Data Set for Manuscript "Optimal Management of Transactive Distribution Electricity Markets with Co-optimized Bidirectional Energy and Ancillary Service Exchanges with Microgrids"

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I. Data of Numerical Examples for the 33-node system

Fig. 1 demonstrates the network of modified IEEE 33-node distribution system with three Microgrids and three distributed generators. The line data are shown in Table I. The Table II shows the basic load data. The hourly load coefficients can be found in Table III. Table IV provides the distributed generators data in distribution system. Table V demonstrates the Microgrid information in distribution system. Table VI-Table XI are data of distributed generators information for each Microgrid. Table XII and Table XIII are price information that used for interactions between Microgrids and Distribution System.

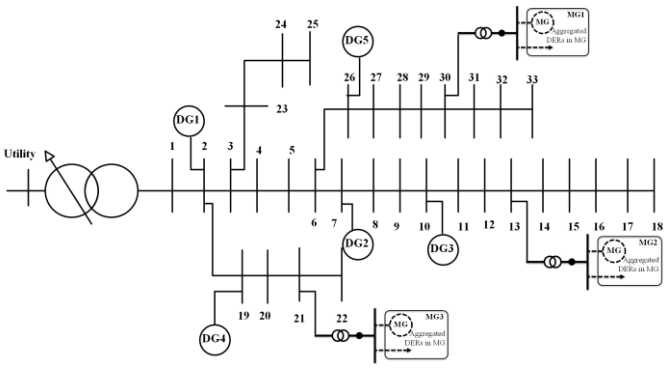

Figure. 1. 33-node distribution system

TABLE I. Line Data

Line No.	From Node	To Node	r(ohm)	x(ohm)
1	1	2	0.0922	0.047
2	2	3	0.493	0.2511
3	3	4	0.366	0.1864
4	4	5	0.3811	0.1941
5	5	6	0.819	0.707
6	6	7	0.1872	0.6188
7	7	8	0.7114	0.2351
8	8	9	1.03	0.74
9	9	10	1.044	0.74
10	10	11	0.1966	0.066
11	11	12	0.3744	0.1238
12	12	13	1.468	1.155
13	13	14	0.5416	0.7129
14	14	15	0.591	0.526
15	15	16	0.7463	0.545
16	16	17	1.289	1.721
17	17	18	0.732	0.574
18	2	19	0.164	0.1565
19	19	20	1.5042	1.3554
20	20	21	0.4095	0.4784
21	21	22	0.7089	0.9373
22	3	23	0.4512	0.3083
23	23	24	0.898	0.7091
24	24	25	0.896	0.7011
25	6	26	0.203	0.1034
26	26	27	0.2842	0.1447
27	27	28	1.059	0.9337
28	28	29	0.8042	0.7006
29	29	30	0.5075	0.2585
30	30	31	0.9744	0.963
31	31	32	0.3105	0.3619
32	32	33	0.341	0.5302

TABLE II. LOAD DATA

Node No.	P (kw)	Q (kvar)
2	100	60
3	90	40
4	120	80
5	60	30
6	60	20
7	200	100
8	200	100
9	60	20
10	60	20
11	45	30
12	60	35
13	60	35
14	120	80
15	60	10
16	60	20
17	60	20
18	90	40
19	90	40
20	90	40
21	90	40
22	90	40
23	90	50
24	420	200
25	420	200
26	60	25
27	60	25
28	60	20
29	120	70
30	200	600
31	150	70
32	210	100
33	60	40

TABLE III. HOURLY LOAD COEFFICIENTS

Time	Coefficient
1	0.5409
2	0.5291
3	0.5248
4	0.5595
5	0.5446
6	0.5458
7	0.6270
8	0.6772
9	0.6933
10	0.7299
11	0.7485
12	0.7515
13	0.8625
14	0.9461
15	0.9517
16	0.9721
17	0.9994
18	1.0000
19	0.9641
20	0.9610
21	0.8674
22	0.8073
23	0.6084
24	0.5855

TABLE IV. DISTRIBUTED GENERATOR IN DS

DG No.	Location	Maximum Active Output (p.u.)	Minimum Active Output (p.u.)	Minimum up time (h)	Minimum down time (h)
1	2	0.06	0	8	3
2	7	0.06	0	8	3
3	10	0.08	0	10	4
4	19	0.06	0	8	3
5	26	0.04	0	6	2

TABLE V. DISTRIBUTED GENERATOR IN DS

DG No.	Ramp up rate (p.u./h)	Ramp up rate (p.u./h)	Ramp down rate (p.u./h)	Maximum reserve output (p.u.)	Minimum reserve output (p.u.)
1	0.01	0.01	0.012	0.004	0
2	0.01	0.01	0.012	0.004	0
3	0.015	0.015	0.02	0.005	0
4	0.01	0.01	0.012	0.004	0
5	0.08	0.08	0.01	0.003	0

TABLE VI. COST OF DISTRIBUTED GENERATOR IN DS

DG No.	Startup cost ($)	Shut down cost ($)	Operation cost ($)	Reserve up cost ($)	Reserve down cost ($)
1	0.08	0.03	0.05	0.04	0.04
2	0.08	0.03	0.05	0.04	0.04
3	0.1	0.03	0.04	0.03	0.03
4	0.08	0.03	0.05	0.04	0.04
5	0.07	0.04	0.06	0.05	0.05

TABLE VII. DISPATCHABLE DISTRIBUTED GENERATORS IN MG 1

DG #	Maximum Power (p.u.)	Maximum Reserve (p.u.)	Operation cost ($)	Reserve cost ($)	Maximum full capacity running time (h)
1	0.06	0.006	0.06	0.05	8
2	0.04	0.004	0.07	0.06	6
3	0.04	0.004	0.07	0.06	6

TABLE VIII. DISPATCHABLE DISTRIBUTED GENERATORS IN MG 2

DG #	Maximum Power (p.u.)	Maximum Reserve (p.u.)	Operation cost ($)	Reserve cost ($)	Maximum full capacity running time (h)
1	0.04	0.004	0.07	0.06	6
2	0.04	0.004	0.07	0.06	6
3	0.04	0.004	0.07	0.06	6

TABLE IX. DISPATCHABLE DISTRIBUTED GENERATORS IN MG 3

DG #	Maximum Power (p.u.)	Maximum Reserve (p.u.)	Operation cost ($)	Reserve cost ($)	Maximum full capacity running time (h)
1	0.06	0.006	0.06	0.05	8
2	0.04	0.004	0.07	0.06	6

TABLE X. MICROGRID OUTPUT

MG NO.	Location	Max/Min Active Output (p.u.)	Max/Min Reserve (p.u.)
1	30	±0.1	±0.04
2	13	±0.1	±0.04
3	21	±0.1	±0.04

TABLE XI. RENEWABLE ENERGY PROFILE IN MGS

Time	MG 1	MG 2	MG 3
1	0.0048	0.0000	0.0033
2	0.0045	0.0000	0.0032
3	0.0037	0.0000	0.0026
4	0.0031	0.0000	0.0021
5	0.0027	0.0000	0.0019
6	0.0019	0.0000	0.0014
7	0.0018	0.0000	0.0012
8	0.0018	0.0010	0.0020
9	0.0012	0.0024	0.0025
10	0.0006	0.0036	0.0030
11	0.0006	0.0045	0.0035
12	0.0008	0.0051	0.0041
13	0.0010	0.0053	0.0044
14	0.0011	0.0053	0.0045
15	0.0010	0.0047	0.0040
16	0.0011	0.0040	0.0035
17	0.0011	0.0031	0.0030
18	0.0012	0.0020	0.0022
19	0.0011	0.0008	0.0014
20	0.0013	0.0000	0.0009
21	0.0015	0.0000	0.0011
22	0.0021	0.0000	0.0015
23	0.0033	0.0000	0.0023
24	0.0045	0.0000	0.0031

TABLE XII. ENERGY MARKET PRICE

Hour	Market Price ($/p.u.)
1	0.0350
2	0.0310
3	0.0335
4	0.0354
5	0.0385
6	0.0388
7	0.0373
8	0.0428
9	0.0458
10	0.0511
11	0.0611
12	0.0790
13	0.0758
14	0.0766
15	0.0754
16	0.0898
17	0.1255
18	0.1203
19	0.1061
20	0.1005
21	0.0874
22	0.0810
23	0.0694
24	0.0667

TABLE XIII. REGULATION MARKET PRICE

Time	Regulation Up MG to DS Market Price ($/p.u.)	Regulation Up DS to MG Market Price ($/p.u.)	Regulation Down DS to MG Market Price ($/p.u.)	Regulation Down MG to DS Market Price ($/p.u.))
1	0.0336	0.0336	0.0288	0.0288
2	0.0406	0.0406	0.0348	0.0348
3	0.0434	0.0434	0.0372	0.0372
4	0.0462	0.0462	0.0396	0.0396
5	0.0476	0.0476	0.0408	0.0408
6	0.049	0.049	0.042	0.042
7	0.04676	0.04676	0.04008	0.04008
8	0.0532	0.0532	0.0456	0.0456
9	0.0546	0.0546	0.0468	0.0468
10	0.056	0.056	0.048	0.048
11	0.063	0.063	0.054	0.054
12	0.0826	0.0826	0.0708	0.0708
13	0.07975	0.07975	0.068352	0.068352
14	0.08069	0.08069	0.069168	0.069168
15	0.07932	0.07932	0.067992	0.067992
16	0.09672	0.09672	0.082896	0.082896
17	0.12355	0.12355	0.1059	0.1059
18	0.11967	0.11967	0.102576	0.102576
19	0.11642	0.11642	0.099792	0.099792
20	0.10973	0.10973	0.094056	0.094056
21	0.09379	0.09379	0.0804	0.0804
22	0.086	0.086	0.073716	0.073716
23	0.07202	0.07202	0.06174	0.06174
24	0.0687	0.0687	0.058884	0.058884