Energy Performance Contracting and Application in Energy Conservation of Industrial Boilers

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ABSTRACT

Development of energy performance contracting (EPC) was introduced in this paper. The basic models generally include energy conservation benefit payment, energy conservation benefit sharing, and energy conservation amount guarantee, etc. The essence of EPC is that energy service companies (ESCO) share the energy conservation benefits with customers. Recent progress on the critical success factors of EPC projects and the analysis methods was briefly introduced. Taking the pulverized coal industrial boiler as an example, application of EPC in energy conservation of industrial boilers was described.

INTRODUCTION

In the early 70s of last century, a new energy conservation mechanism, namely energy performance contracting (EPC) was developed based on the market operation in the developed countries. The specialized energy service company (ESCO), which is operated based on EPC and taking profits as the aim, has been developed rapidly, especially in the US, Canada and Europe. Now it has become a new energy conservation industry. The contents of EPC include energy conservation project planning, energy efficiency audit, project design, project financing, training, equipment and parts (material) procurement, construction, project acceptance, operation, energy conservation monitoring and system maintenance, namely a complete set of services provided by ESCO for users [1]. Sometimes, according to the users’ needs and wishes, ESCO can also provide part of services mentioned above. In short, the goal of EPC is to recover the investment costs and make profits by sharing the energy conservation benefits with users through a variety of flexible operating models after the project being put into operation [2]. The basic models of EPC and their characteristics were introduced in this paper. The critical success factors of EPC projects were described. At last, taking the pulverized coal industrial boiler as an example, application of EPC in energy conservation of industrial boilers was described.
EPC MODELS AND CHARACTERISTICS

The essence of EPC is that ESCO share the energy conservation benefits with customers by providing advanced energy saving equipment and technical services. The binding of interests between energy saving equipment manufacturers and users is realized through EPC. In the market environment without the implementation of EPC, the energy saving equipment provider are only responsible for the quality of the equipment, rather than the energy conservation effect. In the market environment with EPC, the equipment manufacturers are not only responsible for the equipment, but also the energy conservation effect [3], as shown in Fig. 1.

![Energy conservation mode with EPC.](image)

The basic models of EPC generally include energy conservation benefit sharing, energy conservation benefit payment, and energy conservation amount guarantee, etc.

Energy Conservation Benefit Sharing Model

ESCO provides the project funds and the whole process of services. After the completion of the project, during the contract period, the user shares the energy conservation benefits generated through the project with ESCO according to the proportion specified in the contract. After the contract period, the equipment and energy conservation benefits belong to the user. The cash flow of the user is always positive [4], as shown in Fig. 2.

![Energy conservation benefit sharing model.](image)

Energy Conservation Benefit Payment Model

The user commissions ESCO to conduct the energy conservation transformation. The user provides part of the project funds and ESCO provides the whole process of services. After the completion of the project, the amount of energy conservation is detected and confirmed according to the index specified in the contract. If the contract amount is achieved, the user will pay the rest of the project funds to ESCO [5].
Energy Conservation Amount Guarantee Model

ESCO guarantees reduction of energy costs by a certain percentage. The user pays the project funds and service fee to ESCO. If the committed energy conservation amount is not achieved, ESCO will compensate. The service fee is generally 25%-40% of the project funds. Some user can’t accept this part of costs psychologically.

Energy Expenses Entrusting Model

Operation and maintenance of the user’s energy system are managed by ESCO, and the user pays for energy expense regularly. The user’s benefits come from the reduction of the energy expense. This type of contract can effectively avoid the risk of ESCO and recycle funds. But the project scope is required to be easily defined and not in conflict with the user’s main business.

Energy Management Service Model

The user commissions ESCO to conduct the energy planning. ESCO provides the overall design of the energy saving project, construction, installation and commissioning of the energy saving equipment. ESCO provides not only energy saving transformation, but also energy management services. During the equipment operation period, ESCO obtains reasonable benefits through energy management services, while the user obtains benefits generated from the energy expense reduction [6].

Besides, ESCO can also cooperate with the user through the energy saving equipment leasing. It means that ESCO leases the energy saving equipment to the user. After the leasing period, the equipment will be transferred to the user free of charge. The user pays for the equipment leasing to ESCO monthly or quarterly. The contract can be divided to a leasing contract and a service contract, avoiding the loss caused by tax [7].

CRITICAL SUCCESS FACTORS OF EPC PROJECTS

As the energy conservation service industry developed from the simple energy conservation transformation of lighting equipment to complex capital intensive projects, the critical success factors also gradually increase [8]. Zhang et al. [9] analyzed 357 energy saving projects distributed in 10 aspects, such as industrial boiler transformation and cogeneration, and then divided the critical success factors into two categories: external factors and internal factors. External factors include the energy policy of the local government, supporting financing and tax policy, energy measurement and standards, laws and regulations. Internal factors include internal technical factors, internal management factors and internal financing ability. Pantaleo et al. [10] proposed critical success factors aimed at cogeneration projects. The factors were classified to into three types: factors related to supply, demand and policy structure. Qu et al. [11] divided 19 critical success factors into five types: external factors, users, ESCO, contract and project itself.

The critical success factors of EPC projects vary in different fields. The critical success factors proposed by some researchers are only aimed at specific types of EPC projects. At the same time, due to the subjectivity of classification, the same
critical success factor may even be divided into different types. So far, a consensus on the critical success factors of EPC projects has not been reached [12].

The analysis methods of critical factors include factor analysis, entropy weighting coefficient, analytical hierarchy process/network analysis, among which factor analysis is the most widely used method. Based on the survey data, the critical factors can be classified according to the correlation. The factors in each category have common characteristics. After the classification, the factors will be more controllable. But this method has a certain degree of subjectivity. The critical factors can also be determined through the entropy weighting coefficient method by calculating each index weighting. The higher the index weighting is, the greater the impact of this index on the EPC project is. Analytical hierarchy process is helpful for decision makers to solve complex system problems. But the interaction between different layers or the same layer is not taken into account. The correlation between feedbacks and problems is considered by network analysis based on analytical hierarchy process [13].

APPLICATION OF EPC IN ENERGY CONSERVATION OF INDUSTRIAL BOILERS

The technology of pulverized coal industrial boiler with high efficiency is a new type of coal fired industrial boiler technology, whose core is pulverized coal combustion. Due to the advanced pulverized coal combustion technology, the thermal efficiency can be increased significantly, up to more than 90%. Compared to the traditional coal fired boilers, the thermal efficiency is increased by 20%~30%. The pulverized coal industrial boiler is an upgrading product of the traditional coal fired boiler. The pulverized coal boiler system is a kind of technology intensive and complex system. Because of its high construction investment, high degree of specialization needs during operation and management, specialized channels for fuel with stable quality, it is not suitable for application under the traditional mode. But under EPC mode, the pulverized coal industrial boiler system with high efficiency has the following advantages [5]:

1) The user does not need to undertake capital or technical risks during the project implementation. The user can obtain the benefits generated by energy conservation and equipment provided by ESCO. The user’s enthusiasm of transformation can be effectively improved. Win-win results can be achieved.

2) The energy saving rate is high. The energy saving rate of the pulverized coal boiler is generally 30%~40%, up to 50%. According to the projects implemented, the average investment recovery period is 1-3 years.

3) The competitiveness of the user can be enhanced. After the energy saving transformation, the costs of energy consumption are reduced and the competitiveness of products is improved. At the same time, the environment quality is improved and a green enterprise image is established.

4) Energy conservation can be guaranteed. ESCO can commit the energy conservation amount and ensure that customers can achieve reduction of energy consumption costs immediately after the project implementation.

Energy conservation benefit sharing model was widely adopted in early EPC projects of pulverized coal industrial boilers. With this model, customers can enjoy the benefits of energy conservation without investment. Therefore, it’s easier for customers to accept the project, which is conducive to promotion of pulverized coal
industrial boilers. However, this model is lack of effective measures for protection of ESCO. Determination of energy conservation amount is usually controversial.

Under energy expenses entrusting model, ESCO invests in the industrial boiler system and takes charge of operation during the contract period. ESCO promises to supply steam/ hot water with lower price. During the contract period, ESCO manages the boiler system operation. As the using right and ownership of boiler system are not separated, the rights and interests of ESCO can be effectively guaranteed. At the same time, ESCO can ensure the good running state of boiler system so that the best energy saving effect can be achieved. For a complex system such as pulverized coal industrial boiler, the energy expenses entrusting model is applicable.

For the energy conservation amount guarantee model, customers have to pay for the energy conservation effect in advance. There is almost no difference with direct procurement. For the pulverized coal industrial boiler system, as the initial construction investment is very high, application of this model is not much.

CONCLUSIONS

The essence of EPC is that ESCO share the energy conservation benefits with customers by providing advanced energy saving equipment and technical services. The basic models of EPC generally include energy conservation benefit sharing, energy conservation benefit payment, and energy conservation amount guarantee, etc. Recent progress on the critical success factors of EPC projects and the analysis methods was briefly introduced in this paper. At last, aimed at energy conservation of industrial boilers, application of EPC in the promotion of the pulverized coal industrial boiler was described.

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REFERENCES