Integration of distributed energy resources in the distribution system expansion planning considering a method of forecasting EV charging demand: Study data

Table 1 shows the data for the substations, while the demand data for each node is shown in Table 2. The parameters related to DG units are shown in Tables Table 3–Table 5. Also, energy storage systems were considered to have a capacity of 1000 kW, an investment cost of kUS$ 1000, and a life cycle of 15 years. The candidate nodes for the installation of wind turbines, photovoltaic modules, non-renewable generators, EV charging stations, and energy storage systems, are respectively: Ω_{wt} = {4, 5, 9, 11, 16, 19}, Ω_{pv} = {3, 4, 7, 8, 10, 13, 14, 15, 19}, Ω_{gt} = {3, 5, 9, 11, 14}, Ω_{R} = {3, 4, 6, 8, 13}, e Ω_{b} = {4, 7, 8, 12}. The PV units have a nominal power capacity of 100 kW and are composed by 40 modules with 2.5 kW each. A maximum of 40 generators of this type can be installed throughout the system. The power factors for PV and WT/GT units are defined as 0.98 and 0.90, respectively. Finally, Table 6presents the data for the two alternative EV charging stations.

Table 1 Substation data

s	SI_i^S(kVA)	SF_i^S(kVA)	C_i^S(kUS$)	ζ_i^s (ton/MWh)
21	10000	5000	750	0.5600
22	10000	8000	1200	0.5600
23	10000	8000	1200	0.5600
24	8000	7000	1050	0.5600

Table 2 Demand data

Node	Period 1	Period 2	Node	Period 1	Period 2
1	4000	10402	13	850	2063
2	500	1429	14	1990	2488
3	2761	3701	15	1020	1275
4	463	1578	16	0	1960
5	444	1555	17	1512	2890
6	860	1701	18	0	2653
7	2120	4150	19	0	1425
8	888	1110	20	0	1984
9	1672	2090	21	0	0
10	1268	2835	22	0	0
11	1764	2205	23	0	0
12	812	2015	24	0	0

Table 3 Gas turbine data

$\overline{P}_f^{gt}$(kW)	2000	$Q_{f,1}^{gt}$(kVAr)	-857
$P_{f,1}^{gt}$(kW)	1807	$Q_{f,2}^{gt}$(kVAr)	0
$P_{f,2}^{gt}$(kW)	2000	$Q_{f,3}^{gt}$(kVAr)	857
$P_{f,3}^{gt}$(kW)	1807	$Q_{f,4}^{gt}$(kVAr)	1428
$P_{f,4}^{gt}$(kW)	1400	ζ^{wt} (ton/MWh)	0.5600

Table 4 Photovoltaic module data

$\overline{P}_u^{pv}$(kW)	100	NOCT (°C)	45
ζ^{pv}	0.0584	δ	-0.004
C_u^{pv}(US$/kW)	700	c^{opv}(US$/kWh)	0.0004

Table 5 Wind turbine data

$\overline{P}_k^{wt}$ (kW)	2000	$Q_{k,1}^{wt}$ (kVAr)	-1605
$P_{k,1}^{wt}$ (kW)	1194	$Q_{k,2}^{wt}$ (kVAr)	-575
$P_{k,2}^{wt}$ (kW)	1915	$Q_{k,3}^{wt}$ (kVAr)	0
$P_{k,3}^{wt}$ (kW)	1877	$Q_{k,4}^{wt}$ (kVAr)	1085
$P_{k,4}^{wt}$ (kW)	1205	ζ^{wt} (ton/MWh)	0.0276
C_k^{wt}(US$/kW)	1000	c^{owt}(US$/kWh)	0.001

Table 6 EV charging station data

c	P_c^{PR}**(kW)**	C_c^{PR}**(kUS$)**
1	330	3000
2	110	1000