STUDY ON THE UTILIZATION OF DIFFERENT TYPES OF GEOTHERMAL HEAT PUMP (GHP) SYSTEMS

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Abstract: Geothermal heat pumps can be installed in almost all areas to provide greater efficiency in heating and cooling of buildings, supplying hot water. The purpose of this study is to investigate the different problems with respect to cost, technology and measures about geothermal heat pump (GHP) systems by collecting information from relevant literature, random surveys, discussion forums and expert groups.

Keywords: *Geothermal heat pumps, Utilization, cost, technology, measures*

INTRODUCTION

Geothermal energy is one of the cleaner forms of energy now available in commercial quantities. The benefits resulting from the installation of large numbers of geothermal heat pumps(GHP) systems are reduction in carbon dioxide emissions, lower heat radiation from urban areas, and decrease in peak power demands. Geothermal energy provides an enormous resource for low-temperature applications such as heating and cooling buildings, drying agricultural products, and process heating for industry. For example, geothermal heat pumps can be installed in almost all areas of China to provide greater efficiency in heating and cooling of buildings and supplying hot water than either all-electric systems, and the thermal energy of higher temperature systems can be used to produce electricity.

Geothermal energy can be used directly for a host of processes requiring thermal energy for swimming pools, space heating, and domestic hot water. The U.S., Japan, and the European Community are continuing experiments in the utilization of GHP systems. In Iceland, more than 95% of the buildings are supplied with heat and domestic hot water from geothermal systems, and this heat has directly replaced the burning of fossil fuels. The domestic application of GHP heating system centralizes mainly in Tianjin, Beijing, Hebei and Xi'an etc. The application in Tianjin is relatively universal today, the GHP heating area of Tianjin has reached five millions m^2. Calculated according to the replacing heating boiler of coal fired, it has replaced the coal more than one hundred and ten thousands tons during every heating season, and gotten well benefit of environmental protection. Rapidly growing energy needs around the world will make geothermal energy exceedingly important.

There's rich resource of geothermal heat in China. It Has been discovered that geothermal heat appears more than 3000 points, in which type of high temperature was no more than 175 places, and centralize mainly in Tibet, Yunnan and Taiwan. The source of mid-low temperature geothermal heat spreads in 30 nation-wide province, city and autonomous region, the annual natural resource of heat release is measured for the kJ of 1.04×10^{17}, convert into 3.56 billion tons of standard coal. For instance: Tibet Yangba well reach 330 ℃ in 2007 meters deep places, Tibet Yangyi well also have 207 ℃. The most of mid-low temperature geothermal heat (less than 105 ℃) are the hydro-thermal type resource of low temperature in China, and uniquely suitable for direct using.

Geothermal heat pumps can be used in a variety of installations. A system is comprised of 1) the heat pump mechanical unit, 2) the closed-loop or open-system ground heat exchanger, and 3) the building water loops. In closed-loop systems, water or a mixture of water and an environmentally safe antifreeze solution is circulated through a pipe to remove heat from, or reject heat to the ground. In a vertical installation, the heat exchanger loop is a U-shaped pipe inserted in a hole 50 to 150 m (meters) deep. In horizontal installations, the heat exchanger loop is either rigid or flexible pipe laid in trenches about 2 m deep. Flexible tubing shaped in a spiral (often called a "slinky") and placed in a trench can be used to increase the effective heat exchange surface area of a horizontal loop and to reduce the length of trenching by 40%. The open vertical system uses a water well to provide groundwater to the heat pump, and, depending on need, the water can be used within the building, can be discharged at the surface, or can be injected in a second well. In single-well, open installations, water can be withdrawn from the bottom of the well, circulated through the heat pump, and returned to the top of the well. This method depends on the open communication with the groundwater system, is often a lower cost option, and is used in large commercial applications where space is limited.

COST PERFORMANCE EVALUATION

The GHP heating system is suitable for winter heating or supplying hot water especially. It can be divided into two kinds: the ordinary type and the high temperature type. The former can heat 7-12 ℃ underground water up 45-50 ℃; The latter apply to promotion of low temperature GHP heating water of 30-40 ℃ to 65-70 ℃; Both system hot coefficient COP can reach 3-4, i.e. spends a copy of price namely, can get the heat of 3-4 times. And compared with the way use conventional energy to heat up hot water, undoubtedly, it has saved energy largely, and then has also decreased the environmental pollution produced by using fossil fuel in course of power manufacturing. The GHP of high temperature is suitable for application in north city residential heating (maintain original indoor radiator), to replace the seriously pollusive heating boiler of coal fired.

As far as the operation cost concerned, use the price of Beijing, 1.4 Yuan per m^3 of natural gas, 0.38 Yuan per kWh of the electric to comparison.

Heating using natural gas, the calorific value of natural gas is 33,500 kJ/m^3, using the 90% of thermal efficiency; burn 1 m^3 can get heat:

$Q = 33,500 \times 0.9 = 30,150\ kJ/m^3$

Heating using the GHP, take COP = 3.5, get same heat needed power consumption is:

$W = Q/COP = 30,150\ /\ 35 = 8,614.3(kJ) = 2.4(kWh)$

Cost can know fairly:

GHP charge of electricity = $0.38(yuan/Kwh) \times W = 0.38 \times 2.4 = 0.91$ (Yuan)

The cost of natural gas of 1 m^3= 1.4(Yuan)

Therefore the GHP heating system can reduce operation cost:

$Y = (1.4-0.91)/1.4 = 35.0\%$

By statistical data the per unit cost of GHP heating system when sum into the GHP well is 15.41 Yuan per m^2, match with the boiler of coal fired, when not summing the well is only 7.70 Yuan per m^2, as the 60% of boiler, it is proved that the cost of GHP heating system is very low.

TECHNICAL ADVANCES NEEDED FOR FUTURE GHP SYSTEMS

The following technical advances were considered to make GHP systems more effective and attractive in the future:

- Improvement of the performance of heat pumps, particularly for single-family housing.
- Selection of a heating and cooling system that is most suitable for GHP systems.
- Development of a highly efficient vertical ground heat exchanger.
- Implementation of new tools and techniques to reduce drilling costs.
- Preparation of drilling manuals.

Although there are no serious technical problems associated with the GHP systems, the most important projects to be considered to reduce their costs are the development of small-sized, highly mobile drilling rigs designed primarily for heat- exchanger holes, and the preparation of drilling manuals (items d. and e. in the list above).

TASKS TO ASSIST IN THE INTRODUCTION, PROMOTION AND WIDESPREAD ACCEPTANCE OF GHP

To promote the widespread introduction of GHP systems, the establishment of a support system is very important. This system should be primarily directed toward:

- Basic Research

New developments to improve the thermal efficiency of vertical ground heat exchanger are expected in the future. While the basic studies on this subject have been mostly completed in Europe and the USA, presently in China the lack of the subsurface data needed to install vertical ground heat exchangers may slow down the introduction of GHP systems. The collection of such information is urgently needed.

- Applied Research

Applied research on the use of GHP systems has also been mostly done in Europe and the USA, where the main efforts have been directed toward their introduction in different regions. On the other hand, in China the most urgent tasks to be undertaken are the standardization of systems, preparation of technical manuals, and testing the reliability of the systems by conducting demonstrations.

- Promotion Activities

GHP promotion centers should be created. Their activities should include solving the various problems associated with the installation and use of GHP systems and for the preparation of subsidiary systems.

CONCLUSIONS

The geothermal heat pump is the bridge of high-tech accesses to environmental protection. It can get the effect of environmental protection using the geothermal heat of low temperature below 40 ^{0}C or lower than environmental temperature. The operation cost of GHP heating system can be reduced 30-70% than directly use electricity or natural gas. The geothermal heat of this respect can be used in changing energy structure, environmental protection and other aspect, have important denotation. Therefore our country should support application and the development of this technology vigorously, carries out and popularizes project demonstration.

Currently the number of GHP systems installed in the USA is about 400,000, and is expected to increase by approximately 50,000 units per year (i.e., about 12% annual growth). Geothermal heat pump systems (with vertical and horizontal ground heat exchanger, lake loops, etc.) are considered to suit the requirements of China from both the topographical and environmental points of view.

Tasks to Assist in the Introduction, Promotion and Widespread Acceptance of GHP Systems include the gathering of geological data, the standardization of systems, the preparation of manuals, the demonstration and monitoring activities, the establishment of a GHP system distribution network, and the creation of a subsidy program.

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