Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 104 (2016) 245 – 250

Energy Procedia

CUE2016-Applied Energy Symposium and Forum 2016: Low carbon cities & urban energy systems

An empirical study of influencing factors on residential building energy consumption in Qingdao City, China

Fan Feng[a], Zhengwei Li[a]*, Yingjun Ruan[a], Peng Xu[a]

a: Department of Mechanical and Energy Engineering, Tongji University, Shanghai, China

Abstract

Residential building sector is one of the major contributors to global electricity energy consumption. Current researches have demonstrated that the residential building energy consumption is determined by many factors, including climate conditions, household and building characteristics, and occupant behavior. However, the extent to which each factor contributes to the total energy consumption has remained unclear, especially in developing countries such as China. To partially answer this question, an empirical study was conducted in five residential real estates in Qingdao city. Questionnaires were distributed to around 500 families, whose electricity consumption from Feb to Aug, 2015 was then collected from local electricity bureaus. Based on the collected data, correlation analysis was performed to exploit the relative role of each factors. Results reveal that occupant behavior is the most important parameter on cooling energy use, compared with household characteristics and urban geometry.

Peer-review under responsibility of the scientific committee of the Applied Energy Symposium and Forum, CUE2016: Low carbon cities and urban energy systems.

Keywords: residential building; energy consumption; household characteristics; urban geometry; China

1. Introduction*

Residential building energy consumption occupies a significant portion of global energy usage. Residential building energy use could be attributed to by four variables: building (shape, material and construction), system (electrical appliances), occupant (household statistics and energy related behaviour), and context (urban geometry and local climate). The relationships have been widely studied [1-5]. Fan surveyed 3446 households in the greater Sydney region in Australia, and both electricity usage and household statistics of each household were collected [1]. Among the factors investigated, the number of occupants is found to have the largest impact on household energy consumption. Chen studied the residential building winter energy use in seven typical cities in China, and found that the influential factors differ significantly in different cities [2]. In Chongqing city, the influential factors include construction year, annual income, orientation, and the usage of heaters; while in Hong Kong, only family income is

* Corresponding author. Tel.: +86-187-2192-2352; fax: +021-69589843.
E-mail address: zhengwei_li@tongji.edu.cn.

Peer-review under responsibility of the scientific committee of the Applied Energy Symposium and Forum, CUE2016: Low carbon cities and urban energy systems.
doi:10.1016/j.egypro.2016.12.042

identified as the major factor. The importance of household characteristics was proved by Chen again. For both new and old residential buildings in Shanghai, floor area and number of family members are identified as the main reason causing energy use differences [3].

To study the impact of occupant behaviour, Chen collected data in Hangzhou city, China (642 families in winter, and 838 families in summer) [4]. His analysis shows that occupant age is a more influential factor than family income. A study of the US residential energy use by Steemers was also dedicated to exploit the role of occupant. It is found that occupant behavior do affect the energy consumption, significantly in summertime but marginally in wintertime. [5].

Through the literature review, the roles of microclimate (caused by both urban geometry and building typology) and occupant behaviour on building energy use have been commonly accepted, but the extent to which energy use is affected by these two set of factors is seldom studied. With the identified gap in mind, a residential building energy survey was recently taken in Qingdao City, a northeastern city of China. During the survey, the impact of occupant behaviour on space cooling is mainly focused.

2. 2. Description of the survey procedure and preprocessing techniques

2.1. Survey procedure

The first step is to choose the survey samples. To make the urban geometry variable rather comparable, five housing estates were selected: Lushang, Hai'er Eastern Town, Lihai Garden, Haiqing Garden and Dianye. Lushang, Dianye and Haiqing Garden are in the Zhuhai Rd. Neighborhood, while Hai'er Eastern Town and Lihai Garden are in the Fushan Hou Neighborhood, as shown in Fig. 1. From Table 1, these five estates have different floor area ratios (FAR), which means the local building typologies are different, and different the green area ratio(GAR), which might lead to different microclimates conditions. Further, since these five estates were built at different years, the level of building insulation and airtightness level might vary dramatically as well. Furthermore, the market price of Lushang is about 50% higher than that of other four estates, thus the residents of these five estates are expected to have different economic status.

Fig 1. Location of the surveyed real estates

Table 1. Information of the surveyed estates

Names	Construction year	Floor Area Ratio	Green Area ratio	Proximity to sea（m）	Neighborhood
Lushang	2013	5.2	30%	1000	Zhuhai Rd.
Hai'er	2006	1.6	40%	3100	Fushan hou
Lihai	2003	1.15	45%	2100	Fushan hou
Haiqing	1999	3	35%	500	Zhuhai Rd.
Dianye	1970	1.9	40%	500	Zhuhai Rd.

Secondly, in each estate, around 100 survey questionnaires were distributed to its residents through the local residential committee. The questionnaire mainly includes three types of questions: household characteristics, occupant preferences, and energy usage. Finally, the exact amount of electricity usage of each housing unit was fetched through local electricity bureau.