Energy 91 (2015) 60–71

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

What to allocate and how to allocate?—Benefit allocation in Shared Savings Energy Performance Contracting Projects

Tiancheng Shang [a, *], Kai Zhang [a], Peihong Liu [b], Ziwei Chen [a], Xiangpeng Li [a], Xue Wu [a]

[a] College of Management and Economics, Tianjin University, Tianjin 300072, China
[b] School of Languages and Culture, Tianjin University of Traditional Chinese Medicine, Tianjin 300193, China

ARTICLE INFO

Article history:
Received 12 February 2015
Received in revised form
22 June 2015
Accepted 11 August 2015
Available online xxx

Keywords:
Energy Performance Contracting
Shared Savings EPC Projects
Energy savings benefit allocation
Bargaining game theory

ABSTRACT

EPC (Energy Performance Contracting), as a mechanism grounded in markets, is important for the energy saving industry. The issue of energy savings benefit allocation in Shared Savings Energy Performance Contracting Projects is one obstacle frustrating the rapid growth of the energy performance contracting mechanism. Currently, studies on this issue primarily adopt the equilibrium principle of gains, which allocates risks and benefits according to their contribution in a dynamic alliance and has its limitations. In fact, the negotiation between the ESCO (Energy Service Company) and the client for the energy savings benefit allocation is a bargaining process. Therefore, Rubinstein bargaining game theory is used to examine this bargaining process and obtain an effective bargaining interval that satisfies both sides. Consequently, the problem of "what to allocate" is resolved. Furthermore, an energy savings benefit allocation bargaining model is established. In this model, both sides' equilibrium offer strategy is analyzed. Thus, the bargaining strategies and benefit allocation quota are noted. Then, the allocation duration and proportion can be determined based on the ESCO's total benefit allocation quota considering the time value of money and the risk factor. Consequently, the problem of "how to allocate" is resolved. This study offers a new perspective for analyzing energy savings benefit allocation in Shared Savings EPC projects.

1. Introduction

EPC (Energy Performance Contracting) [1] is an increasingly popular market-oriented energy saving mechanism. It uses reduced energy costs to pay for the total cost of implementing an EPC Project. An ESCO (Energy Service Company) [1,2], called an Energy Management Company by Chinese scholars, is a profit-oriented professional company based on EPC mechanisms [3–5]. Currently, the Shared Savings Model [6], Guaranteed Savings Model [6,7] and Chaffee Model [8] are the three primary Energy Performance Contracting business models in China.

The Shared Savings Model is funded and implemented by an ESCO. Although the clients do not make capital contributions, they share the energy savings created by EPC projects with the ESCO. This structure encourages clients who simultaneously lack awareness of energy conservation and lack adequate funding [9,10] to voluntarily join the EPC Projects. Therefore, given the model's broad applicability, the Shared Savings Model is more suitable for the current development stage of the energy service industry in China. Additionally, this model holds the front position in China's energy service industry and has attractive development prospects.

An energy savings benefit allocation, also called a benefit allocation, is critical for the implementation of Shared Savings EPC Projects. In fact, the total energy savings and benefits allocation scheme directly affects the profit of clients and ESCOs [11]. Recent research regarding the benefit allocation of EPC projects focused on capital and project risk management, measurement and verification. Mills et al. [12] proposed an analysis framework addressing capital and project risk management in energy saving projects. In this analysis framework, energy efficiency and investment decision experts use communication to quantitatively evaluate the existing risk. In addition, by setting an example of financial risk analysis in the building energy efficiency field, experts provide technical guidance and empirical analysis addressing how to identify,

* Corresponding author. Tel.: +86 13820172165.
E-mail addresses: stc1965@hotmail.com (T. Shang), zhangkaitju@163.com (K. Zhang), cathyliu65@163.com (P. Liu), z_chenziwei@163.com (Z. Chen), Xiangpengl2008@163.com (X. Li), wuxue1123@126.com (X. Wu).

http://dx.doi.org/10.1016/j.energy.2015.08.020
0360-5442/

quantify, and manage risk. Mills [13] also analyzed methods for risk transfer by insurance firms. Boonekamp [14] evaluated six energy savings measuring methods using eight key indicator dimensions. More importantly, they noted the advantages and disadvantages of each method. However, considering that current methods cannot meet the European Union's requirements for energy savings' measurement, the researchers proposed using a bottom-up energy trend simulation method to measure the energy savings achieved by all energy saving measures. In fact, the primary EPC business models in different countries are generally different. For example, the US government encourages the broad application of Guaranteed Savings EPC Projects, which, to some extent, leads to a situation in which foreign scholars minimally focus on the benefit allocation of Shared Savings EPC Projects.

The Shared Savings Model holds the front position in China, and in recent years, Chinese scholars have recognized the importance of benefit allocation in Shared Savings EPC Projects and conducted research in this field. Scholars primarily focused on principles and methods in benefit allocation. Wang and Wang [15] discussed the issues that exist in Shared Savings EPC Projects by analyzing the implementation of these projects in China. At the same time, they proposed solutions to define benefit allocation quotas and allocation duration. Finally, according to the equilibrium principle of gains with risk, they also built a benefit allocation model based on risk measurement. Unlike Liu and Lv [16] combined the Analytic Hierarchy Process with Fuzzy Evaluation to conduct risk assessments for EPC Projects, and they identified benefit allocation quotas and allocation durations based on a risk coefficient according to the equilibrium principle of gains and risks. However, allocating the energy savings in accordance with the risk sharing ratio between ESCOs and clients is clearly defective.

Wang et al. [17] introduced the dynamic alliance negotiation model into EPC Project benefit allocation research. In their minds, the benefit allocation quota of every stakeholder is proportional to a risk sharing ratio, a resource input ratio, work effort and a contribution coefficient. Similarly, the researchers used Fuzzy Evaluation based on AHP to determine the indicators' weight and solve the model. Thus, the energy savings benefit allocation mechanism between ESCOs and clients was established. It is worth noting that this method is based on a cooperative game. However, in reality, the benefit allocation between an ESCO and a client is a non-cooperative game process. In addition, despite the above three indicators, there are other factors that can impact the benefit allocation process.

Zhang et al. [18] determined the benefit allocation duration of EPC Projects using complete information dynamic game theory. First, it was assumed that clients know the ESCOs' opportunity costs. At the same time, clients aimed to achieve revenue maximization after satisfying ESCOs' minimum profits. In this situation, the benefit allocation duration is calculated; the ESCO then calculates the project's investment quota according to the given allocation duration. This method ignores the differences between EPC Projects and BOT Projects in practical applications. In BOT Projects, the owner determines the concession period in the bidding documents, whereas the contractors make their own offers in accordance with the length of that period. However, the benefit allocation quota is jointly defined by the ESCO and the client. It is wrong to regard the benefit allocation duration and the benefit allocation quota as separate parts. Moreover, it is also wrong to delineate the benefit allocation duration and the EPC Project's investment in two stages.

Overall, Shared Savings EPC Projects develop rapidly in China. At the same time, the equilibrium principle of gains with risks and a benefit allocation according to the contribution in a dynamic alliance is adopted to allocate the energy savings owned by ESCOs and their clients. However, the limitations that exist in the two methods are inevitable. Consequently, to a certain extent, the promotion and development of EPC projects is restricted. Bargaining theory, as an effective means to solve the benefit allocation issue, has been widely applied to construction practices. In fact, the negotiation between the client and the ESCO for energy savings benefit allocation is a bargaining process. Therefore, bargaining theory is used in this research to analyze the problem of “what to allocate” (benefit allocation quota) and “how to allocate” (allocation scheme).

In Shared Savings EPC Projects, clients sign energy service contracts with ESCOs. According to these contracts, it is the ESCO's duty to finance the project and provide service throughout the entire process [9]. However, a client needs to support the ESCO for the contract duration. Consequently, ESCOs share the energy savings with their clients [19] to obtain a repayment of their investment, repay the loan and obtain their due profits. When the contract expires, the client owns all of the energy savings and the entire EPC Project. This structure guarantees that clients have a positive cash flow all the time. The Shared Savings Model is shown in Fig. 1.

The energy savings created by a Shared Savings EPC Project should be allocated to both sides in an agreed proportion [9] for the contract duration and should be owned by the client when the contract expires. See Fig. 2.

Currently, in Shared Savings EPC Projects, participants allocate the energy savings by defining the ESCOs' benefit allocation duration and proportion during the contract period. The benefit allocation proportion represents the proportion of energy savings to be allocated, which is computed in time units such as by year, quarter or month according to the energy service contract agreement made by the ESCO and the client [11]. The benefit allocation duration is the time limit over which the ESCO and the client allocate the energy savings benefit according to the energy service contract [16,20]. Currently, the allocation duration in China tends to be lengthy [11]; the average is over 4.5 years and the longest is more than 10 years.

This work is intended to solve the benefit allocation issue between an ESCO and its client. We analyze the existing research methods and adopt Rubinstein bargaining model to address this issue. The rest of the paper is organized as follows. In Section 2, we introduce the Rubinstein bargaining model. In Section 3, we provide the effective bargaining interval and present the results of the energy savings benefit allocation scheme. In Section 4, we discuss the four aspects in bargaining process and introduce a simple quantitative example to illustrate the theory presented. In Section 5 we present the main conclusions derived from this research and discuss limitation of the allocation scheme presented.

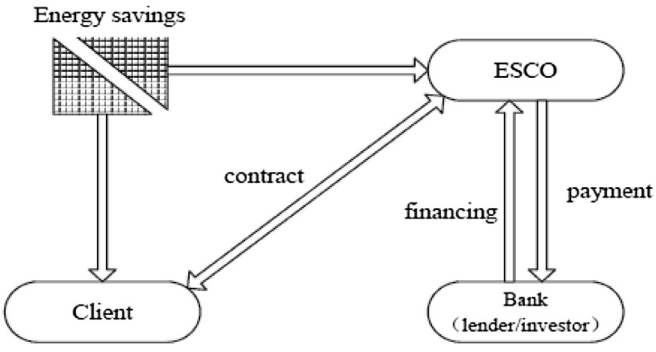

Fig. 1. Shared Savings EPC Business Model.