Integrated Energy Service Platform Under the Umbrella of Ubiquitous Power Internet of Things

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Abstract. Integrated energy service is the trend and direction for grid companies to participate in the energy market competition and seek their own transformation. The construction and improvement of Ubiquitous power Internet of things is the basis for grid enterprises to gain advantages in the competition of integrated energy services. In the past, the literature usually focused on technical explanations and application scenarios. This paper first constructed a comprehensive Ubiquitous power Internet of Things ecosystem and further explored the role of the integrated energy service platform.

1. Introduction
Beginning in 2014, a new round of power system reform was launched. The contents of the "Opinions of the Central Committee of the Communist Party of China and the State Council on Further Deepening the Reform of the Power System" pointed out that the revenue model of power grid enterprises has changed from the sale price difference to the permitted cost plus reasonable income; the regulatory agencies have also strengthened the supervision of transmission and distribution costs; In addition, the power transaction reform has led to multi-party direct transactions, cross-provincial cross-regional transactions compliance and popularization, so the profit margin of grid companies will be compressed. After the sales side is opened, more and more entities will join the power market.

At present, China is in a critical period of energy transformation, and the problems of high energy costs are very serious. Comprehensive energy services can effectively improve energy efficiency, reduce investment and operation costs, help promote energy supply side reform, and promote and enhance the international competitiveness of energy-related industries. In China, manufacturing accounts for 55% of energy consumption, and energy costs are the largest cost after labor and raw materials. The traditional energy supply system is relatively independent. Energy suppliers such as power companies, heat companies, and gas companies are fighting each other. There is a lack of unified coordination and optimization in planning, construction, and operation. The adoption of integrated energy services will undoubtedly shorten the energy chain and reduce the use. Energy and service costs. Especially in the context of the current US shale gas revolution, which has brought about a significant drop in energy costs, the introduction of a positive tax reform policy, and the promotion of a large number of manufacturing returns, promoting the development of integrated energy services and reducing the energy consumption of large energy-using enterprises such as manufacturing. Cost and improving the international competitiveness of enterprises have important social significance. Integrated energy services have two meanings: first, comprehensive energy; second, comprehensive services, including operations, investment, engineering and other services.

The development path of integrated energy services can be divided into two modes: one is the industrial chain extension mode, represented by the development models of Huadian, GCL, and Xinao,
among which GCL is dominated by combined heat and power (CHP) and photovoltaic. At the same
time, to the development of smart energy, Xinao is dominated by gas, and at the same time it is
distributed to gas deep processing (cold, heat, electricity supply); the other is electricity sales +
integrated service mode, compared to the first mode, the requirements of this model for the industrial
base are relatively low, which is the development model of the power grid enterprises in the future.

The mission of the Ubiquitous power Internet of Things is to break down the barriers that hinder
the formation of an open shared energy ecosystem. For example, barriers between different energy
sources such as cold, heat, gas, and electricity need to be broken through the construction of an
integrated energy system. One of the keys. State Grid Co., Ltd. released on January 13, 2019, in the
"No. 1 Document" of 2019, ranked "the Ubiquitous power Internet of Things with comprehensive state
perception, efficient information processing, and convenient and flexible application" ranked first in
the annual key work. At this point, the “Ubiquitous power Internet of Things” is regarded as the
“second network” that is integrated with the power grid. It has become the focus of the company's
comparison with the “strong smart grid”, which will integrate IoT technology and big data technology.
New technologies such as artificial intelligence technology and deep penetration and integration with
the new generation of power energy systems to realize the maximum real-time online interconnection
of people and things involved in energy and power production and consumption, and then become
fully loaded. It also penetrates the next-generation information communication system of power grid
production and operation, enterprise management and external customer service. As an infrastructure
that effectively supports the efficient, economic and safe operation of China's energy internet, the
Ubiquitous power Internet of Things has become a strategic emerging research and industrial
development direction in the field of power and energy.

Compared with newly entered market players and energy suppliers, grid companies have the
following advantages. The first is closer contact with upstream energy suppliers and downstream user
groups. Although the direct transaction can be realized after the sales side is opened, the cost of
establishing such a transaction relationship is high, and the two parties will pay a high cost in the
process of seeking cooperation. Secondly, the transportation infrastructure is complete and the
coverage area is wide. To provide better distribution services for both parties; finally, the information
advantage, the grid enterprises have accumulated a large number of information on energy suppliers
and user groups, can formulate more reasonable strategies according to the needs of both parties,
provide better services, and save more Cost, achieving a win-win situation.

In the future, the development model of power grid enterprises should be transformed into
integrated services. Therefore, this paper takes power grid enterprises as the core and points out its
role in participating in the comprehensive energy service market competition and the Ubiquitous
power Internet of Things construction, so as to find a new development path.

2. Literature review

2.1 Ubiquitous power internet

Wang Yi et al. (2019) focused on the research framework of Ubiquitous power Internet of things in the
era of 5G communication, deeply analyzed the connotation of Ubiquitous power Internet of things,
introduced the development and characteristics of 5G communication, and analyzed 5G
communication and pan on this basis[1]. The relationship between the power Internet of Things,
explore the potential applications of 5G communication in the Ubiquitous power Internet of Things,
and analyze some key technologies of 5G communication, these key technologies will play an
important role in power services; in addition, the Ubiquitous power is also studied. The energy
efficiency management problem of 5G communication network in the Internet of Things; Finally, the
key research on the Ubiquitous power Internet of Things in the era of 5G communication is prospected.

Li Xiangzhen et al. (2019) expounded the basic concepts, characteristics and four-layer architecture
of the Ubiquitous power Internet of Things, and then analyzed the key technologies of the Ubiquitous
power Internet of Things, and analyzed and summarized the difficulties that may be encountered[2].
Finally, the actual needs and application prospects of the Ubiquitous power Internet of Things are studied.

Fu Xinxin et al. (2019) explained and analyzed some key technologies involved in the construction of Ubiquitous power Internet of things, including perception, communication, power management, big data, computing, security, etc., and combined the research results of Internet of Things in recent years[3]. In order to solve these key technologies, some suggestions and references are put forward, and technological innovation is necessary to solve these key technologies.

Liu Jianming (2018) studied the research and application of the Internet of Things technology in power transmission and distribution systems. Through in-depth analysis of the application scenarios of wireless sensor networks in the smart grid, the company has established an international leading level for smart grid transmission and transformation. The sensor network application system of power distribution, power consumption and other major links, and proposed key technical issues such as IoT application sensing layer, network layer, application layer and information security to meet the characteristics of power application[4]. The demonstration project verified the power Internet of Things. The effect of applications in the power grid industry.

Zeng Ming (2019) proposed the main characteristics and architecture of the Ubiquitous power Internet of Things from the basic concept of the Ubiquitous power Internet of Things, and then elaborated the synergistic development relationship between the Ubiquitous power Internet of Things and the strong smart grid and energy Internet. On the basis of the functional design and construction timing, the Ubiquitous power Internet of Things implementation proposal for the multi-dimensional business scenarios such as transmission, substation, distribution, electricity, and operation management is proposed[5]. In order to solve the problem of the acquisition and application of massive data of energy Internet by using Internet of Things technology, the three streams of energy flow, business flow and data flow are realized.

2.2 Integrated energy service

The integrated energy system is the next generation of intelligent energy system. The source, network and load of multiple energy sources are deeply integrated and closely interacted. It is necessary to use systematic, integrated and refined methods to analyze, design, operate and manage the entire energy system. Energy production, transmission, storage and use, thereby greatly improving the sustainability, safety and reliability of energy systems and reducing energy prices[6].

The main problem facing integrated energy system research is how to understand, quantify and optimize the integration and interaction of multiple energy flows. The integrated energy system has the following characteristics. 1. The advantages of different energy systems can be complemented in system planning and operation. For example, the current large-scale power storage technology is still immature and expensive, but the heat storage and gas storage technologies are mature and cost-effective, and the complementary advantages of the systems can be more exploited through the integrated energy system. 2. Facilitate large-scale access and efficient use of renewable distributed energy. For example, when a renewable energy power generation access power system encounters a system operation constraint problem, the excess electric energy can be converted into hydrogen gas and then injected into the natural gas pipe-grid network (the natural gas pipe-grid network is widely covered in Europe). Maximize the use of renewable resources. 3. Provide physical support for efficient and flexible energy trading. Integrated energy systems can provide a robust, flexible, and integrated interconnected physical system that enables more efficient and flexible energy trading (such as end-to-end transactions) to fully exploit distributed energy (power generation, energy storage, and flexible loads)’ flexibility and value[7].

Bi Wei et al. (2018) believe that the comprehensive energy service needs to reach three goals in turn, firstly to save energy and improve utilization rate; secondly, to provide customers with high-quality services, increase customer viscosity, and continuously develop customer groups; The scope of business is to obtain new profit growth points[8].

China Southern Power Grid Co., Ltd. actively responded to the electricity reform and built the
first “Internet + Smart Energy Integrated Demonstration Community” in Guangzhou, designing an integrated energy service system for users, mainly including four-in-one, centralized meter reading, smart home, charging facilities, etc. The integration of energy and information has been realized, providing users with efficient and convenient power supply services [9].

3. Ubiquitous power internet and ecological vision

3.1 Definition of Ubiquitous power internet
Ubiquitous power internet refers to the interconnection and interaction of information between any time, any place, anyone, or anything. The Ubiquitous power Internet of Things refers to the interconnection and interaction of power users and their equipment, power grid enterprises and their equipment, power generation enterprises and their equipment, suppliers and their equipment, as well as people and things.

3.2 The characteristics of Ubiquitous power Internet of Things
The Ubiquitous power Internet of Things is the application of the Internet of Things technology in the power system. Its essence is to realize the sharing of various information sensing devices and communication information resources, thus forming a physical entity with self-identification, perception and intelligent processing. The synergy and interaction between entities enables the mutual sensing and feedback control of related objects to form a more intelligent power production and living system. The characteristics of the Ubiquitous power Internet of Things are based on the existing power grid entities and communication technologies. The physical interconnection of different energy systems, the interconnection of time and space information, and the commercial interconnection are combined. It has holographic perception, Ubiquitous connectivity, open sharing, and fusion innovation. Characteristics. Holographic perception refers to the dynamic acquisition of status information of different devices and different users in each link of “transmitting – transmitting – changing – using” RFID, sensors, etc. Ubiquitous connection refers to the connection of all devices and users’ information and data in the power system to the entire time and space through a power private network or a mobile network. Open sharing refers to the use of intelligent technology to share and manage data on a unified platform, improve data quality, mine effective information, achieve data access, and comprehensive real-time interaction. Convergence innovation means that through different devices, users, different time and space information, the whole business is realized online, and the power grid is safe and stable. A smart integrated energy service platform will be built to open up the power market and promote power reform.

3.3 Ubiquitous power internet construction goals
Taking advantage of the Ubiquitous IoT big data is the main goal of its construction. The sources of power data vary, including different types of time and space, such as control, measurement, and monitoring, to achieve massive data. Unified analysis and in-depth mining are its primary construction goals. Different power data service objects, breaking data barriers and achieving different business penetration are the second phase of construction goals. Ultimately, applying power data to all walks of life and promoting business models that are widely involved in different industries is its ultimate goal. It can be foreseen that with the realization of Ubiquitous power Internet of Things, data knowledge mining technologies such as big data and artificial intelligence technologies represented by machine learning and deep learning will be widely applied and developed.

3.4 After the completion of the Ubiquitous power Internet of Things ecological layout plan
When considering the overall ecological layout of the Ubiquitous power Internet of Things, it is necessary to consider not only the three main themes, but also to include other possible entities in the Ubiquitous ecosystem of the Internet of Things, to promote multi-party cooperation, and to make the overall supply chain more perfect. The integrated energy service platform can provide better and more
complete services for all entities, and can also reduce costs, improve efficiency, and achieve win-win results. Schematic diagram is shown in Figure. 1

Figure 1. Ubiquitous power Internet of Things ecological layout plan

Energy supplier. There are raw material suppliers, equipment suppliers and other entities around the energy supplier. The integrated energy service platform can help multiple parties make decisions by collecting and analyzing data from multiple parties, including pricing, trading, and transportation.

Power grid enterprise. There are entities such as infrastructure parties, sellers and technical partners around the grid companies. The integrated energy service platform can promote cooperation between the two parties and simplify the cooperation process, including the bidding process and outsourcing cooperation.

Users. Users can be subdivided into residential, industrial and commercial users. The integrated energy service platform can provide corresponding services for different users according to the quantity and time of electricity consumption of different users, including power transactions and differential electricity prices.

4. Integrated energy service platform

4.1 Integrated energy service concept
The integrated energy system is the next generation of intelligent energy system. The source, network and load of multiple energy sources are deeply integrated and closely interacted. It is necessary to use systematic, integrated and refined methods to analyze, design, operate and manage the entire energy system. Energy production, transmission, storage and use greatly increase the sustainability, safety and reliability of energy systems and reduce energy prices.

4.2 Characteristics of integrated energy services
In the system planning and operation, the advantages of different energy systems can be complemented. For example, the current large-scale power storage technology is still immature and expensive, but the heat storage and gas storage technologies are mature and cost-effective, and the complementary advantages of the systems can be more exploited through the integrated energy system.

Facilitate large-scale access and efficient use of renewable distributed energy. For example, when a renewable energy power generation access power system encounters a system operation constraint problem, the excess electric energy can be converted into hydrogen gas and then injected into the natural gas pipe-grid network (the natural gas pipe-grid network is widely covered in Europe), so that the natural gas pipe-grid network is widely covered in Europe. Maximize the use of renewable resources.

Provide physical support for efficient and flexible energy trading. Integrated energy systems can
provide a robust, flexible, and integrated interconnected physical system that enables more efficient and flexible energy trading (such as end-to-end transactions) to fully exploit distributed energy (power generation, energy storage, and flexible loads)’ flexibility and value.

Enhance the system’s safety and reliability and ability to cope with unexpected situations, and achieve a lower cost independent supply of energy. The integrated energy system can provide energy island operations, and maintain normal energy supply when there is no external energy supply or external supply disruption. This kind of energy island is of great significance for powering remote areas and alleviating the energy supply crisis in big cities.

Improve energy efficiency and reduce energy costs. Coordinated control between multiple energy systems can greatly increase the flexibility of the system, allowing system components to operate in a technically and economically optimized state, resulting in increased energy efficiency and reduced costs.

Strongly coupled multi-energy systems may increase the risk of system cascade accidents, such as failures in the power system that may result in interruptions in gas supply and heating. Therefore, it is necessary to study and formulate effective countermeasures.

### 4.3 The goal of integrated energy services

The main objectives of integrated energy services are as follows: firstly, energy saving and efficiency reduction, and lowering energy supply costs; secondly, increasing customer stickiness, providing customers with better and more comprehensive services, consolidating and expanding user groups; Fourth, expanding business scope and driving Industrial development, cultivating new market formats and gaining new profit growth.

### 4.4 The features of integrated energy service platform

As shown in Figure 2, The integrated energy service platform is a system that provides energy services. The service aims to provide energy to users and improve energy efficiency. Clients include energy suppliers, energy consumers, and energy delivery units. Energy suppliers include primary energy suppliers such as oil, coal, and natural gas; renewable energy and secondary energy suppliers such as wind power, biomass power plants, and solar photovoltaic power plants. Energy users include residents, industry, and businesses. Energy transmission units include thermal transportation, natural gas transportation, power transmission and other related enterprises. Technical requirements include a synergistic mechanism on the energy side. The coordination of the energy supply side ensures the stable supply of natural gas, petroleum, coal, heat, electricity, wind power, photovoltaic power generation and other electricity. Use energy-side coordination to provide balanced power for industrial users, residential users, and enterprise users.

![Figure 2. Comprehensive energy service platform construction map](image)

### 4.5 Technical Support

**Cloud Computing Technology (CCT):** CCT provides high-speed massive computing support for
IES platforms. Combined with edge computing, CCT enables IES to provide timely and comprehensive services to all members of the energy Internet ecosystem. Based on CCT, Energy Internet has strong interoperability and can meet the trading needs of generators (including distributed power and micro-grid operators), network operators, users, and power sales companies at any time and any place. CCT can also provide technical support for various business models of ecological members, such as B2B, B2C, C2C, etc.

**Big data analysis technology**: access to new load data such as pipe network security monitoring, economic operation, energy trading and user energy metering, gas metering and distributed power supply, electric vehicle, etc., the amount of data will be more than the amount of smart energy meter data Much bigger. Big data analytics technology captures, manages, and processes these vast amounts of data, including structured and unstructured data, and supports integrated energy service platforms to provide personalized, accurate, timely, and full-service services to energy Internet ecosystem members. From the perspective of big data processing, big data key technologies include: big data collection, big data preprocessing, big data storage and management, big data analysis, big data presentation and application big data retrieval, big data visualization, big data application. Big data security, etc.

**5G technology.** The fifth-generation mobile communication (5G communication) technology has developed rapidly, and various technologies and constructions including standard setting and base station construction have been greatly developed. China is expected to achieve commercial scale in 2020. Compared with 4G/3G/2G communication, 5G communication has a big leap in bandwidth and delay. 5G communication attempts to use the communication network to achieve the Internet of Everything, is expected to become the core technology for the realization and construction of the Internet of Things. From the perspective of the Internet of Everything, the power grid and the 5G communication network have their commonalities. The former provides power supply and the latter meets communication needs.

Artificial intelligence technology. NGAI technology, which is mainly represented by advanced machine learning theory, big data, and cloud computing, has strong optimization processing ability and powerful learning ability to cope with high-dimensional, time-varying, and nonlinear problems. Distributed high-frequency access, such as distributed energy storage, electric vehicles and other new energy sources, provide complex solutions for complex nonlinearities, uncertainties, and time-space differences. Artificial intelligence gives the "brains" that power equipment thinks, so that it can calculate and fuse the perceived information and then report the corresponding conclusions to the user.

**IntelliSense technology.** IntelliSense technology includes technologies such as data sensing, acquisition, transmission, processing, and service. The intelligent sensor acquires the operational status parameters of the transmission and distribution network, the electrified transportation network, the information communication network, the natural gas network operation status data, the user-side various types of networked energy-using equipment, the distributed power supply and the micro-grid, and the sensor data is processed and aggregated.

**Demand response technology.** Demand response refers to the user's response to electricity prices or other incentives to change the way electricity is used. By implementing the demand response, it is possible to reduce the load demand in a short period of time, and also to adjust the load in a certain period of time to achieve peak shifting. In addition to the corresponding technical support, this technology also needs to formulate corresponding electricity price policies and market mechanisms.

### 4.6 Integrated energy service platform and application layer

The functions of the IES platform: data statistics, data analysis, and integrated management

- Application layer basic business: status monitoring, operation and maintenance, smart meter, power trading, customer service, etc.

- Application layer expansion services: After meeting the basic power service functions, the IES platform can also consider providing other services to customers.

- Financial services: Provide financial products and services to optimize customer cash flow.
One-stop service: Provide one-stop professional electricity service for distribution network design, investment, construction and operation.

5. Future thinking
The IES platform described above is limited to grid companies and their supply chains. However, the IES market is not just a grid enterprise. Therefore, the future IES platform can be considered as other participation in the IES market. Provide services. For grid companies, their customer resources, information resources and infrastructure hospitals are the primary goals in building a Ubiquitous power Internet of Things and maintaining their core strengths in the grid market, and in this market, they are also unique. Advantages, but this advantage may not be obvious when participating in the competition in the IES market. Therefore, when participating in the competition of the IES market, on the one hand, consider participating in the competition at the business level, on the other hand, you can also consider participating in the competition at the service level. This is because, while providing services to other entities, it is able to understand the dynamics and intentions of other competitors, and also adjust its own strategy and planning, and itself can also serve as a new profit growth point for power grid companies. The development has brought considerable benefits.

This paper believes that grid companies must actively change their mindset when participating in the comprehensive energy service market competition, that is, from sellers to service providers, not only provide quality services to upstream suppliers and downstream customers, but also provide services to competitors in other fields. This is not only a requirement for exploring new development paths, but also the general trend of the future IES market.

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