Analysis of Sustainable Energy Development Paths in Northwest China from the Perspective of Energy Revolution

Huan DU[1,2]* and Xingyuan FENG[2]

[1] Northwest University, Xi'an, China; 165688575@qq.com

[2] Xi'an University of Finance and Economics, Xi'an, China; 165688575@qq.com; xing75889021@icould.com

* Corresponding author: 165688575@qq.com

Abstract: The period of the fourteenth Five-Year Plan is critical for the growth of China's energy revolution. As an energy-rich region of China, Northwest China offers inherent advantages for the growth of the energy industry. China will be able to achieve its goals of carbon peaking and carbon neutrality due in great part to its energy development plans. The research begins by comparing the underlying conditions of energy development in Northwest China. The paper next evaluates the level of fossil and sustainable energy sector clustering in Northwest China, revealing that the challenges involved with developing fossil and sustainable energy are dissimilar. Using the problems as a guide and the "energy revolution" promotion requirements and energy base construction as a foundation, the development of fossil energy in Northwest China must lengthen the industrial chain to improve the added value of products, and promote the synergistic and complementary development of the energy industry cycle, fossil energy, and sustainable energy. Optimizing the power transmission structure, capitalizing on the national power market reform, and promoting international energy cooperation are vital for fostering a sustainable energy sector.

Keywords: energy revolution; green-oriented transition; sustainable energy; fossil energy

JEL Classification: Q01; Q30; Q40

1. Introduction

Economic and social progress depend on energy. It generates most carbon emissions and fuels industrial growth. Carbon peaking during the 14th Five-Year Plan will lead to major energy sector adjustments. The new energy development effort must be founded on China's energy resource endowment, first formed and then broken, planned and step-by-step implementation of carbon peak action, in-depth promotion of the energy revolution, and improved clean and efficient use of coal. It must accelerate green transformation, conservation, and low-carbon industry growth. China's energy resources are "rich in the west and poor in the east" and "more coal, less oil, and poor gas." East and west energy demands differ structurally. East and central energy supplies are inferior to west ones, creating a supply-demand mismatch. However, China's energy-rich west is economically underdeveloped. This research begins with Western energy industry growth. It then assesses industrial agglomeration to identify industry development issues and produces policy suggestions that fulfill industrial development and "energy revolution" requirements. Based on western China's energy resources, this study takes the rise of the energy sector as a reference, evaluates industrial development challenges through the lens of industrial agglomeration, and proposes policy proposals that fulfill industrial development norms and the "energy revolution."

1.1. Fossil Energy Resources Distribution in Five Northwestern Provinces

Northwest China's fossil energy resources mainly consist of coal and oil/gas. Coal reserves in Northwest China account for 33.11% of national total, with Xinjiang having 2.19 trillion tons of resources and 180.37 billion tons of reserves, ranking first. Shaanxi (176.338 billion tons), Gansu (165.6 billion tons) and Ningxia (172.111 billion tons, 31 billion pro) rank fourth, seventh and sixth respectively. Oil production is decreasing while natural gas is increasing. NW China's petroleum distribution is uneven. The government added 1.322 billion tons of proven geological petroleum reserves in 2020, up 17.7%. Northern Xinjiang's Junggar, Tarim, and Changji oil fields have 100 million tons of geological reserves.

There have been numerous studies in recent years on the energy resources of the five northwestern provinces of China. A study by Wang et al. (2019) investigated the distribution and characteristics of coal resources in the region, finding that coal-bearing strata in the region are mainly distributed in the Neogene and Quaternary systems. Zhang et al. (2019) conducted an analysis of the oil and gas resources in the region, finding that the region has large reserves of oil and gas, but that the resources are unevenly distributed. Yang et al. (2020) studied the petroleum resources of the region, concluding that the Junggar, Tarim, and Changji oil fields in northern Xinjiang have 100 million tons of geological reserves. A recent study by Li et al. (2021) focused on the natural gas resources in the region, finding that the region has abundant natural gas resources and that Shaanxi and Xinjiang are the major contributors to natural gas production in the region, accounting for 54.2% and 38.4% respectively.

Northwest China produced 66.59 million tons of oil in 2019, down 2.6% from 2018. Shaanxi decreased 3%. Northwest oil production reveals inequality. In 2019, Xinjiang produced 42.13%, Gansu 13.65%, and Qinghai 3.44% of the five Northwest provinces' oil. Shaanxi produced 40.68%. In 2020, China's natural gas sector added 30.0% more proven reserves, 105,1458 million cubic meters. Natural gas resources in Northwest China have been more concentrated in Shaanxi and Xinjiang over the last decade, with Shaanxi accounting for 54.2% of natural gas production in 2019 and Xinjiang accounting for 38.4%, while Gansu and Qinghai accounted for 0.17% and 7.2% of natural gas production, respectively.

1.2 Sustainable Energy in Northwest China

The development of sustainable energy sources in northwest China is critical to both economic growth and environmental protection. As the energy revolution continues to advance, researchers must identify effective strategies for developing renewable energy sources in the region. This section compares research on hydropower, wind, and solar resources in Northwest China and assesses their impact on energy sustainability.

Hydropower is a reliable and clean energy source that is widely used in Northwest China. To examine the development of hydropower in the region, Chen et al. (2020) studied hydropower development in the Yellow River basin, a major river in Northwest China. They found that hydropower is the largest source of renewable energy in the basin and accounted for 62% of the region's total energy production in 2017. Few and mostly concentrated in Qinghai, Northwest China's hydropower resources are growing slowly. The Yellow River Basin is crucial for the development and use of Northwest China's water resources, and Qinghai Province, the area with the highest hydropower resources there, has a potential reserve of 21.87 million kilowatts. Hydropower could be a major contributor to energy sustainability in the region if the impacts of hydropower are managed more effectively.

Wind energy is another important source of renewable energy in Northwest China. Gong et al. (2018) studied wind energy development in the region and found that wind power accounted for 8.2% of the region's energy production in 2016.Wind energy could provide a clean and cost-effective alternative to traditional energy sources. Wind energy resources are abundant in northwest China, but they are concentrated in the provinces of Xinjiang, Gansu, and Qinghai and are not distributed evenly. Figure 1 shows that Xinjiang has 23.61 million kilowatts of installed wind power, ranking first in Northwest China and accounting for 8.38% of the country, up 20.7% from 2019. The remaining four Northwest Chinese provinces, including Gansu, have installed wind power capacity according to their proportions.

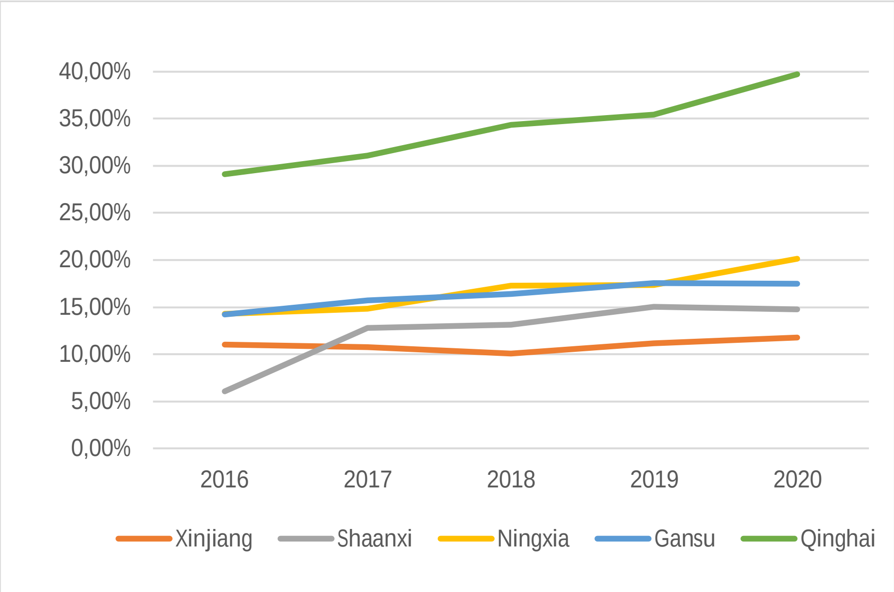

Figure 1. Northwest provinces installed solar power capacity accounted for the proportion of total installed capacity in each province trend

A lot of solar energy resources in the whole area of the five northwest provinces. Solar energy is becoming increasingly important for energy sustainability in Northwest China. Wang et al. (2019) studied the potential for solar energy development in the region and found that solar power could be a major contributor to energy production in the future.

The installed solar power capacity in Northwest China will rise between 2016 and 2020, as shown in Figure 2, and each province's share of the nation's installed capacity will gradually rise as well. In 2020, Qinghai Province will have 16.01 million kilowatts of solar power capacity, up 42.7% from the year before. Xinjiang follows with 12.66 million kilowatts, up 18.2% from 2019. Qinghai Province generates 39.73 percent of its electricity from solar power. Ningxia follows with 20.14 percent of installed capacity from solar.

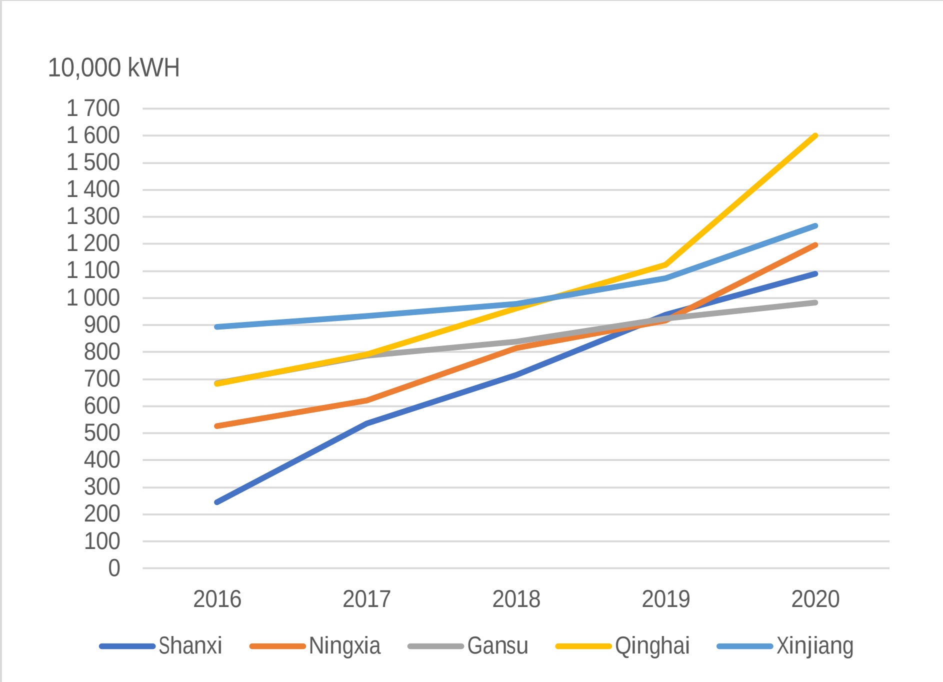

Figure 2. Installed wind power capacity by province in Northwest China, 2016-2020

In conclusion, hydropower, wind, and solar energy are all important sources of renewable energy in Northwest China. While hydropower is currently the region's largest source of energy production, other renewable energy sources such as wind and solar energy could also play a major role in the region's energy sustainability. To maximize the potential of these energy sources, a comprehensive policy framework and adequate investment in infrastructure should be implemented.

2. Methodology

2.1. Fossil Energy Industry Aggregation Level Measurement in Northwest China

This research uses locational entropy and spatial Gini coefficient investigations to create a spatial capacity agglomeration model to characterize Northwest China's fossil energy sector growth. This model shows each province's fossil energy clustering compared to national production.

$$EAD_i = \frac{EP_{ij}}{EP_i} / \frac{EP_j}{EP} \tag{1}$$

EAD_i represents the energy industry agglomeration of province i, EP_{ij} denotes the i province's fossil energy production, EP_i denotes the i province's total output value for that year, EP_j denotes the nation's total fossil energy production, and EP denotes the nation's total output energy value for that year. The production of standard coal is first converted in the computation from coal, coke, and crude oil output; the conversion coefficients are displayed in Table 1. The years 2007 to 2018 were chosen as the sample period for this study based on the availability of data, and the data were taken from the China Statistical Yearbook, the statistical yearbooks of each province, and the China Energy Statistical Yearbook from 2008 to 2019.

Table 1. Fossil energy conversion factor for standard coal

	Coal	Coke	Crude Oil	Petrol	Gasoline	Diesel	Fuel oil	Gas
factor	0.7143	0.9714	1.4286	1.4714	1.4714	1.4571	1.4286	1.3300

2.2. Sustainable Energy Industry Aggregation Level Measurement in Northwest China

Locational entropy, also known as the local specialization rate or the specialization index, is a key indication of regional specialization that has been widely employed for centuries. It refers to the proportion of a region's total industries occupied by a certain industry compared to the proportion represented by domestic industries. Currently, it is also used to assess the degree of aggregation of a certain industry in a particular geographic region. The formula for its computation is as follows:

$$LQ = \frac{E_{\mathrm{ij}}}{E_{\mathrm{i}}} / \frac{E_{\mathrm{kj}}}{E_{\mathrm{k}}} \quad (2)$$

The economic significance of location entropy is the value of an industry's share in a particular region relative to its share in the economy as a whole. Where E_{ij} represents the total output value of industry *j* in nation or region *i*, E_i represents the total production value of region *i*, EP_{kj} represents the total output value of industry *j* in country or region *k*, and E_k represents the total output value of country or region *k*. In equation (2), the total production value may be determined by a variety of factors, including the number of firms, the value contributed, the income of the primary business, and the number of employees.

If the LQ value is less than 1, it indicates that the degree of specialization of industry *j* in region *i* is lower than or near to the national average and that there is no discernible aggregation tendency for industry *j* in region *i*. If the LQ value is larger than 1, it indicates that the degree of specialization of industry *j* in region *i* exceeds the national average. Within area *i*, there is a substantial concentration of industrial *j*. This indicator is created to indicate the clustering of industries within an area and the agglomeration at the regional and factor levels.

3. Results

3.1. Northwest China Fossil Energy Industry Agglomeration Results

The total standard coal production is then calculated using the conversion coefficient in accordance with the calculation formula for the industrial agglomeration measure specified in Section 3.2, after first obtaining the energy production statistics for each province in China from CAMAR. Following that, we determined the locational entropy of every province, and the results are displayed in Table 2.

Table 2. Fossil energy industry location entropy index

Province	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Growth Rate/%
Shanghai	0.20	0.21	0.19	0.59	0.61	0.64	0.70	0.20	0.22	0.22	0.22	0.20	0.34
Yunnan	1.42	1.39	1.02	0.84	0.77	0.69	0.70	0.63	0.64	0.61	0.64	0.71	-50.05
Neimenggu	4.25	4.93	5.37	0.74	0.81	0.78	1.06	7.04	6.92	7.27	9.35	9.93	133.84
Beijing	0.15	0.17	0.18	0.37	0.32	0.30	0.24	0.12	0.11	0.10	0.09	0.08	-45.36
Jilin	0.86	0.87	0.85	1.02	1.08	1.05	0.94	0.56	0.53	0.48	0.45	0.44	-48.59
Sichuan	0.80	0.74	0.67	0.39	0.40	0.37	0.36	0.47	0.43	0.44	0.36	0.28	-65.32
Tianjin	0.79	0.66	0.69	2.74	2.48	2.24	2.12	0.65	0.73	0.72	0.72	0.75	-4.85
Ningxia	3.33	3.21	3.83	1.59	1.25	2.30	2.56	4.56	4.44	4.34	4.57	4.42	32.87
Anhui	1.07	1.20	1.21	0.42	0.39	0.36	0.37	0.87	0.92	0.87	0.84	0.77	-28.07
Shandong	0.80	0.78	0.78	1.35	1.40	1.46	1.51	0.82	0.87	0.97	0.97	0.87	9.30
Shaanxi	9.19	8.27	7.89	3.50	3.43	3.23	3.39	9.78	10.85	10.66	10.00	10.29	11.94
Guangdong	0.16	0.17	0.17	0.54	0.52	0.53	0.55	0.17	0.19	0.20	0.19	0.20	26.19
Guangxi	0.17	0.13	0.13	0.32	0.63	0.76	0.75	0.31	0.30	0.31	0.36	0.34	108.74
Xinjiang	2.84	3.08	3.32	5.23	5.12	4.88	5.10	3.55	3.73	4.15	4.19	4.41	55.49
Jiangsu	0.20	0.19	0.18	0.37	0.40	0.41	0.43	0.18	0.19	0.19	0.17	0.15	-27.00
Jiangxi	0.54	0.54	0.49	0.53	0.50	0.50	0.49	0.37	0.33	0.31	0.23	0.20	-62.83
Hebei	0.90	0.84	0.87	1.37	1.50	1.55	1.45	0.73	0.80	0.80	0.74	0.74	-17.73
Henan	1.16	1.15	1.20	0.70	0.64	0.63	0.65	0.70	0.67	0.64	0.58	0.55	-52.24
Zhejiang	0.12	0.13	0.13	0.36	0.37	0.33	0.32	0.10	0.10	0.10	0.10	0.10	-20.58
Hainan	0.85	0.78	0.77	2.10	2.03	1.87	1.44	0.52	0.60	0.60	0.51	0.57	-33.44
Hubei	0.28	0.26	0.24	0.52	0.50	0.44	0.46	0.19	0.18	0.17	0.17	0.15	-46.40
Hunan	0.60	0.53	0.52	0.28	0.33	0.35	0.33	0.34	0.26	0.23	0.18	0.18	-69.31
Gansu	1.77	1.68	1.63	1.78	1.98	1.86	1.85	1.42	1.45	1.49	1.45	1.32	-25.42
Fujian	0.22	0.22	0.25	0.31	0.24	0.27	0.23	0.21	0.22	0.21	0.18	0.18	-17.23
Guizhou	3.01	2.77	3.14	0.59	0.51	0.56	0.52	2.51	2.23	2.23	1.98	1.67	-44.49
Liaoning	1.26	1.16	1.09	2.12	1.98	1.91	1.84	0.80	0.84	1.19	1.18	1.21	-4.07
Chongqing	0.73	0.70	0.60	0.17	0.17	0.14	0.13	0.36	0.32	0.23	0.13	0.13	-81.87
Shaanxi	3.76	3.59	4.10	3.31	3.35	3.59	3.56	4.69	4.95	5.16	5.30	5.36	42.52
Qinghai	1.61	1.72	1.60	1.81	1.92	1.97	1.90	1.47	0.88	1.03	1.14	1.07	-33.56
Heilongjiang	2.22	2.03	1.99	3.21	3.01	2.90	2.84	1.48	1.51	1.59	1.63	1.62	-27.08

According to Table 2, the five provinces with the highest level of fossil energy upstream industry concentration in 2007 were Shaanxi (9.19), Inner Mongolia (4.25), Shaanxi (3.76), Ningxia (3.33), and Guizhou (3.01), and the five highest provinces in 2018 were Shaanxi (10.29), Inner Mongolia (9.93), Shaanxi (5.36), Ningxia (4.42), and Xinjiang (4.42), with little overall change. Simultaneously, China's fossil energy upstream business demonstrates a globally scattered and individually concentrated distribution. In 2018, all provinces have fossil energy upstream industry sites, with Shaanxi, Ningxia, and Xinjiang situated in the northwest among the top 5 provinces. Shaanxi (5.36), Ningxia (4.42), Xinjiang (4.42), Gansu (1.32), and Qinghai are the fossil energy industry agglomeration indices of the five northwest provinces in 2018. (1.07). In recent years, Qinghai and Gansu have dropped, keeping with the trend of robust growth of sustainable energy in Qinghai and Gansu; Xinjiang and Shaanxi have increased; and Ningxia has grown more moderate.

The concentration level of fossil energy upstream industries is decreasing nationwide. The falling areas are mostly in the Middle East, which matches China's low-carbon and green development goal. Some provinces are agglomerating more. The fossil energy sector agglomeration level in Xinjiang rose from 2.84 to 4.41, with a dynamic location entropy growth rate of 55.49%; Shaanxi Province rose from 3.76 to 5.36, with 42.52%; and Inner Mongolia grew from 4.26 to 9.93, ranking 1st in the country with 133.84%. The location entropy of the national fossil energy industry shows obvious geographical differences and gradually shifts from the eastern to the western regions in time, which is consistent with China's energy endowment and the "suppress the east, control the center, develop the west, and determine the industrial development pattern based on resource endowment, market location, environmental capacity, and other factors." This follows China's energy development policy of "restraining the east, managing the center, developing the west, and deciding the industrial growth pattern based on resource endowment, market location, environmental capacity, and other variables."

In conclusion, Northwest China's fossil energy industry remains vital and has grown. According to the above measurement results, the rising level of fossil energy industry agglomeration in Northwest China fully reflects that, around the strategic goal of energy revolution, China gives full play to the advantages of resource endowment in each region, takes advantage of Northwest China's fossil energy advantages, focuses on fossil energy industry development, and improves regional fossil energy industry levels. Since the above analysis of industrial agglomeration level is based on data related to the extraction industry in the upstream industry of fossil energy, the rise of industrial agglomeration level in some provinces in Northwest China actually reflects the expansion of the fossil energy extraction industry in Northwest China from the side. Northwest China's fossil energy extraction business is growing, reflecting the strategic objective of green and low-carbon.

3.2. Northwest Sustainable Energy Industry Agglomeration Index Results

The sustainable energy sector's location entropy index indicates the extent of industrial aggregation in each administrative region and its evolution. The dynamic location entropy index of the sustainable energy business can indicate the proportion of the sustainable energy industry in the region from both a temporal and spatial viewpoint, therefore reflecting the accumulation of sustainable energy in the region. The time view can more accurately describe the pace of aggregation of the sustainable energy sector through time, while the geographical perspective can more accurately indicate the concentration of components. As the statistical index of the yearbook varies over the research period, the comprehensive comparison picks sustainable energy power generation rather than production index for assessment in terms of data accessibility and precision.

At this point in equation 2, E_{ij} represents sustainable energy generation in province *i* (expressed as total power generation minus thermal power generation and hydro power generation), E_i represents total power generation in province *i*, E_{kj} represents national sustainable energy generation, and E_j represents total national power generation in that year.

The sustainable energy sector's dynamic location entropy represents the rate of change of location entropy for this industry, which is also the rate of change of location entropy for the new energy industry, showing the rate of agglomeration development.

The dynamic locational entropy measurement results for each province in China from 2007 to 2019 may be calculated using equation (2), as shown in Table 3, and the ranking of the agglomeration level of the sustainable energy sector in each province is presented in Figure 3.

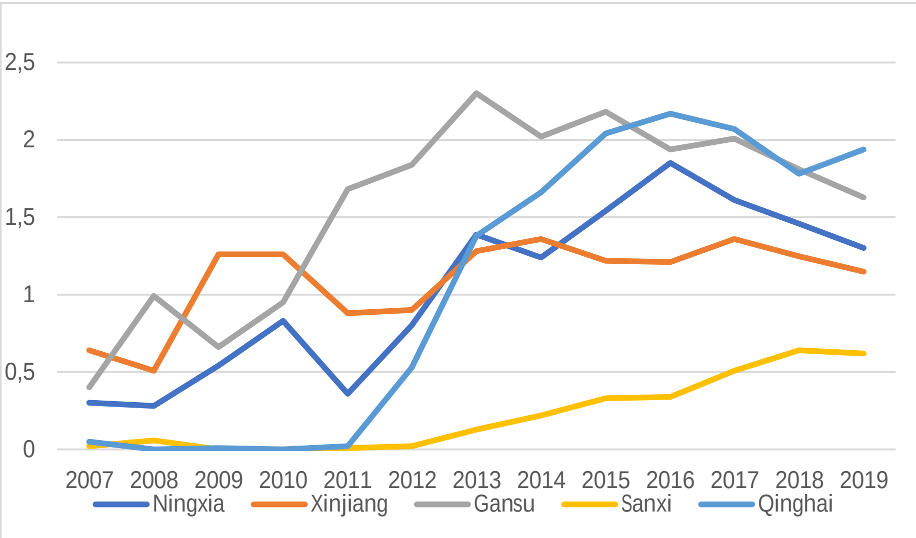

Figure 3. 2007-2019 sustainable energy industry aggregation levels in five northwest provinces

According to dynamic location entropy measurements, China's sustainable energy business exhibits regional agglomeration. The eastern coastal region has greater industrial agglomeration, and sustainable energy sectors are clustered in the east and west. Six of the top 10 provinces by sustainable energy industry agglomeration level in 2019 are eastern provinces, while the other four are western provinces with larger sustainable energy resource endowment.

In the northwest region, since 2007, the sustainable energy industry agglomeration index in Shaanxi has increased from 0.02 to 0.62, in Gansu from 0.4 to 1.63, in Qinghai from 0.05 to 1.94, in Ningxia from 0.3 to 1.3, and in Qinghai from 0.05 to 1.94. These provinces' sustainable energy industry all came from nothing and developed the agglomeration trend. The sustainable energy business is agglomerated in all Northwest provinces, albeit to different degrees. The 2019 measurement findings show that Qinghai has the highest agglomeration

Table 3. Sustainable energy industry aggregation level

Province	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Shanghai	0.17	0.26	0.42	0.35	0.08	0.09	0.16	0.12	0.10	0.10	0.19	0.24	0.23
Yunnan	0.02	0.92	0.00	0.09	0.19	0.35	0.43	0.48	0.56	0.79	0.76	0.67	0.65
Neimenggu	1.00	1.06	2.19	2.72	2.83	2.18	2.19	1.71	1.72	1.66	1.49	1.31	1.16
Beijing	0.00	0.00	0.21	0.29	0.30	0.26	0.21	0.14	0.11	0.11	0.15	0.13	0.13
Jilin	0.94	4.80	1.60	1.65	2.03	1.57	1.43	1.69	1.50	1.34	1.01	1.27	1.25
Sichuan	0.01	0.02	0.01	0.17	0.10	0.01	0.01	0.05	0.06	0.09	0.16	0.18	0.19
Tianjin	0.00	0.24	2.02	1.37	0.06	0.10	0.16	0.19	0.17	0.13	0.18	0.19	0.27
Ningxia	0.30	0.28	0.54	0.83	0.36	0.80	1.39	1.24	1.54	1.85	1.61	1.46	1.30
Anhui	0.00	0.01	0.08	0.09	0.12	0.09	0.08	0.32	0.18	0.29	0.41	0.48	0.46
Shandong	0.10	0.41	0.33	0.34	0.32	0.48	0.47	0.56	0.41	0.39	0.39	0.56	0.78
Shaanxi	0.01	0.07	0.06	0.13	0.09	0.41	0.40	0.48	0.53	0.64	0.75	0.82	0.80
Guangdong	4.96	3.05	3.83	3.40	3.12	3.07	2.72	2.46	2.39	2.17	1.95	1.80	1.86
Guangxi	0.23	1.19	0.60	0.35	0.01	0.09	0.05	0.40	0.07	1.05	1.07	1.05	1.02
Xinjiang	0.64	0.51	1.26	1.26	0.88	0.90	1.28	1.36	1.22	1.21	1.36	1.25	1.15
Jiangsu	1.58	1.45	1.79	1.55	1.38	1.18	1.00	1.06	0.82	0.73	0.74	0.89	0.99
Jiangxi	0.00	0.05	0.03	0.03	0.05	0.04	0.02	0.27	0.27	0.33	0.50	0.61	0.60
Hebei	0.20	1.65	0.53	0.84	1.18	1.49	1.33	1.26	1.14	1.08	1.09	1.08	1.15
Henan	0.00	1.45	0.14	0.10	0.15	0.14	0.06	0.14	0.09	0.14	0.24	0.39	0.50
Zhejiang	5.28	2.93	3.60	2.80	2.75	2.89	2.49	2.22	2.52	2.06	1.74	1.76	1.69
Hainan	0.12	0.07	0.14	0.41	0.49	0.30	0.57	0.46	0.75	2.87	2.77	2.32	2.58
Hubei	0.17	0.38	0.11	0.36	0.11	0.09	0.11	0.26	0.12	0.25	0.31	0.34	0.34
Hunan	0.00	0.00	0.00	0.00	0.14	0.26	0.11	0.34	0.32	0.35	0.39	0.45	0.49
Gansu	0.40	0.99	0.66	0.95	1.68	1.84	2.30	2.02	2.18	1.94	2.01	1.81	1.63
Fujian	0.12	0.23	0.35	0.24	0.37	0.38	1.29	1.64	2.62	2.76	2.87	2.52	2.15
Xizhang	2.97	4.26	2.52	1.74	1.72	2.08	1.76	1.50	1.29	0.75	1.07	1.09	1.21
Guizhou	0.00	0.00	0.00	0.01	0.00	0.13	0.18	0.16	0.31	0.35	0.38	0.36	0.34
Liaoning	0.24	0.29	0.47	1.00	1.49	1.53	2.11	2.41	2.40	2.24	2.19	2.15	2.04
Chongqing	0.07	0.03	0.05	0.05	0.19	0.54	0.06	0.15	0.05	0.08	0.12	0.11	0.14
Shaanxi	0.02	0.06	0.00	0.00	0.01	0.02	0.13	0.22	0.33	0.34	0.51	0.64	0.62
Qinghai	0.05	0.00	0.01	0.00	0.02	0.53	1.38	1.66	2.04	2.17	2.07	1.78	1.94
Heilongjiang	0.28	0.59	0.88	1.21	1.45	1.76	1.86	1.61	1.11	1.06	1.19	1.18	1.19

index at 1.94, followed by Gansu at 1.63, Ningxia at 1.3, Xinjiang at 1.15, and Shaanxi at 0.62. Qinghai's agglomeration index is three times that of Shaanxi, which comes last. This indicates that sustainable energy sector development varies by area.

4. Discussion

Significant energy transformation potential exists in China's Northwest, which could add to the country's efforts to switch to sustainable energy sources (Li et al., 2020). However, the development of the sustainable energy business in the region is not uniform, and some challenges remain to be resolved. The level of coal chemical industry processing and utilization must be improved (Zhang et al., 2018), the level of technology and management must be upgraded, and the length of the industrial chain must be expanded to ensure a better product added value. In addition, the abandoned wind and light rate of the five provinces in the Northwest region is still quite high and must be reduced by the construction of additional power transmission routes and by increasing interprovincial and interregional power transmission (Zhang et al.,2020). To reap the full benefits of the energy transformation plan, it is necessary to take actions tailored to the particular characteristics and circumstances of each location (Liu et al.,2019). To ensure the successful implementation of the energy transformation in Northwest China, it is also necessary to improve the greening of the energy structure, actively promote coal substitution and efficient utilization, improve the energy market mechanism, accelerate the transformation and upgrading of the energy industry, and increase investment in the development of new energy (Duani et al., 2020; Zeng & Wang, 2018; Cai et al., 2019).

5. Conclusions

This study discovered that specific agglomerations are produced by both fossil and alternative energy sources. On the one hand, Northwest China has a very rich resource endowment for fossil energy, while on the other, there is increasing pressure for energy conservation and emission reduction. On the other hand, although there is a trend toward clustering in the sustainable energy sector in Northwest China, there is still a significant disparity in the degree of clustering. The fossil energy industry in Northwest China has seen its issues with energy consumption, reliance, energy processing utilization, industrial chain extension, and industrial clean transformation exacerbated in the context of the energy revolution as a result of agglomeration. Due to the increasingly visible agglomeration, there are issues with the growth of the sustainable energy industry in the northwest provinces, such as significant disparities in industrial development trends and significant differences in consumption levels. As a result, Northwest China should use fossil fuels to improve the added value of products by lengthening the industrial supply chain, using technologies like carbon capture to achieve the circular development of the energy industry, and fostering the synergistic and complementary growth of the fossil fuel industry and clean energy. And we need to take the following actions for sustainable energy: 1. Make renewable energy foundations stronger. 2. Make the best possible use of the current channel while optimizing the power transmission structure. 3. Quicken the pace of the electricity market's transformation; enhance the market's trading system. 4. provide top priority to global energy cooperation and boost capability for building renewable energy sources 5. Pay attention to geographic advantages; increase the peak regulation capability of the electricity infrastructure.

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