Study on Contractual and Relational Governance Mechanism in Energy Performance Contracting Projects Based on Life Cycle

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Abstract. In EPC projects, the cooperative performance between ESCO and the energy users is the result of the interaction of contractual governance and relational governance, and they are related closely in all transaction process of EPC projects. According to the particularity of EPC projects and life cycle theory, the life cycle of EPC projects is divided into three stages including pre-construction period, construction period, and operation period in this paper, and the three-dimensional evaluation index of EPC project performance is defined including energy saving quantity, energy saving quality and energy saving behavior. Then the contractual-relational compound governance model based on EPC project performance is performed when summarizing the functions of contractual governance and the factors of relational governance, and the contractual-relational compound governance strategies during the full life cycle of EPC projects are put forward.

1. Introduction
Energy Performance Contracting (EPC) is an energy saving service mechanism that the Energy Service Company (ESCO) and the energy users agree on an energy saving goal by contract, in which the ESCO provides necessary services to the energy users in order to achieve the energy saving goal, and the energy users pay the inputs and reasonable profits to ESCO with energy saving benefits [1]. In EPC projects, the contract is the basis for maintaining energy saving services and the formal governance mechanism of project transactions, and the formal systems of the rights, responsibilities, and benefits between the ESCO and the energy users are strictly stipulated to reduce the transaction costs caused by project transaction risks and to improve the project performance. However, the purpose of the energy users choosing ESCO is to get the good energy saving benefits, and the ESCO signs a contract aiming to maximize energy saving revenue. The game between revenue and quality fundamentally reveals that either of them will not spontaneously perform the contract [2]. Therefore, relational governance is also used to deal with the complex and uncertain moral risks in the cooperation between the ESCO and the energy users.

The implementation of EPC projects is the result of the interaction of contractual governance and relational governance. Contractual governance stipulates and limits the behavior of the cooperative subjects by signing a contract. Relational governance is an informal cooperation channel, and its purpose is to standardize the behavior of cooperation subjects, raise cooperation efficiency, and improve cooperation performance. Relational governance and contractual governance not only interact on project performance, but also are related closely in the process of project transaction. According to
the particularity of EPC projects, this paper will analyze the contractual governance and relational governance mechanism during the whole process of project implementation, as well as the compound action mechanism of them on project performance.

2. Life cycle and project performance of EPC projects

2.1. Life cycle analysis of EPC projects
The ESCO serves the whole process of project implementation by EPC model, and provides a series of comprehensive services such as energy auditing, project financing, engineering design, raw materials and equipment procurement, civil construction, equipment installation and commissioning, personnel training, project operation and maintenance, and energy saving monitoring to the energy users. According to the operation process of EPC projects and project life cycle theory, the full life cycle of EPC project are divided into three stages, including pre-construction period, construction period and operation period. The pre-construction period includes energy auditing, project financing, and engineering design, the construction period contains materials and equipment procurement, civil construction, equipment installation and commissioning, and personnel training, operation and maintenance, and energy conservation monitoring are included in the operation period.

With EPC model, the ESCO undertakes projects according to the "turnkey" principle, taking on capital risks and most of the technical risks. This is only parts of the basic services that the ESCO provides financing, designing, and installing equipment to the customers, and the maintenance after operation is more important, which is extremely significant for the project success.

2.2. Definition of EPC project performance
The purpose of EPC projects is to improve energy efficiency, and the project benefits come from the energy cost reduction, so it is a performance-based contract between the ESCO and the energy users, and the energy efficiency is the key to select energy service contractor. Therefore, the primary evaluation index of EPC project performance is the project energy saving rate (energy saving quantity) during the benefit sharing period. In addition, the energy users have subjective evaluation standards for energy saving services during the implementation process of EPC projects, so the "satisfaction" index is introduced into the "energy saving quality" concept to broaden the evaluation dimensions of EPC project performance.

Finally, the ESCO builds the cooperative relationship with the energy users relying on the contract, and takes the agreed contract terms as the conduct code. It is affected by double moral hazard in the their actual interaction, and the misconduct between them, such as negligence in contracting, distrust, slack in logistical support, the reduction of energy reference points, the reduction of their own efforts, and the retention of technical hidden peril, can lead to the maximization of self-benefits, but not the energy efficiency. Therefore, the index "energy saving behavior" is added to form the three-dimensional performance evaluation structure of EPC projects, which will help the healthy development of energy performance contracting.

3. Contractual governance and relational governance of EPC projects

3.1. Contractual governance functions of EPC projects
A convergence trend is emerging about the study of contractual governance functions from various perspectives of law, economy, and management [3]. Spike et al. formally proposed a three-function theory of contract in 2014: control/safeguard function, coordination function, and adaptation function [4].

The control function is emphasized mainly in transaction cost theory. The transaction costs in the full life cycle of EPC projects include searching information costs, bargaining and decision-making costs, monitoring and implementation costs. In order to use the control function better, the variables such as contract completeness/complexity, allocation of decision rights between ESCO and the
customers can be designed. The coordination function is mainly reflected in the fact that the contract can coordinate their transaction relationship, and they are the clauses such as the roles and responsibilities of the ESCO and its customers, process monitoring, the appointment of major managers in the contract. These coordination clauses do not prescribe "outcomes" but often "processes". The adaptation function is mainly to cope with the uncertainty of the EPC project contract, such as policy changes, changes in other cooperation entities including financial institutions, governments and the third-party cooperation agencies, and force majeure events.

3.2. Relational governance factors of EPC projects

The current research on the division of relational governance mostly proceeds from the three aspects of norms, behaviors, and states between relationships. Normative governance is a rule or criterion that guides people to conduct behavioral governance, and it is the expected mode of behavioral expectation or behaviors for the transaction parties; Behavioral governance is the behavior and effort for people to develop, maintain or use interpersonal relationships, and relational states refer to the foundation or quality of interpersonal relationships, such as closeness or interaction.

The cooperation between the ESCO and the energy users has the characteristics of constant cooperation technology, exclusive cooperation object, fixed cooperation process, and speculative cooperation behaviors. The cooperation quality and states, affecting later cooperation implementation, determines whether there is a possibility of continued cooperation. Based on the particularity of EPC projects and relational governance theory, the relational governance between the ESCO and its customers is divided into normative governance and behavioral governance from the perspective of transaction costs in this paper, then trust, cooperation, communication, and commitment can be used as the basic dimensions to measure their relationships.

4. Contractual-relational compound governance model in the full life cycle of EPC projects

4.1. Impact of contractual-relational governance on EPC project performance

Contractual governance has a good evasive effect on risks and uncertainties in the transaction process, and effective contractual governance can promote the cooperative performance of EPC projects [5-6]. Wang, etc. introduced control function, coordination function, and adaptability function into the engineering contract firstly, revealing that the multi-dimensional measurement of the contract can explain opportunism and satisfaction more effectively than single-dimensional measurement [7]. The three-dimensional functions of engineering contract affecting the contractual governance of cooperative behavior were studied by Quan, etc. with empirical methods [8]. Relational governance can effectively reduce the obstacles in the trading process, thus maintaining and promoting the harmonious relationship between trading subjects. Zhang and Ma analyzed the impact of relational governance on cooperation performance between the ESCO and the energy users in project life cycle by investigating the ESCO filed in Xi'an City [9].

From the perspective of the synergistic impact of relational governance and contractual governance on project performance, Zheng and Rohrich pointed out that the effective combination of them could promote the realization of transactions [10]. Superpto, etc. discussed the impact of different incentives of relational governance and contractual governance on project performance, and pointed out that the combination of them could improve project performance [11]. Yan, etc. analyzed the interaction path of contractual governance and relational governance and their impact on project management performance by establishing a structural equation model among contractual governance, relational governance and project management performance in public projects [12]. Zheng, etc. conducted an empirical study on the matching relationship between relational governance and contractual governance of PPP projects from the perspective of life cycle [13].
4.2. Contractual-relational governance mechanism based on EPC project performance

From the perspective of EPC project life cycle, the contractual-relational governance mechanism based on project performance is proposed according to the different dimensions of relational governance and contractual governance in this paper:

4.2.1. EPC project governance includes contractual governance and relational governance. Contractual governance is realized through control function, coordination function and adaptation function, and relational governance is divided into normative governance and behavioral governance. Their interaction is manifested as "substitution", "complementation" or "coexistence of complementation and substitution"[14].

4.2.2. EPC project performance is measured by three indicators of energy saving quantity, energy saving quality and energy saving behavior. It is found that contractual governance and relational governance can usually promote project performance in the related studies (the path H1 and H2 shown in Figure 1), and project performance would be improved when combining them (the path H3 shown in Figure 1).

![Figure 1](image-url)  
Figure 1 Contractual-relational governance mechanism based on EPC project performance.

4.3. Contractual-relational compound governance strategies in the full life cycle of EPC projects

Relational governance and contractual governance act on project performance together. Four combined strategies of contractual governance (abbreviated as CG) and relational governance (abbreviated as RG) of EPC projects are proposed in this paper: strong RG & weak CG, weak RG & strong CG, strong RG & strong CG, and weak RG & weak CG. Then different governance strategies are adopted for different stages of EPC project life cycle, as shown in Table 1.

During the pre-construction period of EPC projects, the strong RG & weak CG governance strategy is adopted for energy design and project financing because the ESCO and the energy users pay more attention to cooperation and communication, and the weak RG & strong CG governance strategy used only in project design pays more attention to project design tasks and goals.

During the construction period, the relational governance factors can be weakened in materials and equipment procurement, and the weak RG & strong CG governance strategy can be adopted. Besides, civil construction and equipment installation and commissioning require both parties to keep the...
contract regulations strictly and enhance trust, cooperation and communication between them. Therefore, a strong RG & strong CG governance strategy should be adopted.

During the operation period, the training of equipment users can be carried out according to regulations and procedures, so the weak RG & weak CG governance strategy can be adopted. But the maintenance of the equipment during operation and the monitoring record of energy saving require strict compliance with the contract and trust, cooperation and commitment between them. Therefore, the strong RG & strong CG governance strategy should be used.

Table1. Contractual-relational compound governance strategies in the full life cycle of EPC projects.

| Project Life Cycle          | Main Processes          | Governance Strategies |
|-----------------------------|-------------------------|-----------------------|
| pre-construction period     | energy auditing         | strong RG & weak CG  |
| project financing           | strong RG & weak CG     |
| engineering design          | weak RG & strong CG     |
| equipment procurement       | weak RG & strong CG     |
| construction period         | civil construction      | strong RG & strong CG |
| equipment installation      | strong RG & strong CG   |
| personnel training          | weak RG & weak CG       |
| operation period            | operation and maintenance| strong RG & strong CG |
| energy saving monitoring    | strong RG & strong CG   |

5. Conclusion
Contractual and relational governance mechanism of EPC projects based on life cycle are studied in this paper, and there is the main work as following:

- The functions of contractual governance and the factors of relational governance are summarized, and the contractual and relational governance mechanism of EPC projects are studied;
- The three-dimensional evaluation index of EPC project performance is defined including energy saving quantity, energy saving quality and energy saving behavior, then the contractual-relational compound governance model based on EPC project performance is proposed;
- The life cycle of EPC projects is divided into three stages, including nine main steps, then contractual-relational compound governance strategies in the full life cycle of EPC projects are put forward.

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