

Advantageous Conditions and Recommendation for the Development of Geothermal Industry in Western China

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ABSTRACT

The exploitation of geothermal resources is of great significance in achieving carbon peaking and carbon neutrality goals. The rapid development of the geothermal industry has been occurring in the eastern region of China in recent years. However, due to economic, population, and transportation constraints, geothermal resource utilization is still low in the western region, and the geothermal development process could be more active. It has been demonstrated in this study that vigorous geothermal development in the west is essential for the formation of a new pattern of western development, the construction of the Green Silk Road, and the development of high-quality urban clusters within the west. Multiple favorable conditions and advantages contribute to the development of the geothermal industry in the western region, including abundant geothermal resources, reasonable matching of the market demand, and strong financial and tax policies. Consequently, there is a need for clarification regarding the distribution of geothermal resources in the western region and a need to encourage large-scale development and utilization of these resources. There should be an increase in geothermal demonstration projects in the western region, starting at three levels: high-temperature geothermal, medium-to-low-temperature hydrothermal, and shallow geothermal. In addition, relevant enterprises should establish new energy organizations and management agencies in the western region, and coordination and development of talent teams should be enhanced.

1. INTRODUCTION <HEADING 1 STYLE>

Geothermal energy is a low-carbon, clean, widely distributed, resource-rich, safe, and high-quality renewal energy with the characteristics of sustainable and stable energy supply, diverse utilization methods, and efficient recycling. The development and utilization of geothermal energy are essential to optimize the energy supply and demand structure, reduce greenhouse gas emissions, improve the ecological environment and achieve the goal of "double carbon." Geothermal resources in China account for about 7.9% of the world's total, with recoverable reserves equivalent to 462.65 billion tons of standard coal (Wang et al., 2017a, Lin et al., 2013). Previous studies on geothermal resources in China have mainly focused on the eastern region, covering the resource endowment, development potential, and economic benefits of geothermal resources (Diao et al., 2019, Hou et al., 2018, Wang et al., 2017b, Yuan et al., 2021, Wang et al., 2018, Dai et al., 2019). Compared with the eastern region, the overall progress of geothermal exploration and development in western China could be faster, and the utilization rate of geothermal resources could be higher due to economic, population, and transportation constraints. This paper points out the importance of accelerating the development of the geothermal industry in western China based on the analysis of the national macro policy and the development of the western region. On the other hand, it identifies the favorable conditions and advantages of developing the geothermal industry in western China based on the endowment of geothermal resources, matching conditions with market demand, and favorable policy conditions. Finally, it puts forward three suggestions for accelerating the development of the geothermal industry in western China.

2. SIGNIFICANCE OF ACCELERATING THE DEVELOPMENT OF GEOTHERMAL INDUSTRY IN WESTERN CHINA

First of all, it can accelerate the formation of a new pattern of western development and promote high-quality development in the western region. On May 17, 2020, the China Communist Party Central Committee and the State Council issued the "Guiding Comments on Promoting the Development of the Western Region in a New Era to Form a New Pattern." Concerning optimizing the structure of energy supply and demand, "Comments" pointed out: strengthen the development and utilization of renewable energy, and cultivate several clean energy bases. The western region has a strong demand for winter heating heat, geothermal agriculture, and medium and low-temperature geothermal power generation. The development and utilization of geothermal resources can provide a new model for new urbanization construction and rural revitalization in the western region and promote coordinated regional development, which is of great economic and political significance.

Second, it can promote the construction of the Green Silk Road and build a network connecting the world's energy cooperation. The "Comments" pointed out that building "one belt and one road" as a leader increases the western region's opening up and promotes the accelerated development of green industries in the western region. The white paper "China's Energy Development in a New Era" points out that we should build a green Silk Road, actively promote global energy's green and low-carbon transformation, and widely cooperate in renewable energy. The vigorous development of the geothermal industry in the western region and the strengthening of exchanges and cooperation with countries along the Silk Road Economic Belt will be conducive to integration into the international energy governance system. It will also contribute to the green and low-carbon transition development of all countries and promote the building of a community of human destiny.

In addition, it can promote the development of urban agglomerations in the western region and comprehensive transformation geographically. Since 2016, the State Council has issued the "Chengdu-Chongqing City Cluster Development Plan" and "Lanzhou-

Xining City Cluster Development Plan," aiming to accelerate the development of the central and western regions and expand new space for national economic growth. Geothermal-related industries will lead to a new path of green transformation in urban agglomerations under the "double carbon" background, based on urban agglomeration development." It is of great significance to maintain the prosperity and stability of the western region and support the homeland security and ecological security pattern.

3. ADVANTAGES AND CONDITIONS FOR ACCELERATING THE DEVELOPMENT OF GEOTHERMAL INDUSTRY IN WESTERN REGION

3.1 The western region is rich in geothermal resources, widely distributed, all types, and well-endowed with resources

The high-temperature geothermal resources in the western region are mainly distributed in southern Tibet - western Sichuan - western Yunnan and Qinghai Republic, Xinjiang Tashkurgan, and other areas, with a high-temperature power generation potential of 7.12 million kilowatts, accounting for 84.1% of the country (Pang et al., 2020). The western region's medium and low-temperature geothermal resources are mainly distributed in large and medium-sized sedimentary basins. It is estimated that the annual extractable heat of geothermal fluid is equivalent to 824 million tons of standard coal, approximately 50% of the total annual extractable heat. The average geothermal gradient in the Ordos Basin, Qaidam Basin, and Sichuan Basin in the western region is 2.4-2.9°C/hm (Wang et al., 2017), and there are many areas with high geothermal gradients, such as up to 4.0°C/hm in the Yinchuan Basin and Langyu Basin, 4.43-5.74°C/hm in the Xining Basin, and 6.5°C/hm in the Republican Basin (Zhang et al., 2018). In addition, the western region is rich in associated geothermal resources, such as lithium, boron, bromine, iodine, and other strategic resources; and is rich in high-grade helium resources in several basins with volume fractions well above 0.1% of industrial grade, with helium resource prospects (Tao et al., 2017, Zhang et al., 2020, Li et al., 2016).

3.2 Geothermal resources in the western region match well with market demand and can achieve good economic benefits

In recent years, the rapid development of low and medium-temperature hydrothermal resource applications in the eastern region is that the resources are well-matched with the market. Moreover, there are also areas in the western region where resources and markets are well matched. One is the geothermal field in the Guan Zhong Basin, which is about 360 km long from east to west and 80 km wide from north to south, with an average geothermal heat flow of 69.6 mW-m⁻². The geothermal field is located in Baoji, Xi'an, Xianyang, Xi'an New District, and Weinan, with a total population of 23 million and a GDP of about half Shaanxi Province. Shaanxi Province requires all new buildings with conditions to use geothermal energy for heating, while subsidies are given to rural geothermal energy for heating. Second, the Longxi Basin Group geothermal fields are distributed in Lanzhou, Dingxi, Baiyin and Linxia, and other cities, with a population of 10.65 million. The typical representative is Lanzhou-Yuzhong basin geothermal field, with a total thickness of thermal storage more significant than 300 meters, a porosity of thermal storage of up to 26%, a water temperature at the wellhead up to 73°C, and a water gushing up to 2160 cubic meters in a single day in 2500 meters borehole. In addition, the Chuanshong-Chuannan uplift area in the Sichuan Basin (population of 31 million), the Yinchuan Basin (population of 3 million), and the Xining Basin (population of 3.7 million) all have resources and market matching conditions and have good prospects for the large-scale development and utilization of geothermal energy. Take the Weinan City Vanke City (Phase I) Geothermal Utilization Project as an example. The water temperature at the wellhead is 100~178°C, the reasonable extraction volume can reach 119m³/h, the after-tax internal rate of return is 8.49%, and the investment payback period is nine years, which has a robust anti-risk ability.

Subsection headings should be capitalized on the first letter.

3.3 The new policy provide good opportunities for geothermal development and utilization in the western region

Firstly, the "Guidance on Promoting the New Pattern of Western Development in the New Era" points out that the central government will increase the support for natural resources investigation and evaluation in the western region and give priority to the projects in the western region. Furthermore, central enterprises and their branches, newly located in the western region, are encouraged to register locally. Social insurance premium rates will be appropriately reduced to ensure that the overall burden on enterprises is not increased. Secondly, the Ministry of Finance, the State Administration of Taxation, and the National Development and Reform Commission, on the continuation of the Western Development Enterprise Income Tax Policy Notice, pointed out that the enterprises located in the western region encourage industrial enterprises to reduce the corporate income tax at a rate of 15%; to encourage industrial projects imported for self-use equipment is exempt from tariffs. The "Catalogue of Encouraged Industries in Western Region (2020)" points out that the encouraged industries in the western region may be revised under the actual situation. Finally, the national "14th Five-Year Plan" states that geothermal energy should be developed and utilized according to local conditions. Western provinces and regions respond positively, as Shaanxi Province's "14th Five-Year Plan" points out: expand the comprehensive utilization of geothermal energy, improve the proportion of clean energy; expand the scale of application of hydrothermal geothermal energy in Xi'an, Xianyang, and other areas; Qinghai Province "14th Five-Year Plan" points out: promote the development of conventional and unconventional energy, and build a hydrothermal energy system. and unconventional energy development, build a clean energy production system with water, wind and heat complementary and integrated and optimized; carry out exploration and development of clean energy such as dry heat rock, geothermal and shale gas.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

The vigorous development of the geothermal industry in the western region is of great significance to promoting the high-quality development of the western region and the construction of the Green Silk Road. At the same time, the development of the geothermal industry in the western region has multiple favorable conditions and advantages. Geothermal resources in the western region are abundant, widely distributed, and of all types, with good resource endowment; geothermal resources are well matched with market demand, and the Guanzhong Basin, Longxi Basin Group, Sichuan Basin Chuanshong-Chuannan Uplift Zone, Yinchuan Basin and Xining Basin all have resource and market matching conditions; the central and local governments have successively introduced favorable financial and taxation support The central and local governments have successively issued favorable financial and taxation support policies, providing good opportunities for geothermal development and utilization in the western region.

4.2 Recommendations

First, we should accelerate the mapping of geothermal resource distribution in the western region and promote the large-scale development and utilization of geothermal resources. Therefore, it is recommended that the Ministry of Science and Technology of China establish a significant particular project on geothermal science and technology, focus on deepening the understanding of high-temperature, medium-low-temperature and shallow geothermal resources in the western region, find out the formation mechanism and distribution characteristics of geothermal in the western region, and carry out resource evaluation; draw on the experience of the United States, Iceland and other countries, further improve fiscal and tax incentive policies (Yang et al., 2017), revise the Catalogue of Encouraged Industries in the Western Region (2020 version) The first is to add "geothermal and associated resources" to the list of encouraged industries in western provinces and regions, and encourage local governments and relevant enterprises to carry out large-scale utilization of geothermal resources; carry out exploration of geothermal associated resources in western China, focusing on the investigation and evaluation of strategic resources such as helium, lithium and boron, and accelerate the comprehensive development and utilization of various energy sources.

Second, starting from the three levels of high-temperature geothermal, medium and low-temperature water heat, and shallow geothermal, we will accelerate the construction of geothermal demonstration projects in the western region. For example, in Ganzi Prefecture, West Sichuan Plateau, we will implement demonstration projects of high-temperature geothermal power generation and comprehensive utilization of geothermal gradient; in Guanzhong Basin and Longxi Basin Group, we will implement demonstration projects of direct underground heat exchange for medium and low-temperature geothermal heating and water-soluble helium extraction; in Ordos Basin, Sichuan Basin, Qaidam Basin, Junggar Basin, and Tarim Basin, we will implement demonstration projects of the utilization of abandoned wells in oil areas and comprehensive utilization of waste heat of extracted water. Through the implementation of demonstration projects, further, improve the relevant technical specifications and standards, and lay the foundation for the industrial development of geothermal energy in the western region.

Third, encourage enterprises to set up new energy organizations and management agencies in the western region and strengthen coordination and talent team building. The relevant policies have been introduced to encourage state-owned enterprises such as PetroChina to register new energy companies in the western region to coordinate geothermal resource exploration, technology research, and development, etc.; local governments and enterprises are encouraged to establish new mechanisms for the introduction and training of talents, strengthen the construction of the geothermal energy business talent team, and introduce incentive policies to encourage and guide researchers to take root in the west and serve the country.

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