Study Committee C2

C2 - POWER SYSTEM OPERATION & CONTROL

11151_2022

RES Generation Network Topology Optimization Based on an Adapted Genetic Algorithm

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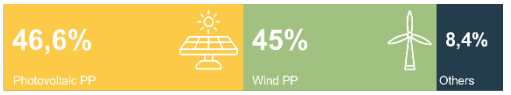
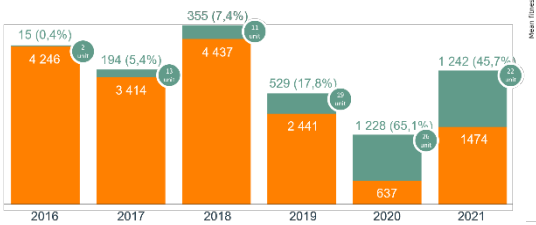
Motivation



Share of different types of RES worldwide



Increasing of the share of the RES in the new PP building in Russia

Raise of share of the RES

Intellectualization of distribution grids

Generation dependence on weather

Hourly changing of the optimal configuration

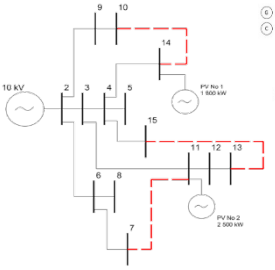
Method/Approach

Genetic algorithm for optimization of grid topology

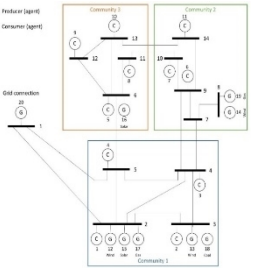
Two crossover types
Two mutation operators
Radial structure test

Distribution grid with only SPP
Distribution grid with WPP, SPP, and CPP

Objects of investigation



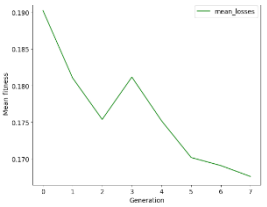
15-bus grid with SPP

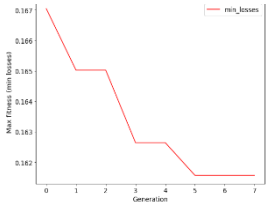


14-bus grid with SPP, WPP, and CPP

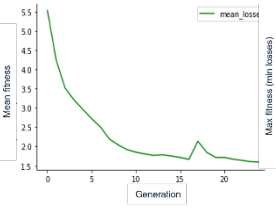
Experimental setup & test results

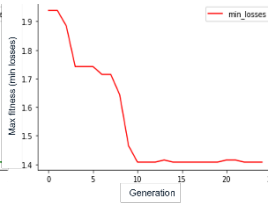
Algorithm results for 15-bus grid with only solar power plants





Algorithm results for 14-bus grid with different power plants





Discussion

Results for 15-bus grid with only solar power plants

	Hours												
Parameters	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
[illegible]	448.9	354.1	306.3	272.5	256.2	258.4	287.8	421.1	430.9	483.9	392.3	333.6	262.4
[illegible]	10.67	9.93	49.4	144.7	222.1	220	228	255.6	182.5	84.6	26.9	9.37	7.05
[illegible]	11.9	9.85	46.04	130.8	195.2	192.9	207.7	225.6	161.6	75.7	23.3	8.84	7.05
[illegible]	11.5	-0.8	-6.8	-7.5	-12.1	-12.3	-9.1	-11.7	-11.6	-11.1	-13.4	-5.7	0

Results for 14-bus grid with different power plants

Hour	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00
Algorithm solution (losses), kWh	1 029	1 055	982	1 099	873	877	1 239	1 036
Exhaustive search (losses), kWh	706	661	568	539	501	546	1 139	1 031
Hour	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
Algorithm solution (losses), kWh	1 399	950	588	927	942	985	1 060	1 000
Exhaustive search (losses), kWh	1 399	686	410	444	614	640	802	735
Hour	17:00	18:00	19:00	20:00	21:00	22:00	23:00	24:00
Algorithm solution (losses), kWh	916	694	835	1 353	1 295	1 338	1 345	1 369
Exhaustive search (losses), kWh	485	458	624	998	1 019	1 047	1 345	1 204

Conclusion

- Fast convergence of the algorithm (about 10-20 iterations), work for various grid and generation structure
- The created set of configurations may be used for the reclosers' switches schedules or for manual commutations
- The algorithm can be applied jointly with systems for the RES generation day ahead forecasting when planning the distribution grid operating modes
- The algorithm and can be applied as the tool for the grid schemes comparison at the project stage

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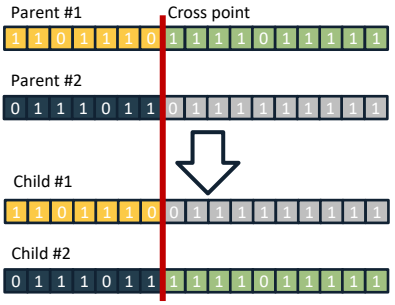
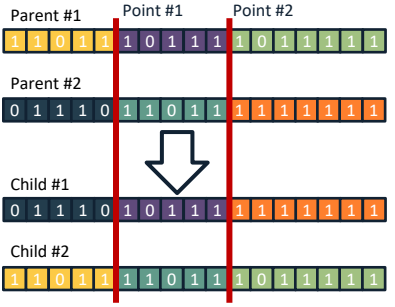
Crossover type 1

Two random parents are selected from the population. A random point of division of the parents' chromosomes is selected. The left part of the first parent and the right part of the second one forms the first child. The right part of the first parent and the left part of the second parent forms the second child.

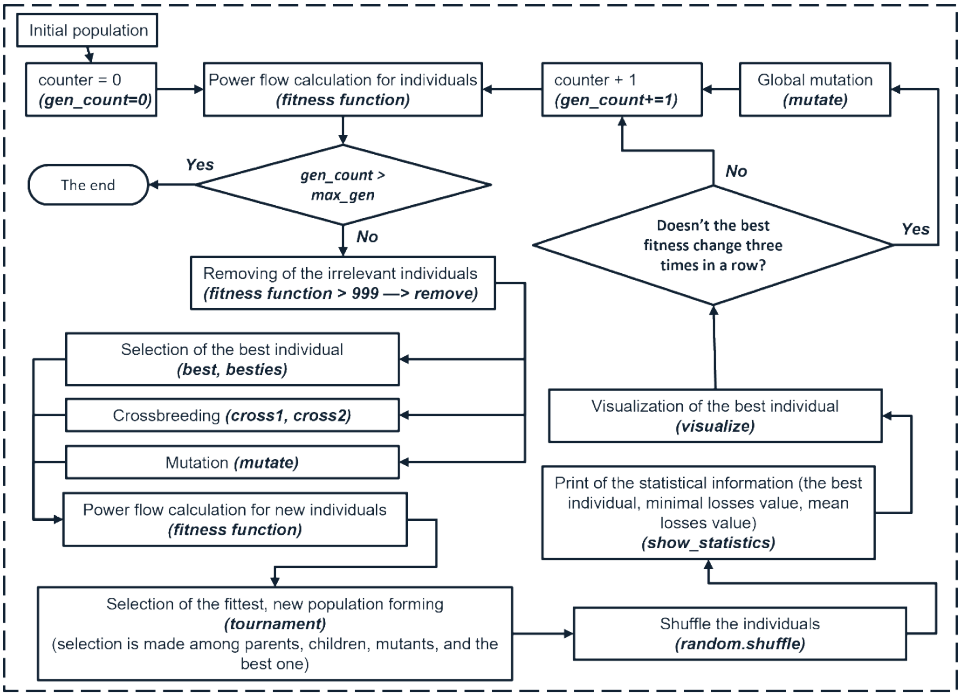


Crossover type 2

Two random parents are selected from the population. Two random points of division of the parents' chromosomes are selected. Parental chromosomes "twist" at these points and get two children.



Flowchart of the genetic algorithm



Flowchart of the genetic algorithm

logo of author's institution

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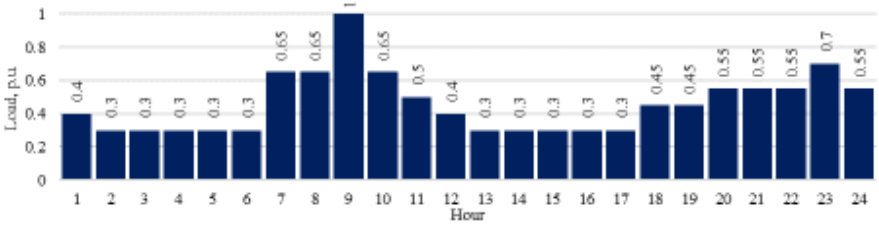
continued

Distribution 15-bus network data

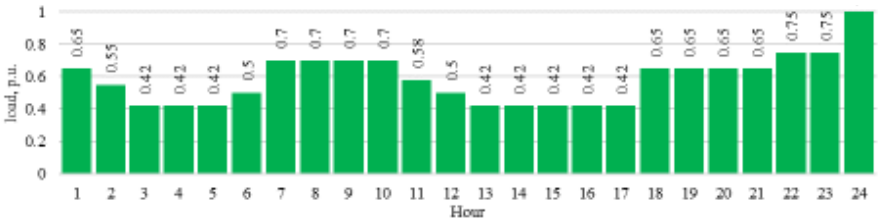
Line data					Load data			
From	To	Resistance, Ohms	Reactance, Ohms	Imax, A	Bus	Max active power, kW	Max reactive power, kVAR	Load curve
1	2	1.35	1.32	265	2	44.1	44.99	1
2	3	1.17	1.14	265	3	70.1	71.44	1
3	4	0.84	0.82	265	4	40	142.82	2
4	5	1.2	1.02	298	5	44.1	44.99	1
2	9	2.01	1.32	298	9	70	71.44	1
9	10	1.68	1.13	298	10	44.1	44.99	2
2	6	2.55	1.72	298	6	140	142.82	3
6	7	1.08	0.73	298	7	140	142.82	1
6	8	1.25	0.84	298	8	70	71.44	1
3	11	1.79	1.21	298	11	140	142.82	2
11	12	2.45	1.65	298	12	70	71.44	3
12	13	2.01	1.36	298	13	44.1	44.99	1
4	14	2.23	1.50	298	14	70	71.44	2
4	15	1.97	0.80	240	15	140	142.82	3
10	14	1.90	1.12	298	–	–	–	–
13	15	2.18	2.12	265	–	–	–	–
7	11	2.98	1.54	263	–	–	–	–

Load curves types

Type 1



Type 2



Type 3