Assessment and Analysis of the Global Development of Integrated Energy

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Abstract. With the acceleration of the transformation of global energy structure, in order to meet the demand for safer, more efficient and cleaner energy in the new era of our country, it is imperative to build a modern energy transformation and system, and integrated energy services gradually play an increasingly important role in the supply side and consumption side. Integrated energy service is a kind of energy supply and service mode to meet the diversified energy production and consumption of end customers. It focuses on the planning, design, construction, operation and service of cold, hot, electric, gas and other systems in three aspects of energy supply, energy use and service, deeply integrates the Internet of things, big data, artificial intelligence and other technologies with energy to form a dynamic level of source, network, load and storage Balanced integrated energy supply and service integration of modern energy system. Based on the analysis of the current situation of foreign and domestic integrated energy, this paper puts forward suggestions and prospects for the development of integrated energy services.

Keywords: Integrated Energy; Energy Transition; Energy Service.

1. Introduction

Modern energy transformation and energy system construction is necessary to satisfy the demand for safer, more efficient and cleaner energy. Integratedly promote the change of energy consumption mode, and build a diversified and clean energy supply system. Integrated energy generally has the ways of multi energy complementation, high efficiency and flexibility, integrated services, etc., to realize planning and design, engineering construction, energy supply, technical services, operation management and terminal services, and deeply integrated information technology and Internet of things technology with each link of energy, forming a modern energy system with dynamic balance of power generation, transmission, distribution and storage. Thus, integrated energy system plays an important role in the modern energy system.
2. Domestic integrated energy development

2.1. Energy Transition
China integratedly promotes the reform of energy consumption mode, constructs a diversified and clean energy supply system, strives to reach the peak of carbon dioxide emissions by 2030, and strives to achieve carbon neutrality by 2060. The main policies and major measures to promote the energy transition include [1]:

1. Promote the revolution of energy consumption, strengthen the control of energy consumption intensity, and cultivate the production and life style of saving energy and using green energy.
2. Promote the revolution of energy supply, adhere to the guidance of green development, establish a diversified supply system, and constantly improve the quality and security of energy supply.
3. Promote the energy technology revolution, focus on promoting the integration and innovation of digital, big data, artificial intelligence technology and energy clean and efficient development and utilization technology, and drive the industrial upgrading.
4. Build a diversified and clean energy supply system, give priority to the development of non-fossil energy, promote the clean and efficient development and utilization of fossil energy, improve the energy storage and transportation peak shaving system, and promote the complementary and coordinated development of regional multi-energy [1].

2.2. Integrated energy development of large domestic energy enterprises
As shown in Table 1, State Grid, China Southern Power Grid, Huadian Group, local energy suppliers and private energy companies, they are constantly exploring the development and service mode of intergrated energy. The project of Pan power IOT which proposed by the State Grid will continue to build energy Internet plus eco-system system of energy technology and intelligence, and create a new integrated energy service industry. In June 2019, State Grid, China Southern Power Grid, Huaneng Group, Huadian Group and other 21 energy suppliers have established "China integrated energy service industry innovation and development alliance", aiming to integrate resources in relevant fields and jointly build an energy service ecosystem. Major domestic energy enterprises are actively carrying out integrated energy service business, and actively exploring energy development mode in line with national and market demand.
Table 1. Development of integrated energy services of major domestic energy groups[1. Social responsibility report of State Grid, China Southern Power Grid, Huadian Group and PetroChina in 2019; 2. Official websites of Jingneng group, Sichuan energy investment group and Xinao group.]

| Types of enterprises | Enterprise name | Integrated energy development strategy | Main business | Integrated energy development |
|----------------------|-----------------|---------------------------------------|---------------|-------------------------------|
| Power grid enterprises | State Grid | February 2019 “action plan of State Grid Corporation of China on promoting the development of integrated energy services business from 2019 to 2020” | Four key business areas are integrated energy efficiency services, multi energy services for cooling and heating, distributed clean energy services and exclusive electric vehicle services | Actively carry out energy and energy efficiency research, participate in the formulation and revision of relevant standards; promote the construction of 11 pilot projects of energy use control system in 7 provinces, and carry out the pilot verification of business model in demand response and customer side energy storage, covering nearly 6000 users. |
| Power generation group | Huadian Group | Notice on clarifying matters related to the development of integrated energy services of the company in 2019 | Integrated energy services, market-oriented electricity sales, smart grid value-added services; engineering construction, high-end equipment manufacturing, science and technology information services; integrated power services | Promote the transformation of energy ecosystem service providers, provide integrated energy-saving transformation services for customers, save 3.096 billion kWh of electricity on the demand side in 2019, and build 788 new charging stations. |
| Petroleum Enterprises | PetroChina | In May 2019, Huadian Group released the integrated energy service business action plan of China Huadian Group Co., Ltd | Multi energy cogeneration, smart and efficient integrated energy service business with Huadian characteristics, carry out research and development and promotion of 25 technologies, and 20 demonstration projects | By the end of 2019, the company has put into operation 18 natural gas distributed energy projects with a total installed capacity of 2.33 million kilowatts, continuing to maintain the leading edge in the industry. |
| Local energy group | Beijing Energy Group | Actively layout energy transformation, and natural gas and LNG business lead green and low-carbon development. | Large scale development of geothermal resources, research and application support of biomass energy, research and layout of all hydrogen industry chain, and promote the development and utilization of clean energy | We will develop geothermal resources in North China, Liaohe, Xinjiang, Kenya, etc., join hands with haipel hydrogen energy technology to build hydrogenation and gas stations, use solar energy to power gas stations in Beijing, and continue to explore and develop biofuel technology. |
| Private enterprise | ENN Group | Beijing Energy Group | Build into a world-class capital integrated energy service group | Research and development and application of key technologies such as intelligent microgrid, multi energy complementary, energy demand side management; energy saving of large capacity power storage, heat storage and cold storage; energy saving transformation of power plant, ultra-low emission; hydrogen production and storage, hydrogenation and other technologies | In April 2019, Jingneng power set up a integrated energy service branch to participate in the investment in the four thermal power centers in Beijing, Changing future science and technology city and the regional energy center in the northern New District of Haidian. In August 2020, the integrated energy project of Yanqing competition area of Winter Olympic Games will be launched. |
| | Zhejiang Energy Group | Strive to build a first-class domestic and internationally competitive integrated energy service provider | A new pattern of energy industry based on the three major industries of "electric power, oil and gas, and energy services" | Promote the implementation of five demonstration projects of integrated energy industry, hydrogen energy, energy storage, smart power plant and biomass circular economy. |
| | | The pan energy network is committed to building an ecosystem of all parties in the energy industry, providing value services for energy consuming enterprises and wisdom support for ecological participants | Around the energy scenarios and needs of energy consuming enterprises, energy suppliers, park governments, integrated energy operators and other main bodies, we provide "integrated energy trading services". | Build a pan energy network platform, focus on energy consuming enterprises, and use data intelligence to promote the substantial improvement of energy efficiency. We will manage 600 million kWh/a of electricity consumption, have more than 500 energy consuming enterprises, and serve industrial parks in more than 20 cities. |
3. Analysis of international integrated energy development

3.1. International integrated energy development

In order to meet the needs of users and market at that time, some developed countries have started to carry out integrated energy related business. In 1909, Germany started to supply natural gas and electricity. In 2000, the United States began to develop integrated energy services. In 2009, Japan began to study integrated energy services. Foreign integrated energy mainly has the following characteristics:

(1) More in line with the needs of the user side. According to the actual needs and resources of end users, as well as the external boundary conditions, the reasonable choice of energy types.

(2) Integrated utilization of energy. To provide users with a wealth of energy, such as heating, cooling, gas supply and energy-saving diagnosis and other integrated energy products.

(3) Diversified energy services. According to the actual demand, provide equipment diagnosis and analysis, system energy saving and management, equipment hosting and other energy services, flexible energy supply and service changes are to meet the needs of new technology, new demand and new business development.

Flexible policies and systems. The development of integrated energy is encouraged by the policies of government electricity price, preferential loan, tax rate reduction and special electricity price which can be seen in Table 2.

Table 2. Some foreign integrated energy policies and systems.

| country       | USA | Japan | Germany | Denmark |
|---------------|-----|-------|---------|---------|
| Green pricing |     |       | √       |         |
| Special subsidy | √  | √     |         |         |
| Mandatory quota |   |       | √       | √       |
| Production tax reduction | √  | √     |       |         |
| Investment tax reduction | √  | √     |       |         |
| Emission subsidy |   |       | √       |         |
| Preferential loan |   | √     | √       | √       |
| Independent fixed price | √  | √     | √       | √       |

3.2. Integrated energy development in typical countries

3.2.1. Germany. In September 2010, "energy strategy 2050 - clean, reliable and economic energy system report" was issued by German federal government [2], which clearly put forward the action roadmap of energy transformation in Germany, so as to ensure the safe supply of energy, protect the ecological environment and ensure the sustainable development of economy and society.

The energy Internet demonstration projects in Germany all use electric energy as the hub of other types of energy transformation, and the main factors for the development of integrated energy in Germany include: (1) the energy transformation policy has been formulated, and the energy structure strategy and time plan have been put forward, as shown in Figure 1. Germany's energy Internet system mainly focuses on clean energy and intelligent power supply [2]. (2) Distributed generation in Germany has increasingly become the choice of industrial customers and households; (3) with the increasing complexity, central energy is increasingly questioned, and new players and business models around data use continue to increase.
As shown in Figure 1, German e-energy project [2] is a technological innovation promotion plan launched by Germany on the basis of smart grid. It proposes to build a new energy network and realize integrated digital interconnection in the whole energy supply system, including smart power generation, smart grid, smart consumption and smart energy storage. The key technologies focus on the integrated utilization of renewable energy, the improvement and upgrading of energy storage devices, the integration of distributed energy system information model and physical model, load demand side response capability analysis, energy efficiency management of energy consumption terminal, and distributed hierarchical control of regional energy system, so as to realize the two-way interaction between energy production and energy efficiency consumption which is presented in Figure 2.

A large number of distributed energy and integrated energy projects in Germany are invested and operated by energy group, government, heating company, power supply company and others. As an energy group in Germany, steag company's integrated service scope is shown in Table 3. The company started mobile heating energy services in 1961, and is currently providing energy services such as mobile power supply, power side energy storage and frequency regulation, air conditioning transformation and optimization, mature system modeling and optimization tools, etc.

| category               | Integrated energy services                                                                 |
|------------------------|---------------------------------------------------------------------------------------------|
| consulting service     | Project management, troubleshooting / fault analysis, quality, safety and control management |
|                       | Feasibility study and basic design, modeling of thermodynamic process by ebsilon, conceptual  |
|                       | planning and design engineering, implementation plan, approval and permission               |
| plan                   | Construction management and commissioning, coordination / project management, troubleshooting |
| build                  | and fault analysis, deadline monitoring, quality management, integrated audit of production   |
| Operation and          | site and suppliers                                                                         |
| maintenance optimization| Customer consultant, on-site key expert management, efficient and reliable operation       |
|                       | management, creating customized power plant simulator                                       |
| dismantle              | Post engineering services improve the availability and efficiency of power plants, optimize   |
|                       | operating procedures, and monitor energy management systems                                  |
|                       | Scheme, approval documents and operation regulations, large parts for other use, radiation   |
|                       | protection and purification                                                                 |

3.2.2. U.S.A. The United States is the first country to study distributed energy and Microgrid. After development, distributed energy has become an important starting point for the U.S. government to save energy and reduce emissions. In the United States, distributed generation will become a model of
efficient use of mineral energy in commercial buildings. Through the adjustment of energy system, it will greatly promote economic growth and improve the quality of life of residents, while minimizing the emissions of pollutants.

In terms of energy services, in 2016, Oracle merged Opower and developed its energy efficiency and energy management system to provide users with interface services, energy services and digital services, including digital services, interface services and energy service [7]. From cloud-native products and better grid management tools to more compassionate customer-interaction programs and deeper analytics across solutions. Energy services include energy efficiency management, peak management and alarm. Opower's big data platform stores and analyzes 600 billion data of 60 million public utility end customers, enabling public utilities to actively meet regulatory requirements, reduce service costs and improve customer satisfaction. Oracle and Opower will provide the most complete, modern and integrated cloud platform for the entire utility value chain of the entire industry (from meter to grid to end user). By analyzing the energy data of users and households [3] (Figure 3), and informing customers of the analysis and optimization results in various forms, and providing suggestions for users to reduce energy consumption, the proportion of suggestions accepted by users is 93%, with an average energy saving of 1% - 2% [3].

![Figure 3. Opower energy services, USA](image)

3.2.3. Japan. Due to the lack of resources in Japan, long-term research on the integrated utilization and management of energy has been carried out for a long time. Since the Fukushima nuclear power accident in Japan, the country has continuously adjusted its energy structure and energy security strategy, which has led to a diversified development mode of energy in Japan and slowed down the utilization rate of primary energy in Japan. Japan's integrated energy has the following characteristics:

1. Continuously development of renewable energy and other energy. Aware of the rapid development crisis of global warming and the Fukushima nuclear power accident in 2011, Japan is seeking to reduce its dependence on nuclear power as much as possible and actively promote the development of renewable energy and distributed energy.

2. Efficient use of energy interconnection. More attention should be paid to regional energy integration, focusing on the penetration of Internet concept in the physical level of energy, and most of the configuration equipment is distributed energy with natural gas as fuel. At the same time, according to the type of users to develop differentiated service strategy, pay attention to technology research and development, improve energy efficiency [4].

3. Perfect energy saving technology and system. Japan's energy-saving technology has penetrated into energy, industry, civil, transportation, construction and other fields in an all-round way. Energy saving can be regarded as "another kind of energy" with the same function as natural gas and electric power. Japan's energy-saving system is mainly composed of three parts: energy-saving policy system, energy-saving legal system and energy-saving management system. At present, due to the benign guidance of Japan's energy-saving policy, the communication among the government, enterprises and
scientific research institutions is closer, and the energy-saving policy is more efficient, which greatly improves the implementation and promotion of Japan's energy-saving policy [5].

4. Suggestions and prospects of future integrated energy services

To develop the integrated energy service industry, deeply study and understand the national strategic value of the integrated energy service industry, as shown in Figure 5, explore the integrated energy business from the aspects of energy supply, construction, operation and maintenance, and energy services, and promote the transformation of the integrated energy service industry

(1) The R&D and promotion of new energy technologies will continue to accelerate. According to bp-2050 energy outlook analysis, the future energy pattern (as shown in Figure 4) will depend on the substantial growth of energy demand, unconventional and renewable resources, especially the development of fuel cells and hydrogen energy, which will significantly affect the future fuel demand. Battery energy storage technology will have a huge impact on the transportation industry and energy industry, and efficient solar power generation will continue to improve energy efficiency and improve people's livelihood. Industrial intelligence, big data and Internet of things will continue to promote the transformation and development of energy.

![Figure 4. Future energy pattern](image)

(2) Accelerate the formation of energy strategy and mode. Adhere to the principle of combining diversified technological innovation with typical demonstration application, and explore the replicable and promotable business model of integrated energy services from point to area. To realize the technology driven development and business model innovation of integrated energy is the only way for the future development of integrated energy. It is necessary to carry out multi-dimensional energy supply and services based on energy and users, including the main directions of energy supply, construction, operation and maintenance and energy services, and actively explore the energy service mode that meets the needs of users and the market.

(3) Based on the Internet of things and Internet technology, build a integrated energy services ecosystem. Based on energy informatization and intelligent technology, promote integrated energy services into the digital energy era, and gradually build an integrated energy data platform. By collecting gas, cold, heat and other energy data, and extending to the internal energy consumption data of the customer side, we will build a integrated energy big data platform, form an up-down industrial chain of energy integrated service business [6], and finally build a integrated energy service ecosystem.

(4) Combined with the construction progress of domestic energy market, this paper explores the electricity market trading, carbon trading and green certificate trading business facing the society. According to the process of market reform, it will gradually expand to power futures, transmission rights and other financial derivatives trading and fuel futures trading, and explore the construction of distributed integrated energy trading service platform.
Figure 5. Main development business of integrated energy services

(5) Give priority to the development of energy services in the park and open the integrated energy service market. Taking the park's integrated energy service as the breakthrough point, the paper explores the integrated energy service in industrial parks, high-tech development zones and commercial centers with large energy demand. According to the principles of top-level design, cascade utilization and user customization of integrated energy system, combined with the diversified energy demand of different users, the integrated energy supply and service system is built by means of energy system architecture, planning consultation, engineering construction, energy supply and management, energy conservation and other services, and the integrated energy service mode of typical park is established.

(6) In order to meet the needs of green buildings, we will actively carry out terminal side integrated energy conservation and energy efficiency services. As an important part of the energy system, energy conservation should not only realize equipment energy conservation, but also pay attention to system energy conservation and management energy conservation, so that energy conservation can truly achieve the goal of service creation value. At the same time, energy-saving service should break through the traditional asset investment mode, take energy-saving technology as the core, information technology as the means, and user demand as the center, so as to build a integrated energy-saving service system and realize the integrated improvement of energy-saving service.

5. Conclusion
To build a safer, cleaner and more efficient energy system, the next step of integrated energy service is to forming mechanism of operation, managements and other value-added service. Once this new business mode develops into a completed industrial chain, integrated energy system can promote the cost saving of the whole society and achieve a sustainable energy development.

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