Renewable Energy Development and Support Policies in Beijing

Renewable Energy Development and Support Policies in Beijing

Wang Fengyun

School of Economics & Management, Beijing Institute of Petrochemical Technology, Beijing, 102617, China

wangfengyun@bipt.edu.cn

Abstract. The development of renewable energy has critical and practical implications for promoting energy structure transformation, stimulating energy production, and revolutionizing energy consumption. Beijing is now faced with challenges of developing renewable energy. Organizing and optimizing renewable energy development mechanisms and support policies are the keys to transforming and upgrading renewable energy. This study analyzes the current state of development of renewable energy such as wind, solar, and biomass energy in Beijing. Support policies for renewable energy in the city are investigated to identify problems that affect renewable energy development. This study provides feasible suggestions for optimizing relevant support policies that can be implemented to achieve energy security and environmental protection.

1. Introduction

For a populous country like China, developing renewable energy is an effective measure to help relieve the pressure of energy consumption and achieve the goals of energy conservation, emissions reduction, and sustainable development. Beijing is the political, economic, and cultural centre of the country with the large migrant population in China. Rapid economic growth and increasing energy consumption have led to unbalanced energy supply and demand and environmental pollution, which hinder the sustainable development of the city. In 2016, energy consumption totalled 69617000 tons standard coal, which constituted a year-over-year growth rate of 1.6%. The total energy consumption of Beijing included 57.26% clean energy, which was comprised of 32.34% natural gas and electricity and 10.4% renewable energies and other energy sources. The unreasonable structure proportion of clean energy indicated the lagging development of renewable energy. Therefore, optimizing the clean energy structure and developing renewable energy are imperative for Beijing. It is necessary to improve people's living standard by constructing a low-carbon, safe and efficient, and urban-rural integrated modern energy system.

In recent years, researchers have conducted in-depth studies into renewable energy development. Arnette et al.[1] balanced annual power generation costs and corresponding greenhouse gas emissions in the southern Appalachian Mountains in the United States to identify optimal development of renewable energy and fossil fuels. Using a modified multiple objective linear programming model, they researched the policies effects of Renewable Portfolio Standard (RPS), carbon emissions tax, and renewable energy production tax exemptions to promote production and use of renewable energy Regional energy planning motivated the wide use of wind and solar energies in the area. Peter et al.[2] researched the development of policies in the United Kingdom to encourage the use of renewable energy heating by a renewable energy price incentive. Implementation of such new policies was more

effective than direct subsidies to renewable energy generators. To examine renewable energy industry development in the United States, Upton[3] used a synthetic control model to compare regions with RPS and those without and discovered the regions with RPS exhibited higher electricity prices and lower energy demand. Rintamäki[4] established a distributed lag model and found that flexible power generation capacity and modes of renewable energy helped solve the problem of price fluctuation that resulted from renewable energy grids.

Chinese scholars have also researched deeply support policies for the development of renewable energy and attained valuable results. Guo[5] adopted a Tobit model with limited dependent variables to perform a regression estimation of the effectiveness of renewable energy policies in China. The results demonstrated that cost allocation and a benchmark feed-in tariff produced active promotional effects on renewable energy industry development. Wang[6] discussed the pricing mechanism of renewable energy from three respects of renewable energy support policies, renewable energy subsidies, and renewable energy pricing models, and then analyzed the existing problems of renewable energy pricing system in China. Xiao[7] asserted that price played an important role in promoting the substitution of renewable energy for fossil energy. Xiao thus proposed policy recommendations for improving renewable energy industry development such as tax on fossil energy and the timely adjustment of subsidies. Yu[8] contended that China had not made reasonable external evaluations concerning renewable energy. Realistic risks and potential risks hindered the implementation of renewable energy technologies. Approaches such as price adjustment, subsidies, and compulsory consumption could be adopted to stimulate enterprises to invest in renewable energy, thereby to promote the development of renewable energy in China.

The results of these studies reveal that the renewable energy industry in China is still developing and needs support from the government and the market. Beijing, as the capital of China, should reference the renewable energy development policies and experiences in other countries to clarify the current status of renewable energy development in the Beijing-Tianjin-Hebei regions and establish regional policies for renewable energy development. Only in this way can the development goal of energy structure transformation be achieved, which will enable the renewable energy industry to thrive.

2. Current status of renewable energy development in Beijing

The development and exploitation of renewable energy has been constantly growing in scale, leading to decreasing application costs. Developing renewable energy is now fundamental for many countries to promote energy structure transformation and fight climate change. Based on the characteristics of Beijing's energy resource endowment, large-scale development of solar, wind, biomass, and geothermal energies can change the energy consumption structure of Beijing, which would have a major effect on ensuring energy security and environmental protection in the city.

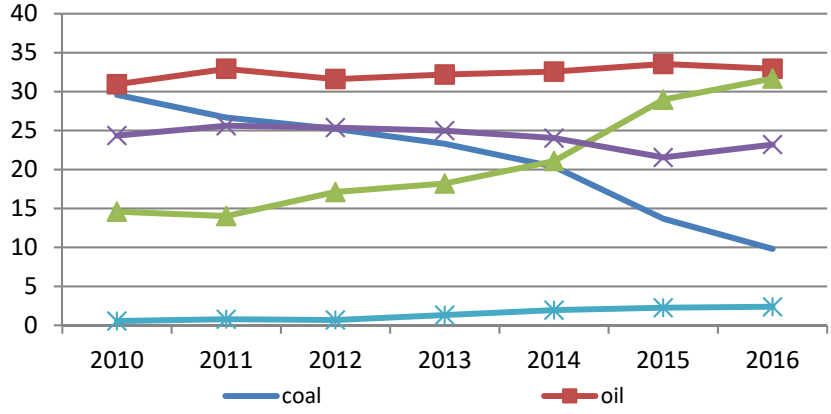

Figure 1 The proportion of major energy consumption in Beijing from 2010 to 2016
Data source：Beijing Statistical Yearbook 2017

The total energy consumption of Beijing has constantly increased. It increased from 63594900 tons standard coal in 2010 to 69617000 tons standard coal in 2016. The proportion of coal to total energy consumption decreased rapidly, plunging to less than 10% in 2016. Petroleum consumption has been relatively stable at 32%. The proportion of natural gas consumption gradually increased and reached 32% in 2016, along with petroleum, and thus became the most consumed energy in Beijing. The proportion of primary power and other energy resources accounted for only 2.38% in 2016 (see Fig. 1). Renewable energy has been developed rapidly in recent years in Beijing. In 2016, renewable energy generation capacity was 2.57 billion KWH in Beijing, achieving a year-over-year growth rate of 53.8%. The energy consumption structure of Beijing exhibited a trend of optimization, but the total amount of renewable energy remained low.

The government published a series of policies and standards that included *Implementation Plans to Revitalize Development of the New Energy Industry in Beijing*, *Development Plan for the 12th Five-Year Plan of New Energy and Renewable Energy in Beijing*, *Guidelines for Expediting Solar Energy Development and Exploitation to Promote Industry Development in Beijing*, and *Technical Regulations Regarding Construction of Solar Energy Heater Systems in Beijing*, which observably promoted the construction and development of renewable energy in Beijing. However, the renewable energy utilization rate lagged behind that of developed countries such as Germany. During the 13th Five-Year Plan, there is crucial for expediting the construction of modern energy systems in the capital. *The 13th Five-Year Plan for Energy Development of Beijing* was officially promulgated that total renewable energy consumption is expected to reach 6200000 tons standard coal by 2020, accounting for above 8% of the total energy consumption. This paper focused on analysis of the development of solar, wind, and biomass energies in Beijing.

2.1. Solar energy

The average solar radiation in Beijing region is 4600–5700 MJ/m^2 annually. Annual hours of sunshine are approximately 2600 hours, which are thus classified as a Class 2 resource in China. Beijing is a region with good solar resources from the national solar energy distribution. Solar energy is a relatively abundant in Beijing's renewable energy, which present the more resource potential, broad prospective application, and strong technical and industrial promotion effects. During the 12th Five-Year Plan period, the Beijing government initiated demonstration construction projects including Golden Sun and Sunny Campus to accelerate the construction of national renewable energy demonstration projects in the Yanqing and Shunyi districts. The government also promulgated and encouraged policies such as distributed photovoltaic rewards and heat pump subsidies to transform district-based demonstrations of renewable energy into large-scale applications. In 2015, the total energy utilization was 4.5 million ton standard coal in Beijing. The photovoltaic power plant reached 165000KW of installed capacity and solar-collector facilities covered areas of 8 million m^2.

After the implementation of the 13th Five-Year Plan, Beijing focused on five major solar construction projects, namely Sunny Campus, Sunny Business, Sunny Communities, Sunny Agriculture, and Sunny Infrastructures. In the Haidian and Shunyi districts, national distributed photovoltaic-power generation facilities were constructed for demonstration purposes. A 20-MW ground-based photovoltaic power station was constructed in the Miyun district, which was the first MW-level solar power station project in China. The scale of applying photovoltaic heaters in residential buildings was further widened. In December 2016, the installed capacity of photovoltaic power stations on the grid of Beijing reached 239.7 MW, and was 45.2% higher than in 2015. The annual power generation capacity was 290 million KWH. Photovoltaic power generation is a key development sector of Beijing. By 2020, Beijing will strive to realize the targets of increasing the installed capacity of photovoltaic power to more than 1000 MW, newly increasing installed capacity of photovoltaic 1 million KW and 1 million m^2 solar collectors area.

2.2. Wind energy

The area of Beijing is 16800 km^2. The scale of wind energy in Beijing is smaller than in other resource-abundant provinces. The regions with abundant wind energy resources are sparsely distributed in Beijing's northwestern region and northern mountain regions. At the southern bank of Guanting Reservoir of Yanqing County, the wind energy resource is abundant, in which the average wind velocity at the 70-m height is 7.11 m/s, generating an average wind power density of approximately 422 W/m^2. There have been built 133 units of wind turbines, with a total capacity of 199.5 MW and an annual effective generating about 2000 hour.

In recent years, Beijing's wind power development and utilization scale has steadily grown. The installed capacity of wind power reached 150000 KW and 200000 KW in 2010 and 2015, respectively. According to the requirements of the 13th Five-Year Plan, preliminary projects such as construction of from fourth-term to eighth-term projects of the Guanting wind power plant and wind–solar complementary power generation projects at Qinghuiling of the Changping district, wind energy assessment in Yanqing, Changping, and Huairou districts, and promotion of the second-term projects in Yanqing's old town and Changping's Qinghuiling are to be completed. Beijing is developing and utilizing wind energy in an orderly manner. By 2020, the installed capacity of newly added wind power generation will reach 450000 KW, and the total capacity of that will arrive 650000 KW.

2.3. *Biomass energy*

Biomass energy in Beijing are distributed in remote suburban districts and counties. Primary biomass utilization methods include the production of biogas and biomass power generation. Regarding the use of biogas, biomass thermal power plants were built in the Pinggu district and generated electricity using straws. Advanced biomass energy demonstration projects such as the biogas supply construction in Liuminying seventh village, large-scale biogas power generation construction projects in Deqingyuan, and the Asuwei landfill gas-power generation construction project effectively improved residential environments and living conditions of suburban farmers and subsequently led to rapid development of biomass energy utilization in Beijing.

In 2010, the total amount of biomass energy consumption was 360 000 tons standard coal, among the cumulative installed capacity of biomass power generation reached 327000 KW, biogas utilization was approximately 18 million m^3, the production of biofuel was about 200 000 tons standard coal. By 2015, Beijing's biomass power generation capacity reached 100000 KW. As the largest biomass project in Asia, the Lujiashan Waste Classification and Incineration Power Plant, was established in 2013 and had generated 628 million KWH by the end of June 2016. As the second largest waste incineration power plant in Beijing, the Gaoantun Waste Incineration Power Plant, which began to operate in July 2016, generated electricity of 220 million KWH, and was equivalent to save 70 000 tons standard coal per year. In June 2017, Nangong Incineration Power Plant was successfully connected to the grid on the first attempt, which was the fifth resource incineration facilities to generate power into the national grid and the annual power generation capacity is 160 million KWH.

The Beijing government promoted waste incineration power generation construction projects in the Shunyi, Tongzhou, and Fanshan regions. Biomass energy utilization has been converting from diverse development methods into concentrated power generation methods. According to the *13th Five-Year Plan Development Plan*, by 2020, the newly added installed capacity of biomass power generation will reach 150000 KW and the total capacity of that will arrive 350000 KW.

3. Implementation of renewable energy policies and existing problems in Beijing

3.1. Support policies for Beijing renewable energy

To promote renewable energy development, the Chinese government has implemented a series of renewable energy support policies. In February 2005, the Chinese government passed the *Renewable Energy Law of the People's Republic of China* as a national support policy for renewable energy development. In response to the nation's plan to promote renewable energy development, Beijing

implemented a series of support policies and regulations. In September 2014, the Beijing government promulgated the *Beijing Haidian District People's Government Notification on the Issuance of Energy Conservation and Emission Reduction Measures*. Demonstration projects of the Haidian distributed photovoltaic power generation completed in due time with grid-connected power generation, which could earn rewards of 0.3 yuan/W for the owner according to the installed capacity. The maximum reward was 1 million yuan. In May 2015, *Guidance Fund Management Regulations for Beijing Caoyang District Energy Saving Development* were established, providing for 600 yuan subsidies for each tons standard coal of energy produced from newly established renewable energy projects (such as solar, geothermal, wind, and biomass energies) that produced 50 tons standard coal or more per year.

In August 2015, the Beijing government promulgated a subsidy policy for distributed photovoltaic power generation, namely the *Reward Fund Management Regulations of Beijing Distributed Photovoltaic Power Generation*. For distributed photovoltaic power generation projects that are connected to the grid between January 1, 2015, and December 31, 2019, the Beijing Municipal Bureau of Finance provided 0.3 yuan/KWH subsidies for the first 5 years of grid-connected distributed photovoltaic power generation on the basis of the national electricity subsidies. Till December 31, 2017, projects receiving the subsidies included 71 industrial and commercial distributed photovoltaic projects yielding a total capacity of 50.3 MW and 5912 household photovoltaic projects that yielded a total capacity of 49.15 MW. If a household project is connected with the national grid based on the mode of "generating power for self-supply and providing residual electricity to the national grid," the project receives subsidies according to the following patterns. If it is for self-supply, the user saves 0.4883 yuan/KWH per kilowatt hour meanwhile enjoys 0.37 yuan/KWH subsidy from the national government and 0.3 yuan/KWH subsidy for five years from Beijing. So, the comprehensive income for the first 5 years is 1.158 yuan/KWH per kilowatt hour; If it is for on-grid power generation, power grid companies purchase photovoltaic electricity generated by households at the benchmark price of desulfurized coal of 0.3598 yuan/KWH. Concurrently, the household power provider receives subsidies of 0.37 RMB/KWH from the national government and 0.3 yuan/KWH for the first 5 years from Beijing. Therefore, the comprehensive income of the on-grid power generated within the first 5 years is 1.03 yuan/KWH.

Regarding applications of geothermal energy and heat pumps, the Beijing government promulgated the *Implementation Opinions Regarding Further Promotion of Geothermal Energy Development and Heat Pump System Utilization of Beijing* in 2013 and the *Engineering Technical Specification for Reclaimed Water Heat Pump Systems and the Engineering Technical Specification for Ground Pipe Heat Pump Systems* in 2015. Driven by these policies, the utilization scale of geothermal and heat pump has increased rapidly and the utilization methods and fields have been expanded constantly in Beijing.

In summary, the Beijing government has issued a series of renewable energy policies and attained remarkable outcomes. In particular, the regional photovoltaic power generation policies have resulted in the rapid development of the solar power generation industry. But there are short of specific local support policies of wind power, waste incineration, and biomass power generation in Beijing, which are mostly subsidized according to national standards. During the implementation process of policies, the energy consumption structure in Beijing has been optimized at a certain extent and the proportion of renewable energy consumption has increased steadily.

3.2. Existing problems of Beijing renewable energy development

Although Beijing's renewable energy has developed rapidly in recent years, there are still some problems in the development process. Details are as follows.

3.2.1. The subsidy efficiency of renewable energy should be improved

The low subsidy threshold for renewable energy causes large financial gaps, which is not conducive to promoting the technical update of renewable energy enterprises in Beijing. Information asymmetry and many other reasons prevent supervisory departments from timely and accurately understanding the

power generation costs. Consequently, optimal subsidy prices cannot be provided. Numerous repeated low-level construction projects cause low subsidy efficiency. In addition, following China's power reform pushing forward, the direct transaction scale of the power market will also be expanded. An increasing number of coal-fired generating units have decided to participate in direct transaction and market competition. If the renewable energy price does not apply dynamic adjustment according to costs and external factors, renewable energy will lack competitiveness in direct transactions of the electricity market.

3.2.2. The technical standard system for renewable energies needs further improvement.
The current technical standard system for renewable energy in Beijing is imperfect, resulting in inadequate on quality and efficiency of renewable energy development. Some enterprises used inferior renewable energy equipment to earn subsidies. Although the Beijing government published nine local technical codes such as the *Technical Specifications for the Installation of Solar Water Heating Systems*, the standardization process is still in its infancy and the standard system needs further amelioration. Moreover, renewable energy is diverse and complex in type, sources, technical categories and technical industrialization levels, and involves a number of governmental management sectors. There is a lack of oversight of stipulations and standards that have been issued.

3.2.3 The supervision system and related regulations are not sound enough
As the capital of China, Beijing is advantaged with respect to economics, culture, natural resources, and political system. regional renewable energy regulations must be established. The current renewable energy support policies of Beijing focus on photovoltaic power generation. But Wind power, biomass energy power generation and others lack of regional support policies. The Beijing government has promulgated a series of regulations and policies to encourage renewable energy development. However, there is a lack of relevant policies or regulations in terms of financial support, pricing and quality requirements of related products.

4. Countermeasures and suggestions
In the current economic situation, as the capital of China, Beijing should be at the forefront of leading the energy highly efficient green and intelligent transformation. Renewable energy development in Beijing should involve the following aspects.

4.1. Implement flexible and technically competitive dynamic subsidy systems
A competitive energy market can facilitate the coordinated development of renewable energy production, supply, and marketing. In reviewing the subsidy programs, the Beijing municipal government should strictly controll the newly increasing renewable energy enterprises and gradually reduce the subsidy for current power generation enterprises. Subsidies should be given to renewable energy generation enterprises with lower comprehensive costs, higher power generation efficiency, and more technical achievements. These measures can promote technical innovation in the power generation industry, and reduce costs and enhance market competitiveness. The government can also subsidize consumers of renewable energy or give them tax preferences. The government should reduce the renewable energy price, expand market capacity of renewable energy products, and accelerate production and supply of such products.

4.2. Enhance the capability of independent innovation in technology research and development
The existing renewable energy technical resources of Beijing should be integrated to optimize relevant technical standards and industry service systems. The Beijing government should appropriately use its advantages as a convergence place of universities and research institutes. Based on these technological and innovative advantages, Beijing should expedite the development of new energy, new technologies, comprehensively improve the capacity for independent innovation and industrial promotion of renewable energy technologies. The government should promote the construction of microgrids for

new energy, adopt advanced Internet and information technologies to realize smart matching and collaborative operations for energy production and use, participate in the power market by a new business mode and form a new carrier of efficient and clean energy utilization.

4.3. Improve renewable energy monitoring systems

Regulations for the renewable energy industry should be established to ensure renewable energy development. To facilitate the rapid and steady development of renewable energy, the Beijing government should establish renewable energy development and use plans that conform to local conditions and legalize the plans through legislative procedures. On the basis of enacting the *Beijing Renewable Energy Law*, the Beijing government should establish comprehensive renewable energy law system from multiple aspects to construct technology-oriented mechanism, information disclosure mechanism and market credit mechanism for enhancing renewable energy development and utilization.

4.4. Promote the collaborative development of regional renewable energy

Beijing alone cannot satisfy the higher needs of green energy utilization for the entire city. The Hebei province and nearby regions have abundant renewable energy resources such as wind and solar energies. Cooperation of the city and regional governments in the Beijing-Tianjin-Hebei region should implement renewable energy for heating and absorb excess renewable energy electricity. In addition, the government should Integrate Beijing's advanced technology research and development capacity, project development capacity and huge market demand with the rich resource endowment of Beijing-Tianjin-Hebei region and its surrounding areas to facilitate the collaborative development of renewable energy.

Acknowledgments

This research was supported by the National Social Science Fund Project (Grant No. 17BJY057).

References

[1] Andrew N. Arnette, Christopher W. Zobel. (2011) The role of public policy in optimizing renewable energy development in the greater southern Appalachian mountains. Renewable and Sustainable Energy Reviews, 15(8):3690-3702.
[2] Peter M. Connor, Lei Xie, Richard Lowes, Jessica Britton, Thomas Richardson. (2015) The development of renewable heating policy in the United Kingdom. Renewable Energy, 75:733-744.
[3] Gregory B. Upton, Brian F. Snyder. (2017) Funding renewable energy: An analysis of renewable portfolio standards. Energy Economics, 66(8):205-216.
[4] Tuomas Rintamäki, Afzal S. Siddiqui, Ahti Salo. (2017) Does renewable energy generation decrease the volatility of electricity prices? An analysis of Denmark and Germany. Energy Economics, 62(2):270-282.
[5] Guo Xiaodan, Yan Jingjing, Bi Luguang. (2014) Regional deconstruction, effectiveness and improvement of the renewable energy policy in China. Comparative Economics & Social Systems, 6:176-187.
[6] Wang Fengyun. (2017) A review on the pricing mechanism of renewable energy. Price: Theory & Practice, 8:52-55.
[7] Xiao Wenhai, Dong Anping, Wei Wei. (2015) The price policy choice of renewable energy to replace fossil energy. Jiangxi Social Sciences, 35(2):47-51.
[8] Yu Pingping, Yang Dongning.(2012) Low carbon energy: renewable energy incentives and patterns. Academic Monthly, 44(3):83-89.