Discussion on Industrial Internet Platform Construction Based on Power Internet of Things

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Abstract: At present, the development of industrial Internet platform is in a period of large-scale expansion. Since 2017, China has issued a series of documents, such as the Guidance on Deepening "Internet + Advanced Manufacturing" to Develop Industrial Internet, the Action Plan for Industrial Internet Development (2018-2020), and the Industrial Internet App Cultivation Project (2018-2020), which constantly points out the direction for the development of the industrial Internet industry. The power Internet of Things connects the equipment, customers and data in all links of energy production, transmission and consumption in real time, fully bearing the production and operation of power grid, enterprise management and new business development, etc. It has the characteristics of ubiquitous terminal access, open platform sharing, computing cloud collaboration, convenient and flexible application, etc. This paper aims to discuss how the power Internet of Things can help the construction of the industrial Internet, provide strong data resource support and service for the safe and economic operation of the power grid, improve business performance, improve service quality, cultivate and develop strategic emerging industries, and open up a new road for management innovation, business innovation and value creation.

1. Introduction
In order to thoroughly implement the central strategy of general secretary Xi Jinping's "four revolutions, one cooperation" new strategy for energy security, and implement the central strategy of national energy security, network power, digital economy and industrial Internet innovation development, the State Grid Company will promote the construction of Platform + Ecology, focus on the energy Internet industry chain, and expand the platform business as the key work. In the future, more upstream and downstream enterprises will participate to promote the formation and development of energy Internet Ecology.

2. Smart Energy Management Status
China set up the National Energy Commission in 2010; In 2016, the National Development and Reform Commission issued the Guiding Opinions on Promoting the Development of "Internet Plus" Smart Energy, and set up several demonstration industrial bases. Considering the actual needs of industrial parks and the development status of new energy power stations, this paper summarizes the current relatively mature collaborative planning steps of new energy integrated management and control system, which are detailed as follows: 1) Analyze the regional status of industrial parks; 2)
Analyze the output characteristics of the energy supply side; 3) To predict the energy utilization characteristics of the load side of the industrial park; 4) Establish the coupling model of new energy system; 5) Planning scheme.

In recent years, the United States has put forward a plan for the development of an integrated energy system and promulgated the Energy Independence and Security Act, which clearly requires that the major sectors of society that supply and use energy must carry out a comprehensive control plan for new energy. Canada has promulgated a number of bills on the development of comprehensive control system of new energy, clearly pointing out that the planning and construction of a comprehensive energy system covering the communities of the whole country, with the energy management center as the core and the comprehensive utilization of all kinds of energy, is also an important measure of the Canadian government to deal with the energy crisis and achieve the target of greenhouse gas emission reduction by 2050. In Europe, on the basis of the power market mechanism, the European Union Electra project and E-Dema project put forward the concepts of "net-element interconnection" and intelligent energy router respectively. By analyzing the characteristics of multi-energy load and the operation of equipment, the optimization model was established to realize the optimal force distribution of the system and improve the overall efficiency. The University of Manchester has integrated the energy system in Manchester area from three aspects of energy mode, energy saving strategy and demand response, and developed an interactive platform between the integrated energy power/heat/gas/water system and users. By adjusting the running state of energy load and controlling the peak-valley difference, the peak-valley reduction and valley filling can be realized. A comprehensive energy interaction platform has been developed in Germany. The innovation is that users can choose the mode of lowest energy consumption cost, the mode of maximum consumption of new energy and the mode of power grid support, which not only guarantees the safety of power grid operation, but also maximizes the interests of users.

At the same time, energy industries around the world are also integrating with the industrial Internet. The German company Siemens has launched the MindSphere industrial Internet platform, which is the application of cloud computing technology in the industrial field and belongs to the Platform-as-a-Service PaaS. It connects down to field devices and up to MindApp, a variety of applications. MindSphere is a secure, scalable industrial end-to-end solution that connects assets to an operable industrial Internet platform for increasing productivity and efficiency across the entire business. GE has launched the basic system platform PREDIX for the entire industrial field, which is applied in various fields such as industrial manufacturing, energy and medical treatment. The edge connection layer is mainly responsible for collecting data and transmitting it to the cloud. The platform layer provides a globally secure cloud infrastructure that meets the needs of daily industrial workloads and oversight. The application service layer is mainly responsible for providing industrial micro-services and the framework of various service interactions. It mainly provides the environment for creating, testing and running industrial Internet programs and the micro-service market.

3. Current situation of energy big data management platform
The Ministry of Industry and Information Technology, the State-owned Assets Supervision and Administration of the People's Republic of China, and the National Energy Administration are jointly promoting the construction of the energy industry Internet platform (National Energy Intelligent Information Platform), creating the application model of the industrial Internet in the energy field, forming replicable and popularizing experience, so as to promote the landing application of the industrial Internet in the energy industry. For example, Sunlight Power, a leading enterprise in the photovoltaic inverter industry, has released IsolarCloud, its fourth-generation photovoltaic power station operation and maintenance management system, and built a photovoltaic cloud platform together with Ali Cloud. In 2018, TBEA's intelligent TB-eCloud energy management platform was selected into the industrial Internet platform integrated innovative application pilot demonstration project of the Ministry of Industry and Information Technology. Platform on the photovoltaic power station, the huge amounts of data real-time acquisition and efficient transmission in all directions,
precise, intelligent processing, multidimensional exhibition, providing asset management, production management, fault prognosis, physical examination rate, knowledge base, the remote expert diagnosis, and other functions, to steady increase power station earnings, asset security, standardized management, supporting group decisions, The operation and maintenance management of the whole ecological chain and the whole life cycle of the photovoltaic power station can be realized efficiently, intelligently and conveniently.

In recent years, the state and various provinces and cities have successively issued policies to encourage the development of distributed photovoltaic projects and other new energy. The photovoltaic industry has made great progress, the cost of photovoltaic equipment has decreased year by year, and the photovoltaic construction technology has become more mature. Considering the geographical factors, the central and eastern regions of China have developed economy and a considerable number of industrial parks, so photovoltaic projects in industrial parks have a great space for development.

4. Intelligent energy management platform for industrial parks

The intelligent energy management platform of the industrial park follows the national standard of the integration system of industrialization and industrialization, adopts the concept of low-carbon energy saving, green manufacturing and the construction of "Internet +" technology. Aiming at key energy-consuming enterprises, the intelligent energy management platform realizes the integration of energy flow, information flow and business flow with energy flow as the entry point. At the same time, the power, steam, water, natural gas and other energy resources of the enterprise are collected, analyzed and managed in real time, and the energy efficiency indicators of the enterprise, workshop and assembly line are assessed online according to the requirements of the national energy management system GBT23331 and the international energy standard ISO50001, as well as the in-depth management of key energy-using equipment. Through data analysis, horizontal and vertical comparison and analysis, the system can find out the improvement points of energy saving, provide a basis for enterprise energy saving management, help enterprises to achieve fine production management, help enterprises to save energy and reduce consumption, and enhance the competitiveness of the industry. The system can also be integrated with the original system of the enterprise display, such as the enterprise's ERP system, production management system, environmental monitoring management system, etc. Through real-time energy use monitoring and data analysis with the original relevant systems of the enterprise, the system can help enterprises to complete horizontal and vertical data analysis of products, assembly lines and workshops, and help enterprises to better scientific management through energy consumption data per unit product.

4.1. The overall architecture

Intelligent energy management platform and landing process, the overall architecture design should fully consider the platform of economic and social benefits, consider the price performance ratio and input-output ratio and so on many factors, in the process of planning, design, design should be highly reliable products and technologies and leading and advanced consciousness, and adopt scientific method system planning, design. The overall architecture of the smart energy management platform is as follows:
The overall architecture design of smart energy management platform can be divided into: access layer, cloud computing layer, application service layer and user layer.

1. Access layer: access to power grid operation data and social enterprise data.
2. Cloud computing layer: storage and computing processing of massive data.
3. Application service layer: realize smart energy network planning and design, and evaluation business application services, including data collection, data integration, task management, computing integration, interactive display.
4. User layer: serve power grid enterprises for distribution network planning, design and planning evaluation; It serves the government, energy consumption enterprises, energy suppliers, energy investors and electricity users, and meets the business needs of power grid planning, design and review of various parties.

4.2. The technical architecture

Figure 1 Overall architecture of smart energy management platform

Figure 2 The technical architecture
(1) Data integration technology

Data integration is the primary stage of data fusion and the basic problem to be solved in this stage is the problem of big data collection. There is a large amount of electrical data and non-electrical data in the intelligent energy management platform, and the structure is often irregular and dynamic. The method of data extraction based on extended regular expression can be used to build wrappers for various data sources and provide the basis for data integration. Aiming at the problems of system heterogeneity, syntax heterogeneity and semantic heterogeneity in big data, a heterogeneous data integration method based on XML and ontology is adopted. For system and syntax heterogeneity problems, the advantage of middleware is used to package the underlying data to form a unified interface, so as to achieve the purpose of user consistent operation. For the problem of semantic heterogeneity, it is necessary to use ontology technology to build the corresponding semantic model, so as to form a basic method to normalize the different expressions of the same concept.

(2) Data storage technology

According to the different structural characteristics of smart energy management platform data, different types of database management systems are used to effectively organize and manage the data. The parallel relational database based on MPP architecture is used to manage large-scale structured data. The data collected by various sensors (such as time series data such as electricity consumption) can be managed by a key-value stored NoSQL database to adapt to the typical "write once, read many times" WORM access mode. According to the data heat, value density and access mode characteristics, based on the storage strategy of "logical pooling", a hybrid distributed data storage and management technology scheme is proposed. In terms of data storage strategy, high-performance storage pool is adopted for core operation data and key data, in which NVM with higher performance can be selected for data caching and acceleration. High bandwidth storage pool is used for data that needs batch analysis and processing. Low-cost storage pools are used for data with low value density but need to be stored for a long time.

(3) Data mining technology

Big data mining has put forward many basic and general analysis methods, including classification, clustering, outlier, prediction, evolution, correlation, regression, decision tree, neural network, support vector machine, principal component analysis, hypothesis testing and so on. But for intelligent energy management platform big data situation in terms of perception and knowledge discovery, and the basis of existing general large data mining analysis method is not applicable, must be fully considered, depth combined with intelligent energy management platform big data in the data structure, data cycle, the characteristics of time and space characteristics, in view of the diversity of intelligent energy management platform big data application scenarios, The applicability and advantages and disadvantages of various algorithms were evaluated, and the boundary conditions and control parameters of various algorithms were optimized accordingly. The state awareness algorithm and knowledge discovery model suitable for the big data business application of smart energy management platform were proposed.

(4) Data visualization technology

For a wide variety of data types, to carry out the flow data visualization, text, data visualization, superposition of spatio-temporal data display and so on big data visualization technology research, and combined with the characteristics of regional data, considering its presentation, display technology and standard, USES the mature suite and custom development way of the combination of the above technical ability cure for technical components, adaptive distributed database, To meet the needs of massive multi-source heterogeneous big data fusion and rapid display.

Provide comprehensive, interactive, multi-dimensional and dynamic display for the data results formed after the analysis; Adopt the mainstream technology of big data visualization, including text visualization, network graph visualization, spatiotemporal data visualization, multidimensional data visualization and other forms, and support visual analysis of human-computer interaction, such as task model, interaction model, user interface model, etc. The rich client is used for PC display, and the mobile terminal supports different terminals of Android, IOS and tablet computers. It can integrate
with big data analysis tools and present the analysis results of big data analysis tools as data sources. With a wealth of graphical display technology, support pie chart, histogram, matrix diagram and causality diagram and other forms; Support 2D, 3D graphic display, support but not limited to static analysis diagram, interactive dynamic analysis diagram and text summary; It can achieve seamless integration with the existing database platform of the enterprise, and supports a variety of database interfaces, including MYSQL, Oracle, SQLSERVER, etc., and can directly query data from the database.

4.3. Application architecture
Intelligent energy management platform construction, can grasp the operation of the regional energy supply side, the energy of statistical analysis, statistical analysis mainly includes energy flow, total energy, and information such as monitoring and statistical analysis of all kinds of energy, including the large data analysis technology combined with expert assessment, operational diagnosis on the basis of the transmission parameter acquisition, The platform monitors the energy saving services on the demand side, obtains the trend and composition chart of the energy consumption (such as gas, water, electricity, etc.) of the equipment of the enterprise, compares the operating conditions in different periods, and obtains the year-on-year and sequential analysis. On this basis, according to the energy consumption index calculation model of the platform, the fluctuation of the platform and its floating relationship with the reference standard value are statistically analyzed to control the energy consumption cost of the equipment and optimize the energy consumption of the energy equipment.

Intelligent energy management platform realizes energy predictive service and energy scheduling and balance. According to the historical energy consumption information, provide the energy prediction analysis of the energy consumption unit in different regions, different industries and different energy types; And according to the analysis of energy monitoring data, overall planning of regional energy, to achieve the optimal allocation of all kinds of energy and energy scheduling in the whole region.

4.4. Business architecture
Through the analysis of wisdom energy business scenarios, and according to the regional energy supply and consumption present situation, combining with the development trend of energy utilization at home and abroad, regional wisdom energy management advanced experience at home and abroad for reference, and set up platform function architecture, building integrated intelligent energy management platform in the region and implement and develop e-government, online customer service channels, It is convenient for users to develop intelligent energy management services.

5. Conclusion
The essence of energy Internet is the efficient and comprehensive utilization of energy. The energy metering collection of large particles in the Industrial Park factories goes deep into the process flow for fine-grained energy metering collection, so as to realize the data sharing of industrial energy consumption, build the intelligent energy management platform of the industrial park, open up the data island among industries, and support the sharing of industrial manufacturing and energy data and the development of new energy supply Macro control to achieve energy saving and efficiency of industrial park.

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References
[1] N. Saxena, A. Roy and H. Kim, (2017) Efficient 5G Small Cell Planning With eMBMS for Optimal Demand Response in Smart Grids, in IEEE Transactions on Industrial Informatics, vol. 13, no.
3, pp. 1471-1481.

[2] H. T. Ansari, S. PremKumar and V. Saminadan, (2016) Heterogeneous network modeling for smart grid technology, 2016 International Conference on Communication and Signal Processing (ICCSP), pp. 2336-2339.

[3] H. Chou, (2018) A Heterogeneous Wireless Network Selection Algorithm for Smart Distribution Grid Based on Chi-square Distance, 2018 10th International Conference on Communications, Circuits and Systems (ICCCAS), pp. 325-330.

[4] Q. Wang, F. Zhao and T. Chen, (2018) A Base Station DTX Scheme for OFDMA Cellular Networks Powered by the Smart Grid, in IEEE Access, vol. 6, pp. 63442-63451.

[4] F. Knirsch, D. Engel, M. Frincu and V. Prasanna, (2015) Model-based assessment for balancing privacy requirements and operational capabilities in the smart grid, 2015 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT), pp. 1-5.