

Green Energy Development System under the Background of Environmental Sustainability

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Abstract: With the continuous advancement of economic globalization, energy demand is expanding and energy consumption is excessive, which leads to energy shortage. Unreasonable energy use also brings great challenges to the environment and affects the balance of the ecosystem seriously. The rise of the third industrial revolution has injected new vitality into energy system. The construction of energy Internet system, which integrates Internet technology and energy technology, has become a new energy system of sustainable development. It has put forward the reform scheme for the mismatch of energy demand points and environmental pollution. The deepening of sustainable development strategy accelerates the promotion of energy Internet system, promotes the large-scale utilization and sharing of renewable energy. It also provides a new idea for realizing green energy structure and efficient energy utilization. Firstly, based on the core concept of energy Internet system, this paper reviews the relevant research on energy Internet system in academic and industrial circles, and gives the preliminary definition of energy Internet system market. On this basis, it puts forward the development goal of energy Internet system market. It compares the new energy Internet system market with the traditional single energy market, highlighting the characteristics of energy Internet system market, it is reflected in the diversified transformation of market trading subjects, the diversification of market trading objects, the increasing dependence of information technology and the improvement of the matching degree of supply and demand. Then, the integrated architecture of the energy Internet system market is carried out, and the issues related to the transaction mode and operation mechanism of the energy Internet system market are discussed. Finally, the frontier problems of energy Internet system market are summarized, and the research prospect of energy Internet system market is put forward.

Keywords: Energy Internet system market; integrated architecture; transaction mode; operating mechanism

1 Introduction

With the growing population of developing countries, energy demand is more and more vigorous, and the utilization of fossil energy is growing day by day. The carbon dioxide emission from the combustion of



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fossil energy has gradually highlighted the environmental pollution problem, which has brought serious ecological imbalance. The traditional fossil based non-renewable energy is gradually exhausted, which can not meet the needs of human development in the future. It will make human survival and development face severe challenges. Energy crisis has become a problem that people have to face. In order to solve the existing crisis, it is urgent to reduce the dependence on non-renewable energy. Countries are actively looking for new energy. Renewable energy into the world's vision, and it has been highly concerned by countries. However, renewable energy has the characteristics of geographical dispersion and randomness of production, it is difficult to effectively use. The explosive development of Internet technology has subverted traditional industries and accelerated the idea of using Internet thinking and technology to transform the traditional energy industry. It makes the true integration of renewable energy and the Internet and provides a feasible scheme for the implementation of the strategy of energy sustainable development.

At present, the energy Internet system has not yet formed a unified and standard definition, but the core concept development goals, basic structure and main features of the energy Internet system have reached a preliminary consensus in academia and industry. Dong et al. [1] considered that the energy Internet system is a complex multi-network flow system with power system as the core, Internet and information technology as the foundation, distributed renewable energy as the main energy. It is closely coupled with natural gas network, transportation network and other systems. Tian et al. [2] integrated the characteristics of Internet technology and energy Internet system, the energy Internet system is understood as an energy interconnection and sharing network based on power grid, using renewable energy technology, smart grid technology and Internet technology to integrate multiple energy networks such as power grid, natural gas network, hydrogen energy network and electrified transportation network, so as to absorb high penetration renewable clean energy and activate new business models. Ding et al. [3] understood the energy Internet system from the perspective of green and sustainable development, the energy Internet system integrates the user's energy demand information with the use and inventory status of electricity, coal and other energy with the help of modern network information technology. Through the analysis of advanced technical means such as big data and cloud computing, the energy demand and supply can be reasonably allocated, and finally the network sharing platform of energy information is established. Ma et al. [4] regarded the energy Internet system as the next generation energy system with power system as the center, smart grid as the backbone, Internet, big data, cloud computing and information communication technology as the link. It uses advanced power and intelligent management technology to achieve the high integration of energy and information in the coordination of vertical source, network, load and storage. Huang et al. [5–9] discussed and introduce several concepts and key technologies of energy Internet system, including microelectronics technology, energy storage technology, demand side response, etc. Zhou et al. [10] analyzed the demand driving effect and research status of energy Internet system, and establishes the technical framework model of energy Internet system. Zhao et al. [11] used the complex network theory to establish the energy Internet system topology model from the macro structure point of view, which provides a reference for the design and optimization of the energy Internet system.

Based on the integration of the above core concepts of energy Internet system, this paper preliminarily defines the energy Internet system. Energy Internet system is a mechanism based on information technology, which integrates scattered resources through intelligent network and realizes multi type energy comprehensive transaction and optimal allocation through market competition. According to the analysis of energy Internet system in the book of the third industrial revolution by Jeremy Rifkin, a famous American economist, the characteristics of energy Internet system mainly include the following aspects. 1) Renewable energy as the main primary energy. 2) Support the access of large-scale distributed generation. 3) Wide area energy sharing based on Internet technology 4) Support the transition from fuel vehicles to electric vehicles [12].

This paper first gives the initial definition and development goals of the energy Internet system market, and highlights the transcendence of the energy Internet system market through the comparison between the energy Internet system market and the traditional single energy market. Secondly, it puts forward the construction of energy Internet system market integration architecture. Thirdly, it discusses the transaction mode and operation mechanism of energy Internet system market. Finally, it summarizes the prospect of frontier research in the energy Internet system market.

2 Basic Concepts and Characteristics of the Energy Internet System Market

Energy Internet system is not only the upgrading of energy system or unilateral optimization of network structure, but also the central system platform of energy flow and information flow. It has strong integration ability and coordination ability among various energy systems. As a new form of energy sharing, it puts forward new requirements for the establishment of market. First of all, this paper defines the Internet energy system market and proposes the development goal of energy Internet system market. It compares the new energy Internet system market with the traditional single energy market and refines the characteristics of the Internet energy system market.

2.1 Preliminary Definition and Construction Goals of the Energy Internet System Market

The core concept of the energy Internet system can be summarized as multi-energy complementarity, multi-network coupling, support for large scale distributed device access, extensive user side participation, and in-depth integration of information technology. Energy Internet system is based on information technology, integrates scattered resources through intelligent network, and realizes comprehensive transaction and optimal allocation of multiple types of energy through market competition. According to the core concept of the energy Internet system, this paper defines the energy Internet system market. The energy Internet system market is supported by information technology and distributed entities as the main participants in the context of the energy Internet system. It is to realize the optimal allocation of energy by highly coupling the Internet technology and energy system, to access and consume renewable energy on a large scale. It maximizes the effective use of resources and makes economic efficient and sustainable development. Through market competition, it is a mechanism to realize comprehensive transactions and optimal allocation of multiple types of energy such as electricity, natural gas, heating/cooling, and renewable energy.

Based on the preliminary definition of the energy Internet system market, the development goals of the energy Internet system market can be summarized as follows: 1) Multi energy integration to balance energy supply. 2) Achieve the optimal matching of energy production and consumption, and realize the pattern of low-carbon economy. 3) Provide flexible and open energy consumption market and realize equal and flat energy sharing network. 4) Break the barriers of the participants in the energy Internet system to achieve the interactive flow of energy flow and information flow.

2.2 The Transcendence of Energy Internet System Market

Electricity and natural gas markets have undergone structural adjustment and restructuring [13], especially the structural adjustment and reorganization of the electricity and natural gas markets. The market of electricity and gas are supplied through large-scale centralized supply, the hot/cold market widely exists in two forms: decentralized supply and regional centralized supply. Among them, decentralized supply meets its own heat/cooling needs through self-provided boilers, heat pumps, coolers, and other equipment; regional centralized supply realizes heating/cooling in a certain area through a heat pipe network. Compared with the traditional single power, natural gas and regional hot/cold markets, There are many differences in the energy Internet system market, as shown in [Tab. 1](#).

Table 1: Comparison of energy internet system market and traditional single energy market

Project	Energy Internet system market	Electricity market	Natural gas market	Regional hot/cold market
Market subject	Diversification	Single power	Single natural gas	Single hot/cold
Market object	Diversification	Single power	Single natural gas	Single hot/cold
Information dependence	Strong	Weak	Weak	Weak
Relationship between supply and demand	High matching	Low matching	Low matching	Low matching

2.2.1 Market Subject from Energy Production and Supply to Diversification

There are thick barriers between producers *and* consumers in the traditional single energy market, and the planning, construction, investment and operation of the main body are relatively independent. However, the energy Internet system market has the characteristics of open sharing, which makes more industrial entities participate in the energy Internet system.

2.2.2 Market Object from Single Energy Commodity to Multiple Energy Commodity

The energy type of traditional single energy market is relatively single, while the energy Internet system market supports the comprehensive transaction of multiple types of energy, and multi energy coupling helps to realize the optimal allocation of energy.

2.2.3 Information Technology Dependence from Weak to Strong

The traditional single energy market is relatively weak in dependence on information technology, while the energy Internet system market is relatively high in dependence on information technology. Information sharing provides flexibility for market operation, and information publicity improves the credit degree of the industry.

2.2.4 The Relationship Between Supply and Demand from Low Matching to High Matching

The relationship between supply and demand in the traditional single energy market do not match, resulting in excessive consumption of fossil energy, resulting in pollution emissions. The energy Internet system market promotes the energy consumers' right to choose independently. As a result, the energy Internet system market no longer has restrictions on the size of transactions, it is easier to enter and exit the market. The degree of game is more complicated. It promotes the consumption of large-scale renewable energy. It improves the efficiency of energy utilization and reduces energy consumption.

3 Energy Internet System Market System Integrated Architecture

For general commodities, the connotation of market system refers to the organic unity of various markets. In this chapter, according to the four research perspectives of subject architecture, object architecture, time architecture and space architecture, the integrated architecture of energy Internet system market system is carried out.

3.1 Subject Architecture

The energy Internet system market is open, equal and flat, so that more industry entities participate in the energy Internet system transactions and promote the growth of emerging industries. The energy Internet system market can be divided according to the energy production link (source) - energy transmission link (Network) - energy consumption link (load) [14]. The market subject is divided into energy producers in the production link, energy transporters in the transmission link and energy consumers in the consumption link.

1. Energy producers in the production link. According to the energy system, energy producers can be divided into centralized energy producers and distributed energy producers. They mainly produce or provide multi energy production equipment, conversion equipment and storage equipment, including electricity, gas and heat. Through the planning and configuration of energy production links, energy demand and energy supply can be optimized and coordinated.
2. Energy transporters in the transmission link. Energy transporters provide transmission channels for the circulation of energy commodities, including long-distance transmission and short-distance transmission. The energy commodities transmitted mainly include electricity, gas and heat. Reasonable planning of energy transmission network is helpful to reduce transmission cost and achieve efficient transmission.
3. Energy consumers in the consumption link. They include industrial users, commercial users and residential users, as well as single retailers, integrated energy retailers and energy service providers [15]. The single retailer or integrated energy retailer sells to end users by purchasing from the wholesale market. Energy service providers mainly operate or manage distributed energy or provide various value-added services for users, including energy microgrid operators, distributed wind power, photovoltaic, energy storage devices, electric vehicles/charging piles, natural gas distributed energy and other flexible resource operators, as well as energy consulting, management and information service companies [16].

3.2 Object Architecture

The diversification of market subject in the energy Internet system market has gradually led to the varied object. With the increase of energy users in the energy Internet system and the increased awareness of market participation, energy conservation and environmental protection, users are no longer limited to energy consumption, but new demands have emerged. The energy Internet system market provides a free platform for users' energy demand, and produces new business models and new formats. Through the market mechanism of competition and complementarity, the symbiosis of various elements of energy Internet system is realized. As shown in Fig. 1, equipment, energy, services and other derivatives in the energy Internet system market can be freely traded [17]. Energy Internet system products can be divided into basic energy commodity, auxiliary service goods, value-added services goods and financial derivative.

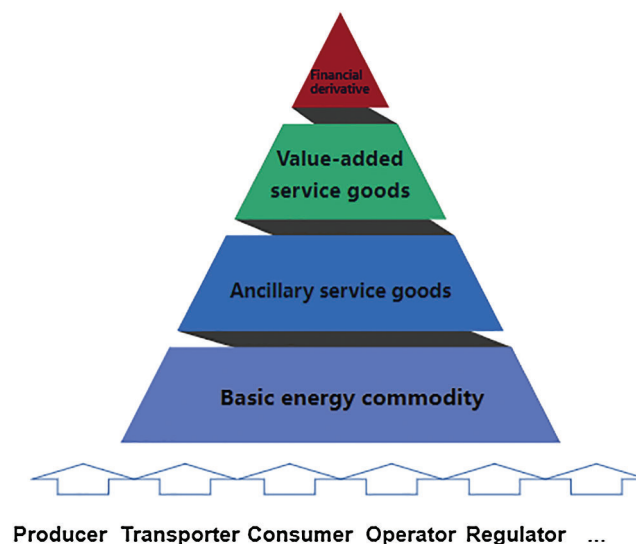


Figure 1: Energy Internet system market

1. Basic energy commodity. It refers to the energy consumed in the field of commodity circulation. Electricity, gas and heat are the most basic energy commodities for human production and life. They are only the external forms of energy, which can be transformed or replaced each other to a certain extent. Electric goods refer to the quantity and capacity of electricity generation form, while hot goods are heat without heat production. Natural gas commodity is gas volume, which can be divided into pipeline natural gas, liquefied natural gas (LNG) and compressed natural gas [16].
2. Auxiliary service goods. It refers to the auxiliary measures on energy commodity transportation, quality and system safety. Auxiliary service goods have also become trading commodities in the energy Internet system market. The main types of auxiliary services are peak shaving, frequency modulation, cold standby, voltage and reactive power support and black start services [18]. As a large capacity energy storage equipment, the battery of electric vehicle charging station can also be used as reserve capacity to participate in auxiliary service market [15]. The blockchain can provide an open and fair accounting and trading platform for power auxiliary services, realize workload proof and automatic cost compensation of auxiliary services in wind and fire bundling and wind storage joint dispatching. It facilitates more resources (such as electric vehicles, demand response, etc.) to participate in the identification and settlement of auxiliary services [19].
3. Value-added service goods. It is a variety of extended business services provided according to customers' needs after the completion of conventional services, such as accurate prediction of various loads and new energy, analysis of energy consumption behavior and formulation of energy utilization scheme. With the increasing awareness of energy conservation and environmental protection of market participants in the energy Internet system, users are more inclined to intelligent service mode, resulting in new demand for value-added services. Through the data value-added innovation service content and method, personalized energy bill can be provided to users, which can not only omit the trouble of processing data by users themselves, but also make users intuitively know their own consumption behavior and make targeted adjustments. Build a community platform provide users with more intimate and convenient services, and make users get the fun of interactive behavior.
4. Financial derivative. It is a derivative of finance. It usually refers to financial instruments derived from underlying assets, such as forward, futures, swap (SWAP) and options. In the energy Internet system market. Through the trading of energy and its financial derivatives, the optimal allocation of resources can be realized in the energy system. The birth of each new technology requires a large amount of investment to support research and development. Building energy Internet system market is a huge, systematic and complex project. Perfect financial mechanism can escort this huge and complex project. Enterprises in the energy industry and Internet industry are encouraged to issue energy financial derivatives, so as to raise sufficient funds for its technology research and development. Financial innovation can also provide financial and technical support for the construction of energy Internet system [16], such as energy futures and options, energy transmission rights and carbon emissions.

3.3 Time Architecture

Energy Internet system market can be divided into short-term, medium-term and long-term markets according to different trading time. Spot market is a necessary condition to ensure the stable operation of the market. Different trading commodities have different time intervals. Power is not suitable for large-scale storage, and its production, transmission, distribution and use must be completed during a limited time, so the electric power spot market is generally composed of the day before, day, and real-time markets. Compared with electricity, natural gas has the characteristics of easy large-scale storage. At present, there are mainly three methods including pipeline gas storage, LNG gas storage and underground

gas storage. Therefore, natural gas spot transactions generally refer to short-term transactions within 30 days (with a maximum of 3 months) [20]. Taking into account the differences in the transmission and storage characteristics of electricity, gas, heat and other energy commodities, the short-term market continues to be divided into three stages: real-time, day-to-day and months. In order to effectively avoid the price risk prevailing in the spot market, it is necessary to establish a forward market and a futures market in the energy Internet system market. The forward and futures markets are both medium-and long-term markets.

The types of commodities involved in different time-scale markets in the energy Internet system. As the core trading objects, the trading of basic energy commodities such as electricity, gas and heat generally exists in the short-term, medium-term and long-term markets. There are many types of auxiliary service commodities. Drawing on the experience of the electric auxiliary service market, for auxiliary service commodities that have little change in demand and the supply is mainly determined by the characteristics of the equipment, the medium and long-term market is mainly established, such as interruptible/control load and black start service. For ancillary service commodities whose demand changes greatly in a short period of time and market transactions are greatly affected by changes in supply, a short-term spot market is generally established. At present, power reserve transactions are mainly carried out in the previous day and real-time market, and the reserve and energy joint clearance model has been widely used. In addition, Value-added service goods is an extended business service provided according to the customer's demand after completing the conventional service, so it is necessary to establish a short-term market. Financial derivative refers to financial instruments derived from underlying assets, such as forward, futures, swap and options, and establish medium and long-term markets.

3.4 Spatial Architecture

The spatial structure of the energy Internet system market can be divided into central centralized market and regional distribution market according to the different market scope, transaction scale, participants and energy types. The central centralized market is responsible for large-scale energy transactions in the wide-area energy Internet system. It plays the role of energy wholesale market, which has certain requirements for the scale of the participants. The participants can only be centralized energy suppliers and large energy users. Market access is difficult. The regional distribution market is responsible for the free transaction in the regional energy Internet system, it acts as the role of the energy retail, which has no restriction on the scale of the participants. The participants can be distributed energy suppliers, energy users, etc. The market access is easy. Compared with electricity and natural gas, the biggest difference in heating power is that it cannot be transmitted over long distances. Therefore, hot/cold transactions are all carried out in regional distribution markets. The central centralized market only involves large-scale transactions of electricity and natural gas.

In summary, this paper constructs an integrated energy Internet system. 1) From the subject level, the energy Internet system market is an organic unity composed of energy producers in production, energy transmission in transmission and energy consumers in consumption. 2) From the object level, the energy Internet system market refers to the organic unity composed of basic energy commodity, auxiliary service goods, value-added service goods and financial derivatives. 3) From the time level, that is, taking various trading time intervals as the analysis clue, the energy Internet system market refers to the organic unity composed of short-term market composed of spot market and medium and long-term market composed of forward and futures markets. 4) From the spatial level, that is, taking the market scope, transaction scale, participants and energy types as the analysis clue, the energy Internet system market refers to the organic unity composed of central centralized market and regional distribution market. The main line of subject-object-time-space constitutes the energy Internet system market.

4 Energy Internet System Market Implementation Mechanism

In order to ensure the fairness and openness of the market, it is necessary to formulate a reasonable implementation mechanism according to the market system of energy Internet system. Based on the above preliminary definition of the energy Internet system market, the market transaction mode and operation mechanism of energy Internet system are mainly studied, which are applicable to the comprehensive transaction of electricity, gas and heat.

4.1 Transaction Mode of the Energy Internet System Market

Energy transaction in the energy Internet system market can be conducted through bilateral contracts and centralized bidding. According to different time intervals, the transaction mode of energy Internet system market is also different. Bilateral contracts is the main transaction mode in the energy Internet system market, and the necessary centralized bidding is set as the auxiliary transaction link. Different types of energy transactions and portfolio transactions are also applicable to the above two transaction modes.

Bilateral contracts refers to a contract signed by both parties through independent negotiation, which stipulates that a certain amount of a certain subject matter will be bought and sold in a predetermined manner at a certain time in the future at a predetermined price [21]. Therefore, under the bilateral contract transaction mode, the supply and demand sides negotiate to determine whether the subject matter of the transaction is basic energy goods, auxiliary service goods, value-added service goods or financial derivatives, etc. Other transaction details include transaction mode, delivery price, delivery time, transaction quantity, etc. Among them, the contract price is often related to the clearing price of centralized bidding. Bilateral contracts is mainly applicable to non real-time short-term market and medium and long-term market.

Bilateral contracts enhance the flexibility of renewable energy transactions. However, due to the lack of direct competition, it is difficult to obtain the lowest price. In addition, large-scale bilateral contract transactions may reduce the efficiency of system scheduling and increase the demand for ancillary services. Most countries allow renewable energy to participate in centralized bidding. In the short-term market, especially in the real-time market, centralized bidding must be set up. Centralized bidding refers to that market participants quote prices to market organizers according to quotation rules, such as trading centers. The trading center conducts market clearing according to the bidding rules, and determines the medium scalar and bid winning price of each market participant [21]. The clearing cycle of the real-time market of energy Internet system is different for different types of energy. For example, the centralized trading of natural gas and heat can be cleared every 1 hour, and the centralized centralized electricity transaction can refer to the electricity real-time market transaction mechanism of MISO in the United States [22], the clearing result rolls every 5 minutes. With the continuous maturity of the energy Internet system market, in order to further restore the commodity attribute of energy, except for the real-time market, the composition of centralized contracts in other markets will gradually decrease.

Bilateral contracts and centralized bidding are widely used in the energy Internet system market. Figs. 2 and 3 show typical transaction methods. According to the spatial structure of the the central centralized market and regional distribution market, the multi energy comprehensive transaction in the energy Internet system market presents the characteristics of hierarchical level and sub region.

The market participants of the central centralized market of energy Internet system market include energy suppliers and large energy users, which have certain scale restrictions on the participants. Bilateral contracts and centralized bidding coexist in the central centralized market. In order to meet the dynamic balance of energy supply and demand and network security constraints, energy suppliers and large users need to participate in the centralized bidding process of the central centralized market in addition to trading through bilateral contracts.

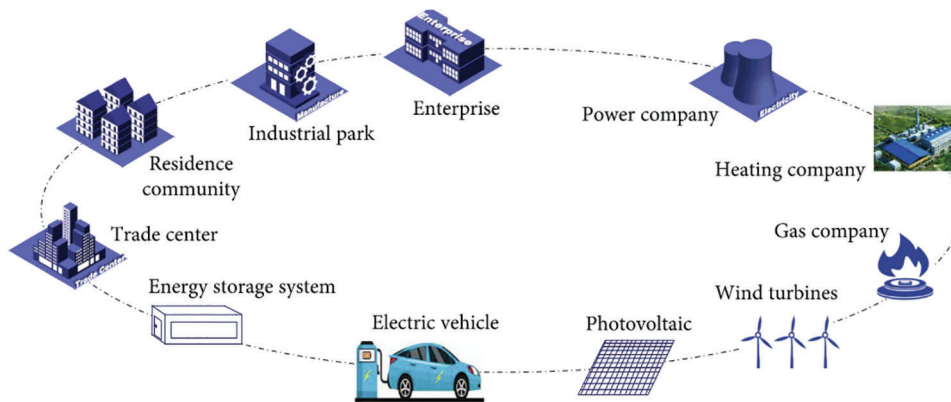


Figure 2: Typical trading methods of the central centralized market of the energy Internet system

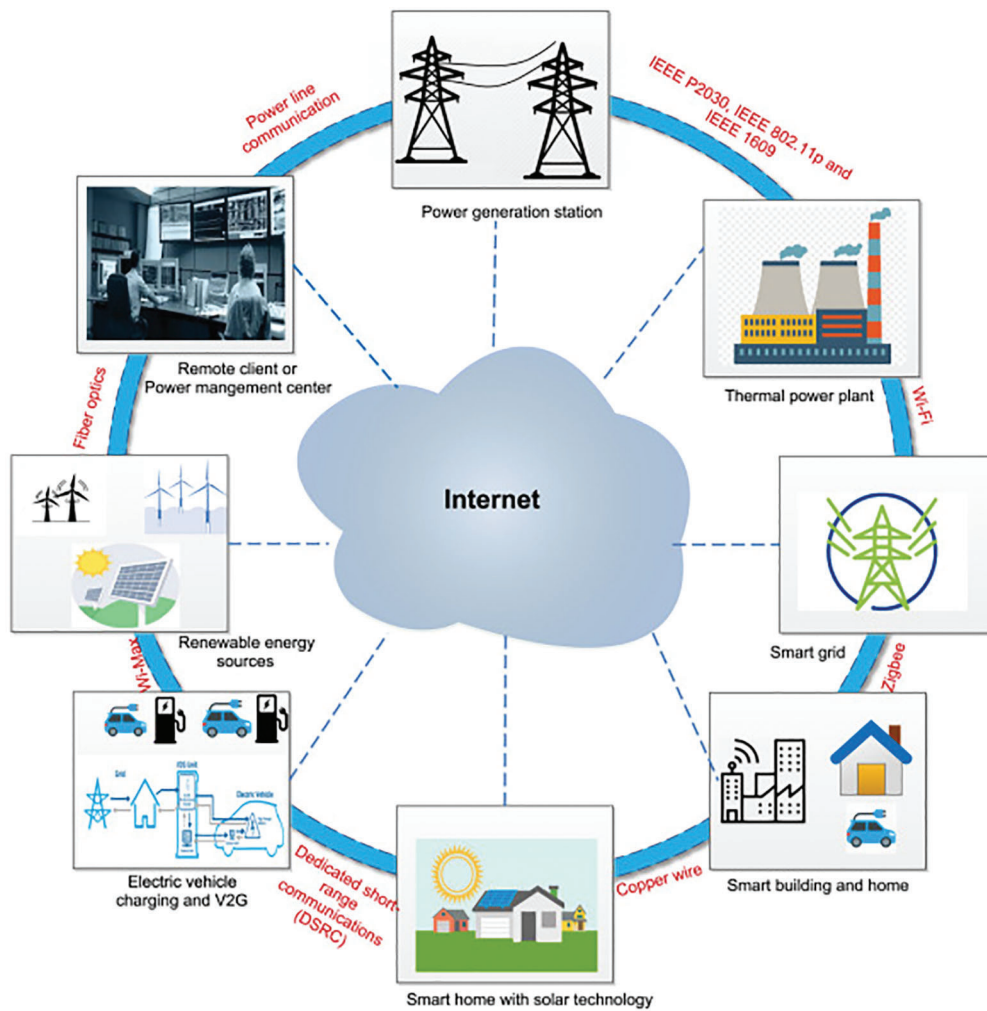


Figure 3: Typical trading methods of the regional distribution market of the energy Internet system

The regional distribution market of energy Internet system market is a flexible trading platform, which is specially provided for small-scale decentralized market participants. The scale of market participants is no

longer limited. The regional distribution market is a flat, free and equal market. The transaction mode of regional distributed market is mainly bilateral transaction, which is no longer limited to the single retailer user mode. The access of distributed equipment and the emergence of production and consumption users make the point-to-point distributed energy transaction on the demand side possible. The regional distribution market optimizes the production, transmission, utilization and storage process of energy resources to realize horizontal multi energy complementary and vertical source grid load storage coordination. By using Internet thinking, the energy flow, information flow, resource flow and value flow of energy system are deeply integrated to realize energy consumption nearby and trans provincial trade, fully tap the energy consumption potential to realize multi energy complementary and efficient utilization.

4.2 Operating Mechanism of the Energy Internet System Market

The operating mechanism of the energy Internet system market is mainly composed of price mechanism, competition mechanism, supply and demand mechanism and incentive mechanism. The operation of energy Internet system market mechanism is manifested in the interrelation and interaction among price, competition, supply and demand, incentive mechanism. The process of its function is also the circulation process in which the above-mentioned mechanisms fit and restrict each other. Among them, the price mechanism is the core.

4.2.1 Price Mechanism

Bilateral contracts are mainly priced by negotiation between two parties. Centralized trading can adopt different pricing mechanisms, such as matching price, system marginal price, partition marginal price and node marginal price according to the type of energy. Both the day ahead market and the real-time market of PJM electricity spot market in the United States adopt the local marginal price (LMP) mechanism, while the auxiliary service adopts the price mechanism of marginal clearing price of the whole network without distinguishing the node differences. The day ahead electronic trading organized by Amsterdam power exchange adopts the price mechanism of marginal clearing, which is applicable to all the cleared trading electricity in the exchange [23]. Take cost pricing as an example to analyze the pricing strategy. According to the theory of marginal opportunity cost, the resource price P should be equal to its marginal opportunity cost MOC , which is the sum of marginal production cost, marginal user cost and marginal external cost.

$$P = MOC = MPC + MUC + MEC \quad (1)$$

Since the project of expanding green energy production capacity is leaps and bounds, and each period of investment is completed at one time, the average incremental cost AIC can be used to define the marginal opportunity cost MOC of green energy supply, so that the price and new output The average unit cost is equal, that is, its price is equal to the average incremental cost AIC , that is

$$P = MOC = AIC \quad (2)$$

Among them, the increment in the average incremental cost refers to the increased supply capacity of the green energy project. The average incremental cost should include the average incremental production cost $AIPC$ and the average incremental external cost $AIEC$. The sum of the present value of costs and external costs is divided by the newly discounted green energy consumption. Among them, the size of external costs can be determined according to the new waste treatment costs and new energy use costs. Therefore, the AIC formula for urban green energy can be expressed as follows:

$$AIC = AIPC + AIOC = \frac{\sum_{t=0}^n \frac{I_t - C_t - F_t}{(1+r)^t}}{\sum_{t=0}^n \frac{Q_t}{(1+r)^t}} \quad (3)$$

Among them: Q_t represents the increased green energy consumption in the t year, which can be determined by the portion of the predicted green energy consumption in the t-year that exceeds the existing green energy supply capacity. I_t represents the new production cost in the t-year, including the t Year and the provision of new green energy supply capacity and capital cost and operation and maintenance cost related to consumption. C_t represents the capital cost and operation and maintenance cost of waste treatment increased by the new waste treatment volume in year t. F_t represents the reduced energy cost due to new green energy consumption in year t. n represents the planning time, generally at least 20 years. r represents the discount rate, that is, the opportunity cost of capital.

4.2.2 Competition Mechanism

It is conducive to promoting the survival of the fittest in the energy Internet system market. For example, the electric power system reform puts forward the measures of opening the electricity selling side market and allowing five different types of market subject to gradually sell electricity, thus forming a competitive pattern of “buying more and selling more” in the power market. It makes electricity sales have become a new business model. Power suppliers can provide customers with stable and preferential electricity prices, personalized service packages or corresponding value-added information to attract and collect user resources, and purchase electricity in the electricity market on behalf of users [15].

4.2.3 Supply and Demand Mechanism

In the energy Internet system, the formation of multi-energy complementary system, the access of a large number of distributed devices and the emergence of production and consumption users promote energy substitution and sharing, and increase the flexibility of the demand side. In addition, with the strengthening of market concept and energy-saving awareness, users will actively change the type and time of energy consumption according to the market price, and participate in the demand side response actively, thus further enhancing the elasticity of energy demand. It is conducive to the balance of market supply and demand. In addition, it is necessary to establish a two-level market system conducive to the circulation of the energy market, so as to improve the transparency of the energy market, effectively realize the optimal allocation of various forms of energy to achieve the balance of supply and demand of energy commodities.

4.2.4 Incentive Mechanism

The mechanism is helpful to mobilize the enthusiasm of the market and promote social energy conservation and emission reduction. Countries have taken a series of incentive measures to traditional energy industry, users, comprehensive energy supply enterprises and other related parties, and put forward specific measures and methods from the aspects of tax preference, financial subsidies, goal orientation, investment financing services, cost-benefit sharing, etc. In the meanwhile, the government also introduces punishment mechanism and mandatory order to improve the smooth flow of incentive measures. Through scientific incentives and reasonable guidance, users can make decisions independently and consider low-carbon environmental protection. It promotes enterprises to participate in nationwide carbon emission trading and other forms of green development transactions, giving full play to the characteristics of clean energy and high energy utilization efficiency of energy Internet system. It improves the sustainable development ability of the whole industry.

5 Prospect of Frontier Research in the Energy Internet System Market

The construction of the energy Internet system market promotes the industrial technology upgrading and supply-demand structural adjustment of energy industry. At present, it is still in the initial stage. In addition to drawing on the research results of the existing electricity, natural gas, regional cooling and heating markets, it also needs the support of many technologies and other conditions. The future perfect energy Internet system market is formed by various technologies and mechanisms which have been tested, eliminated and evolved. With the continuous evolution of the energy Internet system market, there will be more complex problems, and there is still a long way to go to improve the energy Internet system market.

5.1 Realize Multi Energy Open Interconnection of Energy Internet System Market

In the traditional energy system, different energy industries are relatively closed, such as power, heating, cooling, gas and oil. They have limited interconnection. Different systems are planned and operated in isolation, which is not conducive to energy efficiency and renewable energy consumption. The energy Internet system breaks the barrier, starting from various forms of energy interconnection, such as electricity gas coupling, electricity heat coupling, electricity gas heat coupling, etc., to realize the comprehensive utilization of electricity, heat, cold, gas, oil, transportation and other energy sources. It also connects wind energy, solar energy, tidal energy, geothermal energy, biological energy and other renewable energy sources, forming an open and interconnected comprehensive energy system. Interconnection is an important manifestation of openness, providing a platform for energy sharing and trading, connecting supply and demand. It is the basis for energy Internet system to create value. Interconnection includes various energy forms, energy systems, heterogeneous devices, and various participants. Through the construction of integrated energy system and the conversion of various energy forms and the technology of cheaper and large capacity heat storage, the consumption level of renewable energy can be significantly improved, and its fluctuation can be suppressed [17]. For example, in the user side, through the construction of integrated energy system, the multi energy demand of users can be met pertinently, and the energy comprehensive utilization rate can be effectively improved under the premise of taking the user as the center. In the transmission network side, multi energy open Internet can reduce network construction and improve system reliability.

5.2 Improve the Technical Support of Energy Internet System Market

The construction of energy Internet system market needs to be supported by technologies in energy production, conversion, transmission, storage and access, and technology driven as catalyst to promote the smooth operation and effective operation of energy Internet system market. In terms of energy production, distributed photovoltaic, wind power and other new energy technologies will realize low-carbon and clean energy Internet system. In terms of energy conversion, CCHP units will realize free and efficient conversion energy to promote the reliability and flexibility of energy system. In terms of energy transmission, wireless charging technology and high voltage direct current technology will realize the convenience of energy transmission. In terms of energy storage, high-efficiency battery and heat pump will realize low-cost and efficient storage of various forms of energy. In terms of energy connection, multi section direct technology and solid-state transformer area will realize free access of power generation equipment. For example, it can be carried out by the management agencies of residential property or industrial zones and high-tech zones with advanced energy cogeneration technology, efficient electricity, heat and cold conversion technology, low-cost electricity/heat hydrogen production technology, etc. Efficient energy storage technology may lead to energy bank. Users can choose to store their surplus energy in the energy bank. Under the premise of considering the storage cost (Commission) and loss (negative interest rate), they can withdraw the corresponding energy from the bank and clear and settle the energy profit and loss [15].

5.3 Optimize the Energy Service Mode in the Energy Internet System Market

Energy Internet system market is an integrated market composed of many kinds of energy commodities. The demand of market users not only stays in the demand of energy itself, but also puts forward new service demand. The traditional energy service has been difficult to adapt to the demand of new environment. The emergence of new energy service has completely broken the limitations of traditional energy service. Its rich service forms and contents can directly attack the pain points of users' energy consumption and meet the diversified energy demand of users. Its large-scale development promotes the rapid development of energy Internet system market [24]. The service mode is more diversified and platform oriented, it takes the user as the core and the demand side as the leading, the value-added services are centered on the actual needs of users. From the technical point of view, relying on the Internet of things, the Internet, cloud computing, big data, regional chain and other high-end technical methods, we can study the user behavior feature extraction and local detail analysis method covering load characteristics and typical energy consumption mode [25,26], influencing factors and sensitivity intensity of energy consumption behavior [27,28] to analyzes the basic energy consumption demand and incremental value demand of users, so that we can explore the differences in marketing potential and credit status of users. The energy Internet system market has been extended to the whole market. The traditional active push mode can no longer meet the development trend of energy Internet system market. It uses service composition theory [29], content-based (CB) [30] collaborative filtering (CF) [31], frequent pattern tree (FP Tree) [32] and other theoretical methods to achieve the scale recommendation of service products.

5.4 Strengthen the Market Information Physical Security of Energy Internet System Market

With the continuous opening of energy Internet system market, information interaction is more frequent, and the information security problem of energy Internet system market will become prominent gradually. The security of information transmission and storage, user privacy, and man-made malicious attacks may affect the security and reliability of the entire energy Internet system market. Although network attacks can not directly lead to the destruction of physical systems, it is likely to damage the normal functions of information systems. The energy Internet system market is highly dependent on information. The control and coordination of physical equipment of energy Internet system depends on Information System to a great extent [1]. Therefore, the problem of information physical security will lead to complex physical interaction process, and affect the smooth progress of the entire energy Internet system market ultimately. The problem of information security has attracted the attention of many countries. The U.S. Congress specially approved the budget to fund the research on information security of industrial systems. Back et al. [33] introduced game theory as a mathematical tool to analyze the influence of the game between attacker and dispatcher on the process and result of network attack. Ten et al. [34] began to study the modeling of network attack process earlier and propose that the attack tree was used as the modeling tool of the attack process, and the loss of load after the attack was taken as the quantitative index of the attack consequence.

6 Conclusions

Energy Internet system market is an important symbol of the energy revolution and the product of the high integration of Internet technology and energy technology. In order to achieve the high matching of energy supply and demand and realize the optimal allocation of energy, the construction of energy Internet system market has become the focus of academic and industrial circles. Compared with traditional single energy markets such as electricity, natural gas, regional hot/cold, the transcendence of energy Internet system market are highlighted, which are mainly reflected in the pluralistic transformation of market trading subjects, the diversified development of market trading objects, the enhancement of information technology dependence and the improvement of the matching degree of supply and demand. Based on the definition of energy Internet system by scholars, this paper defines the concept of energy

Internet system and energy Internet system market and propose the construction goal of energy Internet system market. It further puts forward the construction of energy Internet system market integration architecture and discusses the transaction mode and mechanism of energy Internet system market. Finally, it summarizes the prospect of frontier research in the energy Internet system market. Energy Internet system is a new direction of interdisciplinary and interdisciplinary. Its development is inseparable from interdisciplinary and industry university research cooperation. There are many key problems and technologies need to be solved. Domestic and foreign scholars and all walks of life need to work together to realize the innovation of energy Internet system market mode and create a new diversified market pattern.

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