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Analysis of interactions among the barriers to energy saving in China

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Abstract

Since China became the second largest energy consumer and carbon dioxide emitter, the problem of energy consumption and environmental pollution has drawn the world's attention. Meanwhile, Chinese government has put high emphasis on the problem. One project of energy saving initiated by Chinese government has been put into practice. However, many difficulties need to be dealt with to meet the expected aim of social development. The objective of this article is to investigate the interactions among the major barriers which prevent the practice of energy saving in China. Obviously, a clear definition of relationships among the barriers to energy saving helps top leaders make relevant decisions to solve the problem of economic sustainability, energy security and environment pollution in the future. To date, studies specifying energy-saving barriers have often focused on analyzing these barriers separately. As a result, a holistic view in understanding the barriers to energy-saving project is lacking. Interpretive structural modeling (ISM) is utilized to summarize the critical barriers hindering the project of energy saving in China and to explain the interrelationships among them. Suggestions for energy-saving practice and future research are provided.

Keywords: Energy saving; Barriers; Interpretive structural modeling

1. Introduction

Today China is experiencing rapid development and the future society, with higher level of modernization and standard of living, will consume more energy. Since China has become the second largest energy consumer and carbon dioxide emitter (Lu and Ma, 2004), its issues of energy consumption and environmental pollution are catching the world's eyes. Meanwhile, Chinese government has put high emphasis on these issues. One project of energy saving initiated by the government has been putting into practice. In recent years, China has presented two remarkable development objectives. One objective is to build a well-off society in all round way, which was raised at the 16th National Congress of the Communist Party of China in 2002. Another objective, put forward at the 10th National Congress of P.R. of China in 2006, is to reduce 20% of energy consumption at the end of the 11th Five-Year Plan.

It is inevitable for China to make such decisions. From 2002 till now, the elasticity of energy consumption is between 1.0 and 1.57, which shows that the progress is more and more dependent on the quantity than the quality of the energy consumption. It was once considered that China abounds in energy resources. Thus, its economic development was based on high-resource consuming pattern. However, two challenges are confronting China and drawing more and more attentions in recent years. The first one is the conflict between economic sustainability and environmental pollution. The ever increasing fossil fuel prices and the fact that oil reserves are not sufficient for the expanding energy demands will prevent China from building the well-off society in all round way. The second challenge is that China will face an enormous pressure of greenhouse gas mitigation. China is a Party of the United Nations Framework Convention on Climate Change, and all Parties have an obligation to mitigate climate change (Ni and Johansson, 2004). Additionally, In the light of

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global warming due to human enhancement of the greenhouse effect, there is a clearly growing concern about the sustainable development of the world. In order to realize sustainability, the Chinese government has no other choices but energy-saving practices. At the stage of rapid economic development, China is urged to increase energy efficiency, strengthen energy conservation, develop renewable energy and optimize energy structure as well.

Nevertheless, the implementation of energy-saving program may be a great challenge for the top policymakers as it involves many operational aspects, including economy, politics, environment, technology, management, etc. That is to say, the practice of energy saving is not free from barriers. To move towards the path of sustainable energy, it is necessary to identify and analyze the barriers to energy saving in China.

The barriers not only affect the operation of energy saving but also influence one another. Thus, it is very essential to understand the mutual relationships among the barriers. The identification of the barriers that are at the root of some barriers (called driving barriers) and those which are most influenced by the others (called driven barriers) would be helpful for the policymakers to implement the energy-saving programs. This can be a guide for taking appropriate action to tackle barriers in energy-saving project. An analysis of the barriers hindering energy saving and their interaction with the various aspects in integrative planning can be a valuable source of information for decision makers.

To date, many studies identifying the barriers to energy saving in some countries (including China) and regions have been made. Fang and Zeng (2007) illustrated some barriers and challenges facing the energy management in China. Yang (2007) also analyzed some main barriers to energy saving in China. On the basis of the research conducted by Bioenergy Network of Excellence, McCormick and Ka berger (2007) identified the major barriers that hinder the application of energy and developed an innovative methodology to identify key barriers. Lidula et al. (2007) carried out a study on the barriers to clean and sustainable energy in the ASEAN member countries. Mayfield et al. (2007) provided a new framework to deal with the barriers to enhance the efficiency of biomass operation. Sharma et al. (1995) tried to examine the objectives of waste management in India. Furthermore, some barriers, through a series of studies, were identified by the New York State Energy Research and Development Authority and Oak Ridge National Laboratory (ORNL) (Tonn and Peretz, 2007). Although China's issues of energy saving are specific due to its current situation, it would be helpful to use the relevant reference of other countries.

2. Definition and methodology

Energy security will be one of the biggest threats to China's sustainability development because of the high price and external dependency of energy. In fact, the endeavor to energy saving is an important measure to deal with energy saving. The objective of energy saving can only be achieved by the efforts of all parties, including industries such as steel, coal, chemistry, building, transportation, service, R&D of new energy and the government. Therefore, 13 barriers to energy saving were pointed out according to the research scope. Lack of an efficient framework of energy saving gives importance to macroscopic research. Therefore, a study specifying relationships among these barriers to energy-saving practice will be made in this paper.

Interpretive structural modeling (ISM) can be applied to identify the main barriers to energy saving. Warfield (1974, 1990) introduced ISM and provided detailed descriptions and operating procedures. Malone (1975) conducted a brief review. ISM is a suitable modeling technique for analyzing the impact of one element on other elements and for getting better insights into the system considered. It provides us means by which order can be imposed on the complexity of such elements (Mandal and Deshmukh, 1994; Jharkharia and Shankar, 2005). The method is interpretive in that the group's judgment decides whether and how the items are related. Based on the relationships, an overall structure can be acquired and well depicts the relationships graphically. Owing to its good flexibility, it is widely used in many technical, economic and social systems. Additionally, ISM is intended as a group-learning process but it can also be used individually. The ISM methodology is an interactive learning process in which a set of different and directly (indirectly) related elements affecting the system under consideration is structured into a comprehensive systemic model (Tonn and Peretz, 2007). An examination of the direct and indirect relationships among the barriers of the energy saving can give a clearer picture of the situation than considering individual factors alone in isolation. Therefore, the barriers of the energy saving in China have been analyzed by using the ISM, which shows the interrelationships of the barriers and their levels. In addition, these barriers are categorized according to their driving power and dependence.

3. Main barriers of energy saving

A number of difficulties stand in way of the Central Government's goal of energy saving. For example, China's energy industry is flooded with high energy-consuming manufacturers. After review of literatures on energy saving and opinion of experts from energy industry and academia, 13 barriers to energy saving were put forward. The literature review as well as the experts' opinion was used to develop the relationship matrix, which was later applied in the ISM model.

These barriers are lack of awareness of energy saving (LA), lack of experience in technology and management (LETM), lack of funding or financing difficulties (LFFDs), limited policy framework (LPF), lack of research personnel or trained manpower (LRTP), lack of public participation