# Structure and path analysis of digital transformation of power grid development under the background of new power system

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**Abstract.** Under the development trend of economic globalization, the new power system with new energy as the main body develops faster and faster. After China's power system enters the intelligent development environment of the Internet, a new generation of digital technologies such as artificial intelligence, mobile Internet, big data and cloud computing begin to transform the traditional power grid system, which not only speeds up the pace of digital transformation of power grid development. New development goals and effective measures are also proposed. Therefore, after understanding the practical significance of the digital transformation of power grid development in the context of the development of new power systems, this paper mainly studies the problems faced by the new power system and the design framework, and deeply discusses the commonly used digital technical means and development paths, so as to provide an effective basis for the reform and development of the power industry.

**Keywords:** power system; Digital transformation; Dual carbon target; Accurate perception; Intelligent recognition.

## 1. Introduction

In the process of urban construction and development, the "dual carbon policy" has begun to continue to advance, which has brought new opportunities and new challenges to the development of new power systems. According to the analysis of the current development trend of China's energy, new energy has the characteristics of randomness, volatility and accuracy, which not only speeds up the transformation pace of energy and power safety and reliability, supply demand and clean and low-carbon, but also orderly realizes the important strategic task of dual carbon goals. At present, the power supply, grid, energy storage and other links in the new power system are mutually coupled and highly electric, and the development framework of each link is shown in Figure 1 below: [1.2.3]
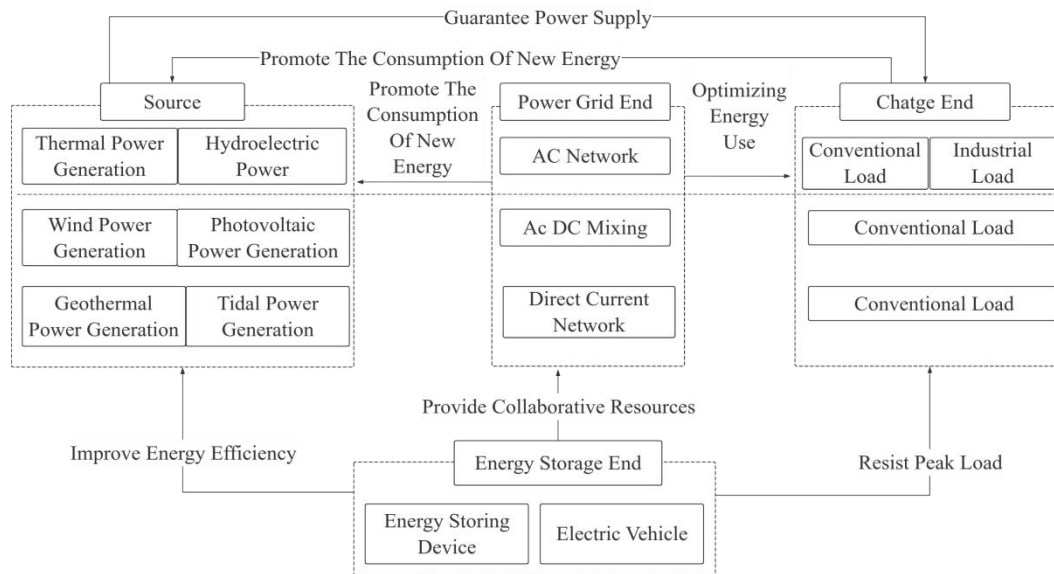
FIG. 1 The overall development framework of the new power system

Based on the above analysis, it can be seen that digital transformation technology, as one of the technical means used in the new power system, on the one hand, it will use scientific and effective data processing technology to help the new power system operate and process huge data structures, and ensure the deep integration of power system and computing technology based on powerful computing capabilities, so as to form a new large-scale power system. On the other hand, it can create a new technical structure for the power system, and gradually expand the power grid service from the main business of high-quality electricity to the digital industry. In essence, digital transformation is the use of digital technology to control the fundamental change of business, processes and services, firstly, with a flexible and efficient sensitive architecture, secondly, according to the pattern shown in Figure 2 below, digital physical deep coupling, and finally based on digital transformation, promote the fundamental change of the enterprise. ［4.5.6］
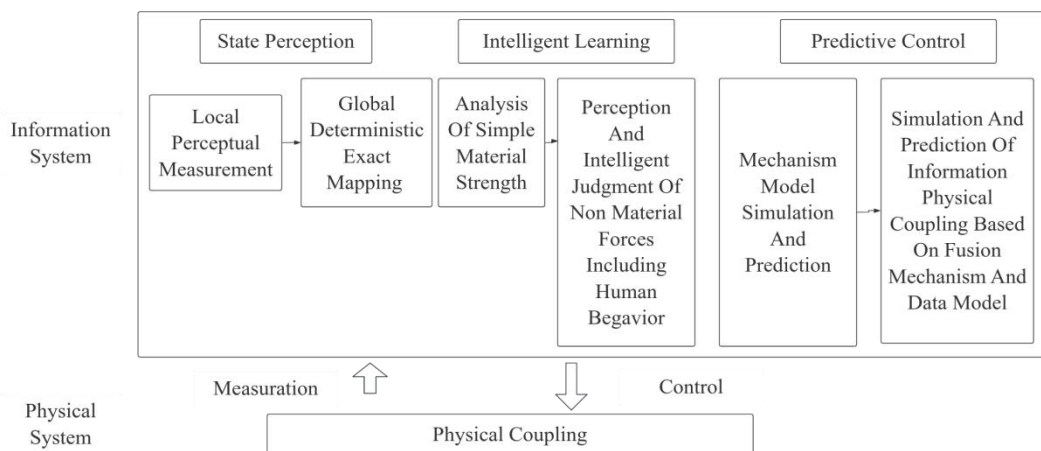


Figure 2 Model structure diagram of measurement and control

From the perspective of current construction and development, new energy power generation has the characteristics of large power error, large energy output fluctuation and seasonal deviation, and the new energy needs such as clean green and low marginal cost also put forward higher

requirements for the design of market mechanism. Therefore, the branch system is designed with the support of the original electronic technology, and the digital power is regarded as the development carrier. The use of green, digital and collaborative development methods can safely and efficiently use clean energy, so as to guide the new power system to achieve measurable, observable and controllable development goals.

In the context of the essential changes in the main body of the power supply, the new power system will face development problems such as power balance, system support, multi-element coordination of source and network load and storage, carbon emission reduction and carbon assessment while achieving digital transformation and development. In view of the technical challenges and development opportunities faced by the new power system, the rational use of big data, cloud computing, digital twin digital technology, etc., to guide the power system to develop in the direction of flexibility, stability and security, build a new power system architecture suitable for a high proportion of new energy, and ultimately achieve the goal of carbon peak and carbon neutrality in an orderly manner. ［7.8.9］

Under the guidance of the digital platform, the digital transformation of the new power system has become an inevitable trend in the development of the power industry. The use of digital transformation technology to realize the intelligent reform of the power system, carry out the construction and management application of digital infrastructure in an all-round way, and scientifically solve the digital perception problems of the power system in power generation, transmission, substation, distribution and transmission. It not only meets the electricity demand of urban residents, but also lays the foundation for the creation of smart cities. Therefore, from the perspective of the development background of the new power system, this paper systematically studies the digital transformation framework and effective path of power grid development, in order to provide technical support for the reform and development of the power industry in the new era.

## 2. Method

### 2.1 Transformation Architecture

The digital transformation architecture is a system architecture that utilizes advanced digital technology to comprehensively, timely and accurately obtain the key information of power equipment during the operation of the network system, regards data as the core basis, deeply integrates the whole life cycle management links such as design, manufacturing, operation and maintenance, and finally realizes the deep interaction between the physical entity of the equipment and the digital virtual twin. According to the analysis of the architecture shown in FIG. 3 below, it can be seen that it is mainly divided into four levels: First, the data acquisition layer collects all the data information, and after summary calculation, it can grasp the working status of the power equipment. The most important technical problem is the intelligent perception of the power equipment status. Secondly, the data processing layer mainly provides data communication, data management, data support and other services, and uses the Internet of Things platform of power equipment to achieve data transmission, data cleaning, data storage, data sharing, etc. The most important thing is to ensure the security and reliability of data information. Thirdly, the data analysis layer will help physical entity and digital twin map each other after building physical mechanism model and data-driven model, and comprehensively diagnose and evaluate the working state of the equipment, including digital twin modeling and simulation, big data analysis, artificial intelligence and other technical concepts. Finally, the data application layer will be supported by

intelligent operation and R&D design of power equipment, which includes important functions such as visual display line, state assessment, fault prediction, operation risk and life assessment, equipment and optimization design.〔10.11.12〕
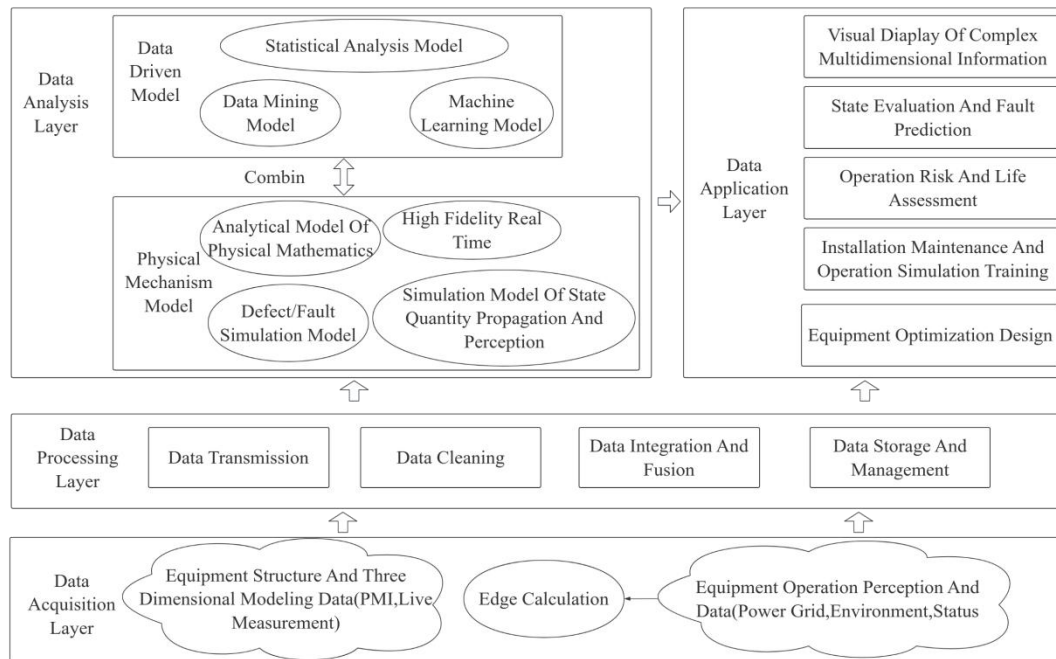
Figure 3 System architecture diagram

## 2.2 Key Technologies

First, intelligent perception. The operation of digital transformation system architecture requires a large number of sensors and intelligent sensing terminals, which mainly provide operating data and status information for system operation. Advanced and reliable state of power equipment, intelligent perception technology is the basic basis for power equipment to achieve intelligence and digitalization, including special sensing technology, sensing reliability assurance technology and terminal edge computing technology. Taking the special sensor technology for power equipment as an example, it is more safe and reliable than the general sensor, very suitable for application in special operating environment, withstand all kinds of transient strong electromagnetic field interference, high temperature and humidity and other harsh weather conditions, and can withstand strong electromagnetic field, thermal field and mechanical stress, with high insulation strength. It meets the needs of digital transformation system architecture for power grid development in the new era. Nowadays, the research speed of new power special sensors is getting faster and faster, and a large number of advanced technologies are widely used in system design, among which the common sensor application environment and main advantages are shown in Table 1 below. These technologies are very suitable for the research and production of sensors installed inside the equipment, which can facilitate the staff to perceive the internal operating status of the equipment. It is the focus of future digital power equipment state perception.〔14.15〕

Table 1 Types and analysis of special sensing technologies

| sensing technology | Applicable scenario | Main advantages |
|---|---|---|
| MEMS/ chip sensor | Relatively mature state parameters such as temperature, vibration, sound and gas composition. | Miniaturization, can be built in：High consistency and reliability: low cost |
| Low Power Passive Wireless Sensor and Sensor Network | High-voltage side state parameters of equipment: other scenes where active wired deployment is difficult. | Self-energy environment, built-in: low installation and maintenance costs, flexible and convenient. |
| Optical/optical fiber integrated sensor | Vibration, partial discharge, temperature, pressure, strain and other multi-parameters are monitored separately or integrated. | High insulation strength, can be built-in: directly sense multiple state parameters inside the equipment. |
| New materials and advanced sensing technology | Giant magnetoresistance broadband current sensor, flexible material vibration sensor…… | Improve measurement performance: reduce sensor volume: extend sensor life. |

Second, intelligent recognition. Since the state information data of power transmission and transformation equipment comes from a wide range of sources, including structured and unstructured types, an adaptive deep learning defect identification algorithm is proposed for the new power system combined with sample size. The data information samples such as the fault and abnormal status of the transmission equipment are not enough, the historical fault data appears, and the online monitoring system is not installed, resulting in the loss of a large number of precious data. In order to scientifically solve the problem of low accuracy of algorithm model caused by too few samples, on the one hand, it is necessary to expand the coverage ability of condition monitoring system of power transmission and transformation equipment, and on the other hand, it is necessary to expand fault samples by increasing data samples. For example, some scholars have proposed to use the fault case generation method of strategy gradient sum to solve problems, which has strong convergence and can effectively solve high-latitude or complex space problems, and is very suitable for processing discrete data with diverse distribution and large changes. Some scholars have also proposed a comprehensive evaluation method for the state of high-voltage cables with multi-state quantity characteristics and change rules, built a database containing various curve graphs, and summarized and analyzed the characteristics and change rules of each state quantity under different states. It should be noted that the internal data acquisition methods of power transmission and transformation equipment are limited, and it is impossible to effectively understand the development law of defects. Therefore, future scholars propose to pay attention to the intelligent defect identification research of multiple spatio-temporal data coupling, so as to master more

abundant defect monitoring data and provide an effective basis for system identification and application.

Third, online monitoring. The online condition monitoring system as shown in the following figure is constructed, and the multi-physical micro sensor and the customized power sensor chip are integrated together. It can not only understand the working status of the power equipment, but also collect and process more data information according to the multi-physical field model of the equipment, and timely warn the equipment with abnormal status, so as to facilitate the scientific and effective management and control of the employees of the power enterprise.
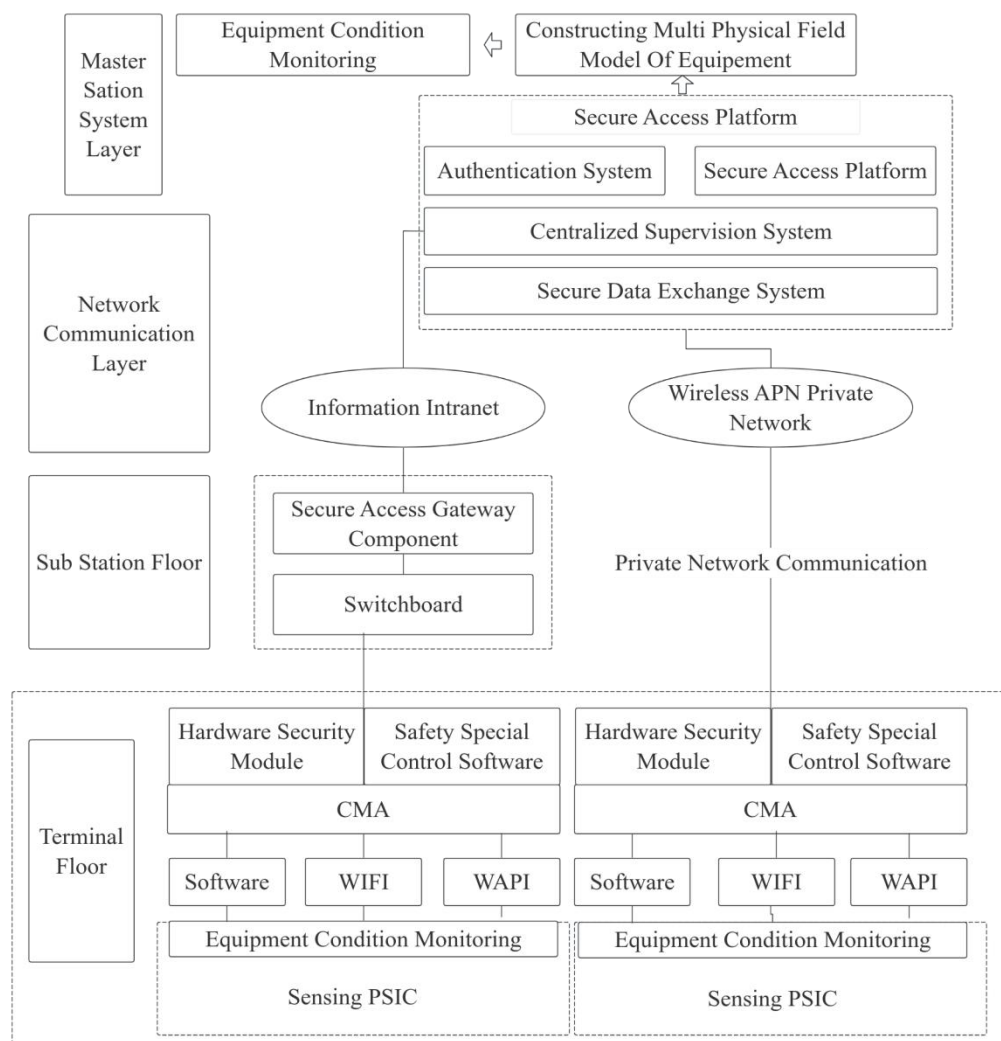


FIG. 4 Structure diagram of on-line condition monitoring system

## 3. Result analysis

In the context of the continuous growth of global resources, the development of new power systems and digital transformation should attach great importance to the application of new energy innovation, such as pumped energy storage as the current technology is relatively mature, the application of safe and reliable, the cleanest economic power system, not only can be used for the system of peak loading, valley filling, frequency modulation and other aspects. We can also improve the electricity price mechanism by constructing electricity fee allocation and dredging.

Solar power generation will not be limited by regional conditions, there is no application risk of exhaustion, and it has the advantage of high energy quality, so it can bear the functions of base load, peak regulation and frequency modulation in the new power system, and can also supplement the operation of other energy sources as a new energy source. At the same time, it can flexibly adjust the application of resources and effectively maintain the safe and stable operation of the power system. Therefore, some scholars have proposed to use artificial intelligence, cloud computing, big data and other technologies to gradually improve the equipment system of new energy flexible grid-connection and distributed energy open access, and build matching industrial policies and system architecture in combination with market conditions, so as to create a power grid system model required for the development of the new era. The new power system with digital transformation as the core can truly meet the basic needs of intelligent perception and information collection of power equipment, meet the application system of future digital power business, organically integrate the power operation process, improve the digital management level of key nodes, enhance the regulation ability and safety performance of the distribution network, and truly realize the long-term development goals of economic reform and energy control. After comprehensively considering the urgent development needs of the digital power equipment system, domestic and foreign scholars systematically studied the basic definition, connotation characteristics and system architecture of the digital power equipment according to the characteristics of the new power system and the application status of digital technology, and clarified the key technologies of the system application and the main problems faced by the development. The future development trend of digital power system is forecasted. Although there is still a certain gap in the requirements of digital transformation to the safe, controllable, flexible and efficient, intelligent technology of new power equipment, with the continuous development of social economy and science and technology, future technology applications and system requirements will inevitably reach the expected goals.

## Conclusion

In summary, a large number of access to new energy applications, so that the new era of power grid and system construction face new challenges. Based on economic development and urban construction, the research on the new power system and digital transformation architecture, and the identification of relevant supporting technologies and management measures in each link can effectively solve a series of problems brought about by the reform of the power system, fundamentally improve the reliability and safety of the new power system, and truly meet the electricity needs of urban residents.

## Reference

[1] Structure and path analysis of digital transformation of power grid development business [J]. Low Carbon World, 2023, 13(3):130-132.

[2] Zhihui Ren. Power grid digital upgrade helps energy structure optimization [J]. Electric Age, 2023(7):1-1.

[3] Guopeng Zhou, Chunyang Zhao, Junjie Kang, Liang Zhao, Zheng Li. Typical development model of energy service oriented to the integration of source and network load and storage [J]. Guangdong Electric Power, 2022, 35(7):23-31.

[4] Kun Sheng,Ziyan Wu , Zhiyong Li. Application Architecture of new urban Power System based on Digital Twin Technology [J]. Electrotechnical Engineering, 2023(6):100-103. (in Chinese)

[5] Typical information security threats and countermeasures of new power system in digital transformation [J]. New Industrialization, 2022(003):012.

[6] Xi Li , Lin Liu, Yifeng Bu, et al. Research on the development path of new power system -- Based on the goal of "dual carbon" [J]. Urban Intelligence, 2022(19):0160-0162.

[7] Dan Luo. Research on the path of optimizing electricity business environment under the background of digital transformation [J]. Journal of Xidian University: Social Science Edition, 2022, 32(3):9-19.

[8] Yigang Tao, Jing Tan, Min Li, et al. Research on Application of Digital Technology in Power Distribution network [J]. Electric Power System Equipment, 2023(6):13-15.

[9] Sheng Wang, Jian Tan, Wenbo Shi, et al. The experience of new power system construction in the United Kingdom and its inspiration to the development of provincial power grid in China [J]. Huadian Technology, 2022(007):044.

[10] Huiqiang Ji. Research on business model of low-carbon and digital transformation of power grid enterprises under energy reform [J]. Enterprise Management, 2022(S01):30-31.

[11] Fuzhong Hao. Strong foundation and solid Foundation guarantee the high-quality development of the company with digital security system [J]. Henan Electric Power, 2022(6):18-19.

[12] Chao Ma, Tao Deng, Qinyong Zhou, et al. Research on standard digital transformation for Power Industry: Demand analysis, transformation path and application scenario [J]. Standardization in China, 2022(23):87-92.

[13] Changsheng Miao. Exploration and practice of digital transformation of electric power enterprises in China [J]. Journal of Sichuan University of Arts and Sciences, 2022, 32(1):69-74.

[14] Zhengtian Lai. Research on key technologies of digital transformation for new power system [J]. Power Supply and Electricity, 2022, 39(2):1-1. (in Chinese)

[15] Jun Wu, Xiang Li, Ziling Mo, et al. Research on Enterprise System Operation business development Strategy based on new power system -- A case study of China Southern Power Grid Co., LTD. [J]. Enterprise Reform and Management, 2022(5):4.