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Thoughts and Countermeasures on Promoting Energy Revolution in the Beijing–Tianjin–Hebei Region

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Abstract: The coordinated energy development of the Beijing–Tianjin–Hebei metro area is a significant national energy strategy in China. This study analyzes the evolution process of energy production, consumption, and structure proportion in the Beijing–Tianjin–Hebei metro area. The analysis indicates that the energy supply in this region is less than the energy consumption. Despite the ample renewable energy resources available in the region, its energy consumption is principally based on fossil energy sources. Energy efficiency in the region requires further improvement. Since the Beijing–Tianjin–Hebei coordinated development strategy was proposed six years ago, the ecological environment in this region has continuously improved, but still has significant challenges. Because energy enables economic and social development, and is closely related to the environmental quality, the promotion of the energy revolution is imperative. To promote energy innovation within the Beijing–Tianjin– Hebei region, energy efficiency should be further improved to control energy consumption. In addition, the energy supply structure should be optimized to provide a useful foundation for coordinated development. The energy technology revolution should be promoted to create a new driving force for economic growth. The existing energy system should be revolutionized to improve the market environment for economic and social development. Finally, rural energy revolution should be accelerated to prevent point source pollution in rural areas.

Keywords: Beijing–Tianjin–Hebei region; energy revolution; coordinated development; ecological environment; economic development

1 Introduction

The Beijing–Tianjin–Hebei region has an area of 2.16×10^5 km^2, with a total population of more than 100 million people. Beijing, Tianjin, and Hebei have physical proximity, integrated communities, and similar cultures, which are natural advantages in cooperation. In May 2013, General Secretary Xi Jinping proposed a survey in Tianjin to promote the development of both Beijing and Tianjin in the new era of socialist modernization. In August of the same year, he proposed to promote the coordinated development of the Beijing–Tianjin–Hebei region when studying the development of Hebei. In February 2014, he hosted a symposium and emphasized the importance of realizing the coordinated development of the Beijing–Tianjin–Hebei region. It was deemed necessary to build a new capital economic circle and promote the future innovation of regional development systems and mechanisms. It was also necessary to explore and improve the layout and form of urban agglomerations. In addition, it was determined that it was necessary to provide demonstrations and models for the optimal development of regional development along

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with the exploration of ecological civilization construction and the promotion of the coordinated development of the population, resources, and environment. The realization of the complementary advantages enjoyed by the Beijing–Tianjin–Hebei region and the promotion of the Bohai Rim Economic Zone and northern hinterland development were also priorities. Finally, it was necessary to adhere to complementary advantages, mutual benefit (win-win), solid progress, and to find a path of scientific, sustainable, and coordinated development [1,2].

While the Beijing–Tianjin–Hebei region is developing rapidly, there are many prominent problems. For example, the ecological environment in the Beijing–Tianjin–Hebei region continues to deteriorate, the urban system development is unbalanced, the disparity between regional and urban–rural development continues to increase, and there is significant variation in energy efficiency. Energy is the physical basis and source of power for the development of the energy economy and society. Therefore, the promotion of the energy revolution, realization of fundamental changes in energy production, and utilization methods are key to realize the coordinated development of the Beijing–Tianjin–Hebei region. This paper introduces the status and main characteristics of energy development in the Beijing–Tianjin–Hebei region and analyzes the situation and challenges faced in the coordinated development of this region. In addition, this study also proposes that the energy revolution is an important component for promoting the coordinated development of the eco-environmental protection and economic society of the Beijing–Tianjin–Hebei region. Finally, this study presents specific countermeasures and suggestions, providing consultation and reference for promoting the coordinated development of this region.

2 Current status and main characteristics of energy development in Beijing–Tianjin–Hebei region

2.1 Current status of energy development in Beijing–Tianjin–Hebei region

According to long-term statistical data, the characteristics and changes in energy supply and demand in different cities in the Beijing–Tianjin–Hebei region have evident temporal and spatial differences, but the overall energy situation in various regions is gradually improving [3–5].

2.1.1 Beijing city

From the perspective of total energy production, the overall fluctuations are not large, and the annual total production volume from 2010 to 2017 always remained within the range from 3.5×10^7 to 4.2×10^7 tons of coal equivalent (tce). A specific trend is shown in Fig. 1 [3].

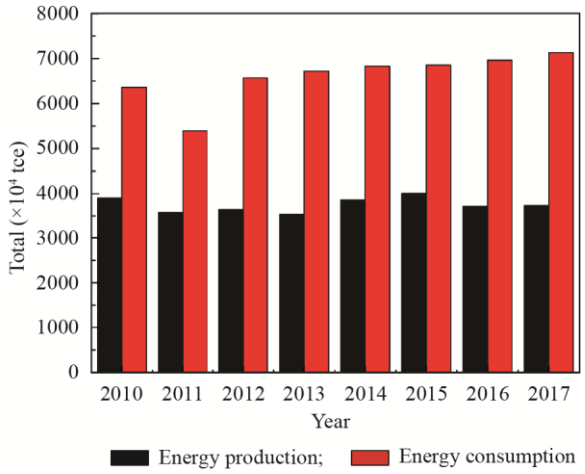

Fig. 1. Total energy production (in tons of coal equivalent [tce]) and consumption in Beijing.

The annual total energy consumption in Beijing increased from 2010 to 2017. In 2017, the total energy consumption in Beijing was 7.13284×10^7 tce. This represented an annual increase of 2.4% and was the highest level observed in Beijing for all the years analyzed. While the total energy production maintains stable, the total energy consumption keeps increasing, and the pressure on energy supply increases.

In terms of consumption structure, it can be seen from Fig. 2 [3] that the proportion of clean energy consumption, such as natural gas and non-fossil energy, is increasing, exceeding 60% of the overall energy consumption. This shows that Beijing's energy consumption structure is gradually becoming optimized. The current energy

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consumption is dominated by clean energy sources.

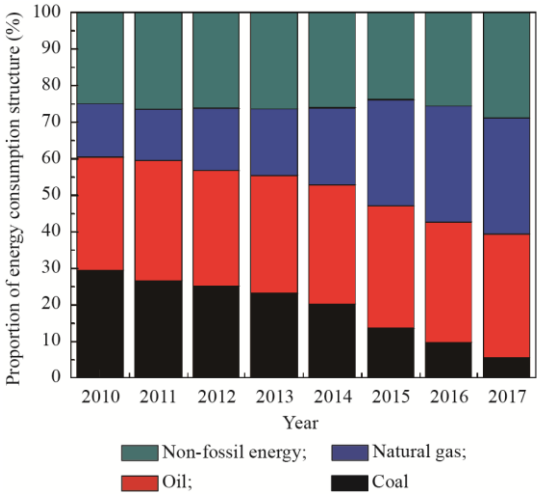

Fig. 2. Energy consumption structure in Beijing.

2.1.2 Tianjin city

From 2010 to 2014, the total primary energy production in Tianjin decreased from 5×10^7 to 4.7×10^7 tce. However, in 2015, the primary energy production increased slightly, reached a maximum, and then showed a downward trend. In 2017, the total primary energy production in Tianjin was 4.87×10^7 tce. Overall, as shown in Fig. 3 [4], the total primary energy production was maintained at approximately 5×10^7 tce, and the trend was relatively stable. During the same period, Tianjin's total energy consumption was approximately 8×10^7 tce.

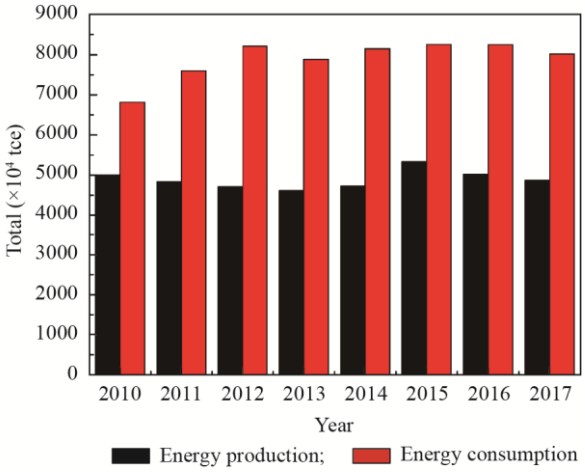

Fig. 3. Total energy production and consumption in Tianjin.

The energy consumption structure of Tianjin is improving, but overall, coal and oil are still in a dominant position in the energy structure of Tianjin. The proportion of coal consumption declines annually. By the end of 2017, coal consumption accounted for 35% of the total energy consumption, a decrease of 15 percentage points from 2010. However, the proportion of natural gas and non-fossil energy consumption continues to increase. In 2017, the combined consumption of the two accounted for 35.33%, with an increase of 19 percentage points from 2010, as shown in Fig. 4 [4].

2.1.3 Hebei Province

In terms of energy production, the Hebei Province has significant energy resources, with considerable reserves of coal, oil, and natural gas. As shown in Fig. 5 [5], in 2017, the total energy production in the Hebei Province was 6.779×10^7 tce, which is similar to that in 2016. In 2012, energy production reached 9.56×10^7 tce, and then decreased rapidly, maintaining a production level of approximately 7×10^7 tce.

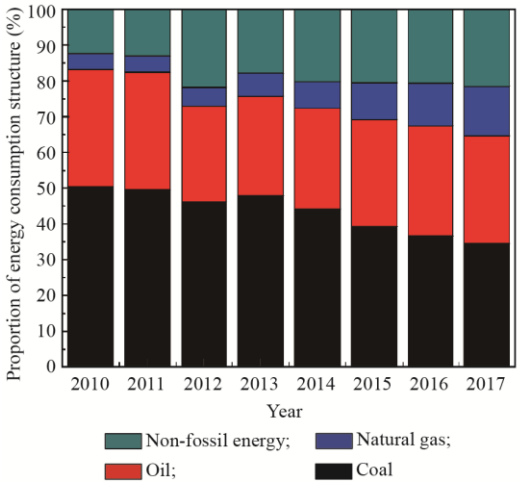

Fig. 4. Ratio of energy consumption structure in Tianjin.

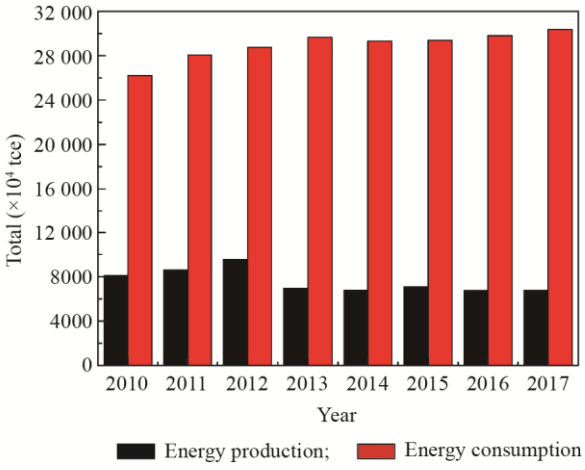

Fig. 5. Total energy production and consumption in Hebei Province.

The total energy consumption of the Hebei Province showed a gradually increasing trend. The total energy consumption in 2017 was 3.0385×10^8 tce, exceeding 3×10^8 tce for the first time. This is more than three times the total energy consumption of Beijing and Tianjin.

In terms of the consumption structure, the energy structure of the Hebei Province has always been dominated by coal, and the proportion of clean energy such as natural gas has been too low to reduce air pollution. The proportion of coal in Hebei's energy consumption has been as high as approximately 90%, while the consumption of oil, natural gas, and non-fossil energy accounts for only a small portion of this consumption. As shown in Fig. 6 [5], in 2017, energy consumption in the Hebei Province consisted of coal, oil, natural gas, and non-fossil energy, which accounted for 84%, 8%, 4%, and 4%, respectively.

2.2 Main characteristics of energy development in Beijing–Tianjin–Hebei region

2.2.1 Relatively poor fossil energy resources and significant renewable energy development potential

In terms of fossil energy, the accumulated proven coal reserves in the Beijing–Tianjin–Hebei region are approximately 2.5×10^{10} t. The reserves are principally located in the Hebei Province and Beijing. There are abundant oil and gas resources located principally in Tianjin. Tianjin has two national key oil and gas fields in Bohai and Dagang, which contain proven oil reserves of 4×10^9 t and an oil field area of more than 100 km^2 [6–8]. In terms of renewable energy, the amount of developable wind energy in the Beijing–Tianjin–Hebei region is approximately 8×10^7 kW, which is mainly located in the Zhangjiakou and Chengde Bashang areas. Solar energy resources are relatively abundant in the country and are exceeded only by the Qinghai–Tibet and northwestern regions. In the Zhangjiakou–Chengde area of northern Hebei, the annual number of sunny hours are 3000–3200, which is a

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characteristic of second-class area of solar energy resources. The annual number of sunny hours in Beijing, Tianjin, and the central-eastern Hebei are 2200–3000, characteristic of third-class solar resource areas. Biomass resources are abundant. The annual output of straw exceeds 4.1×10^7 t, whereas the annual usable amount of tree branches is approximately 2×10^6 t. The annual output of human, livestock, and poultry manure is approximately 1.435×10^8 t. Geothermal energy reserves are considerable, and the amount of geothermal energy resources in the Hebei Province is equivalent to 9.4×10^9 tce [9].

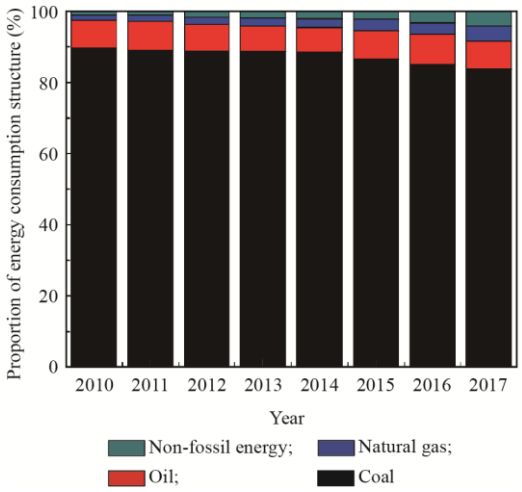

Fig. 6. Ratio of energy consumption structure in Hebei Province.

2.2.2 Fossil energy domination (especially coal) of consumption structure compared to clean energy

According to the latest statistical annual data (Fig. 7), among the total energy consumption in the Beijing–Tianjin–Hebei region, fossil energy consumption accounts for more than 88% since a long time, of which coal consumption accounts for more than 70%. In the Hebei Province, coal consumption accounted for 84% in 2017, nearly 24% higher than the national average. In recent years, owing to the implementation of "coal to gas" and other policies, the proportion of regional clean energy consumption has continued to increase, but it is still low and needs to be increased further [10].

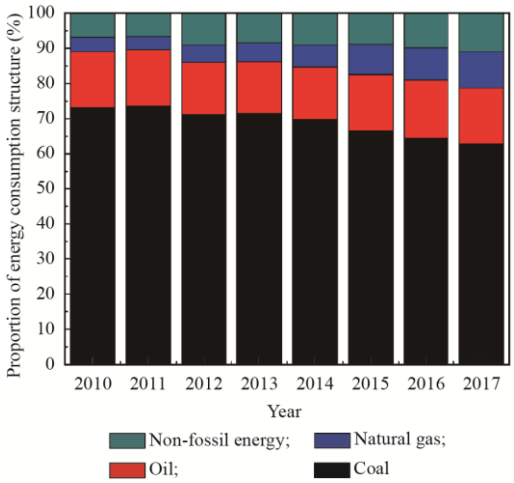

Fig. 7. Proportion of energy consumption structure in Beijing–Tianjin–Hebei region.

2.2.3 Variable energy use with marginal levels of clean and efficient utilization

In 2017, the energy consumption of Beijing–Tianjin–Hebei per 10 000 CNY of gross regional production was approximately 0.56 tce, slightly higher than the national average. Compared with the Pearl River Delta and Yangtze River Delta during the same period, the gap was significant. Especially in the Hebei Province, the energy consumption per 10 000 CNY of gross regional production in 2017 was 1 tce, which was nearly double the national average [10]. In addition, a large volume of bulk coal in rural areas emits flue gas at low heights and burns without

any environmental protection measures, which causes serious pollution. According to statistics, the annual volume of bulk coal burned in the Beijing–Tianjin–Hebei region exceeds 3.5×10^7t. More than 90% of low-quality bulk coal with ash and sulfur contents exceeds the standard. It is estimated that the pollutant emissions of the direct combustion of 1 ton of bulk coal are ten times higher than those of industrial coal.

3 Problems and challenges faced by Beijing–Tianjin–Hebei region for advancing the energy revolution

3.1 Need to optimize the energy resource supply and consumption structure

The recent and rapid economic development of the Beijing–Tianjin–Hebei region has resulted in a continuous increase in the energy demand. In addition, the overall energy consumption structure of the region is unbalanced. The resource reserves of fossil fuels, especially coal, are very limited and cannot meet the needs of rapid development. This intensifies the dependence of the regional energy supply on external sources. The energy demand gap is mainly mitigated by external energy transfer-in and energy import, presenting a challenging energy resource situation. In addition, the high-quality energy represented by renewable energy accounts for a low proportion of energy consumption. This has a serious impact on the regional ecological environment and restricts the sustainable economic and societal development in the Beijing–Tianjin–Hebei region.

3.2 Increasing external constraints for ecological and environmental factors

The Beijing–Tianjin–Hebei region is one of China's important economic development engines and energy consumption centers. It is also the region with the most serious air and water pollution and the most acute conflicts between resources, environment, and development. In the last five years, a significant improvement is observed in the ecological environment of the Beijing–Tianjin–Hebei region in terms of water resources, water environment, and coordinated control of air pollution (Fig. 8 [11–15]). While achieving positive results, it is important to realize that the ecological environment in the Beijing–Tianjin–Hebei region is still precarious.

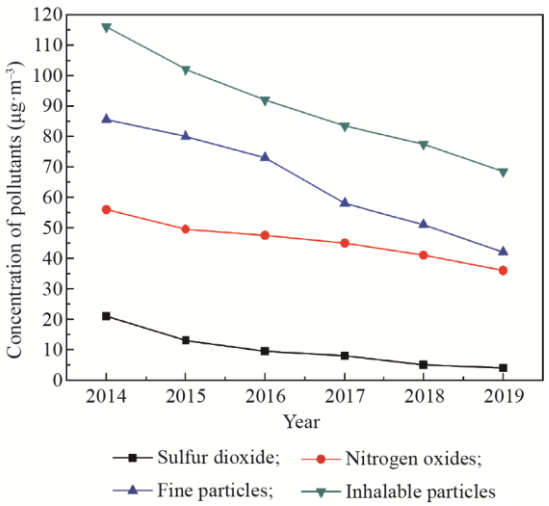

Fig. 8. Changes in the concentration of pollutants in Beijing from 2014 to 2019.

First, air quality improvements are still difficult to realize. In 2019, the emission intensity of pollutants per unit area in the Beijing–Tianjin–Hebei region and surrounding areas ("2 + 26" area) were higher than the national average. Sulfur dioxide (SO_2) levels were a factor of 1.36 greater than the national average, nitrogen oxides (NO_x) levels were a factor 1.48 greater than the national average, and fine particulate matter ($PM_{2.5}$) levels were a factor 2.77 greater than the national average level. According to the 2019 assessment of the comprehensive environmental air quality index, six of the 13 prefecture-level and larger cities in the Beijing–Tianjin–Hebei region were ranked in the top 20 most polluted cities; five ranked in the top ten [12].

Second, the state of water resources is problematic, and the red line of the water supply has been broken. Beijing, Tianjin, and Hebei account for 2.3% of China's land area and less than 1% of the water resources, 8% of China's population, 9.5% of its industrial added value, and nearly 26% of its steel production. Water resources have historically been severely overallocated, making it one of the most water-scarce regions in China [16]. In 2017, the

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per capita water resources of Beijing, Tianjin, and Hebei were only 6.85%, 5.16%, and 11.8%, respectively, of the national average [16].

Third, the problem of ecosystem degradation is serious. Forest quality has declined, grasslands have degraded, and ecological water has been diverted. This has led to wetland shrinkage and functional degradation. The existing eight wetlands, including Baiyangdian and Beidagang, are drying up and have water pollution issues. The area of desertified land in the region has reached 4.4×10^4 km^2, accounting for 20.4% of the region. The soil erosion area is 5.8×10^4 km^2. Although some treatment measures have been taken in recent years, damage during treatment is quite common [17].

3.3 Unbalanced economic and social development

Compared with the Pearl River Delta and Yangtze River Delta, there is a gap in the regional development of the Beijing–Tianjin–Hebei region. This is principally reflected in the economic development and income gap between the Hebei Province, Beijing, and Tianjin. In 2019, the per capita gross regional production of the Hebei Province (46 200 yuan) was 28.13% that of Beijing and 51.16% that of Tianjin. The per capita disposable income of Hebei Province (35 738 CNY) was 48.39% that of Beijing and 77.49% that of Tianjin. Consequently, due to the high level of public services and the combination of various high-quality resources, Beijing and Tianjin have most of the universities, scientific research institutions, invention patents, and innovative talents in the Beijing–Tianjin–Hebei region. Simultaneously, due to the agglomeration effect of resources, they can gather more market-oriented elements more effectively. In contrast, human resources in the Hebei Province, especially high-end human resources, appear to be very scarce.

This factor results in an apparent phenomenon. The coordination within the Beijing–Tianjin–Hebei region is relatively loose. The radiation driving effect of Beijing on the surrounding areas was not obvious. Instead, the Beijing, Tianjin and poverty belt is an example of a siphon effect.

3.4 Improving the coordinated development of rural energy

In recent years, the total energy consumption in rural areas has steadily increased, and the use of clean energy has attracted significant attention from society. However, the use of clean energy is less in rural than in urban areas. Most residents choose coal instead of cleaner alternatives. This is because of its cost, ease of distribution over large sparsely populated areas, and convenience. Consequently, rural residents will continue to use bulk coal.

The Beijing–Tianjin–Hebei region provides certain subsidies for the use of clean energy, such as solar energy. However, considering factors such as the energy economy and the convenience of technical services, subsidies are not sufficient to motivate farmers to switch to clean energy. Some bulk coal is of poor quality and has more significant air-pollution effects than industrial coal. This is also one of the major causes of serious air pollution in the Beijing–Tianjin–Hebei region. In addition, there is a lack of dust removal equipment in rural areas. This has a serious impact on the ecological environment and also endangers human health.

4 Promoting energy revolution to facilitate the coordinated development of Beijing–Tianjin–Hebei region

In the past six years, the Beijing–Tianjin–Hebei region has achieved remarkable coordinated development. However, it also faces special difficulties including the significant conflicting needs of resources, environment, and development. This issue has gained global attention. Through research, we have found that energy, being the basis for economic and social development, has been the catalyst for this attention. The Beijing–Tianjin–Hebei region has problems such as the extensive development mode of high energy consumption industries such as iron and steel metallurgy, in addition to an irrational energy structure, low utilization efficiency, and large total consumption. These are the direct causes of the serious imbalance of the atmosphere, water resources, soil, and other ecological environments in the Beijing–Tianjin–Hebei region and the low quality and efficiency of economic development. The Hebei Province is key to the adjustment of the energy structure of the Beijing–Tianjin–Hebei region. There is a problem of coal domination in the energy structure. Electricity, natural gas, and coal all rely on supply from outside the region. In the coordinated development of the Beijing–Tianjin–Hebei region, as a major national strategy, regional traditional energy development methods have reached a critical stage where fundamental changes must be made. Thus, it is imperative to promote an energy revolution.

Promoting the energy revolution is conducive to improving the ecological environment in the Beijing–Tianjin–Hebei region. Energy is closely related to the environment. The entire process of energy production and consumption,

directly or indirectly, has a major impact on the ecological environment. Advancing the energy revolution can promote changes in energy production and usage. Therefore, promoting energy-saving technologies and improving energy utilization efficiency will effectively control the total consumption of fossil energy, optimize the energy supply structure, and fundamentally reduce the sources of environmental pollution.

Promoting the energy revolution is conducive to the transformation of the economic development mode, optimization of the industrial structure, and improvement of the quality and efficiency of economic development in the Beijing–Tianjin–Hebei region. Promotion of the energy consumption revolution and the improvement of regional energy production and consumption structure will promote the development of upstream and downstream industrial chains and related industries and stimulate new development. In addition, promoting the energy technology revolution and increasing the input of technological innovation factors will have many benefits. It will help to transform from resource-dependent, extensive-expansion high-carbon economic development mode to technological-innovative and low-carbon development mode with improved connotation, thus creating a high-grade, precision, and advanced industrial structure.

Promoting the energy revolution is conducive to the formation of a good external environment for economic, social, and ecological development. At present, the institutional constraints of China's energy industry are becoming increasingly apparent, and deepening reforms are imperative. Administrative monopoly, market monopoly, and disorderly competition coexist in the energy industry, and the price mechanism has significant issues. There is an urgent need to enact lasting reforms, provide unencumbered market forces, correct price mechanisms, and build an institutional mechanism conducive to the sustainable energy development.

5 Suggestions for promoting energy revolution in Beijing–Tianjin–Hebei region

We suggest further implementation of new development concepts, the establishment of red line (ecological red line) awareness, and bottom line (environmental quality bottom line) thinking. In addition, we suggest the promotion of energy sector supply side reforms, the clean and efficient use of coal as the primary energy transition task, and controls on total energy consumption. Finally, we suggest the promotion of regional economic and social development, improvement of the ecological environment, and assistance for the coordinated development of the Beijing–Tianjin–Hebei region.

5.1 Recommendations to save energy, increase efficiency, and control the total energy consumption

It is recommended that policy incentives and public opinion propaganda be adopted to guide the society to transform traditional energy use concepts, firmly establish energy conservation awareness, and decrease unreasonable energy consumption. This can be initiated in the fields of transportation, industry, and construction in the Beijing–Tianjin–Hebei region.

First, advocacy of "green travel" should increase. Actively encourage entities to operate shuttle buses and schools to operate school buses, encourage ridesharing, improve various cycling facilities, and further increase the proportion of travel by public transport. Initiate pilot projects that use the prior year's displacement and mileage data as the basis for vehicle and vessel tax collection and use economic levers to guide the public to reduce driving. Second, industrial energy-saving and efficiency improvement projects should continue. We advocate effective improvement of industrial energy efficiency standards and the transformation of stocks, the continuation of comprehensive energy-saving technical renovation projects for existing industrial boilers and motors, the active promotion of energy-efficient boilers and electrical products, the recycling of waste heat and pressure and waste resources in industrial enterprises, and the improvement in energy efficiency of end-use product as well as the energy efficiency level of energy-intensive industries. Third, projects focused on improving energy efficiency of buildings should be implemented. According to the climate characteristics of the Beijing–Tianjin–Hebei region, it is necessary to establish energy-saving standards for urban and rural buildings and strongly promote the energy-saving renovation of existing buildings through the installation of insulation layers and other measures. Considering the differences between urban and rural areas, it is recommended to provide appropriate subsidies for energy-saving renovation and insulation of housing in the outlying suburbs of Hebei, Beijing, and Tianjin to reduce farmers' demands for bulk coal for source heating.

5.2 Optimization of energy supply structure and consolidation of material foundation for coordinated development

Based on the dual attributes of coal as a resource and energy, the clean and efficient use of coal should continue.

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It is also necessary to increase and improve the construction of wind power bases in the Zhangbei area. The government should facilitate complete support to utilize the renewable energy in northern Hebei and increase the supply of clean energy in the region. This requires priority support for the development, consumption, and output of clean and renewable energy sources in the region, such as wind, photovoltaic, geothermal, and nuclear power. In addition, energy cooperation should be improved. It is necessary to further increase the clean energy transmission outside Inner Mongolia, Shanxi, and other regions. The government should increase the rate of energy infrastructure construction, such as ultra-high-voltage (UHV) power transmission, large-capacity power transmission channels, and natural gas supply pipelines. Examining the practical difficulties of coal usage and replacement in the Beijing–Tianjin–Hebei region, this problem is more prominent in the Hebei Province compared to the surrounding areas. The government should attempt to limit coal outside the region and provide clean energy alternatives.

5.3 Promotion of energy technology revolution and a "new engine" for economic growth

We should adhere to innovation-driven development and coordinate the application promotion, demonstration tests, and concentrated research of the energy technology revolution. It is necessary to apply and promote relatively mature new energy technologies, such as ultra-low emission technologies for coal-fired power plants, distributed energy technologies, comprehensive straw utilization technologies, and energy storage technologies. Enterprises should seize the opportunity of Internet Plus, to create a "dual engine" of energy Internet and Internet energy, and promote the scientific and reasonable allocation of various elements. At the same time, relying on Beijing–Tianjin's scientific and technological resource advantages (the National Engineering Technology Research Centers, the National Energy R&D Centers, and the State Key Laboratories), the government should facilitate the roles of enterprise innovation and actively promote the construction of an innovative consortium of industry–university–research–user. In the technical fields of coalbed methane development and utilization, many improvements are possible. These include: the efficient development of oil and gas resources, efficient and clean power generation, UHV power transmission, large-scale intermittent power generation and grid connection, implementation of smart grids, nuclear fuel post-processing, and other technical solutions. It is necessary to deploy a number of strategically leading cutting-edge technologies and key research projects, increase the rate of demonstration tests for major engineering technologies, develop an alternative to the bottleneck technology that restricts energy development, and form a new economic growth point for the energy industry.

5.4 Promotion of the energy system revolution and building a useful external market system

The first objective is improvement of policies and regulations for the promotion of the energy system revolution. The government should establish and improve the legal system with regards to energy. These improvements include: the law's foundation and leadership, laws regarding specific energy sources (coal, electric, oil, and gas), and changes to energy administrative regulations at the departmental and local government levels. The regulation changes should use a technical basis for the support and supplement of standards and norms. Government should rely on scientific legislation to promote law-abiding by all people, thus creating a favorable situation where systems are used to standardize energy governance and ensure the realization of various expected indicators of energy development. The second objective is to improve the market credit system. It is necessary to establish a credit rating system for market entities and establish the credit records of corporate legal persons and their responsible persons and employees. In addition, this system should incorporate records into a unified information platform to increase transparency regarding the status of various enterprises. This system would be traceable and verifiable, establish a credit rating system for market entities to improve incentive mechanisms for trustworthy entities, and penalties for dishonest ones. Penalties and restraints on untrustworthy entities should be improved. The third objective is to study the establishment of the Beijing–Tianjin–Hebei Energy Development Fund. By referring to the practice in United Kingdom and the United States, part of the fund may be jointly funded by the state and the Beijing–Tianjin–Hebei region, some are drawn directly in accordance with a reasonable portion of the retail electricity utilities, and some comes from special donations from public utility companies, providing long-term low-interest financing to support renewable energy research and development. This fund can be used to improve energy efficiency, reduce production capacity scientifically and orderly, support low-income groups, and help with industrial upgrading and demonstration.

5.5 Accelerating the rural energy revolution and strengthening the control of rural, point-source pollution

First, it is necessary to accelerate the promotion of clean replacement projects for bulk coal and unify bulk coal quality standards. In addition, the improvement of the supervision for the processing and production, storage and

transportation, distribution, and sales is recommended. Additional suggestions include the elimination of circulation channels for low-quality, bituminous coal into the Beijing–Tianjin–Hebei region to ensure the supply of clean coal, the development of clean energy sources such as household photovoltaics and large and medium-sized biogas in accordance with local conditions, and the encouragement of the construction of new energy delivery methods for farmers. These new construction projects would fundamentally affect ground sources and include air source heat pumps and biomass heating projects. It would change the energy structure in rural areas. In addition, we must strengthen the construction of a comprehensive rural energy service system, expediate the transformation of rural power grids, and establish the rural energy statistics system. Finally, improved construction of training systems for rural energy technology to provide service system support for enhanced development and utilization of clean energy in rural areas is vital.

References

[1] The State Council of the PRC. Outline of Beijing–Tianjin–Hebei coordinated development plan [R/OL]. (2018-04-13) [2020-10-25]. http://www.bjchp.gov.cn/cpqzf/315734/tzgg27/1277896/index. html. Chinese.

[2] Xinhua News Agency. Open up bright prospects for the development of high quality: The CPC Central Committee, with Comrade Xi Jinping as its core, plans to promote the 5th anniversary record of Beijing–Tianjin–Hebei coordinated development [EB/OL]. (2019-02-25) [2020-10-25]. http://www.xinhuanet.com/politics/ leaders/2019-02/25/c_1124161618.htm. Chinese.

[3] Beijing Municipal Bureau of Statistics. Beijing statistical bulletin of national economic and social development in 2019 [R]. Beijing: Beijing Municipal Bureau of statistics, 2020. Chinese.

[4] Tianjin Bureau of Statistics. Tianjin statistical bulletin of national economic and social development in 2019 [R]. Tianjin: Tianjin Bureau of statistics, 2020. Chinese.

[5] Hebei Provincial Bureau of Statistics. Hebei provincial statistical bulletin of national economic and social development in 2019 [R]. Shijiazhuang: Hebei Provincial Bureau of Statistics, 2020. Chinese.

[6] Tianjin Bureau of Statistics. General situation of Tianjin [R]. Tianjin: Tianjin Bureau of statistics, 2020. Chinese.

[7] Beijing Municipal Commission of Planning and Natural Resources. Table of reserves of Beijing mineral resources in 2018 [R]. Beijing: Beijing Municipal Commission of planning and natural resources, 2019. Chinese.

[8] Department of Natural Resources of Hebei Province (Marine Bureau). General situation of Hebei provincial mineral resources [R]. Shijiazhuang: Department of Natural Resources of Hebei Province (Oceanic Bureau), 2019. Chinese.

[9] Development and Reform Commission of Hebei Province. 12th five year development plan of new energy industry in Hebei Province [J]. Management and Technology of Small and Medium Enterprises, 2010 (26): 9–13. Chinese.

[10] Hebei Provincial Bureau of Statistics. Hebei economic yearbook of 2018 [R]. Shijiazhuang: Hebei Provincial Bureau of Statistics, 2019. Chinese.

[11] Ministry of Ecology and Environment of the PRC. State of the environment bulletin of China in 2014 [R]. Beijing: Ministry of Ecology and Environment, 2015. Chinese.

[12] Ministry of Ecology and Environment of the PRC. State of the environment bulletin of China in 2019 [R]. Beijing: Ministry of Ecology and Environment, 2020. Chinese.

[13] Beijing Municipal Bureau of Water Resources. Beijing water resources bulletin (2018) [R]. Beijing: Beijing Water Affairs Bureau, 2019. Chinese.

[14] Beijing Municipal Bureau of Ecological Environment. Beijing ecological environment bulletin in 2019 [R]. Beijing: Beijing Municipal Bureau of Ecological Environment, 2020. Chinese.

[15] Beijing Municipal Bureau of Ecological Environment. Beijing ecological environment bulletin in 2014 [R/OL]. Beijing: Beijing Municipal Bureau of Ecological Environment, 2015. Chinese.

[16] Ministry of Industry and Information Technology, Ministry of Water Resources, Ministry of Science and Technology, et al. Beijing– Tianjin–Hebei industrial water saving action plan [R/OL]. http:// www.gov.cn/xinwen/2019-09/18/content_5430869.htm. Chinese.

[17] Liu X X. Optimizing regional development pattern by environmental space [N]. China Environment Daily, 2015-05-12(5). Chinese.