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Energy Costs Hosting Model: The most suitable business model in the developing stage of Energy Performance Contracting

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ABSTRACT

Energy Performance Contracting (EPC) is a significant business mechanism to reduce energy consumption of existing buildings. At present, there are three basic business models of EPC: Guaranteed-Savings Model, Shared-Savings Model and Energy Costs Hosting Model. We suppose that the Energy Costs Hosting Model, in which building owners, Energy Service Companies (ESCOs) and financial institutions can achieve optimal benefits, is the most suitable business model in the developing stage of EPC. We construct benefits distribution models which involve three stakeholders based on interval-valued fuzzy Shapley value, adjust these values according to the actual allocation of energy-saving benefits and compare the benefits of the three stakeholders in the three business models. We conclude that Energy Costs Hosting Model can bring the maximum benefits to these three stakeholders and the participation of governments and authoritative institutions of authentication and appraisal can solve two major problems: 'unshared information' and 'lack of supervision system'.

1. Introduction

In recent years, the energy consumption of the building industry has been increasing. Buildings are responsible for at least 40% of global energy consumption and more than 30% of greenhouse gas emission (Yang et al., 2016). Therefore, it is crucial to reduce energy consumption of existing buildings from the perspective of sustainable development (Xu et al., 2015). Energy Performance Contracting (EPC) which emerged in North America in the 1970s after the first oil crisis was introduced to the electricity industry (Adelaar et al., 1997). EPC has achieved a great success at that time and it was soon followed by other industries. It has been an essential method to reduce energy consumption and emission since it was applied in the building industry (Yik and Lee, 2004). (see Figs. 10 and 11)

EPC, an advanced energy management method and a market-oriented energy-saving mechanism, enables the energy cost savings to offset the expense of implementing, maintaining and operating energy-saving measures (Vine et al., 1998). It can be classified into three business models according to different types of cooperation among building owners, Energy Service Companies (ESCOs) and financial institutions (Painuly, Park, Lee and Noh, 2003), namely Guaranteed Savings Model (Limaye, D.R. & Limaye, E.S. 2011), Shared Savings Model (Qian and Guo, 2014; Akman, Okay, E. & Okay, N. 2013) and Energy Costs Hosting Model (Goldman et al., 2005). In Europe and the United States where EPC has reached the mature stage, the Guaranteed Savings Model is the most widely accepted one. In contrast, the Shared Savings Model is the most popular model in countries where EPC is still developing. This difference arouses our attention and we wonder whether there is a preferred business model in different stages of EPC. Although scholars (Vine (2005)) have focused on analyzing income distribution, ways of risk-taking, operating mechanism and contract terms in a certain business model, few studies (Shang et al. (2015); Songer and Molenaar, 1998) systematically compare the three business models from these aspects. To fill this gap, we attempt to find out which business model can bring greatest benefits to all stakeholders in the developing stage of EPC. This is the first part of the research.

Meanwhile, all business models share several common problems, including financing difficulties, lack of trustworthiness and

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limited technical capacity. Governments should act as guides to cope with these problems (Bertoldi et al., 2006). Moreover, the information between building owners and ESCOs is asymmetric. Since building owners only have limited expertise, ESCOs have the possibility to gain extra profit from the difference between the expected energy savings of the building owners and the actual energy savings they can achieve. Authoritative institutions of authentication and appraisal should be involved to deal with such a problem. In this case, it is impossible to overcome all these obstacles in the EPC projects even in the most favorable business models we have found when we do not take these two participants into account. Hence, the most important part of our study is to quantitatively analyze the ability of governments and authoritative institutions of authentication and appraisal after verifying the feasibility of the Energy Costs Hosting Model.

The three main participants in EPC projects are building owners, ESCOs and financial institutions. In the previous researches, the relationship between building owners and ESCOs is usually competitive. They just want to obtain the greatest benefits for themselves. However, non-cooperative game focuses on individual gains but ignores the overall benefits. From the long-term perspective, the stakeholders of EPC should cooperate to make the most energy savings benefits rather than individual benefits in order to achieve the common goal of energy saving. Therefore, we use interval-valued fuzzy Shapley value which is a solution concept in cooperative game theory to equitably distribute and compare their benefits in the three business models to determine the most appropriate one. This approach is also applied to the case which also includes governments and authoritative institutions of authentication and appraisal while the previous study just made recommendations about the actions they should take. Finally, some recommendations are put forward to promote this model and to refine the EPC market.

2. Literature review

Energy Performance Contracting refers to an exceptional energy saving mechanism that building owners contract with ESCOs who provide energy audits, energy-saving facilities and technological upgrading. ESCOs finance these performance-based projects and devote themselves to reducing energy consumption and improving energy efficiency as well (Bertoldi et al., 2006; Lu and Shao, 2016). Former studies of EPC mainly focused on three aspects: ESCOs, contract terms and business models (Ouyang and Shen, 2017).

2.1. The first aspect is about ESCOs

Goldman et al. (2005) analyzed the development status of ESCOs in the U.S. markets and affirmed that EPC would have a good prospect with both financial and non-financial support. Vine, 2005 compiled a report about the evolution trends in 38 countries. He considered that the development of EPC was optimistic in most countries and would be popular subsequently in more and more countries. Maria and Reinhard (2016) analyzed the risks that affect the performance of ESCOs in Russian and provided that ESCOs should develop sector-specific contractual plans based on the cooperation with different industries. Yuan et al. (Yuan et al., 2016) reviewed the condition of ESCOs market in China. During 2005 to 2013, the total output growth of EPC market in China had increased 73.2 times. But they also pointed out that the development of EPC depended on the support from law, policy and finance. Thus, EPC should improve the market mechanism independently to get more long-term development. In addition, the studies have paid much attention to deal with the difficulties that ESCOs face. Deng et al. (Deng et al., 2015) built model based on Monte-Carlo simulation to maximum the revenue of ESCOs. These studies have emphasized the role of ESCOs. However, the three stakeholders are indispensable. Hence, we highlight the total revenue in this paper. The second aspect is about contract terms, including contract frameworks and the length of the contract period. Larsen et al. (Larsen et al., 2012) concluded that benefit-cost frameworks should comprise non-energy benefits. Ghosh et al. (Somik et al., 2011) thought that the ambiguity of contract periods is one of the barriers for EPC's further development in private building sector. Deng et al. (Deng et al., 2014) took the contract period as the guarantee of energy cost savings and constructed an optimization model to obtain the optimal length of contract period. These theoretical studies still lack the practical relevance. With the development of EPC, spotlight has turned to the business models and relevant studies are as follows:

2.2. The Guaranteed Savings Model of EPC

This business model is prevailing in Europe and the United States (Shang et al., 2015). Building owners invite ESCOs to participate in energy conservation projects where ESCOs guarantee certain levels of energy savings. The energy-saving income in the project all belongs to the building owners and they must pay remuneration to the ESCOs. Nevertheless, the ESCOs should compensate the building owners the shortfall for the failure to reach the guarantee. In emerging EPC markets, the building owners are also responsible for financing from financial institutions and evaluating the financing risk (Xu and Wu, 2015). Lee et al. (Lee et al., 2015a) proposed a framework based on the collar option model to determine the profit distribution ratio in this business model.

2.3. The Shared Savings Model

The Shared Savings Model is popular in developing countries (Ouyang and Shen, 2017). The reason why the Shared Savings Model can be more prevalent than the Guaranteed Savings Model in developing countries is that the Shared Savings Model is supported by more policies (Qian and Guo, 2014). Building owners cooperate with ESCOs who provide professional energy-saving services to reduce the energy consumption and these two partners share the energy-saving benefits depend on a pre-negotiated distribution proportion (Lee et al., 2015b). In this business model, the ESCOs are responsible for financing from the financial institutions and undertaking the financing risks, but the building owners must pay higher remuneration to the ESCOs. There are many studies in respect of the Shared Savings Model. Some studies on the Shared Savings Model analyzed the implementation and defined benefit principles and quotas to set up a benefit allocation according to the risk measurement. Xing et al. (Xing et al., 2016) used the robustness of the Shared Savings Model to build a bidirectional moral hazard of the benefit distribution.

2.4. The Energy Costs Hosting Model

This business model is gradually emerging in practice and relevant research is still very scarce (Goldman et al., 2005). Like the contractors in the engineering contracting model of Design-Build (Molenaar and Songer, 1998), ESCOs undertake a series of energy-saving works, such as purchasing and using less energy, promoting the energy efficiency, decreasing the ways to energy use, encouraging the government assessment of energy efficiency and providing funds for technical and equipment updating. The ESCOs can obtain all the benefit if they reach the energy-saving targets.