Scientific
Research
Publishing

Discussion on Energy Internet and Its Key Technology

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Abstract

Energy and environmental problems are among the important factors restricting economic development. The development of green energy is an important measure to deal with energy and environmental problems, such as wind energy and photovoltaic. Energy Internet is an important mean to promote the transformation of the energy structure, improve energy efficiency and reduce pollution. In introduction, the energy Internet is put forward. Then the architecture and characteristics of energy Internet, such as integration, openness, intelligence and marketization of energy Internet are analyzed. Next, key technologies such as energy router, virtual power plant and network security technology are discussed. Finally, a few suggestions for the development of energy Internet are proposed, and hoped to promote the development of energy Internet.

1. Introduction

With the global non-renewable energy depletion, energy has become an important factor restricting economic development. The face of global energy problems, the development of green, renewable wind energy, solar energy or other new energy is our only choice. However, whether it is the traditional oil, coal and other fossil fuels or the current strong development of wind energy, solar energy and other new energy, there are uneven distribution or source-charge uncoordinated problem [1], and the solution to this problem is to carry out energy Interconnection, to achieve the "source-network-charge" the organic joint, that is, "energy Internet". Jeremy Rifkin in the "third industrial revolution"

in the Internet technology and energy system to achieve the idea of interaction [2], since its inception, the third industrial revolution and energy Internet in China caused a wide range of Attention [3].

Energy Internet is an energy system with the information on the Internet as the main reference object, the big grid for the core network of energy transmission and the oil and gas pipeline network, transportation network, heat transfer network as a supplementary network. It combines the advanced Internet of things, information Internet, large data processing, power electronics and other technologies, achieve the energy conversion and transmission of precise control, "source-network-charge" in harmony, to meet people's demand for energy and harmonious development with the environment.

Energy Internet is to meet the needs of future development, is an important means to solve future energy problems [4]. This paper mainly discusses the architecture, characteristics and some key technologies of energy Internet.
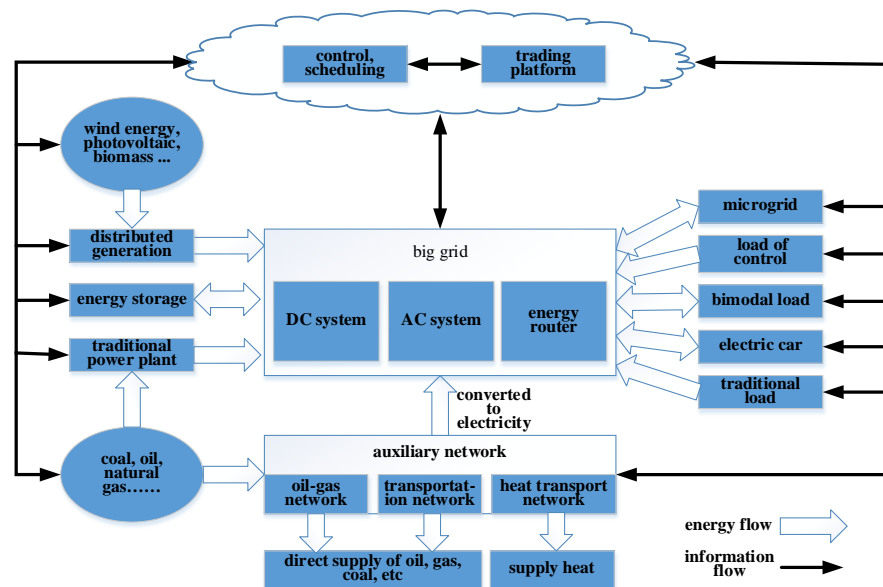
2. The Architecture of Energy Internet

Energy Internet aims to optimize the energy structure, to adapt to a variety of new energy access, give full play to the advantages of different energy, and the use of advanced technology to improve energy efficiency and improve user satisfaction [5].

Power has some advantages, such as fast transmission speed, easy to convert, easy to use, etc., so the energy Internet is mainly a big grid as the main energy transmission channel. Energy Internet is the operation of information on the Internet as the main reference object. But the transmission of electricity and information transmission is not the same characteristics, such as information is time-division multiplexing, intermittent transmission without affecting the user's general experience, but the intermittent transmission of electricity will affect the motor and other general load of normal work, that is, power grid of the "energy bandwidth" needs to match the total amount of load. Therefore, the big grid needs to combine with the load of control, energy storage, bimodal load, etc., the use of technology of advanced control to ensure that the power transmission capacity is greater than the total uncontrollable load, and improve the user's experience satisfaction.

Based on the advantages of power and combined with the concept of energy Internet from the introduction, and the characteristics of distributed power generation and tram access. This paper argues that include energy supply, energy consumption, energy trading, energy transmission control, etc. should be included in the energy Internet. The architecture is shown in **Figure 1** (the bimodal load is the object that can play two roles of energy supply and demand, such as a cell or residential with photovoltaic power generation).

In the energy Internet, the subject include primary energy suppliers, power grid companies, oil and gas companies, transportation companies, hot suppliers, users, trading platform, scheduling and control center, etc., they are interoperable

Figure 1. The architecture of energy internet.

and sharing the information, to achieve "source-network-charge" between the highly coupled.

The dispatching control center as the central nervous system of the energy Internet, it can make judge, analysis and decision-making based on the information of the user, power grid, trading platform and other information generated, etc., with environmental protection as the main constraints, to achieve energy optimization configuration.

Energy transmission network based on the power grid, which includes AC transmission network and DC transmission network, supplemented by an oil and gas pipeline network, besides, the core of energy interconnection—energy routers, to achieve the energy bi-directional and long-distance transmission.

3. The Features of Energy Internet

Energy Internet can make a variety of energy interoperability, allowing all constituent elements to exchange information and interaction, with some characteristic such as, integration, openness, intelligence [6], efficient [7], market, interactive and so on.

First, fusion. Energy Internet is the realization of energy and information interoperability for the main purpose. Therefore, the energy Internet requires the industry to achieve "horizontal interconnection, vertical through", will be different types of energy and different companies running between the energy network to achieve a unified, to meet people's energy demand in time and space.

Second, openness. Openness is not only open to the information interface, but also on the physical interface. Energy supply and demand regardless of the size of the body can be free access to the energy Internet and participate in market transactions. Compared with the traditional energy unidirectional and radiant supply network, the energy Internet has a unified standard physical and in-

formation interface, achieve the two-way flow of energy with information sharing.

Third, intelligent. Energy Internet is a very large energy supply network and the demand of energy is random in time or space. At the same time it needs energy supply network is safe and reliable to meet the large-scale intermittent of new energy access, so the need for energy networking with intelligence, to achieve fault self-diagnosis, self-healing, self-control, adaptive and other functions.

Fourth, efficient. Energy Internet needs to cope with future energy shortages and increasingly serious environmental problems, the need for the system to absorb large-scale centralized wind energy, photovoltaic and small-scale decentralized new energy power generation, intermittent new energy and network to achieve safe and reliable control [8], to build a clean and environmentally friendly energy supply system.

Fifth, the market. Energy Internet should have the characteristics of the market, the use of market economic equality, competitiveness, autonomy and other characteristics, so that the supply and demand can be free trading on the market-trading platform. Energy market through the floating price is to influence the behavior of the market participants, especially energy consumers [9]. the energy market according to the time and space, the nature of the user, the amount of differences in the development of a variety of charges for users to choose , Thus affecting the user behavior, and ultimately achieve the survival of the fittest, and promote the purpose of optimizing the energy allocation. Energy market development of a variety of charges for the user to choose according to differences of the time and space, the nature of the user, the amount of demand, thus affects the behavior of user, ultimately achieves the aim of the survival of the fittest, and promotes the optimizing distribution of energy.

Sixth, interactive. The subject of the energy Internet is a high degree of coupling, is an important sign of further marketization and liberalization of energy transactions, the need to achieve the "source-network-charge" interaction to activation and integration the of both sides of the market supply and demand. "Source-network-charge" interaction requires information network interoperability and physical structure interconnection, and ultimately achieves the two-way flow of information and energy, and promotes the market development of energy Internet.

4. Key Technologies for Energy Internet

4.1. Smart Grid

The power grid is the core transmission channel of power of the energy Internet, because the speed of power transmission is the fastest in all current energy transmission. It will be an important form to achieve rapid energy transmission and scheduling in the future. Many aspects such as electromagnetics, material science, information science, automation and so on are involved in the genera-

tion, transformation, transmission, distribution and power consumption of the smart grid, so it requires a lot of talent to cooperate or escort. With the breakthrough of material science and power electronic technology, the advantage of DC transmission is more obvious. DC transmission will be the main mode of energy transmission in the future. In the development of smart grid, we need to conduct research on flexible DC power transmission and large power system operation and control, MTDC, fault diagnosis and self-healing, distributed power access and control, to build an economic, safe and reliable, environmentally friendly power grid.
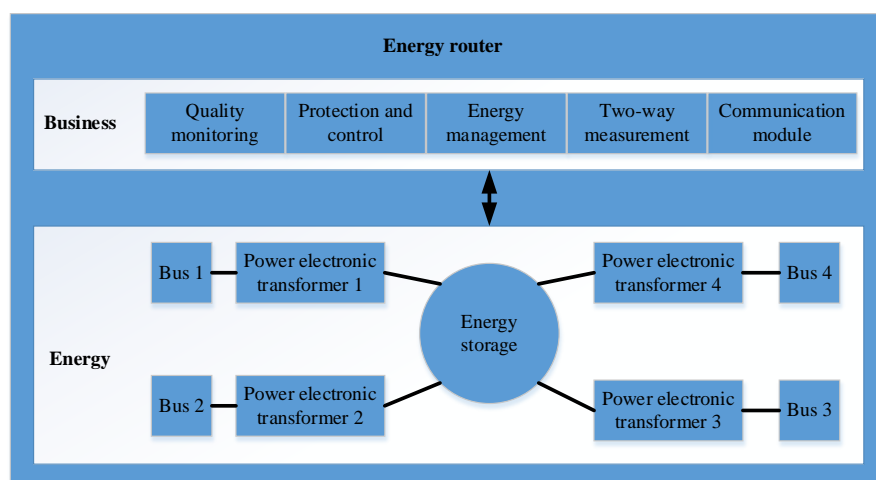
4.2. Energy Router

In the energy Internet, an important component is the energy router [10]. Because of the main energy transmission channel of the energy Internet is the power grid, this section focuses on energy routers that involve electrical components, as showed in **Figure 2**.

The energy equivalent to the existing substation routers in the network, but in the main structure is different from the substation, the main difference is the energy router using power electronic transformer and add storage unit.

Power electronic transformer: power electronic transformer is the core component of energy router, achieves the transformation of electrical energy by power electronics technology. According to the architecture, the form includes AC/DC, DC/DC and DC/AC. It can facilitate the transmission of different power level networks, various distributed power supplies and various users to access, achieve the two-way electric transmission.

Energy storage: energy storage is the energy center of the energy router, and the energy flowing into the energy router is stored after the power electronic transformer; instead, the energy of the outflow to get from the energy storage. Energy storage can realize the power flow balance and reduce the loss through the charging and discharging of energy storage unit.

Figure 2. Schematic diagram of energy router.

Business: business includes quality-monitoring, protection and control, energy management, bidirectional measurement, communication module, etc. achieve control and protection of energy networks, power marketing, and synergies with other energy routers or other systems.

The energy flow of the energy router needs to through the energy storage unit, this method with the following advantages:

- There is no need to synchronize the time of the bus;
- At present, a lot of new energy generation and grid process needs to go through the DC/AC link, so it can reducing equipment costs and losses by direct access from the DC power grid;
- With the development of electric vehicles, electric vehicle electricity consumption in the sharp rise, it can reduce the AC/DC conversion losses and related equipment investment costs by direct supply through the DC.

4.3. Virtual Power Plant

The concept of virtual power plants was proposed by the EU FENIX project [11] at first. At present, the virtual power plant has no unified standard definition, according to the majority of the literature, VPP includes various distributed power supply, controllable load, energy storage station and other objects, combination of advanced measurement techniques and communications technologies into an organic whole, regulated by a broker or a control center, as shown in **Figure 3**.

As can be observed in the diagram, VPP is a simplified version of the energy internet. VPP has the advantages of multiple complementary, scheduling, anti risk ability, through the integration of auxiliary networks such as oil, gas and network, the coupling and interaction between objects can be deepened, to achieve energy local interconnection, which can be used as a LAN for the future energy internet. VPP and the energy Internet in the technical there are many coincidences, therefore, to strengthen the virtual power plant research, is great significance achieve technical reserves for promoting the development of energy in the future.
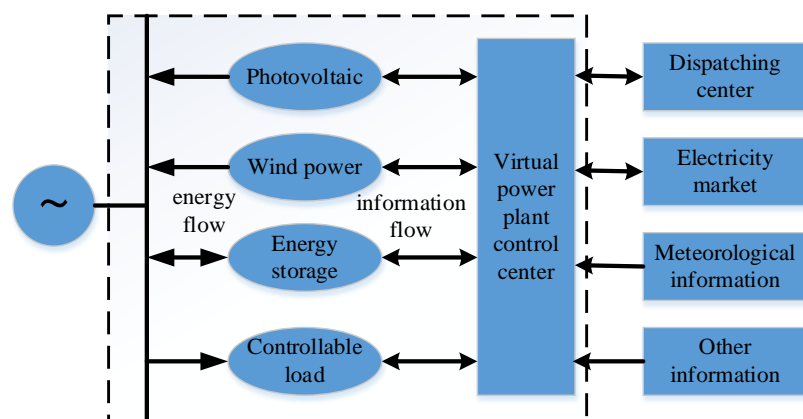
Figure 3. Sketch map of virtual power plant structure.

4.4. Cyber Security

In December 2015, the Black Energy virus attacked the Ukraine electric power system, caused thousands of homes without electricity [12]. According to ICS-CERT (industrial control system, network emergency response group) included in the industrial control network attacks in 2015, the energy sector accounted for 16%. The recent outbreak of extortion virus—"Eternal Blue", brought a warning to our cyber security.

The energy transmission and sales network of energy Internet is highly open, any energy supplier and consumers are free to access, compared with the conservative and close communication network, such as the traditional power grid and transportation network, it will face a more severe test. Therefore, improving protection technology of the network security and doing a good job of network security protection is of great significance to ensure the safe operation of the energy internet. To ensure the safe and reliable transmission of information, there can study on network architecture, information encryption, strong self-healing physical information channel, firewall and so on.

4.5. System Planning

The energy Internet is highly integrated with fossil energy, waterpower, and renewable energy sources, such as wind energy and light energy, and it is highly coupled with material, energy and information [13]. The development of energy Internet requires material science, information and communication, electricity, energy, environment and other disciplines as technical support, at the same time it was impacted by environmental requirements, safety requirements, energy policy, energy market and other aspects. Besides, compared with the traditional closed and independent energy supply system, the objects of the energy Internet are more and the system is more open, which makes the system more complex. Therefore, it is necessary to build a highly autonomous, two-way interactive, safe and reliable energy Internet system from a whole, which should consider the following aspects:

- The optimization of the energy structure in the energy Internet.
- Renewable energy consumption in the energy Internet.
- The proportion of controllable load and energy storage in the energy internet.
- Consider with energy policy, energy market orientation and environmental requirements.

5. Conclusions

The face of increasingly severe energy, the environment brought about by the test, the energy Internet will be an important means of future green energy applications. This paper mainly studies the characteristics and architecture of energy Internet, business demand and key technologies. The paper argues that:

- Energy Internet is an energy supply and demand system which based on the

power grid, the traditional fossil energy, wind energy, solar energy and other energy interoperability, "source-network-charge" to interactive and highly marketed and liberalized trading.

- Energy routers are the core of the future energy Internet, thus it needs to intensify efforts to study, especially the main components—power electronic transformers.

- In order to promote the development of energy Internet, this paper puts some suggestions as following:

- Establish demonstration project of energy Internet. Such as, establish the local energy Internet based on the virtual power plant model.

- Speed up the establishment of energy Internet standard system to guide the development of energy Internet, avoid the waste of resources because different manufacturers the blind development of related technologies according to their own standards or understand.

- The development and improvement of energy trading rules.

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