Analysis of Employees’ Energy Conservation Behaviour in the Office Buildings—Based on the Structural Equation Model

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Abstract. Energy consumption and climate change have become an urgent task for economic and social development around the world. Building energy consumption and the indoor environment are largely influenced by users' behaviours. Recently, more and more attention has been paid to users' behaviour towards energy saving. By issuing questionnaires, this paper investigates the relationship between energy saving willingness, energy saving perception, and energy saving behaviour of office workers. The result shows that psychological factors such as environmental values, energy saving knowledge, perception of behaviour control, and preference can indirectly affect employees’ energy saving behaviours. Psychological ownership and subjective norms have no obvious effect on promoting energy-saving behaviours. Besides, factors of policy, atmosphere, and publicity have significant effects on energy saving behaviours. Factors such as working age, education, and occupation can significantly promote employees' energy-saving behaviours.

1. Introduction
With the economic and social development, the problem of energy shortage and environmental pollution has been widely concerned all over the world. According to China Building Energy Use from 2000 to 2016, China's building energy consumption accounts for 20.6% of the total social energy consumption. Public buildings accounting for 18% of the floor space and 38% of the total building carbon emission[1]. The carbon emission intensity of public buildings is about 2.23 times of the residential buildings. Therefore, it is urgent to save energy in public buildings. Over the past few years, energy efficiency measures in public buildings have focused on new technologies, new materials and new equipment. Policies and Standards on energy saving technology and design for public buildings include the renewal of energy saving equipment, research and development of energy saving materials, and promotion of energy saving technologies, which has greatly promoted energy conservation from the perspectives of science, technology and equipment. However, science, technology, and equipment do not fully exert their designed energy saving potential, and human behaviour will directly affect the energy consumption level of buildings. Office buildings are the public buildings that are most affected by energy saving behaviour. As the subject of behaviour, employees are directly involved in the energy use of office buildings. Employees' energy saving preferences, awareness, sensitivity and other factors play a key role in energy saving in the operation and management stage of office buildings. Different from residents' energy saving, employees' energy consumption and energy saving behaviours are affected by
different corporate culture, office environment, organizational atmosphere and so on. The incentive policy for employees to save energy in China is not mature and widespread enough, and the actual response of the policy in enterprises is not clear. Therefore, it is necessary to better understand the needs of employees and combine the existing problems in implementation to further improve the policy. How to guide employees in office buildings to save energy is of great significance to energy conservation and emission reduction in China's building construction field. In this paper, employees' energy saving behaviours in office buildings are analysed through questionnaires. Starting from the key factors, the paper analyses the action mechanism among the factors affecting employees' energy saving behaviour, intending to provide the basis for enhancing their energy saving awareness and promoting their energy saving behaviour, which will be helpful to further promote office building energy saving.

2. Theoretical research on influencing factors of energy saving behaviour

2.1. Energy Saving Knowledge
Harland believes that the lack of energy saving knowledge is one of the reasons for the obstacles of residents' energy consumption behaviour[2]. Han took Dutch households as objects to discuss their energy-saving behaviours. The results show that energy saving behaviour is largely determined by knowledge[3]. Frick and other scholars have reached the same conclusion: Environmental knowledge can significantly promote the transformation of residents' awareness of environmental behaviour into specific environmental behaviour[4].

2.2. Habit and Preference
Bento proposed that consumers' different preferences would affect the use of energy saving products, leading to low efficiency[5]. Lv believed that the energy-saving habits of residents have a direct impact on their energy-saving behaviours, and the cultivation of good habits is conducive to saving household energy consumption[6]. Zhang found that employees’ subjective norms and psychological ownership would indirectly affect their behavioural intention to save energy[7].

2.3. Perception of Behavior Control
Klockner showed that the perception of behaviour control can reflect behavioural intention in advance and take the latter as the intermediary to influence environmental behaviour[8]. Gao believes that the perception of behaviour control in the work environment will have a positive impact on energy saving behaviours[9]. Cai takes the purchase behaviour of new energy vehicles as the entry point and adopts the technology acceptance model to study consumers' purchase behaviour of low-carbon products. The results show that the perception of behaviour control is one of the key factors determining the purchase behaviour[10].

3. Construction of Energy Saving Behaviour Model for Office Building Employees

3.1. Variable selection
Based on the viewpoints in the literature related to the study of energy saving behaviours, the variables selected in this paper include Environmental Values (EV), Energy Saving Knowledge (ESK), Subjective Norm (SN), Perception of Behaviour Control (PBC), Psychological Ownership (PO), Preference and Habit (PH), Energy Conservation Behaviour (ECB), and Behaviour Intention of Energy Conservation (BIEC).

3.2. Model Construction and Hypothesis Generation
According to the theory of planned behaviour, the paper takes the path analysis between influencing factors, behaviour intention of energy conservation and behaviour of energy saving as the research subject. Within the structural equation model, energy saving behaviour is endogenous latent variable or
dependent variable, influencing factor is an exogenous latent variable or independent variable, and behaviour intention of energy conservation is an intermediary variable. Hypotheses are as follows:

H1: Environmental values have a significant positive impact on the behaviour intention of energy conservation.

H2: Energy saving knowledge has a significant positive impact on the behaviour intention of energy conservation.

H3: Subjective norm has a significant positive impact on the behaviour intention of energy conservation.

H4: Perception of behaviour control has a significant positive influence on the behaviour intention of energy conservation.

H5: Psychological ownership has a significant positive impact on the behaviour intention of energy conservation.

H6: Preference and habit have a significant positive effect on the behaviour intention of energy conservation.

H7: Behaviour intention of energy conservation has a significant positive impact on energy conservation behaviours.

3.3. Measurement Index Generation
The observed variables corresponding to 8 latent variables in the questionnaire were scored by 5-Point Likert Scale (see Table 1). Employees score based on their actual situation.

| Variable | Numbering | Description |
|----------|-----------|-------------|
| EV       | EV1       | I will have a sense of satisfaction and achievement when implementing energy-saving behaviour. |
|          | EV2       | Energy conservation is conducive to sustainable development. |
|          | EV3       | Protecting the environment, saving energy and reducing emissions is not only the responsibility of the government and enterprises, but also mine. |
| ESK1     |           | Standby power consumption of office appliances accounts for up to 10% of office power consumption in China. |
| ESK2     |           | If you don't use a computer for a short period time, the power consumption can be reduced to less than 50% by using the computer's "sleep" mode. |
| ESK3     |           | Energy-efficient lamps use less electricity than incandescent lamps. |
| ESK4     |           | Every one degree increase in air conditioning temperature can save 8% of electricity. |
| ESK5     |           | Properly reduce the brightness of the computer screen can save electricity. |
| SN1      |           | Influenced by the type of role I play in the company. |
| SN2      |           | Influenced by my boss. |
| SN3      |           | Influenced by the behaviour of colleagues. |
| SN4      |           | Influenced by public figures. |
| PBC1     |           | I will implement energy saving behaviour if I am willing to do, even if the external conditions for energy conservation are harsh. |
| PBC2     |           | When the implementation of energy-saving behaviour encountered difficulties, I can always solve the problem. |
| PBC3     |           | When implementing the energy-saving behaviour, I will not give up even if I feel there are obstacles. |
| PO       | PO1       | I feel like I own the company. |
I think I have a lot to do with the success or failure of the company.
I would like to consider the company as my second home.
The company gave me a great sense of belonging.
It's natural for me to save energy in the company.
Saving energy has become a habit for me.
Turn off the lights when I leave the office.
Take the initiative to switch your computer to a power-saving mode in time to reduce standby power consumption.
Take the stairs more often than the elevator.
Moderate the use of air conditioning, heating equipment.
Power off after using the printer.
Take the initiative to stop colleagues from wasting energy.
Actively cooperate with the company to carry out energy saving measures.
Be willing to change your daily energy habits to save energy.
Persuade colleagues to save energy.
Use energy efficient products in your office whenever possible.
Be willing to turn on less air conditioning to save energy.
Participate in low-carbon energy saving activities and actively respond to energy saving activities.

3.4. Survey and scale test
An online questionnaire was used to carry out a formal investigation in Beijing, Shanghai, Hangzhou, Ningbo, Changsha, Kunming and Shenzhen. 332 online questionnaires were issued in their office buildings, with a 100% effective rate. In order to ensure the validity of the formal questionnaire data, the reliability of the formal questionnaire should be tested again before statistical analysis. The test results are shown in Table 2.

| Variable | Number of Items | Value of Cronbach's Alpha |
|----------|----------------|--------------------------|
| EV       | 3              | 0.889                    |
| ESK      | 5              | 0.863                    |
| SN       | 4              | 0.897                    |
| PBC      | 3              | 0.894                    |
| PO       | 4              | 0.936                    |
| PH       | 2              | 0.832                    |
| ECB      | 7              | 0.851                    |
| BIEC     | 5              | 0.884                    |
| Total    | 33             | 0.932                    |

The values of Cronbach's Alpha all exceed 0.8, which proved the reliability of the scale data. To facilitate the construct validity test, the behaviour intention of energy conservation can be regarded as a mediator, and the behaviour of energy saving can be regarded as a dependent variable. The behaviour intention of energy conservation can be regarded as an independent variable to conduct exploratory
factor analysis and confirmatory factor analysis. The test results show that the data has good quality, and the questionnaire structure is reasonable.

3.5. Model Test Based on Structural Equation

Based on the test results, the previous model and path should be modified. BIEC plays a mediating role between EV, PBC, PH, ESK, and ECB. BIEC plays a complete mediating role for ESK on ECB, while the other factors play partial mediating roles. All situational factors have a moderating effect on ECB. Some of the social demographic factors will have a significant impact on the ECB. The modified model is shown in Figure 1.

![Figure 1. the modified model of factors which affect employees' ECB in an office building.](image)

4. Conclusion

4.1. Part of psychological factors acts on energy conservation behavior through the behavior intention of energy conservation.

Psychological factors of environmental values, energy saving knowledge conservation, perception of behaviour control, preference and habit, and psychological ownership have a significant positive effect on employees’ behavioural intention of energy conservation. Environmental values have the most significant influence on the behaviour intention of energy conservation. Environmental values, energy saving knowledge conservation, perception of behaviour control, habit and preference have a significant positive effect on energy saving behaviour. Environmental values have the most significant effect on energy conservation behaviour. The behaviour intention of energy conservation has a significant positive influence on the energy conservation behaviour.

4.2. Employees' energy conservation behaviors are different

There are significant differences in employees' energy conservation behaviours due to their different education levels. Employees with master degrees or above are more likely to adopt energy conservation behaviours. Knowledgeable employees are more likely to understand energy saving knowledge and accept energy saving publicity. Those who have received high-level education and accepted the concept of environmental protection are more willing to adopt energy conservation behaviours in their work.
4.3. Situational factors affect energy saving behavior
Policy, publicity, education, and organizational energy saving atmosphere factors all have a positive impact on employees' behaviour intention of energy conservation. The analysis shows that individuals' behaviours can be affected by group behaviours. With a strong energy saving atmosphere, valid propaganda and stable policy implementation, the behaviour of employees will tend to energy saving. In conclusion, the energy saving behaviours of employees can be guided by government guidance, enterprise promotion, and property participation.

The government should strive to improve energy conservation policies and energy statistics system, encourage enterprises to establish and improve energy conservation incentive system, and strengthen the publicity and education of energy conservation throughout the society. Enterprises should actively introduce the energy saving accountability system and incentive system to encourage employees' energy conservation behaviours. The mid-level managers should play a leading role in the company. Besides, intelligent energy-saving office equipment should be widely promoted. The property management should drive energy saving enthusiasm, promote the energy management services mechanism, and create a good atmosphere of energy conservation in the office building.

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