Study and design on the typical plan for regional hybrid energy internet

Zhenyu Zou, Shuai Zheng and Zhicheng Sha
Shandong Electric Power Engineering Consulting Institute Corp, Ltd. 106 Minziqian Road, Jinan, Shandong, China

Abstract. The emergence of the energy internet has changed people's understanding of energy production, transmission, storage, conversion, consumption and so on. However, how to promote the development of the energy of the Internet, how to make it with the existing various types of energy entities organic integration, so that it can play an important role, we still need do more in-depth research and practice. After introducing the current situation for energy internet at home and abroad, the definition, character and motion traits of regional energy internet, this paper comprehensively studied typical scheme for regional energy internet based on Multi-energy complementary and developed the feasible suggestion key techniques and directions on development for regional energy internet.

1. Introduction
Energy Internet is a complex multi-net flow system formed by tight coupling with gas networks, transportation networks and other systems based on the Internet and other advanced information technologies, with distributed renewable energy as the main primary energy source and with the power system at the core[1]. The system function, technical framework, information technology and development prospect of the energy Internet are analyzed and expatiated in the documents, respectively, which provides a technical foundation for regional energy management under energy interconnection[2].

Based on the present development of the energy Internet both at home and abroad, this paper presents the definition and characteristics of the regional energy Internet[3], analyzes application patterns of a variety of intelligent control equipment and management technologies by systematically studying the typical plan for the regional energy Internet according to the characteristics of energy flow and information flow based on multi-energy complement, and puts forward a new operating mechanism by summarizing the operation characteristics of the regional energy Internet[4]. In the end, the paper puts forward feasible proposals in respect of the key technologies and directions for future development of the regional energy Internet[5].

2. Regional energy Internet
Energy Internet is a “Wan” of multi-energy information combination built based on the Internet philosophy, correspondingly, the regional energy can be regarded as a “Lan”, known as "regional energy Internet”. Externally it transfers information with "Wan" and settles energy accounts, and internally it provides energy management and service for regional users\[6\]. The regional energy Internet is the basis for multi-energy system analysis, and also a concrete embodiment of multi-energy system characteristics\[7\]. From the perspective of functions, the multi-energy system can integrate various forms of energy organically and regulates distribution of them according to prices, environmental impact and other factors; from the perspective of energy services\[8\], it can shift electricity from peak periods to off peak periods for reasonably use energy by reasonable regulation with different needs of users taken into account; from the perspective of the energy network, it can promote the development of various energy technologies by collaborative analysis of electrical networks, natural gas networks, heating networks and so on. A region can be as large as a city, town, community, or as small as an industrial park, a large enterprise, building, which in general covers an integrated energy system of power, gas, heating, hydrogen and electrified transportation as well as related communication and information infrastructure, essentially characterized by energy generation, transmission, transformation, storage, consumption and other processes\[9\]. In this regional network where various energies are integrated, carriers of information include “power flow”, “gas flow”, “information flow” and “material flow”, etc. Due to its small size, the government, energy companies and large industrial enterprises can take the lead to construct and implement the regional energy Internet, and therefore it has higher practical values\[10\]. As a part of the energy Internet, the regional energy Internet involves a number of energy procedures in different forms and with different characteristics. It includes the energy procedures that can be easily controlled and intermittent ones that are hard to control; includes the energies that are difficult to store in large capacity and the energies that are easy to store and transfer; and there is collaborative supply at the energy generation end and coordinative optimization at the energy consumption end\[11\].

3. Main characteristic of the regional energy internet

Compared with the main energy Internet across regions, the regional energy Internet takes all local industrial businesses and residents as its user groups and meets the load demand of the local users by data analysis, energy coordination and optimization of the scheduling mechanism based on collection of data on energy production, consumption, transport, storage and other information. Correspondingly, as a link to contact different regional energy Internets, the cross-regional energy Internet realizes long-distance transmission of energy across regions depending on large backbone networks of power transmission, power transmission and other systems, ensuring safe and steady operation of all regional energy Internets within coverage and providing external interfaces when there is energy overflow or gap on the regional energy Internets. In order to fit the energy supply and demand patterns within the region, the regional energy Internet has developed some characteristics differentiating itself from the cross-regional energy Internet based on fully absorbing excellent experience in the Internet development.

3.1. Multi-energy complement

In order to meet the complex load demand of users in the region, the regional energy Internet has distributed a lot of distributed energy facilities within the coverage, with types covering distributed CCHP system, Combined Heat and Power (CHP), photovoltaic power generation, solar collector system, hydrogen generation station, ground source heat pump and other forms, which constitute a
compound supply system combining power, heat, cold, gas and many other forms of energy, effectively realizing cascaded utilization of energy. Besides, the regional energy Internet provides standard plug and play interfaces for access of all types of distributed energies, but it has also put forward higher request for optimization and control of the energy Internet. To this end, gas-electrical coordination planning, P2G, V2G, fuel cell technologies and other technologies promoting multi-energy integration will play a more important role in the future.

3.2. Two-way Interaction
The regional energy Internet will break the existing source-network-load pattern of energy flow and create a free two-way controllable multi-terminal energy flow pattern, and the distributed energy router will make it possible for energy interconnection of any node within the region. The industry barriers between original heating companies, electricity companies and gas companies will be broken by establishment of energy conversion stations or energy hubs, and residents equipped with distributed generation units are expected to participate in energy supply along with other energy suppliers. In the future, along with the rapid development of the electric car industry, the intelligent electric vehicles centered traffic network will also be integrated into the existing energy Internet mode.

3.3. Full self-government
Different from the traditional energy use patterns, the regional energy Internet makes full use of various energy resources in the region to build a self-sufficient energy system and fully consume distributed energy resources within the region to realize efficient use of various energy facilities. And as an essential part of the main energy Internet, the regional energy Internet maintains a two-way controllable energy flow form with the backbone energy networks and carries on energy and information exchanges with other regional energy Internets through the large backbone energy networks.

In conclusion, the regional energy Internet is mainly characterized by using the "Internet plus" thinking to reset the energy network needs and achieve a high degree of integration of energy and information, so as to promote the construction of informatization infrastructure of energy networks. By introducing online trading platforms, big data processing and other technologies, the energy Internet will fully tap data on energy production, transport, consumption, transformation, storage and other information, and explore technologies by means of energy demand forecasts, demand-side responses and other information to guide energy production and scheduling.

4. Typical plan for the regional energy Internet

4.1. Overview of the planned region
The region is planned to cover an area of about 64 square kilometers in total, which will be constructed along with new-type urbanization in combination with comprehensive management of canal ecology, building all unincorporated villages into creative towns. So far 1100 mu of the land has been constructed and used, with buildings covering an area of 540,000 square meters. The new land planned for construction will be 2200 mu and the new construction area will be 1.5 million square meters by 2020, mainly for shopping center, maker base, film and TV production base, elderly care and health care base, spa resort, education and other industries. According to the comprehensive development plan for the near future and energy use characteristics in different functional areas, the regional maximum power load is measured 30MW.
4.2. Study on the plan
To build the intelligent energy system for the planned region according to the collaborative development idea of “source-network-load and Internet plus”, based on planning and load demand characteristics of the entire 64 square kilometre region, the whole regional energy system includes energy stations (distributed rooftop PV – PV town, farmers light complementary, biomass, waste and biogas power generation for centralized heating, distributed gas CCHP, LNG vaporizing stations), energy networks (integrated tube galleries in the park, connected through power, heating and gas networks between energy stations and linked together with the user load), integrated energy control centres—building an integrated energy control system based on information networks, big data, cloud computing, the Internet and other technologies, to realize order form-based production, intelligent visualized selective consumption, multi-dimensional optimal allocation of energy production elements; employing distributed centralized heating to make gas, electricity, heating, cooling, water and other integrated energies couple with each other, thus improving the efficiency of energy utilization.

The original unincorporated villages will be merged into 14 new featured towns. And all new buildings in the towns will be combined with PV organically, maximizing the use of renewable energy. The planned PV installed capacity is up to 25MW. And each town will be equipped with a gas CCHP energy station, realizing centralized heating and cooling supply in the neighbourhood to reduce energy loss. The surrounding areas of villages and town will be arranged with PV units to improve the efficiency of land use; use of electric vehicles will be promoted and integrated charging piles will be installed in the park to reduce greenhouse gas emissions while consuming the renewable energy.

The plan for the near future is developed around the existing region and the area to be developed before, a total of 3300 mu, planning to supply heating and cooling and provide hot water for life based on the advanced air-source heat pumps by using the distributed energy for natural gas engine CCHP distributed energy at the core, supplemented by distributed PV and wind energy systems, linked by power, shift electricity from peak periods to off peak periods based on energy storage units (including cool storage, heat storage, electricity storage), and optimize the use of energy by storing cool and heat with valley point electricity; the supporting works include distribution networks, comprehensive pipe racks, sewage treatment, building of car charging piles, integrated street lamps with scenery storage and integrated energy management centre; and complete intelligent energy use and measurement units along with completion of the buildings.

4.2.1. Multi-energy complement. According to energy requirements in 2020, with construction of the gas CCHP system at its core, the plan seeks comprehensive utilization of various renewable energy sources (solar power, wind energy, air source heat pumps, integrated street lamps with scenery storage), takes advantage of off-peak power at night to reduce the difference between peak and valley electricity, regulates changes in load of users by means of cool storage, heat storage and power storage, thus constituting an integrated intelligent energy system of multi-energy complement of primary and secondary energies within the region, to realize green, efficient and economical energy use.

According to the preliminary estimate, annual consumption of natural gas will be 40 million Nm3, 5.5 million kWh of solar power, 800,000 kWh of wind power, and 600,000 kWh generated by landscape lamps. Due to the massive use of air source heat pumps and energy storage for energy supply, the proportion of non-fossil fuel energy supplies will be over 30%.
4.2.2. Integration and optimization. By comprehensive intelligent use and management of multiple energy resources by means of “Internet plus”, energy conversion stations can be placed in the neighborhood according to different load demands of distributed users for integration and optimization by interconnection between power, heating and gas networks. A reasonable and economical operation plan should be developed by installing meters at the user end and analyzing the energy use habits of the users based on big data. In terms of energy production, solar and wind power as well as other renewable sources of energy will be used as preferences for heating supply within the region, with the shortfall to be supplemented by gas or power, besides, cool storage, heat storage, power storage street lamps, and other energy storage ways will be employed to maximize development and use of the renewable energy and increase the consumption proportion of the renewable energy.

A total of 28MW internal combustion engine generator set will be built at the energy station, fume waste heat and jacket heat after natural gas combustion and utilizing will enter the lithium bromide unit for further use, supplying cool in summer and heat or domestic hot water in winter after heat transfer, to realize cascaded utilization of energy. The overall efficiency for energy utilization at the energy station is about 84.3%.

As the day is a peak time in cities, PV power can complement urban consumption, helping reduce gas consumption of the energy station. The project gives priority to the use of renewable energy, which will be fully consumed if energy storage units are used in combination.

By centralizing the management of energy supply and building an integrated energy management system, the basic parameters of users can be automatically transmitted to the energy monitoring center through the remote monitoring device. The center will collect and analyze the data and regulate the operating parameters of the system in time. With accumulation of historical data, the system can forecast energy use, facilitating energy scheduling preparation. An integrated supply-purchase-sale electricity information acquisition system measuring in real time on demand will be built for construction of the power service platform, to build an intelligent and green interactive service system.

4.2.3. System reliability. Because the system is based on grid-connected operation, it can guarantee the sustainable and stable supply of electricity and other energy sources. If the external power supply is interrupted at night due to any special circumstance, the internal combustion engine generator set can be ensured to start quickly (less than 30 minutes from start to full load), providing power protection for the park. The energy station is equipped with two gas sources. There is pipeline gas connecting the station besides its own LNG storage tanks and gasification plant. Even if the two gas sources are at failure, the power from the empirical grid will ensure cold and heat supply in the park. The energy supply reliability rate is over 99.5%.

4.2.4. System intelligence. The integrated energy management system is a large open platform for energy management services supported by big data, Internet of things, mobile Internet and other technologies. The system is in a hierarchical distributed structure and performs intelligent processing of all information it “has sensed” on production, transmission and consumption of power, heat (cool), water, gas and other energy with the help of the cloud data center, to monitor and manage the whole energy system.

The integrated energy management system can change energy users’ passive consumption in the planned mode, and can provide a platform for implementation of the market-oriented energy pricing mechanism, so that energy market players can be energy producers and consumers and actively
engage themselves in balancing energy supply and demand, realizing interactions between different energy producers, interactions between different consumers and interactions between producers and consumers.

5. Summary
The typical plan presented in this paper creates a solution that is based on cooperation and joint development between energy suppliers and users, subject to sharing revenues and risks. Technically, natural gas, solar and wind power as well as other clean energy are used to replace coal, with cascaded utilization of the gas turbine waste heat, utilization of waste energy of air source heat pumps, integrated innovation of cool (heat) storage units, having different types of energy complement each other, to improve the overall efficiency of energy utilization, create clean energy demonstration zones, and employ big data, cloud computing and other advanced Internet technologies in combination with intelligent energy control strategies to control energy use. It will provide a strong demonstration effect to optimizing urban energy structures, full exploitation of renewable resources, increasing the proportion of energy consumption of gas and electricity, achieving secured and reliable energy supply, diversifying and cleaning energy supply patterns.

Energy construction and development of the energy Internet will be a long and gradual process, and the plan put forward in this paper will be also constantly modified and improved in practice. Construction of the energy Internet needs to be advanced jointly by physical energy systems, information and communication systems, optimal scheduling systems and auxiliary control systems, which complement each other and need harmonious development.

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