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Literature Review of Contract Energy Management Insurance Services

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Abstract

Under the global trend of energy saving and carbon reduction, the contract energy management market in China is showing a broad development prospect. There are mainly four types of contract energy management modes: Energy Saving Benefit Sharing (Engineering Procurement Construction), Energy Cost Trusteeship, Energy Saving Guarantee, and Financing Lease; among them, Energy Saving Benefit Sharing Contract is the most common and widely popularized contract mode. This service mode requires higher comprehensive quality of energy-saving service companies, and the cycle of contract implementation is longer, energy-saving service companies need to bear greater risks. In order to better promote the development of contractual energy management in China, this paper introduces insurance into the category of contractual energy management, and shares the risk of energy-saving service companies through multi-party game.

Keywords

Contract Energy Management; Game; Insurance.

1. Study on Contractual Energy Management

Under the global trend of pursuing energy saving and carbon reduction, the contract energy management market is showing a broad development prospect in the face of the dual challenges of energy shortage and environmental pollution. The essence of contract energy management is that energy saving service companies (ESCO) use advanced energy-saving renovation technology and new energy management programs to implement energy saving and emission reduction for their customers, and some of the benefits generated are paid to ESCO, and some are received by the customers. The advantages of this model promote the emergence of the energy-saving service industry, while new energy-saving retrofit technologies are developed, and most importantly, energy consumption is significantly improved. However, the inherent mode of operation of a contract energy management program is characterized by a long payback period and potentially high risk. Initially, energy service companies (ESCOs) need to invest huge costs, but there is still a possibility that the initial expected energy savings or energy efficiency benefits are not realized upon project completion due to a variety of reasons, thus making it difficult to recover the investment costs.

In order to meet this challenge, it is crucial to conduct an in-depth study on the insurance service strategy of China's contracted energy management programs. The core objective of this study is to reduce the risk borne by ESCOs through the use of insurance, especially to provide a basis for decision-making in the selection of insurance for energy efficiency projects to ensure cost recovery by reducing risk in unpredictable situations. This paper is expected to provide support for the insurance service strategy of China's contract energy management ESCOs, so that they can have more confidence and stability in their business operations.

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1.1. Research on Energy Efficiency Benefit Sharing EPC Models

Carbonara et al. (2018) proposed that the value of contract energy management model in the energy saving market is still far from being developed, the main reason is that there is no allocation of the proportion of benefits between the ESCO and the owner and matching the optimal contract energy management model for the project[1]. Nowadays, the most commonly used model in contract energy management is the energy saving benefit sharing model, scholars analyze the energy saving benefit sharing EPC model benefits from two perspectives, the first is the impact of EPC under energy saving benefit sharing: Vreeken (2013) found that EPC model can overcome certain obstacle factors in terms of energy efficiency, and concluded that the building sector should apply this model to carry out energy-saving renovation[2]. Lu and Sun developed an energy efficiency benefit sharing model under complete information to analyze its impact on energy efficiency sharing ratio and performance level from the perspective of project characteristics and cost structure[3]. Nord et al. (2014) analyzed the relevant data of several energy-saving retrofit cases in Norway, and found that buildings with energy-saving retrofits using the EPC model can effectively save part of the energy consumption[4] .Polzin et al. (2016) argued that the EPC model can effectively reduce the financial risk as well as the technical investment risk, solve the lack of government funds, and transfer the risk to ESCOs and transfer the risk to ESCOs, which can effectively increase the interest of energy-using units in retrofitting[5]. Li and Liu(2019) establishes a game model in which ESCOs and energy-using enterprises act as Stackelberg leaders to analyze the effects of different decision-makers on the benefit distribution decisions of both parties[6].

Second, the risk issue of EPC model: Mills et al. (2006) systematically studied the EPC project[7].In this study, the risk of energy efficiency is analyzed, and the method of risk identification and relative risk response initiatives are proposed for different project risks. Zou (2016)standing in the owner's point of view adopts the method of game theory to analyze the imbalance of interests brought by the energy saving service company to the owner in the energy saving benefit sharing contract [8]. Sheble and Berleant (2002) identifies the risks of ESCOs in the electric power industry and gives a detailed discussion on the probability and level of their operational risks, and argues that ESCOs bear most of the risks in the process of retrofitting in this model[9].

Due to the fierce competition in the existing market, some scholars believe that the process of negotiating the distribution of energy-saving benefits between energy-using units and ESCOs is a bargaining process, for example, Shang et al. (2015) utilized Rubinstein's bargaining game theory to establish a bargaining model for the distribution of energy-saving benefits by taking into account the time value of money and risk factors [10]. Li(2010) introduced Rubinstein bargaining theory and constructed a model of energy saving benefit allocation, pointing out that the allocation of energy saving benefits should meet the cost expenditure of both parties and be allocated according to the net present value[11]. Qian and Guo(2014) establish a benefit sharing bargaining model between ESCOs and energy users under the uncertainty of the value of the energy saving benefit sharing contract energy management project, and by introducing penalties and promises the energy saving benefit sharing contract can eliminate the impact of uncertain energy saving on the execution of the contract to a certain extent[12].

In addition to this, the energy saving benefit sharing model can be introduced into the supply chain, for example, Liao et al.(2021) analyzed their profits and emission reduction effects comparatively by establishing a game model for upstream and downstream enterprises of the supply chain in three modes: decentralized decision-making, centralized decision-making, and cooperation with ESCOs [13]. Zhao and Shi (2015) established supply chain models with and without ESCO participation when suppliers and manufacturers cooperated for emission reduction respectively, and found that when ESCOs were strong enough in emission reduction R&D and sufficient to meet the supply chain's demand, the actual overall emission reduction

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effect of the supply chain was better than that of the supply chain's autonomous emission reduction[14].

Existing research on the issue of energy efficiency benefit-sharing EPC strategy involves less, but in the context of energy saving and carbon reduction, energy saving service enterprises bear significant risks while needing to make decisions, so the research in this paper in the energy efficiency benefit-sharing EPC model, research when ESCOs in order to share the risk of insurance purchases of the strategy.

1.2. Research on the Operation Mode of Energy-saving Service Enterprises

Research on the operation mode of energy-saving service enterprises mainly analyzes the project implementation control and financing mode of contract energy management, and generally focuses on comparative analysis and qualitative research. For example, Su (2013) compares three types of contract energy management business models, namely energy saving benefit sharing, energy saving guarantee, and energy cost trusteeship, analyzes the characteristics of each type of contract energy management model, and describes the key management activities at each stage of contract energy management through enterprise questionnaire surveys[15]. Liang (2012) investigates and analyzes the financing difficulties in the process of contract energy management cooperation, considers the degree of fit between various financing methods and the characteristics of the contract energy management service mechanism, and explores the application of financing leasing and the construction of investment and financing trading platforms to solve the financing difficulties [16]. Ping (2013), in the study of contract energy management project financing mode, proposes to introduce the concepts of financial derivative transactions such as financial leasing, collection and guarantee and pledge of project revenue right into the contract energy management operation as a way to improve the capital turnover rate of energy-saving service enterprises and alleviate the pressure of their financing [17]. Chen (2010) combined with the theory of energy economics to propose a model for the implementation of contractual energy management within an enterprise group, and to determine the basic process of implementation and the control of the implementation process [18]. Zhang (2010) utilized the real option theory to conduct a quantitative study on the pricing of carbon emission rights, which is the core issue in the contract energy management innovation model for carbon emission reduction [19]. Liu (2007) argued that the financing difficulties of contract energy management mainly come from both banks and energy-saving service enterprises, and analyzed that the key to solving the problem is to increase the credit of energy-saving service enterprises and to adopt a new model of self-reimbursable trade financing [20].

At the same time energy saving benefit sharing EPC has a greater risk for energy saving service enterprises, scholars focus on its performance evaluation, operation process direct transaction costs, risk transfer and other content. For example, Lee et al. (2013) conducted a probabilistic risk evaluation study of energy saving and consumption reduction in energy performance contracting projects based on simulation methods, and applied sensitivity analysis and Monte Carlo simulation analysis to propose a specific method for evaluating energy savings [21]. Gilbert and Anios (2015) conducted a systematic study on the optimal design of bilateral contracts for energy procurement[22]. Luan (2010) summarizes the main risks of energy-saving service enterprises in the contract energy management project, specifically there may be credit aspects, policy aspects, as well as the risk aspects of the project itself, and gives a response to the risk provides specific measures[23]. Lee and Rajagopalan(2008) analyze the specific operation process of the contract energy management project for the low-carbon energy-saving renovation in the field of buildings[24]. Goldman et al. (2007) analyzed the contract management of contract energy management programs for energy saving service companies applying the energy saving guarantee model in the United States [25]. Sorrell s (2007) examines the

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characteristics of the contractual energy management mode of operation by comparing project production costs and transaction costs through a case study of energy conversion equipment application[26]. Bannai et al. (2007) obtained the real data information of project operation from the energy-saving service enterprises implementing contract energy management projects, and investigated the correlation between the trading rules of financial derivatives and the energy-saving benefits of the projects under the mechanism of contract energy management through quantitative calculation and analysis [27]. Mills et al. (2006) applied the Monte-Carlo simulation model to examine the risk matrix of energy efficiency projects covering economic, technical, construction and operation, and measurement and inspection, etc. Evan Mills focused on the specific study of risk transfer of energy efficiency insurance[28]. Li (2012) proposed a risk control system for energy-saving service enterprises for contract energy management projects based on the whole life cycle theory and analyzed and demonstrated the feasibility of establishing a risk control system [29]. Most of the scholars' studies show that there are risks in many places in the whole process of contract energy management projects, especially the operation mode of energy-saving service enterprises determines the characteristics of its big risks.

2. Insurance Research under the Perspective of Game

Scholars' research based on the game perspective mainly focuses on the competition among insurance companies, insurance product design, risk management and other aspects, and this paper summarizes the literature from two aspects. First, competition and pricing in the insurance market: game theory has been used to analyze the strategic interactions among different insurance companies in the insurance market; by building game models, researchers can explore the strategic choices of insurance companies in pricing, product design and marketing, as well as the impact of these strategies on the competitive landscape of the market.Golubin (2006) investigated Pareto-optimal insurance decision-making in a static model. decisions[30]. Dutang et al. (2013) considers the effects of market premiums, solvency, market share, and underwriting performance on policyholder competition among non-life insurers to find a Nash equilibrium and a Stackelberg equilibrium at the level of premiums[31]. Bensoussan et al. (2014) study two insurers in the framework of a non-zero and stochastic differential game in terms of their relative performance[32]. Wei et al. (2021) study the behavior of a Stackelberg mixed duopoly price competition game in the insurance market between a state-owned public insurer and a private insurer[33].Li et al. (2021) assume that the risk exposure of an insurer is affected by all the insurers in the market, and that multiple insurers compete with each other to sell insurance contracts by controlling the premiums, using a dynamic pricing game model to price insurance contracts[34].

Second, risk sharing and reinsurance: some other scholars have applied game theory to study the risk sharing mechanism among insurance companies, especially the reinsurance market. Researchers use game models to analyze the design of reinsurance contracts and the formation of reinsurance prices, as well as the stability and efficiency of the reinsurance market.Powers and Shubik (1998) focus on the relationship between the law of large numbers and the oligopoly effect of the number of firms in the market, and use a game-theoretic model of the equilibrium of the insurance market to study this issue[35]. Hipp and Plum (2000) use the Cramér- Lundberg model to describe the risk process of an insurance company and assumed that the insurance company's surplus is invested in a risky asset whose dynamic process obeys a Geometric Brownian Motion (GBM)[36].Kaluszka (2001) investigated the optimal reinsurance strategy under a mean-variance model[37].Liu and Yang (2004) investigated the problem of optimal investment of an insurance company in the money market and in a risky asset[38]. Powers and Shubik (2006) consider reinsurance companies as additional players and study the

optimal number of reinsurance companies in the insurance market[39]. Højgaard and Taksar(2004) consider the optimal investment with the objective function of maximizing the expected discounted cumulative dividends when the insurance company invests its surplus in a risky asset and a risk-free asset separately, the optimal reinsurance and the optimal with-profits strategy[40].Picard (2009) considers an extension by allowing insurers to offer participatory contracts (e.g., reciprocal contracts) that reveal the level of risk of policyholders, where moral hazard and adverse selection play an important role[41]. Policyholders indicate the amount they are willing to pay and insurers indicate the amount of risk they are willing to underwrite.Wang et al. (2021) study a class of nonzero and stochastically differentiated Nash equilibrium solutions of the reinsurance game between two insurers by applying a nonlinear risk process under a time-consistent mean-variance criterion[42].Zeng (2010), Taksar and Zeng (2011) study the Nash equilibrium solution of the reinsurance game between two insurers by applying proportional reinsurance and non-proportional reinsurance to study a zero-sum stochastic differential game between two insurers[43][44]. Liu et al. (2022) assumed that the management of an insurance company wants to maximize the expected utility of the relative difference between its terminal surplus and that of its competitors at a fixed point in time, and constructed the Nash equilibrium as a strategy by solving the Hamilton-Jacobi-Bellman equations, which introduced a strategy based on the Feynman-Kac formula as an iterative scheme to numerically compute optimal proportional reinsurance policies[45].

3. Literature Review

The most commonly used mode of contract energy management in China is the energy saving benefit sharing type, and ESCO of energy saving service enterprises under this mode bear huge risk pressure and financing pressure. To solve this problem, insurance, as the most common way of risk sharing, is introduced into contract energy management. Existing research on contract energy management seldom considers insurance, and it is of practical significance to explore the issues of policyholders and beneficiaries from the perspective of gaming, which is also the direction of future development.

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