Research on Solar Energy Resources in Hexi Region of Gansu Province

Wu Dan¹234*, Meng Tingting¹234

¹ Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi’an 710075, China
² Institute of Shaanxi Land Engineering and Technology Co., Ltd., Xi’an 710075, China
³ Key Laboratory of Degraded and Unused Land Consolidation Engineering, Ministry of Land and Resources, Xi’an 710075, China
⁴ Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi’an 710075, China

*Corresponding author’s e-mail: 843969970@qq.com

Abstract. The excessive exploitation and utilization of non-renewable resources by humans has caused a lot of energy depletion, which has caused great changes in the climate system and has a great impact on human production and life. The development and utilization of new energy by human beings has become a hot issue in recent years. As the most important renewable green energy source, solar energy resources have been widely used in many countries and regions. The paper analyzes the solar radiation in the Hexi region for about 21 years in time and space to analyze the availability of solar energy resources in Hexi area.

1. Introduction

The sun is a huge treasure trove of energy, and its advantages are more prominent than conventional energy sources. The scale of solar energy utilization in China began in the 1970s, and the Chinese government has always included research and development of solar energy and renewable energy technologies into scientific and technological research projects, and formulated a series of policy measures to assist the solar energy utilization industry. [1] At present, China's solar energy resources development has been at the forefront of the world. The solar energy industry in Gansu Province has shown a strong and weak situation. The two strong energy sources are rich in solar energy and the degree of solar energy utilization is relatively high; the weak is the development of solar energy related industries, and the transmission and absorption capacity of electric energy generated by new energy sources is weak. Compared with developed regions, Gansu Province lacks enterprises with a certain scale. The development of solar energy industry has cost constraints, weak technology and small scale of enterprises, and weak competitiveness. In addition, the regional economic development is relatively slow, resulting in imbalance between supply and demand in the market. At the same time, the limited financial expenditure on solar energy has largely restricted the development of the solar energy industry in Gansu.
2. Climate profile of the study area

The Hexi region is a temperate continental arid and semi-arid climate with its unique climate characteristics:

(1) Precipitation is relatively rare. The precipitation in Hexi region shows a trend of increasing from northwest to southeast, and the precipitation is very uneven in spatial distribution. The annual precipitation in most parts of Hexi is below 150mm, and the annual precipitation in the western region is below 100mm, among which Dunhuang, Anxi and Ding New Year's precipitation is less than 100mm, Dunhuang is 42.2mm, which is the place with the least annual precipitation in Hexi area; folk music, ancient The annual precipitation of Lang and Wushaoling is more than 300mm, and Wushaoling is 405mm, which is the place with the most precipitation in Hexi. The distribution of rainfall season in Hexi region is extremely uneven, generally more in summer, less in winter, centered in spring and autumn, and autumn rain is more than 60C, decreasing to both ends in turn; the coldest month is January, the average temperature is -11.8--7.2°C The hottest place is the most spring rain, characterized by rain and heat during the same period [2].

(2) Enough heat. The annual average temperature in Hexi is 0-9.5°C. The hottest month in all parts is July, the average temperature is 11.4-24°C. The Dunhuang in the west end, the coldest place is the northernmost Wushaoling; the average temperature difference is mostly above 14°C, and the temperature is worse in summer than in winter. The average annual temperature difference is mostly above 26°C [3].

(3) Wind energy resources are abundant. The regional distribution trend of annual average wind speed in Hexi region is larger in the northwest and southeast. Except for parts of central and eastern Hexi, the annual average wind speed is above 3m/s. Although Wusiling is in the southeast, Its altitude is relatively high, and the annual average wind speed is 5.1m/s. It is the place with the largest annual average wind speed in Hexi area. The annual average wind speed in Liangzhou District is only 1.8m/s, which is the place with the lowest annual average wind speed in Hexi area, and the wind speed is interannual. The change is small [4].

(4) The illumination is sufficient. The Hexi area has a high altitude, low dryness, high air transparency, long sunshine hours, and abundant solar energy resources. Its geographical distribution gradually decreases from northwest to southeast, and the seasonal distribution is strong in summer, long in sunshine, weak in winter, short in sunshine, and centered in spring and autumn [3].

3. analysis of total solar radiation changes

3.1 Changes in total solar radiation during the year

The annual distribution of the average solar radiation at each station in the past 21 years is shown in Figure 1. It can be seen from the figure that the total solar radiation during the year of Dunhuang, Jiuquan and Minqin stations is approximately normal, and the average monthly radiation is 530.6MJ/(m²•a) and 512.0MJ/(m²•a), respectively. 530.4MJ/(m²•a); the monthly total radiation has a small difference in value from January to February. From March onwards, the value increases, and peaks in May, and gradually declines in May and August, starting from September. The decline was noticeable and began to flatten in November; the maximum monthly total radiation of the three radiation stations appeared in May (second in June, and more in April, July and August), with values of 763.90 MJ/(m²•a), 740.24MJ/(m²•a) and 757.90MJ/(m²•a); the minimum values are all in December, with values Of 256.38 MJ/(m²•a) and 253.38MJ/(m²respectively).•a) and 297.43MJ/(m²•a).
3.2 Interannual variation of total solar radiation

The specific resource richness level is shown in Table 1:

| Indicator 1 | Indicator 2 | Resource richness       |
|-------------|-------------|-------------------------|
| ≥1740KW·h/(m²·a) | >6300 MJ/(m²·a) | Abundant resources       |
| 1400-1740KW·h/(m²·a) | 5040-6300MJ/(m²·a) | Rich in resources        |
| 1160-1400KW·h/(m²·a) | 3780-5040MJ/(m²·a) | Lack of resources        |
| <1160KW·h/(m²·a)      | <3780MJ/(m²·a)   | Poor resources           |

In Table 1, both indicators 1 and 2 indicate the solar radiation energy received per unit area, 1 KW·h/(m²·a)=3.6MJ/(m²·a).

Figure 2 shows the annual total solar radiation changes in Dunhuang, Jiuquan and Minqin. It can be seen from the calculation that the average annual total solar radiation of Dunhuang in 21 years is 6335.91 MJ/(m²·a), of which 8 years is lower than the average value, and the linear tendency rate is 4.96 MJ/(m²·a). The radiation showed an upward trend; the average annual solar radiation of Jiuquan in 21 years was 6115.59 MJ/(m²·a), of which 9 years was lower than the average and the linear tendency rate was -3.16 MJ/(m²·a). The total solar radiation showed a slight downward trend; the average annual solar radiation of Minqin in the past 21 years was 6249.01 MJ/(m²·a), of which 10 years was below the average and the linear tendency rate was -13.62 MJ/(m²·a), the downward trend is more obvious. After significant testing, only Minqin has a significant downward trend, and there is no significant change in the other two places.

The extreme value distribution of total solar radiation over the years is: the maximum value of Dunhuang is 6671.14MJ/(m²·a) (2012), the minimum value is 5302.20MJ/(m²·a) (2010); the maximum value of Jiuquan is 6362.56MJ/(m²·a) (1995), the minimum value is 5807.58MJ/(m²·a) (2010); the maximum value of Minqin is 6613.26MJ/(m²·a) (1997), and the minimum value is 5950.46MJ/(m²·a) (2010). In the past 21 years, the total solar radiation in the Hexi region is between 5302-6672 MJ/(m²·a), which is a region rich in solar energy resources. The minimum concentration is concentrated in 2010, which is likely to be related to climate anomalies in the year.
3.3 Seasonal variation of total solar radiation

From Figure 3, there is a significant seasonal variation in total solar radiation. In summer, the total solar radiation is the strongest. The average summer time of the three stations is 2124.6MJ/(m²•a), which is more than twice that of winter; the second is spring, which is 1935.4MJ/(m²•a); the autumn is 1303.3MJ/(m²• a) The weakest is only 928.8MJ/(m²•a) in winter.

The calculations show that the average annual total solar radiation in the spring, summer, autumn and winter of 1993-2013 in the period of 1993-2013 is 30%-31%, 33%-34%, 20%-21%, respectively. 14%-16%, very stable. From the year-to-year changes of the three radiation sites in Hexi region (Figure 4), it can be seen that the maximum values of the total solar radiation in Dunhuang in spring, summer and autumn all appeared in 1998 and 2009, both in 2010. There is a minimum value, which is more fluctuating in spring and summer, and smaller in autumn and winter. The solar radiation in Jiuquan has similar changes in the four seasons, but the annual change is not big, and the changes in the four seasons are relatively flat. The total solar radiation of Minqin In the spring and summer of 2002, there was a great value, and the fluctuation range was large. The autumn and winter seasons were stable and there was no obvious fluctuation. In general, the total solar radiation in summer is the largest, followed by spring, autumn, and winter. The seasonal changes are large, and the total radiation in spring and summer is more than twice that in winter.

Through the significance test, there is no significant change in the total solar radiation of Dunhuang and Jiuquan in the four seasons. In addition to the significant decline in winter, Minqin has not changed significantly in other seasons.
Figure 3  Three stations in the four seasons of total solar radiation

4. Discussion

The total solar radiation of Dunhuang, Jiuquan and Minqin is between 5302-6672 MJ/(m²•a), which is a region with abundant solar resources. In the year of change, the maximum amount of radiation appeared in May, and the minimum appeared in December. Seasonally, the order of total solar radiation is summer, spring, autumn, and winter. By analyzing the solar energy resources in the Hexi region for 21 years, it has been found that the solar energy resources in the western region have been richer-rich areas and the solar energy resources are relatively stable in the past 21 years.

References:
[1] Chen Shaoyong, Guo Junting, Shang Junwu. Evaluation of Solar Energy Resources in Baiyin City[J]. Journal of Gansu Sciences, 2012, 24(4): 0036-0041.
[2] Yin Xuelian, He Jianfeng. Characteristics of Climate Resources in the Middle of Hexi Corridor and Its Development and Utilization[J]. Arid Zone Research, 2010, 2: 1-7.
[3] Wang Yaoqi, Wei Zhigang. Direct solar radiation and atmospheric transparency in Hexi region[J]. Acta Meteorologica Sinica, 1995, 53(3): 375-379.

[4] Yang Xiaoling, Ding Wenkui, Dong Anxiang, et al. Distribution characteristics of climate resources in Hexi Corridor and its development and utilization [J]. China Agricultural Meteorology, 2009, 30: 1-5.

[5] Ma Quantao, Yang Hua, Xie Yunhua. Discussion on solar energy resource assessment and its development and utilization [J]. Science and Technology Innovation Guide, 2010, 7:0023.

[6] Kendall M G. 1938. A new measure of rank correlation[J]. Biometrika, 30:81-93.