Survey of Geothermal Heating and Cooling Technologies

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ABSTRACT
The need to find new applications for renewable energy technology has grown as a result of the depletion of fossil resources and rising energy demand. In the Indian HVAC business, geothermal heating and cooling represents a recent development. Heat pump systems are used to utilize the heat from the ground to heat and cool areas, resulting in a 51% reduction in HVAC electricity consumption and a decrease in CO2 emissions. Lower operating costs and longer equipment life are geothermal energy's primary future hopes. Recent developments in geothermal heating and cooling systems are reviewed in this article.

Keywords: *heat pump, ground loop, air handling unit, heating, cooling*

I. INTRODUCTION

Previously, the air conditioning system was considered a symbol of luxury. Now that the world is growing faster, it has become a need of the day. The residential and commercial sector contributes to more than 30% of the total electricity consumption. Of this, the HVAC system consumes 64% of the electricity. As the need for HVAC increases, so does the demand for energy. Therefore, fossil fuels are used on a large scale to meet this requirement, increasing CO2 and particulate matter emissions, leading to global warming. This has paved the way for renewable energy sources and the viability of "geothermal heating and cooling". The name geothermal is derived from the words "Geo" means earth and "Thermal" means heat. The Earth's heat is produced by gravitational collapse and the radioactive decay of isotopes. The soil provides a stable temperature at approximately 6 to 8 m in the range of 16 to 29 °C throughout the year. The geothermal system is also called "geothermal heat pump (GHP) system, ground source heat pump (GSPH) system or geothermal exchange system, and works on the basic principle of stable temperature heat pump of the land to provide heating and cooling. Ground loops are used to connect ground and space for heating or cooling applications (Figure 1)

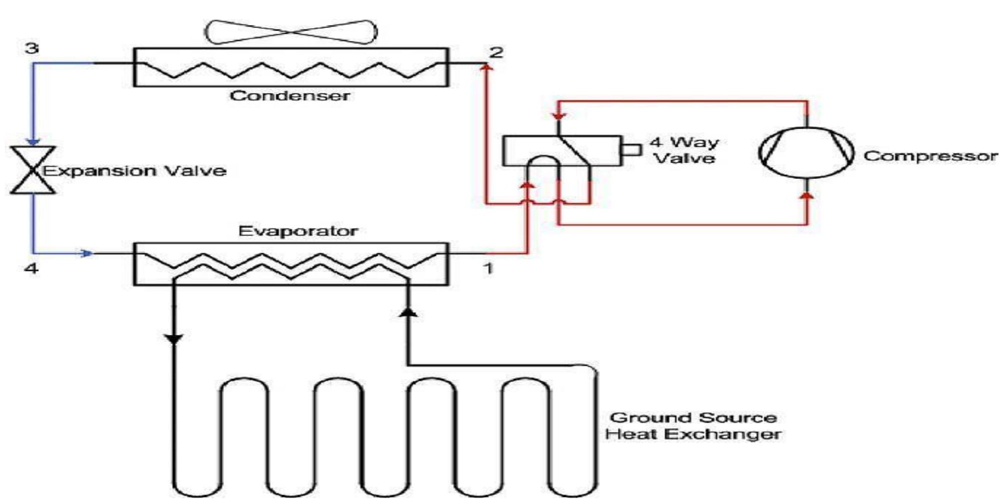

Figure 1: Schematic Diagram of Geothermal Heating and Cooling System

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II. COMPONENTS OF GSPH'S

Geothermal Grounding System The geothermal grounding system connects the space to be cooled or heated to the ground using copper pipes (high thermal conductivity) or high-density polyethylene (HDPE). The thermal conductivity of copper is 380 W/mK, while the thermal conductivity of HDPE pipes is 0.42 to 0.51 W/mK. The diameter of the pipe ranges from 29 to 38 mm. As pipe length increases, the overall efficiency of the system also increases, with the required pipe length depending primarily on geographic and building character. There are two types of GSPH system:

2.1 Open Loop

There are two wells, one to drink water and another to impoverish the water. Water is injected from the first well to extract or reject heat as per requirement and then expelled to the second well. The water requirement is 5.67–7.57 lpm per ton (Figure 2). The main drawback of this system is the quality of the water, which affects the useful life of the components and increases maintenance costs. Additionally, local environmental regulations may be restrictive.

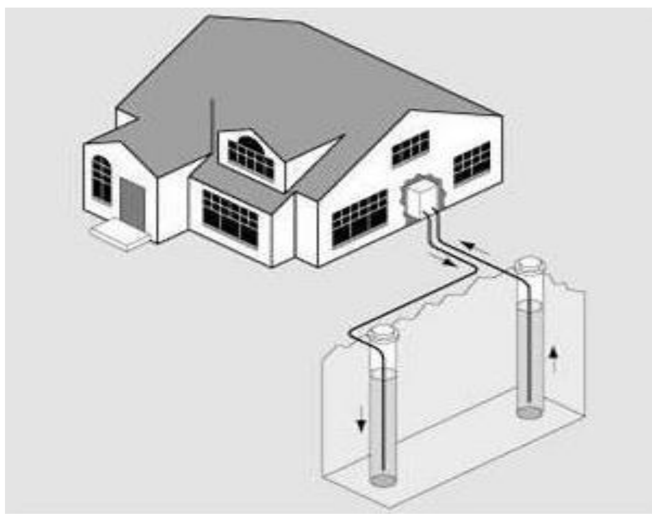

Figure 2: Open Loop System-Schematic

2.2 Horizontal Loop

Horizontal loops are typically found between 1 and 2 m depth. If more land is available, a horizontal circuit can be used. After the installation of this system, we cannot use this land for any other use; therefore, there is tied capital in this system (Figure 3). Furthermore, the soil temperature varies from pitch to pitch and there is no constant temperature. Horizontal loops require approximately 232 m2/t of area, but are easy to install and less expensive.

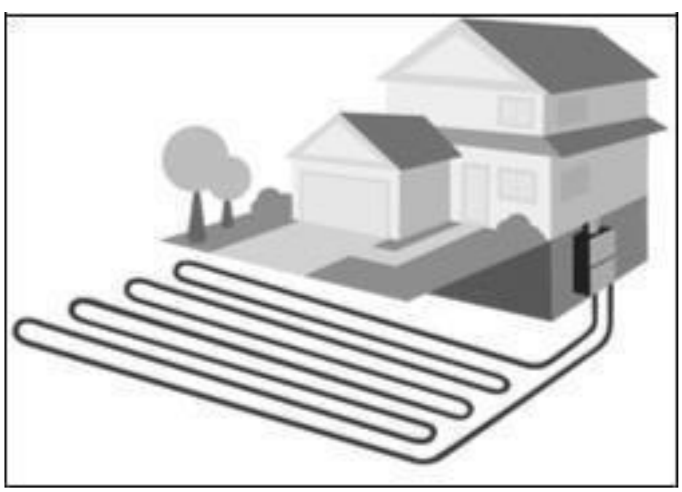

Figure 3: Horizontal Loop

2.3 Vertical Loop

Holes are drilled into the ground. The spacing between two wells is at least 5 to 6 m (Figure 4). This type of system requires between 23 and 27 m2/t of surface. The installation cost, being a function of the depth of the pipe and the geology of the location, is greater than the horizontal cost. The advantages of the vertical loop are; lower space requirement, lower variations due to temperature and thermal properties of the soil and higher efficiency.

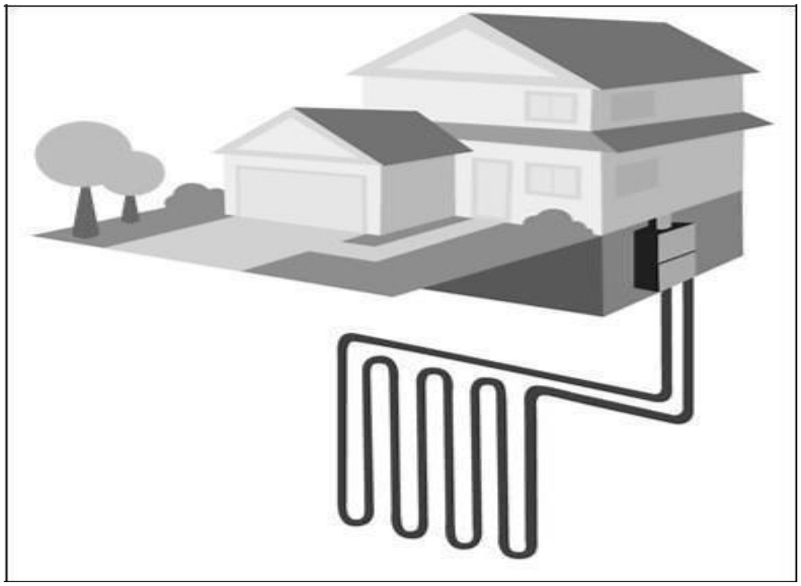

Figure 4: Vertical Loop System

III. GEOTHERMAL HEAT PUMP SYSTEM

The heat pump system consists of a compressor,condenser, expansion valve and evaporator and is governed by the second law of thermodynamics. It raises the temperature of the vapor by isentropic compression. The cooling effect is produced by expanding the compressed vapor in the expansion valve and lowering its temperature. In summer it acts as a refrigerator. The heat pump does not generate heat but rather transfers heat from a lower temperature to a higher temperature. The heat pump converts 1 KW of electricity into 3 KW of useful work [8]. Therefore, the COP of a heat pump is higher than that of a refrigerator. A heat pump has an average life of +20 years.

IV. GEOTHERMAL HEAT PUMP SYSTEM OPERATION WORKING

4.1 Heating mode

In winter, when heating is needed in the room, the water in the ground loop absorbs heat from the ground and thus increases the temperature of the water in the pipe.The expanded vapor coolant circulates inside the heat-conducting copper pipes, and because the coolant absorbs heat from the ground loop water, its temperature increases. This refrigerant vapor is further sent to the compressor where it is compressed at high pressure and temperature.Hot refrigerant vapor passes from the copper coil of the air handling unit (AHU). Cold air from the house is passed through this copper coil by a fan or blower, absorbing heat from the hot refrigerant vapor and warming the room.

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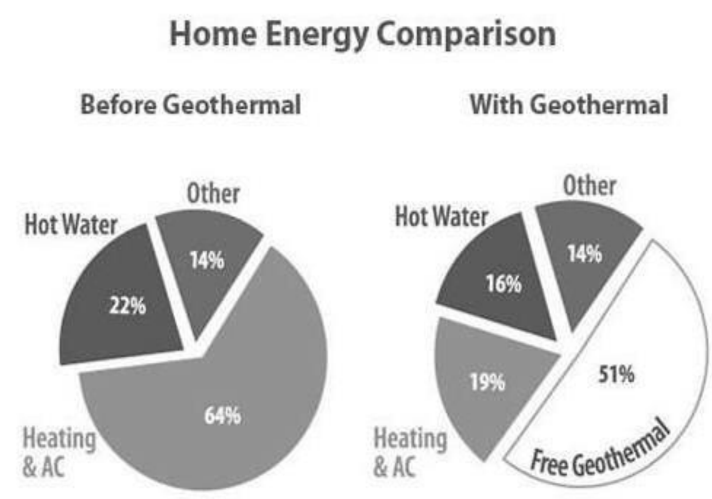

Figure 5: Energy Savings by GSHP's.

4.2 Cooling mode

In cooling mode, operational reversal of heating mode occurs.The water in the circuit rejects its heat to the earth and the temperature of the water decreases.The hot refrigerant from the compressor rejects its heat to the groundwater and the temperature of the refrigerant vapor decreases. After this, the refrigerant vapor expands in the expansion valve, further reducing its temperature. This cold refrigerant then circulates in the copper coil of the AHU.

Hot air from the room passes through the cold refrigerant coil, where the hot air rejects heat. Now this cold air reaches the room. The hot refrigerant is returned to the compressor, where it is compressed at high temperature and pressure, and the entire cycle is repeated. Additionally, with space heating and cooling, we can obtain hot water by installing a super-heater in the system.

V. COMPARISON& ADVANTAGES

From Figure 5 it is observed that 51% of the energy is free and the energy needed for heating and air conditioning, and water heating has also been reduced. The heat pump has greater efficiency and also this system does not depend on the outside temperature, as in the case of the traditional HVAC system. Lower maintenance and operation costs; since the heat pump system is installed inside the house, protecting it from harsh weather and climate conditions. It also requires 50% less energy. The Ministry of New and Renewable Energy (MNRE) in New Delhi, in a bid to boost the use of renewable sources and reduce carbon footprint, is providing loans, tax credit concessions and many more incentives. Water conservation is 100% due to the replacement of the chiller with ground circuits and also the low cost of water heating. Geothermal heating and cooling is environmentally friendly as it saves a large amount of CO2.

VI. CONCLUSION

Due to its high installation costs and general lack of understanding about geothermal technology and its collection methods, this technology is growing more slowly than other RES technologies.

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