Systems Data

- **Garver System**

Generation and load levels			
Bus	**Generation capacity (MW)**	**Generation (MW)**	**Load (MW)**
1	150	50	80
2	0.0	0.0	240
3	360	165	40
4	0.0	0.0	160
5	0.0	0.0	240
6	600	545	0.0

Existing circuits in the base topology				
Transmission line	**Existing circuits**	**Resistance (Ω)**	**Reactance (Ω)**	**Capacity (MW)**
1-2	1	10	40	100
1-4	1	15	60	80
1-5	1	5	20	100
2-3	1	5	20	100
2-4	1	10	40	100
3-5	1	5	20	100

Candidate circuits				
Transmission line	**Resistance (Ω)**	**Reactance (Ω)**	**Capacity (MW)**	**Investiment cost (million dollars)**
1-2	10	40	100	40
1-4	15	60	80	60
1-5	5	20	100	20
2-3	5	20	100	20
2-4	10	40	100	40
3-5	5	20	100	20
1-3	9	38	100	38
1-6	17	68	70	68
2-5	8	31	100	31
2-6	8	30	100	30
3-4	15	59	82	59
3-6	12	48	100	48
4-5	16	63	75	63
4-6	8	30	100	30
5-6	15	61	78	61

- **IEEE-24 Bus System**

Generation and load levels							
Bus	**Generation capacity (MW)**	**Generation**					**Load (MW)**
		- G0 - (MW)	**- G1 - (MW)**	**- G2 - (MW)**	**- G3 - (MW)**	**- G4 - (MW)**	
1	576	576	576	465	576	520	324
2	576	576	576	576	576	520	291
3	0.0	0.0	0.0	0.0	0.0	0.0	540
4	0.0	0.0	0.0	0.0	0.0	0.0	222
5	0.0	0.0	0.0	0.0	0.0	0.0	213
6	0.0	0.0	0.0	0.0	0.0	0.0	408
7	900	900	900	722	900	812	375
8	0.0	0.0	0.0	0.0	0.0	0.0	513
9	0.0	0.0	0.0	0.0	0.0	0.0	525
10	0.0	0.0	0.0	0.0	0.0	0.0	585
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	1773	1773	1773	1424	1457	1599	795
14	0.0	0.0	0.0	0.0	0.0	0.0	582
15	645	645	645	645	325	581	951
16	465	465	465	465	282	419	300
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	1200	1200	1200	1200	603	718	999
19	0.0	0.0	0.0	0.0	0.0	0.0	543
20	0.0	0.0	0.0	0.0	0.0	0.0	384
21	1200	1200	1200	1200	951	1077	0.0
22	900	900	900	900	900	900	0.0
23	1980	1980	315	953	1980	1404	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Existing circuits in the base topology				
Transmission line	**Existing circuits**	**Resistance (Ω)**	**Reactance (Ω)**	**Capacity (MW)**
1-2	1	5.403	1.39	175
1-3	1	5.403	21.12	175
1-5	1	4.699	8.45	175
2-4	1	5.811	12.67	175
2-6	1	5.695	19.20	175
3-9	1	6.701	11.90	175
3-24	1	1.335	8.39	400
4-9	1	1.335	10.37	175
5-10	1	17.093	8.83	175
6-10	1	17.093	6.05	175
7-8	1	9.498	6.14	175
8-9	1	12.291	16.51	175
8-10	1	12.291	16.51	175
9-11	1	6.615	8.39	400
9-12	1	6.615	8.39	400
10-11	1	6.615	8.39	400
10-12	1	6.615	8.39	400
11-13	1	6.615	4.76	500
11-14	1	0.615	4.18	500
12-13	1	6.615	4.76	500
12-23	1	.000	9.66	500
13-23	1	3.181	8.65	500
14-16	1	8.205	3.89	500
15-16	1	8.205	1.73	500
15-21	2	22.092	4.90	500
15-24	1	.000	5.19	500
16-17	1	.000	2.59	500
16-19	1	.000	2.31	500
17-18	1	9.498	1.44	500
17-22	1	9.498	10.53	500
18-21	2	9.498	2.59	500
19-20	2	9.498	3.96	500
20-23	2	8.205	2.16	500
21-22	1	8.205	6.78	500

Candidate circuits				
Transmission line	**Resistance (Ω)**	**Reactance (Ω)**	**Capacity (MW)**	**Investiment cost (million dollars)**
1-8	1.938	13.44	500	35
2-8	5.403	12.67	500	33
6-7	4.699	19.20	500	50
13-14	5.811	4.47	500	62
14-16	8.205	6.20	500	86
16-23	6.701	8.22	500	114
19-23	1.335	6.06	500	84
1-2	5.403	1.39	175	3
1-3	5.403	21.12	175	55
1-5	4.699	8.45	175	22
2-4	5.811	12.67	175	33
2-6	5.695	19.20	175	50
3-9	6.701	11.90	175	31
3-24	1.335	8.39	400	50
4-9	1.335	10.37	175	27
5-10	17.093	8.83	175	23
6-10	17.093	6.05	175	16
7-8	9.498	6.14	175	16
8-9	12.291	16.51	175	43
8-10	12.291	16.51	175	43
9-11	6.615	8.39	400	50
9-12	6.615	8.39	400	50
10-11	6.615	8.39	400	50
10-12	6.615	8.39	400	50
11-13	6.615	4.76	500	66
11-14	0.615	4.18	500	58
12-13	6.615	4.76	500	66
12-23	0.000	9.66	500	134
13-23	3.181	8.65	500	120
14-16	8.205	3.89	500	54
15-16	8.205	1.73	500	24
15-21	22.092	4.90	500	68
15-24	0.000	5.19	500	72
16-17	0.000	2.59	500	36
16-19	0.000	2.31	500	32
17-18	9.498	1.44	500	20
17-22	9.498	10.53	500	146
18-21	9.498	2.59	500	36
19-20	9.498	3.96	500	55
20-23	8.205	2.16	500	30
21-22	8.205	6.78	500	94

- **South Brazilian System**

Generation and load levels			
Bus	**Generation capacity (MW)**	**Generation (MW)**	**Load (MW)**
1	0.0	0.0	0.0
2	0.0	0.0	443.1
3	0.0	0.0	0.0
4	0.0	0.0	300.7
5	0.0	0.0	238
6	0.0	0.0	0.0
7	0.0	0.0	0.0
8	0.0	0.0	72.2
9	0.0	0.0	0.0
10	0.0	0.0	0.0
11	0.0	0.0	0.0
12	0.0	0.0	511.9
13	0.0	0.0	185.8
14	1257	944	0.0
15	0.0	0.0	0.0
16	2000	1366	0.0
17	1050	1000	0.0
18	0.0	0.0	0.0
19	1670	773	0.0
20	0.0	0.0	1091
21	0.0	0.0	0.0
22	0.0	0.0	81.9
23	0.0	0.0	458.1
24	0.0	0.0	478.2
25	0.0	0.0	0.0
26	0.0	0.0	231.9
27	220	54	0.0
28	800	730	0.0
29	0.0	0.0	0.0
30	0.0	0.0	0.0
31	700	310	0.0
32	500	450	0.0
33	0.0	0.0	229.1
34	748	221	0.0
35	0.0	0.0	216.0
36	0.0	0.0	90.1
37	300	212	0.0
38	0.0	0.0	216
39	600	221	0.0
40	0.0	0.0	262.1
41	0.0	0.0	0.0
42	0.0	0.0	1607
43	0.0	0.0	0.0
44	0.0	0.0	79.1
45	0.0	0.0	86.7
46	700	599	0.0

Existing circuits in the base topology				
Transmission line	**Existing circuits**	**Resistance (Ω)**	**Reactance (Ω)**	**Capacity (MW)**
1-7	1	1.9380	6.16	270
1-2	2	5.4030	10.65	270
4-9	1	4.6990	9.24	270
5-9	1	5.8110	11.73	270
5-8	1	5.6950	11.32	270
7-8	1	6.7010	10.23	270
4-5	2	1.3350	5.66	270
2-5	2	17.0930	3.24	270
8-13	1	9.4980	13.48	240
9-14	2	12.2910	17.56	220
12-14	2	6.6150	7.40	270
14-18	2	6.6150	15.14	240
13-18	1	6.6150	18.05	220
13-20	1	0.6150	17.03	270
18-20	1	6.6150	19.97	200
19-21	1	0.0000	2.78	1500
16-17	1	3.1810	0.78	2000
17-19	1	8.2050	0.61	2000
14-26	1	8.2050	16.14	220
14-22	1	22.0920	8.40	270
22-26	1	0.0000	7.90	270
20-23	2	0.0000	9.32	270
23-24	2	9.4980	7.74	270
26-27	2	9.4980	8.32	270
24-34	1	8.2050	16.47	220
24-33	1	8.2050	14.48	240
33-34	1	8.2050	12.65	270
27-36	1	12.2910	9.15	270
27-38	2	22.0920	20.8	200
36-37	1	9.4980	10.57	270
34-35	2	8.2050	4.91	270
35-38	1	8.2050	19.80	200
37-39	1	8.2050	2.83	270
37-40	1	8.2050	12.81	270
37-42	1	0.0000	21.05	200
39-42	3	0.0000	20.30	200
40-42	1	8.2050	9.32	270
38-42	3	8.2050	9.07	270
32-43	1	8.2050	3.09	1400
42-44	1	8.2050	12.06	270
44-45	1	8.2050	18.64	200
19-32	1	8.2050	1.95	1800
46-19	1	8.2050	2.22	1800
46-16	1	8.2050	2.03	1800
18-19	1	8.2050	1.25	600
20-21	1	8.2050	1.25	600
42-43	1	8.2050	1.25	600

Candidate circuits				
Transmission line	**Resistance (Ω)**	**Reactance (Ω)**	**Capacity (MW)**	**Investment cost (million dollars)**
1-7	1.9380	6.16	270	4.35
1-2	5.4030	10.65	270	7.08
4-9	4.6990	9.24	270	6.22
5-9	5.8110	11.73	270	7.74
5-8	5.6950	11.32	270	7.50
7-8	6.7010	10.23	270	6.83
4-5	1.3350	5.66	270	4.05
2-5	17.0930	3.24	270	2.58
8-13	9.4980	13.48	240	8.80
9-14	12.2910	17.56	220	11.27
12-14	6.6150	7.40	270	5.11
14-18	6.6150	15.14	240	9.80
13-18	6.6150	18.05	220	11.57
13-20	6.6150	17.03	270	7.17
18-20	6.6150	19.97	200	12.74
19-21	6.0000	2.78	1500	32.64
16-17	3.1810	0.78	2000	10.51
17-19	8.2050	0.61	2000	8.72
14-26	8.2050	16.14	220	10.41
14-22	22.0920	8.40	270	5.72
22-26	0.0000	7.90	270	5.41
20-23	0.0000	9.32	270	6.27
23-24	9.4980	7.74	270	5.31
26-27	9.4980	8.32	270	5.66
24-34	8.2050	16.47	220	10.61
24-33	8.2050	14.48	240	9.34
33-34	8.2050	12.65	270	8.28
27-36	12.2910	9.15	270	6.17
27-38	22.0920	20.8	200	13.24
36-37	9.4980	10.57	270	7.02
34-35	8.2050	4.91	270	3.59
35-38	8.2050	19.80	200	12.63
37-39	8.2050	2.83	270	2.33
37-40	8.2050	12.81	270	8.38
37-42	0.0000	21.05	200	13.38
39-42	0.0000	20.30	200	12.93

Candidate circuits				
Transmission line	**Resistance (Ω)**	**Reactance (Ω)**	**Capacity (MW)**	**Investiment cost (million dollars)**
40-42	8.2050	9.32	270	6.26
38-42	8.2050	9.07	270	6.11
32-43	8.2050	3.09	1400	35.917
42-44	8.2050	12.06	270	7.93
44-45	8.2050	18.64	200	11.94
19-32	8.2050	1.95	1800	23.42
46-19	8.2050	2.22	1800	26.36
46-16	8.2050	2.03	1800	24.31
18-19	8.2050	1.25	600	8.17
20-21	8.2050	1.25	600	8.17
42-43	8.2050	1.25	600	8.17
02-04	6.6150	8.82	270	5.97
14-15	6.6150	3.74	270	2.89
46-10	6.6150	0.81	2000	10.89
04-11	6.6150	22.46	240	14.25
05-11	6.6150	9.15	270	6.17
46-06	6.6150	1.28	2000	16.00
46-03	6.6150	2.03	1800	24.32
16-28	6.6150	2.22	1800	26.36
16-32	6.6150	3.11	1400	36.21
17-32	6.6150	2.32	1700	27.51
19-25	6.6150	3.25	1400	37.75
21-25	6.6150	1.74	2000	21.12
25-32	6.6150	3.19	1400	37.11
31-32	6.6150	0.46	2000	7.14
28-31	6.6150	0.53	2000	7.82
28-30	6.6150	0.58	2000	8.33
27-29	6.6150	9.98	270	6.67
26-29	6.6150	5.41	270	3.89
28-41	6.6150	3.39	1300	39.29
28-43	6.6150	4.06	1200	47.70
31-41	6.6150	2.78	1500	32.63
32-41	6.6150	3.09	1400	35.95
41-43	6.6150	1.39	2000	17.29
40-45	6.6150	22.05	180	13.99
15-16	6.6150	1.25	600	8.17
46-11	6.6150	1.25	600	8.17
24-25	6.6150	1.25	600	8.17
29-30	6.6150	1.25	600	8.17
40-41	6.6150	1.25	600	8.17
02-03	6.6150	1.25	600	8.17
05-06	6.6150	1.25	600	8.17
09-10	6.6150	1.25	600	8.17

- **Colombian System**
  - **Generation and load levels – P1**

Generation and load levels		
Bus	**Generation (MW)**	**Load (MW)**
1	240	0.0
2	0.0	352.90
3	0.0	393.00
4	0.0	0.0
5	40	235.00
6	34	0.0
7	0.0	300.00
8	100	339.00
9	0.0	348.00
10	0.0	60.00
11	80	147.00
12	47	0.0
13	0.0	174.00
14	0.0	0.0
15	0.0	377.00
16	0.0	236.00
17	35	136.00
18	480	36.20
19	900	19.60
20	0.0	202.40
21	0.0	186.00
22	200	53.00
23	0.0	203.00
29	618	339.00
30	0.0	137.00
31	189	234.00
32	0.0	126.00
33	0.0	165.00
34	0.0	77.50

Generation and load levels		
Bus	**Generation (MW)**	**Load (MW)**
35	200	172.00
36	0.0	112.00
37	138	118.00
38	0.0	86.00
39	0.0	180.00
40	305	0.0
41	70	54.80
42	0.0	102.00
43	0.0	35.40
44	23	257.00
45	950	0.0
64	0.0	88.00
65	0.0	132.00
66	200	0.0
67	474	266.00
68	0.0	0.0
69	0.0	71.40
70	30	0.0
71	0.0	315.00
72	0.0	0.0
73	0.0	0.0
74	0.0	0.0
75	0.0	0.0
76	40	0.0
77	0.0	55.00
78	0.0	36.65
79	0.0	98.00
80	0.0	60.00
81	0.0	0.0
82	0.0	0.0
83	0.0	0.0
84	0.0	0.0
85	0.0	0.0
86	0.0	0.0
87	0.0	0.0
88	0.0	0.0
89	0.0	0.0
90	0.0	0.0
91	0.0	0.0
92	0.0	0.0
93	0.0	0.0

o Generation and load levels – P2

Generation and load levels		
Bus	**Generation (MW)**	**Load (MW)**
1	240	0.0
2	165	406.53
3	0.0	490.50
4	0.0	0.0
5	40	293.56
6	34	0.0
7	0.0	374.26
8	230	423.00
9	0.0	434.12
10	0.0	74.21
11	108	183.90
12	47	0.0
13	0.0	217.26
14	0.0	0.0
15	0.0	470.17
16	0.0	294.00
17	35	169.57
18	540	45.20
19	1.340	24.46
20	0.0	252.50
21	0.0	231.70
22	200	66.13
23	0.0	252.50
24	150	0.0
25	86	0.0
26	70	0.0
27	0.0	331.40
28	0.0	406.30
29	618	422.60
30	0.0	166.70
31	189	327.30
32	0.0	157.30
33	0.0	206.53
34	0.0	96.70
35	200	214.60
36	0.0	140.00
37	138	147.30
38	15	108.40
39	0.0	224.00
40	305	0.0
41	100	68.40
42	0.0	127.30
43	0.0	44.20
44	23	321.30
45	1.208	0.0
46	150	151.70
47	0.0	51.50
48	885	750.00
49	0.0	162.00
50	240	528.00

Generation and load levels		
Bus	**Generation (MW)**	**Load (MW)**
51	0.0	159.00
52	0.0	46.50
53	320	0.0
54	0.0	95.30
55	40	279.00
56	0.0	0.0
57	130	281.00
58	190	0.0
59	160	0.0
60	1.216	0.0
61	155	0.0
62	0.0	0.0
63	1.090	44.00
64	0.0	110.55
65	0.0	165.00
66	300	0.0
67	474	332.45
68	0.0	0.0
69	0.0	89.00
70	180	0.0
71	211	393.00
72	0.0	0.0
73	0.0	0.0
74	0.0	0.0
75	0.0	0.0
76	40	0.0
77	0.0	70.00
78	0.0	45.10
79	0.0	123.00
80	0.0	72.00
81	0.0	0.0
82	0.0	0.0
83	0.0	0.0
84	0.0	0.0
85	0.0	0.0
86	300.0	0.0
87	0.0	0.0
88	0.0	0.0
89	0.0	0.0
90	0.0	0.0
91	0.0	0.0
92	0.0	0.0
93	0.0	0.0

o Generation and load levels – P3

Generation and load levels		
Bus	**Generation (MW)**	**Load (MW)**
1	240	0.0
2	165	486.66
3	0.0	587.08
4	0.0	0.0
5	40	351.42
6	34	0.0
7	136	448.03
8	230	505.87
9	0.0	519.69
10	0.0	88.84
11	108	220.15
12	47	0.0
13	0.0	260.08
14	0.0	0.0
15	0.0	562.84
16	0.0	351.90
17	35	203.00
18	540	54.10
19	1.340	29.28
20	45	302.27
21	0.0	277.44
22	200	79.17
23	0.0	302.27
24	150	0.0
25	86	0.0
26	70	0.0
27	0.0	396.71
28	14.0	486.39
29	618	505.96
30	0.0	199.5
31	189	391.88
32	0.0	188.33
33	0.0	247.24
34	0.0	115.81
35	200	256.86
36	44	167.29
37	138	176.30
38	15	129.72
39	15	268.19
40	305	0.0
41	100	81.85
42	0.0	152.39
43	0.0	52.90
44	23	384.64
45	1.208	0.0
46	150	151.70
47	0.0	51.50
48	885	896.26
49	0.0	193.27
50	240	632.75

Generation and load levels		
Bus	**Generation (MW)**	**Load (MW)**
51	0.0	190.45
52	0.0	55.60
53	320	0.0
54	0.0	114.19
55	40	333.59
56	0.0	0.0
57	130	336.94
58	190	0.0
59	160	0.0
60	1.216	0.0
61	155	0.0
62	0.0	0.0
63	1.090	52.77
64	280	132.35
65	0.0	197.58
66	300	0.0
67	474	397.98
68	0.0	0.0
69	0.0	106.61
70	180	0.0
71	424	471.21
72	0.0	0.0
73	0.0	0.0
74	0.0	0.0
75	0.0	0.0
76	40	0.0
77	0.0	82.85
78	0.0	54.07
79	300	146.87
80	0.0	88.34
81	0.0	0.0
82	0.0	0.0
83	0.0	0.0
84	500	0.0
85	0.0	0.0
86	850	0.0
87	0.0	0.0
88	300	0.0
89	0.0	0.0
90	0.0	0.0
91	0.0	0.0
92	0.0	0.0
93	0.0	0.0

o Data of transmission lines for all Colombian Systems

Existing circuits in the base topology			
Transmission line	**Existing circuit**	**Reactance (Ω)**	**Capacity (MW)**
25-28	1	5.65	320
25-29	1	5.70	320
13-14	2	0.09	350
13-20	1	1.78	350
13-23	1	2.77	350
14-31	2	13.07	250
14-18	2	14.94	250
14-60	2	10.67	300
2-4	2	2.71	350
2-9	1	1.22	350
2-83	1	2.00	570
9-83	1	2.00	400
15-18	1	3.65	450
15-17	1	4.83	320
15-20	1	5.13	320
15-76	1	4.14	320
15-24	1	1.45	350
37-61	1	1.39	350
19-61	2	11.05	250
61-68	1	7.89	250
37-68	1	5.44	320
40-68	1	13.20	320
12-75	1	6.41	320
24-75	1	1.61	350
35-36	1	20.74	250
27-35	1	14.98	250
35-44	2	13.58	250
38-68	1	3.89	350
38-39	1	3.00	350
27-80	1	2.42	350
44-80	1	10.14	250
56-81	1	1.14	550
45-54	1	9.46	320
45-50	2	0.70	350
10-78	1	1.02	350
7-78	1	0.43	350
30-64	1	15.33	250
30-65	1	9.10	250
30-72	2	1.73	350
55-57	1	1.74	600
57-84	1	0.87	600
55-84	1	0.87	600
56-57	1	2.40	600
9-77	1	1.90	350
77-79	1	0.97	350
1-59	2	2.32	350
59-67	2	11.80	250
8-59	2	10.56	250
1-3	1	10.40	250
3-71	1	1.36	450
3-6	1	4.97	350

Existing circuits in the base topology			
Transmission line	**Existing circuit**	**Reactance (Ω)**	**Capacity (MW)**
55-62	1	2.81	550
47-52	1	6.44	350
51-52	1	8.59	250
29-31	2	10.42	250
41-42	1	0.94	350
40-42	1	1.53	350
46-53	2	10.41	250
46-51	1	11.41	250
69-70	2	2.28	350
66-69	2	12.17	250
9-69	2	10.98	350
60-69	2	9.06	350
31-32	1	2.59	350
32-34	1	5.40	350
16-18	1	6.25	350
16-23	1	2.38	350
16-21	1	2.82	350
31-34	1	7.92	250
31-33	2	2.48	350
31-60	2	19.44	250
31-72	2	2.44	350
47-54	2	10.03	250
47-49	2	9.42	250
18-58	2	2.12	350
18-20	1	5.04	350
18-66	2	6.64	350
18-21	1	3.48	350
18-22	1	2.09	350
19-22	1	6.91	350
4-5	3	0.49	350
5-6	2	0.74	350
17-23	1	9.13	250
17-76	1	0.20	350
12-17	1	0.86	350
1-71	2	8.41	250
1-8	1	8.10	250
1-11	1	7.99	250
4-36	2	8.50	250
19-58	1	8.26	320
27-64	1	2.80	350
27-28	1	2.38	350
27-44	1	8.93	250
26-27	1	6.57	350
27-29	1	1.66	350
19-66	1	5.16	350
73-74	1	2.14	600
64-65	1	7.41	350
29-64	1	0.63	350
4-34	2	10.16	270
34-70	2	4.15	350
33-34	1	11.39	320
8-71	1	0.75	400

Existing circuits in the base topology			
Transmission line	**Existing circuit**	**Reactance (Ω)**	**Capacity (MW)**
54-63	3	4.95	320
48-63	1	2.38	350
67-68	2	16.60	250
39-68	1	1.45	350
8-9	1	1.68	350
79-87	1	0.71	350
8-87	1	1.32	350
39-43	1	11.63	250
41-43	1	11.42	250
23-24	1	2.55	350
21-22	1	5.49	350
26-28	1	5.12	350
28-29	1	2.81	350
6-10	1	3.37	350
33-72	1	2.28	350
39-40	2	10.20	250
12-76	1	0.81	350
48-54	3	3.96	350
50-54	2	8.76	250
62-73	1	2.72	750
49-53	2	10.08	250
40-41	1	1.86	350
45-81	1	2.67	450
64-74	1	2.67	500
54-56	3	2.67	450
60-62	3	2.57	450
72-73	2	2.67	500
19-82	1	2.67	450
55-82	1	2.90	550
83-85	2	2.67	450
82-85	1	3.41	700
19-86	1	15.13	300
68-86	1	4.04	350
7-90	2	0.50	350
3-90	1	0.74	350
90-91	1	2.67	550
85-91	1	1.39	600
11-92	1	2.67	450
1-93	1	2.67	450
92-93	1	0.97	600
91-92	1	0.88	600

Candidate circuits			
Transmission line	**Reactance (Ω)**	**Capacity (MW)**	**Investiment cost (million dollars)**
52-88	9.80	300	34.190
43-88	18.16	250	39.56
57-81	2.19	550	58.89
73-82	3.74	550	97.96
27-89	2.67	450	13.27
74-89	0.34	550	14.57
73-89	2.46	550	66.65
79-83	4.57	350	15.40
8-67	22.40	250	29.20
39-86	5.45	350	9.88
25-28	5.65	320	9.767
25-29	5.70	320	9.88
13-14	0.09	350	3.90
13-20	1.78	350	5.742
13-23	2.77	350	7.007
14-31	13.07	250	18.622
14-18	14.94	250	20.232
14-60	10.67	300	15.977
2-4	2.71	350	6.662
2-9	1.22	350	5.282
2-83	2.00	570	5.972
9-83	2.00	400	5.972
15-18	3.65	450	7.927
15-17	4.83	320	9.422
15-20	5.13	320	9.652
15-76	4.14	320	9.882
15-24	1.45	350	5.282
37-61	1.39	350	4.937
19-61	11.05	250	16.092
61-68	7.89	250	12.412
37-68	5.44	320	9.652
40-68	13.20	320	18.162
12-75	6.41	320	11.492
24-75	1.61	350	5.512
35-36	20.74	250	27.362
27-35	14.98	250	22.072
35-44	13.58	250	20.347
38-68	3.89	350	7.927
38-39	3.00	350	6.317
27-80	2.42	350	7.007
44-80	10.14	250	17.587
56-81	1.14	550	32.858
45-54	9.46	320	13.562
45-50	0.70	350	4.362

Candidate circuits			
Transmission line	**Reactance (Ω)**	**Capacity (MW)**	**Investiment cost (million dollars)**
10-78	1.02	350	4.937
7-78	0.43	350	4.132
30-64	15.33	250	20.577
30-65	9.10	250	13.677
30-72	1.73	350	5.512
55-57	1.74	600	46.808
57-84	0.87	600	26.658
55-84	0.87	600	26.658
56-57	2.40	600	62.618
9-77	1.90	350	5.857
77-79	0.97	350	5.167
1-59	2.32	350	6.202
59-67	11.80	250	16.667
8-59	10.56	250	15.402
1-3	10.40	250	15.862
3-71	1.36	450	5.167
3-6	4.97	350	9.422
55-62	2.81	550	70.988
47-52	6.44	350	10.572
51-52	8.59	250	12.872
29-31	10.42	250	32.981
41-42	0.94	350	4.707
40-42	1.53	350	5.167
46-53	10.41	250	14.597
46-51	11.41	250	16.322
69-70	2.28	350	6.202
66-69	12.17	250	17.127
9-69	10.98	350	15.747
60-69	9.06	350	13.677
31-32	2.59	350	6.547
32-34	5.40	350	9.767
16-18	6.25	350	10.917
16-23	2.38	350	6.892
16-21	2.82	350	6.892
31-34	7.92	250	12.412
31-33	2.48	350	6.432
31-60	19.44	250	25.982
31-72	2.44	350	6.317
47-54	10.03	250	14.252
47-49	9.42	250	13.562
18-58	2.12	350	5.742
18-20	5.04	350	9.537
18-66	6.64	350	11.377
18-21	3.48	350	7.467
18-22	2.09	350	6.432
19-22	6.91	350	11.722

Candidate circuits			
Transmission line	**Reactance (Ω)**	**Capacity (MW)**	**Investiment cost (million dollars)**
4-5	0.49	350	4.247
5-6	0.74	350	4.477
17-23	9.13	250	12.987
17-76	0.20	350	3.902
12-17	0.86	350	4.707
1-71	8.41	250	14.367
1-8	8.10	250	13.217
1-11	7.99	250	12.527
4-36	8.50	250	13.562
19-58	8.26	320	11.722
27-64	2.80	350	6.777
27-28	2.38	350	6.202
27-44	8.93	250	16.322
26-27	6.57	350	10.917
27-29	1.66	350	5.052
19-66	5.16	350	9.307
73-74	2.14	600	58.278
64-65	7.41	350	11.837
29-64	0.63	350	4.362
4-34	10.16	270	14.942
34-70	4.15	350	8.272
33-34	11.39	320	16.322
8-71	0.75	400	4.477
54-63	4.95	320	9.077
48-63	2.38	350	6.317
67-68	16.60	250	22.072
39-68	1.45	350	5.282
8-9	1.68	350	5.972
79-87	0.71	350	4.477
8-87	1.32	350	5.167
39-43	11.63	250	16.552
41-43	11.42	250	16.322
23-24	2.55	350	6.317
21-22	05.49	350	9.882
26-28	05.12	350	9.307
28-29	2.81	350	6.777
6-10	3.37	350	7.582
33-72	2.28	350	6.202
39-40	10.20	250	16.207
12-76	0.81	350	4.707
48-54	3.96	350	8.042
50-54	8.76	250	12.872
62-73	2.72	750	73.158
49-53	10.08	250	14.252
40-41	1.86	350	5.742

Candidate circuits			
Transmission line	**Reactance (Ω)**	**Capacity (MW)**	**Investiment cost (millon dollars)**
40-41	1.86	350	5.742
45-81	2.67	450	13.270
64-74	2.67	500	13.270
54-56	2.67	450	13.270
60-62	2.57	450	13.270
72-73	2.67	500	13.270
19-82	2.67	450	13.270
55-82	2.90	550	77.498
62-82	1.01	600	30.998
83-85	2.67	450	13.270
82-85	3.41	700	89.898
19-86	15.13	300	20.922
68-86	4.04	350	8.272
7-90	0.50	350	4.247
3-90	0.74	350	4.592
90-91	2.67	550	13.270
85-91	1.39	600	40.298
11-92	2.67	450	13.270
1-93	2.67	450	13.270
92-93	0.97	600	30.068
91-92	0.88	600	27.588