Study on risk evaluation of CCUS construction project of coal-fired power plant

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Abstract: Carbon capture, utilization and storage (CCUS) project has become a hot topic with the approach of dual-carbon target. CCUS construction project of coal-fired power plant is an important focus to achieve zero or negative emissions, but there are many risks in its construction and operation process. At present, there are few researches on the overall risk management of CCUS projects in the whole process at home and abroad, and most of them focus on a single risk factor. Starting from the overall project risk, this paper considers the identification and classification of possible risk factors in CCUS projects of coal-fired power plants, draws risk assessment indicators, and establishes a corresponding evaluation system, which will help project managers to better implement risk management decisions, provide references for risk response measures, and promote the smooth construction and operation of emission reduction projects.

Key words: Coal-fired power plant; CCUS; Risk assessment

Introduction

Carbon capture, utilization and storage (CCUS) projects have gradually become a hot topic with the approaching of the two-carbon target. As an important emission reduction measure, CCUS construction project of coal-fired power plants can greatly reduce the carbon dioxide content emitted by power plants into the atmosphere, and promote the further low-carbon transformation development of coal-fired power plants. However, in the process of the implementation of CCUS project for coal-fired power plants, the large-scale practical application has been affected by various risks. Therefore, based on the theory of risk management, the idea of combining qualitative and quantitative methods, and the conclusions of relevant researches at home and abroad, this paper systematically discusses the overall risk identification of CCUS projects and constructs the risk assessment index system of CCUS projects of coal-fired power plants, which will help project managers to better implement risk management decisions and ensure the smooth construction and operation of emission reduction projects.

1. Identification of risk factors for CCUS projects of coal-fired power plants

1.1 Risk factor identification of CCUS project based on literature research method

Different methods can be adopted to identify risks. According to the actual situation, this paper first adopts the literature research method to identify the risk factors of CCUS projects of coal-fired power plants. By consulting the published previous research results on the risks of CCUS projects, 12 literatures that are closely related to the theme of this paper and are frequently read are finally selected to identify and screen the risk indicators.

The risk factors of CCUS projects of coal-fired power plants identified by 12 research literatures mainly include carbon capture cost, transportation link cost, operation and maintenance cost, investment payback period, carbon emission rights trading market, public attitude, social acceptance, equipment material, CCUS technology development, construction personnel technology and operation level, electricity price subsidy policy, and legal system construction Construction, environmental pollution (such as geological pollution, air pollution, groundwater pollution), natural disasters (such as induced earthquakes), etc. In particular, there is a hidden risk of CO2 leakage, as well as the risk of explosion accidents caused by gas leakage.

1.2 Risk identification of CCUS projects based on ANT perspective

Considering that the identification of risk factors of this type of project needs a more comprehensive perspective to ensure that the project risk can be identified more accurately and completely, this paper adopts another research method based on ANT perspective to carry out risk identification. The ANT perspective focuses on the analysis of actor network translation by constructing the actor network for the development of technology application projects, so as to identify the risk factors in the process of network translation.

The CCUS project involves a wide range of subjects, so the joint efforts and solidarity of the participants are needed to ensure the smooth progress of the project. The interference factors encountered by all kinds of participants in the process of action are strongly related to the project risk factors. Scientific research institutes, government departments, enterprises, international organizations (such as the International Energy Agency IEA), environmental ngos and the public are the main human factors that make up the ANT network of CCUS project. The main non-human factors corresponding to the main human factors include environment, energy resources, capital and technology, which together ensure the smooth implementation of the project.

From ANT's perspective, the smooth development of a project is realized through the successful translation of the network of actors. However, the translation is not always successful, and the translation process may face various risk factors, some actors may actively or passively leave the network in the middle of the project, or even lead to the complete dissolution. The whole development process of CCUS project is analyzed to find out the main human actors and the risk factors that affect their successful translation.

2. CCUS project risk evaluation index system construction

By reading a large number of Chinese and foreign periodical literatures, conducting comprehensive analysis, combining the risk factors identification of CCUS projects from the perspective of ANT, combining similar or similar risk factors, referring to expert suggestions, deleting unreasonable factors and adding unique factors, the risk factor evaluation index system of CCUS projects for coal-fired power plants is finally obtained. It includes 4 types of first-level risks and 11 types of second-level specific risks, as shown in Table 1.

Table 1 Risk evaluation index system of CCUS construction project of coal-fired power plant

	First level indicator layer	Secondary indicator layer
Risk of CCUS construction project of coal-fired power plant	Economic investment risk	Carbon capture transport costs
		Payback period
		Carbon trading price
	Social policy risks	Public attitudes
		Social acceptance
		Policies and regulations
	Personnel Technical risk	Technical process
		Material of equipment
		Personnel level
	Environmental disaster risk	Environmental pollution
		Natural disasters

2.1 Economic investment risks

As an investment and construction project, CCUS project needs to face the risks of high cost, long payback period and price fluctuation of carbon trading market in economic aspects. In the aspect of high cost, the transportation cost of carbon capture is mainly considered. In the whole process of CCUS project operation, the highest proportion of cost is carbon capture and transportation cost, accounting for about 80%. The capture cost is constrained by the capture method and technology, the scale of carbon dioxide capture and the purity of carbon dioxide capture, etc., while the transportation cost needs to consider the distance and mode of transportation and the cost of transportation equipment and materials. As for the risk of investment payback period, the main consideration is that the efficiency of economic return is not satisfactory, because the investment return cycle of a complete process is as long as 10-20 years, and the profit return in the later period is also relatively meager in the case of loss operation in the early stage. At the same time, considering the economic benefits of CCUS project, we must face the risk of competition in the carbon emission trading market. With the establishment of carbon emission trading market, carbon emission trading of our country will become increasingly active, and carbon emission trading is an important means for CCUS projects to achieve the profit target. Therefore, the CCUS project of coal-fired power plants will be affected by the fluctuation of carbon emission trading price, which is a unique economic risk factor that cannot be ignored.

2.2 Social policy risk

Without social recognition and policy support, the construction and operation of CCUS projects for coal-fired power plants will face more severe challenges. The development, construction and operation of large-scale infrastructure projects are bound to affect the lives of the nearby public, especially the projects with hidden dangers to the health of the nearby public. Due to the carbon sequestration requirements of the project, it is bound to need more social recognition. If it cannot be recognized by the public, the resulting public opinion will affect the future development prospects of the project. Therefore, public attitude is a risk factor affecting CCUS projects. Secondly, the risk factor of social acceptance should be considered. At present, CCUS technology is a relatively advanced energy-saving and emission reduction technology, and it is necessary to popularize technology-related content and safety measures to the public and social environmental protection organizations on a large scale, so as to reduce the probability that emerging projects will be restricted by environmental protection organizations and public opinions, and reduce the impact of social acceptance risk on projects. What can not be ignored are the risks of policies and regulations. At present, the policies and regulations on the development of CCUS projects for coal-fired power plants issued by the Chinese government are not complete, and there is no clear description of the specific process specifications of the projects and relevant disciplinary measures, especially the standardization level of carbon trading market needs to be improved. Therefore, based on the current development status of China's CCUS project, there are still certain risks of policies and regulations, and it is necessary to prevent the adverse effects caused by incomplete legal supervision.

2.3 Personnel and technical risks

Due to the advanced technology and huge development potential, CCUS project needs more technical research and development, and the cooperation and operation level of relevant personnel is also a potential risk item. The first is the technical process risk. For China, CCUS-related technologies are still in the development stage, CCUS technology maturity is relatively low, CCUS project experience needs to be improved, and research data is relatively lacking. In particular, it is necessary to consider that different types of technologies will be adopted in each stage of CCUS, such as solution absorption, oxygen-rich combustion, membrane separation technology, etc., and pipeline transportation, ship transportation, oil displacement technology and chemical utilization technology of utilization and storage exist in the

transportation process. Therefore, the technical and technological risks have brought uncertain factors to the smooth construction of the project. Secondly, considering the risk of equipment material. In the operation of CCUS project, it is not only necessary to consider the carbon capture reaction process, but also to select appropriate equipment materials according to the chemical properties of CO2 to complete the work of CO2 capture, transportation and storage. Considering that the construction of the project is not a short-term project, the corrosiveness of carbon dioxide over a long time span needs to be reconsidered. If improper material selection leads to equipment corrosion, damage, and CO2 leakage, it is very likely to cause groundwater pollution. Finally, the technical aspects of operator level risk factors need to be taken into account. At present, China lacks qualified and experienced CCUS operators and instructors, and enterprises need to train CCUS-related technical personnel. In the operation of CCUS related projects, it is easy to cause accidents due to personnel's lack of understanding of the technology, and secondary hazards caused by the failure to properly handle accidents. Therefore, once an accident occurs in a project, experienced technicians are needed to respond quickly and effectively and reduce the hazards. The level of technical personnel is also a factor that determines whether the CCUS project can be carried out smoothly.

2.4 Environmental disaster risk

Common risk types in risk management research include environmental disaster factors, and CCUS projects are no exception. Coal-fired power plant CCUS project has to consider the potential CO2 leakage problem may cause environmental disaster risk. First, the risk of environmental pollution. There may be technical problems in the capture process leading to CO2 leakage, resulting in a sharp increase in carbon dioxide content in the atmospheric environment, leading to significant changes in global climate and the formation of air pollution. At the same time, the main goal of the storage link is to permanently store carbon dioxide underground, which may cause water pollution after CO2 seeps into groundwater or other water bodies during the storage process. In addition, if there are mineral resources in the storage place, CO2 is very likely to react slowly with metal ore during long-term infiltration and leakage. Causing the ore compounds that were originally harmless to the water body to become harmful metals. To sum up, once leakage occurs, the degree of environmental pollution is unpredictable. Second, the risk of natural disasters. Such as earthquake, landslide and other geological disasters will have a great impact on CCUS projects. Sudden natural disasters will cause the smooth construction and normal operation of the project, and will cause large-scale leakage of CO2 gas during the transportation of CCUS, leading to air pollution, etc. At the same time, it may also cause secondary damage such as explosion, and the storage link will cause groundwater pollution and chemical corrosion. Therefore, natural disasters are the risk factors that need to be paid attention to at all times, which will cause a chain reaction of other kinds of risks and lead to greater losses of the project.

3 Epilogue

In this paper, the risks existing in CCUS projects of coal-fired power plants are identified and classified as a whole. Finally, four types of risks, namely economic investment risk, social policy risk, personnel technology risk and environmental disaster risk, are selected as first-level indicators, and the risk assessment index system of CCUS projects is constructed, in order to provide reference for subsequent CCUS project managers of coal-fired power plants to make risk management decisions. To help smooth construction and smooth operation of the project, and further promote energy conservation and emission reduction work.

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