DATABASE OF THE DISTRIBUTION TEST SYSTEM

Paper: Integration of DER in the Planning of Low Voltage Electric Distribution Networks

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Fig. 1 shows the test system used, where the circles are load nodes and dashed lines are new branches. To supply the 138 new secondary demand nodes, it is proposed the installation of 33 new DT (see Table 1), and 147 new secondary branches. Moreover, it is proposed the installation of 15 solar generators, 14 wind generators, and 15 ESS (see Table 1). The nominal voltage of the system is 0.44 kV, the maximum voltage regulation is 10%, and the values for base power and voltage are 300 kVA and 0.44 kV, respectively. Additionally, 6 types of wires, 8 types of DT, and 4 types of DG and ESS are considered (see Tables 2, 3, and 4). The transformation ratio of distribution transformers is 13.2 kV/0.44 kV, and the impedances of Table 3 are located in the primary side of the distribution transformers. Table 5 shows the daily information for the load demand, energy purchase cost, solar DG, and wind DG. Tables 6 and 7 show the information of new secondary circuits and load nodes of the test system.

The energy sale cost is 0.2 [USD/kWh], the interest rate is 10%, the horizon planning is 20 years, and the ZIP load model coefficients are $c_0 = 0.2$ and $c_2 = 0.8$. The charge and discharge efficiencies, the deep of discharge, and the lifetime of the ESS are 90%, 100% and 20 years, respectively. The minimum charging and discharging powers of ESS are equal to zero; and the maximum charging and discharging powers of ESS are considered to be the same, and its values depend on the type of the ESS (see Table 4). The lifetime of solar and wind DG is 20 years, and the maximum number of elements that can be installed for solar DG, wind DG, and ESS in the distribution system are 7, 5, and 6, respectively.

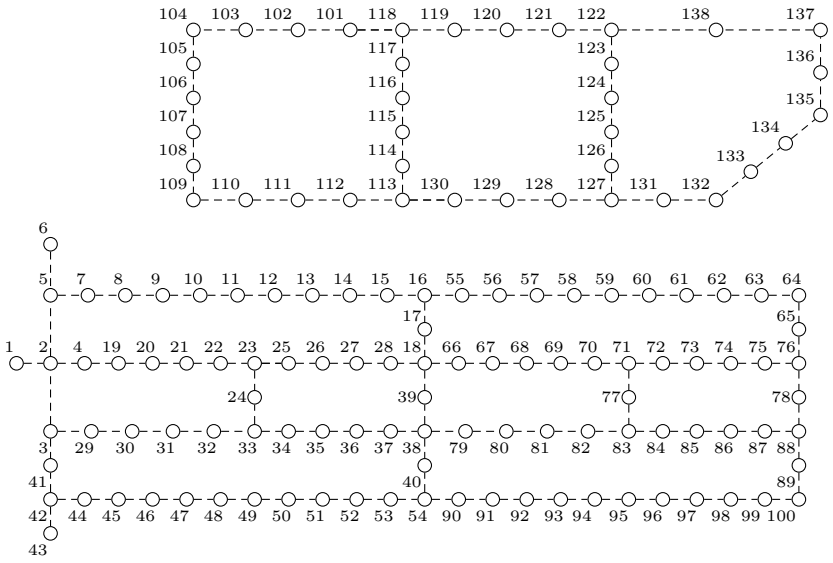

Figure 1: Test distribution system of 138 nodes

Table 1: Candidate nodes for installing DT, DG, and ESS

Element	Nodes
DT	2, 8, 11, 16, 30, 33, 37, 45, 48, 51, 56, 59, 64, 80, 83, 87, 91, 94, 97 104, 106, 109, 111, 113, 116, 118, 122, 124, 127, 129, 132, 135, 137
Solar DG	6, 23, 38, 43, 54, 62, 71, 88, 95, 103, 110, 117, 130, 131, 136
Wind DG	110, 103, 119, 115, 112, 130, 128, 126, 123, 138, 10, 19, 14, 5
ESS	129, 111, 109, 127, 130, 113, 30, 11, 132, 135, 137, 116, 8, 106, 48

Table 2: Information of the wires used in the LV distribution system

Type	R [ohm/km]	X [ohm/km]	Amp	USD/m
1	1.04	0.45	150	14
2	0.65	0.28	180	20
3	0.52	0.22	205	26
4	0.32	0.14	275	40
5	0.26	0.12	305	47
6	0.18	0.10	390	57

Table 3: DT and renewable DG information

	Wind DG		DT				Solar DG	
Type	kW	USD	R HV [ohm]	X HV [ohm]	kVA	USD	kW	USD
1	100	350000	99.7040	142.8940	30	3177.57	50	105000
2	150	525000	61.0916	98.7976	45	3953.07	75	157500
3	200	700000	33.7638	73.9706	75	5502.69	100	210000
4	250	875000	21.2014	49.8900	112.5	7439.72	125	262500
5	—	—	15.1782	43.9150	150	9376.74	—	—
6	—	—	9.9467	29.3356	225	11053.72	—	—
7	—	—	7.1148	25.1490	300	16806	—	—
8	—	—	5.1510	18.9131	400	22408	—	—

Table 4: ESS information

Type	Capacity [kWh]	Charge-discharge power [kW]	C_b^{ESS} [USD]	$O_{\&}M_b^{fx}$ [USD/year]	ϕ_b [%/kWh]
1	100	33.333	32000	2666.667	1.000
2	200	66.667	64000	5333.333	0.500
3	300	100	96000	8000.000	0.333
4	400	133.333	128000	10666.667	0.250

Table 5: Demand, energy cost, and renewable DG curves information

Load level [l]	Load curve [pu]	Energy purchase cost [USD/kWh]	Solar DG curve [pu]	Wind DG curve [pu]
1	0.4891	0.0840	0	0.7500
2	0.4239	0.0800	0	0.7900
3	0.4239	0.0800	0	0.7600
4	0.4022	0.0750	0	0.8600
5	0.4022	0.0750	0	0.8500
6	0.4022	0.0750	0	0.8700
7	0.5000	0.0850	0	0.7700
8	0.5217	0.0900	0.1500	0.6300
9	0.6087	0.1050	0.3600	0.5800
10	0.6522	0.1350	0.6000	0.6000
11	0.6739	0.1450	0.9200	0.5700
12	0.7174	0.1850	0.9400	0.8200

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Load level [l]	Load curve [pu]	Energy purchase cost [USD/kWh]	Solar DG curve [pu]	Wind DG curve [pu]
13	0.7174	0.1850	1.0000	0.6900
14	0.6522	0.1350	0.7000	1.0000
15	0.6304	0.1250	0.5200	0.9300
16	0.6087	0.1050	0.4800	0.8100
17	0.5870	0.0980	0.2800	0.8200
18	0.6957	0.1750	0.1200	0.8700
19	0.9783	0.3050	0	0.9400
20	1.0000	0.3250	0	0.8800
21	0.9348	0.2850	0	0.6800
22	0.8696	0.2750	0	0.5500
23	0.8261	0.2650	0	0.6500
24	0.5435	0.1000	0	0.5200

Table 6: Information of the secondary circuits

From	To	km	Existing	From	To	km	Existing
1	2	0.1440	0	27	28	0.1824	0
2	3	0.1440	0	28	18	0.1800	0
2	4	0.1344	0	18	39	0.1440	0
2	5	0.1440	0	3	29	0.1440	0
5	6	0.1056	0	29	30	0.1560	0
5	7	0.1632	0	30	31	0.1920	0
7	8	0.1440	0	31	32	0.1248	0
8	9	0.1560	0	32	33	0.1632	0
9	10	0.1440	0	33	24	0.1800	0
10	11	0.1800	0	33	34	0.1378	0
11	12	0.1800	0	34	35	0.1800	0
12	13	0.1800	0	35	36	0.1195	0
13	14	0.1800	0	36	37	0.1800	0
14	15	0.1800	0	37	38	0.1920	0
15	16	0.1800	0	38	39	0.1800	0
16	17	0.1440	0	38	40	0.1440	0
18	17	0.1008	0	3	41	0.1440	0
4	19	0.1056	0	41	42	0.1584	0
19	20	0.0864	0	42	43	0.1560	0
20	21	0.0173	0	42	44	0.1560	0
21	22	0.1344	0	44	45	0.1008	0
22	23	0.1800	0	45	46	0.1522	0

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From	To	km	Existing
23	24	0.1800	0
23	25	0.1800	0
25	26	0.1608	0
26	27	0.1800	0
50	51	0.1728	0
51	52	0.1440	0
52	53	0.1440	0
54	53	0.1800	0
40	54	0.1440	0
18	66	0.1344	0
16	55	0.1632	0
55	56	0.1440	0
56	57	0.1560	0
57	58	0.1440	0
58	59	0.1800	0
59	60	0.1800	0
60	61	0.1800	0
61	62	0.1800	0
62	63	0.1800	0
63	64	0.1800	0
64	65	0.1440	0
76	65	0.1008	0
66	67	0.1056	0
67	68	0.0864	0
68	69	0.0173	0
69	70	0.1344	0
70	71	0.1800	0
71	77	0.1800	0
71	72	0.1800	0
72	73	0.1608	0
98	99	0.1440	0
100	99	0.1800	0
89	100	0.1440	0
101	102	0.1080	0
102	103	0.1080	0
103	104	0.1080	0
104	105	0.1620	0
105	106	0.1620	0
106	107	0.1620	0

From	To	km	Existing
46	47	0.1848	0
47	48	0.1800	0
48	49	0.1440	0
49	50	0.1800	0
73	74	0.1800	0
74	75	0.1824	0
75	76	0.1800	0
76	78	0.1440	0
38	79	0.1440	0
79	80	0.1560	0
80	81	0.1920	0
81	82	0.1248	0
82	83	0.1632	0
83	77	0.1800	0
83	84	0.1378	0
84	85	0.1800	0
85	86	0.1195	0
86	87	0.1800	0
87	88	0.1920	0
88	78	0.1800	0
88	89	0.1440	0
54	90	0.1560	0
90	91	0.1008	0
91	92	0.1522	0
92	93	0.1848	0
93	94	0.1800	0
94	95	0.1440	0
95	96	0.1800	0
96	97	0.1728	0
97	98	0.1440	0
119	120	0.1080	0
120	121	0.1080	0
121	122	0.1080	0
122	123	0.1620	0
123	124	0.1620	0
124	125	0.1620	0
125	126	0.1620	0
126	127	0.1620	0
127	128	0.1080	0

Table 6 continued from previous page

From	To	km	Existing	From	To	km	Existing
107	108	0.1620	0	128	129	0.1080	0
108	109	0.1620	0	129	130	0.1080	0
109	110	0.1080	0	130	113	0.1080	0
110	111	0.1080	0	127	131	0.1080	0
111	112	0.1080	0	131	132	0.1080	0
112	113	0.1080	0	132	133	0.1620	0
113	114	0.1620	0	133	134	0.1620	0
114	115	0.1620	0	134	135	0.1620	0
115	116	0.1620	0	135	136	0.1620	0
116	117	0.1620	0	136	137	0.1620	0
117	118	0.1620	0	137	138	0.1080	0
118	101	0.1080	0	138	122	0.1080	0
118	119	0.1080	0	—	—	—	—

Table 7: Nodal information of the test system (FP=0.9)

Node	kVA	Existing	Node	kVA	Existing
1	0.8550	0	70	3.5900	0
2	8.7300	0	71	5.4400	0
3	17.1675	0	72	8.2900	0
4	8.7300	0	73	9.9100	0
5	23.4675	0	74	9.9100	0
6	7.9650	0	75	6.6700	0
7	29.2950	0	76	0.1900	0
8	43.5150	0	77	0.1900	0
9	43.5150	0	78	6.6700	0
10	43.5150	0	79	5.4400	0
11	57.7350	0	80	35.7750	0
12	43.5150	0	81	5.4400	0
13	43.5150	0	82	5.4400	0
14	32.4225	0	83	5.4400	0
15	43.0875	0	84	9.9100	0
16	29.2950	0	85	9.9100	0
17	0.8550	0	86	9.9100	0
18	0.8550	0	87	9.2900	0
19	24.4800	0	88	8.8900	0
20	24.4800	0	89	1.8100	0
21	24.4800	0	90	1.7700	0
22	16.1550	0	91	8.0900	0
23	24.4800	0	92	9.6700	0

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Node	kVA	Existing
24	0.8550	0
25	37.3050	0
26	44.5950	0
27	44.5950	0
28	30.0150	0
29	24.4800	0
30	160.9875	0
31	24.4800	0
32	24.4800	0
33	24.4800	0
34	44.5950	0
35	44.5950	0
36	44.5950	0
37	41.8050	0
38	40.0050	0
39	30.0150	0
40	8.1450	0
41	36.4050	0
42	22.1850	0
43	7.9650	0
44	7.9650	0
45	36.4050	0
46	43.5150	0
47	43.5150	0
48	57.7350	0
49	43.5150	0
50	43.5150	0
51	43.5150	0
52	23.4675	0
53	22.1850	0
54	0.8550	0
55	6.5100	0
56	9.6700	0
57	9.6700	0
58	9.6700	0
59	12.8300	0
60	9.6700	0
61	9.6700	0
62	7.2050	0

Node	kVA	Existing
93	9.6700	0
94	12.8300	0
95	9.6700	0
96	9.6700	0
97	9.6700	0
98	5.2150	0
99	4.9300	0
100	0.1900	0
101	15.4700	0
102	17.2800	0
103	22.6600	0
104	17.2800	0
105	30.9700	0
106	15.4700	0
107	38.6700	0
108	57.4300	0
109	57.4300	0
110	57.4300	0
111	76.2100	0
112	57.4300	0
113	57.4300	0
114	42.8000	0
115	56.8700	0
116	38.6700	0
117	15.4700	0
118	15.4700	0
119	32.3200	0
120	32.3200	0
121	32.3200	0
122	21.3300	0
123	32.3200	0
124	15.4700	0
125	49.2500	0
126	58.8700	0
127	58.8700	0
128	39.6200	0
129	32.3200	0
130	212.5000	0
131	32.3200	0

Table 7 continued from previous page

Node	kVA	Existing
63	9.5750	0
64	6.5100	0
65	0.1900	0
66	1.9400	0
67	5.4400	0
68	5.4400	0
69	5.4400	0

Node	kVA	Existing
132	32.3200	0
133	32.3200	0
134	58.8700	0
135	58.8700	0
136	58.8700	0
137	55.1900	0
138	52.8100	0