

# A Review of the Advancements in Geothermal Heating and Cooling System

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## Abstract

The increasing demand for energy and the depleting fossil fuels have fuelled explorations in new frontiers of Renewable Energy Technology. Geothermal Heating and Cooling is a new advancement in HVAC industry of India. It uses earth's heat for space heating and cooling with the use of Heat Pump systems, saving up to 51% electricity consumption in HVAC, and reduced CO<sub>2</sub> emissions. The main prospects of Geothermal Energy are longer equipment life and lower operating costs. This paper reviews the recent advancements in Geothermal Heating and Cooling System.

**Keywords:** Air Handling Unit [AHU], Cooling, Geothermal, Heat Pump, Ground Loop, Ground Sources Heat Pump system [GSPH's], Heating

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## 1. Introduction

Previously the air conditioning system was considered as the symbol of luxury. Now as the world is growing faster it has become a necessity of the day. Residential and commercial sector contributes to over 30% of total electricity consumption<sup>1</sup>. Out of this, HVAC system consumes 64% of electricity. As the need for HVAC increases, so does the demand for energy. Hence fossil fuels are used on large scale to meet this requirement, increasing CO<sub>2</sub> and particulate matter emissions, resulting in global warming. This has paved the way for renewable energy sources and the feasibility of "Geothermal Heating and cooling"<sup>2</sup>.

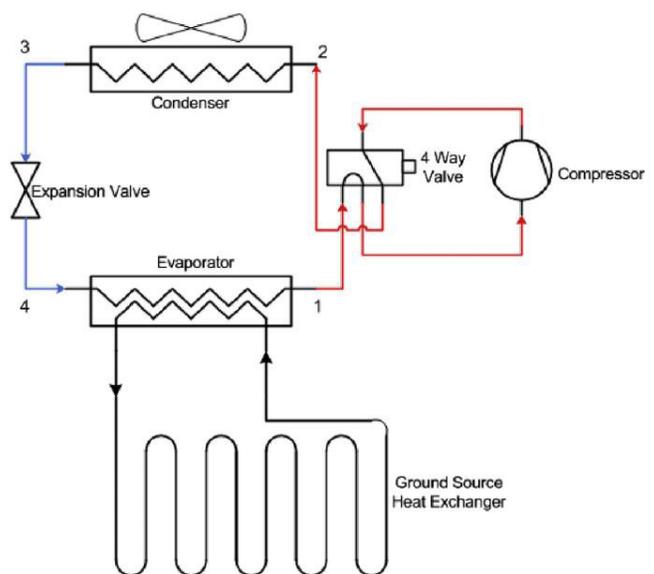
The name Geothermal is derived from the words 'Geo' means earth and 'Thermal' means heat. The earth's heat is produced by gravitational collapse and radioactive decay of isotopes. The soil provides a stable temperature at approximate 6-8 m in range of 16-29 °C all year round<sup>1</sup>. The geothermal system is also called 'Geothermal heat pump system [GHP's], Ground source heat pump system [GSPH's] or Geo-exchange system, working on the basic heat pump principle of stable earth temperature to provide heating and cooling. Ground loops are used to connect the ground and the space for heating or cooling applications.

## 2. Components of GSPH'S

### 2.1 Geothermal Earth Connection System

Geothermal earth connection system connects the space to be cooled or heated with the earth using Copper (high thermal

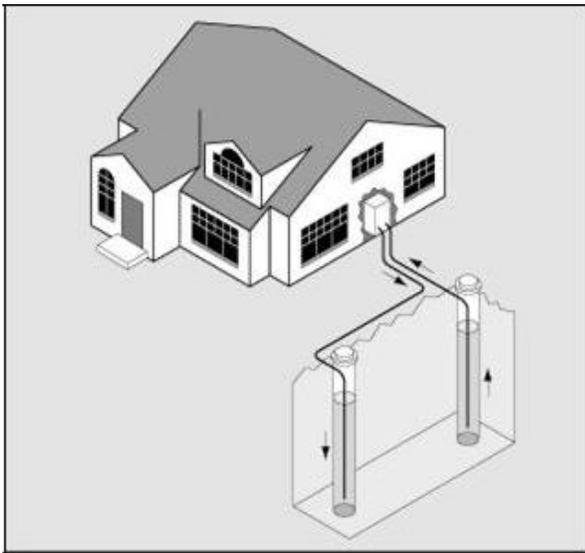
conductivity) or High Density Polyethylene [HDPE] pipes. The thermal conductivity of Copper is 380 W/mK whereas the thermal conductivity of HDPE pipes is 0.42 - 0.51W/mK. The diameter of pipe ranges from 29 mm to 38 mm<sup>10</sup>.



**Figure 1.** Schematic diagram of geothermal heating and cooling system.

As the length of the pipe increases the overall efficiency of the system also increases, with the required length of pipe depending primarily on geographical and building character.

There are two type GSPH's system  
 1) Open loop



**Figure 2.** Open loop system-Schematic.

There are two wells one for taking the water and another for leaning the water. The water is injected from the 1<sup>st</sup> well to extract or reject heat as per the requirement and then ejected into 2<sup>nd</sup> well. The water requirement is 5.67-7.57 lpm per ton<sup>3</sup>.

The main drawback of this system is the quality of water, affecting the component life, and escalating maintenance costs. Also the local environment regulation may be restrictive.

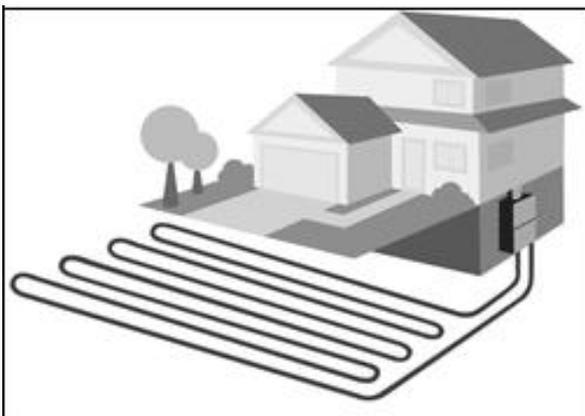
2) Closed loop:

In closed loop system, water is re-circulated through the coil forming a closed loop. The quality of water can be regulated and antifreeze mixture (eg. Methyl alcohol) can be added to avoid freezing.

Closed loop system is further classified into

i. Horizontal loop:

Horizontal loop are normally at 1-2m depth<sup>8</sup>.

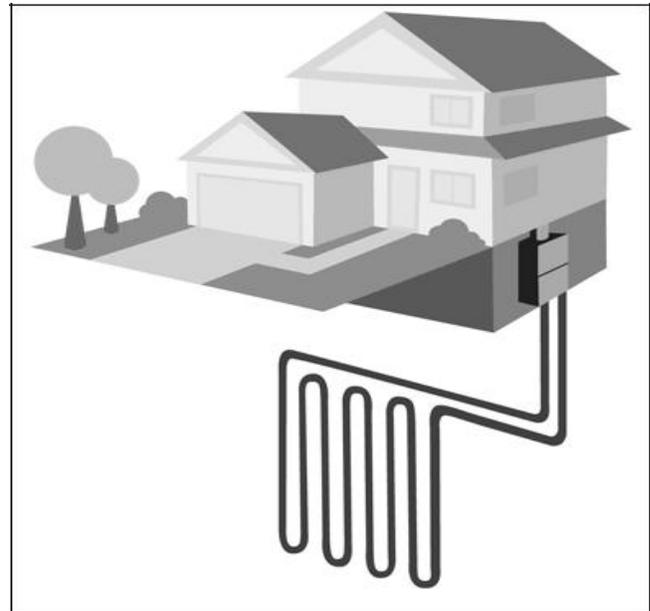


If the available land is more than horizontal loop can be use. After installation of this system we can't used this land for other use, hence capital in tie in this system.

Also the soil temperature varies from the length to length and no constant temperature.

Horizontal loop required approximate 232 m<sup>2</sup> /ton of area, but are easy to installed and less costly<sup>9</sup>.

ii. Vertical loop:



**Figure 3.** Vertical loop system.

Holes are drilled in the earth. The space between two bore holes at least 5-6metre apart. This type of system required 23-27 m<sup>2</sup>/ton of area<sup>9</sup>. The cost of installation, being a function of tube depth and geology of the location, is more than the horizontal.

The advantages of vertical loop are lesser space requirement, lesser variations due of temperature and thermal properties of soil and greater efficiency<sup>10</sup>.

## 2.2 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 vapour by isentropic compression<sup>6</sup>. Cooling effect is produced by expanding the compressed vapour in the expansion valve and lowering its temperature. In summer it acts as a refrigerator. The heat pump does not generate heat but transfer heat from lower temperature to higher temperature.

Heat pump converts 1KW of electricity into 3KW of useful work<sup>11</sup>. Hence COP of a heat pump is greater than a refrigerator. A heat pump has an average life +20 years<sup>7</sup>.

### 2.3 Geothermal Heat Distribution System

It consists of a Air Handling unit [AHU]. This supply the required temperature air to the space whose temperature is to be maintained. Ducts are provided to supply the required air<sup>8</sup>.

### 2.4 Working of Geothermal Heat Pump System

#### i) Heating mode

In winter when heating is required in the room, the water in the ground loop absorbs the heat of earth and thus the temperature of water in the pipe increases.

The expanded vapour refrigerant is circulated within the heat conductive copper pipes and because the refrigerant absorbs the heat from ground loop water, its temperature increases. This vapour refrigerant is further sent to the compressor where it is compressed to high pressure and temperature. The hot refrigerant vapour is passed from the copper coil in Air Handling Unit (AHU). The cold air from the house is blown over this copper coil using a fan or a blower, absorbing heat from the hot vapour refrigerant and heating the room.

#### ii) Cooling mode

In cooling mode, the operational reversal of heating mode occurs. The water in the loop rejects its heat to the earth and temperature of water decreases. The hot refrigerant from the compressor reject its heat to ground water and the vapour refrigerant temperature decreases. After this the refrigerant vapour is expanded in the expansion valve, further reducing its temperature. This cold refrigerant then circulated in copper coil of AHU.

The hot air from the room is passed over the cold refrigerant coil, where the hot air rejects heat. Now this cold air is supplied to the room. The hot refrigerant is sent back to the compressor, where it is compressed to high temperature and pressure, and the whole cycle repeats.

Also with heating and cooling of space, we can get hot water by installing desuperheater in the system.

## 3. Comparison

From the figure it is observed that 51% of energy is free and also the energy required for heating and air conditioning, water heating has also reduced.

## 4. Advantages

The heat pump has higher efficiency and also this system does not depend on outside temperature, as in case of traditional HVAC system<sup>12</sup>.

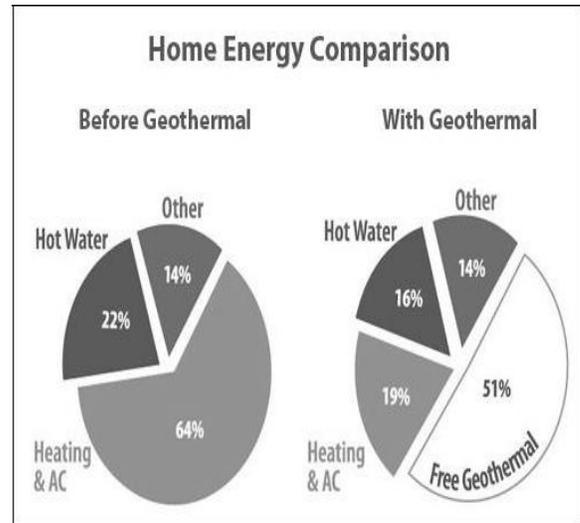


Figure 4. Energy savings by GSHP's.

Lower maintenance and operating costs, as heat pump system is installed within the house, protecting it from harsh weather and climate conditions<sup>12</sup>. Also it requires 50% lesser power The Ministry of New and Renewable Energy (MNRE), New Delhi in a move to boost use of renewable sources and reduce Carbon footprint, is providing loans, concessions in tax credits and many more incentives.

Water conservation is 100% due to the replacement of chiller with ground loops<sup>13</sup> and also low cost of water heating Geothermal heating and cooling is an eco-friendly as large amount of CO<sub>2</sub> is saved

## 5. Future Scope

The growth of this technology is slower than the other RES technology due to high cost of installation and limited knowledge of geothermal technology and its means of harvesting<sup>14</sup>.

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