	0.08174	1
129	82	83	0.0112	0.03665	0.03796	1
130	83	84	0.0625	0.132	0.0258	1
131	83	85	0.043	0.148	0.0348	1
132	84	85	0.0302	0.0641	0.01234	1
133	85	86	0.035	0.123	0.0276	1
134	86	87	0.02828	0.2074	0.0445	1
135	85	88	0.02	0.102	0.0276	1
136	85	89	0.0239	0.173	0.047	1
137	88	89	0.0139	0.0712	0.01934	1
138	89	90	0.0518	0.188	0.0528	1
139	89	90	0.0238	0.0997	0.106	1
140	90	91	0.0254	0.0836	0.0214	1
141	89	92	0.0099	0.0505	0.0548	1
142	89	92	0.0393	0.1581	0.0414	1
143	91	92	0.0387	0.1272	0.03268	1
144	92	93	0.0258	0.0848	0.0218	1
145	92	94	0.0481	0.158	0.0406	1
146	93	94	0.0223	0.0732	0.01876	1
147	94	95	0.0132	0.0434	0.0111	1
148	80	96	0.0356	0.182	0.0494	1
149	82	96	0.0162	0.053	0.0544	1
150	94	96	0.0269	0.0869	0.023	1
151	80	97	0.0183	0.0934	0.0254	1
152	80	98	0.0238	0.108	0.0286	1
153	80	99	0.0454	0.206	0.0546	1
154	92	100	0.0648	0.295	0.0472	1
155	94	100	0.0178	0.058	0.0604	1
156	95	96	0.0171	0.0547	0.01474	1
157	96	97	0.0173	0.0885	0.024	1
158	98	100	0.0397	0.179	0.0476	1
159	99	100	0.018	0.0813	0.0216	1
160	100	101	0.0277	0.1262	0.0328	1
161	92	102	0.0123	0.0559	0.01464	1
162	101	102	0.0246	0.112	0.0294	1
163	100	103	0.016	0.0525	0.0536	1
164	100	104	0.0451	0.204	0.0541	1
165	103	104	0.0466	0.1584	0.0407	1
166	103	105	0.0535	0.1625	0.0408	1
167	100	106	0.0605	0.229	0.062	1
168	104	105	0.00994	0.0378	0.00986	1
169	105	106	0.014	0.0547	0.01434	1
170	105	107	0.053	0.183	0.0472	1
171	105	108	0.0261	0.0703	0.01844	1
172	106	107	0.053	0.183	0.0472	1
173	108	109	0.0105	0.0288	0.0076	1
174	103	110	0.03906	0.1813	0.0461	1
175	109	110	0.0278	0.0762	0.0202	1
176	110	111	0.022	0.0755	0.02	1
177	110	112	0.0247	0.064	0.062	1
178	17	113	0.00913	0.0301	0.00768	1
179	32	113	0.0615	0.203	0.0518	1
180	32	114	0.0135	0.0612	0.01628	1
181	27	115	0.0164	0.0741	0.01972	1
182	114	115	0.0023	0.0104	0.00276	1
183	68	116	0.00034	0.00405	0.164	1
184	12	117	0.0329	0.14	0.0358	1
185	75	118	0.0145	0.0481	0.01198	1
186	76	118	0.0164	0.0544	0.01356	1

Appendix II

RAWM Indices of Test Systems

Table A.II.1 RAWM indices of modified IEEE-30 bus system in DOPF

Lines	From bus	To bus	T1	T2	T3
1	1	2	-2.02	5.75	-2.73
2	1	3	-2.02	5.75	-2.73
3	2	4	-1.90	5.48	-2.57
4	3	4	-2.02	5.76	-2.73
5	2	5	-1.27	-1.05	3.32
6	2	6	9.22	-17.77	9.54
7	4	6	0.94	0.36	-0.30
8	5	7	-1.26	-1.04	3.30
9	6	7	0.13	0.48	0.39
10	6	8	0.05	0.88	0.07
11	6	9	-0.36	1.84	-0.48
12	6	10	-0.36	1.84	-0.48
13	9	11	0.00	0.00	0.00
14	9	10	-0.36	1.84	-0.48
15	4	12	0.03	0.83	0.13
16	12	13	0.50	0.68	-0.18
17	12	14	1.22	-0.53	0.31
18	12	15	1.24	-0.58	0.34
19	12	16	0.03	-0.04	1.01
20	14	15	1.22	-0.53	0.31
21	16	17	0.03	-0.04	1.01
22	15	18	-0.07	-0.77	1.84
23	18	19	-0.07	-0.77	1.84
24	19	20	-0.07	-0.77	1.83
25	10	20	-0.07	-0.77	1.83
26	10	17	1.35	0.23	-0.58
27	10	21	0.95	-0.09	0.14
28	10	22	0.95	-0.09	0.14
29	21	22	0.95	-0.09	0.14
30	15	23	3.69	-5.99	3.30
31	22	24	0.04	0.87	0.10
32	23	24	3.66	-5.95	3.29
33	24	25	-0.52	1.81	-0.30
34	25	26	1.00	0.00	0.00
35	25	27	1.48	0.94	-1.42
36	28	27	0.05	0.88	0.07
37	27	29	5.33	-0.18	-4.16
38	27	30	-0.04	1.00	0.04
39	29	30	0.00	0.00	0.00
40	8	28	0.05	0.88	0.07
41	6	28	0.05	0.88	0.07

Table A.II.2 RAWM indices of modified IEEE-118 bus system in DOPF

Line nos.	From bus	To bus	T1	T2	T3	T4	T5	T6
1	1	2	0.0038	0.9920	0.0417	-0.0220	-0.0315	0.0159
2	1	3	0.0038	0.9920	0.0417	-0.0220	-0.0315	0.0159
3	4	5	-0.0071	1.0072	-0.0027	0.0016	0.0021	-0.0011
4	3	5	0.0005	0.0906	-0.0126	0.9547	0.0489	-0.0822
5	5	6	0.0007	0.9996	0.0031	-0.0021	-0.0028	0.0015
6	6	7	0.0037	0.9572	0.1147	-0.0425	-0.0644	0.0312
7	8	9	-0.0123	1.0066	-0.0155	0.0093	0.0178	-0.0059
8	8	5	-0.0014	1.0014	0.0003	-0.0002	-0.0002	0.0001
9	9	10	-0.0123	1.0066	-0.0155	0.0093	0.0178	-0.0059
10	4	11	0.0390	0.9600	-0.0096	0.0066	0.0087	-0.0046
11	5	11	0.0193	0.9749	-0.0175	0.0145	0.0191	-0.0102
12	11	12	0.0238	0.9714	-0.0346	0.0252	0.0317	-0.0175
13	2	12	0.0026	0.9979	0.0155	-0.0096	-0.0133	0.0069
14	3	12	-0.0008	1.0005	-0.0022	0.0015	0.0020	-0.0011
15	7	12	0.0038	0.9574	0.1145	-0.0424	-0.0644	0.0312
16	11	13	0.0407	0.9586	-0.0039	0.0028	0.0038	-0.0020
17	12	14	-0.0192	0.9790	-0.0481	0.0591	0.0699	-0.0406
18	13	15	0.0407	0.9586	-0.0039	0.0028	0.0038	-0.0020
19	14	15	-0.0032	1.0034	0.0010	-0.0007	-0.0009	0.0005
20	12	16	-0.0328	1.0328	0.0020	-0.0012	-0.0017	0.0009
21	15	17	0.1620	0.8127	-0.0154	0.0256	0.0336	-0.0185
22	16	17	-0.0332	1.0331	0.0020	-0.0012	-0.0017	0.0009
23	17	18	-0.1607	1.1614	0.0100	-0.0065	-0.0089	0.0047
24	18	19	-0.1599	1.1606	0.0100	-0.0065	-0.0089	0.0047
25	19	20	0.9322	0.0678	0.0014	-0.0008	-0.0012	0.0006
26	15	19	1.1381	-0.1349	-0.0072	0.0024	0.0033	-0.0017
27	20	21	1.3080	-0.3082	-0.0049	0.0031	0.0042	-0.0023
28	21	22	1.3075	-0.3078	-0.0049	0.0031	0.0042	-0.0023
29	22	23	1.3071	-0.3074	-0.0049	0.0031	0.0042	-0.0023
30	23	24	0.0319	0.9686	0.0074	-0.0109	-0.0062	0.0091
31	23	25	-0.1959	1.1980	0.0177	-0.0103	-0.0167	0.0073
32	26	25	-0.1414	1.1440	0.0128	-0.0081	-0.0130	0.0057
33	25	27	0.1640	0.8004	-0.0156	0.0380	0.0418	-0.0286
34	27	28	-54.0724	52.9784	4.1903	-1.0055	-1.7947	0.7039
35	28	29	-51.6682	50.6641	4.0092	-0.9617	-1.7166	0.6732
36	30	17	0.0573	0.9385	-0.0051	0.0054	0.0077	-0.0039
37	8	30	-0.0014	1.0014	0.0003	-0.0002	-0.0002	0.0001
38	26	30	-0.1414	1.1440	0.0128	-0.0081	-0.0130	0.0057
39	17	31	-1.1800	2.1511	0.0975	-0.0338	-0.0586	0.0238
40	29	31	-46.9061	46.0801	3.6503	-0.8749	-1.5619	0.6125
41	23	32	-0.4783	1.4739	0.0410	-0.0185	-0.0312	0.0131
42	31	32	-0.8162	1.8011	0.0676	-0.0262	-0.0448	0.0184
43	27	32	-0.0142	1.0149	0.0013	-0.0011	-0.0017	0.0008
44	15	33	-0.0038	1.0106	-0.0013	-0.0028	-0.0047	0.0021
45	19	34	0.0110	0.9925	0.0010	-0.0020	-0.0039	0.0015
46	35	36	-0.0178	1.0388	-0.0054	-0.0098	-0.0129	0.0071
47	35	37	-0.0178	1.0388	-0.0054	-0.0098	-0.0129	0.0071
48	33	37	-0.0264	1.0667	-0.0059	-0.0234	-0.0277	0.0166
49	34	36	-0.0178	1.0388	-0.0054	-0.0098	-0.0129	0.0071
50	34	37	-0.0177	1.0388	-0.0054	-0.0097	-0.0129	0.0071
51	38	37	-0.0058	1.0110	-0.0032	-0.0016	-0.0017	0.0012
52	37	39	-0.0058	1.0272	-0.0179	-0.0111	0.0022	0.0054
53	37	40	-0.0058	1.0285	-0.0191	-0.0112	0.0022	0.0055
54	30	38	-0.0135	1.0285	-0.0108	-0.0030	-0.0032	0.0021
55	39	40	-0.0058	1.0268	-0.0176	-0.0111	0.0022	0.0054
56	40	41	-0.0058	1.0271	-0.0178	-0.0111	0.0022	0.0054
57	40	42	-0.0058	1.0271	-0.0179	-0.0111	0.0022	0.0054
58	41	42	-0.0059	1.0276	-0.0182	-0.0112	0.0022	0.0055
59	43	44	-0.0080	1.0153	-0.0078	-0.0103	0.0048	0.0059
60	34	43	-0.0079	1.0150	-0.0077	-0.0101	0.0048	0.0059
61	44	45	-0.0081	1.0157	-0.0080	-0.0105	0.0048	0.0060

62	45	46	-0.0034	0.9989	-0.0017	-0.0051	0.0078	0.0035
63	46	47	-0.0557	1.0642	0.0063	-0.0299	0.0040	0.0110
64	46	48	-0.0109	0.8529	0.1603	-0.0121	0.0036	0.0062
65	47	49	-0.0165	1.0021	0.0189	-0.0166	0.0041	0.0080
66	42	49	-0.0060	1.0292	-0.0194	-0.0116	0.0023	0.0056
67	42	49	-0.0060	1.0292	-0.0194	-0.0116	0.0023	0.0056
68	45	49	-0.0103	1.0298	-0.0184	-0.0126	0.0046	0.0068
69	48	49	-0.0109	0.8525	0.1607	-0.0121	0.0036	0.0062
70	49	50	-0.0141	0.9886	0.0207	-0.0060	0.0027	0.0081
71	49	51	-0.0141	0.9888	0.0206	-0.0061	0.0027	0.0081
72	51	52	-0.0142	0.9896	0.0204	-0.0068	0.0028	0.0082
73	52	53	-0.0142	0.9896	0.0204	-0.0068	0.0028	0.0082
74	53	54	-0.0142	0.9896	0.0204	-0.0068	0.0028	0.0082
75	49	54	-0.0141	0.9891	0.0205	-0.0064	0.0027	0.0081
76	49	54	-0.0141	0.9892	0.0205	-0.0064	0.0027	0.0081
77	54	55	-0.0146	1.0025	0.0190	-0.0190	0.0036	0.0085
78	54	56	-0.0145	0.9980	0.0192	-0.0146	0.0034	0.0085
79	55	56	-0.0140	0.9440	0.0169	0.0406	0.0043	0.0082
80	56	57	-0.0141	0.9886	0.0207	-0.0060	0.0027	0.0081
81	50	57	-0.0141	0.9886	0.0207	-0.0060	0.0027	0.0081
82	56	58	-0.0141	0.9883	0.0208	-0.0058	0.0026	0.0081
83	51	58	-0.0141	0.9883	0.0208	-0.0058	0.0026	0.0081
84	54	59	-0.0151	1.0244	0.0190	-0.0411	0.0040	0.0088
85	56	59	-0.0152	1.0340	0.0191	-0.0509	0.0041	0.0089
86	56	59	-0.0152	1.0337	0.0191	-0.0506	0.0041	0.0089
87	55	59	-0.0152	1.0352	0.0191	-0.0521	0.0041	0.0089
88	59	60	-0.0141	0.9665	0.0183	0.0157	0.0053	0.0083
89	59	61	-0.0141	0.9598	0.0181	0.0231	0.0048	0.0083
90	60	61	-0.0112	0.9284	0.0772	0.0003	-0.0003	0.0057
91	60	62	-0.0130	0.9023	0.0178	0.0035	0.0819	0.0076
92	61	62	-0.0147	1.0226	0.0204	0.0034	-0.0403	0.0085
93	63	59	-0.0147	0.9961	0.0181	-0.0112	0.0032	0.0086
94	63	64	-0.0147	0.9961	0.0181	-0.0112	0.0032	0.0086
95	64	61	-0.0137	0.9836	0.0231	0.0011	-0.0017	0.0077
96	38	65	-0.9094	1.9065	0.0275	-0.0155	-0.0172	0.0082
97	64	65	-0.0151	0.9903	0.0162	-0.0017	0.0013	0.0090
98	49	66	-0.0172	0.9952	0.0121	-0.0026	0.0016	0.0107
99	49	66	-0.0172	0.9952	0.0121	-0.0026	0.0016	0.0107
100	62	66	-0.0145	0.9918	0.0187	0.0022	-0.0067	0.0085
101	62	67	-0.0145	0.9969	0.0193	0.0028	-0.0130	0.0084
102	65	66	-0.0147	0.9738	0.0165	0.0096	0.0062	0.0086
103	66	67	-0.0146	1.0064	0.0198	0.0031	-0.0232	0.0084
104	65	68	-0.0182	1.0009	0.0163	-0.0106	0.0040	0.0075
105	47	69	-0.0182	1.0086	0.0149	-0.0177	0.0041	0.0083
106	49	69	-0.0179	1.0076	0.0154	-0.0175	0.0041	0.0082
107	68	69	-0.0302	1.0119	0.0133	-0.0090	0.0067	0.0074
108	69	70	-0.1775	1.1023	0.0106	-0.0128	0.0678	0.0094
109	24	70	0.0306	0.9699	0.0072	-0.0108	-0.0060	0.0091
110	70	71	0.0306	0.9699	0.0072	-0.0108	-0.0060	0.0091
111	24	72	0.0306	0.9699	0.0072	-0.0108	-0.0060	0.0091
112	71	72	0.0306	0.9699	0.0072	-0.0108	-0.0060	0.0091
113	71	73	0.0311	0.9693	0.0072	-0.0108	-0.0060	0.0092
114	70	74	0.0049	0.9827	0.0036	-0.0099	-0.0010	0.0196
115	70	75	0.0050	0.9826	0.0036	-0.0099	-0.0010	0.0197
116	69	75	-0.0252	1.0104	0.0134	-0.0124	0.0058	0.0081
117	74	75	0.0056	0.9813	0.0039	-0.0103	-0.0011	0.0207
118	76	77	-0.0086	0.9577	0.0550	-0.0123	0.0019	0.0063
119	69	77	-0.0146	0.9973	0.0191	-0.0124	0.0032	0.0073
120	75	77	-0.0087	0.9582	0.0545	-0.0123	0.0019	0.0063
121	77	78	-0.0876	0.9820	0.0103	-0.0089	0.0872	0.0170
122	78	79	-0.0876	0.9814	0.0103	-0.0089	0.0877	0.0171
123	77	80	-0.0601	0.9933	0.0109	-0.0094	0.0409	0.0245
124	77	80	-0.0751	0.9924	0.0106	-0.0092	0.0618	0.0195

125	79	80	-0.0868	0.9825	0.0103	-0.0089	0.0857	0.0172
126	68	81	-0.0158	0.9982	0.0179	-0.0114	0.0035	0.0076
127	81	80	-0.0158	0.9982	0.0179	-0.0114	0.0035	0.0076
128	77	82	-0.0142	0.9953	0.0197	-0.0118	0.0032	0.0078
129	82	83	-0.0144	0.9950	0.0195	-0.0117	0.0033	0.0084
130	83	84	-0.0144	0.9949	0.0194	-0.0118	0.0033	0.0086
131	83	85	-0.0144	0.9951	0.0195	-0.0117	0.0032	0.0083
132	84	85	-0.0144	0.9950	0.0194	-0.0118	0.0033	0.0085
133	85	86	-0.0259	0.9721	0.0437	-0.0142	-0.0239	0.0481
134	86	87	-0.0273	0.9664	0.0655	0.0109	0.0162	-0.0317
135	85	88	-0.0145	0.9949	0.0194	-0.0116	0.0033	0.0085
136	85	89	-0.0145	0.9950	0.0194	-0.0116	0.0033	0.0084
137	88	89	-0.0145	0.9949	0.0194	-0.0116	0.0033	0.0085
138	89	90	-0.0145	0.9952	0.0194	-0.0116	0.0032	0.0082
139	89	90	-0.0145	0.9945	0.0194	-0.0117	0.0033	0.0090
140	90	91	-0.0145	0.9944	0.0194	-0.0117	0.0033	0.0090
141	89	92	-0.0145	0.9951	0.0194	-0.0116	0.0033	0.0084
142	89	92	-0.0145	0.9948	0.0194	-0.0117	0.0033	0.0086
143	91	92	-0.0145	0.9943	0.0194	-0.0117	0.0033	0.0092
144	92	93	-0.0145	0.9951	0.0194	-0.0117	0.0033	0.0084
145	92	94	-0.0145	0.9951	0.0194	-0.0117	0.0033	0.0084
146	93	94	-0.0145	0.9950	0.0194	-0.0117	0.0033	0.0084
147	94	95	-0.0144	0.9974	0.0196	-0.0118	0.0030	0.0061
148	80	96	-0.0146	0.9963	0.0192	-0.0117	0.0032	0.0076
149	82	96	-0.0149	0.9937	0.0188	-0.0115	0.0035	0.0104
150	94	96	-0.0144	0.9974	0.0196	-0.0118	0.0030	0.0061
151	80	97	-0.0146	0.9963	0.0192	-0.0117	0.0032	0.0076
152	80	98	-0.0146	0.9973	0.0193	-0.0117	0.0031	0.0065
153	80	99	-0.0146	0.9973	0.0193	-0.0117	0.0031	0.0065
154	92	100	-0.0145	0.9946	0.0193	-0.0116	0.0033	0.0088
155	94	100	-0.0140	0.9515	0.0183	-0.0111	0.0038	0.0515
156	95	96	-0.0144	0.9975	0.0196	-0.0118	0.0030	0.0061
157	96	97	-0.0146	0.9962	0.0192	-0.0116	0.0032	0.0076
158	98	100	-0.0146	0.9973	0.0193	-0.0117	0.0031	0.0065
159	99	100	-0.0146	0.9972	0.0193	-0.0117	0.0031	0.0066
160	100	101	-0.0145	0.9945	0.0193	-0.0116	0.0033	0.0089
161	92	102	-0.0145	0.9946	0.0193	-0.0116	0.0033	0.0088
162	101	102	-0.0145	0.9945	0.0193	-0.0116	0.0033	0.0089
163	100	103	-0.0150	1.0327	0.0201	-0.0123	-0.0236	-0.0019
164	100	104	-0.0149	1.0259	0.0200	-0.0121	-0.0172	-0.0018
165	103	104	-0.0150	1.0329	0.0201	-0.0123	-0.0237	-0.0019
166	103	105	-0.0151	1.0357	0.0202	-0.0124	-0.0265	-0.0019
167	100	106	-0.0148	1.0242	0.0200	-0.0120	-0.0157	-0.0017
168	104	105	-0.0149	1.0275	0.0200	-0.0121	-0.0187	-0.0018
169	105	106	-0.0149	1.0254	0.0200	-0.0120	-0.0168	-0.0017
170	105	107	-0.0149	1.0255	0.0200	-0.0120	-0.0169	-0.0017
171	105	108	-0.0145	1.0123	0.0200	-0.0107	-0.0059	-0.0013
172	106	107	-0.0149	1.0255	0.0200	-0.0120	-0.0169	-0.0017
173	108	109	-0.0145	1.0131	0.0200	-0.0108	-0.0065	-0.0013
174	103	110	-0.0148	1.0234	0.0200	-0.0119	-0.0149	-0.0017
175	109	110	-0.0145	1.0135	0.0200	-0.0109	-0.0067	-0.0013
176	110	111	-0.0143	0.9737	0.0188	-0.0125	0.0367	-0.0024
177	110	112	-0.0143	0.9737	0.0188	-0.0125	0.0367	-0.0024
178	17	113	-1.0412	2.0177	0.0862	-0.0310	-0.0535	0.0218
179	32	113	-1.0508	2.0273	0.0863	-0.0311	-0.0536	0.0219
180	32	114	-0.0126	1.0132	0.0012	-0.0010	-0.0015	0.0007
181	27	115	-0.0127	1.0133	0.0012	-0.0010	-0.0015	0.0007
182	114	115	-0.0127	1.0133	0.0012	-0.0010	-0.0015	0.0007
183	68	116	-0.0194	1.3077	0.0251	-0.3620	0.0073	0.0414
184	12	117	0.0056	0.9961	0.0174	-0.0112	-0.0159	0.0080
185	75	118	-0.0087	0.9583	0.0545	-0.0123	0.0019	0.0063
186	76	118	-0.0086	0.9577	0.0550	-0.0123	0.0019	0.0063

Appendix III

Power Flows in Lines of Test Systems

Table A.III.1 Power flows in lines of modified IEEE-30 bus system using COPF (in MW)

Lines	From bus	To bus	Max. Transfer Limit	Case 1 Before Congestion Management	Case 2 After Congestion Management		
				Initial flows	IP	PSO	IP-PSO
1	1	2	130	6.87	26.73	25.04	24.91
2	1	3	130	12.88	23.65	23.22	22.98
3	2	4	65	3.76	17.64	17.42	17.15
4	3	4	130	-5.32	7.06	5.51	5.26
5	**2**	**5**	**10**	**16.30**	**9.64**	**9.98**	**8.21**
6	2	6	65	2.33	16.57	16.31	15.92
7	4	6	90	-5.38	-0.91	-1.16	-1.77
8	5	7	70	6.28	9.60	9.94	10.17
9	**6**	**7**	**10**	**17.63**	**7.59**	**6.49**	**4.27**
10	6	8	32	-1.42	0.28	0.31	-0.02
11	6	9	65	1.03	8.69	7.05	6.35
12	6	10	32	0.59	4.97	4.03	3.63
13	9	11	65	0.00	0.00	0.00	0.00
14	9	10	65	1.03	8.69	7.05	6.35
15	**4**	**12**	**30**	**-33.80**	**25.06**	**23.80**	**27.35**
16	12	13	65	-38.57	-14.26	-15.25	-15.93
17	12	14	32	2.87	2.68	2.71	2.91
18	12	15	32	10.56	10.60	10.67	11.48
19	12	16	32	6.94	1.53	1.08	0.57
20	14	15	16	2.86	2.68	2.70	2.91
21	16	17	16	6.91	1.53	1.08	0.57
22	15	18	16	1.39	-2.40	-2.68	-3.02
23	18	19	16	1.39	-2.41	-2.68	-3.03
24	19	20	32	1.39	-2.41	-2.69	-3.04
25	10	20	32	-1.39	2.42	2.70	3.05
26	10	17	32	4.81	8.89	8.84	7.76
27	10	21	32	-1.11	1.48	-0.28	-0.52
28	10	22	32	-0.69	0.87	-0.17	-0.31
29	21	22	32	-1.12	1.48	-0.28	-0.52
30	15	23	16	-4.74	-4.56	-5.38	-5.58
31	22	24	16	2.72	10.78	9.45	8.67
32	23	24	16	8.05	5.99	4.48	3.19
33	24	25	16	0.11	-2.93	-1.15	-1.98
34	25	26	16	14.34	10.53	11.26	10.19
35	**25**	**27**	**10**	**-14.23**	**-7.49**	**-8.41**	**-7.18**
36	28	27	65	-7.36	1.27	1.43	-0.23
37	27	29	16	0.00	0.00	0.00	0.00
38	27	30	16	0.00	0.00	0.00	0.00
39	29	30	16	0.00	0.00	0.00	0.00
40	8	28	32	-1.43	0.28	0.31	-0.03
41	6	28	32	-5.93	0.99	1.12	-0.20

Table A. III.2 Line flows in lines of modified IEEE-118 bus system using COPF (in MW)

Lines	From bus	To bus	Case 1 Before Congestion Management	Case 2 After Congestion Management		
			Initial flows	IP	PSO	IP-PSO
1	1	2	7.408567	1.787747	1.787911	2.05786
2	1	3	-7.40857	-1.78775	-1.78791	-2.05786
3	4	5	75.2369	82.23361	75.27738	77.34039
4	3	5	-23.5095	-27.9805	-27.8954	-27.4101
5	5	6	16.96001	11.94232	14.80143	13.60194
6	6	7	35.2443	28.84673	30.56998	30.12798
7	8	9	1.130568	1.130501	1.130376	1.130472
8	8	5	-15.2098	-24.4863	-11.713	-16.3674
9	9	10	0.12579	0.125783	0.125769	0.12578
10	4	11	25.83003	24.8522	27.07369	26.41666
11	5	11	18.96923	17.16166	20.22714	19.3206
12	11	12	30.1726	31.34838	26.33345	27.08603
13	2	12	-26.5922	-22.9975	-21.0925	-21.6309
14	3	12	-3.73637	-7.30933	-6.57316	-6.54259
15	7	12	5.436383	14.29784	11.96507	12.74319
16	11	13	-2.34875	1.480249	-1.27222	-0.23416
17	12	14	9.019757	15.30537	14.39829	14.05429
18	13	15	-2.35907	1.473326	-1.28059	-0.24153
19	14	15	-9.85715	-6.03377	-9.64109	-7.93137
20	12	16	-3.97028	-0.20676	-3.96005	-2.60246
21	15	17	7.146123	0.774068	-2.56631	-2.15108
22	16	17	-3.9909	-0.22759	-3.98137	-2.62296
23	17	18	5.245317	6.922158	6.339711	5.571188
24	18	19	5.130664	6.809095	6.227628	5.461314
25	19	20	36.08585	32.59309	28.53504	25.15794
26	15	19	23.60694	20.66758	15.69501	14.29916
27	20	21	-12.3841	-8.24019	-10.5462	-7.82404
28	21	22	-12.4314	-8.27206	-10.5842	-7.85308
29	22	23	-12.4766	-8.29962	-10.6192	-7.87781
30	23	24	-17.6024	-20.7867	-21.4581	-22.8747
31	23	25	-5.27306	-13.5877	-6.22501	-8.56999
32	26	25	10.4131	17.43728	10.5951	12.84308
33	25	27	4.863514	3.556687	4.090466	3.99018
34	27	28	-0.89299	-1.27656	-0.28332	-0.64702
35	28	29	-0.89511	-1.27894	-0.28518	-0.64901
36	30	17	9.603488	17.29771	17.42807	17.15654
37	8	30	14.07924	23.35581	10.58267	15.23696
38	26	30	-10.4131	-17.4373	-10.5951	-12.8431
39	17	31	3.032757	4.760924	1.510779	2.670454
40	29	31	-0.90268	-1.28695	-0.29231	-0.65636
41	23	32	1.497652	-5.33462	0.112609	-1.5529
42	31	32	2.027859	3.360436	1.123461	1.914299
43	27	32	0.731412	1.429897	1.22344	1.259822
44	15	33	27.15462	8.356853	7.67439	11.02857
45	19	34	-7.77188	-5.52745	-6.99181	-5.77459
46	35	36	-11.859	-22.291	-18.6536	-19.5453
47	35	37	0.149725	-19.0835	-15.7185	-16.1818
48	33	37	-28.1444	-12.2171	-15.3648	-16.5325
49	34	36	11.88959	22.35922	18.70491	19.60058
50	34	37	46.58718	-11.9198	-8.86341	-7.73132
51	38	37	-20.8581	0.566626	-2.57578	0.622034
52	37	39	1.524766	-17.7247	-17.2777	-15.81
53	37	40	-4.47756	-25.2458	-25.5839	-24.3735
54	30	38	-6.15728	-11.6259	-17.6586	-14.9881
55	39	40	-16.9125	-42.804	-44.506	-43.5689
56	40	41	4.936909	6.203719	5.922648	5.259689
57	40	42	4.909486	6.179558	5.897756	5.233207

58	**41**	**42**	4.790263	6.054076	5.773661	5.113111
59	**43**	**44**	3.393575	-3.73176	-4.05006	-4.18627
60	**34**	**43**	3.825697	-3.34693	-3.66543	-3.80225
61	**44**	**45**	2.948891	-4.11896	-4.43727	-4.57284
62	**45**	**46**	1.162279	-1.96967	-2.14594	-2.22844
63	**46**	**47**	0.50926	-1.1896	-1.3499	-1.43511
64	**46**	**48**	0.649297	-0.78307	-0.79922	-0.7966
65	**47**	**49**	0.208741	-1.84734	-1.5886	-1.40913
66	**42**	**49**	4.417268	5.674386	5.395438	4.740662
67	**42**	**49**	4.417268	5.674386	5.395438	4.740662
68	**45**	**49**	1.756242	-2.17217	-2.31451	-2.36764
69	**48**	**49**	0.640106	-0.79391	-0.81002	-0.8074
70	**49**	**50**	4.937762	4.469618	3.674595	3.978272
71	**49**	**51**	6.272153	5.685696	4.666878	5.061495
72	**51**	**52**	2.380359	2.169335	1.769303	1.932039
73	**52**	**53**	2.378615	2.167766	1.767993	1.930639
74	**53**	**54**	2.376287	2.165747	1.766513	1.928944
75	**49**	**54**	6.115876	5.578318	4.611298	4.99345
76	**49**	**54**	6.045125	5.519138	4.568541	4.945485
77	**54**	**55**	-4.49145	-4.41317	-3.92099	-4.1981
78	**54**	**56**	-25.505	-24.7804	-21.662	-23.3195
79	**55**	**56**	3.987651	4.07794	3.771023	4.002678
80	**56**	**57**	-4.90979	-4.44547	-3.65624	-3.95779
81	**50**	**57**	4.930816	4.463732	3.670183	3.973364
82	**56**	**58**	-3.8544	-3.48308	-2.8704	-3.10007
83	**51**	**58**	3.87133	3.498943	2.884488	3.114887
84	**54**	**59**	-9.35994	-9.34751	-8.44595	-9.00898
85	**56**	**59**	-6.27369	-6.2836	-5.59359	-6.03146
86	**56**	**59**	-6.4982	-6.5082	-5.78516	-6.24374
87	**55**	**59**	-8.48262	-8.49454	-7.69487	-8.20395
88	**59**	**60**	-8.16369	-8.85215	-8.00866	-8.53783
89	**59**	**61**	-6.78879	-7.29886	-6.50669	-7.00343
90	**60**	**61**	12.37728	14.04351	13.77714	13.94681
91	**60**	**62**	-20.8863	-23.2447	-22.13	-22.8326
92	**61**	**62**	-35.3813	-39.4854	-37.7276	-38.836
93	**63**	**59**	16.07954	14.90404	13.40235	14.36112
94	**63**	**64**	-16.0795	-14.904	-13.4023	-14.3611
95	**64**	**61**	-40.6566	-45.9131	-44.6852	-45.4633
96	**38**	**65**	14.54069	-12.3636	-15.2657	-15.7879
97	**64**	**65**	24.57189	31.00447	31.27889	31.09775
98	**49**	**66**	-6.53194	-8.2927	-6.44918	-7.62831
99	**49**	**66**	-6.53194	-8.2927	-6.44918	-7.62831
100	**62**	**66**	11.04943	12.11606	12.23336	12.42412
101	**62**	**67**	25.57397	18.94449	25.1212	23.31176
102	**65**	**66**	10.91214	2.674649	6.330666	5.819531
103	**66**	**67**	7.94882	-2.75901	4.708747	2.019555
104	**65**	**68**	27.96324	15.75069	9.462024	9.268276
105	**47**	**69**	0.257411	0.610601	0.191069	-0.07382
106	**49**	**69**	0.175758	0.865798	0.458691	0.198749
107	**68**	**69**	8.090727	16.20212	14.17033	14.34846
108	**69**	**70**	-13.5393	-3.10853	-2.98912	-2.69533
109	**24**	**70**	-3.38042	-10.0475	-8.48491	-9.05836
110	**70**	**71**	2.778419	9.143778	7.647904	8.1966
111	**24**	**72**	-2.75532	-9.03218	-7.56493	-8.10368
112	**71**	**72**	2.771636	9.127859	7.634799	8.18251
113	**71**	**73**	2.93E-05	2.93E-05	2.93E-05	2.93E-05
114	**70**	**74**	13.32643	9.607832	8.934264	8.571379
115	**70**	**75**	16.18207	11.64866	10.82656	10.3836
116	**69**	**75**	10.48376	15.90639	15.00699	14.76765
117	**74**	**75**	12.58786	8.9895	8.322537	7.962322
118	**76**	**77**	-0.1702	-5.44638	-5.8199	-5.86065
119	**69**	**77**	11.5113	4.807301	2.725613	2.323768
120	**75**	**77**	-0.12826	-6.74147	-7.20833	-7.2593

121	**77**	**78**	38.6828	58.88678	55.22742	54.15699
122	**78**	**79**	-10.5924	-19.8287	-18.7928	-18.4979
123	**77**	**80**	-11.0276	-23.0776	-22.0343	-21.7446
124	**77**	**80**	-4.87813	-10.6378	-10.149	-10.0132
125	**79**	**80**	-10.6201	-19.8684	-18.8304	-18.5348
126	**68**	**81**	19.85971	-0.45578	-4.7105	-5.08237
127	**81**	**80**	**39.85187**	**27.4593**	**24.7145**	**25.0864**
128	**77**	**82**	-11.8508	-32.7686	-33.5617	-33.4098
129	**82**	**83**	-15.6128	-28.9704	-30.322	-30.3223
130	**83**	**84**	-3.71079	-9.23789	-9.78619	-9.78389
131	**83**	**85**	-12.2896	-20.204	-21.0222	-21.0255
132	**84**	**85**	-4.29011	-9.90248	-10.4666	-10.4653
133	**85**	**86**	0.013142	0.013142	0.013142	0.013142
134	**86**	**87**	0.001391	0.001391	0.001391	0.001391
135	**85**	**88**	0.039093	-6.41186	-6.26572	-6.23677
136	**85**	**89**	0.740303	-5.87865	-5.73196	-5.70243
137	**88**	**89**	0.002199	-6.4467	-6.30013	-6.27113
138	**89**	**90**	-9.6106	-16.1548	-16.5671	-16.6128
139	**89**	**90**	-19.2271	-31.7528	-32.5427	-32.6306
140	**90**	**91**	12.91301	19.95694	20.59456	20.66954
141	**89**	**92**	22.89069	27.44903	28.58815	28.73472
142	**89**	**92**	6.633068	8.07838	8.435518	8.481183
143	**91**	**92**	12.72998	19.70293	20.33242	20.40634
144	**92**	**93**	10.87337	17.03293	17.63086	17.67354
145	**92**	**94**	10.85969	17.01416	17.61158	17.65422
146	**93**	**94**	10.7469	16.85582	17.4471	17.48913
147	**94**	**95**	1.960821	14.96984	15.23432	15.12141
148	**80**	**96**	-3.72053	-13.4466	-13.986	-13.9444
149	**82**	**96**	3.565353	-4.32953	-3.79383	-3.63961
150	**94**	**96**	2.196421	16.87252	17.17084	17.04345
151	**80**	**97**	-3.72827	-13.4706	-14.011	-13.9693
152	**80**	**98**	0.361075	-13.6537	-13.9488	-13.8138
153	**80**	**99**	0.351706	-13.6465	-13.9414	-13.8065
154	**92**	**100**	9.978747	10.2426	10.6952	10.78378
155	**94**	**100**	17.13949	1.581297	2.189337	2.512587
156	**95**	**96**	1.927083	14.89759	15.1606	15.0481
157	**96**	**97**	3.788685	13.59963	14.14613	14.10412
158	**98**	**100**	0.327905	-13.7409	-14.0386	-13.9028
159	**99**	**100**	0.272631	-13.8318	-14.1315	-13.9951
160	**100**	**101**	-9.93956	-10.2034	-10.6523	-10.7401
161	**92**	**102**	10.04915	10.31451	10.77002	10.85917
162	**101**	**102**	-9.97602	-10.2408	-10.6924	-10.7807
163	**100**	**103**	15.8671	-5.21594	-5.0331	-4.71112
164	**100**	**104**	8.092631	-2.33189	-2.1289	-1.96636
165	**103**	**104**	5.779904	-0.2183	-0.02751	0.069553
166	**103**	**105**	9.115535	-0.31574	-0.04469	0.107377
167	**100**	**106**	13.38714	1.586159	2.099423	2.387087
168	**104**	**105**	13.78512	-2.61668	-2.222	-1.96198
169	**105**	**106**	14.8345	14.6439	15.75724	16.17858
170	**105**	**107**	-2.62105	-19.1886	-18.9104	-18.9165
171	**105**	**108**	10.55981	1.509466	0.784806	0.781999
172	**106**	**107**	-6.86601	-23.2215	-23.2488	-23.3693
173	**108**	**109**	-15.4707	-4.85624	-5.21643	-5.32293
174	**103**	**110**	0.871613	-4.77619	-5.05441	-4.98072
175	**109**	**110**	-15.5055	-4.86538	-5.22616	-5.33277
176	**110**	**111**	0.000219	0.00022	0.00022	0.00022
177	**110**	**112**	-14.8476	-9.79623	-10.4383	-10.4711
178	**17**	**113**	2.894274	4.611897	1.494091	2.603044
179	**32**	**113**	-2.80872	-4.51204	-1.41682	-2.51998
180	**32**	**114**	6.966537	3.865589	3.775336	4.041751
181	**27**	**115**	5.010312	3.391803	3.138421	3.365441
182	**114**	**115**	-5.00235	-3.3862	-3.13314	-3.35989
183	**68**	**116**	0.000243	0.000242	0.000243	0.000243

184	**12**	**117**	0.001052	0.001053	0.001052	0.001052
185	**75**	**118**	-0.09282	-5.38263	-5.75604	-5.79681
186	**76**	**118**	0.170196	5.446377	5.819904	5.860651

Table A. III.3 Line flows in lines of modified IEEE-30 bus system using DOPF (in MW)

Lines	From bus	To bus	Max. Transfer Limit	Case 1 Before Congestion Management	Case 3 After Congestion Management		
				Initial flows	IP	PSO	IP-PSO
1	1	2	130	10.26	15.39	15.49	13.94
2	1	3	130	16.21	15.25	15.15	14.44
3	2	4	65	11.49	10.11	10.22	9.56
4	3	4	130	-2.02	-3.68	-2.57	-4.57
5	**2**	**5**	**10**	**13.42**	**6.87**	**6.66**	**6.33**
6	2	6	65	9.29	8.29	8.48	7.24
7	4	6	90	-8.49	-6.07	-5.65	-8.46
8	5	7	70	7.40	6.84	6.64	6.31
9	**6**	**7**	**10**	**11.68**	**8.11**	**6.87**	**8.33**
10	6	8	32	-1.64	-1.85	-1.58	-2.43
11	6	9	65	0.94	2.10	2.43	1.60
12	6	10	32	0.54	1.20	1.39	0.91
13	9	11	65	0.00	0.00	0.00	0.00
14	9	10	65	0.94	2.10	2.43	1.60
15	**4**	**12**	**30**	**31.31**	**24.52**	**21.50**	**22.01**
16	12	13	65	-21.46	-20.18	-20.32	-14.71
17	12	14	32	1.90	2.22	2.01	1.50
18	12	15	32	6.57	8.53	7.71	5.62
19	12	16	32	2.90	2.16	2.47	1.01
20	14	15	16	1.90	2.21	2.01	1.50
21	16	17	16	2.89	2.16	2.47	1.01
22	15	18	16	-0.61	-1.38	-1.04	-1.64
23	18	19	16	-0.62	-1.38	-1.04	-1.64
24	19	20	32	-0.62	-1.38	-1.04	-1.64
25	10	20	32	0.62	1.38	1.04	1.65
26	10	17	32	8.82	7.32	7.46	8.92
27	10	21	32	-4.84	-3.38	-2.93	-5.05
28	10	22	32	-3.12	-2.01	-1.75	-3.00
29	21	22	32	-4.86	-3.38	-2.93	-5.06
30	15	23	16	-6.64	-11.56	-10.74	-12.76
31	22	24	16	4.29	4.83	5.55	4.90
32	23	24	16	4.77	7.58	8.41	7.35
33	24	25	16	-0.55	-4.58	-3.13	-4.82
34	25	26	16	14.17	8.48	11.26	11.26
35	**25**	**27**	**10**	**-14.73**	**-9.10**	**-8.41**	**-6.13**
36	28	27	65	-8.44	-9.25	-7.91	-12.12
37	27	29	16	0.00	0.00	0.00	0.00
38	27	30	16	0.00	0.00	0.00	0.00
39	29	30	16	0.00	0.00	0.00	0.00
40	8	28	32	-1.64	-1.85	-1.58	-2.43
41	6	28	32	-6.79	-7.39	-6.32	-9.67

Table A. III.4 Line flows in lines of modified IEEE-118 bus system using DOPF (in MW)

Lines	From bus	To bus	Case 1 Before Congestion Management	Case 3 After Congestion Management		
			Initial flows	IP	PSO	IP-PSO
1	1	2	6.47	-0.72	0.69	0.65
2	1	3	-6.47	0.72	-0.69	-0.65
3	4	5	43.93	44.72	39.66	37.42
4	3	5	-20.86	-28.93	-25.63	-23.97
5	5	6	0.90	-6.12	-3.22	-3.48
6	6	7	43.78	42.94	39.62	37.90
7	8	9	1.13	1.13	1.13	1.13
8	8	5	-4.60	-5.92	0.00	-0.33
9	9	10	0.13	0.13	0.13	0.13
10	4	11	20.52	18.98	19.71	18.83
11	5	11	17.10	15.42	16.75	16.10
12	11	12	21.35	19.18	16.66	15.20
13	2	12	-24.81	-24.70	-21.63	-19.89
14	3	12	-3.88	-10.18	-7.75	-7.11
15	7	12	16.25	23.10	21.76	21.06
16	11	13	-1.20	-1.36	-2.70	-3.39
17	12	14	12.80	10.98	14.40	14.43
18	13	15	-1.21	-1.37	-2.72	-3.40
19	14	15	-8.49	-7.90	-11.00	-11.97
20	12	16	-4.11	-3.87	-5.58	-5.37
21	15	17	-6.16	-4.59	-5.48	0.23
22	16	17	-4.13	-3.89	-5.60	-5.39
23	17	18	8.52	6.31	6.20	5.47
24	18	19	8.40	6.20	6.09	5.36
25	19	20	35.11	25.49	24.38	28.26
26	15	19	17.02	13.44	12.21	16.66
27	20	21	-16.34	-13.21	-13.46	-11.89
28	21	22	-16.40	-13.26	-13.50	-11.93
29	22	23	-16.47	-13.31	-13.55	-11.97
30	23	24	-35.34	-32.86	-42.08	-34.57
31	23	25	-0.41	2.07	2.83	-1.84
32	26	25	6.74	4.07	2.44	7.21
33	25	27	6.05	5.86	4.98	5.09
34	27	28	0.00	0.19	0.67	-0.21
35	28	29	0.00	0.18	0.67	-0.21
36	30	17	20.89	15.48	15.38	14.03
37	8	30	3.47	4.79	-1.13	-0.80
38	26	30	-6.74	-4.07	-2.44	-7.21
39	17	31	0.29	-0.42	-1.75	0.95
40	29	31	-0.01	0.18	0.66	-0.22
41	23	32	6.25	7.55	6.99	4.05
42	31	32	0.20	-0.32	-1.17	0.64
43	27	32	0.75	0.59	0.81	0.78
44	15	33	20.44	9.79	8.04	8.46
45	19	34	-10.05	-6.21	-6.43	-6.62
46	35	36	-6.45	-18.93	-18.14	-17.94
47	35	37	-4.69	-13.78	-15.13	-15.32
48	33	37	-30.98	-15.79	-15.62	-15.19
49	34	36	6.46	18.98	18.19	17.99
50	34	37	0.01	2.27	-7.84	-9.63
51	38	37	-3.65	0.87	2.17	1.52
52	37	39	-17.72	-8.83	-14.14	-15.32
53	37	40	-22.22	-17.97	-22.63	-23.65
54	30	38	-24.37	-14.97	-19.17	-22.25
55	39	40	-34.29	-37.34	-41.47	-42.37
56	40	41	4.27	3.16	3.46	3.41

57	40	42	4.25	3.13	3.42	3.38
58	41	42	4.13	3.03	3.31	3.27
59	43	44	-4.23	-3.68	-5.20	-5.59
60	34	43	-3.84	-3.29	-4.82	-5.21
61	44	45	-4.61	-4.06	-5.58	-5.98
62	45	46	-2.50	-2.26	-2.87	-2.96
63	46	47	-2.04	-1.93	-2.14	-2.02
64	46	48	-0.46	-0.34	-0.74	-0.94
65	47	49	1.09	1.31	0.21	-0.79
66	42	49	3.77	2.67	2.95	2.91
67	42	49	3.77	2.67	2.95	2.91
68	45	49	-2.13	-1.82	-2.74	-3.05
69	48	49	-0.47	-0.35	-0.75	-0.95
70	49	50	4.95	4.63	3.58	3.44
71	49	51	6.29	5.87	4.54	4.37
72	51	52	2.39	2.22	1.71	1.67
73	52	53	2.39	2.22	1.70	1.67
74	53	54	2.39	2.22	1.70	1.67
75	49	54	6.14	5.74	4.48	4.35
76	49	54	6.07	5.67	4.43	4.31
77	54	55	-4.54	-4.25	-3.70	-3.94
78	54	56	-25.76	-24.02	-20.45	-21.59
79	55	56	4.04	3.80	3.53	3.89
80	56	57	-4.92	-4.60	-3.57	-3.42
81	50	57	4.94	4.62	3.58	3.43
82	56	58	-3.86	-3.62	-2.81	-2.68
83	51	58	3.88	3.63	2.82	2.69
84	54	59	-9.46	-8.87	-7.94	-8.58
85	56	59	-6.36	-5.90	-5.20	-5.71
86	56	59	-6.59	-6.11	-5.37	-5.91
87	55	59	-8.58	-8.04	-7.23	-7.83
88	59	60	-7.74	-7.05	-6.80	-8.07
89	59	61	-6.51	-5.88	-5.52	-6.58
90	60	61	11.01	10.47	11.76	13.64
91	60	62	-19.09	-17.85	-18.89	-22.06
92	61	62	-32.23	-30.20	-32.19	-37.58
93	63	59	17.17	16.40	13.80	13.78
94	63	64	-17.17	-16.40	-13.80	-13.78
95	64	61	-36.44	-34.49	-38.13	-44.33
96	38	65	-20.92	-16.01	-21.53	-23.96
97	64	65	19.27	18.08	24.33	30.54
98	49	66	-7.72	-7.64	-6.62	-7.71
99	49	66	-7.72	-7.64	-6.62	-7.71
100	62	66	9.87	9.00	10.12	12.23
101	62	67	23.97	21.30	22.92	24.03
102	65	66	15.05	14.34	10.71	7.50
103	66	67	8.55	7.15	6.67	3.35
104	65	68	-16.92	-12.48	-8.13	-1.16
105	47	69	-3.18	-3.29	-2.40	-1.28
106	49	69	-2.93	-3.06	-2.09	-0.95
107	68	69	6.20	1.07	2.07	9.85
108	69	70	-3.15	-15.24	-14.60	-5.26
109	24	70	-8.44	-9.02	-8.71	-9.16
110	70	71	7.61	8.16	7.87	8.29
111	24	72	-7.53	-8.07	-7.78	-8.20
112	71	72	7.60	8.15	7.85	8.28
113	71	73	0.00	0.00	0.00	0.00
114	70	74	5.97	13.74	13.65	8.85
115	70	75	7.21	16.69	16.59	10.72
116	69	75	10.32	9.25	9.80	12.44
117	74	75	5.39	13.06	12.97	8.23
118	76	77	-7.41	-3.82	-3.44	-5.50
119	69	77	-7.19	0.59	2.26	0.34

120	75	77	-9.19	-4.70	-4.23	-6.81
121	77	78	36.98	53.65	56.73	54.03
122	78	79	-13.33	-16.73	-17.38	-18.04
123	77	80	-16.31	-18.61	-19.08	-20.92
124	77	80	-7.46	-8.51	-8.73	-9.62
125	79	80	-13.36	-16.76	-17.41	-18.08
126	68	81	-23.13	-13.55	-10.20	-11.00
127	**81**	**80**	**-33.14**	**-23.56**	**-20.21**	**-21.01**
128	77	82	-37.25	-34.66	-34.53	-35.66
129	82	83	-40.26	-34.47	-34.73	-33.63
130	83	84	-13.82	-11.49	-11.59	-11.14
131	83	85	-27.05	-23.52	-23.67	-23.01
132	84	85	-14.63	-12.21	-12.32	-11.86
133	85	86	0.01	0.01	0.01	0.01
134	86	87	0.00	0.00	0.00	0.00
135	85	88	4.96	-0.18	-0.07	-4.17
136	85	89	5.73	0.48	0.59	-3.59
137	88	89	4.92	-0.22	-0.11	-4.20
138	89	90	-9.07	-11.93	-12.21	-15.48
139	89	90	-18.16	-23.65	-24.19	-30.46
140	90	91	13.88	16.14	16.57	19.79
141	89	92	29.18	27.65	28.44	29.41
142	89	92	8.63	8.15	8.39	8.70
143	91	92	13.69	15.94	16.36	19.54
144	92	93	15.88	16.02	16.28	17.81
145	92	94	15.86	16.01	16.27	17.79
146	93	94	15.72	15.86	16.12	17.63
147	94	95	13.87	14.33	13.85	15.67
148	80	96	-15.60	-14.55	-14.24	-15.01
149	82	96	2.34	-0.76	-0.38	-2.64
150	94	96	15.63	16.15	15.61	17.67
151	80	97	-15.63	-14.57	-14.26	-15.04
152	80	98	-14.57	-14.23	-13.53	-14.86
153	80	99	-14.56	-14.22	-13.53	-14.85
154	92	100	9.59	9.54	10.00	10.66
155	94	100	1.67	0.98	2.51	1.62
156	95	96	13.80	14.26	13.78	15.60
157	96	97	15.78	14.71	14.40	15.19
158	98	100	-14.67	-14.32	-13.62	-14.96
159	99	100	-14.77	-14.41	-13.71	-15.06
160	100	101	-9.55	-9.51	-9.97	-10.62
161	92	102	9.65	9.61	10.07	10.74
162	101	102	-9.59	-9.54	-10.00	-10.66
163	100	103	-6.76	-10.54	-7.84	-9.31
164	100	104	-2.53	-2.21	-1.53	-1.99
165	103	104	0.09	1.69	1.64	1.55
166	103	105	0.01	1.95	2.05	1.85
167	100	106	0.24	3.63	4.11	3.74
168	104	105	-2.52	-0.58	0.05	-0.50
169	105	106	9.68	21.19	20.32	20.79
170	105	107	-23.60	-10.35	-11.38	-12.61
171	105	108	11.30	-9.57	-6.94	-6.92
172	106	107	-26.25	-16.26	-17.04	-18.39
173	108	109	-15.10	-15.61	-13.33	-14.92
174	103	110	-6.97	-14.30	-11.62	-12.82
175	109	110	-15.13	-15.65	-13.36	-14.96
176	110	111	0.00	0.00	0.00	0.00
177	110	112	-22.33	-30.30	-25.27	-28.10
178	17	113	0.29	-0.41	-1.66	0.92
179	32	113	-0.22	0.47	1.72	-0.85
180	32	114	7.30	7.21	4.77	6.21
181	27	115	5.28	5.07	3.48	4.50
182	114	115	-5.27	-5.06	-3.48	-4.50

183	68	116	0.00	0.00	0.00	0.00
184	12	117	0.00	0.00	0.00	0.00
185	75	118	-7.34	-3.75	-3.38	-5.43
186	76	118	7.41	3.82	3.44	5.50

REFERENCES

Deregulation

[1] R. Christie and I. Wangensteen, "The energy market in Norway and Sweden: the spot and futures markets," *Power Engineering Review, IEEE*, no. March, pp. 55–56, 1998.

[2] L. L. Lai, *Power system restructuring and deregulation*, John Wiley & Sons, Inc. New York, 2001.

[3] M. Shahidehpour and M. Alomoush, *Restructured electrical power system*, Marcel Dekker Inc., New York, 2001.

[4] Y. R. Sood, N. P. Padhy, and H. O. Gupta, "Wheeling of power under deregulated environment of power system-a bibliographical survey," *IEEE Transaction on Power Systems.*, vol. 17, no. 3, pp. 870–878, Aug. 2002.

[5] Y. H. Song and X. F. Wang, "Operation of market-oriented power systems," Springer-Verlag, London Limited, 2003.

[6] W. Hogan, "Electricity market structure and infrastructure," *Conference on Acting in time on Energy Policy, Harvard University,* Sep 18-19, 2008.

[7] G. Hamoud, "Feasibility assessment of simultaneous bilateral transactions in a deregulated environment," *IEEE Transaction on Power Systems.*, vol. 15, no. 1, pp. 22–26, 2000.

[8] A. David and F. Wen, "Market power in electricity supply," *IEEE Trans. Energy Conversion*, vol. 16, no. 4, pp. 352–360, 2001.

[9] E. Bompard, Y. C. Ma, R. Napoli, and C. W. Jiang, "Assessing the market power due to the network constraints in competitive electricity markets," *Electric Power Systems Research*, vol. 76, no. 11, pp. 953–961, Jul. 2006.

[10] P. N. Biskas, D. I. Chatzigiannis, and A. Bakirtzis, "European electricity market integration with mixed market designs—Part I: Formulation," *IEEE Transaction on Power Systems.,* vol. 29, no. 1, pp. 458–465, Jan. 2014.

[11] P. N. Biskas, D. I. Chatzigiannis, S. Member, A. G. Bakirtzis, and S. Member, "Mixed market designs — Part II : solution algorithm and case studies," *IEEE Transaction on Power Systems.,* vol. 29, no. 1, pp. 466–475, Jan. 2014.

[12] I. Kockar and F. Galiana, "Combined pool/bilateral dispatch: Part II - Curtailment of firm and nonfirm contracts," *IEEE Transaction on Power Systems.*, vol. 17, no. 4, pp. 1184–1190, 2002.

[13] S. H. Hosseinian, R. Jamalzadeh, M. Choopani, and M. M. Ardehali, "Payment cost minimisation auction for deregulated electricity market using mixed-integer linear programming approach," *IET Generation, Transmission & Distribution*, vol. 7, no. 8, pp. 907–918, Aug. 2013.

[14] P. Wang, H. Zareipour, and W. Rosehart, "Descriptive models for reserve and regulation prices in competitive electricity markets," *IEEE Transactions on Smart Grid*, vol. 5, no. 1, pp. 471–479, Jan. 2014.

[15] Y. Dai, Y. X. Ni, C. M. Shen, F. S. Wen, Z. X. Han, and F. F. Wu, "A study of reactive power marginal price in electricity market," *Electric Power Systems Research*, vol. 57, no. 1, pp. 41–48, Jan. 2001.

[16] W. Zhang, F. Li, and L. Tolbert, "Review of reactive power planning: objectives, constraints, and algorithms," *IEEE Transaction on Power Systems.,* vol. 22, no. 4, pp. 2177–2186, 2007.

[17] A. J. Conejo, J. M. Arroyo, Alguacil N., Guijarro A. L., "Transmission loss allocation: a comparison of different practical algorithms", *IEEE Transaction on Power Systems.*, vol. 17, no. 3, pp. 571-576, 2002.

[18] Z. Xu, Z. Dong, and K. Wong, "Transmission planning in a deregulated environment," *IEE Proceedings Generation, Transmission & Distribution,* pp.326-334, May, 2006.

[19] P. Maghouli, S. H. Hosseini, M. O. Buygi, and M. Shahidehpour, "A multi-objective framework for transmission expansion planning in deregulated environments," *IEEE Transaction on Power Systems.*, vol. 24, no. 2, pp. 1051–1061, May 2009.

[20] A. Motamedi and H. Zareipour, "A transmission planning framework considering future generation expansions in electricity markets," *IEEE Transaction on Power Systems.,* vol. 25, no. 4, pp. 1987–1995, May 2010.

[21] F. Munoz, B. Hobbs, J. Ho, and S. Kasina, "An engineering-economic approach to transmission planning under market and regulatory uncertainties: WECC case study," *IEEE Transaction on Power Systems.*, vol. 29, no. 1, pp. 307–317, Jan. 2014.

[22] Published in Gazette of India, The Electricity Act, 1910, India.

[23] Published in Gazette of India, The Electricity (Supply) Act, 1948, India

[24] Published in Gazette of India, The Electricity Regulatory Commissions Act, 1998, India

[25] Published in Gazette of India, The Electricity Act, 2003, India

[26] S. Singh and S. Srivastava, "Electric power industry restructuring in India: present scenario and future prospect," *IEEE Imitational Conference on Electric Utility Deregulation, Restructuring and Power Technologies (DRPT2004), Hong Kong*, pp. 20–23, April 2004.

[27] S. A. Khaparde, "Power sector reforms and restructuring in India", *IEEE Power Engineering Society General Meeting*, vol.2, pp. 2328 – 2335, June 2004.

[28] Published in Gazette of India, National Electricity Policy, 2005, India

[29] Published in Gazette of India, Tariff Policy, 2006, India

[30] D. P. Sharma, P. S. C. Nair, and R. Balasubramanian, "Performance of Indian power sector during a decade under restructuring : a critique $," Indian Institute of Technology, Delhi, (http://www.iitd.ac.in).

[31] S.K. Parida, S.N. Singh and S.C. Srivastava, "Ancillary Services Management Policies in India: An Overview and Key Issues," *The Electricity Journal,* vol. 22, no. 1, pp. 88-97, Feb. 2009.

[32] Staff Paper, "Ancillary services in Indian context: an approach paper," Power System Operation Corporation Limited India, 2010.

[33] http://www.cercind.gov.in

[34] Approach Paper, "Terms and conditions of tariff regulations: Control Period 1.4.2014 to 31.3.2019", Central Electricity Regulatory Commission, India.

[35] F. F. Wu and P. Varaiya, "Coordinated multilateral trades for electric power networks: theory and implementation", *Electrical Power and Energy Systems*, vol. 21, pp. 75-102, 1999.

[36] R. W. Ferrero and V. C. Ramesh, "Transaction analysis in deregulated power systems," *IEEE Transaction on Power Systems.*, vol. 12, no. 3, pp. 1340–1347, 1997.

[37] J. D. Weber, T. J. Overbye, and C. L. DeMarco, "Modeling the consumer benefit in the optimal power flow," *Decision Support Systems*, vol. 24, pp. 279–296, Jan. 1999.

[38] J. Weber and T. Overbye, "An individual welfare maximization algorithm for electricity markets," *IEEE Transaction on Power Systems.*, vol. 17, no. 3, pp. 590–596, Aug. 2002.

[39] F. Nishimura, R. D. Tabors, M. D. Ilic, and J. R. Lacalle-Melero, "Benefit optimization of centralized and decentralized power systems in a multi-utility environment", *IEEE Transaction on Power Systems.*, vol. 8, no. 3, pp. 1180-1186, Aug. 1993.

[40] M. Anvar, "Decentralized control of interconnected electric power systems in competitive markets," *Electric power systems research*, vol. 8, no. 3, pp. 1180–1186, 1995.

[41] A. Bottcrud, M. D. Ilic, and I. Wangcnstccn, "Optimal Invcstmcnts in Power Generation Under Centralized and Decentralized Decision Making," *IEEE Transaction on Power Systems.*, vol. 20, no. 1, pp. 254–263, Feb. 2005.

[42] P. Correia, "Decentralised unit commitment in a market structure: problem formulation and solution advancement," *IEE Proceedings Generation, Transmission & Distribution,* vol. 153, no. 1, pp. 121-126, Jan. 2006.

[43] Y. R. Sood, N. P. Padhy, and H. O. Gupta, "Deregulated model and locational marginal pricing," *Electric Power Systems Research*, vol. 77, pp. 574–582, Apr. 2007.

[44] A. Soroudi, M. Ehsan, R. Caire, and N. Hadjsaid, "Hybrid immune-genetic algorithm method for benefit maximisation of distribution network operators and distributed generation owners in a deregulated environment," *IET Generation, Transmission & Distribution*, vol. 5, no. 9, pp. 961–972, 2011.

[45] J. A. Aguado and V. H. Quintana, "Inter-utilities power-exchange coordination: a market-oriented approach," *IEEE Transaction on Power Systems.*, vol. 16, no. 3, pp. 513–519, Aug. 2001.

[46] P. Biskas and A. Bakirtzis, "Decentralised security constrained DC-OPF of interconnected power systems," *IEE Proceedings Generation, Transmission & Distribution,* vol. 151, no. 6, pp.747-754, Nov. 2004.

[47] L. Jianhua, "Cross-region bilateral transaction curtailment model based on fuzzy theory," *IEEE/PES Transmission and Distribution Conference & Exhibition: Asia and Pacific Dalian, China*, pp. 1-4, 2005.

[48] F. Milano, C. A. Cañizares, and M. Invernizzi, "Voltage stability constrained OPF market models considering contingency criteria," *Electric Power Systems Research*, vol. 74, no. 1, pp. 27–36, Apr. 2005.

[49] O. Alsac and B. Stott, "Optimal load flow with steady-state security," *IEEE Transactions on Power Apparatus and Systems,* vol. PAS-93, no. 3, pp. 745–751, May 1974.

[50] M. Huneault and F. D. Galiana, "A survey of the optimal power flow literature", *IEEE Transaction on Power Systems.*, vol.6, no. 2, pp. 762-770, May 1991.

[51] J. W. M. Cheng, F. D. Galiana, and D. T. Mcgillis, "Studies of bilateral contracts with rcspcct to stcady-statc sccurity in a dcrcgulatcd environment," *IEEE Transaction on Power Systems.,* vol. 13, no. 3, pp. 1020–1025, Aug. 1998.

[52] A. K. David and R.S.Fang, "Security-based rescheduling of transactions in a deregulated power system," *IET Generation, Transmission & Distribution*, vol. *146*, no. 1, pp. 13–18, Jan. 1999.

[53] J. Condren, T. W. Gedra, and P. Damrongkulkamjorn, "Optimal power flow with expected security costs," *IEEE Transaction on Power Systems.*, vol. 21, no. 2, pp. 541–547, May 2006.

[54] X. J. Lin, C. W. Yu, and A. K. David, "Optimum transient security constrained dispatch in competitive deregulated power systems," *Electric Power Systems Research*, vol. 76, no. 4, pp. 209–216, Jan. 2006.

[55] C. J. Dent, L. F. Ochoa, and G. P. Harrison, "Network distributed generation capacity analysis using OPF with voltage step constraints," *IEEE Transaction on Power Systems.,* vol. 25, no. 1, pp. 296–304, Feb. 2010.

[56] H. Zhang and P. Li, "Probabilistic analysis for optimal power flow under uncertainty," *IET Generation, Transmission & Distribution*, vol. 4, no. 5, pp. 553–561, 2010.

[57] S. Fadil, A. Yazıcı, and B. Urazel, "A security-constrained economic power dispatch technique using modified sub-gradient algorithm based on feasible values and pseudo scaling factor for a power system area including limited energy supply thermal units," *Electric Power Components and Systems*, vol. 39, no. 16, pp. 1748–1768, Oct. 2011.

[58] H. Yu and W. D. Rosehart, "An Optimal Power Flow Algorithm to Achieve Robust Operation Considering Load and Renewable Generation Uncertainties," *IEEE Transaction on Power Systems.*, vol. 27, no. 4, pp. 1808–1817, Nov. 2012.

[59] D. Gayme and U. Topcu, "Optimal power flow with large-scale storage integration," *IEEE Transaction on Power Systems.,* vol. 28, no. 2, pp. 709–717, May 2013.

[60] A. J. Conejo and A. J. Aguado, "Multi-area coordinated decentralized DC optimal powcr flow", *IEEE Transaction on Power Systems.*, vol. 13, no. 4, pp. 1272-1278, Nov. 1998.

[61] P. N. Biskas, A. G. Bakirtzis, Nikos I. Macheras, and N. K. Pasialis, "A decentralized implementation of dc optimal power flow on a network of computers" *IEEE Transaction on Power Systems.*, vol. 20, no. 1, pp. 25–33, Feb. 2005.

[62] P. Biskas and A. Bakirtzis, "Decentralised OPF of large multiarea power systems," *IEE Proceedings Generation, Transmission & Distribution,* vol. 153, no. 1, pp. 99-105, Jan. 2006.

[63] A. G. Bakirtzis and P. N. Biskas, "A decentralized solution to the DC-OPF of interconnected power systems," *IEEE Transaction on Power Systems.,* vol. 18, no. 3, pp. 1007–1013, Aug. 2003.

[64] D. I. Sun, B. Ashley, B. Brewer, A. Hughes, and W. F. Tinney, "Optimal power flow by Newton approach" *IEEE Transactions on Power Apparatus and Systems,* vol. PAS-103, no. 10, pp. 2864– 2880, Oct. 1984.

[65] J. Yuryevich and K. P. Wong, "Evolutionary programming based optimal power flow algorithm," *IEEE Transaction on Power Systems.*, vol. 14, no. 4, pp. 1245–1250, Nov. 1999.

[66] A. G. Bakirtzis, P. N. Biskas, C. E. Zoumas, and V. Petridis "Optimal power flow by enhanced genetic algorithm," *IEEE Transaction on Power Systems.,* vol. 17, no. 2, pp. 229–236, May 2002.

[67] H. Y. Yamin, K. Al-Tallaq, and S. M. Shahidehpour, "New approach for dynamic optimal power flow using Benders decomposition in a deregulated power market," *Electric Power Systems Research*, vol. 65, no. 2, pp. 101–107, May 2003.

[68] P. Somasundaram, K. Kuppusamy, and R. P. Kumudini Devi, "Evolutionary programming based security constrained optimal power flow," *Electric Power Systems Research*, vol. 72, no. 2, pp. 137–145, Dec. 2004.

[69] W. Tang, M. S. Li, Q. H. Wu, and J. R. Saunders, "Bacterial foraging algorithm for optimal power flow in dynamic environments," *IEEE Transactions on circuits and systems—I*, vol. 55, no. 8, pp. 2433–2442, Sep. 2008.

[70] M. R. AlRashidi and M. E. El-Hawary, "Applications of computational intclligcncc tcchniqucs for solving thc rcvivcd optimal powcr flow problem," *Electric Power Systems Research*, vol. 79, no. 4, pp. 694–702, April 2009.

[71] X. Bai and H. Wei, "Semi-definite programming-based method for security-constrained unit commitment with operational and optimal power flow constraints," *IET Generation, Transmission & Distribution*, vol. 3, no. 2, pp. 182–197, 2009.

[72] F. Capitanescu and L. Wehenkel, "Sensitivity-based approaches for handling discrete variables in optimal power flow computations," *IEEE Transaction on Power Systems.*, vol. 25, no. 4, pp. 1780–1789, Nov. 2010.

[73] M. Dolan, E. Davidson, I. Kockar, G. W. Ault, and S. D. J. McArthur, "Distribution power flow management utilizing an online optimal power flow technique," *IEEE Transaction on Power Systems.*, vol. 27, no. 2, pp. 790–799, May 2012.

[74] F. Milano, C. A. Cañizares, and A. J. Conejo, "Sensitivity-based security-constrained OPF market clearing model," *IEEE Transaction on Power Systems.*, vol. 20, no. 4, pp. 2051–2060, Nov. 2005.

[75] M. Todorovski and D. Rajicic, "An initialization procedure in solving optimal power flow by genetic algorithm," *IEEE Transaction on Power Systems.*, vol. 21, no. 2, pp. 480–487, May 2006.

[76] H. Yoshida, K. Kawata, Y. Fukuyama, S. Takayama, and Y. Nakanishi, "A particle swarm optimization for reactive power and voltage control considering voltage security assessment," *IEEE Transaction on Power Systems.*, vol. 15, no. 4, pp. 1232–1239, Nov. 2000.

[77] G. Verbic and C. Cañizares, "Probabilistic optimal power flow in electricity markets based on a two-point estimate method," *IEEE Transaction on Power Systems.*, vol. 21, no. 4, pp. 1883–1893, Nov. 2006.

[78] S. K. Bath, J. S. Dhillon, and D. P. Kothari, "Security constrained stochastic multi-objective optimal power dispatch," *International Journal of Emerging Electric Power Systems*, vol. 8, no. 1, Jan. 2007.

[79] H. R. Cai, C. Y. Chung, and K. P. Wong, "Application of differential evolution algorithm for transient stability constrained optimal power flow," *IEEE Transaction on Power Systems.*, vol. 23, no. 2, pp. 719–728, May 2008.

[80] R. A. Jabr, "Optimal Power Flow Using an Extended Conic Quadratic Formulation," *IEEE Transaction on Power Systems.*, vol. 23, no. 3, pp. 1000–1008, Aug. 2008.

[81] W. M. Lin, C. H. Huang, and T. S. Zhan, "A Hybrid Current-Power Optimal Power Flow Technique," *IEEE Transaction on Power Systems.*, vol. 23, no. 1, pp. 177–185, Feb. 2008.

[82] F. Li, and R. Bo, "DCOPF-based LMP simulation: algorithm, comparison with ACOPF, and sensitivity," *IEEE Transaction on Power Systems.*, vol. 22, no. 4, pp. 1475–1485, Nov. 2007.

[83] H. Wang, C. E. Murillo-Sánchez, R. D. Zimmerman, and Robert J. Thomas, "On computational issues of market-based optimal power flow," *IEEE Transaction on Power Systems.*, vol. 22, no. 3, pp. 1185–1193, Aug. 2007.

[84] C. Lehmkoster, "Security constrained optimal power flow for an economical operation of FACTS-devices in liberalized energy markets," *IEEE Transactions on Power Delivery,* vol. 17, no. 2, pp. 603–608, April 2002.

[85] A. Berizzi and M. Delfanti, "Enhanced security-constrained OPF with FACTS devices," *IEEE Transaction on Power Systems.,* vol. 20, no. 3, pp. 1597–1605, Aug. 2005.

[86] R. Z. Mihano, A. J. Conejo, and F. Milano, "OPF-based security redispatching including FACTS devices," *IET Generation, Transmission & Distribution,* vol.2, no. 6, pp. 821–833, April, 2008.

[87] X. Wang, Y. Song, and Q. Lu, "A coordinated real-time optimal dispatch method for unbundled electricity markets," *IEEE Transaction on Power Systems.,* vol. 17, no. 2, pp. 482–490, 2002.

[88] R. D. Christie, B. F. Wollenberg, and I. Wangensteen, "Transmission management in the deregulated environment," *Proceedings of the IEEE*, vol. 88, no. 2, pp. 170–195, Feb. 2000.

[89] M. Doll and J. F. Verstege, "Congestion Management in a Deregulated Using Corrective Measures Environment," no. C, pp. 393–398, 2001.

[90] D. Gan and D. V. Bourcier, "Locational market power screening and congestion management: experience and suggestions," *IEEE Transaction on Power Systems.*, vol. 17, no. 1, pp. 180–185, Feb. 2002.

[91] A. Kumar, S. C. Srivastava, and S. N. Singh, "Congestion management in competitive power market: A bibliographical survey," *Electric Power Systems Research*, vol. 76, no. 1–3, pp. 153–164, Sep. 2005.

[92] B. K. Talukdar, A. K. Sinha, S. Mukhopadhyay, and A. Bose, "A computationally simple method for cost-efficient generation rescheduling and load shedding for congestion management," *International Journal of Electrical Power & Energy Systems*, vol. 27, no. 5–6, pp. 379–388, Jun. 2005.

[93] E. Shayesteh, M. P. Moghaddam, A. Yousefi, M. Haghifam, and M. K. Sheik-El-Eslami, "A demand side approach for congestion management in competitive environment," *European Transactions on Electrical Power*, vol. 20, pp. 470–490, 2010.

[94] P. N. Biskas and A. G. Bakirtzis, "Decentralised congestion management of interconnected power systems," *IEE Proceedings Generation, Transmission & Distribution*, vol. 149, no. 4, pp. 432–438, July 2002.

[95] S. Hao and D. Shirmohammadi, "Congestion management with ex ante pricing for decentralized electricity markets," *IEEE Transactions Power Systems,* vol. 17, no. 4, pp. 1030–1036, Nov. 2002.

[96] P. Wei, Y. Ni, and F. Wu, "Decentralised approach for congestion management and congestion price discovering," *IEE Proceedings Generation, Transmission & Distribution*, vol. 149, no. 6, pp. 645-652, Nov. 2002.

[97] J. A. Aguado, V. H. Quintana, M. Madrigal, and W. D. Rosehart, "Coordinated Spot Market for Congestion Management of Inter-Regional Electricity Markets," *IEEE Transaction on Power Systems.*, vol. 19, no. 1, pp. 180–187, Feb. 2004.

[98] R. Mendez and H. Rudnick, "Congestion management and transmission rights in centralized electric markets," *IEEE Transaction on Power Systems.*, vol. 19, no. 2, pp. 889–896, May 2004.

[99] S. Hao, "Decentralized Approach to Intermarket congestion management," *IEEE Transaction on Power Systems.,* vol. 20, no. 2, pp. 675–683, May 2005.

[100] K. Liu, Y. Ni, F. F. Wu, and T. S. Bi, "Decentralized Congestion Management for Multilateral Transactions Based on Optimal Resource Allocation," *IEEE Transaction on Power Systems.,* vol. 22, no. 4, pp. 1835–1842, Nov. 2007.

[101] A. Huang, S. K. Joo, K. B. Song, J. H. Kim, and K. Lee, "Asynchronous decentralized method for interconnected electricity markets," *International Journal of Electrical Power & Energy Systems*, vol. 30, no. 4, pp. 283–290, May 2008.

[102] S. Visalakshi and S. Baskar, "Covariance matrix adapted evolution strategy-based decentralised congestion management for multilateral transactions," *IET Generation, Transmission & Distribution*, vol. 4, no. 3, pp. 400- 417, 2010.

[103] S. Tao and G. Gross, "A congestion-management allocation mechanism for multiple transaction networks," *IEEE Transaction on Power Systems.*, vol. 17, no. 3, pp. 826–833, Aug. 2002.

[104] M. I. Alomoush and S. M. Shahidehpour, "Fixed transmission rights for zonal congestion management," *IEE Proceedings Generation, Transmission and Distribution*, vol. 146, no. 5, pp. 471-476, 1999.

[105] X. Wang, Y. Song, and Q. Lu, "Lagrangian decomposition approach to active power congestion management across interconnected regions," *IEE Proceedings Generation, Transmission & Distribution*, vol. 148, no. 5, pp. 497–503, Sep. 2001.

[106] A. G. Bakirtzis and P. N. Biskas, "Decentralised DC load flow and applications to transmission management" *IEE Proceedings Generation, Transmission & Distribution*, vol. 149, no. 5, pp. 600–606, Sep. 2002.

[107] S. S. Oren and A. M. Ross, "Economic congestion relief across multiple regions requires tradable physical flow-gate rights," *IEEE Transactions Power Systems,* vol. 17, no. 1, pp. 159–165, Feb. 2002.

[108] B. J. Kirby and J. W. Van Dyke, Congestion management requirements, methods and performance indices, U. S. Department of Energy, June 2002, (http://www.osti.gov/bridge).

[109] A. Kumar, S. C. Srivastava, and S. N. Singh, "A zonal congestion management approach using real and reactive power rescheduling," *IEEE Transaction on Power Systems.,* vol. 19, no. 1, pp. 554–562, Feb. 2004.

[110] N. Athanasiadis, G. E. Chatzarakis, E. Athanasiadis, and D. Fourlaris, "Analysis and Future Prospects for Cross-border Congestion Management Methods for the European Electricity Market," *Electrical Engineering*, vol. 89, no. 6, pp. 509–517, Jun. 2006.

[111] H. Y. Yamin and S. M. Shahidehpour, "Transmission congestion and voltage profile management coordination in competitive electricity markets," *International Journal of Electrical Power & Energy Systems*, vol. 25, no. 10, pp. 849–861, Dec. 2003.

[112] A. Conejo, F. Milano, and R. García-Bertrand "Congestion management ensuring voltage stability," *IEEE Transaction on Power Systems.*, vol. 21, no. 1, pp. 357–364, Feb. 2006.

[113] M. Esmaili, H. A. Shayanfar, and N. Amjady, "Congestion management considering voltage security of power systems," *Energy Conversion and Management*, vol. 50, no. 10, pp. 2562–2569, Oct. 2009.

[114] H. Singh, S. Hao, and A. Papalexopoulos, "Transmission congestion management in competitive electricity markets," *IEEE Transaction on Power Systems.,* vol. 13, no. 2, pp. 672–680, May 1998.

[115] E. Bompard, P. Correia, G. Gross, and M. Amelin, "Congestion-management schemes: a comparative analysis under a unified framework," *IEEE Transaction on Power Systems.*, vol. 18, no. 1, pp. 346–352, Feb. 2003.

[116] T. Peng and K. Tomsovic, "Congestion Influence on Bidding Strategies in an Electricity Market," *IEEE Transaction on Power Systems.,* vol. 18, no. 3, pp. 1054–1061, Aug. 2003.

[117] M. Liu and G. Gross, "Role of Distribution Factors in Congestion Revenue Rights Applications," *IEEE Transaction on Power Systems.*, vol. 19, no. 2, pp. 802–810, May 2004.

[118] N. Acharya and N. Mithulananthan, "Influence of TCSC on congestion and spot price in electricity market with bilateral contract," *Electric Power Systems Research*, vol. 77, no. 8, pp. 1010–1018, Jun. 2007.

[119] F. Li and R. Bo, "Congestion and price prediction under load variation," *IEEE Transaction on Power Systems.,* vol. 24, no. 2, pp. 911–922, May 2009.

[120] N. Acharya and N. Mithulananthan, "Locating series FACTS devices for congcstion managcmcnt in dcrcgulatcd clcctricity markcts," *Electric Power Systems Research*, vol. 77, no. 3–4, pp. 352–360, Mar. 2007.

[121] N. Karmarkar "A new polynomial-time algorithm for linear programming," Combinatorica, vol. 4, no. 4, pp. 373–395, April 1984.

[122] L. S. Vargas, V. H. Quintana, and A. Vannelli, "A tutorial description of an interior point method and its applications to security-constrained economic dispatch," *IEEE Transaction on Power Systems.,* vol. 8, no. 3, pp. 1315–1324, Aug. 1993.

[123] X. Yan and V. Quintana, "An efficient predictor-corrector interior point algorithm for security-constrained economic dispatch," *IEEE Transaction on Power Systems.,* vol. 12, no. 2, pp. 803–810, May 1997.

[124] Y. Wu, A. S. Debs, and R. E. Marsten, "A direct nonlinear predictor-corrector primal-dual interior point algorithm for optimal power flows," *IEEE Transaction on Power Systems.,* vol. 9, no. 2, pp. 876–883, May 1994.

[125] X. Yan and V. H. Quintana, "An infeasible interior-point algorithm for optimal power-flow problems," *Electric Power Systems Research*, vol. 39, no. 1, pp. 39–46, Oct. 1996.

[126] G. L. Torres and V. H. Quintana, "An interior-point method for non-linear optimal power flow using voltage rectangular coordinates," *IEEE Transaction on Power Systems.,* vol. 13, no. 4, Nov. 1998.

[127] H. Wei, H. Sasaki, J. Kubokawa, and R. Yokoyama, "An interior point nonlinear programming for optimal power flow problems with a novel data structure," *IEEE Transaction on Power Systems.*, vol. 13, no. 3, pp. 870–877, Aug. 1998.

[128] J. A. Momoh and J. Z. Zhu, "Improved interior point method for OPF problems," *IEEE Transaction on Power Systems.*, vol. 14, no. 3, pp. 1114–1120, Aug. 1999.

[129] R. A. Jabr, A. H. Coonick, and B. J. Cory, "A homogeneous linear programming algorithm for the security constrained economic dispatch problem," *IEEE Transaction on Power Systems.*, vol. 15, no. 3, pp. 930–936, Aug. 2000.

[130] M. Madrigal and V. H. Quintana, "A security-constrained energy and spinning reserve markets clearing system using an interior-point method," *IEEE Transaction on Power Systems.*, vol. 15, no. 4, pp. 1410–1416, Nov. 2000.

[131] R. A. Jabr, a. H. Coonick, and B. J. Cory, "A primal-dual interior point method for optimal power flow dispatching," *IEEE Transaction on Power Systems.*, vol. 17, no. 3, pp. 654–662, Aug. 2002.

[132] R. a. Jabr, "A Primal-Dual Interior-Point Method to Solve the Optimal Power Flow Dispatching Problem," *Optimization and Engineering*, vol. 4, no. 4, pp. 309–336, Dec. 2003.

[133] S. Patra and S. K. Goswami, "A non-interior point approach to optimum power flow solution," *Electric Power Systems Research*, vol. 74, no. 1, pp. 17–26, Apr. 2005

[134] S. Patra and S. K. Goswami, "Optimum power flow solution using a non-interior point method," *International Journal of Electrical Power & Energy Systems*, vol. 29, no. 2, pp. 138–146, Feb. 2007.

[135] X. Zhang, S. Petoussis, and K. Godfrey, "Nonlinear interior-point optimal power flow method based on a current mismatch formulation," *IEE Proceedings Generation, Transmission & Distribution,* vol. 152, no. 6, pp. 795–805, Nov. 2005.

[136] F. Capitanescu, M. Glavic, D. Ernst, and L. Wehenkel, "Interior-point based algorithms for the solution of optimal power flow problems," *Electric Power Systems Research*, vol. 77, no. 5–6, pp. 508–517, Apr. 2007.

[137] I. A. Farhat and M. E. El-Hawary, "Interior point methods application in optimum operational scheduling of electric power systems," *IET Generation, Transmission & Distribution*, vol. 3, no. 11, pp. 1020–1029, Nov. 2009.

[138] Q. Jiang, G. Geng, C. Guo, and Y. Cao, "An Efficient Implementation of Automatic Differentiation in Interior Point Optimal Power Flow," *IEEE Transaction on Power Systems.*, vol. 25, no. 1, pp. 147–155, Feb. 2010.

[139] Q. Jiang and G. Geng, "A reduced-space interior point method for transient stability constrained optimal power flow," *IEEE Transaction on Power Systems.*, vol. 25, no. 3, pp. 1232–1240, Aug. 2010.

[140] C. Chung, W. Yan, and F. Liu, "Decomposed predictor-corrector interior point method for dynamic optimal power flow," *IEEE Transaction on Power Systems.,* vol. 26, no. 3, pp. 1030–1039, Aug. 2011.

[141] K. Xie, Y. H. Song, J. Stonham, E. Yu, and G. Liu "Decomposition model and interior point methods for optimal spot pricing of electricity in deregulation environments," *IEEE Transaction on Power Systems.*, vol. 15, no. 1, pp. 39–50, Feb. 2000.

[142] S. Granville, "Optimal reactive dispatch through interior point method," *IEEE Transaction on Power Systems.,* vol. 9, no. 1, pp. 136-146, Feb. 1994.

[143] J. Momoh and S. X. Guo, E. C. Ogbuobiri, and R. Adapa, "The quadratic interior point method solving power system optimization problems," *IEEE Transaction on Power Systems.*, vol. 9, no. 3, pp. 1327–1336, Aug.1994.

[144] M. Liu, S. Tso, and Y. Cheng, "An extended nonlinear primal-dual interior-point algorithm for reactive-power optimization of large-scale power systems with discrete control variables," *IEEE Transaction on Power Systems.,* vol. 17, no. 4, pp. 982–991, Nov. 2002.

[145] G. D. Irisarri, X. Wang, J. Tong and S. Mokhtari, "Maximum loadability of power systems using interior point non-linear optimization method," *IEEE Transaction on Power Systems.,* vol. 12, no. 1, pp. 162–172, Feb. 1997.

[146] J. Kennedy and R. Eberhart, "Particle swarm optimization," *Proceedings of ICNN'95 - International Conference on Neural Networks*, vol. 4, pp. 1942–1948, 1995.

[147] M. R. Alrashidi and M. E. El-Hawary, "A survey of particle swarm optimization applications in power system operations," *Electric Power Components and Systems*, vol. 34, no. 12, pp. 1349–1357, Dec. 2006.

[148] M. R. AlRashidi and M. E. El-Hawary, "A survey of particle swarm optimization applications in electric power systems," *IEEE Transactions on Evolutionary Computation,* vol. 13, no. 4, pp. 913–918, Aug. 2009.

[149] J. G. Vlachogiannis and K. Y. Lee, "A Comparative Study on Particle Swarm Optimization for Optimal Steady-State Performance of Power Systems," *IEEE Transaction on Power Systems.*, vol. 21, no. 4, pp. 1718–1728, Nov. 2006.

[150] Y. Del Valle, G. K. Venayagamoorthy, S. Mohagheghi, J. C. Hernandez, R. G. Harley, "Particle swarm optimization: basic concepts, variants and applications in power systems," *IEEE Transactions on Evolutionary Computation*, vol. 12, no. 2, pp. 171–195, April 2008.

[151] Y. Shi and R. Eberhart, "A modified particle swarm optimizer," *Proceedings of IEEE International Conference on Evolutionary Computation, IEEE World Congress on Computational Intelligence (Cat. No.98TH8360)*, pp. 69–73, 1998.

[152] "1999_Empirical Study of Particle Swarm Optimization.pdf." .

[153] M. Richards and D. Ventura, "Choosing a starting configuration for particle swarm optimization," 2004.

[154] K. T. Chaturvedi, M. Pandit, and L. Srivastava, "Self-Organizing Hierarchical Particle Swarm Optimization for Nonconvex Economic Dispatch," *IEEE Transaction on Power Systems.*, vol. 23, no. 3, pp. 1079–1087, Aug. 2008.

[155] M. Abido, "Optimal power flow using particle swarm optimization," *International Journal of Electrical Power & Energy Systems*, vol. 24, pp. 563–571, 2002.

[156] N. Mo, Z. Y. Zou, K. W. Chan and T. Y. G. Pong, "Transient stability constrained optimal power flow using particle swarm optimisation," *IET Generation, Transmission & Distribution*, vol. 1, no. 3, pp. 476–483, 2007.

[157] P. E. O. Yumbla, J. M. Ramirez, and C. A. C. Coello "Optimal power flow subject to security constraints solved with a particle swarm optimizer," *IEEE Transaction on Power Systems.*, vol. 23, no. 1, pp. 33–40, Feb. 2008.

[158] J. Hazra, S. Member, and A. K. Sinha, "Congestion Management Using Multiobjective Particle Swarm Optimization," *IEEE Transaction on Power Systems.,* vol. 22, no. 4, pp. 1726–1734, Nov. 2007.

[159] S. Dutta and S. P. Singh, "Optimal rescheduling of generators for congestion management based on particle swarm optimization," *IEEE Transaction on Power Systems.,* vol. 23, no. 4, pp. 1560–1569, Nov. 2008.

[160] Y. Pablo Oñate, J. M. Ramirez, and C. A. Coello Coello, "An optimal power flow plus transmission costs solution," *Electric Power Systems Research*, vol. 79, no. 8, pp. 1240–1246, Aug. 2009.

[161] Z. L. Gaing, "Particle swarm optimization to solving the economic dispatch considering the generator constraints," *IEEE Transaction on Power Systems.*, vol. 18, no. 3, pp. 1187–1195, Aug. 2003.

[162] J. B. Park, K. S. Lcc, J. R. Shin, and K. Y. Lcc, "A Particlc Swarm Optimization for Economic Dispatch With Non-smooth Cost Functions," *IEEE Transaction on Power Systems.*, vol. 20, no. 1, pp. 34–42, Feb. 2005.

[163] D. N. Jeyakumar, T. Jayabarathi, and T. Raghunathan, "Particle swarm optimization for various types of economic dispatch problems," *International Journal of Electrical Power & Energy Systems*, vol. 28, no. 1, pp. 36–42, Jan. 2006.

[164] A. I. Selvakumar and K. Thanushkodi, "A New Particle Swarm Optimization Solution to Nonconvex Economic Dispatch Problems," *IEEE Transaction on Power Systems.*, vol. 22, no. 1, pp. 42–51, Feb. 2007.

[165] G. Baskar and M. R. Mohan, "Security constrained economic load dispatch using improved particle swarm optimization suitable for utility system," *International Journal of Electrical Power & Energy Systems*, vol. 30, no. 10, pp. 609–613, Dec. 2008.

[166] J. G. Vlachogiannis and K. Y. Lee, "Economic load dispatch — a comparative study on heuristic optimization techniques with an improved coordinated aggregation-based PSO," *IEEE Transaction on Power Systems.,* vol. 24, no. 2, pp. 991–1001, May 2009.

[167] B. Mahdad, T. Bouktir, K. Srairi, and M. E. Benbouzid, "Economic power dispatch with discontinuous fuel cost functions using improved parallel PSO," *Journal of Electrical Engineering and Technology*, vol. 5, no. 1, pp. 45–53, March 2010.

[168] P. Bajpai, S. Punna, and S. Singh, "Swarm intelligence-based strategic bidding in competitive electricity markets," *IET Generation, Transmission & Distribution*, vol. 2, no. 2, pp. 175–184, 2008.

[169] T. A. A. Victoire and A. Jeyakumar, "Unit commitment by a tabu-search-based hybrid-optimisation technique," *IEE Proceedings Generation, Transmission & Distribution*, vol. 152, no. 4, pp. 563–574, July 2005.

[170] A. A. A. Esmin, G. Lambert-torres, and A. C. Z. De Souza, "A Hybrid Particle Swarm Optimization Applied to," *IEEE Transaction on Power Systems.*, vol. 20, no. 2, pp. 859–866, May 2005.

[171] B. Liu, L. Wang, Y. H. Jin, F. Tang, and D. X. Huang, "Improved particle swarm optimization combined with chaos," *Chaos, Solitons & Fractals*, vol. 25, no. 5, pp. 1261–1271, Sep. 2005.

[172] T. A. A. Victoire and A. E. Jeyakumar, "Hybrid PSO–SQP for economic dispatch with valve-point effect," *Electric Power Systems Research*, vol. 71, no. 1, pp. 51–59, Sep. 2004.

[173] Y. Yare, G.K. Venayagamoorthy, and U. O. Aliyu, "Optimal generator maintenance scheduling using a modified discrete PSO," *IET Generation, Transmission & Distribution,* vol. 2, no. 6, pp. 834–846, 2008.

[174] J. Park, Y. Jeong, J. Shin, and K. Y. Lee "An improved particle swarm optimization for nonconvex economic dispatch problems," *IEEE Transaction on Power Systems.*, vol. 25, no. 1, pp. 156–166, Feb. 2010.

[175] S. Chakraborty, T. Senjyu, A. Yona, A. Y. Saber, and T. Funabashi, "Solving economic load dispatch problem with valve-point effects using a hybrid quantum mechanics inspired particle swarm optimisation," *IET Generation, Transmission & Distribution*, vol. 5, no. 10, pp. 1042-1052, 2011.

[176] Z. L. Gaing and C. H. Lin, "Contingency-constrained optimal power flow using simplex-based chaotic-PSO algorithm," *Applied Computational Intelligence and Soft Computing*, vol. 2011, pp. 1–13, 2011.

[177] A. Hoballah and I. Erlich, "Online market-based rescheduling strategy to enhance power system stability," *IET Generation, Transmission & Distribution*, vol. 6, no. 1, pp. 30-38, 2012.

[178] T. Niknam, M. R. Narimani, J. Aghaei, and R. A. Abarghooee, "Improved particle swarm optimisation for multi-objective optimal power flow considering the cost, loss, emission and voltage stability index," *IET Generation, Transmission & Distribution*, vol. 6, no. 6, pp. 515-527, 2012.

[179] B. Zhao, C. X. Guo, and Y. J. Cao, "A multiagent-based particle swarm optimization approach for optimal reactive power dispatch," *IEEE Transaction on Power Systems.*, vol. 20, no. 2, pp. 1070–1078, May 2005.

[180] S. Kannan, S. M. R. Slochanal, P. Subbaraj, and N. P. Padhy, "Application of particlc swarm optimization tcchniquc and its variants to generation expansion planning problem," *Electric Power Systems Research*, vol. 70, no. 3, pp. 203–210, Aug. 2004.

[181] A. Shunmugalatha and S. M. R. Slochanal, "Optimum cost of generation for maximum loadability limit of power system using hybrid particle swarm optimization," *International Journal of Electrical Power & Energy Systems*, vol. 30, no. 8, pp. 486–490, Oct. 2008.

[182] Y. W. Jeong, J. B. Park, S. Jang, and K. Y. Lee, "A new quantum-inspired binary PSO: application to unit commitment problems for power systems," *IEEE Transaction on Power Systems.*, vol. 25, no. 3, pp. 1486–1495, Aug. 2010.

[183] P. Faria, J. Soares, Z. Vale, H. Morais, and T. Sousa, "Modified particle swarm optimization applied to integrated demand response and dg resources scheduling," *IEEE Transactions on Smart Grid*, vol. 4, no. 1, pp. 606–616, March 2013.

[184] World-wide existing websites of various independent system operators (ISOs).

List of Publications

Journals

1. B. Singh, R. Mahanty and S.P. Singh, "Congestion management with social welfare in centralized and decentralized power market using Interior Point initialized PSO", *IET Generation, Transmission & Distribution,* April 2014. *(Communicated)*
2. B. Singh, R. Mahanty and S.P. Singh, "Centralized and decentralized optimal decision support for congestion management", *Int. J. Electric Power and Energy Systems,* July 2013. *(Communicated)*
3. B. Singh, R. Mahanty and S.P. Singh, "Optimal Rescheduling of Generators for Congestion Management and Benefit Maximization in a Decentralized Bilateral Multi-Transactions Power Network", *Int. J. Emerging Electric Power Systems,* pp. 1-7, vol. 14 (1), April 2013. *(ISSN: Online 1553-779x, ISSN: Print 2194-5756, DOI: 10.1515/ijeeps-2013-0024, April 2013)*
4. B. Singh, R. Mahanty and S.P. Singh, "Optimal power flow with benefit maximisation in coordinated bilateral power market", *Int. J. Power and Energy Conversion*, pp. 268-277, vol. 4(3), June 2013. *(ISSN: Print 1757-1154, ISSN: Online 1757-1162, DOI: 10.1504/IJPEC.2013.054845, June 24, 2013)*

Conferences

1. B. Singh, R. Mahanty and S.P. Singh, "Security Constraints Optimal Power Flow Using Primal-Dual Interior Point Optimization Technique," *National Conference on Mathematical Modeling and Computer Simulation,* MMCS, Deptt. of Applied Mathematics, Institute of Technology, Banaras Hindu University, Varanasi, March 23-25, 2012.
2. B. Singh, R. Mahanty, and S. P. Singh, "Security Constraints Optimal Power Flow and Generator Rescheduling Using Interior Point Optimization Technique," *Proc. National Conf. on Competitive Electricity Markets and Regulatory Frame Work I*ssues & Challenges*, Power System Division, CPRI, Bangalore,* pp. 1-6, 16-17 Feb., 2012.
3. B. Singh, R. Mahanty and S. P. Singh, "Interior point optimization based congestion management in centralized power network," *National Conference on Emerging trends in electrical and electronics engineering,* ETEEE, Deptt. of Electrical Engineering , KNIT Sultanpur, U.P., 26-27 Nov., 2011.
4. B. Singh, R. Mahanty and S.P. Singh, "A Decentralized Congestion Management Using Interior Point Method*," IEEE Power and Energy Society General Meeting*, pp. 1-7, July 24-29, 2011, Detroit, Michigan, USA.
5. B. Singh, R. Mahanty and S.P. Singh, "Congestion Management Solution for Decentralized Power Network using Interior Point Optimal Power Flow," *National Conference on Mathematical Modeling and Computer Simulation,* MMCS, Deptt. of Applied Mathematics, Institute of Technology, Banaras Hindu University, Varanasi, pp. 294-300, March 25-27, 2011.
6. B. Singh, R. Mahanty, and S. P. Singh, "A decentralized congestion management using interior point method," *Proc. National Conf. on Power, Instrumentation, Energy and Control (PICON-2011), Electrical Engineering Department, AMU, Aligarh,* pp. 294-300, 12-13 Feb., 2011.