Study on Development and Utilization of Shallow Geothermal Energy in Jilin Province

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Abstract. Under the current trend of striving for economic, energy-saving, low-carbon and environmental protection, geothermal energy has received wide attention due to its advantages such as energy conservation and environmental protection. The so-called geothermal energy is a kind of energy from the interior of the earth. It has a strong vitality. The heat stored in the earth is about 170 million times of the global coal reserves, and the annual heat from the earth through the surface is about 100 billion barrels. The thermal equivalent of petroleum. Shallow geothermal energy is an important part of the earth's thermal energy. It usually refers to the low-temperature geothermal resources located in the shallow rock mass of the earth's crust, which is located at a depth of 15 to 200 meters above the Earth's surface. In new and renewable energy sources, shallow geothermal energy is a new energy source that is competitive with current trends. This paper introduces the utilization and development of shallow geothermal energy in Jilin Province to enrich the research results of shallow geothermal energy in Jilin Province.

Introduction

Shallow geothermal is a new type of energy that is renewable, clean and environmentally friendly. The development and utilization prospects are very broad. With the rapid development of the economy of Jilin Province and the continuous improvement of people's living standards, the demand for heat and cooling in heating, air conditioning, living, and hot water is increasing. As a very important new energy source, shallow geothermal energy is of great practical significance to alleviate energy stress in our province and promote energy structure adjustment, especially to reduce carbon dioxide emissions and build a resource-saving and environment-friendly harmonious society.

Basic Situation of Shallow Geothermal Energy in Jilin Province

The formation of geothermal energy generally requires three essential conditions, including heat source, thermal reservoir, and heat conduction channel. The heat source is the source of heat for the geothermal fluids and rocks in the heat reservoir. It can be a magma sac formed by modern volcanic activity, or it can be heat transfer from the upper mantle or thermal convection from a modern active fault zone that communicates deep heat sources. The thermal reservoir is a stratum, rock mass or structural zone buried in the ground with effective voids and permeability. The stored geothermal fluid can be developed and utilized, and is divided into layered heat storage and strip heat storage.

Jilin Province is located in the northeastern part of China. Jilin Province is rich in geothermal resources. Its unique geothermal geological conditions lead to diverse geothermal types and uneven distribution. By the end of 2015, Jilin Province had used a shallow geothermal heating/cooling area of 2 million square meters and a hydrothermal geothermal heating area of 5 million square meters.

The geotectonic location of Jilin Province is in the composite part of the Xinhuaixia tectonic system and the Yinshan-Tianshan zonal tectonic system. Due to the influence of multiple tectonic
movements, the structural system and structural form of our province have become complicated and diverse. The Xinhuaxia tectonic system is the main structural system of our province, and the Huaxia-type tectonic system and the NW-trending tectonic belt are the latest tectonic systems in our province. They intersect each other to form the basic structural framework of our province. These tectonic systems control sedimentation, metamorphism, and mineral formation, while also controlling magma activity and underground heat, mineral water formation and storage. Also, due to the strong rise of the eastern mountainous areas. In addition, the strong cutting of the surface water flow. The valleys are mostly "V" shaped, some of the heat storage structures are cut through, and the hot water is exposed to the surface. The most typical one is the hot springs on the north and southwest sides of Changbai Mountain.

The Characteristics of Shallow Geothermal Energy

Shallow geothermal energy originates from the shallow part of the earth's crust. Due to the combination of solar radiation, heat carried by rainfall infiltration and deep earth heat flow, it maintains a certain amount of heat and becomes a low-quality heat source with huge thermal energy reserves. Shallow geothermal resources have the following characteristics:

Shallow geothermal regeneration ability: Shallow geothermal heat is not only regenerative, but also low in mining cost due to the recharge of geothermal heat and water circulation.

Shallow geothermal distribution is extensive: geothermal resources are stored in groundwater and rock and soil. The thermal energy in groundwater is below the groundwater level, and the groundwater type is diving. The recharge conditions are good, the water temperature changes little, and the development cost is the lowest. The water source heat pump is prioritized for development and utilization; the shallow geothermal in the rock mass of the soil is affected by the geological conditions, and the development and utilization is difficult. The difficulty is: the hard rock mass of the soft rock layer of the soil, and the geological conditions of Jilin Province, low plain plain soil high plain soil and soft rock formation hilly mountainous hard rock formation.

Shallow geothermal storage is large: due to the wide distribution of shallow geothermal heat, no matter whether the geothermal reserves in groundwater or rock and soil are considerable, it should be developed and utilized as early as possible to alleviate energy shortage.

Shallow geothermal development and utilization: The temperature of shallow geothermal is too low, and it is not suitable to directly use its energy. Only by using heat pump technology to extract the heat in the water and the heat in the rock and soil, it can become a good heat source.

The Development Characteristics of Shallow Geothermal Energy Application in Jilin Province

As of December 2014, according to incomplete statistics, 131 cities and counties (cities, districts) have developed and utilized ground source heat pump projects. The most significant application of ground source heat pump in Jilin Province is the development and application of groundwater source heat pump.

The number of ground source heat pump projects and service area show a rapid growth trend. 2005-2010 is the initial development stage of ground source heat pump system, and 2011-2018 is the period of rapid development of ground source heat pump system. At present, the application of ground source heat pump in Jilin Province has been relatively mature, regardless of the number of buildings or the number of buildings. According to statistics, from the beginning of 2005, 66,400 square meters, the construction area of the ground source heat pump system for heating and cooling by the end of 2014 totaled 205.2. Ten thousand square meters, due to the inability to obtain data for 2015-2018, the index of regression data was used to predict the data for 2015-2018.
Ground source heat pump coverage is suitable for multi-class buildings. At present, heat pump systems are used in different building types, including residential quarters, libraries, stadiums, training centers, enterprise factories, and gas stations (Figure 2).

Apply ground source heat pump project imbalance. Ground source heat pumps are mainly developed and utilized groundwater source heat pump systems. The proportion of groundwater source application systems accounts for 96%. Surface water sources and soil source systems account for only a small part of them. The application of ground source heat pumps has obvious imbalances (such as figure 3).
The province's ground source heat pump projects are widely distributed. At present, more than 131 ground source heat pump projects have been promoted and applied in various cities (prefectures) and counties (cities, districts) in the province. The promotion and application of Jilin City is relatively extensive, and Changchun City only accounts for 4% (Figure 4).

The province's ground source heat pump system has a good application effect. In the development and utilization of ground source heat pump technology in various cities (states) and counties (cities, districts) in Jilin Province, there are also relatively good projects, such as: Aswan Hotel in Jilin Province, Fitness Center in Jilin City, Shengbo International Hotel in Hunchun City, Project units such as Hunchun Oriental Light Industry Market and Da'an Experimental Primary School, the heating and cooling effects of these projects can achieve the expected results. The Jilin Provincial Library and the Hadashan Water Control Project have applied well. Among them, the
Jilin Province library has a radiation area of 60,000 square meters. Compared with the period when the ground source heat pump was not used, the amount of coal used was reduced by nearly 1,000 tons. At the same time, the environmental impact, the carbon dioxide emissions decreased by nearly 2,300 tons.

From the application of ground source heat pump system, energy saving is more obvious in places with high load and high energy consumption such as shopping malls and hotels, and the initial investment per unit area is also reduced. In areas where geology and water temperature are advantageous, the economic input of ground source heat pumps will also be much lower. If some buildings have special requirements for appearance, external noise and safety, the emergence of ground source heat pumps just solves these problems.

The Main Problems of Shallow Geothermal Energy in Jilin Province

Through the investigation of the application of ground source heat pump systems throughout the province, the current application of ground source heat pump systems in various cities (states) and counties (cities, districts) mainly has a poor management system, popularization and application of blindness, and groundwater source heat pump system recharge. Not many issues such as recharge requirements:

The preliminary survey and evaluation of ground source heat pump system project is not standardized. The non-standardization of preliminary survey and evaluation has caused the development and utilization value of some projects to be small, and some projects cannot be used in succession, resulting in waste of resources and loss of energy.

Lack of long-term monitoring and research. In recent years, some of the province's large number of ground source heat pump systems have not established a monitoring system for underground heat transfer systems, and lack of dynamic monitoring of the adverse effects of underground temperature fields, groundwater ecological environment and groundwater volume changes in adjacent buildings;

The problem of recharge of groundwater source heat pump project is outstanding. The application of groundwater source heat pump system, first of all, is the problem of groundwater recharge. In the standard specification of ground source heat pump technology, the requirements for recharge are very strict, and 100% of the same layer must be recharged. Blindly adding the number of recharge wells due to difficulty in refilling, increasing the cost of the heat pump system;

The distance between the water intake and the recharge well is unreasonable. The design of the spacing between the pumping well and the recharge well is unreasonable, which may lead to the phenomenon of system operation and thermal breakthrough, which affects the normal operation of the system.

Suggestions for the Development and Utilization of Shallow Geothermal Energy in Jilin Province

The northeastern region spans the mid-temperate zone and the cold temperate zone from south to north. It belongs to the temperate monsoon climate, with four distinct seasons, warm and rainy summers, and cold and dry winters. Jilin Province is located on the eastern side of the mid-latitude Eurasia. It belongs to the temperate continental monsoon climate with four distinct seasons and the same season of rain and heat. The spring is dry and windy, the summer is hot and rainy, the autumn is high and the winter is cold and long. The cold weather in Jilin Province has reached 150 days. In such a geographical and climatic environment, the use of geothermal energy for the environment and economy of Jilin Province is very obvious. Jilin Province vigorously develops and utilizes shallow geothermal energy. The author suggests the following:

Conduct research on the status quo of shallow geothermal energy development and utilization in Jilin Province. The focus is on the implementation of relevant policies, existing problems, and a summary of the need to improve the supplements. On the basis of the investigation, the conditions
and scope for the development of shallow geothermal energy in Jilin Province were clearly defined. Determine the extent to which shallow geothermal energy is used. The groundwater source heat pump system is preferentially selected in suitable areas of geological conditions; the buried heat pump system is preferentially selected in areas where groundwater is not suitable. In areas with suitable development conditions, encourage new or renovated office buildings, industrial plants, hospitals, hotels, schools, large shopping malls, commercial buildings and other public buildings, as well as residential buildings and residential buildings in rural areas to use shallow geothermal energy to encourage coal combustion. The oil-fired boiler is replaced by a heat pump system. Government-invested schools, hospitals, gardens, administrative undertakings, office buildings and other public welfare projects, heating and cooling systems give priority to the use of shallow geothermal energy, and the required investment can be arranged from the government's fiscal fixed assets investment. Support for relevant scientific research results. Encourage the research and development of shallow geothermal energy and the research and development of relevant technologies of ground source heat pump system, and formulate an attractive and attractive incentive policy for breakthrough scientific research results.

Strengthen management and monitoring to enable the orderly development of shallow geothermal energy resources. The Ministry of Land and Resources’ "Notice on Promoting the Development and Utilization of Shallow Geothermal Energy" shall strengthen the orderly development and standardized management of shallow geothermal energy resources in Jilin Province from the investigation and evaluation, Jilin Land and Resources Management Department and the energy management department in accordance with the notification requirements. Strengthen the monitoring of the impact on the geological environment.

Issue relevant construction specifications as soon as possible. On November 30, 2005, the former Ministry of Construction issued the national standard “Technical Specifications for Ground Source Heat Pump System Engineering” (GB50366-2005). Three years later, a partial revision of the specification was approved in March 2009 (implemented on June 1, 2009). The "Specifications for the Evaluation of Shallow Geothermal Energy", prepared by the Ministry of Land and Resources, has entered the release process. From the perspective of industry management, the "Specifications" made specific requirements for regional exploration and evaluation of shallow geothermal energy resources and exploration and evaluation of engineering sites. Jilin Province should also organize professional talents and experts and scholars to organize planning standards that are compatible with the topography and geomorphology of Jilin Province. The content covers the preparation of shallow geothermal energy exploration work, on-site investigation, drilling sampling and testing, and on-site heat exchange hole construction. Tests, suitability zoning, resource calculation, and economic benefit assessment are the main basis for conducting shallow geothermal energy exploration and evaluation in our city. At the same time, the shallow geothermal energy exploration and evaluation method system should be further studied and improved.

Develop new preferential policies to encourage the promotion and application of shallow geothermal energy. Including the development of related technologies, the rational use of resources and market regulation, etc., support in the economy (initial investment, operation period), and increase the promotion of energy conservation and environmental protection advantages of shallow geothermal energy resources, and improve various departments (government, design institute, Environmental protection and energy conservation awareness of developers, properties and users. Introduce project preferential policies. In areas with suitable geological conditions and high environmental protection requirements, it is recommended that relevant government departments give a certain proportion of subsidies to the system investment, so as to minimize the initial investment burden of users; relevant government departments support investors to give priority to the use of value-added tax and corporate income tax. The geothermal energy of the floor is the heating and cooling of the building, so-called “green tax”; from the geological survey to the land use, the relevant departments should guide the “green light” across the line, simplify the relevant approval procedures, and fully support it. The limitation of the buried pipe heat pump system is
mainly the thermal conductivity of the rock and soil body, and the buried heat exchanger covers a large area, which is limited by the engineering site and outdoor geological conditions. Where conditions permit, the units using the heat pump system may appropriately relax the land use policy, such as relaxing the land use period and increasing the green area; etc.; the electricity price and water fee during the operation of the system. At present, the relevant state departments emphasize the approval system for water use. In some places, the water source is extracted and discharged twice, which increases the operating cost of the groundwater source heat pump system. Therefore, the promotion of groundwater heat pump requires the government to consider all aspects from the perspective of sustainable development. It is recommended that the relevant departments adjust the water source use policy of groundwater source heat pump system, and re-determine the management and charging of recycled groundwater in the underground heat exchange system. Contribute to the electricity price of ground source heat pump system. For example, shallow geothermal energy heating can use civil electricity price, or increase capacity, etc., increase peak-to-valley electricity price difference, encourage the application of energy storage technology in the system to cut peaks and fill valleys, scientific electricity Simplify the approval procedures for heat exchangers. The approval of the heat exchange well shall be different from the water supply well approval procedure and shall not be examined and approved by the water authority. The land and resources management department shall strengthen the review of the mining plan, and the water authorities shall focus on strengthening the management and monitoring during the operation period.

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