Supplementary Material for “A Second Order Cone Programming Model for PEV Fast-Charging Station Planning”

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Abstract

This supplementary material describes the detailed information of the test system in the paper “A Second Order Cone Programming Model for PEV Fast-Charging Station Planning”. Note that these parameter values are for illustration and not necessarily representative of a particular transportation/power system network. Readers are encouraged to substitute their own parameter values.

I. Distribution System

The diagram of the 110 kV high voltage distribution network is shown in Fig. 1. We assume node 1 is connected to a 220 kV/110 kV transformer with 150 MVA capacity.

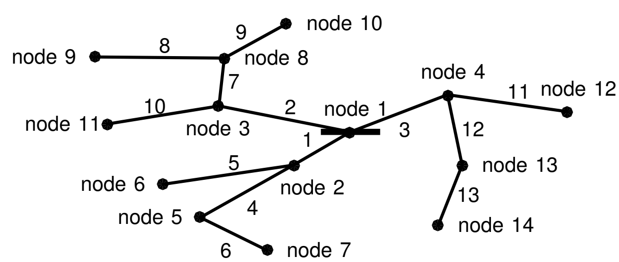

Fig. 1. A 110 kV distribution network used for the case study.

A. Branch Parameters

The branch parameters are listed in Table I.

B. Load Data

The peak load data are listed in Table II. The load at each node is assumed to be composed by residential load, commercial load and agricultural load.

II. Scenario Preparation

A. Load Profile Scenario

We used PG&E static residential, commercial and agricultural load profiles [1] to generate 24 representative scenarios, i.e., weekday and weekend of 12 months, of three types of load profiles, which are respectively shown in Figs. 2–4. Then the time-varying load at each bus i is calculated as follows:

$$L_i(\omega,t)=\overline{L_i}\times\left(\alpha_i^{\mathrm{R}}\times L^{\mathrm{R}}(\omega,t)+\alpha_i^{\mathrm{C}}\times L^{\mathrm{C}}(\omega,t)+\alpha_i^{\mathrm{A}}\times L^{\mathrm{A}}(\omega,t)\right). \tag{1}$$

Where, $\overline{L_i}$ is the summation of active load, reactive load and compensation given in Table I, which is the peak load in a day. α_i^{R}, α_i^{C} and α_i^{A} are representatively the load component ratio of residential, commercial and agricultural load given in Table I. $L^{\mathrm{R}}(\omega,t)$, $L^{\mathrm{C}}(\omega,t)$, $L^{\mathrm{A}}(\omega,t)$ are respectively the corresponding per-unit load profiles of each scenario.

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TABLE I
BRANCH PARAMETERS OF THE DISTRIBUTION NETWORK

Branch ID	From Bus	To Bus	Length(km)	R (p.u.)	X (p.u.)	Capacity (MVA)
1	1	2	30	0.0317	0.0760	50.00
2	1	3	70	0.0739	0.1774	50.00
3	1	4	20	0.0211	0.0507	50.00
4	2	5	110	0.1793	0.2870	27.00
5	2	6	70	0.1952	0.1913	20.25
6	5	7	60	0.1674	0.1640	20.25
7	3	8	50	0.0815	0.1305	27.00
8	8	9	30	0.0837	0.0820	20.25
9	8	10	40	0.1116	0.1093	20.25
10	3	11	60	0.1674	0.1640	20.25
11	4	12	40	0.1116	0.1093	20.25
12	4	13	80	0.1304	0.2088	27.00
13	13	14	60	0.1674	0.1640	20.25

TABLE II
LOAD DATA OF THE DISTRIBUTION NETWORK

Bus ID	Active load (MW)	Reactive load (MVAR)	Reactive compensation (MVAR)	Load Component (%)		
				Residential	Commercial	Agricultural
1	0	0	0	0	0	0
2	3.7500	3.0000	0	40	50	10
3	7.5000	5.0625	0	40	50	10
4	1.8750	1.6875	0	40	50	10
5	3.7500	1.5000	0.4688	40	40	20
6	5.6250	2.8125	0.3750	40	40	20
7	2.8125	2.2500	0	40	30	30
8	9.3750	5.6250	2.2500	40	30	30
9	8.4375	3.7500	9.3750	40	20	40
10	1.1250	0.1875	1.1250	40	20	40
11	1.8750	1.6875	3.3750	40	20	40
12	1.8750	1.3125	0	40	10	50
13	1.8750	1.6875	0	40	10	50
14	3.9375	1.8750	3.3750	40	10	50

B. Traffic Flow Scenario

The traffic flow scenarios are generated from NHTS data [2]. First, we generate the distribution of departure time from home every day, i.e., D, in [2] (note that only the first departure event is used). Then, we assume the PEVs arrive at the transportation network according to the distribution D and travel in the transportation network with an average speed of 80 km/h. Thereafter, we calculate the traffic flow arriving at each transportation node based on the distribution D of time when PEVs arrive at the transportation network, driving speed and driving paths.

Take a single path as an example. Let 0 denote the arrival node, then the traffic flow node 0, i.e., $\lambda_0(t)$, follows the distribution D. Then the traffic flow of node i on the same path can be calculated as:

$$\lambda_i(t + \frac{d_{i0}}{v}) = \lambda_0(t), \tag{2}$$

where, d_{i0} is the distance between node 0 and node i; $v = 80$km/h is the expected drive speed.

Because NHTS data does not distinguish weekday and weekend, therefore, we simply assume the original distribution D is the distribution in weekday and we generate the distribution in weekend by decreasing the total traffic flow by 20%. We also assume all the arrival distributions D in all the12 month are the same.

The distributions of the time when PEVs arrive at the transportation network in weekday and weekend are illustrated in Fig. 5.

REFERENCES

[1] PG&E, "2000 static load profiles." [Online]. Available: https://www.pge.com/nots/rates/2000_static.shtml, accessed Sep 30, 2016.

[2] A. Santos, N. McGuckin, H. Y. Nakamoto, D. Gray, and S. Liss, "Summary of travel trends: 2009 national household travel survey," tech. rep., 2011.

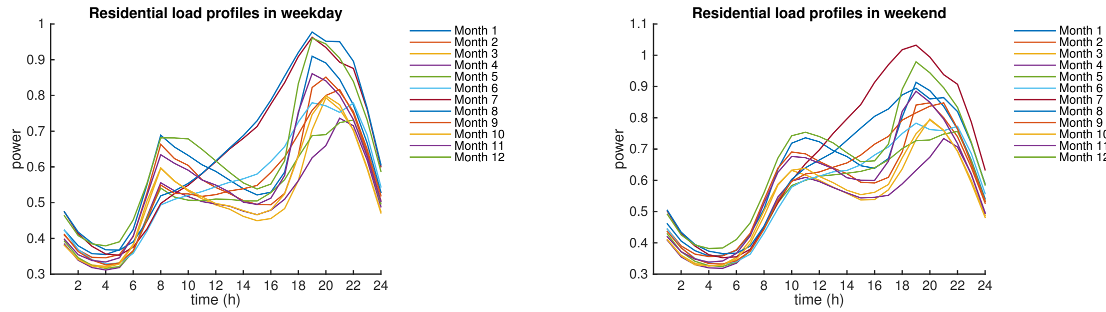

Fig. 2. Residential load profiles.

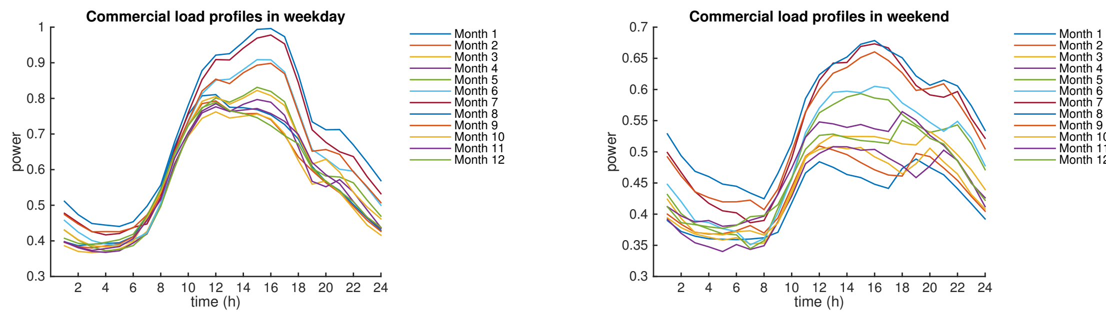

Fig. 3. Commercial load profiles.

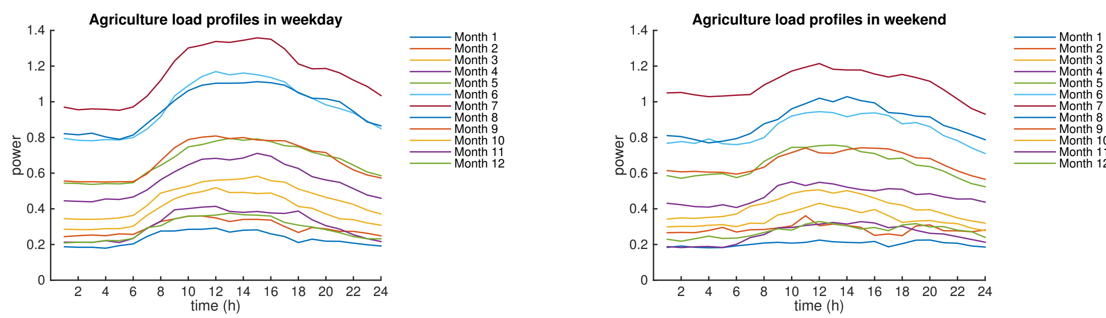

Fig. 4. Agricultural load profiles.

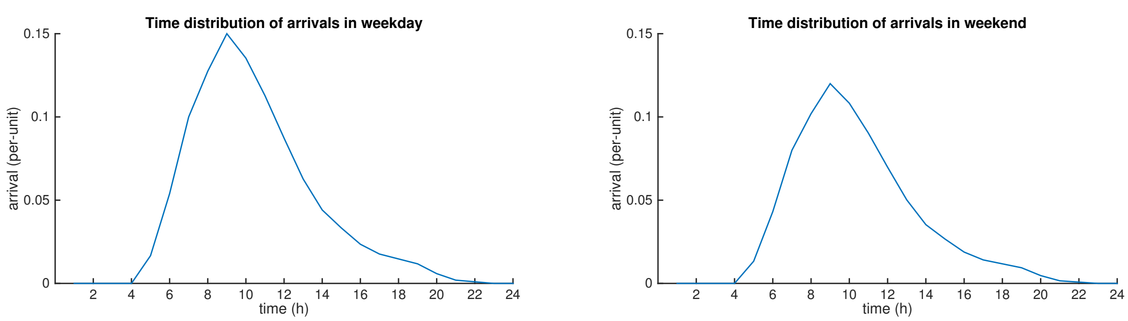

Fig. 5. Distributions of the time when PEVs arrive at the transportation network.