



Residential electricity consumption behavior: Influencing factors, related theories and intervention strategies



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ARTICLE INFO

Keywords:

Residential electricity consumption
Influencing factors
Behavior interventions
Theories

ABSTRACT

The proportion of residential electricity consumption in the total energy consumption has increased rapidly in the past decades all over the world. It is becoming increasingly important to promote household energy conservation for the sustainable development of a country in the case of resource constraints. This paper reviews and evaluates the existing research works which are related to the residential electricity consumption behavior. Particular attention is given to the following aspects. (1) Factors influencing residential electricity consumption in social psychology. (2) Theories of social psychology in understanding residential electricity consumption behavior. (3) Different interventions aiming at encouraging households to reduce electricity consumption. Finally, we discuss the challenges and opportunities of research on residential electricity consumption behavior in the big data era.

1. Introduction

Environmental pollution and scarcity of resources have become major factors that affect the sustainable development of global economy since 21st century [1]. Irrational use of energy has led to environmental pollution and unsustainable development for a long time. Electricity has played an essential role in our society [2]. However, the main way of generating is thermal power, which accompanied with air pollution. In this sense, reducing electricity consumption has been important implications for sustainable development of society. The power demand of residents is a part of the social power demand. The proportion of residential electricity consumption has growing with increasing household appliances and population. Residents only know the monthly consumption of electricity before the popularity of smart meters. They have few information about the daily consumption of electricity, and people always receive the past electricity consumption bills after several months. The comparison of electricity consumption was lacked. Meanwhile, residents do not care about consumption of electricity. With the popularity of first generation of smart meters, people could know their electricity consumption every day and even every 15 min [5]. People can pay off their electricity consumption bills on the Internet. The pattern of electricity consumption is more like the use of mobile phone. During this period, people have begun to pay more attention to electricity consumption gradually, so information makes the residents really give attention to their

consumption bills and related electricity consumption behavior.

At present, many scholars have done a lot of researches on residents' energy-saving behavior [3]. From the perspective of content, the researches mainly focus on the following three aspects. The first aspect is the analysis of the main factors that have effects on residential electricity consumption behaviors, including household characteristics, socio-economic factors, social-psychology factors and related environmental behavior theory [17]. The second aspect is the statistical analysis of electricity consumption's data. The regular pattern of electricity consumption was found [6]. For example, residents with the similar load profile can be clustered into one class with the help of cluster analysis. The third aspect is the implementation of intervention [11]. The researchers made an intervention on residents based on psychological factors and mode of action. So we can reduce electricity consumption by means of energy-saving intervention strategy.

With the development of big data and cloud computing, it is more convenient to study the behavior hiding behind the electricity consumption [34]. By means of the Internet technology, researchers can be more convenient to investigate the behavior of residents that related to electricity consumption. During big data era, it is possible to store and analysis massive data. Power Company can give feedbacks about electricity consumption to customers more frequently through big data analysis [25]. We can draw more reliable conclusions with the support of data mining, and further make more effective interventions.

The purpose of this paper is to review and summarize literatures

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related to residential electricity consumption. Firstly, the paper analyzes the vital factors influencing residential electricity consumption. Secondly, we review the social psychological factors, their mechanism of effecting, and related behavior theory. Finally we summarize the five most common intervention strategies and research direction of residential electricity consumption in big data era.

2. Social psychological factors influencing residential electricity consumption behavior

Home is the basic unit of electricity consumption, therefore the reduction of electricity consumption per household will reduce the electricity consumption of the whole society [27]. So we need to find the factors which have significant impacts on household consumption of electricity in order to reducing electricity consumption. Different families have different structure, cultural background and ideological concept. Under the influence of kinds of factors and their interactions, each family has a different load profile. Meanwhile, different load profile also reflect different family types and consumption behaviors. This section summarizes the characteristics of the household from many literatures [29,30,32,33] including: (1) Number of family members. (2) Children. (3) Age composition of family members. (4) Level of education. (5) Social status of family. (6) Family economic situation. (7) The type of a house. The effects of different family characteristic factors on household electricity are described in the following.

- (1) Number of family members. The relationship between the number of households and electricity consumption has been studied by many scholars. The majority of literatures showed that the number of households has a positive impact on electricity consumption. With the increasing number of households, household electricity consumption will also increase. Leahy and Lyons [7] studied the electricity consumption of single and double people in Ireland. By comparison, they found that a single apartment have less than 19% of the electricity consumption per week. Yohanis et al. [8] studied the relationship between the number of households and electricity consumption in an apartments in Northern Ireland. The results showed that the apartment lived with four people or more people are used to consume highest average annual electricity consumption. And there was no obvious difference between houses lived with two people and three people in average annual electricity consumption. Bartiaux and Gram-Hanssen [9] investigated the relationship among the number of families, housing type and electricity consumption. The results indicated that the correlation between the number of households and electricity consumption is the most significant. In the three types of housing (independent, semi-independent, apartment). The number of households has always been significantly associated with electricity consumption.
- (2) Children. Children is also an important factor affecting electricity consumption [35]. Many scholars have made researches on the relationship between the composition of the family members and electricity consumption. There are two opposite results. A part of the studies found that the composition of family members had a significant impact on consumption of electricity. For example, Mcloughlin et al. [10] studied on the relationship between household electricity consumption and whether the family have children or not. They found that the family had children consume more electricity than the family had no children. Brounen et al. [12] found that the family with a child consume more 1/5 electricity than the family without children. With the growth of the child, household electricity consumption will also increase. In Brounen's opinion, children tended to play computer, watch TV, play games or other electrical device, these activities would lead to consume electricity. However, Bartiaux and Gram-Hanssen [9] had opposite conclusion. They found that the family with two or more children (children 0–9 years old) had a negative impact on the electricity consumption, and having children has reduced the average electricity consumption. Gram-Hanssen found that the effect was significant in the Danish region, but was not in Belgium. Wallisn et al. [87] analyzed the influence of the number of adolescents on electricity consumption, they found that adolescents' frequent purchasing of IT appliances led to higher electricity consumption. Cramer et al [24]. found that children under 3 years old had no significant effect on household electricity consumption in the American family. However, for the family has children over 3 years old, there was a significant impact on consumption of electricity. However, in Ireland, Leahy and Lyons [7] showed that families with children had no significant difference in electricity consumption. Nakamura [28] showed that the mother having child was easier to participate in some schools and community organizations, and they tend to know the information of energy conservation.
- (3) Age composition of family members. According to Yohanis et al. [8], the age of family member had influence on household electricity consumption. And electricity consumption is relatively high, when the age of the family member is 50–65. Electricity Consumption is relatively lower, when the age of family member is less than 50 years old or over 65 years old. Leahy and Lyons [7] pointed out that electricity consumption of household where age of the family member is between 45 and 64 was significantly higher than that of 35–44 years old in Ireland. Household electricity consumption decreased significantly when age of the family member is more than 64 years old. Mcloughlin et al. [10] found that household electricity consumption of family where age of the member is 18–35 was less than 36–55 or 56. Researchers believed that this is middle-aged family has more children and rooms. So the consumption of electricity is more. Kavousian et al. [26] found that in the United States, these families whose age of the family member is more than 55 or 19–35 consume less electricity. Filippini et al. [27] found in the India area, the family whose age of responsible members is less than 45 have less consumption than the family whose age of responsible members is older.
- (4) Level of education. The educational level of the family member has influence on electricity consumption. The conclusion is also uncertain. Bartiaux and Gram-Hanssen et al. [9] found that household electricity consumption decreased significantly as the level of education increased. The family members with higher degree of education consumed less electricity than the family members with low education level. However, According to Cramer et al. [24], the educational level of family members had no significant impact on electricity consumption both in the United States and Holland.
- (5) Social status of the family. Social status has different influence on electricity consumption according to current research's conclusions. Mcloughlin et al. [10] found that socio-economic status of a family had a significant impact on household electricity consumption. And there was a significant positive correlation between socioeconomic status and household consumption. The higher social status of household consumption was accompanied with more electricity consumption. However, according to Leahy and Lyons [7], family members' economic status had no significant impact on household electricity demand.
- (6) Family economic situation. Economic situation mainly involves two aspects [54]. On the one hand, it is the family income; On the other hand, it is the family disposable income. These two aspects reflect the economic situation of a family. A large number of literatures showed that household electricity consumption increased with income. Yohanis et al. [8] found that in Northern Ireland, the households whose annual incomes of more than 30,000 Irish pounds consumed more electricity than the low income families which has annual income of 10,000 Irish pounds.

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