Energy technology revolution and China’s air pollution governance

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Abstract. Energy revolution and environment protection are two core missions of the Chinese government. In the wintertime of 2017-2018, China suffered a serious gas shortage, which exposed the problems in the energy and environment sector. The government explained the shortage by providing the reasons of gas storage capacity inadequacy, pipeline networks interconnection problem, and the Central Asia’s gas supply reduction. The air pollution governance policies have huge influence on the shortage. Energy is one of the factors that could profoundly affect the air pollution governance. From the reasons analysis of the shortage, some energy technology challenges are revealed. The energy technology revolution should incorporate the arrangements of the air pollution control into its development process, and focus on the issues of enhancing the response to environmental policies, establishing a sustainable dynamic mechanism, and emphasizing the innovation of concept and approach. For promoting the energy technology revolution, the following strategies should be applied: a) ensuring sufficient investment; b) reforming the energy systems and mechanisms; c) improving the policies and laws; and d) strengthening international cooperation.

1. Introduction
The issues of energy revolution and environmental protection have become the strategic concern of Chinese society. According to the Outline of the 13th Five-Year Plan for Economic and Social Development of China, building a modern energy system and accelerating the improvement of the ecological environment have been identified as two major goals of the Chinese government. In terms of the energy, the discourse of energy revolution, which was firstly proposed by Chinese President Xi Jinping and then detailed by the official document of Energy Production and Consumption Revolution Strategy (2016-2030) (EPCRS), represents the importance and necessity of transforming the energy development approach of China. There are five general directions of promoting the energy revolution, i.e., energy consumption, energy supply, energy technology, energy system, and energy international cooperation. Furthermore, many specific measures are prescribed under each direction for solving the problems of ensuring the energy security. The strategy with its measures would profoundly affect the process of China’s environmental governance and other aspects of the development [1].

Environment pollution is still a major challenge of the sustainable development of China’s economy and society. Implementing the most stringent environmental protection system and fighting for the campaigns of air, water, and soil pollution prevention and control have been promised and initiated by the Chinese government, according to the 13th Five-Year Plan for Ecological and Environmental Protection (2016-2020). Among the environmental challenges, air pollution is particularly striking because of its severe negative impacts on human health and economic
development. The unreasonable economic development model, which depends heavily on resources consumption and pollution-intensive industries, could be recognized as the primary cause of the continuous air pollution of China [2]. Although many measures have been taken for the air pollution governance, such as an action plan has been formulated and many laws have been revised, it is foreseeable that the problems would continue because a series of fundamental challenges are still unresolved.

Energy is one of the key factors that could profoundly affect the air pollution governance. Accelerating energy structure adjustment and increasing clean energy supply have been proposed by the Chinese government according to the Air Pollution Prevention and Control Action Plan issued in 2013. However, to implement the measures of the action plan, a series of challenges and constraints should be concerned. In the winter heating season of 2017-2018, a severe gas shortage hit many cities and areas in northern China, which revealed the problems in achieving the goals of the action plan. For a just society the benefits and costs of energy services should be fairly disseminated [3]. Energy as one of the primary goods should be properly distributed despite the consideration of environmental protection. In short, we should coordinate the energy development and air pollution control; the energy technology could facilitate this process. This study focuses on the issue of energy technology revolution for promoting the air pollution governance in China. First, through the gas shortage case analysis, the challenges in energy technology are presented. Second, the key aspects of the energy technology revolution are redefined in response to the air pollution governance. Third, some strategies are proposed for promoting the energy technology revolution.

2. Energy technology challenges reflected by the gas shortage case

2.1. The gas shortage event
In the heating season of 2017-2018, China suffered a desperate shortage of natural gas, which produced many negative impacts on the economic and social development. For instance, about 1% of the 25,000 villages that participated in the action of coal to gas or electricity, were faced with heating problems due to lack of adequate gas supply, according to the investigation released by the Ministry of Ecology and Environment (MEE) in its routine press conference of February 2018. The increment consumption of natural gas in 2017 is more than 34 billion cubic meters and the resource supply gap of northern China in the wintertime is about 5 billion cubic meters, according to the 2017 Domestic and Foreign Oil and Gas Industry Development Report issued by the Economics and Technology Research Institute of China National Petroleum Corporation (CNPC). From Table 1 we could find more details to present the situation of the shortage. The increment consumption of natural gas in 2017 is more than 34 billion cubic meters and the resource supply gap of northern China in the wintertime is about 5 billion cubic meters, according to the 2017 Domestic and Foreign Oil and Gas Industry Development Report issued by the Economics and Technology Research Institute of China National Petroleum Corporation (CNPC). From Table 1 we could find more details to present the situation of the shortage. The increment consumption of natural gas, electricity and coal in 2017 is particularly noticeable. As we know, since 2013 China has been working on implementing the action plan. Therefore, the demand of natural gas dramatically increased while the coal witnessed a remarkable decrease. With the improvement of the electrification, the demand for electricity was also rising. Actually, almost every year China would be confronted with the supply tension of natural gas but not as serious as the wintertime of 2017-2018.

2.2. Energy technology challenges
Before exploring the energy technology challenges, we should analyze the reasons of the gas shortage. The MEE holds that the gas shortage exposed the problems in energy sector, such as inadequate gas storage capacity, lack of pipeline networks interconnection, incompetence on the works of restricting the non-residential use and ensuring the residential use of gas, and unreasonable system and mechanism of gas supply and utilization (see the routine press conference of MEE on February 27, 2018). The National Development and Reform Commission (NDRC) believes that comprehensive factors resulted in the rapid growth of gas demand in the wintertime of 2017-2018, and the gas supply reduction from Central Asia intensified the shortage. Meanwhile, many other obstacles also exerted bad influence on the balance of the gas supply and demand, such as the insufficient investment in exploration and exploitation, the fluctuation risk due to the undiversified supply system, the lack of
integration and efficiency of resource utilization especially constrained by the fragmental pipeline networks, the lack of methods to adjust the peak demand, and the disorderly development of gas supply and utilization (see the press conference held by the NDRC on April 27, 2018). In addition to these explanations from the government departments, we could find other reasons from more wide perspectives. First, the possible impacts of the environmental policies are not adequately assessed. The year of 2017 is critical because many indicators set by the action plan must be completed. Therefore, many local governments introduced radical measures to limit the utilization of dirty energy, which could be seen as the major reason of the shortage. Second, many constraints from the energy infrastructure affected the gas supply. Actually, there were surpluses of gas in southern China and international energy market when the shortage broke out and sustained. However, they cannot be effectively transported to the northern areas due to the problems of the energy infrastructure, such as the port does not have the ability to accept large quantities of imported liquefied natural gas (LNG). Furthermore, the areas mostly affected by the shortage were located in where the energy infrastructure was relatively poor, e.g., the remote rural areas. Third, the clean energy still cannot be used as an important supplement for solving the gas supply crisis. The problems of long-distance transportation, storage and stability are not resolved.

From the reason analysis above, we could identify some challenges in energy technology. First, the gas storage technology should be concerned. The gas storage capacity in many local places of China does not reach the target of daily average of 3 days, according to the data published by the NDRC. The construction of the planed gas storage facilities needs the support of technology. Second, the technology to promote the interconnection of energy networks would be a major challenge. Fragmentation is a distinct feature of China’s energy transportation system. Many early designs of energy networks did not consider the issue of raising energy from other directions. Third, building an integrated platform to monitor and manage the energy supply and demand needs breakthroughs of technology. Fourth, energy infrastructure construction needs to overcome many difficulties of technology. The shortage exposed the weaknesses in basic energy services of China. Extending and optimizing the energy infrastructure should consider the technology issue. Last, the development and utilization of clean energy requires extensive technological breakthroughs especially on solving the problems of transportation and stability.

Table 1. Increment consumption of China’s major energy sourcesa.

| Year | Increment Consumed (%) |
|------|------------------------|
|      | Natural Gas | Electricity | Coal | Crude Oil |
| 2017 | 14.8        | 6.6         | 0.4  | 5.2       |
| 2016 | 8.0         | 5.0         | -4.7 | 5.5       |
| 2015 | 3.3         | 0.5         | -3.7 | 5.6       |
| 2014 | 8.6         | 3.8         | -2.9 | 5.9       |
| 2013 | 13.0        | 7.5         | 3.7  | 3.4       |

aThe data are collected from the Statistical Communiqué of China on National Economic and Social Development.

3. Energy technology revolution in the context of air pollution control
The EPCRS emphasized four aspects of promoting the energy technology revolution as follows: 1) applying advanced energy efficient technologies; 2) promoting the technologies of development and utilization of clean and low carbon energy; 3) developing smart energy system technologies; and 4) strengthening the basic research on energy science and technology. These directions could provide significant guidelines to the development of China’s energy sector. However, the energy system goes beyond the pure considerations of just technology and economics [4]. The energy technology
revolution should focus on the major practical needs in China’s sustainable development. The fact that China must improve its air pollution governance cannot be avoided for the energy revolution. The requirements and value orientation of the air pollution governance should be incorporated into the energy technology revolution.

3.1. Enhancing the response to environmental policies
From the gas shortage analysis, we could find that energy technology is an important element of the air pollution governance. Actually, there is a trilemma in the relationship between energy and the environment. The energy trilemma refers to the interactions among energy security, energy equity, and environmental sustainability according to the definition of the World Energy Council. “The notion of a trilemma reflects the difficulty of striking a balance among these three criteria because an improvement in one criterion tends to be harmful to the other two.”[5] Energy technology could be an effective approach to deal with the trilemma. Unreasonable energy development and utilization are the causes of air pollution. Through the application of energy technology, many environmental problems could be solved. For instance, the coal gasification technology can largely solve the pollutant emission problem from the coal direct combustion. However, the air pollution governance has its own logic and concerns. The energy technology should enhance the response to related environmental policies. Many of the measures proposed by the action plan cannot be successfully implemented without the support of energy technology. In the process of the response, the critical work is to find the challenges or problems that need to be addressed. From the gas shortage case, we could find the challenges in gas storage, transportation, utilization, etc. Then the corresponding technology strategies could be given.

3.2. Establishing a sustainable dynamic mechanism
The air pollution governance is a continuous process, so the development of related energy technology needs the support of sustainable dynamic mechanism. In China, the traditional paradigm in the field of energy and environment is the administrative management, which has the features of power dependence, short term goals, and pressure driving [6]. This paradigm has a major problem in sustainability. From the gas shortage event, we could see that the order or plan from the government is the main driving force of the development of related energy technology. In China’s energy sector, the reality is that most of the resources and related exploitation are controlled by the state-owned enterprises (SOEs). The SOEs are one of market players, but they must implement the orders from the national authorities. Although they have the motivation to develop some technologies, the interest conflicts are inevitable. The air pollution governance could be recognized as providing public goods. The tragedy of the commons would happen if lack of the coercive arrangements [7]. The development and utilization of energy would produce negative externalities, which should be internalized. The SOEs are stakeholders of the air pollution governance, and the economic interests are priorities of their consideration. Solving this conflict should reform the energy system.

3.3. Emphasizing the innovation of concept and approach
The energy sector is deeply influenced by the evolution of different concepts. In the history of human development, the use of energy has a significant characteristic of the gap of generations. Coal is more efficient than wood, and electricity is more convenient than coal. In different energy generations, the energy structure, the energy utilization ways, the energy use impacts, and the applicable energy technology are totally different. The energy generations represent a fundamental difference in concept. According to the theory of energy generation, energy is an important factor that could determine the development of civilization and the transfer of power in international relations. Therefore, promoting the energy generation shift and optimizing the development and utilization of energy becomes the mission of many countries and regions. Nowadays, we are experiencing the third industrial revolution, which provides many opportunities to the development of energy. China accounted for 23% of global energy consumption and 27% of global energy consumption growth in 2016 according to the data of BP. China is one of the major energy consumers in the world, and promoting the energy revolution is
significant not only for increasing the sustainability of the energy development but also for building a beautiful China and ecological civilization. The following concepts should be concerned for promoting the energy technology revolution and air pollution governance, i.e., the green and low carbon development, the big data, the internet plus and internet of things, the block chain, the cloud computing, the artificial intelligence, etc.

4. Strategies for promoting the energy technology revolution

4.1. Ensuring sufficient investment

The financial support for the research and application of related energy technology is essential. Providing the energy technology involves a wide range of entities and sectors that have their unique logic of action. For the private enterprises, profit is the most important consideration, which makes them reluctant to consider the investment in many energy technologies. The private investment might encounter many risks or costs, such as long time-consuming, large sunk costs, and uncertain returns. In addition, the monopoly of China’s energy industry limited the entry and competitiveness of private investment. For the SOEs, the complex decision making and accountability system would affect the investment plan on related energy technology. The SOEs are regulated by a range of government departments, who have different responsibilities and functions. It is difficult to coordinate their positions and interests. For instance, many large SOEs monopolized the energy supply channels and related energy infrastructure operating rights; therefore, any participation of other players would challenge their interests. For ensuring the investment, we could take the following measures. First, the central government can formulate a special financial support plan. Second, the barriers should be removed for encouraging and protecting the private investment. Third, the access limitation on foreign investment should be appropriately reduced.

4.2. Reforming the energy systems and mechanisms

The energy technology revolution cannot ignore the problems in the energy systems and mechanisms, which consists of four critical elements centered on energy market, i.e., the basic system, the competitive structure, the operation mechanism, and the regulatory system. The main problem in China’s energy sector is that the systems and mechanisms cannot satisfy the needs of building a modern energy system according to the EPCRS. Although many market-oriented reforms have been implemented since the reform and opening up policy, many planned economy practices have been retained in the energy sector in China. This fact could become a major challenge of the energy technology revolution. The air pollution governance requires the response of the energy technology. It is necessary to reform the unreasonable aspects of the traditional practices from the following approach. First, the government’s improper intervention to the energy market should be eliminated. Second, the arrangements for fair treatment of the energy market participants should be planned and implemented. Third, the regulation especially on anti-monopoly should be highlighted. Fourth, the related government agencies and their functions should be integrated for adapting to the new normal.

4.3. Improving the policies and laws

The legislation in China’s energy sector is full of problems. For instance, although the comprehensive energy legislation (energy law) has been discussed for more than a decade, it still has not passed. The energy technology revolution under the background of air pollution governance involves multiple legal relations. Therefore, a targeted legislation that fully considers the special situation is needed. For promoting the energy technology revolution, a necessary and feasible way is to recommend that the State Council issues an administrative regulation. At the same time, other laws should be formulated or revised for including the relevant considerations. For the policies, the most obvious problem is the lack of coordination. The environmental policy often conflicts with the energy policy; the gas shortage event is a good example. The policies between different government departments are often inconsistent. Therefore, the work on enhancing the coordination of policies is important. Finally, the
impact assessment of policies should be applied. The lesson we learned from the gas shortage is that there is not enough awareness of the impact of the environmental policies. The policy impact assessment can also provide guidelines for the development of related energy technologies.

4.4. Strengthening international cooperation
In the context of globalization, the production and application of knowledge requires extensive collaboration. The energy technology revolution should strengthen international cooperation. First, the government should build some contact and communication mechanisms with relevant foreign research and development institutions. Second, the intellectual property rights of foreign technologies should be fully protected through creating a good policy and legal system. Third, the access to the domestic energy market should be appropriately opened up. Fourth, domestic energy enterprises should speed up going out and try to cooperate with more energy entities. Fifth, the government should promote the signing of relevant cooperation agreements with other countries and organizations.

5. Conclusions
The challenges from the air pollution governance should be carefully addressed. In the heating season of 2017-2018, a gas shortage happened in China, which exposed the problems in the energy and environment sector. Although the shortage can be explained by the reasons of gas storage capacity inadequacy, pipeline networks interconnection problem, and the Central Asia’s gas supply reduction, lack of impact assessment of environmental policies can be recognized as the main reason. From the shortage case analysis, we find many energy technology challenges. Promoting the energy technology revolution could help the air pollution governance. The following things should be concerned for integrating the energy technology revolution and air pollution governance: 1) enhancing the response to environmental policies; 2) establishing a sustainable dynamic mechanism; and 3) emphasizing the innovation of concept and approach. Four approaches should be highlighted for supporting the energy technology revolution: 1) ensuring sufficient investment; 2) reforming the energy systems and mechanisms; 3) improving the policies and laws; and 4) strengthening international cooperation.

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