Characteristics of Energy Production and Consumption in Sichuan Province and Development Strategies

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Abstract. The new energy revolution has put forward new requirements for energy production and consumption. This study systematically analyses the characteristics of energy production and consumption in Sichuan Province from 2015 to 2018. According to our analysis, natural gas and hydropower were the main sources of energy production in Sichuan Province, while the outputs of coal and, in particular, oil did not match consumption demand. Meanwhile, the industrial sector and household consumption were the main energy-consuming sectors in Sichuan. This study opines that, on the one hand, Sichuan Province should continue to develop and expand the production and consumption of clean energy and explore expanding the production of wind and solar energy. On the other hand, the province should devote attention to research and development for improving the efficiency of high-carbon fossil energy utilisation. Additionally, Sichuan Province also needs to focus on increasing the inventory of coal- and oil-based energy. The three aspects above require technological innovation. Hence, developing and introducing related technologies and talents is a long-term energy development solution for Sichuan Province.

1. Introduction
Currently, a new round of the energy revolution has emerged and the development of clean and low-carbon energy has become a major trend. As a result, China is actively advancing reforms in domestic energy production and consumption to ultimately achieve energy transformation and establish a clean, low-carbon, safe, and efficient modern energy system [1]. As an important link in the overall pattern of socioeconomic development in China, Sichuan Province is an advanced base for the development of West China [2], the most powerful inland province with an open economy to South Asia, and it promotes West China to the world [3]. As energy is the foundation of social development in Sichuan Province, it is of great significance to understand the characteristics of energy production and consumption.
and consumption in Sichuan Province and formulate an energy development policy that meets the requirements of the new round of the energy revolution. Earlier studies on energy production and consumption in Sichuan Province, such as one conducted in 2015 [4] and two in 2006 [5,6], systematically analysed the characteristics of energy production and consumption in the province and proposed countermeasures and suggestions for energy development. However, these studies did not examine the energy production in Sichuan Province relative to the national level. Moreover, studies on energy production and consumption in Sichuan Province have been few and far between in recent years. This study is thus able to supplement the deficiencies of related studies.

2. Basic characteristics of energy production in Sichuan Province compared to energy production in China

According to the data in the China Energy Statistical Yearbook, the raw coal and coking coal outputs in Sichuan Province in 2017 were 47,985,100 and 10.721,600 tons, accounting for 1.36 and 2.49 percent of the total raw coal and coking coal outputs in China, respectively (see Figure 1a). Sichuan had a relatively low crude oil output of 86,700 tons, constituting 0.05 percent of the total crude oil output in China. The output of other energy sources, namely, gasoline, kerosene, diesel, and fuel oil, were 2,803,400, 460,500, 2,918,800, and 305,900 tons, accounting for 2.11, 1.09, 1.59, and 1.15 percent of the total output of various energy sources in China, respectively (see Figure 1b).

The production of natural gas in China is mainly concentrated in Shaanxi, Sichuan, and Xinjiang. In 2017, the natural gas outputs in these three regions were 41.940 billion, 35.639 billion, and 30.704 billion cubic meters, respectively, while natural gas outputs in other regions were relatively low (see Figure 1c).

As shown in Figure 1d, there are many types of electricity production in China, including thermal power, hydropower, nuclear power, wind power, and solar power generation. In 2017, thermal power and hydropower generation constituted 71.79 percent and 18.32 percent of the total power generation in China, respectively. Power generation in Sichuan Province only accounted for 5.36 percent of the total power generation in China, while hydropower generation in Sichuan Province constituted 25.56 percent of the total hydropower generation in China, making the province the top hydropower producer in the country. Moreover, Sichuan Province does not generate nuclear power and only produces a small amount of wind and solar power.

The analysis above shows that, compared to the energy production and composition in China, the energy production in Sichuan Province mainly revolves around natural gas and hydropower generation, while the outputs of other energy sources are still too low to constitute a scale advantage.
3. Analysis of the characteristics of energy production and consumption in Sichuan Province

3.1. Energy Production and Composition in Sichuan Province

According to the data in the Sichuan Statistical Yearbook, crude oil and raw coal outputs in Sichuan Province continued to decline, while natural gas and primary power outputs continued to increase from 2015 to 2018. From the perspective of energy composition, in 2018, the outputs of natural gas, primary power, raw coal, other energy sources, and crude oil in Sichuan Province accounted for 39.85, 33.12, 23.85, 3.09, and 0.09 percent of the total energy production in Sichuan Province, respectively. Moreover, in 2017, the total power generation in Sichuan Province was 348.038 billion kilowatts per hour, where hydropower and thermal power generation were 304.12 and 38.445 billion kilowatts per hour, constituting 87.38 and 11.05 percent of the total power generation in Sichuan Province, respectively. In other words, hydropower generation is the main component of the power generation in Sichuan Province. Based on the above data, clean energy is the main source of energy in Sichuan Province, with the clean energy output in the province continuing to rise, which is in line with the main theme of this new round of the energy revolution (see Figure 2).
Figure 2. Total energy production and its composition in Sichuan Province.

3.2. Energy Consumption and Composition in Sichuan Province

3.2.1. Energy Consumption and Composition. From 2015 to 2018, the total energy consumption in Sichuan Province continued to increase, while the consumption of coal-based fuels started to decline in 2018 after continuous increase from 2015 to 2017. Meanwhile, the consumption of natural gas, primary power, and other energy sources continued to grow (see Figure 3) in line with the requirements for energy consumption in the new round of the energy revolution. Regarding consumption composition, the consumption of coal-based fuels, primary power, oil fuels, natural gas, and other energy sources in Sichuan Province in 2018 accounted for 37.22, 25.94, 23.35, 20.00, and 3.64 percent of the total energy consumption in the province, respectively. Coal-based and oil fuels, whose total consumption constituted 60.57 percent of the total energy consumption, continue to be the main components of energy consumption in Sichuan Province. Furthermore, raw coal and crude oil outputs in Sichuan Province only accounted for 23.85 and 0.09 percent of the total energy production in the province, respectively, thus leading to an evident mismatch between energy production and consumption.

Figure 3. Total energy consumption and its composition in Sichuan Province.

3.2.2. Energy Consumption and Composition of Major Sectors. Regarding the energy consumption of the different sectors in Sichuan Province, the industrial sector is the main coal-consuming sector, with its coal consumption in 2018 accounting for 97.23 percent of the total coal consumption of all sectors. The transportation, warehousing, and postal sector is the main oil-consuming sector, with 35.54 percent of the total oil consumption of all sectors. Natural gas consumption is mainly concentrated in the industrial sector and household consumption, accounting for 61.46 and 20.49 percent of the total consumption of natural gas, respectively. Electricity consumption also mainly revolves around the industrial sector and household consumption, with 62.46 and 18.96 percent of the total electricity consumption, respectively (see Table 1).
Table 1. Consumption from main energy sources in different sectors in Sichuan Province.

| Sector                                         | Coal   | Oil    | Natural gas | Electricity |
|------------------------------------------------|--------|--------|-------------|-------------|
| Agriculture, forestry, animal husbandry, and fishery | 0.61%  | 3.91%  | 0.42%       | 0.67%       |
| Industrial sector                               | 97.23% | 17.31% | 61.46%      | 62.10%      |
| Construction sector                              | 0.14%  | 12.63% | 0.42%       | 1.99%       |
| Transportation, warehousing, and postal sector    | 0.06%  | 35.54% | 8.36%       | 2.37%       |
| Wholesale, retail and accommodation, and catering sector | 0.35%  | 6.66%  | 5.28%       | 5.28%       |
| Other service sectors                            | 0.26%  | 7.25%  | 3.15%       | 8.63%       |
| Household consumption                            | 1.36%  | 16.70% | 20.49%      | 18.96%      |

4. Results
Based on the above analysis, energy production and consumption in Sichuan Province have the following characteristics.

First, clean energy sources, such as natural gas and hydropower generation, are the main components of energy production and consumption in the province. Their proportions demonstrate a continuous increase, which is in line with the main theme of the new round of energy revolution.

Second, energy production and consumption in Sichuan Province do not match. Coal and oil outputs accounted for 23.85 and 0.08 percent of the total energy production in Sichuan Province, respectively. However, coal-based and oil fuel outputs accounted for 37.22 and 23.35 percent of the total energy production in the province, respectively, where the outputs of coal and, in particular, oil failed to match consumption demand.

Third, the industrial sector and household consumption are the main energy-consuming sectors in Sichuan Province, while the transportation, warehousing, and postal sector has a large demand for oil.

5. Development strategies
According to the Energy production and consumption revolution strategy (2016–2030) [1], jointly issued by the National Development and Reform Commission and the National Energy Administration, China will strive to achieve sustainable growth in the use of renewable energy, natural gas, and nuclear energy, as well as significantly reduce the use of high-carbon fossil energy from 2021 to 2030. Meanwhile, it is necessary for Sichuan Province to strengthen the exploration and development of conventional and unconventional natural gas and build natural gas production and supply areas in Sichuan. Against this backdrop, energy development in Sichuan Province should focus on three aspects. The first is to broaden energy sources, that is, continue to develop and expand the production and consumption of clean energy. In addition to continuously exploring and exploiting natural gas, as well as developing green and eco-friendly hydropower generation, it is necessary to investigate expanding the production of wind and solar energy. The second aspect is reducing energy inefficiency.
At present, coal- and oil-based energy are still the main sources of energy consumption in Sichuan Province. Hence, it is necessary to advance research and development to improve the efficiency of coal- and oil-based energy utilisation and reduce the total consumption of high-carbon fossil energy. The industrial sector, household consumption, and the transportation sector should be the main frontiers for the research, development, and application of technologies related to broadening energy sources and reducing energy inefficiency in Sichuan. The third aspect is that Sichuan Province needs to focus on increasing the inventory of coal-based and oil fuels in case of emergency owing to the mismatch between the production and consumption of related energy sources. Realising these three aspects requires technological innovation; hence, developing and introducing related technologies and talent is a long-term energy development solution for Sichuan Province.

6. References

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