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Integrated Two-Level New Energy Monitoring and Big Data Centers: A Comprehensive Approach for Urban Sustainability

Abstract: - With the help of the quick development of big data, the Internet of Things, and other related technologies, the construction of new energy monitoring and big data centres aims to enhance the control capability of urban new energy stations. Inefficient operation and maintenance of new energy stations, as well as chaotic production control, are the reasons behind this action. Given the limitations of the current stage of new energy big data platform construction, the construction of group-level new energy monitoring and big data centres to achieve a high degree of integration and sharing of resources and experience has become an inevitable development of the new energy industry. This project aims to achieve multi-level integration in decision-making from the bottom up by using the background of the construction of the Wenzhou New Energy Two-Level Centre as a guide, organising the business processes for new energy production and equipment control, designing the technical architecture of the platform for cloud-side collaboration, providing guidance for the heterogeneous data processing and analysis of new energy assets in the cloud, and acting as a model for the development of the group-level intelligent platform for the new energy industry.

Keywords: cloud-side collaboration; monitoring and big data platform; architecture design; new energy sources

I. INTRODUCTION

The role that green energy planning and construction play in the process of urban development has grown in importance as a result of the ongoing deterioration of environmental issues on a global scale and the growing attention given to the idea of sustainable development [1-3]. Wenzhou, a major regional centre in Zhejiang Province, for example, is located near the coast and has an abundance of renewable energy resources, such as wind, solar, and ocean energy. It has been designated as a national pilot project for low-carbon city construction. The city's water depth of 0 to 50 metres in the sea area allows for the development of wind power technology up to 5.8 million kw or so. Of these, the near-shore islands and the coastal prominence of the wind resource are a class of area, and have a high density of wind and uniformity, the wind having no variety of characteristics. Wenzhou land wind energy resources theoretical reserves of 1.5 million kw, technology can be developed for more than 650,000 kw. The Wenzhou sea area has enormous tidal energy reserves. It experiences strong tides and semi-diurnal tides, with average tidal ranges of 4 to 5 metres and maximum tidal ranges of 6 to 8 metres. The area has a 4120 MW installed capacity for tidal energy, and there are 17 possible sites for tidal power stations. These sites are among the richest in the nation. This indicates that Wenzhou is especially well-suited for projects involving the production of ocean energy, offshore wind power, and offshore photovoltaic systems. But as of right now, Wenzhou is still in the early stages of its use and development of green energy, and its full potential is still many years away.

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Wenzhou City is concurrently confronted with increased challenges related to environmental protection and low-carbon, green energy transformation. Wenzhou City's economy has been growing steadily, and it has a high industrial output value and population density. However, because of its traditional industrial energy structure and resource endowment, the city's reliance on coal will be difficult to overcome in the near future. Wenzhou's reliance on fossil fuels remains high—91.3% in 2021, according to the city's energy white paper statistics—and is entirely dependent on outside transfers. In contrast, non-fossil energy makes up a relatively small portion of the city's total energy consumption—only about 8.7%—and its share of green energy consumption is lower than the province as a whole. The kinetic energy of scientific and technological innovation to support the cultivation and upgrading of the green energy industry is insufficient, as is the intensity of research and development investment made by the entire society. Additionally, the level of advanced industrial foundation and modernization of the industrial chain is still lacking, and the development of strategic emerging industries is lagging behind. These contradictions also exist between sustained healthy and coordinated rapid economic development and the insufficient carrying capacity of resources and environment, as well as the difficulty of sustained improvement of environmental quality. As a result, Wenzhou City's urban green energy planning and construction study can more effectively investigate and implement sustainable energy development strategies, enhance energy efficiency, lower pollution levels, and accomplish the mutually beneficial development of the environment and the economy. Using big data analysis techniques, this study aims to create a rational and scientific urban green energy planning and construction programme that takes into consideration Wenzhou City's environmental carrying capacity, energy demand, and current energy structure.

A common theme among some of the current research is the use of quantitative analysis to examine patterns of urban energy consumption, followed by the formulation of relevant technical standards and policies to support the growth of green energy based on this analysis and summary. Nevertheless, there is currently insufficient global research to address the issue of "the lack of linkage and complementarity between various energy species, energy supply and demand structure is not close enough" or to take into account the development of a green energy planning system in Wenzhou City. Thus, the goal of this paper is to thoroughly examine this issue in order to offer a useful road map for the integration and development of high-quality renewable energy sources in Wenzhou City.

II. RELATED WORK

Urban green energy planning and construction have been the subject of numerous attempts at research conducted by academics both domestically and internationally. For instance, [4] developed a system architecture for energy big data planning and research based on the development law and industry direction of the energy sector, along with the theory of Internet big data. They also sorted out the process of multi-source energy big data collection, management, and analysis; proposed a mechanism and algorithm for obtaining and analysing energy big data; and conducted empirical demonstration through the Jiangsu energy planning and research platform. In order to improve the resolution of energy consumption, [5] gathered a range of big data at the city level. They then created a research framework to better utilise these data and offer fresh theoretical and practical recommendations for high-resolution energy spatial distribution. [6] We analysed the spatial distribution characteristics of commuting linkages and carbon emissions using multi-source spatial and temporal big data, including Baidu map trajectory data, urban land use data, and web crawling data. Based on the findings of the correlation and spatial autocorrelation analyses, we created multivariate and geographically weighted regression models to further investigate the effects of the four categories of built environment factors, including transportation facilit. [7] Following an analysis of the technical difficulties encountered by new energy big data applications, the functional architecture of a new energy big data platform is developed from three perspectives: data fusion, intelligent computing, and application services. Key technologies are then suggested for various business objects, including new energy operators and grid companies. Based on the suggested platform architecture and key technologies, an application platform utilising new energy big data in a particular area is built. The use of big data analytics (BDA) to process, analyse, and extract information that can be integrated and utilised in energy systems is covered in [8–10].

These studies, in particular, go over common uses of BDA in energy systems, such as how it can be applied to solve important problems that face present and future energy network operations and how it can help create more intelligent and adaptable energy systems.

III. OVERALL STRUCTURE

The current common system architecture aims to achieve the construction goal of "centralised control, regional management, intelligent operation and maintenance, and efficient power generation" by constructing a multi-level management system from the power station - regional production and operation management centre - group, relying on digital management cloud platform[11]. Using the China Wenzhou Group's construction of a monitoring and big data centre as an example, this centre is positioned as the group's new energy data storage centre (data cloud), monitoring and support centre, diagnosis and analysis centre, and technology innovation centre. Its primary functions include operation monitoring and index analysis, equipment diagnosis and analysis and fault pre-warning, data management and information security monitoring, technical supervision and equipment management, online technical support and post-evaluation, Support for Technology and Data Application Innovation, as illustrated in Figure 1. The main functions of the regional centralised control centre include statistical analysis of production indicators, remote inspection of equipment parameters, automatic early warning of equipment status, regional production data centre, and management chain data flow coupling centre. The centre is positioned as a regional centralised operation monitoring, equipment management, statistical analysis centre, and maintenance scheduling centre[12-14].

A workable solution for energy system planning at the regional planning level can be found with the "Carbon Pinch Point" planning approach (CEPAP) [15], which is based on altering the previous model of increasing the supply of resources to meet the growing energy demand (Figure 1). In addition to generating a regional building energy mix and optimising carbon emission targets, it can offer workable solutions for energy system planning at the regional planning level (Fig. 1). Setting goals for building energy consumption and the region's environmental impact, figuring out how much energy is available in the area, estimating regional energy loads, choosing the best energy systems and technological paths to attain efficient energy allocation and use, and assessing the regional energy system's effects on the environment and energy use are the primary steps.

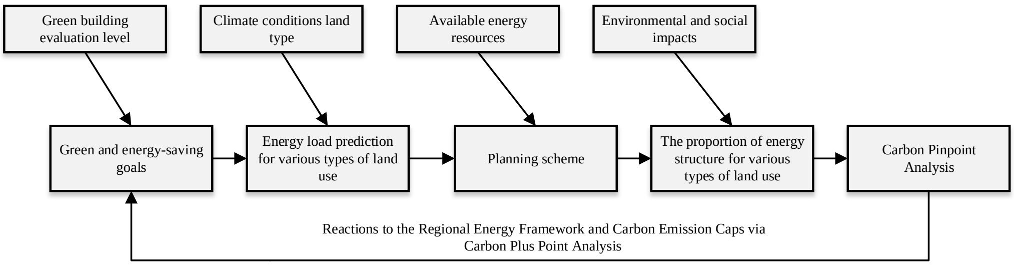

Figure 1 Schematic diagram of the "CEPAP" methodology.

3.1 Data aggregation layer

In the process of data aggregation, the data tagging, edge computing, protocol specification, configuration synchronisation, and other access guarantee capabilities are used primarily for accessing and aggregating the production data that the centralised control centre accesses, as well as the operation and management data of other group systems, such as the Internet of Things architecture from the data source to the monitoring and big data centre [15].

Data sources, data collection and transmission, central data gathering and data access rule configuration, data prefabrication processing rules, and data persistence are all included in the data gathering process, as seen in Figure 2. In particular, the data collection layer uses edge computing, Internet of Things, and data transmission technologies, among others, to gather data information from wind power plants and photovoltaic power stations, such as real-time operation data of the plants, real-time operation data of box and table transformers, real-time operation data of boosting stations, data of the stations' active and reactive control systems, data of protection and fault information, and data of power metering inform . Using the designated transmission protocols and transmission paths, the energy IoT gateway sends the data to the energy IoT hub. After the data is prefabricated through the operations of data collection and communication, data tagging, data preprocessing, edge computation, etc., the energy IoT gateway then transmits the data to the distributor through the data IoT-Hub. After the distributor distributes the data, the data is then persisted through the streaming and batch processes[16].

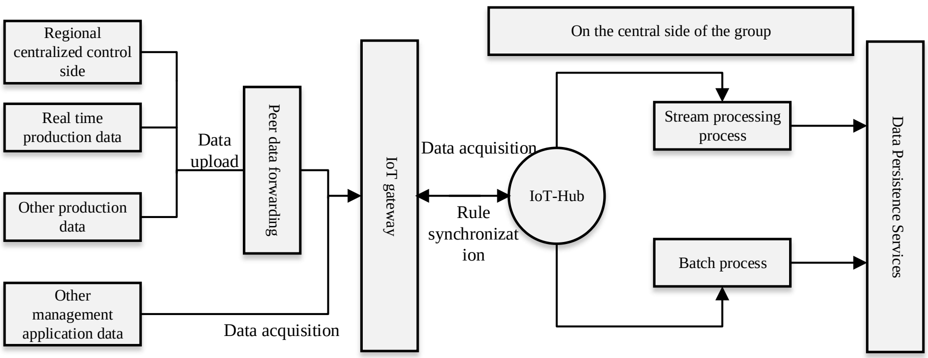

Figure 2 Data aggregation flow

3.2 Application fusion

Application fusion can satisfy the needs of new energy users in terms of integration, consistency, openness, maintainability, manageability, and quick interaction because it is predicated on the data center's open service function, which serves as the last carrier of new energy business scenarios. Containers, microservices, public component services, message buses, application markets, and application platform operations are all part of the application platform's technical architecture design, which helps prevent issues that arise from new energy enterprises' software systems going online at different times. These issues include the data of each system being defined and stored separately, the lack of connectivity and interaction, and the well-known phenomenon of data silos.

Through the operation and management of containers, containerization indirectly realises the application's online functionality as well as its operation and maintenance. It does this by integrating the application's functional content with its supporting dependency systems in a self-sufficient ecosystem. In the current application market, containerization combined with microservices is a common method for quickly developing, deploying, and operating applications. Microservices Engine facilitates the deployment, management, and upkeep of applications using microservices architecture as well as the microservices transformation of enterprise applications. It offers comprehensive support for microservices development, operation, and governance. The public component services are separated into two sections: the business domain services are derived through the abstraction and extraction of various applications to realise the unification at the level of the application platform and form the platform's business service provision source, thereby achieving the reuse of business data. The integration application component offers unified public component services for various application services in the platform, realises integrated operation and maintenance services for various applications, and ensures the security of the platform. Texting Service Bus integrates components across various platforms, realises multiple communication protocols between the component and service layers, and maps the components into services at the service layer. The foundation of the application market is portal technology architecture, which realises on-demand platform architecture to satisfy the application experience of various user perspectives by seamlessly integrating multiple system access to meet the service provider, consumer, and system manager access portal. An integrated application operation and maintenance management portal, including account management, application registration, application subscription, service guarantee, and configuration management, is offered by the application platform operation.

It realises multi-system integration and data fusion, and ultimately realises an intelligent operation system integrating online and offline, as well as visual business management such as asset management, risk control, and indicator analysis from the perspective of centralised monitoring. This is based on the unified entrance of regional centralised control, equipment health management, power prediction, business intelligence, big data platform, third-party asset management, and other systems. The production and operation monitoring system for wind power and photovoltaic units can keep an eye on substations, environmental data, power quality, wind/photovoltaic power prediction, AGC/AVC, and more. It can also perform tasks like statistical index monitoring, data statistics query, intelligent production report, benchmarking and assessment push, and fault statistics analysis. The centralised wind/photovoltaic power prediction system facilitates the centralised power prediction of wind power, photovoltaic power generation, and other new energy assets owned by the Group. This helps the Group, its subsidiaries, and power stations to develop safe production and operation plans in a scientific and reasonable manner, lower the risks associated with production and operation of the power stations, and keep improving the power stations' power generation efficiency, which in turn raises the level of operation and management of the Company[17]. New energy equipment operation and maintenance data can serve as the basis for fault diagnosis and early warning systems for wind power and photovoltaic equipment, helping to achieve the goals of cost reduction and efficiency gains, environmental prediction data in-depth mining and analysis, diagnosis and analysis of performance inefficiencies, damage to components, and component safety risk. It can also accept equipment failure, equipment alarms, and other sub-health alarm data information, through multi-dimensional analysis, equipment health evaluation. Furthermore, it can be integrated with the meteorological power prediction system and the production control system to create a planned operation and maintenance system, like the equipment health management system architecture depicted in Figure 3.

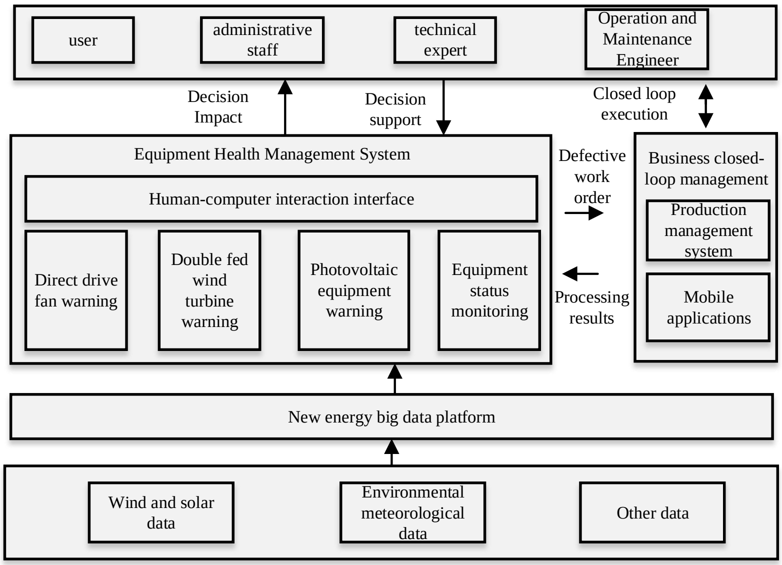

Figure 3 Equipment Health Management System Architecture

IV. APPLICATION CASES AND BENEFITS

It is currently the largest industrial Internet system in the industry, with access to over 13,000 wind turbines, a photovoltaic power generation capacity of over 3 million k W, real-time data collection from over 6 million measurement points, and daily data processing exceeding 30 billion. As part of the project, a full range of diagnostics, optimisation, expert analysis, and the issuance of a corresponding thematic report were carried out[19-20].

Using a project in Wenzhou as an example, the intelligent analysis platform's diagnostic conclusion notes that the power generation model deviation and other power generation loss for the project are 240.92k W-h and -621.11k W-h, respectively. The system optimisation platform data analysis is combined with this information to yield a total of seven recommendations for improving efficiency in terms of safety, quality, and efficiency, amounting to approximately 270 hours. When the parity feed-in-tariff is calculated, the direct economic benefit of the wind farms can be increased by approximately 10 million yuan annually, or 200 million yuan over the course of a 20-year operation cycle. A single wind farm can increase its direct economic benefit by roughly 10 million yuan annually, and over the course of its 20-year operation cycle, it can increase by about 200 million yuan. The economic benefits are estimated to be at least tens of billions of dollars if they are fully extended to the remaining wind farms in the Group.

The wind farm system optimisation platform, using a project in Wenzhou2 as an example, analyses the power generation in the project during the three phases of pre-production, engineering, and production by examining the various aspects of wind resources, equipment dependability, and power generation performance. It then makes optimisation recommendations. Although the wind farm has more advanced power generation hours in the area, lower on-site power limitation levels, and better resources, there is still much space for efficiency and quality enhancement. (1) The largest losses from capacity reduction are seen in wind farms. The platform analyses issues with equipment vibration, high temperature, yaw to wind, pollution, and calibration of the blade's zero angle. By treating the equipment and optimising the parameters, efficiency should increase by roughly 120 hours. It is anticipated that equipment management and parameter optimisation will increase efficiency by roughly 120 hours. (2) The turbine's power scatter distribution is larger and its power curve is less regular. By optimising air density and upgrading control parameters, efficiency is anticipated to increase by roughly fifty hours. (3) After optimising the entire field control, the wind farm's overall tail current loss is expected to decrease to 4.69%, with a 1% efficiency improvement anticipated in roughly 20 hours. (4) The project can operate in windy conditions, can turn off wind speed delay technology, and is anticipated to increase efficiency in roughly 30 hours (with a 1% increase in efficiency).

V. CONCLUSION

This paper's practical application case study of the system demonstrates how the system optimisation platform and intelligent analysis platform have improved power generation benefits and decreased operational risks with impressive results. This not only increases the business's economic efficiency but also offers substantial backing for the development and promotion of urban green energy planning. With the system's ongoing improvement and promotion, a wider range of applications in the new energy sector are anticipated in the future.

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