Development status and some considerations on Energy Internet construction in Beijing-Tianjin-Hebei region

Xinxin Zhang a,b,∗, Kaili Xu a,b, Maogang He c
a MOE Key Laboratory of Enhanced Heat Transfer and Energy Conservation, Beijing University of Technology, Beijing 100124, PR China
b Beijing Key Laboratory of Heat Transfer and Energy Conversion, Beijing University of Technology, Beijing 100124, PR China
c MOE Key Laboratory of Thermo-Fluid Science and Engineering, School of Energy and Power Engineering, Xi’an Jiaotong University, Xi’an 710049, PR China

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ABSTRACT

The coordinated development of the Beijing-Tianjin-Hebei region has become China’s national strategy with great and far-reaching significance. The construction of Energy Internet is an important measure to strengthen the coordination of green energy development in Beijing-Tianjin-Hebei region and promote the development of renewable energy. In this paper, based on the development status of renewable energy in the Beijing-Tianjin-Hebei region, the problems and challenges existing in the renewable energy development in the Beijing-Tianjin-Hebei region and related considerations for their solution are reviewed and discussed. Energy Internet has also become a booster for the rapid development of clean and renewable energy. The policies on the Energy Internet Construction issued by Beijing, Tianjin, and Hebei during the 13th Five-Year Plan Period (2016–2020) and at the beginning of the 14th Five-Year Plan Period (2021–2025) are summarized. The focuses of all these policy documents are analyzed. The development status of seven Energy Internet demonstration projects in Beijing-Tianjin-Hebei region is reviewed. On this basis, some considerations on Energy Internet construction in the Beijing-Tianjin-Hebei region are analyzed and proposed.

1. Introduction

Since the reform and opening up of China, there have been Yangtze River Delta and Pearl River Delta urban groups in the south, while Beijing is the only ‘Big Mac’ city in the north. Beijing has not only assumed the functions of the political center of the capital, but also the functions of the national cultural center, science and technology center, education center, medical center and northern economic center. Too many urban functions lead to the population entering Beijing far larger than other first-tier cities. In order to ease the non-capital functions, resolve Beijing's big city disease, adjust and optimize the urban layout and spatial structure, Chinese government approved the plan outline of the coordinated development of the Beijing-Tianjin-Hebei (BTH) region in April 2015, and published the final plan in 2016. On April 1st, 2017, the Communist Party of China Central Committee and the State Council decided to establish Xiongan New Area in Hebei Province as part of the larger BTH development plan. The establishment of Xiongan New Area not only alleviates the pressure on Beijing’s population, but also promotes the coordinated development of the BTH region which has become China’s national strategy with great and far-reaching significance.

Energy is an important material basis for urban construction, operation, and development. Marked by the Paris Agreement, “decarbonization” in the field of energy is becoming a global consensus. China has made a commitment to the international community that China would strive to reach peak carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060. By the end of 2020, China’s cumulative installed capacity of renewable energy has accounted for 1/3 of the global total installed capacity of renewable energy, ranking first in the world [1]. This has laid a solid foundation for achieving the goal of peak carbon dioxide emissions and carbon neutrality. As far as the BTH region is concerned, the vigorous development of renewable energy has led to an explosive growth of wind and solar power [2]. Zhangjiakou City, Hebei Province is the first and only national-level renewable energy demonstration zone approved by the State Council. In 2019, the city’s total renewable energy power generation exceeded 25 billion kWh, with a year-on-year increase of 15%, accounting for 49.0% of the total power generation [3]. This is also in line with the trend of energy structure.
planning of world-class cities based on carbon-free electricity and renewable energy [4, 5, 6].

Major breakthroughs have been made in energy technology, and the economic feasibility of low-carbon energy technology has been gradually enhanced. In the medium and long term, the technical economy of renewable energy power generation will gradually surpass the fossil energy power generation technology. However, how to absorb the electricity generated by renewable energy has become an urgent problem to be solved at present. Moreover, the decentralization of power generation technology has also led to the low energy utilization efficiency. Therefore, the combination of technology and network is imperative. At the same time, the freely shared Internet thinking has brought about a revolution in energy system, and the era of "Internet +" has swept through. Under this background, Jeremy Rifkin, an American economist and futurist, proposed the concept of "Energy Internet" in his book "The Third Industrial Revolution" in 2011, and considered that the integration of Internet technology and renewable energy is the solid foundation of the third industrial revolution [7]. Energy Internet treats microgrids as infrastructures at the end of future energy systems for a combination of the Internet and renewable energy sources, thereby allowing the access of large amounts of distributed energy resources and converting energy supply from centralized to distributed [8, 9]. Energy Internet has also become a booster for the rapid development of clean and renewable energy.

Under the framework of the "Beijing-Tianjin-Hebei Energy Coordinated Development Plan (2016–2025)" issued by the National Development and Reform Commission and the National Energy Administration, the "Beijing-Tianjin-Hebei Energy Coordinated Development Action Plan (2017–2020)" has just been implemented. Eight coordinated tasks were mentioned in this plan, three of which were related to the Energy Internet, namely: management coordination, innovation coordination, and market coordination [10]. Among the first 55 "Internet + " smart energy (Energy Internet) demonstration projects announced by the National Energy Administration, 7 are in the BTH region. 4 of them are in Beijing and 3 are in Hebei [11].

A variety of research work has focused on the renewable energy resources within Beijing, Tianjin and Hebei region. Representative work includes establishment and optimization of renewable energy installation planning within BTH region [12], decarbonising electricity systems through renewable cooperation [13], regional allocation of renewable energy quota [14], impacts of renewable energy development on CO₂, NOₓ and SO₂ emissions in BTH region [15], the flexibility pathways for integrating renewable energy into coal dominated power system [2], and the performance of the energy system in the BTH region under different scenarios of wind and solar power penetration [16]. Moreover, the Energy Internet has also attracted a lot of attention [8, 9, 17, 18, 19, 20]. The research work on energy Internet mostly focuses on technology architecture construction theory [17], architecture establishment of microgrid energy management system [18], evaluation model and case study [19], and optimal planning strategy [20]. However, according to literature surveys, few papers cover Energy Internet construction policies and Energy Internet demonstration projects in China. Therefore, in this paper, based on the development status of renewable energy in the BTH region, the problems and challenges existing in the renewable energy development in the BTH region and related considerations for their solution are reviewed and discussed. Considering the advantages of Energy Internet in deep integration of renewable energy and Internet information technology, the policies on the Energy Internet Construction issued by Beijing, Tianjin, and Hebei during the 13th Five-Year Plan Period (2016–2020) and at the beginning of the 14th Five-Year Plan Period (2021–2025) are summarized and analyzed. The development status of seven Energy Internet demonstration projects in BTH region is also reviewed. On this basis, some considerations on Energy Internet construction in the BTH region are analyzed and proposed.

2. The development status of renewable energy in the BTH region

2.1. Renewable energy resources

2.1.1. Solar energy

Beijing, Tianjin and Hebei all have good solar energy resources. The solar energy resources in China are classified into four divisions: rich, relatively rich, general, and poor. The BTH region belongs to the “relatively rich division”. Beijing has an annual radiation amount of about 5061 MJ/m² with an annual sunshine time reaching up to 2761 h. In the past 30 years, the average total solar radiation in Tianjin has reached 5966 MJ/m², and the annual sunshine time has stayed at 2471–2769 h. Hebei receives an annual radiation of 4981–5966 MJ/m². Zhangjiakou and Chengde, which locate in the north of the province, has an average sunshine time as high as 3000–3200 h [2]. The utilization level of solar energy in the BTH region is at the forefront in China. China's first solar thermal power generation demonstration project, which was approved in May 2009, is located in Beijing's Yanqing-Badaling area. It is China's first megawatt solar tower power plant that has successfully generated power. Yizhuang town, Daxing district, Beijing, which has a 20MW Gold Sun photovoltaic roof project approved in December 2010, is national centralized application demonstration area of solar photovoltaic power generation. Currently, through the installation of solar photovoltaic power generation equipment on the building roof, Beijing has realized the combination of solar photovoltaic power with building [21]. Building-integrated, grid-connected distributed solar photovoltaic systems have been vigorously promoted by Beijing and Tianjin. As far as Hebei Province is concerned, since the beginning of the 12th Five-Year Plan period, a large number of concentrated solar photovoltaic power plants have been successfully built, and a complete industrial chain of solar photovoltaic power generation has been formed.

2.1.2. Wind energy

As an inland city, Beijing has almost no offshore wind resources and small onshore wind amount and low wind speed. Beijing locates in wind energy distribution zone III, namely available zone. Beijing has a wind resource reserve which approximately equals to 4.6 billion kilowatt [21]. Wind farms in Beijing are concentrated on the south bank of the Guanting reservoir in Yanqing county. In 2008, with the last ten wind turbines of Guanting wind farm successfully passed the acceptance of the power company and officially connected to the grid for power generation, Beijing achieved a zero breakthrough in the development and utilization of wind energy. According to Beijing’s energy development plan during the 13th Five-Year Plan period, by 2020, Beijing’s newly installed wind power generation capacity would reach 450,000 kW, reaching a total capacity of 650,000 kW. In contrast, the coastal areas of Tianjin and Hebei Province have rich wind power resources. Hebei, in particular, has become a key area for wind power development in the BTH region due to its superior resource conditions and vast land area. Wind power development is at the forefront of China. Zhangjiakou, which locates in wind energy distribution zone II, has an exploitable 40 GW of wind energy resource and become one of the important wind power bases in China [13]. Tianjin vigorously accelerates the construction of coastal wind power base and promotes the non-grid-connected wind power desalination industry.

2.1.3. Geothermal energy

The BTH region is rich in geothermal resources. Winter heating, boiler feed water, greenhouse cultivation, bath care, industrial utilization, and aqua culture have been realized by using geothermal water. As Beijing is an inland city, Beijing has almost no offshore wind resources and small onshore wind amount and low wind speed. Beijing locates in wind energy distribution zone III, namely available zone. Beijing has a wind resource reserve which approximately equals to 4.6 billion kilowatt [21]. Wind farms in Beijing are concentrated on the south bank of the Guanting reservoir in Yanqing county. In 2008, with the last ten wind turbines of Guanting wind farm successfully passed the acceptance of the power company and officially connected to the grid for power generation, Beijing achieved a zero breakthrough in the development and utilization of wind energy. According to Beijing’s energy development plan during the 13th Five-Year Plan period, by 2020, Beijing’s newly installed wind power generation capacity would reach 450,000 kW, reaching a total capacity of 650,000 kW. In contrast, the coastal areas of Tianjin and Hebei Province have rich wind power resources. Hebei, in particular, has become a key area for wind power development in the BTH region due to its superior resource conditions and vast land area. Wind power development is at the forefront of China. Zhangjiakou, which locates in wind energy distribution zone II, has an exploitable 40 GW of wind energy resource and become one of the important wind power bases in China [13]. Tianjin vigorously accelerates the construction of coastal wind power base and promotes the non-grid-connected wind power desalination industry.
geothermal reservoirs of Gaoyuzhuang Formation, with the first-phase installed capacity of 280 kW and geothermal heating of 30000 m² [23].

2.1.4. Biomass energy

Beijing has relatively abundant biomass energy resources, which are mainly distributed in the suburbs. At present, the application ways of biomass energy are generating biogas and biomass power generation. As of 2014, there have been 128 biogas projects in normal operation in Beijing, among which 15 projects have the daily biogas production capacity of more than 500 m³ [24]. With respect to biomass power generation, four waste incineration power plants with a total capacity of 100MW in Beijing, namely Gaotantun, Nangong, Liulitun, and Asuwei, were put into use in 2010 [21].

In Tianjin, the methane production from municipal solid waste via landfill treatment is 0.04 million tons [25]. The Tianjin Ninghe Biomass Power Generation Project, which was completed and put into operation in 2018, has a construction scale of processing 500 tons of domestic waste per day, and the straw incineration power generation project has a scale of processing 300,000 tons of biomass straw per year [26]. Hebei Province, where Xiongan New Area is located, ranks 5th-8th in China in terms of the number of biomass power generation projects, installed capacity, and on-grid electricity [27]. Reed, which is a special product of Baiyangdian in Xiongan New Area, can be used as the main biomass fuel for biomass power plants and waste incineration power plants.

2.2. Problems and challenges existing in the renewable energy development in the BTH region and related considerations for their solution

At this stage, the renewable energy development in the BTH region still has the following problems to be solved.

(1) Renewable energy industry in the BTH region lacks scientific planning and development system and mechanism are imperfect. It is required that the BTH region make a clear plan for the mechanism and system of new energy industry. China's new energy industry is still in the initial stage of industry development. The core technology is urgently to be broken through and the industry has great potential for development. It should take the opportunity of the coordinated development of the BTH region to establish the core position of new energy technology innovation and drive the technology improvement and leap of the national new energy industry.

(2) The integrated planning of the BTH region has not yet been realized. The development of new energy industry contains strong technical and social factors of production. At the early stage of development, the market has great uncertainty. The development of new energy industry cannot completely rely on the spontaneous behavior of market, and it needs to rely on government guidance. Especially in the aspect of spatial layout, sufficient preliminary planning is needed. The spatial planning of the new energy industry should fully consider the coordinated development of the BTH region to achieve a unified planning.

3. The development status and some considerations on Energy Internet construction in Beijing-Tianjin-Hebei region

Energy Internet is a new business paradigm. Successful transformations of various traditional industries under the influence of Internet inspired the birth of the concept of Energy Internet. In the Energy Internet, consumers, prosumers, communities, microgrids, and utility companies (defined as different types of Energy Cells) all participate in the energy market in an equal and leveled playground [28].

Renewable energy has the advantages of being renewable, low-carbon and environmentally friendly. Nowadays, its basic utilization form is the conversion into electric energy for transmission and use. However, it also has the characteristics of randomness, intermittence, volatility, anti-peak regulation, and geographical imbalance distribution, which results in the variability and relative unpredictability of the power generation output of renewable energy utilization system. According to the characteristics of renewable energy, its power generation fluctuates at the second, minute, hour, and seasonal level, and it is difficult to change the power generation output in real time according to the grid dispatching instructions, which causes many problems in the acceptance and utilization of the power grid. In addition, in order to ensure reliability, the traditional energy grid is relatively conservative and closed; different types of energy grids are separated from each other and the degree of interconnection is limited, which is not conducive to the improvement of comprehensive energy efficiency and the consumption of renewable energy. Therefore, it is urgent to introduce the concept of Internet's open interconnection into energy network, and construct energy Internet to break the above barrier.

3.1. Policy support

China first proposed the construction of a global energy Internet in July 2014. Since then, the State Council, the National Development and Reform Commission, the National Energy Administration, and the Ministry of Industry and Information Technology have issued a series of documents that have greatly promoted and encouraged the research and construction of China's Energy Internet. Specific to the Beijing-Tianjin-Hebei region, the policy documents related to the Energy Internet issued during the 13th Five-Year Plan period are listed in Table 1 and those issued at the beginning of the 14th Five-Year Plan period are listed in Table 2.

The policy documents issued by Beijing during the 13th Five-Year Plan period emphasize the following three aspects.

(1) Promote the development of the Energy Internet by strengthening the construction of the Energy Internet infrastructure, encouraging new modes of energy storage operation, and launching pilot demonstrations of the regional Energy Internet.

(2) Accelerate the promotion and application of Energy Internet standards, improve the research and development capabilities and industrialization levels of key Energy Internet technologies and products, and cultivate a group of Energy Internet companies with international competitiveness.

(3) According to the advanced concept of Energy Internet, focus on the development of new energy micro grid demonstration projects. Relying on the Energy Internet system, build an energy

| Region | Title of the policy document | Release time |
|--------|-----------------------------|--------------|
| Beijing | Beijing's Energy Development Plan during the 13th Five-Year Plan Period | June, 2017 |
| Tianjin | Tianjin's Energy Development Plan during the 13th Five-Year Plan Period | November, 2017 |
| Hebei | Hebei's Energy Development Plan during the 13th Five-Year Plan Period | September, 2017 |
| Beijing | Implementation Opinions of the Beijing Municipal People's Government on Actively Promoting the Internet + Action | January, 2016 |
| Tianjin | Construction of Smart City in Tianjin during the 13th Five-Year Plan Period | November, 2016 |
| Hebei | Development plan of new and renewable energy in Beijing during the 13th Five Year Plan Period | August, 2016 |
| Beijing | Development plan of renewable energy in Hebei province during the 13th Five-Year Plan Period | October, 2016 |
| Hebei | Implementation Opinions of the People's Government of Hebei Province on Promoting the Internet + Action | December, 2015 |
integration architecture with power grid as the "backbone network", microgrid and distributed energy as the "Lan", and open and peer-to-peer information as the data source.

The policy documents issued by Tianjin during the 13th Five-Year Plan period emphasize the following two aspects.

1) Promote the construction of the city's Energy Internet and increase the development of distributed and shared energy.

2) Innovate the "Internet + New Energy" development model to promote the construction of smart city.

The policy documents issued by Hebei during the 13th Five-Year Plan period emphasize the following three aspects.

1) Vigorously promote smart micro-grid and "Internet +" smart energy demonstration projects. Actively develop "Internet +" smart energy. Promote the deep integration of the Internet, information technology and the energy industry.

2) Promote the technological progress of the Energy Internet to lay the foundation for the further development and utilization of renewable energy.

3) "Internet +" Smart Energy. Improve the level of intelligence in energy production. Build a diversified energy network. Innovate the final energy consumption model.

The 14th Five-Year plans of Beijing for national economic and social development and the outline of long-term goals for 2035 emphasizes the adoption of the "negative restriction list + positive encouragement list" management model for the Energy Internet field. The 14th Five-Year plans of Tianjin for national economic and social development and the outline of long-term goals for 2035 emphasizes the promotion of the construction of Binhai Energy Internet Comprehensive Demonstration Zone.

3.2. Demonstration project

The first batch of 55 demonstration projects of Energy Internet has been announced by the National Energy Administration in June 2017. Among these first 55 demonstration projects, 7 are in the BTH region. 4 of them are in Beijing and 3 are in Hebei. The brief introduction of all these 7 demonstration projections is given in Table 3.

### Table 2. Policy documents related to the Energy Internet issued by Beijing, Tianjin, and Hebei during the 14th Five-Year Plan period.

| Region   | Title of the policy document                                                                 | Release time |
|----------|-----------------------------------------------------------------------------------------------|--------------|
| Beijing  | The 14th Five-Year plan of Beijing for national economic and social development and the outline of long-term goals for 2035 [37] | January, 2021 |
| Tianjin  | The 14th Five-Year plan of Tianjin for national economic and social development and the outline of long-term goals for 2035 [38] | February, 2021 |

### Table 3. Brief introduction of 7 demonstration projections of Energy Internet in Beijing and Hebei.

| Region                          | Demonstration project name                                                                 | Construction and management                                      | Project status                                                                 |
|---------------------------------|-------------------------------------------------------------------------------------------|------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Beijing                         | Comprehensive Pilot Demonstration of Energy Internet in Beijing Economic and Technological Development Area (Lunan) | Beijing Zhongmin Zhizhong Energy Technology Co., Ltd.             | The cryogenic liquid air energy storage system in the project is well adapted to the energy storage needs of surrounding large and medium-sized industrial enterprises. Integrated with combined cooling, heating and power, it has achieved high comprehensive energy efficiency and made full technical preparation for the market-oriented reform of the key distribution network link of energy Internet. |
| Beijing                         | "Internet +" Smart Energy Project in Industrial Park, Beijing Economic and Technological Development Area | Beijing Jingkai Investment Development Co., Ltd                  | The total installed capacity of the distributed photovoltaic project is 2.4MW, providing about 2.88 million kWh of "green power" for the park throughout the year, and reducing about 2870 tons of carbon emissions in the park annually. As a newly built project, the 1.5MW distributed photovoltaic project has planned new technologies such as energy management cloud platform, big data, intelligent control, etc., and has become an important project of the energy Internet smart photovoltaic demonstration project of the Economic Development Industrial Park. |
| Beijing                         | Beijing Yanqing Energy Internet Comprehensive Demonstration Zone                           | Yanqing Park Management Committee of Zhongguancun Science and Technology Park | As one of the core sections of the Beijing Yanqing Energy Internet Comprehensive Demonstration Zone project, on January 8, 2019, the "Beijing Yanqing Energy Internet Green Cloud Computing Center" project with a planned investment of RMB 7 billion was officially launched in Zhongguancun Yanqing Park. By the end of 2020, the delivery of 6,000 cabinets would be completed, and the corresponding supporting cloud computing and service systems would be completed. The project serves the energy Internet and its related cloud service industries, and provides important support for the big data processing, energy control center, energy trading center, and energy cloud construction of the Yanqing Energy Internet project. |
| Jingneng Haidian North New Area Energy Internet demonstration project | Jingneng Capital Energy Internet Project Management Office (Beijing Energy Group Co., Ltd.) | Jingneng Capital Energy Internet Project Management Office (Beijing Energy Group Co., Ltd.) | The air conditioning and heating area of the project is about 200,000 square meters, the cooling load is 9450kW, and the heating load is 10506kW. The total distributed photovoltaic capacity on the roof of the project is 423.5kW, and the average annual total power generation is about 400,000 kWh. It adopts self-use and surplus self-generation grid connection mode. The total amount of battery energy storage system is about 8MW, and the average annual discharge amount is about 4 million kWh, which plays the role of peak-shaving and valley-filling and balancing the power grid. 10 sets of 120kW dual-gun fast DC charging piles and 10 sets of 7kW single-gun slow-charging AC Charging pile have been built in the project. Photovoltaic and energy storage systems not only reduce the installed power capacity of the park, but also bring about 400,000 RMB of electricity price income to the owners every year. |

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### 3.3. Some considerations on Energy Internet construction in the BTH region

According to the development route of global Energy Internet and the national strategic plan of Energy Internet construction, the following points need special attention.

1. **Standardization of Energy Internet development.** Under the framework of the existing standard system, a standard entitled “Internet of Energy, Part 1: General” has been issued [39]. This standard specifies the overall technical framework of the Energy Internet, specific interaction objects of the entities participating in Energy Internet, information exchange methods, system-level evaluation, and relevant specifications of typical devices. It provides guiding suggestions for the future construction and operation of Energy Internet in the BTH region.

2. **The construction of Energy Internet in the BTH region is a large-scale and highly complex system project, which includes the integration and optimization of multi energy systems in the region and the interconnection and integration of energy networks in the surrounding regions.** During the construction process, the development direction of urban energy system should be comprehensively considered from multiple perspectives.

3. **It is necessary to establish multiple energy integration transmission and supply channels with electric energy as the basic form, so as to realize the conversion and comprehensive application of multiple energy sources.** This will be of great significance for the operation of Energy Internet in the BTH region on the wide area layer, local area layer, and terminal application layer.

4. **Constructing an Energy Internet in the BTH region requires a complete policy guarantee system.** The following basic principles should be followed when designing the policy system: the principle of reciprocity, the principle of feasibility, the principle of incentives, the principle of normative policies, the principle of adapting measures to local conditions, and the principle of continuity. When constructing the Energy Internet policy system in the BTH region, the government must give priority to the construction of the legal and regulatory system and act as a strong backing for the policy system to promote the development of the Energy Internet.

5. **The construction of the Energy Internet is a long-term and complex development process.** It is difficult to effectively build the Energy Internet in the BTH region only by relying on the government's mandatory guidance policies and market mechanisms. At this time, the government needs to adopt the following supporting policies: optimizing financial subsidies, tax reduction and exemption, innovative financing methods, and training energy Internet talents.

### 4. Conclusion

The coordinated development of the Beijing-Tianjin-Hebei (BTH) region has become China's national strategy with great and far-reaching significance. Energy is an important material basis for urban construction, operation, and development. Beijing, Tianjin, and Hebei all have good renewable energy resources.

The construction of Energy Internet is an important measure to strengthen the coordination of green energy development in Beijing-Tianjin-Hebei region and promote the development of renewable energy. Beijing, Tianjin, and Hebei have issued a lot of policy documents related to the Energy Internet during the 13th Five-Year Plan period and at the beginning of the 14th Five-Year Plan period. The focuses of these policy documents are different. The first batch of 55 demonstration projects of Energy Internet has been announced by the National Energy Administration in June 2017. Among these first 55 demonstration projects, 7 are in the BTH region. 4 of them are in Beijing and 3 are in Hebei. All these demonstration projects are progressing well. Constructing an Energy Internet in the BTH region requires the Standardization and a complete policy guarantee system. The government must give priority to the construction of the legal and regulatory system and act as a strong backing for the policy system to promote the development of the Energy Internet.

The current study only focused on policy support, demonstration project, and some consideration on Energy Internet construction in the Beijing-Tianjin-Hebei region. However, the current development and construction of the Energy Internet in the Beijing-Tianjin-Hebei region is still in the initial stage of exploration and development, and its integration and open construction process will inevitably face problems and challenges from concepts, mechanisms, technologies, and markets. For example: (1) lack of overall planning and design; (2) barriers to cross-border cooperation; (3) key technologies urgently need to be broken through; (4) market mechanisms need to be improved.

At present, the comprehensive evaluation of the development of the Energy Internet is still in its infancy, and the evaluation of the Energy Internet at the national level is basically blank. It is recommended to build an energy Internet development evaluation indicator system from the three dimensions of development status, development potential, and development effectiveness. The development status can focus on the evaluation of typical projects, key policies and key technologies; the development potential can focus on the evaluation of market potential, the multi-energy potential and the information integration potential; the
development effectiveness can focus on the evaluation of comprehensive energy efficiency, renewable energy utilization and project effectiveness.

Declarations

Author contribution statement

All authors listed have significantly contributed to the development and the writing of this article.

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Additional information

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