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Solar Energy Resources in Desertification Regions of China and Development Suggestions

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Abstract: To achieve the goal of carbon peaking and carbon neutralization, we need to accelerate the construction of a clean, low-carbon, safe and efficient energy system, implement renewable energy substitution actions, and constantly increase the proportion of non fossil energy consumption. China's deserts, Gobi and desert areas cover a vast area, and solar energy resources are abundant. The regions that can be developed by technology account for more than 60% of the whole country. Give full play to the characteristics of desert, Gobi and desert areas that are rich in wind and solar energy resources, have good construction conditions, and are less affected by land use. In combination with the power grid and consumption and utilization conditions, comprehensively promote large-scale development and high-quality development of solar energy, it is an important measure to promote the clean, low-carbon, safe and efficient transformation of the energy structure. To vigorously develop photovoltaic projects in desert, Gobi and desert areas, we need to adhere to large-scale and intensive development, to adhere to multi energy complementary ecological integration development, demonstration and guidance, which can help strengthen the comprehensive utilization of land, solar energy resources and other resources, and also obtain significant ecological, economic and carbon reduction benefits. At the same time, developing photovoltaic bases in desert regions can also improve the supply capacity of renewable energy and increase the supply level of clean low-carbon energy.

1. Desert resources in China

China is one of the countries with the largest distribution of deserts in the world. The area of desertified land is 1.3 million square kilometers, accounting for 13% of the total land area of the country. The desert covers a total area of 687800 square kilometers, mainly distributed in Xinjiang, Inner Mongolia, Tibet, Gansu, Qinghai, Shaanxi and other provinces, among which the famous "eight deserts" and "four sandy lands" are distributed, as shown in figure 1.

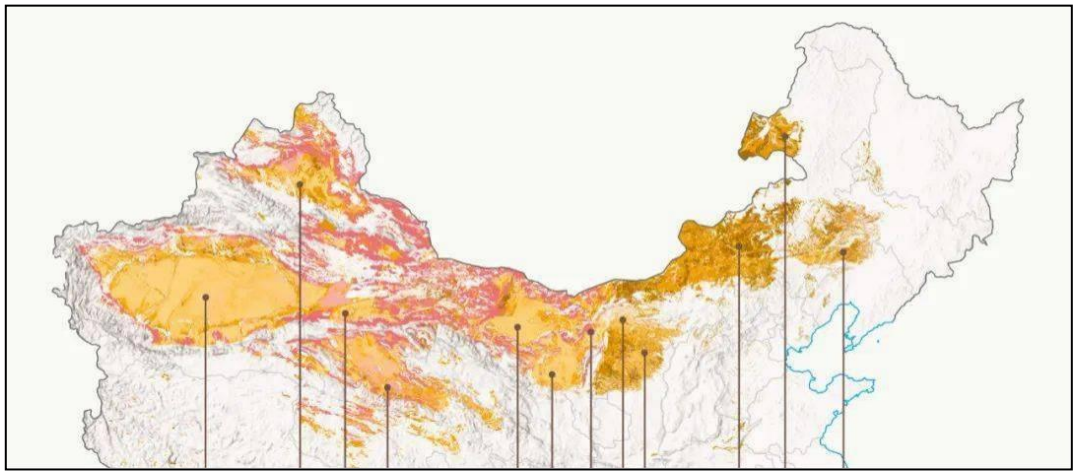

Figure 1: Desert Distribution Map of China (Source: State Forestry and Grassland Administration)

2. Necessity of developing photovoltaic base in desert regions

First, the desert covers a large area. The area of desertified land in China is 1.3 million square kilometers, accounting for 13% of the total land area of the country. It is mainly distributed in Xinjiang, Inner Mongolia, Qinghai, Gansu, Ningxia, Shaanxi and other provinces, with the exploitable amount accounting for more than 60% of the country.

Second, desert areas have good solar energy resources. China has a vast area of desertification, there are rich solar energy resources, long sunshine time and strong solar radiation in desert areas, which have the natural advantages of developing photovoltaic. The photovoltaic power generation hours in desert areas are high, which is conducive to reducing the power generation cost of photovoltaic projects.

Third, the ecological benefits of photovoltaic development in desert are outstanding. Through the multi integrated circular development model of “power generation on board, planting under board, sand control and soil improvement, and comprehensive utilization of water resources”, we will use photovoltaic to control the sand, wind prevention, and grass fixation, systematically protect and repair the desert, Gobi, and desert areas,to improve the local ecological environment and living environment, and achieve the integrated development and friendly development of new energy and ecology.

Fourth, the economic benefits of photovoltaic construction in desert areas are significant. Give full play to the advantages of solar energy resources in northwest China and the unused land in desert, Gobi and desert areas, build large photovoltaic base projects and send them to the eastern and central regions through transmission channels, which can not only realize the complementary advantages of the western and eastern central regions in land resources, green energy, economic and social development, but also promote investment, stable growth, drive industry and economy, and help rural revitalization.

Fifthly, the carbon reduction benefit of photovoltaic construction in desert is obvious. The construction of large-scale photovoltaic base projects is not only conducive to promoting the large-scale and high-level development of new energy such as photovoltaic, but also can provide stable and high-quality green power support for economic and social development, promote the green and low-carbon transformation of China’s energy, and promote the realization of carbon peak and carbon neutral goals.

3. Analysis of solar energy resources and photovoltaic power generation in China

3.1. Solar energy resources and distribution in China

The total solar radiation resources in China are abundant[1], and the regional differences are large. Generally, the overall distribution has the characteristics which "the plateau is larger than the plain, and the dry area in the west is larger than the humid area in the east". According to the long-term observation data accumulated by more than 700 meteorological stations across the country, the annual total solar radiation in various parts of China is roughly between 930 and 2333 kWh m^2, and the average value is about 1628 kWh/m^2[2]. Among them, the Qinghai-Tibet Plateau is the most abundant, with an annual total radiation of more than 1800 kWh/m^2, and even more than 2000 kWh/㎡ in some areas. The resources in the Sichuan Basin are relatively low, with areas below 1000kWh/m^2, as shown in figure 2.

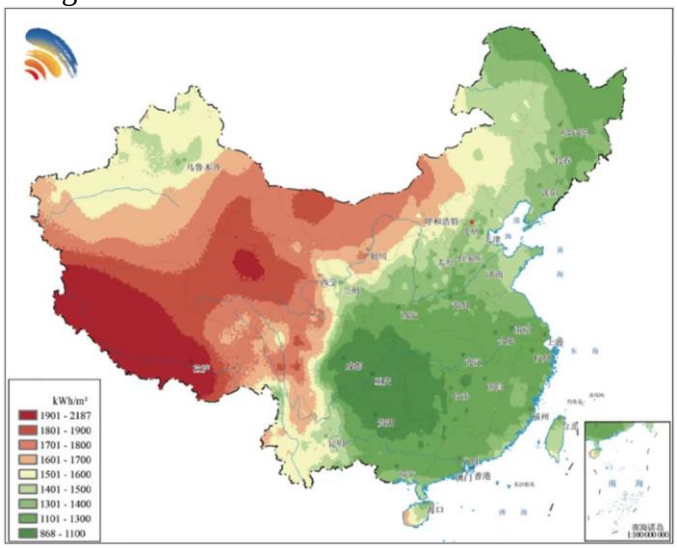

Figure 2: Distribution of total horizontal irradiation in the national annual horizontal plane in 2021 (source: China Meteorological Administration)

3.2. Solar energy resources and distribution in desert provinces

In the west of Inner Mongolia, the west of Jiuquan, Gansu, the west of Qinghai, the west of Tibet, and the eastern edge of Xinjiang, the total annual solar radiation on the horizontal plane exceeds 1750kWh/m^2, It belongs to the belt with the most abundant solar energy resources; In most regions of Xinjiang, eastern Inner Mongolia, northern Shaanxi, Ningxia, eastern Jiuquan, Gansu, eastern marginal region of Qinghai, eastern Tibet and other regions, the annual total solar radiation at horizontal level is 1400~1750kWh/m^2， It belongs to the belt with abundant solar energy resources.

As shown in figure 3, in the five provinces in northwest China and Inner Mongolia, the utilization hours of solar energy in most regions in the first year can reach more than 1600 hours. In Haixi Prefecture of Qinghai, Ha-mi of Xinjiang, and other regions, the utilization hours of solar energy can reach more than 2000 hours.

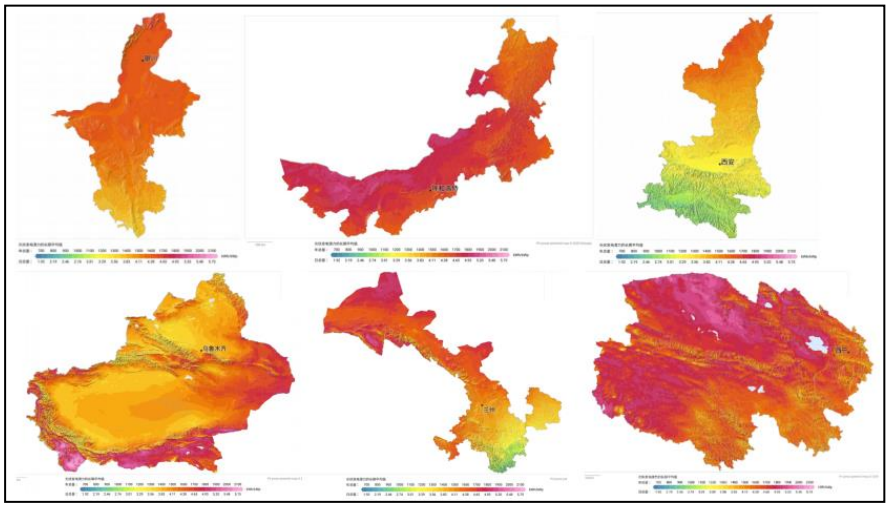

Figure 3: Solar energy resources of provinces/regions involved in desert area (from left to right, from top to bottom, Ningxia, Inner Mongolia, Shanxi, Xinjiang, Gansu, Qinghai)

4. Problems in developing photovoltaic base in desert regions

Power consumption and transmission problems. First, the geographical distribution of solar energy resource areas and load centers in China is generally mismatched. In resource rich areas, the power load is small and the consumption problem is prominent; second, the configuration of export channels for large-scale scenery bases is not yet sound.

The investment cost is high. First, the project construction cost, long-distance transportation cost, living cost and environmental protection cost all increase the initial investment cost of the project; Second, the anti sand cost, water cost and equipment maintenance cost of PV modules have increased the operation and maintenance cost in the later stage of the project.

The market mechanism is not sound. First, public resource platforms such as the national electricity market, meteorology and other key information data are not transparent, and market mechanisms such as carbon emission rights, energy use rights and power trading rights are not sound; Second, the power market mechanism, price mechanism, security mechanism and dispatching management related to the new power system are not perfect; Third, the green cost of scenery has not been fully channeled, and the green value of environmental and ecological benefits has not been fully reflected.

The industrial policies are not matched. First, the types of scenic land and tax standards in various provinces are not sound; second, there is a lack of industrial support policies for environmental benefits, ecological restoration benefits and economic benefits of scenery; third, there is a lack of guiding policies for diversified development and cooperation models.

5. Development suggestions on photovoltaic construction in desert areas

It is priority to focus on optimizing and improving the construction of power grid and transmission project. First, we should improve the UHV(ultra high voltage) AC grid in North China, East China and Central China to provide support for UHV power transmission; Second, it's necessary to focus on renewable energy development bases, and strengthen the related power grid construction, especially focus on solving the constraints of large-scale grid connected renewable energy transmission in Gansu, Xinjiang, western Inner Mongolia, northern Hebei and other regions.

It is necessary to accelerate scientific and technological progress, to reduce costs and increase efficiency. First, we should comprehensively sort out the list of key technologies of the new power

system, focusing on the core technologies that really “choke”; Second, it’s necessary to focus on new energy storage, hydrogen energy, large capacity fans, offshore fans and other technologies, we should increase science and innovation efforts, to improve power generation capacity, and reduce the cost of electricity.

It is necessary to adhere to power market reform and improve relevant systems and mechanisms. First, we should improve the mechanisms related to adapting to the new power system, and improve the cost mitigation mechanism, guarantee the consumption mechanism, industrial supporting mechanism. Second, it’s necessary to introduce new energy related electricity price policies and guarantee mechanisms. It fully reflects the green value of its environmental and ecological benefits. Third, we also need to strengthen information disclosure and establish a market environment for fair competition among multiple entities. Opening the national electricity market and meteorological data, which can promote market competition and transparency of transactions, and strengthen supervision and disclosure. Implementing the competitive allocation indicators of each province as soon as possible to avoid the rush of loading and the imbalance of the supply chain industry chain.

We need to continuously improve the supporting facilities of relevant industrial policies. First, we should improve and rationalize the land and tax charging standards of each province. It is suggested to continue the preferential tax policy of 50% of VAT on photovoltaic projects; the second is to strengthen policy guidance and improve the industrial support policy for environmental, ecological and economic benefits of scenery; the third is to innovate diversified development cooperation mode. Through industrialization, ecological construction will be guided to realize the four-wheel drive development of “desertification control, ecology, industry and poverty alleviation”.

6. Conclusions

Under the target of “Carbon Peaking and Carbon Neutrality”, renewable energy will accelerate the replacement of fossil energy. In the future power system, renewable energy power generation will become the main body. Northwest China has a large amount of solar energy resources, which will be the main area for the growth of renewable energy power in China.

It is necessary to steadily promote the construction of large-scale photovoltaic bases focusing on desert, Gobi and desert. First, give priority to energy bases close to load centers, and also give priority to the development of large-scale solar bases such as the western Inner Mongolia, that are close to the load center in North China. The second is to focus on the power supply and power peak regulation in different areas. In areas with many coal-fired power units, we should give priority to the construction of new energy base projects, and develop thermal power-centered “wind-solar-fired storage” bases based on thermal power. The third is to scientifically select the transmission conditions, select provinces with better delivery conditions, and fully consider the strength of the power grid in the power-receiving provinces and the risks in provinces with more hydropower. Fourth, we should actively strive for the construction of new energy projects in the existing and under-construction power transmission channels and the “point-to-network” communication channels corresponding to coal-fired power. For example, the DC transmission channels such as Qinghai to Henan, Shanghai Temple to Shandong, and the AC transmission channels such as Inner Mongolia to Tianjin South.

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