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Dynamic electricity demand prediction for UK households

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Abstract

The nature of domestic electricity load is highly dependent on the demand of occupants. Domestic energy use, especially for electricity, is not only based on residents activities, also related with the type of electrical appliances and weather conditions. To manage and optimise electricity generation and the effective use of energy storage, it is important to be able to accurately predict electricity demand. This paper presents high-resolution real load energy data for three UK dwellings throughout the year. Seasonal models have been produced for each dwelling and the use of electrical appliances at certain times are analysed to predict the number of active occupants. The possibility of active occupancy at each thirty seconds is generated stochastically by Markov-Chain technique and Markov-Chain Monte Carlo method is used to predict the active occupant profiles and the related electricity demand dynamically. The methodology can be used for any other domestic dwelling type to generate corresponding active occupant profile. The predicted electricity profile can be used for effective demand side management.

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Keywords: Domestic occupancy, Electricity demand, Dynamic prediction

1. Introduction

Distributed electricity generation and demand side management require detailed energy use profiles, which are highly in accordance with the activity of occupants, especially for electricity demand. Electricity consumptions for different UK households vary from day to day and house to house because of diverse occupancy pattern and occupant behaviour which are known as occupant activity profile. How people spend their time at home is the key issue when configuring the occupant activity model. For particular household, daily realistic occupant active profile requires very large amount data sets which are

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not ideally possible currently, especially for very short-term resolution, like below 10 minute. However, electricity load profile which presents the use of appliances, such as lighting, cooking, washing etc. highly depends on the number of occupant and related occupancy pattern [1]. Detailed electricity load provides a possible solution to generate synthetic occupancy data in occupant activity modelling. By analysing the real load, "active occupant" can be defined as a person who is at home and using electricity appliance, and also not asleep, even this person does not have energy-saving behaviour. Thus, identify the number of active occupant is the key issue when conducting occupant activity modelling. Meantime, to generate synthetic occupancy data, the possibility of active occupancy at each time is generated stochastically by Markov-Chain technique and Markov-Chain Monte Carlo method is used to predict the active occupant profiles and the related electricity demand dynamically.

2. Number of active occupancy

One-day Time-Use Survey (TUS) [2] has been conducted in the United Kingdom in year 2000, which involves many thousands of participants to present how people spent their time in 24-hour diaries, also including weekday and weekend. By analysing TUS data, Richardson et al. [3] have proved that aggregate occupancy profile for large amount households can be predicted stochastically with any single weekday and weekend. However, the result cannot reflect the patterns of daily consistency because of its individual diaries. In order to address the number of active occupant for consistency profile, it is very important to analysis the real load data, which can present the type of appliance and occupant energy behaviour.

2.1 Appliances component

The most common electrical appliance in UK domestic household has been analyzed in this paper, which can be divided into two domains: Occupancy related and non-occupancy related. The former one contains the appliances which may be switched-on if there is an active occupant, which including standby appliance, most kitchen and house clean appliance, also with lighting. The later one contains the continuous and cycle appliance, these electrical appliance is always switched-on regardless the occupant is active or not. It should be noticed that the appliance with standby model may be changed to continuous category because of the occupant energy behaviour. It is clear that if there is non-active occupant at certain time, the real load should be less than the total of non-occupancy related and standby appliances consumption, which can be identified by occupant patterns.

2.2 Occupancy pattern

There are some most common scenarios of household occupancy pattern in the UK, which are as follows: (a) unoccupied period is from 09.00 to 13.00, the occupants have the part-time job during morning; (b) unoccupied period is from 13.00 to 18.00, the occupants have the part-time job during afternoon; (c) unoccupied period is from 09.00 to 17.00, the occupants have the full-time job; (d) The house is occupied all the time; the family of this type of household may have infant to look after or is of retired couples and single or weekend. Therefore, by analysing the occupancy pattern, we can identify the load of non-active occupant. For example, as the first scenario the dwelling is unoccupied during morning in weekdays, which means the average load during these times can represent the non-active occupant load, also at sleeping hours, in this report, this load is in the range of 0.08kW to 0.4kW for each household.

2.3 Average Electricity Consumption of Occupant (AECO)

When people are active in the house, they may use the electrical appliances or share with other occupants, and also related consumption will beyond the non-active occupant load, which mean there is at least one person is active. Electricity consumption is also highly related to household size. The data in this paper is used the measured real load with thirty-second resolution of three UK households in [4], which the