Research on the Development of Green Supply Chain in Power Industry under Dual-Carbon Background

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Abstract. In the context of the "dual carbon" goal, the development of green supply chain management in the power industry has become an important research topic. This study focuses on the challenges and opportunities of green supply chain management in the power industry. Taking the State Grid Corporation of China as an example, it studies the theoretical innovation and development path of the State Grid Corporation of China in promoting the implementation of green supply chain management in the industry, and explores the development path of low-carbon, circular and sustainable supply chain in the power industry. The results show that green supply chain management can help power enterprises achieve sustainable development and contribute to global climate change prevention and environmental protection.

Keywords: Dual carbon;The power industry;Green Supply Chain Management

1 Introduction

At present, more than 130 countries and regions around the world have proposed the goal of "carbon neutrality", covering 90% of global GDP, 85% of the total population, and 88% of carbon emissions. China's "dual carbon" goal refers to carbon peak and carbon neutrality, which means that China promises to achieve carbon emissions peak by 2030 and carbon neutrality by 2060.The "dual carbon" goal is China's medium and long-term transformation and development strategy. The power industry needs to accelerate the transformation of clean energy, reduce carbon emission intensity, improve energy efficiency, and build a low-carbon, safe and efficient energy system. At the same time, enterprises need to develop and implement carbon emission reduction strategies, strengthen carbon emission management, promote the coordinated development of upstream and downstream enterprises in the industrial chain, and actively carry out green supply chain management. As an innovative environmental management method, green supply chain management in the power industry integrates the concepts of life cycle and extended producer responsibility. Relying on the supply relationship between upstream and downstream enterprises, with the core enterprise as the fulcrum, it mainly promotes the continuous improvement of green performance throughout the supply chain through green supplier management, green procurement, and other work. These measures will help achieve the "dual carbon" goal and promote the sustainable development of the power industry.

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2 Carbon Emissions and Electricity Composition Status

Since 2006, China has been the world's largest emitter of carbon dioxide. According to the IEA's "CO2 Emissions Report 2022", China's carbon dioxide emissions in 2022 reached 114.77 million tons, a decrease of 2.3 million tons from the previous year, accounting for 0.2% of the total, basically flat, but this is the first time since 2015 that China's annual total has decreased. Among them, although the growth of carbon emissions in the power industry has slowed down compared to the past ten years, it still reached 2.6%, mainly due to the increase in coal use. The increase in carbon emissions from burning energy reached 8.8 million tons. Global data shows that global electricity demand increased by 2.7%. Although the carbon intensity of the power generation industry decreased by 2.0%, the absolute growth of carbon dioxide emissions ranked first in the world, increasing by 1.8%, or 261 million tons. However, the use of clean energy also significantly reduced carbon dioxide emissions. The increase in solar photovoltaic power generation and wind power generation was significant, effectively preventing further growth in global carbon dioxide emissions[1].

According to data from China's National Energy Administration, as of the end of 2022[2], China's power industry's installed capacity for cumulative electricity generation was approximately 2.56 trillion kilowatts, with energy sources such as thermal power, hydropower, nuclear power, wind power, and solar power accounting for 52.0%, 16.1%, 2.2%, 14.3%, and 15.3% of the total, as shown in Figure 1.

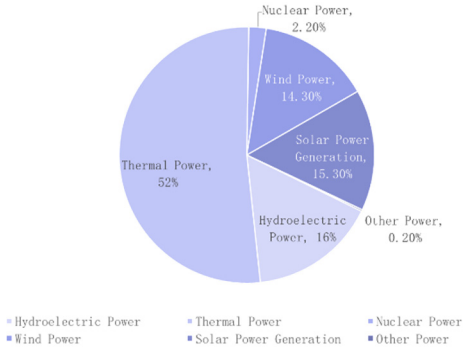

Fig. 1. Percentage of installed capacity of various types of power generation in 2022

Among them, the highest year-on-year increase was solar power generation (up 28.1%) and wind power (up 11.2%). The China Electricity Council released data showing that the transformation and green development achievements of the power industry are significant, including the following conclusions: first, non-fossil energy generating capacity accounts for nearly 50% of the total installed capacity, with newly installed capacity reaching a record high and continuing the trend of green and low-carbon transformation; second, full-scale non-fossil energy generation increased by 8.7% compared to the previous year, with coal-fired electricity generation accounting for more than 60% of total generation and still being the primary source of electricity supply in China; third, electricity investment increased by 13.3% compared to the previous year, with non-fossil energy generating investment accounting for 87.7% of total power generation investment.

The power industry has also continued to promote the application of new energy and optimize and adjust the structure of power supply. It is expected that in 2023, new generating capacity installed will once again reach a record high, with installed capacity for non-fossil energy generating facilities expected to increase by 180 million kilowatts, with installed capacity for grid-connected wind power reaching approximately 430 million kilowatts and grid-connected solar power reaching approximately 490 million kilowatts. Solar power and wind power installed capacity will both exceed hydropower installed capacity for the first time in 2023, fully reflecting effective integrated planning in the power industry for new energy generation and further guiding cooperation between suppliers and downstream enterprises.

3 The current situation of green supply chain structure in the power industry

According to the above definition of concepts, the power supply chain can be divided into five major links: power generation, power transmission, power transformation, power distribution, and power consumption. Among them, power generation mainly refers to the production of electric energy, with the power generation enterprise as the node; power transmission, power transformation, and power distribution refer to the process of transportation and distribution of electric energy, with the power grid company as the node; the power consumption link mainly involves the users of electric energy, namely the end consumers. It can be seen that in the power supply chain, the power grid enterprise undertakes the upstream and drives the downstream, forming a power supply and demand network with the power generation enterprise and the end power users, thus forming the main power supply chain. In addition, the operation of the supply chain also involves external participants, such as suppliers, national and local governments, industry and environmental protection organizations, etc. The specific descriptions are as follows, as shown in Figure 2.

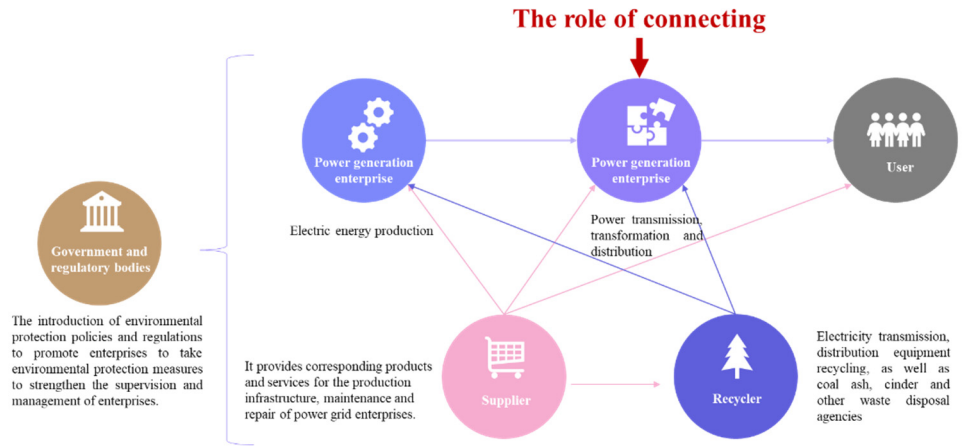

Fig. 2. The current situation of green supply chain structure in the power industry

Green development is an important measure to promote sustainable economic and social development and protect the ecological environment. By promoting the green and low-carbon

development of the supply chain and improving the ability to serve the "dual carbon" goal, the power industry will achieve a virtuous cycle with economic development and environmental protection. The State Grid Corporation of China, supported by the supply chain platform, plays the role of application driving and demand leading in the large-scale centralized procurement, focuses on green and low-carbon sustainable development, builds green and low-carbon standards, evaluation and certification system, and deepens the green and low-carbon transformation of the whole business of the supply chain.

Overall, the main issues in the construction of a green supply chain in the power industry focus on insufficient technological innovation in green energy, insufficient internal motivation, the failure to implement a market-based long-term mechanism, and insufficient information transparency, as shown in Figure 3.

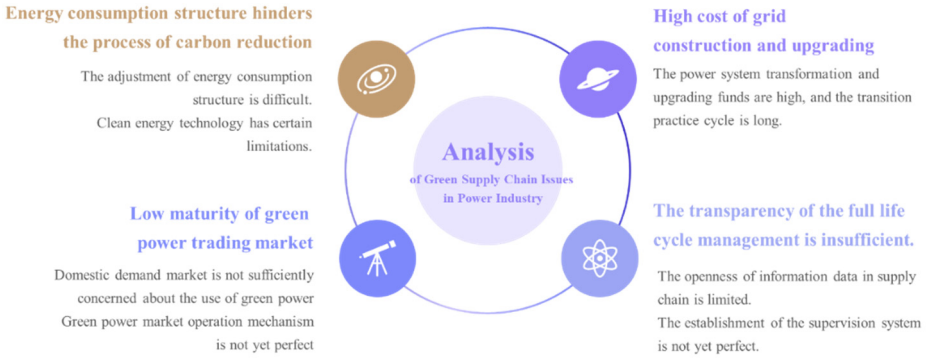

Fig. 3. Analysis of green supply chain issues in the power industry

Based on these issues, combined with the practical experiences of "green supply chain" construction both domestically and internationally, to guide more companies in the supply chain to lead and participate in the construction of a "green supply chain", the following measures should be taken[3]:

1)Use emerging energy technologies to promote the construction of a green power supply system, fully considering environmental impacts in all stages, including green power generation technology, green procurement technology, green logistics technology, and supply chain integration technology.

2)Use green financial tools to reduce companies' financing costs, such as using green credit services to compress companies' accounts receivable periods and alleviate their financial pressure, thereby helping the supply chain to timely receive returns and ensuring project operation. Core companies can adopt this approach to guide capital flows to key links in the construction of a "green supply chain" and accelerate companies' green transformation.

3)Establish a long-term mechanism in line with green development in the power industry, continuously strengthening the establishment of relevant rules and regulations, such as using carbon emission reduction rights to convey green electricity consumption willingness, actively promoting the connection mechanism between green electricity trading and carbon emission reduction, reflecting the green and low-carbon value of the power industry's green transformation.

4)Increase the visibility and traceability of the supply chain, actively promote the use of technologies such as the Internet of Things and blockchain to achieve real-time data recording, sharing, and monitoring, improve the digital level of overall supply chain operation, thereby enhancing information transparency, allowing core companies and the public to obtain relevant information, providing necessary data support for the construction of a "green supply chain"[4].

4 State Grid Corporation of China's green supply chain development

In order to accelerate the transformation and upgrading of the company's supply chain to a green and digital direction, a three-level supply chain management structure of "headquarters-province-city" has been established in terms of organizational system to achieve intensive, specialized and systematic management by State Grid Corporation of China. In terms of institutional system, a common supply chain institutional system has been established to systematically solidify institutional rules and work processes, covering all business links of the supply chain. In terms of procurement standard system, a standardized, structured and digitalized grid material procurement standard system has been established to unify equipment specifications and parameters across the national grid, ensuring fair participation of market entities in competition. In terms of data standard, materials are classified to form data categories, and a data dictionary specification for supply chain interconnection is established to achieve mutual recognition and sharing of data standards.

State Grid Corporation of China adheres to the overall idea of "procurement as the starting point, platform as the focus, and integration as the breakthrough point" and accelerates the key digital construction tasks of "one code and two flows" and "one platform and two libraries" to comprehensively promote the construction of State Grid Corporation of China's green supply chain. In line with the "business + technology" dual leadership model, a green supply chain coordination group has been established to operate in the manner of a "project construction command" and accelerate the innovative construction of State Grid Corporation of China's green supply chain. Initial innovations have been made in three aspects. Firstly, theoretical innovation. A supply chain chain master theory has been innovatively proposed, forming a complete theoretical system for State State Grid Corporation of China's supply chain, including goals, theories, directions, paths, and mechanisms. A supply chain development methodology with the characteristics of State Grid Corporation of China has been put forward, achieving a leap from zero to one in theoretical system. Secondly, digital construction innovation. From an enterprise-level perspective, catching the bridging role of material flow and event flow, the material ID and enterprise-level work order are creatively combined, standardizing and onlineizing all links of the supply chain business, and proposing a digital construction path with the characteristics of State Grid Corporation of China's green supply chain "one code and two flows", laying a solid foundation for the national grid green supply chain platform and achieving a leap from enterprise-level to industry-level. Thirdly, business innovation. On the basis of fairness and impartiality, national policies and company strategies are integrated into tendering and procurement by innovatively proposing the business innovation concept of "five leading procurements" (sunshine procurement, green procurement, innovation procurement, intelligent procurement, and LCC procurement), finding the entry point of each work item, and achieving a leap from procurement support to procurement leadership[5].

Based on interviews, communication and research with executives of State Grid Corporation in the early stage, it was found that in the operation of green supply chain of State Grid, the green supply chain industry-level and procurement demand-led chain-owner theory was innovatively proposed. Through the input, storage and output of enterprise resources, an input-output model was established. The model analyzes the resource input and output situation of each node, excavates the nodes that can be improved, and collaborates with the whole supply chain to minimize emissions. The PDCA cycle concept was introduced, which divides product quality management into four stages: planning, execution, inspection and handling. That is to make plans, implement plans, verify implementation results. Circular economy efficiency is a popular research issue in green supply chain research. Based on the multi-input and multi-output characteristics in the model, data envelopment analysis (DEA) was used to evaluate the comprehensive efficiency of decision-making units (DMUs) with multiple inputs and outputs. State Grid Corporation applies circular economy theory to each link of green supply chain management. For example, in procurement process, non-environmentally friendly materials should be minimized as raw materials that can be reused and recycled should be used as much as possible. In production process, waste emissions should be minimized as much as possible to improve resource utilization efficiency and waste recovery utilization rate, so as to help enterprises achieve efficient resource utilization systemically.

The theoretical innovation of the green supply chain of the State Grid Corporation of China mainly includes the chain leader theory, industry standard system, commercial and technological ecological construction, and learning-oriented social organization construction. In the digital construction of the green supply chain, especially in promoting the full-cycle management of equipment and the connection of all links of the supply chain, the State Grid Corporation of China attaches great importance to coordinating and sorting out the five major frameworks of business, application, data, technology, and security from the company level, connecting business processes, strengthening the "five unifications" of enterprise-level data, breaking the boundaries of various links, departments, and professions of the company, and realizing the mutual recognition of standards, business communication, and data sharing among various professions, companies, and enterprises on the chain. The State Grid Corporation of China has fully utilized its advantages in the ultra-large-scale procurement market, proposed the innovative concept of "Five Leading Purchases", and improved the proportion of procurement evaluation through the establishment of evaluation models in green and low-carbon, digital and intelligent manufacturing, innovation, life cycle cost (LCC) procurement, and intelligent procurement. It has used market-oriented means to encourage enterprises to spontaneously increase green and digital upgrades, create an efficient, flexible, controllable industry-level digital supply chain, and take the lead in the competition of major countries in energy transformation[6].

5 Conclusion

Climate change is a challenge facing all of humanity, and promoting the green and low-carbon transformation of the supply chain is the only way to address climate change. It is also an important way to promote the construction of an ecological civilization, promote high-quality development and protect the environment. In recent years, China's carbon emissions have remained at high levels, and energy and power emission reduction has been the main

battleground in China. As of the end of 2019, energy combustion accounted for about 88% of all carbon dioxide emissions, and the power industry accounted for about 41%. Therefore, the power industry is not only a key sector for carbon emissions, but also a pillar industry of the national economy. The green development of the supply chain is not a one-time accomplishment, but gradually improves through continuous monitoring, evaluation and development. Only by finding problems in carbon footprint tracking, pointing out problems in low-carbon evaluation, and solving problems in full-chain development can we continuously explore new green and low-carbon development paths, accelerate carbon information disclosure and green information disclosure, improve green and low-carbon technology and management system improvement, achieve the green and low-carbon development goal of grid supply chain, establish a green supply chain development model for the power industry, promote the development of green and low-carbon standards for the industry, and provide theoretical and practical basis and reference for the green and low-carbon development of the national energy system and even other industries.

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