Applying Dijkstra's Algorithm in Distribution Networks Reconfiguration for Energy Losses Optimization – Supplementary Material[1]

Ezequiel C. Pereira – Cemig-D, João Antônio de Vasconcelos – PPGEE/UFMG,
Carlos H. N. R. Barbosa – DEELT/UFOP, Mateus A. O. Leite CEFET-MG

INTRODUCTION

This is the supplementary material for the article "**Applying Dijkstra's Algorithm to the Distribution Networks Reconfiguration Problem for Energy Losses Minimization**". It is subdivided in the following way: 1. Benchmark Networks; 2. CEMIG-D Feeders Cases; and 3. Bibliography references.

1. BENCHMARK NETWORKS

In this section it will be presented the detailed results for each one of the evolutionary algorithm executions. In the main article, the developed algorithm was tested in four well known benchmark networks, the 33, 70, 84 and 136 buses networks. Table 1 shows these network main characteristics and also includes another benchmark network, the 119 buses network, which also will be detailed ahead.

Table 1 – Benchmark networks characteristics.

Nº Buses	**33**	**70**	**84**	**119**	**136**
Nº Lines/Tie switches	37	74	96	118	156
Nº Gerators/Feeders	1	1	11	1	8
Nº NO switches(cycles)	5	5	13	15	21
Voltage Level (kV)	11	12.66	11.4	11.0	13.8
Active Load (MW)	3.7	3.8	28.3	22.7097	18.31
Reactive Load (MVAr)	2.3	2.7	20.7	17.0411	7.93
Original Losses (kW)	202.69	225.00	531.99	1,296.57	320.36
Optimal Losses (kW)	139.55	99.66	469.88	869.71	280.19
References	[1]	[2]	[3]	[4]	[5]

Table 2 is an expansion from the main article Table comparing the results in terms of average number of power flows with other relevant works from the literature.

[1] Ezequiel C. Pereira is an electrical engineer at Cemig Distribuição S.A. (http://www.cemig.com.br/) since 2006 and a PhD student in the postgraduate program at UFMG (e-mail: ezequiel@ufmg.br). João A. de Vasconcelos He has been with the Electrical Engineering Department at the Federal University of Minas Gerais, since 1985, now retired, but still active with several duties at the Electrical Engineering Graduate Program supervising PhD and master students and coordinating research and development projects for several agencies and power utilities (jvasconcelos@ufmg.br). Carlos H. N. R. Barbosa is a full professor at DEELT/UFOP (email: cbarbosa@ufop.edu.br) and Mateus A. O. Leite is a full professor at CEFET-MG (mateusantunes@cefetmg.br)

Table 2 - Comparison of the proposed algorithm results with other relevant works in terms of the average number of power flow runs

Work/Year	33 buses	70 buses	84 buses	119 buses	136 buses
[4]2007[(1)]				177	
[6]/2008	**24**	-	291		**600**
[7]/2011	252	3,283	-		-
[8]/2012	-	-	-	**53**	-
[9]/2013	202	1,679	-		-
[10]/2013	482	539	1,380		9,040
[11]/2014	57.6	-	-		**419.0**
[12]/2015	68.6	133.0	163.2		-
[13]/2015	-	**10.0**	-		-
[14]/2016[(2)]	71.5	-	185.0		**808.5**
[15]/2016[(2)]	71.5	-	168.5		**841.5**
[16]/2018	1,800	6,000	-		-
[17]/2019	900	-	3,600		-
[18]/2008	**11**	**-**	**24**	**26**	**-**
Prop. EA.	29.0	30.0	70.9	83.0	1,002.7

[(1)] As reported by [18].

[(2)] The number of PF executions was not reported, so it is estimated by $N_{PF} = N_p \cdot G \cdot iT_{mean}$, in which N_p is the population size, G is the maximum number of generations and iT_{mean} denotes the average number of iterations.

33 buses network

The 33 buses network was presented by [19] and popularized by Zhu's work "**Optimal reconfiguration of electrical distribution network using the refined genetic algorithm**" [1]. In the main article, this network is minimized using only the Branch Exchange heuristic iteratively, which the parameters are detailed in Table 3. For this simulation, the population size was set equal to one (i.e. the network original configuration) and the cycle optimization order for the Branch Exchange was set to larger cycles first, explaining why all the executions in Table 4 show the same results.

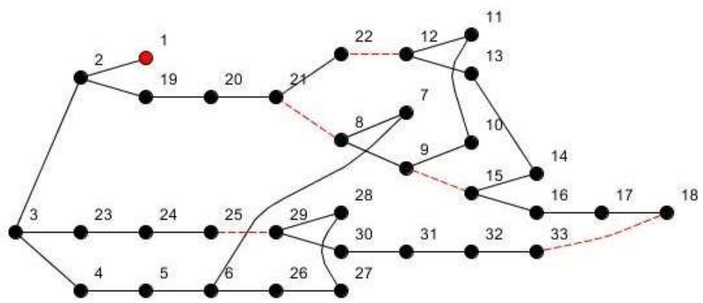

Figure 1 - 33 buses feeder in its original configuration. Source: Author.
Legend: red dashed lines: normally open – NO switches.

Table 3 – Parameters and mean results for the 33 buses network reconfiguration.

Initial configuration - open switches / Losses (kW)	s33, s34, s35, s36, s37 / 202.69
Optimal configuration – open switches / Losses (kW)	s7, s9, s14, s32, s37 / 139.55
Initial population size	1
Maximum population size	10
Maximum generations	5
Branch Exchange cycle order	Largest cycles first
Number of successes (10 runs)	10/10
Mean number power flows - EA	1
Mean number power flows runs – local search	28
Mean number power flow runs – total	29

Table 4 - Results per run (33 buses network).

Runs / Generations	1	2	3	4	5	6	7	8	9	10	
Initial conf.	0.2027	0.2027	0.2027	0.2027	0.2027	0.2027	0.2027	0.2027	0.2027	0.2027	
1	0.1396	0.1396	0.1396	0.1396	0.1396	0.1396	0.1396	0.1396	0.1396	0.1396	
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	Average
nº PF (EA)	1	1	1	1	1	1	1	1	1	1	1.0
t(s)	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2
nº PF (LS)	28	28	28	28	28	28	28	28	28	28	28.0

* nº PF(EA): number of power flows spent in the Evolutionary Algorithm part;
* nº PF(LS): number of power flows spent in the local search part.

70 buses network

The 70 buses network[2] was originally presented by [20] as a "69 buses" system, as the buses numbering used to start from 0. It was popularized by the [2] work's "**Enhanced genetic algorithm-based fuzzy multi-objective approach to distribution network reconfiguration**". In the main article, this network is minimized using only the Branch Exchange heuristic iteratively, which the parameters are detailed in Table 5. For this simulation, the population size was set equal to one (i.e. the network original configuration) and all the 10 executions from Table 6 show the same results, because the cycle optimization order for the Branch Exchange was set to larger cycles first.

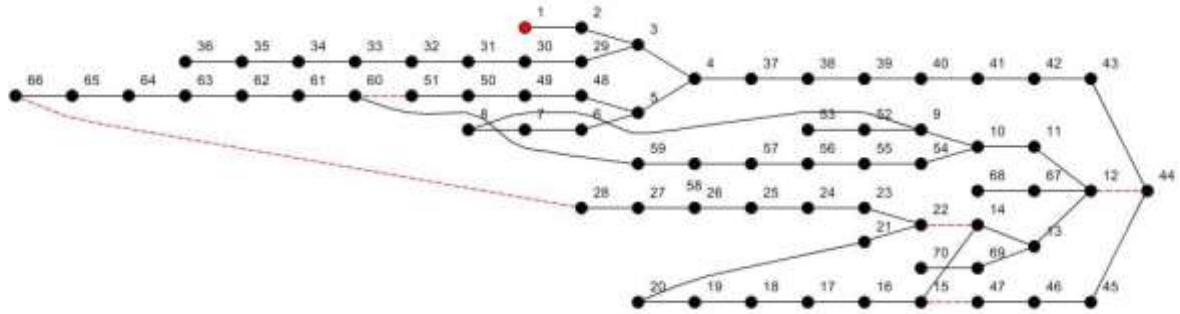

Figure 2 - 70 buses feeder in its original configuration. Source: Author.
Legend: red dashed lines: normally open – NO switches.

Table 5 - Parameters and mean results for the 70 buses network reconfiguration.

Initial configuration - open switches / Losses (kW) [3]	s18, s23, s25, s38, s59 / 225.00
Optimal configuration – open switches / Losses (kW)	s18, s20, s31, s65, s67 / 99.68
Initial population size	1
Maximum population size	10
Maximum generations	5
Branch Exchange cycle order	Largest cycles first
Number of successes (10 runs)	10/10
Mean number power flows - EA	1
Mean power flows runs – local search	29
Mean power flow runs – total	30

[2] In the literature, there is another 70 bus system presented by [26].
[3] In the (Huang, 2002) labelling, the normally opened switches – NOs in initial configuration are: s70, s71, s72, s73, s74, and in the optimal configuration are: s13, s21, s59, s62, s70.

Table 6 - Results per run (70 buses network).

Runs / Generations	1	2	3	4	5	6	7	8	9	10	
Initial conf.	0.22502	0.22502	0.22502	0.22502	0.22502	0.22502	0.22502	0.22502	0.22502	0.22502	
1	0.09968	0.09968	0.09968	0.09968	0.09968	0.09968	0.09968	0.09968	0.09968	0.09968	
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	**Average**
nº PF (EA)	1	1	1	1	1	1	1	1	1	1	1.0
t(s)	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
nº PF (LS)	29	29	29	29	29	29	29	29	29	29	29.0

* nº PF(EA): number of power flows spent in the Evolutionary Algorithm part;
* nº PF(LS): number of power flows spent in the local search part.

84 buses network

The 84 buses network was originally presented by the work "Network Reconfiguration of Distribution Systems Using Improved Mixed-Integer Hybrid Differential Evolution" [3]. It is a real network from Taiwan Power Company –TPC. The original work presents the minimum power losses as 469.88kW for the following tie switches: 7, 13, 34, 39, 42, 55, 62, 72, 83, 86, 89, 90 and, 92, but the work later [21] reported the optimum, changing the tie switch number 42 to 41 with the same approximate value (469.89kW). So, probably the first work reported it wrongly, as the power losses calculated with that first configuration is 471.10 kW.

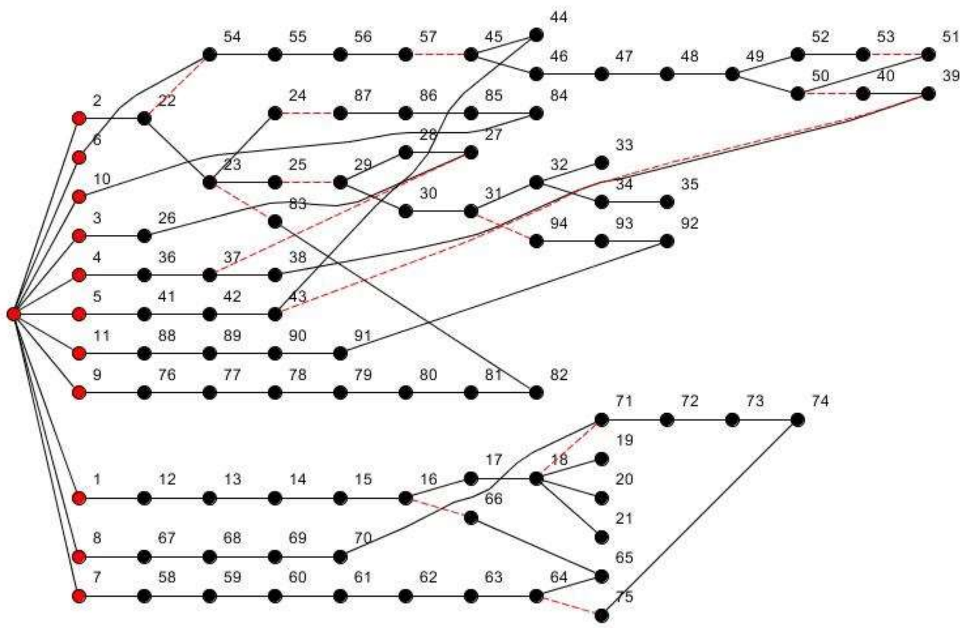

Figure 3 - 84 buses feeder in its original configuration. Source: Author.
Legend: red dashed lines: normally open – NO switches.

In the main article, this network is minimized using only the Branch Exchange heuristic iteratively, which the parameters are detailed in Table 7. For this simulation, the population size was set equal to one (i.e. the network original configuration) and the 10 executions, in Table 8, are different, because the cycle optimization order for the Branch Exchange was set to random.

Table 7 - Parameters and mean results for the 84 buses network reconfiguration

Initial configuration - open switches / Losses (kW)	84,85,86,87,88,89,90,91,92,93,94,95,96 / 532.01
Optimal configuration – open switches / Losses (kW)	7,13,34,39,42,55,62,72,83,86,89,90,92 / 469.89
Initial population size	1
Maximum population size	10
Maximum generations	5
Branch Exchange cycle order	Random order
Number of successes (10 runs)	10/10
Mean number power flows - EA	1
Mean power flows runs – local search	69.9
Mean power flow runs – total	70.9

Table 8 - Results per run (84 buses network).

Runs / Generations	1	2	3	4	5	6	7	8	9	10	
Initial conf.	0.5320	0.5320	0.5320	0.5320	0.5320	0.5320	0.5320	0.5320	0.5320	0.5320	
1	0.4699	0.4701	0.4701	0.4701	0.4699	0.4699	0.4699	0.4699	0.4701	0.4701	
2	0.0000	0.4699	0.4699	0.4699	0.0000	0.0000	0.0000	0.0000	0.4699	0.4699	
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**Average**
nº PF (EA)	1	1	1	1	1	1	1	1	1	1	1.0
t(s)	0.6	0.7	0.6	0.7	0.6	0.5	0.6	0.5	0.7	0.8	0.6
nº PF (LS)	57	75	72	75	65	59	65	59	83	89	69.9

* nº PF(EA): number of power flows spent in the Evolutionary Algorithm part;

* nº PF(LS): number of power flows spent in the local search part.

119 buses network

The 119 buses network was originally presented in the work [4] "An improved TS algorithm for loss minimum reconfiguration in large scale distribution systems". In order to minimize this network, it used an initial population size of 10 individuals and a maximum population size of 20, as shown in Table 9. Also, in the line "**nº selection (EA)"** shows the contribution from the Differential Evolution operators in the new individuals creation.

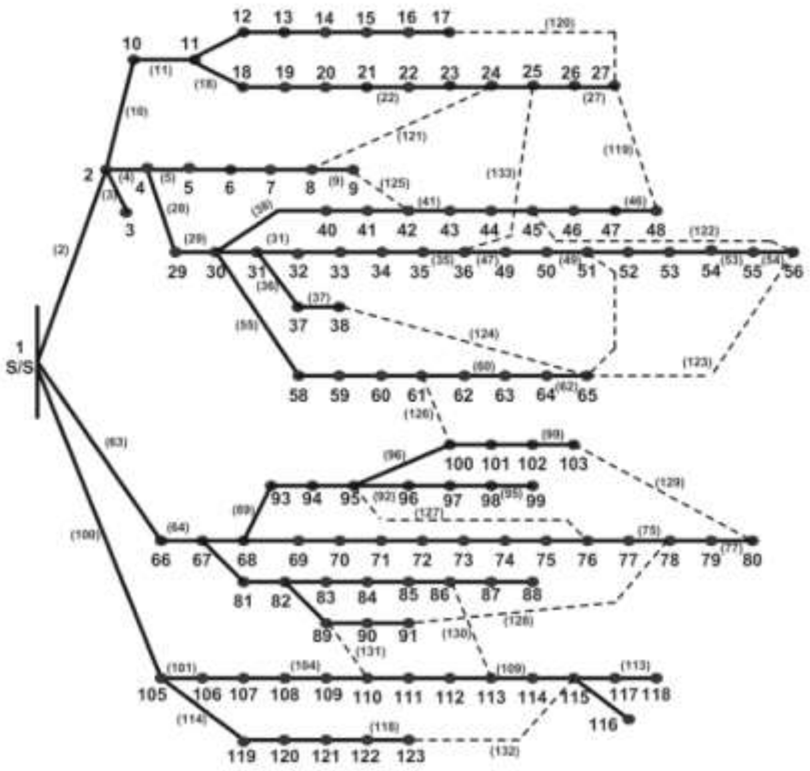

Figure 4- 119 buses feeder in its original configuration. Source: [22].

Table 9 - Parameters and mean results for the 119 buses network reconfiguration.

Initial configuration - Losses (kW)	1,296.57
Optimal configuration – Losses (kW)	869.71
Initial configuration - open switches	119,120,121,122,123,124,125,126,127,128,129,130,131,132,133
Optimal configuration – open switches	24,27,35,40,43,52,59,72,75,96,99,110,123,130,131
Initial population size	10
Maximum population size	20
Maximum generations	5
Branch Exchange cycle order	Largest cycles first
Number of successes (10 runs)	10/10
Mean number power flows - EA	15
Mean power flows runs – local search	68
Mean power flow runs – total	83

Table 10 - Results per run (119 buses network)

Runs / Generations	0	0	0	0	0	0	0	0	0	0	
Initial conf.	1.29657	1.29657	1.29657	1.29657	1.29657	1.29657	1.29657	1.29657	1.29657	1.29657	
1	0.86971	0.86971	0.86971	0.86971	0.86971	0.86971	0.86971	0.86971	0.86971	0.86971	
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	**Average**
nº FP (EA)	14	15	12	19	16	14	13	17	15	15	15.0
t(s)	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
nº FP (LS)	68	68	68	68	68	68	68	68	68	68	68.0
nº selections(EA)	1	1	1	1	1	1	1	1	1	1	1.0

* nº PF(EA): number of power flows spent in the Evolutionary Algorithm part;

* nº PF(LS): number of power flows spent in the local search part.

136 buses network

The 136 buses network was originally presented in the work [5] “**Reconfiguração de Sistemas de Distribuição Radiais utilizando o Critério de Queda de Tensão**” as a “135 buses system”, as the buses numbering used to started from 0. It is a real network from Três Lagoas, Mato Grosso state, Brazil.

This network is more difficult to minimize than the others, because of its greater search space. So, in this case, it was necessary to use an initial population size of 15 individuals and a maximum population size of 50, as shown in Table 11. Also, in Table 12, the line “**nº selection (EA)”** shows the contribution from the Differential Evolution operators in the new individuals creation.

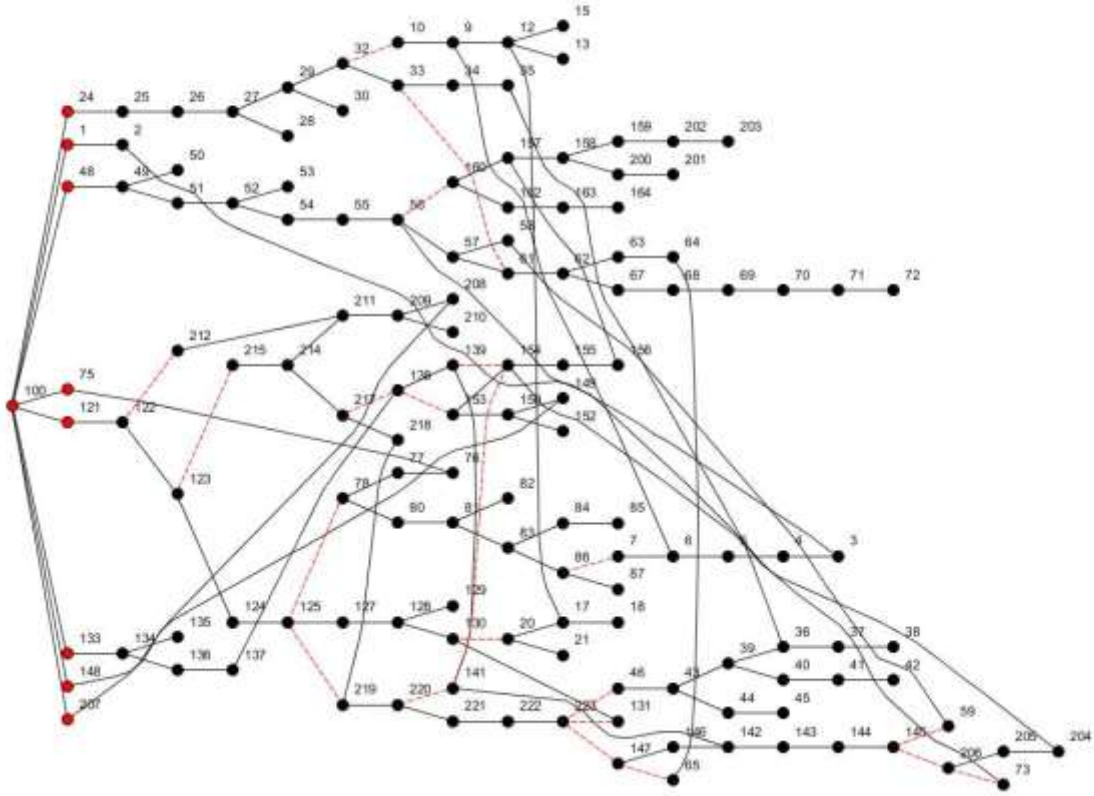

Figure 5- 136 buses feeder in its original configuration. Source: Author

Table 11 - Parameters and mean results for the 136 buses network reconfiguration.

Initial configuration - Losses (kW)	320.36
Optimal configuration – Losses (kW)	280.19
Initial configuration - open switches	136,137,138,139,140,141,142,143,144,145,146,147,148,149,150,151,152,153,154,155,156
Optimal configuration – open switches	7,35,51,90,96,106,118,126,135,137,138,141,142,144,145,146,147,148,150,151,155
Initial population size	15
Maximum population size	50
Maximum generations	30
Number of successes (10 runs)	10/10
Mean number power flows - EA	114.2
Mean power flows runs – local search	888.5
Mean power flow runs – total	1002.7

Table 12 - Results per run (136 buses network)

Runs / Generations	0	0	0	0	0	0	0	0	0	0	
Initial conf.	0.32036	0.32036	0.32036	0.32036	0.32036	0.32036	0.32036	0.32036	0.32036	0.32036	
1	0.28075	0.28048	0.28022	0.28022	0.28075	0.28075	0.28048	0.28022	0.28075	0.28030	
2	0.28030	0.28030	0.28022	0.28022	0.28022	0.28022	0.28030	0.28022	0.28075	0.28022	
3	0.28019	0.28022	0.28022	0.28022	0.28022	0.28022	0.28030	0.28022	0.28022	0.28022	
4	0.00000	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	
5	0.00000	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	
6	0.00000	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	
7	0.00000	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	
8	0.00000	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	
9	0.00000	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	
10	0.00000	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	
11	0.00000	0.28022	0.28019	0.28019	0.28022	0.28022	0.28022	0.28022	0.28022	0.28022	
12	0.00000	0.28022	0.00000	0.00000	0.28022	0.28022	0.28022	0.28022	0.28022	0.28019	
13	0.00000	0.28022	0.00000	0.00000	0.28022	0.28022	0.28019	0.28022	0.28022	0.00000	
14	0.00000	0.28022	0.00000	0.00000	0.28022	0.28022	0.00000	0.28022	0.28022	0.00000	
15	0.00000	0.28022	0.00000	0.00000	0.28022	0.28022	0.00000	0.28022	0.28022	0.00000	
16	0.00000	0.28022	0.00000	0.00000	0.28022	0.28022	0.00000	0.28022	0.28022	0.00000	
17	0.00000	0.28022	0.00000	0.00000	0.28022	0.28019	0.00000	0.28019	0.28022	0.00000	
18	0.00000	0.28022	0.00000	0.00000	0.28022	0.00000	0.00000	0.00000	0.28022	0.00000	
19	0.00000	0.28022	0.00000	0.00000	0.28022	0.00000	0.00000	0.00000	0.28022	0.00000	
20	0.00000	0.28019	0.00000	0.00000	0.28019	0.00000	0.00000	0.00000	0.28022	0.00000	
21	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.28022	0.00000	
22	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.28022	0.00000	
23	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.28022	0.00000	
24	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.28022	0.00000	
25	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.28022	0.00000	
26	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.28019	0.00000	
27	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
28	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
29	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
30	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	**Average**
nº FP (EA)	30	159	86	87	157	134	97	116	177	99	114.20
t(s)	4.0	17.2	12.1	10.9	20.8	15.4	11.4	19.3	21.8	10.2	14.32
nº FP (LS)	423	1167	681	808	1007	1016	832	972	1275	704	888.50
nº selections(EA)	3	10	7	6	9	8	8	8	10	8	7.70

* nº PF(EA): number of power flows spent in the Evolutionary Algorithm part;

* nº PF(LS): number of power flows spent in the local search part.

2. CEMIG-D FEEDER CASES

In this section, it will be presented the Cemig-D feeders reconfigurations. As stated in the main article, the methodology was implemented in an OpenDSS[23] customization and applied in 41 Cemig-D feeders, which the total simulated energy loss reduction for the 41 cases was 139 MWh/month. Figure 6 shows the Graphic User Interface for the OpenDSS customization, which codes are published in [24].

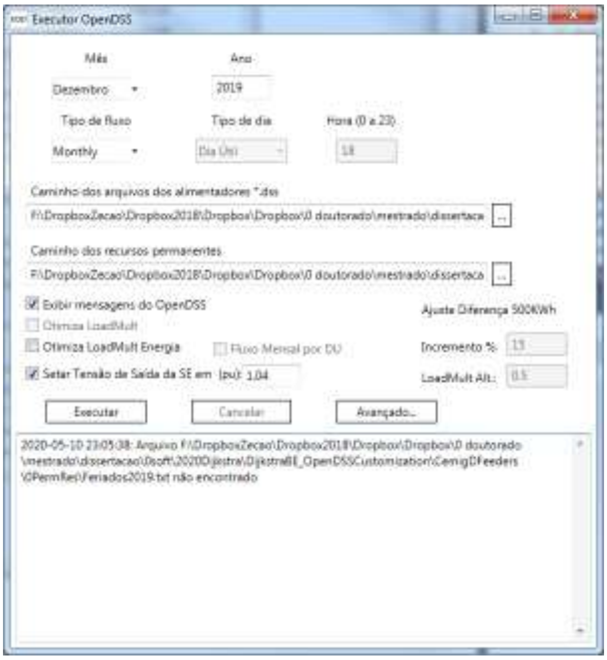

Figure 6 – Graphic User Interface for OpenDSS customization (Portuguese version).

Table 13 is a more detailed version from the main article Table 5, as it also presents the energy loss before and after the switching operation. All the switching operations were implemented in the field during the years 2019 and 2020. These cases also will be detailed ahead.

Table 13 – Energy losses reduction for Cemig-D reconfiguration cases.

Feeder(1)	nº NO Switches	nº NC Switches	nº PF	NO Switch	NC Switch	SE Energy(2)	Losses Before(2)	Losses After(2)	Losses Red. (2)	% Losses Red.	($/year) (3)
SFIQ410	5	458	14	195463	252959	1,903	171.2	158.4	12.9	7.5%	7,725
PSAU13	8	272	26	44055	44169	2,582	166.8	157.1	9.7	5.8%	5,811
ANAD08	4	183	12	230516	47915	3,527	135.0	122.8	12.2	9.0%	7,329
AMN06	7	364	21	233454	53296	2,152	181.3	169.5	9.2	5.1%	5,497
SLAT309	1	107	4	208241	208259	4,270	239.9	233.9	5.9	2.5%	3,560
IIIU12	5	281	24	162316	297374	1,525	217.1	211.3	5.8	2.7%	3,483
CGAU10	2	73	8	293937	300623	2,330	91.1	87.1	4.1	4.5%	2,437
VCS11	3	150	8	76647	76649	2,319	114.2	111.0	3.3	2.9%	1,960
COJ08	2	70	10	286963	242613	728	28.2	25.1	3.1	11.0%	1,866
SSP06	8	95	22	237583	52689	1,973	76.1	73.9	2.2	2.8%	1,294

(1) Month considered: Dec/2018 for all feeders, except feeder IIIU12 (Dec/2019).
(2) Unit: MWh/month.
(3) Energy price considered 50.0 US$/MWh.

Case 1: SFIQ410 Feeder (city São Francisco/MG)

Maneuver Details: Close: switch nº 195463 **Open**: switch nº 252959

Closing the NO switch n. 195463, all the loads downstream started are energized through the 150.0 mm^2 protected network (represented in green), eliminating the 2.0 km “bottleneck” composed by 0.4 km 2 AWG 33.63 mm^2 and 1.6 km 150.0 mm^2 cables.

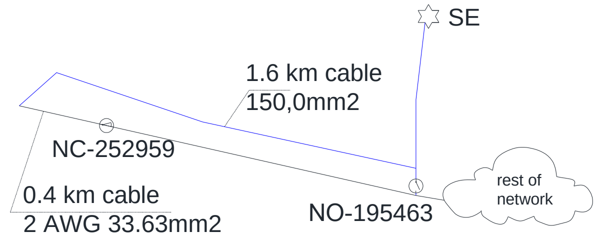

Figure 7 – SFIQ410 feeder switch operation schematic - Link Google Maps.

Case 2: PSAU13 feeder

Maneuver Details: Close: switch nº 44055 **Open**: switch nº 44169

This is a typical case of load balancing. After the switching operation, the load from one neighborhood is split between two circuits, the first one gains access to the substation by the switch nº 44055 with a distance 1.99 km closer.

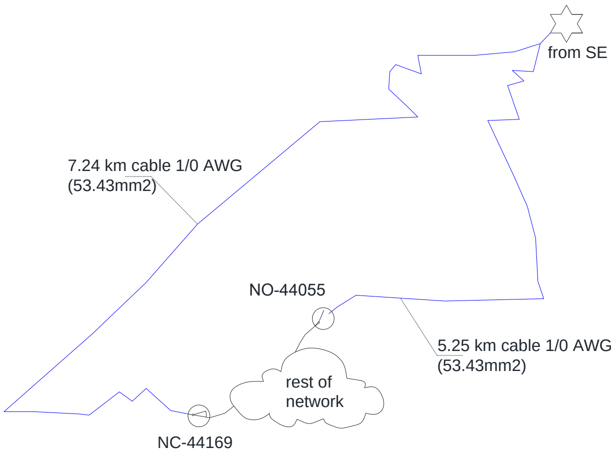

Figure 8 – PSAU13 feeder switch operation schematic - Link Google Maps.

Case 3: ANAD feeder

Maneuver Details: Close: switch nº 230516 **Open**: switch nº 47915

The algorithm discovered a better path (with lesser losses and also more reliable) feeding the loads by a protected 150.00 mm^2 cables better than the conventional 336.4 MCM (170.50 mm^2) cables.

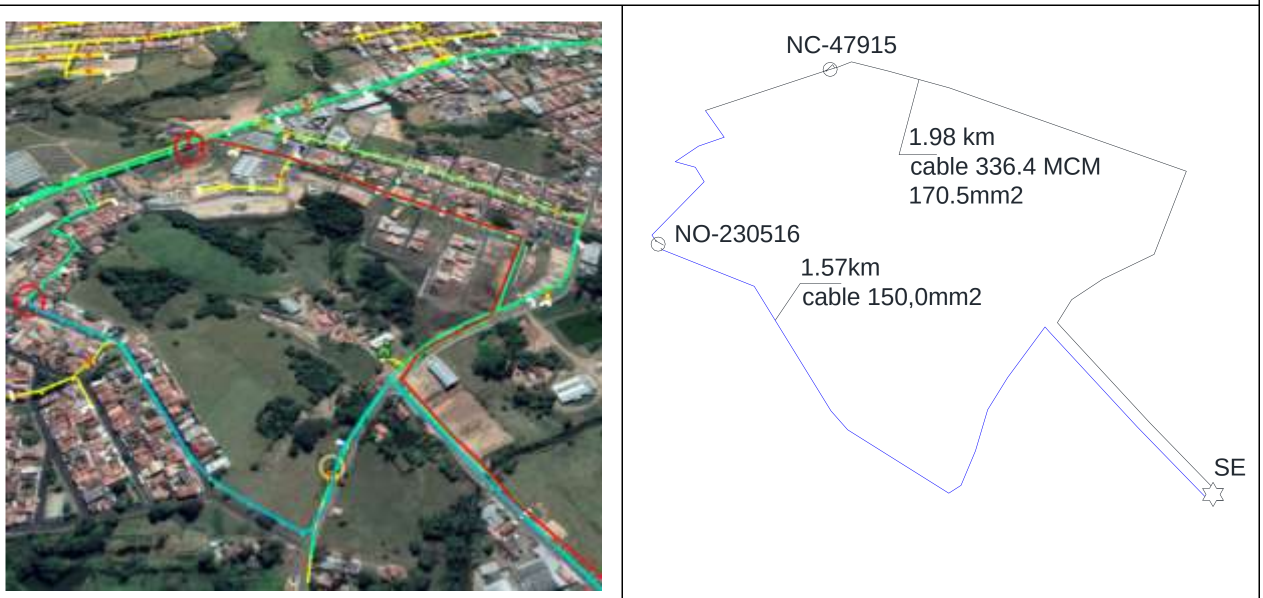

Figure 9 – ANAD08 feeder switch operation schematic - [Link Google Maps.]

Case 4: AMN06 feeder (Almenara city)

Maneuver Details: Close: switch nº 233454 **Open**: switch nº 53296

After maneuvering, the 1 kilometer 95.0 mm^2 cables bottleneck was eliminated (represented by the red dashed line in **Error! Reference source not found.**Figure 10). Also, the feeder trunk was reduced by approximately 900 meters, with an access to the substation by the overhead crossing over Jequitinhonha river.

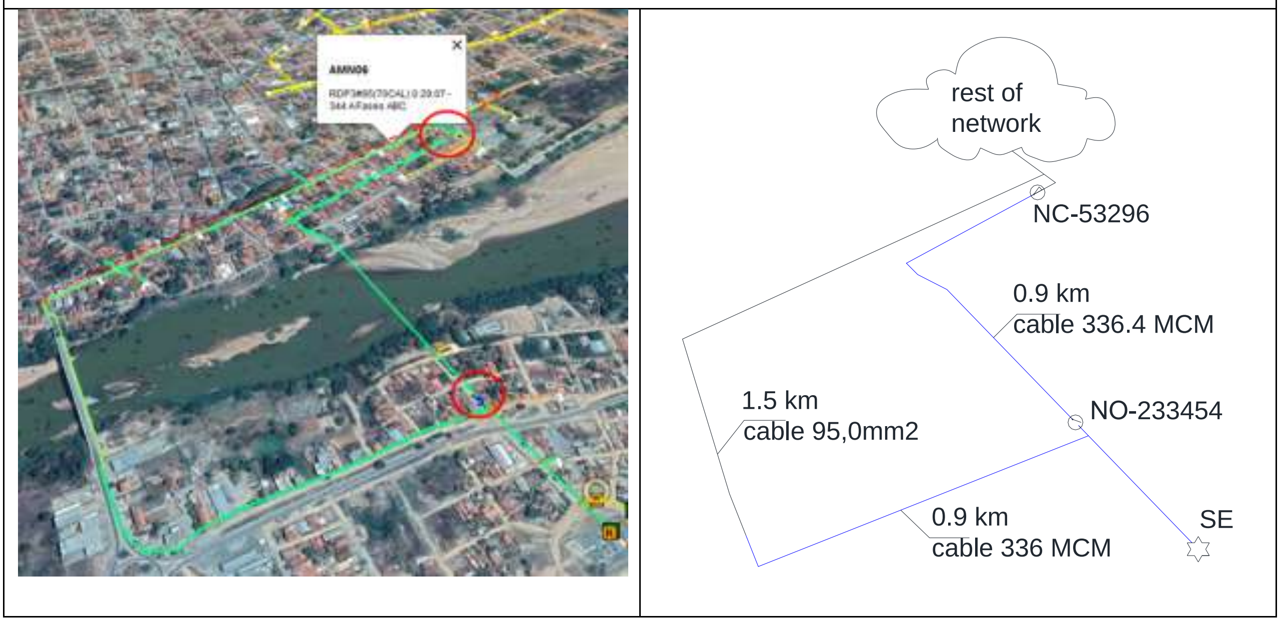

Figure 10 – AMN06 feeder switch operation schematic - [Link Google Maps.]

Case 5: SLAT309 feeder

Maneuver Details: Close: switch nº 208241 **Open**: switch nº 208259

After the maneuver the feeder trunk was shortened by 280m. It is an interesting case, as the conductors are the same, one can't guess that 280 meters will make such a difference in the energy losses.

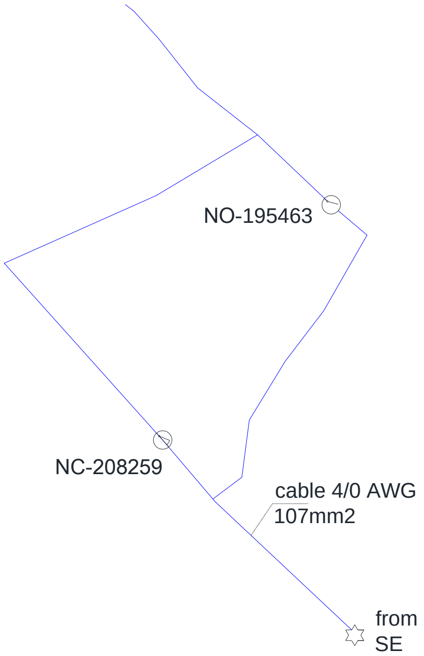

Figure 11 – SLAT309 feeder switch operation schematic - [Link Google Maps]

Case 6: IIIU12 feeder

Maneuver Details: Close: switch nº 162316 **Open**: switch nº 297374

After the switching operation, 10% of the feeder load (2 low voltage consumers 217 rural consumers) is fed by a 7.17 km shorter path. Table 14 shows this voltage level analysis before and after the switching operation at peak load hour (6 p.m.).

Table 14 – Voltage levels in switches before and after the switching operation at peak load hour.

Switch nº	Before SO (pu)	After SO (pu)
162316	0.9904(1) 0.9843	0.9832
297374	0.9873	0.9986(1) 0.9807

(1) Substation side.

The benefits of this switching operating highlight an interesting fact. Even with the by-pass of the voltage regulator bank nº 74576, the voltage level of the operated load was kept inside the regulatory limits[25] and only worsened a little bit (0.9873 pu before and 0.9832 pu after the switching operation). On the other hand, the voltage profile in the whole municipality of Ibiraci is increased by 0.0113 pu (0.9986 pu – 0.9873 pu) which is a greater benefit for this switching operation.

Usually, switching operation which by-passes voltage regulators banks reduces the power losses, but the drawback is exactly feeding the load with a lower voltage level, which is not desirable in most cases (What is the main purpose of installing a VRB?). So, this type of switching is only attractive only if the voltage can be maintained within the regulatory limits, as this case.

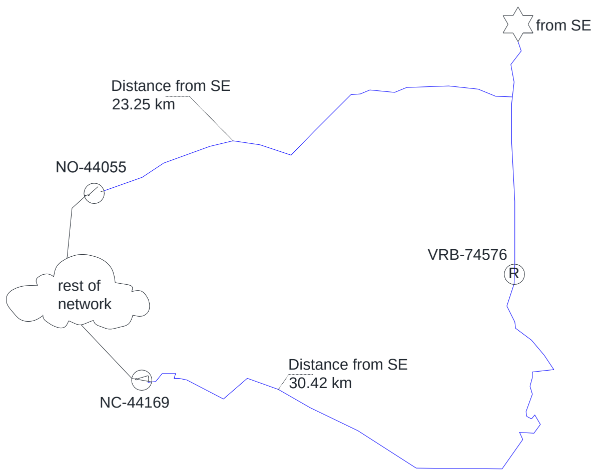

Figure 12 – IIIU12 feeder switch operation schematic - Link Google Maps

Case 7: CGAU10 feeder

Maneuver Details: Close: switch nº 293937 **Open**: switch nº 300623

The new NC switch 293937 is feed by protected 50.00 mm^2 cables, showing lesser losses than the old switch feed by 2 AWG (33.63 mm^2) cables. Another benefit is that the NC switch is a vacuum recloser having the capacity to re-energizes the grid in case of faults not sustained.

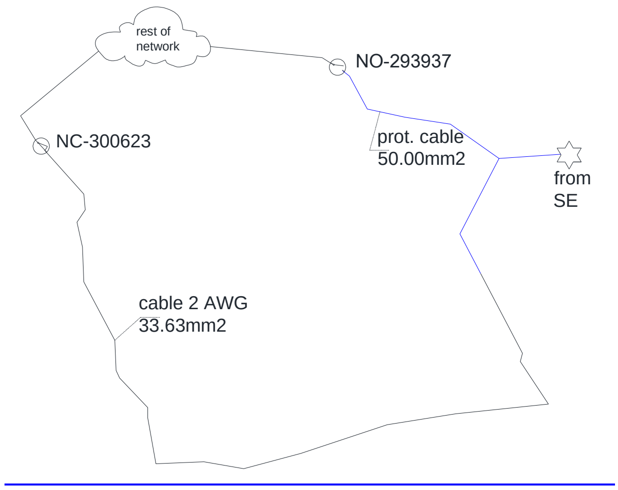

Figure 13 – CGAU10 feeder switch operation schematic - [Link Google Maps]

Case 8: COJ08 feeder

Maneuver Details: Close: switch nº 286963 **Open**: switch nº 242613

The new NC switch 286963 is feed by protected 150.00 mm^2 cables, showing lesser losses than the old switch feed by 1/0 AWG (53.43 mm^2) cables.

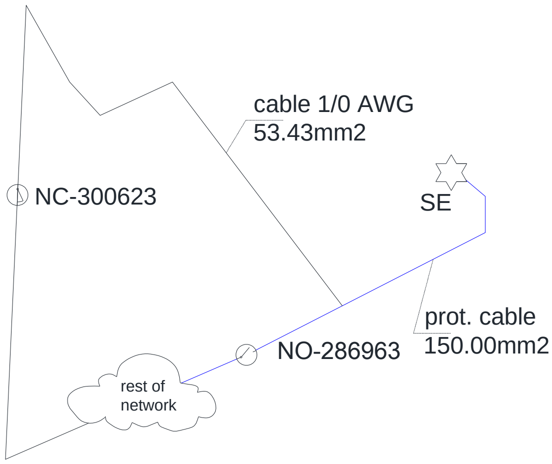

Figure 14 –COJ08 feeder switch operation schematic - [Link Google Maps]

Case 9: VCS11 feeder

Maneuver Details: Close: switch nº 76647 **Open**: switch nº 76649

This case is similar to the case nº4. The conductors in both parts are the same and after maneuvering the feeder trunk was shortened by 200m.

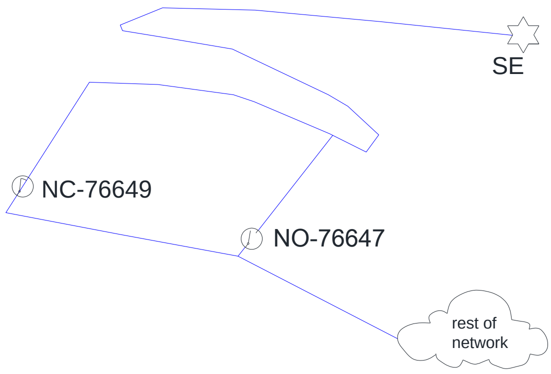

Figure 15 – VCS11 feeder switch operation schematic - Link Google Maps

Case 10: SSP06 feeder

Maneuver Details: Close: switch nº 237583 **Open**: switch nº 52689

The algorithm discovered a better path (with lesser losses and also more reliable) feeding the loads by the protected 150.00 mm^2 cables better than the conventional 1/0 AWG (53.43mm^2).

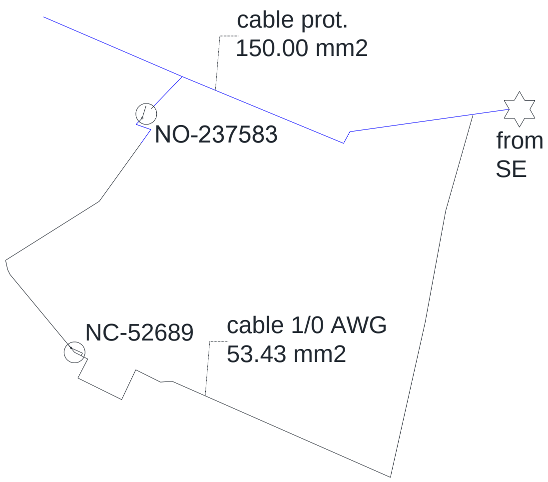

Figure 16 – SSP06 feeder switch operation schematic - Link Google Maps

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