

Digital Transformation of the Power Industry in a Dual-Carbon Context

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Abstract. On a global scale, under the strict control of carbon emissions and the requirements of sustainable development, various industries are moving towards a more environmentally friendly and efficient direction. As one of them, the power industry is facing great challenges and opportunities in the dual-carbon context. The aim of this paper is to explore how the power industry can adapt to the dual-carbon context through digital transformation to improve energy efficiency, reduce carbon emissions and provide a more reliable power supply. The paper covers the application of digital technologies in the power industry, including the discussion of five major Technologies such as Artificial Intelligence, Big Data, etc., and in this way constructs the evaluation index of digital green governance, and finally analyzes the application with the characteristics of the power industry.

Keywords: Digital transformation; power industry; green development; digital governance

1 Introduction

In the background of China's "3060" Dual-Carbon development goals, the demand for accelerating digital economy, green transformation, and promoting the high-quality development of the industry chain has become clearer. Based on China's "Dual-Carbon" goal, the power industry, in order to green development, must accelerate environmental protection governance, promote the clean utilization of coal and reduce pollution emissions. As according to relevant survey data, photovoltaic and wind power will become the main energy sources in 2050, accounting for 83% of China's total power generation capacity^[1].

However, on the one hand, due to the limitations of photovoltaic and wind power, the stability and continuity of the power system cannot be ensured. On the other hand, China currently has a large installed capacity of coal-fired power generation, which, despite the introduction of phase-out mechanisms and policies, poses a certain threat to the industrial and economic development of some regions that are highly dependent on coal, as well as facing stability challenges in the transition process and difficulties in practice.

Currently, under the advocacy of the national "Dual-Carbon" goal, in order to realize sustainable development, enterprises need to innovate the green technology applied in the whole process of

supply chain as much as possible. In the field of green management in the electric power industry, an enterprise digital transformation technology system has been formed, which consists of five parts: source prevention technology system, green production technology system, green marketing technology system, end-to-end governance technology system, and green logistics technology system. The enterprise digital transformation technology system contains multifaceted and multidimensional green digital technologies (as shown in Fig. 1). Vial creates a theoretical framework, which includes eight elements^[2]. The application of green digital technology can improve the supervision of the environmental performance of the supply chain, enhance the efficiency of enterprise green management, and realize the win-win cooperation between enterprises and suppliers.

Combining these technical characteristics, this paper proposes the application of digital technology in the digital transformation of the power industry in the context of dual-carbon, reasonable evaluation metrics for the digital governance, and a theoretical framework for the green digital construction.

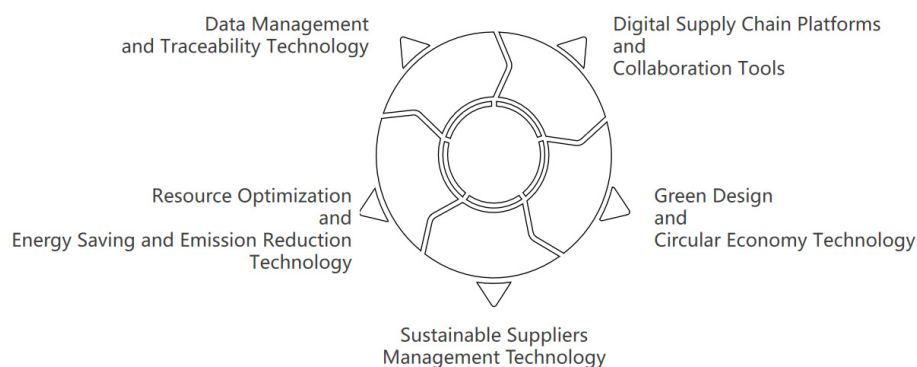


Fig. 1. Green digitization main application technologies.

2 Functions of the five technologies

The advent of digital technology provides an opportunity to tackle the challenges in the green development of the power industry, which has an impact from multiple channels, such as technological effect, human capital effect, and structural effect, so that the enterprise can realize the greening of the whole life cycle of product design, product manufacturing, supply chain, and recycling^[3], as shown in Fig. 2.

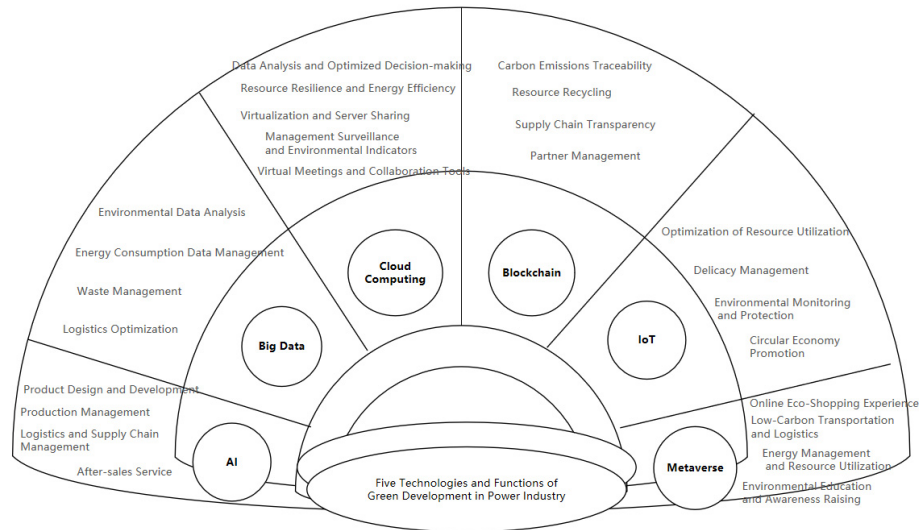


Fig. 2. Five technologies and functions of green development in the power industry.

The digital transformation of the power industry can be based on ABCD+IoT technologies, i.e. artificial intelligence, blockchain, cloud computing, big data and IoT technologies. Compared with traditional technology, digital technology has higher scientific and technological content and lower ecological and environmental impact, improving production efficiency and product quality while reducing corporate pollution emissions and promoting the green and low-carbon transformation of the supply chain. In the process of enterprise digital transformation, a number of digital economy construction and transformation reports have pointed out that "digital technology has a revolutionary effect on the achievement of sustainable development goals^[4]".

Digital technology helps enterprises to realize whole-process monitoring and eliminate the digital gap across sectors and enterprises, thereby achieving detailed management of environmental, social and economic benefits. For instance, through IoT, companies can monitor real-time environmental data such as carbon emissions and water utilization to develop more detailed assessments and solutions. Blockchain can ensure the degree of visualization and traceability of the power industry supply chain, allowing companies, users and relevant regulatory agencies to have a more specific view of green chain operations. Artificial intelligence technology, on the other hand, can help power enterprises optimize their policy-making plans and further reduce carbon emissions through assessment and measurement.

In general, it is a critical mission of digital transformation in the dual-carbon context to deeply integrate digital technologies with the full cycle of the enterprise's business processes, gradually forming a green management system with precise access, timely updating, full-area computing, and multi-dimensional synergies.

On the other hand, green technology innovation also demonstrates the green concept of enterprises, integrating green chain construction with digitalization processes, and realizing the traceability of the green chain by consolidating and evaluating data from various business layers. The ESG concept mentioned above is also data-oriented, which reveals that the green

construction of enterprises must focus on "high transparency". Therefore, stable and reliable digital facilities, accurate data collection and analysis mechanisms are all significant factors in green construction, and the visualization of data can also present the current status and problems of green construction vividly to the management staff. It should be emphasized that this link is not only limited to internal management, but also requires the establishment of a close partnership for sustainable development.

3 Digital transformation governance evaluation metrics

In the process of power industry digital transformation, there are also serious governance challenges. Governance activities also need to be closely focused on the digital transformation strategy, with institutional planning and scientific control models established at the top level. In 2021, China Academy of Information and Communications released a report on the Development of Enterprise Digital Governance Applications, which constructed a framework for enterprise digital governance from five levels: objectives, strategies, mechanisms, applications and objects^[5]. Chen Qun, LI Jiabin and Chen Zhe constructed an evaluation system for the digital development level of China's construction enterprises from the inputs, platforms, governance and outputs of digitization, and launched a discussion on digital governance in terms of digital supervisory capacity, emphasis, and development planning^[6]. This paper further combines the national green development strategy and discusses the evaluation metrics from three aspects: strategic system construction, sustainable development and innovation capacity. The details are shown in Tab. 1

Table 1. Digital Transformation governance evaluation metrics for power industry

First-level indicators	Second-level indicators
Strategic System-Building	Percentage of digital strategy documents
	Mention of digital strategy
	Digital strategy implementation process
Sustainable Development	Risk prevention and control mechanisms
	Material supplier dependency
	Supply Chain Quality
Innovation Capacity	IoT technical inputs
	AI technology investment
	Visual data analysis tool utilization

First of all, similar to energy projects, digital transformation requires specific strategic planning to establish a strategy that meets the enterprise's own strategy, from the enterprise strategy, thinking, technology, capabilities, talents and other levels. It is vital to systematically and comprehensively plan and formulate strategic plans for green management's main business and IT technology, and develop feasible digital transformation solutions by combining digital concepts and structures.

The second is sustainable development. Enterprise sustainable development strategy refers to the pursuit of self-survival and development of enterprises in the process, not only to take into account the realization of business objectives and the improvement of the market position, but also maintaining prosperity in the leading competitive field and the future expansion of the business environment. Digital transformation is the key to achieving sustainable growth for the

enterprise in terms of preventing risks, reducing dependence on material suppliers and improving the quality of the supply chain.

Finally, it is the innovation capability. Digital power refers to the utilization of information technology to achieve full life cycle collaboration through networked sharing, visual cognition, and high-performance computing, so as to provide intelligent engineering products and services. The digitization process of enterprises requires new technology applications, giving full play to the enabling role of digital innovation capabilities, establishing business organizational processes, forming a good internal culture and leadership, accelerating business system and business model innovation, promoting traditional business innovation, transformation and upgrading, fostering the development of digital new business. Through the full servitization of business, it builds an open and cooperative value model, responds quickly to meet and lead the market demand, and maximizes the value benefits.

According to the decided weighting process, the weight value of each indicator is obtained as α_n , where n is the number of the two-level indicator. Therefore, if the score of the two-level index is set as χ_n and the weighted score is γ_n , then:

$$\gamma_n = \alpha_n \times \chi_n \quad (1)$$

The final score of enterprise digital governance evaluation is obtained by summarizing the scores of all first-level indicators as:

$$S = \sum \gamma_i \quad (2)$$

Dummy variables $i = 1, 2, 3$ were set, respectively representing the score results of Strategic System-Building, Sustainable Development and Innovation Capacity Index.

4 Green digital transformation in power industry

Combined with the practical situation of enterprise green construction, the following points are illustrated. First, the green construction of enterprises is a self-organizing process of a sophisticated system, paying full attention to the evaluation and regulation system, and the laws construction. Second, enterprises should make full use of the international standard system to promote their own ecological civilization construction, regulate production behavior, and accelerate the development and use of green products. Third, based on the supply chain operation mode, building a cooperation framework for green construction, and jointly promoting the integrated management and synergy of the green and digital industrial chain. Finally, it integrates green construction with digital transformation, promotes the green transformation of traditional technology from the technological dimension, takes data as the basic element, realizes whole-chain visualization management, and provides effective support for enterprise green construction.

The digital construction of the power industry is an important assurance for the high-quality development, covering planning and design, bidding and procurement, manufacturing, construction and installation, operation and Maintenance, decommissioning and recycling. Especially in the promotion of full-cycle management of equipment, supply chain, etc., insisting on enterprise-level integration is the first principle of the company's digital transformation. Never view digital transformation only from the perspective of the profession, and fall into the path of dependence on the "professional system" and "departmental system".

Instead, standing in the overall perspective of the enterprise, targeting the development of the enterprise grid business, we introduce chain thinking into enterprise digitization construction. Attention should be paid to integrating and sorting out the 5 major architectures of business, application, data, technology and security from the enterprise level, linking up business processes, strengthening enterprise-level data unification, breaking down enterprise boundaries, and realizing mutual recognition of standards, interoperability of business, and sharing of data. The operation process is shown in Fig. 3.

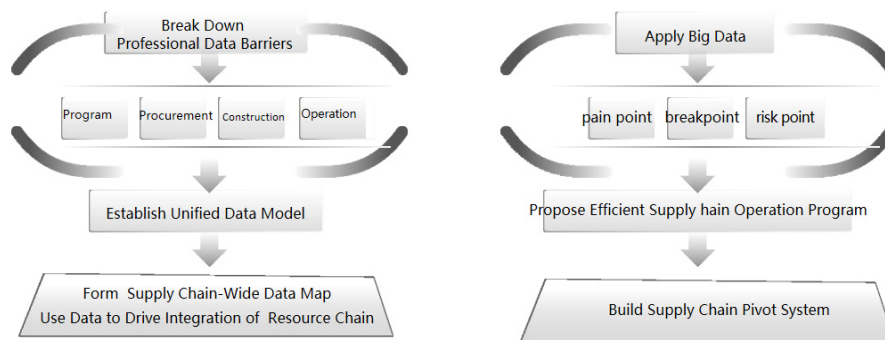


Fig. 3. Green digital transformation operational process for power Industry.

5 Conclusions

Digital transformation of the power industry in a Dual-Carbon context is necessary to meet the challenges of climate change and energy efficiency. Digital technologies such as Artificial Intelligence, Blockchain, Cloud Computing, and Big Data present opportunities and challenges for the power industry. Through effective planning, the power industry is expected to achieve lower carbon emissions, higher energy efficiency, and a more reliable power supply in the process of digital transformation, contributing to a sustainable future.

The digital transformation of the power industry also faces several challenges. First, digital transformation requires huge capital investment, especially in renewing and upgrading existing infrastructure. In addition, security and privacy issues cannot be ignored, as an attack on the power system could lead to serious consequences.

In the future, digital transformation will continue to evolve in the power industry. More smart devices and sensors will be deployed for higher levels of automation and monitoring. Artificial intelligence will be used for more accurate load forecasting and energy market management. Blockchain will drive decentralization of the energy market and facilitate the spread of renewable energy. The power industry will also continue to improve energy storage technologies to cope with the intermittent nature of renewable energy.

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