Analysis of typical characteristics and main functions of urban energy internet under city energy reformation

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Abstract. The construction of urban energy internet is an important starting point for realizing the national energy revolution strategy and promoting the high-quality development of city energy. At present, the research on urban energy internet is extensively carried out, and the definition of urban energy internet is also varied. This article summarizes the current mainstream views, summarizes and refines the structure, features, and main functions of the urban energy internet. Through combing the structure, features, and main functions, it enriches and improves the theoretical basis of the urban energy internet model and other research.

1. Introduction
The construction of urban energy internet is an important starting point to realize the national energy revolution strategy. Since the proposal of the National Energy Revolution Strategy, the practice of implementing the National Energy Revolution Strategy through the construction of the Energy Internet has continued to advance. In July 2015, the "State Council's Guiding Opinions on Actively Promoting the "Internet+" Action" was released [1], and "Internet+" smart energy became one of the key actions. The implementation of national macro-guidance in different cities requires specific methods of urban energy reform and urban energy internet development based on the development stages, development goals, and resource endowments of different cities. Therefore, it is necessary to analyze the relationship between the city and energy from different dimensions such as urban industry, environment and spatial structure, and to study the method of energy transformation from the perspective of urban sustainable development, and therefore the demand and construction method of urban energy Internet construction.

As early as 2011, American scholar Jeremy Rifkin proposed the Internet development vision for people to decentralize and freely produce and share renewable energy [2]. In terms of the architecture design of the Energy Internet [3,4], taking the FREEDM system as an example, it was developed by the US FREEDM Research Center established in 2008. Through research on key technologies such as high-bandwidth digital communications, distributed control, power electronics, etc. It supports plug-and-play, intelligent and efficient, safe and stable green energy network that can operate independently. Energy Internet technology has aroused widespread concern in China. State Grid Energy Research Institute, National University of Defense Technology, Information Technology Research Institute of Tsinghua University, Xinao Group, etc. have also proposed the concept of energy Internet [5-7]. With the continuous advancement of practice, the understanding of urban energy internet is also gradually adjusted. This article summarizes and analyzes the current research progress of urban energy internet in terms of urban energy internet structure, characteristics and main functions.
2. Urban Energy Internet Hierarchy

From the perspective of the layered structure, the urban energy Internet architecture can be deconstructed from three levels: the first layer is the physical layer, which including the actual energy production, conversion, transmission, storage, and consumption; the second layer is the information layer, which including the collection, transmission, processing and storage of information related to the operation of the energy system and user production and consumption; the third layer is the application layer, which including control scheduling, value-added services, market transactions, energy finance, supervision and management based on physical operation and data analysis.

2.1. Physical layer

The physical layer is the material foundation of the urban energy internet. Use the equality, openness, and sharing characteristics of the Energy Internet, take electricity as a medium, to promote the organic integration of various energy sources, and realize the efficient development, optimal configuration, and effective use of interconnection and interoperability, centralized and decentralized coexistence of various energy sources. Chemical energy, heat energy and other forms are mutually transformed to better meet people's basic needs for energy supply sufficiency and cleanliness, and to deal with issues such as climate change and energy resource crisis.

The physical layer of the urban energy Internet mainly includes physical facilities at all levels of energy and physical equipment at all levels of information. Considering that the transportation system and other energy consumption systems are the ultimate energy consumption subjects, they will not be repeated here. The main considerations related to the transportation system are electric. The car and its charging pile are equal to the content related to the power grid infrastructure.

The energy physical facilities mainly include four levels, namely the main network layer, the urban distribution network layer, the multi-level urban regional energy internet layer, and the micro-energy layer.

(1) Main network layer

The main network layer mainly includes the main electricity network and the main gas network, in the study of the single urban energy internet, the main function of the main urban network is to provide the city with electricity and natural gas and other types of energy, to meet the urban production and living energy needs;

(2) Urban distribution network layer

The urban distribution network layer mainly includes the urban distribution network, the urban gas network, the urban hot and cold network, due to the heating / cooling economic radius limit, the range of hot and cold energy supply is relatively small, the urban distribution network supplies energy for all levels of regional urban energy users.

(3) Multi-level urban regional energy internet layer

The multi-level urban regional energy internet layer mainly exerts the efficiency advantage of centralized cooling/heat supply for the peripheral microenergy network supply, including large-scale heat and electricity triple supply, waste combustion power generation/heating, large and medium-sized geothermal heating stations. The main function of the multi-level urban regional energy internet layer is to realize the coordination of centralized power generation, hot and cold supply and distributed power generation and hot and cold supply, and to meet the user's energy needs.

(4) Micro-energy layer

The micro-energy layer is the main body to achieve multi-energy complementarity, including energy production, storage and utilization of energy microsystems in all aspects, including distributed renewable energy generation / heating, small thermal power triple supply, small geothermal, fuel cells, P2G, etc.

2.2. Information layer

The information layer is an energy communication network covering all regions and fields of urban energy, and it is the intelligent support of the urban energy Internet. Promote the distribution automation
of the city's coverage, promote the use of gas, hot and cold information intelligence collection, pilot and promote new communication technology, synchronously build a city-wide coverage, different energy varieties, different grid gas level communication network, for the urban energy Internet to provide efficient information support.

The main function of the information layer of urban energy Internet is to realize the seamless interface between the application layer and the physical layer through information collection, transmission, analysis and processing and storage.

From the data source collected by the information layer, there are two main ways, namely, distributed data and centralized data collection. Distributed data acquisition mainly uses various advanced sensors to collect relevant operating data directly from various elements of the physical layer, including micro-energy network and urban area energy Internet data, and centralized data collection mainly utilizes the existing network operation database of various large energy enterprises, collecting the relevant data of the physical layer, including micro-energy network, urban regional energy Internet data, and the relevant data of the urban main network and distribution network.

From the operation control process, it is based on various applications as the core, through the information layer to transfer the control instructions to the physical layer, to achieve the precise control of the various elements of the physical layer.

2.3. Application layer
Relying on the urban energy Internet, we will carry out integrated energy services such as energy management, energy efficiency improvement, energy-assisted value-added services, financial services, energy storage services, electric vehicle recharge, etc., improve the efficiency of the entire energy system, strengthen the coordination of energy systems with other systems, and improve the quality of development of the whole city. Its typical applications include unified scheduling, energy trading, municipal interaction, open sharing, application warehousing, etc.

One of the important foundations of the application layer is the city's energy service management platform. Build an energy service management platform, collect all kinds of energy information in all aspects of energy, realize the unity of energy flow-information flow-value flow, promote the open sharing and standardization of all kinds of energy subjects, and realize the coordinated operation of source-net-lotus-storage.

3. Typical characteristics of urban energy Internet
The urban energy Internet has the following typical characteristics:

(1) Cleanliness: The large number of access to clean renewable energy is a typical feature of the urban energy Internet. Urban Energy Internet will greatly increase the proportion of clean energy in the future energy structure and become the basic platform to support the optimization and transformation of urban energy structure. The conversion of clean energy into electricity is the most efficient and convenient way to use it. At present, the intermittent, volatile and low energy flow density of renewable energy sources such as wind and solar energy have become bottlenecks that restrict their role in energy supply. The smart grid as the core of the energy Internet will be able to adapt to the needs of clean energy development by promoting the intelligent development of the power grid, upgrading functions, and promoting the optimal utilization of various energy forms.

(2) Distributed: Urban Energy Internet will be a centralized and distributed combination of system optimization and local autonomy complement the interconnection, layering, convergence of urban energy transformation and configuration network. The distributed energy system characterized by a variety of energy dispersion and step utilization will form the end node and realize the intensive and efficient utilization of energy. In the urban energy internet, a large number of decentralized energy is dispersed into the distribution network in various forms, which makes the urban energy supply mode from centralized to centralized and distributed combination, and the integration of distributed energy into the urban energy internet makes energy can quickly and efficiently achieve in-place balance and cross-regional balance.
(3) Interconnection: The interconnection of the urban energy Internet is reflected in the interconnection of the physical layer of equipment including power load network energy storage and the interactive sharing of information layers between various energy systems, and the unified distribution of various systems, so that the energy system sits in a coordinated, efficient and stable manner. The super-large urban energy internet will be a new urban energy information network platform with the deep integration of information communication technology and energy technology, the information flow is instant and smooth, the energy flow is economically efficient and the business flow interacts with each other.

(4) Intelligent: The widespread use of various intelligent devices and the improvement of the level of urban information automation make the production and distribution of energy and management of the whole process can achieve active control and optimize the scheduling, urban energy Internet has a strong adaptive capacity. The comprehensive penetration and sharing of value-added information is not only the technical guarantee of energy Internet to realize high intelligence, but also the basis for its full value function. Big data, cloud computing, Internet, Internet of Things technology will be integrated with new energy, smart grid technology, shaping the energy Internet from the traditional energy network of the essential attributes.

(5) Flexibility: The construction of the urban energy Internet has changed the traditional large network and large energy station-based energy supply model, the integration of various energy sources in the city and the mutual benefit at the multi-time scale, greatly improving the flexibility and reliability of energy system operation. Urban Energy Internet will play the fundamental role of the market in the energy system by realizing the original plug-and-play, promoting the innovation and integration of the Internet economy, and satisfy the higher demands of the multi-identity, independent choice and open sharing of urban users.

(6) Open: The urban energy Internet should be an open, fair and flat two-way energy sharing network, the energy generation unit energy storage unit and consumption unit can be plug-and-play, any node is the same status relative to other nodes, energy exchange does not have priority. With the full penetration of Internet concept, the energy Internet will be more open and shared, value innovation ability. Users will rely on seamless device-level access, system-level optimized configuration, two-way interaction of energy information to meet the identity requirements of energy providers and multiple users, and stimulate a more dynamic business model to promote the sustainable development of energy services.

4. Key functions of urban energy Internet
Urban Energy Internet has four functions, such as "energy integration optimization, information intelligent interaction, convenient smart service, value co-construction and sharing".

4.1. Energy Optimization Configuration
The most basic function of urban energy internet is to realize the supply and rationing of urban energy, urban energy Internet is the carrier of energy transmission and rationing within the city, and realize the orderly and efficient rationing of various energy sources within the city. At the same time, the urban energy internet makes full use of the supply and demand differences of various energy sources due to different forms of time and space, and realizes the development mode of combining the concentration and distribution of various energy sources, which is the basic platform for optimizing the configuration of energy across forms and across space-time regions. The overall balance of urban energy and the local balance of regional energy develop together to realize the optimal allocation of resources. The connection integrates different categories of energy, has a variety of energy transmission and resource optimization configuration functions, to achieve the complementary and complementary functions of installed-scale energy.

4.2. Information Intelligence Interactive
Urban Energy Internet is an important hub of information in urban areas, through various measurement devices to transmit equipment and information processing platform, can efficiently collect and process
the energy system in operation of large amounts of data generated, to achieve real-time data transmission and sharing between energy suppliers and users. The information intelligent interaction function is to realize the real-time wide area awareness and interconnection of different locations, different devices and different information, to realize the information sharing and improve the system perception, control and response ability. The information intelligence interaction function can promote the level of informationization of energy infrastructure. Information intelligence interactions can drive the digital transformation of energy companies. Information intelligence interactions drive digital transformation of users.

4.3. Convenient Smart Energy Services
Urban energy Internet construction can enhance the refinement of energy regulation. Through the aggregation analysis of data, through the assistance of many kinds of energy analysis tools, it provides tools for the government to better formulate energy planning, market policy, industrial subsidy policy, and market supervision to promote the construction of a scientific norm, overall and coordinated urban energy governance system. The construction of urban energy Internet system can provide users with more convenient and intelligent energy services. Urban energy Internet construction can effectively obtain the terminal equipment measurement data, whether it is the global monitoring and control of the operation of the power grid, or the portrayal and learning of users’ electricity behavior, will provide great help, on the basis of data acquisition combined with advanced technology under the Internet of Things, can further break the technical barriers of energy services, and constantly expand its service content, to provide users with more convenient and intelligent energy services.

4.4. Value Co-building Sharing
Governments, energy enterprises, equipment manufacturers, Internet of Things enterprises, Internet enterprises, users, etc. participate in the construction, so that relevant parties to obtain project information, interaction with project developers, to promote new business, new business, new economic development. Urban Energy Internet creates a value creation platform for the upstream and downstream industrial chains, and realizes the sharing and opening of resources and capacity. Through the Internet thinking to promote the transformation and development, mining potential public value, promote sustainable urban development. Public consultation and public participation play an important role in giving the public the opportunity to participate in the planning of projects.

5. Conclusion
This paper analyzes and summarizes the structure, characteristics and main functions of urban energy internet under the urban energy reform, in order to support the high-quality development of urban energy and urban energy reform, accelerate the construction of urban energy Internet, it is necessary to form a unified framework, and then clear the function, carry out related construction. The three-tier structure of urban energy Internet has universal applicability, and the energy optimization configuration function, the interaction of information intelligence, the convenient smart energy service and the value co-construction and sharing function can promote different subjects to participate in the construction of urban energy Internet and obtain the benefits.

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