Journal of Environmental Friendly Materials, Vol. 4, No. 1, 2020, 47-54.

Review Article

The Geothermal Energy and the its Effects on Global Environmental Pollution

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Received: 09 April 2020 - Accepted: 11 June 2020

Abstract

Today, with regard to population growth, there is a need for more renewable energy sources that can easily serve different human needs without harming the environment; therefore, designing energy saving buildings as well as protecting natural resources is one of the main responsibilities of the experts. One of the types of renewable energies is geothermal energy, which is one of the least costly, most beneficial of these energies and a good alternative to fossil fuels, and the generation of electricity and the heating and cooling of buildings by the heat pump are a number of its applications. This article attempts to explain the use of this energy in heating and cooling buildings and the need to use this cheap and clean energy instead of using fossil fuels. Increasing population and increasing economic prosperity on the other requires energy. The increasing need for energy has led people to increasingly use fossil fuels (coal, oil, gas) but the nonrenewable and contaminations that have emerged, such as global warming, ice melting, and the collapse of the natural ecosystem of the planet, have reduced the use of these energy sources. Therefore, the use of energy sources that are unlimited and cause the least pollution has attracted the attention of researchers in recent decades, which they call the sources of new and renewable energy. One of these sources is geothermal energy, which we will continue to explain.

Keywords: Geothermal Energy, Renewable Energy, Energy Applications, Environment.

1. Introduction

The geothermal energy source is the natural heat of the earth that comes from molten or magma. This energy is generated by radioactive decay of the isotope of potassium and other elements that are dispersed in the earth's crust and also due to the high pressure of the mass. Experience shows that as the depth of the earth increases, the temperature rises to about 3 degrees per degree for every 100 meters. In some areas of the earth's crust, which has favorable conditions, high temperatures can be achieved and used. Extracting heat directly from the planet is not possible. To do this, there must be a conveyor fluid that can be steam or hot water, or both, to bring heat from under the surface of Earth to the surface of Earth, but this heat should be close to it. Usually there are areas where there is a volcano or continuous earthquake that has such features [1, 2].
Exploitation of geothermal energy is simply presented in Fig. 1. The water generated by the earth receives the thermal energy of Earth after penetrating into underground aquifers and flowing into areas with geothermal energy near the surface of Earth. The density of this water decreases after warming and the pressure increases, and in the form of hot water or steam from a pore on the earth's crust, it finds its way to the surface of Earth. These are the hot springs that we see in certain areas of the Earth. In these areas, steam can be extracted industrially from the inside by digging wells with a depth of 80 to 100 kilometers, with a temperature up to 650 to 1200 degrees Celsius and used its thermal energy [3, 4].

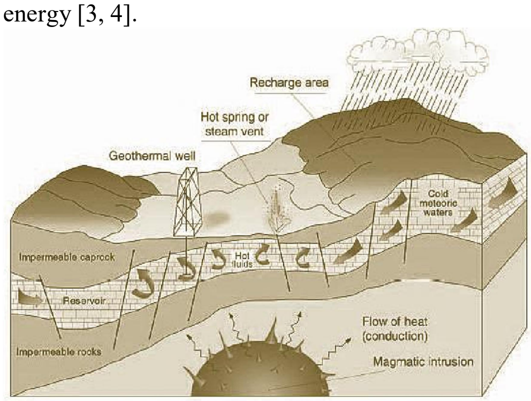

Fig. 1. Simple plan of an ideal geothermal system [5].

As shown in Fig. 1., in order to achieve geothermal energy, the environment must have special geological conditions, and geothermal energy cannot be obtained at any location. Some features of these areas are as follows [6]:
-There is geothermal energy near the penetrating waters to underground aquifers.
-- There is enough water in these areas.
-- Proper vents on the earth's crust for hot water.

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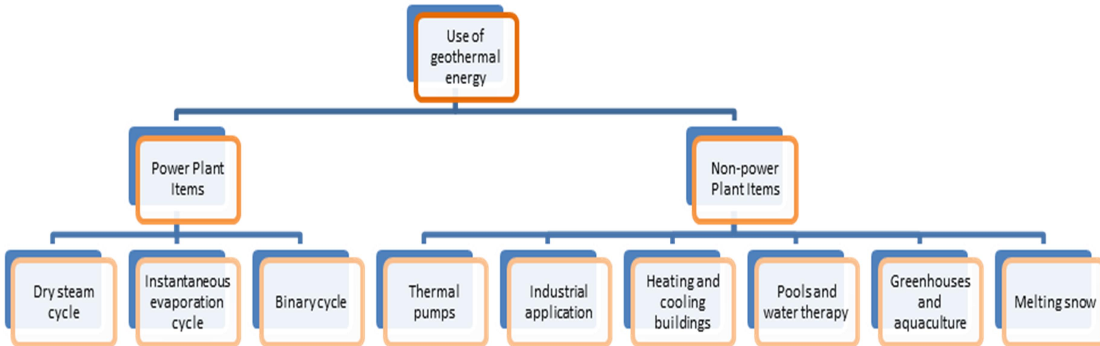

Fig. 2. Use of Geothermal Energy [7].

2.1. Use of Geothermal Power Plants

Most power generation plants rely on fossil fuels, but in a hot-earth geothermal power plant, the outlet from the earth provides the energy needed to generate electricity. The thermal energy of the molten magma in the Earth, in areas close to the crust, creates geothermal potentials [8]. To reach this source, through deep well drilling (about 1500 to 3000 meters), a hot fluid is brought to the surface where the pressure in the reservoir causes the fluid to flow naturally through these wells. On the surface of the earth, the hot fluid is guided through the transfer lines from the well to the separator. In the separator, the pressure suddenly decreases and a large proportion of the high-pressure hot fluid is converted to steam, the steam generated is directed toward the turbine, and the steam-driven force turns the turbine blades In the separator, the pressure suddenly decreases and a large proportion of the high-pressure hot fluid is converted to steam, the steam generated is directed toward the turbine, and the steam-driven force turns the turbine blades and the turbine transmits power directly to the electric generator, and finally the motion of the generator generates electricity which is transmitted by the transmission system to the national network and is used to reach the desired destinations [9].

2.2. Non-Power Plant Uses

Another direct use of geothermal energy is the use of heating and cooling for residential and office space. In this method, instead of using gas or gaseous burners to heat the geothermal fluid in heat exchangers. In this method, instead of using gas or gas burners for heating the geothermal fluid in heat exchangers, and in addition to heating the spaces, it is possible to use a geothermal fluid to provide a spa bath for washing and bathing, which for this type of heat use the fluid should be about 50 to 100 degrees Celsius. It is also used in swimming pools and water treatment centers. In this method, using heat exchangers, geothermal fluid is heated to the pool water and directly used for water treatment. For this type of use, the fluid temperature should be about 30 To 50 degrees Celsius. In other cases, it can be used in greenhouses for the growth of plants, fruits and vegetables [10]. To create such greenhouses, hot water is required at a temperature of about 80120 degrees Celsius. Another use of geothermal waters for breeding aquatic species is from other applications of direct use of geothermal energy, which was used to grow certain fish, and these ponds should be thermal at about 20 to 40 degrees Celsius. Other uses are geothermal waters for melting snow and preventing frost in the passageways. For this purpose, pipes are laid underground (streets and roads), and hot water is transferred to these pipes during the cold seasons and is used for melting snow and preventing frost. The temperature of this water should be about 20 to 50 degrees. We will continue to explain how to use geothermal energy in heating and cooling buildings [11].

3. Use of Geothermal Energy in the Heating and Cooling of Buildings by Thermal Pumps

If we draw the curve of temperature changes in the air and in the depths of the Earth within a year, the depth of the Earth increases, the temperature changes over the year will have less variation. So, from a depth of 3 to 4 meters from the surface of the Earth, changes in temperature and its fluctuations over the course of a year are negligible. This is while the temperature changes in the air are very volatile. This means that the Earth is a good source of heating for the cold months of the year, and its heat can be used to heat the buildings, and it can also be used to provide cooling in the cold months of the year [12]. The technology of thermal pumps is based on the principle that at a depth of 2 to 3 meters of the Earth, its temperature is steady and in winter it is warmer than air and in the summer is colder than ambient air. Geothermal cooling and heating systems consist of heat pumps that collect energy from the underground with the help of energy, and transfer the fluid from the pipes to the unit installed inside the building [13].

This unit absorbs the heat of the inside of the pipes and, by using compression rules, increases the heat and reaches the optimum temperature for heating the building. The heat from the thermal pumps is not generated by combustion, and only heat is transferred from place to place. Also, in summer the warm air inside the building enters the device through a sucker and after cooling it is again blown into the room. Inside the device, the heat is transferred to the refrigerant, and after passing the refrigerant from the respective cycle, the heat contained therein is transmitted by a two-pipe converter into the water inside the ground coil installed inside the polyethylene pipes. The energy efficiency of these systems is 300 to 400 percent (compared to the most modern gas systems with 98 percent efficiency), and for every $ 1 spent on this system, we save $ 3 to $ 4. In fact, a single system works with two heating and cooling systems. Using these systems reduces 66 percent of greenhouse gas emissions and consumes electricity by 75 percent less than traditional heating systems [14].

3.1. Classification Based on Thermal Cycles

Thermal pumps are divided into several types according to the thermal cycles [15]:
- Thermal pump with compression system
- Thermal pump with absorption system

3.1.1. Thermal Pump with Compression System

Most thermal pumps with a compression system are a type of steam pump with a thermal pump system. The main structure of the thermal pump with the vapor compression system is formed as evaporator, condenser, compressor and expansion valve, as shown in (Fig. 3.).

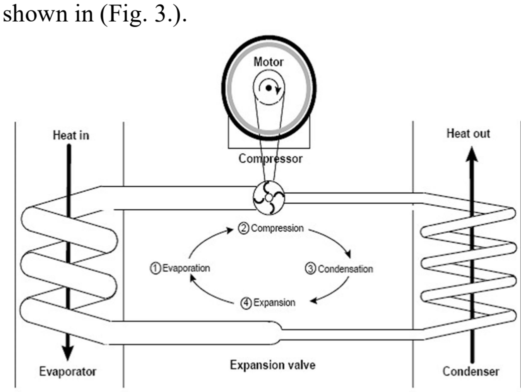

Fig. 3. Thermal pump with steam compression system [16].

In a compressor, the gas refrigerant is condensed and converted to gas at high pressure and temperature. This gas with high pressure and high temperature in the condenser releases heat to the outside and turns into liquid. This liquid high-pressure refrigerant fluid is expanded through the expansion valve and converted to a fluid with low pressure and temperature. This Liquid refrigerant fluid in the evaporator absorbs heat from low ambient air and turns into steam, which results in the possibility of heat transfer from low temperature to high temperature through this cycle [17].

3.1.2. Thermal Pump with Absorption System

The difference in absorption thermal pump with a compression thermal pump, other than the condenser and evaporator, is that the absorption thermal pump has two types of thermal exchanger called the generating and absorbent, which actually do the compressor. The absorption thermal pump is separated into a thermal pump with a first and second type absorption system. Fig. 4. shows the structure of the absorption thermal pump. In the first type, the absorbent material and the refrigerant circulate between the absorber and the generator. In the evaporator, the vapor pressure is reduced by the vapor of the refrigerant and then absorbed into the adsorbent by the liquid and thus the heat is produced. The fluid pressure is increased by the pump and then enters the generator. Within it, the refrigerant inside the liquid is heated up by a thermal source from outside such as the heater, and thus the steam is separated and directed to the condenser [18]. The refrigerant vapor releases heat after distillation. The heat generated in the absorbent is used. The thickened liquid is returned to the adsorbent through the expansion valve. The thermal pump with second-type adsorption system is structurally identical to the first-type, But reverses the flow of fluid, adding lowtemperature heat such as exhaust to the generator and evaporator, Then remove the heat at high temperature from the absorber and form the cycle. In this case, the stimulus energy is only low temperature; the exhaust increases the low temperature with its energy to the high temperature [19].

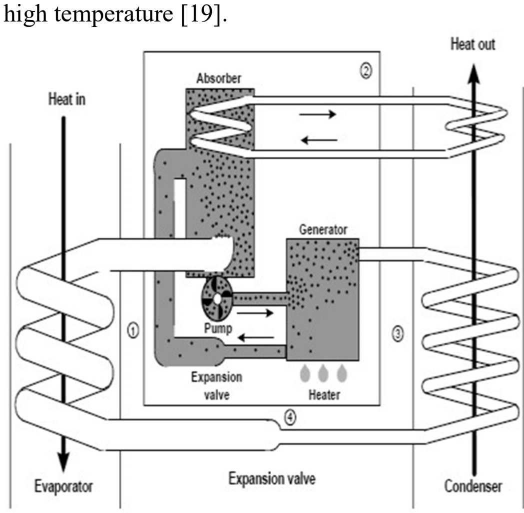

Fig. 4.Thermal pump with absorption system [20].

3.2. Source Classification
3.2.1. Air Thermal Pumps

Thermal pumps are divided into two main types of air and ground thermal pumps, based on the source used for exchanging heat and cold [21].
Air heat pumps, in the winter, receive heat from the outside and release heat in the summer. There are two main types of air heat pumps, the most common type of air-to-air heat pump, which received heat from the air in the winter and it, transmits it to indoor air, and in summer, it transfers heat from the air to the ambient air. The other type is the Air-to-Water heat pump that works in the building, with a radiator or fan coil heating system. In the cold season, the heat pump receives heat from the outside, heating it to the water system. In the heating season, the heat pump transfers heat from the indoor water distribution system to the environment. An air heat pump works in three cycles: the heating cycle, the cooling cycle and the defrost cycle [22].

3.2.1.1. Heating Cycle

In the heating cycle, the heat is taken out of the air, given to the inside. Fig. 5. shows the components of an air heat pump (heating cycle). First, the liquid refrigerant crosses the expansion valve and converts it into a low-pressure steam-liquid mixture. Then the mixture passes through the outer coil (evaporator coil) and gets warm and at low pressure it turns into liquid and vapor. In the accumulator, the two-phase refrigerant fluid section is separated and the steam section is sent to the condenser after compression in the compressor. The heat released from the hot refrigerant in the condenser will heat the home [6].

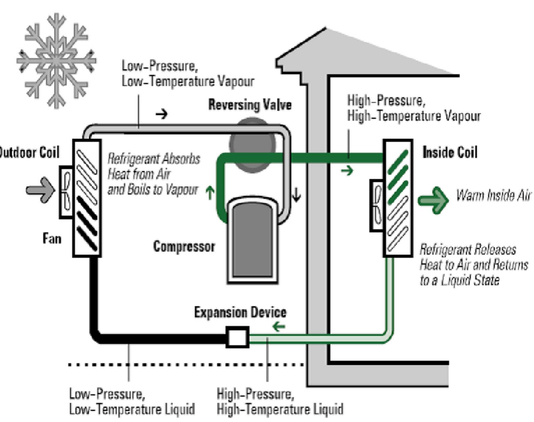

Fig. 5. Components of an air heat pump (heating cycle) [23].

3.2.1.2. Cooling Cycle

To cool in the summer, the heat pump absorbs heat from the indoor air and transfers it to the environment. Fig. 6. shows the components of an air heat pump (cooling cycle).
Similar to the heating cycle, the liquid refrigerant passes through the expansion valve and turns into a liquid mixture - low pressure steam. The refrigerant then goes to the inner coil (acting as the evaporator) and, by absorbing the inside temperature, the refrigerant turns into a low-temperature steam. The inverting valve sends this steam to an accumulator, where the two-phase flow fluid portion is separated and the saturated vapor is compressed in the compressor. Finally, the inverting valve sends the gas that is now warm to an external coil (which acts as a condenser). The heat transferred to the outside air in the condenser causes the refrigerant to become liquid. This fluid returns to the expansion valve and the cycle repeats. During the cooling cycle, the moisture in the air after discharging over the inner coil is distilled and collected in a container below the coil or comes out of the house [6].

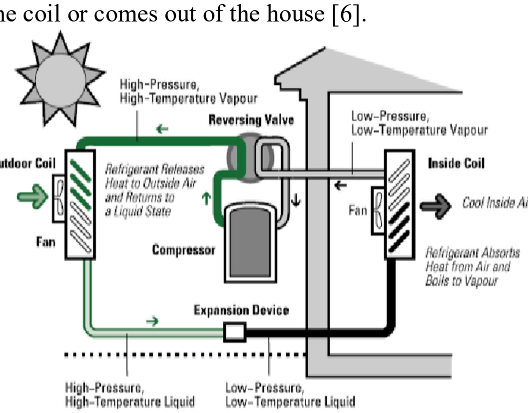

Fig. 6. Components of an air heat pump (cooling cycle) [12].

3.2.1.3. Defrost Cycle

If the outside air temperature, when the heat pump works in the heating mode, reaches near or below the freezing point, the moisture in the air passing through the outer coil is distilled off and formed thrush on the coil. The generated thrush reduces the efficiency of the coil because it reduces heat transfer to the refrigerant [24].
To eliminate thrust, the heat pump must operate in a diffract mode. First, the machine is in cooling mode by reversing valve. This action sends hot gas to melt the thrush, to the outer coil, and the external fan also turns off. In this case, the heat pump returns the cold air to the house. An air heating system is used to heat it before it is spread throughout the house [25].

3.2.2. Heat Pump with Ground Source

The temperature of the earth is almost constant despite ambient air. Ground heat pumps use ground or underground water or both, as a heat source in the winter and as a summer thermal well.
Therefore, ground heat pumps are also referred to as earth energy system (EES). In the winter, heat from

the ground is transmitted to the air through a fluid such as groundwater or a water solution and an antidote by a heat pump. In the summer, on the contrary, this process occurs, that is, heat is taken from the inside air, transferred to the ground by the groundwater or the water solution and antifreeze [26].

Ground heat pumps have two main parts: an underground piping circuit outside the building, and a heat pump unit inside the building. A ground heat pump device is placed inside the building. An outside plumbing system can be an open system or a closed loop. In an open cycle heat pump, heat transfer is made between groundwater and indoor air and this means that groundwater is drained out of the well by a low power pump and then this water is fed into the heat pump with thermal source to provide cooling or heating, For example in a heating mode, well water is introduced into a heat exchanger and its heat is reduced [27].

This water then drains into surface waters such as a river or pond, or flows into another well [28, 29].

In heat pumps with closed systems, heat transfer to the ground is carried out by a plumbing ring buried in the basement and for example, in heating mode, the heat is taken up from a soil by a water solution and antifreeze or refrigerant in a direct expansion system that is cooled by a heat pump refrigeration system several degrees of surrounding soil. Fig. 7. shows the components of a ground heat pump, in accordance with the shape of these pumps, has three major parts: The heat pump, the primary heat exchanger (open loop or closed loop systems), and air transfer systems (piping) or hot and cold water to the room [30].

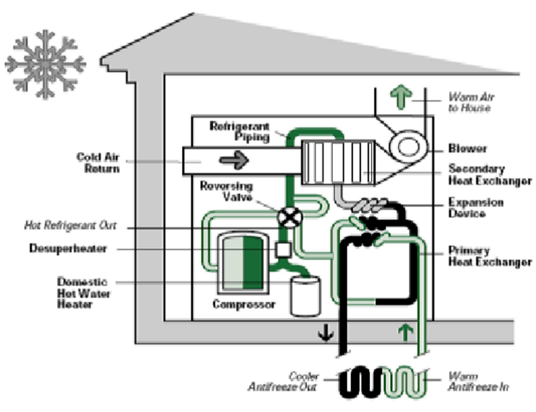

Fig. 7. Components of a ground heat pump [31].

3.2.2.1. Heating Cycle

In the heating cycle, groundwater (in open system) or a mixture of water and antifreeze (in closed systems) or refrigerants circulated through the underground piping system heat from the ground and transfer it into a heat exchanger (evaporator) to the refrigerant during the refrigeration cycle [30]. In, an open system, the water is drained after transferring energy to the refrigerant, into the pond or well. In a closed system, an antifreeze mixture is sent to the underground piping system outside the building to receive heat from the ground.

3.2.2.2. Cooling Cycle

In the cooling cycle, the refrigerant flow is changed by the control valve. The refrigerant takes the heat in the building and transfers it directly to groundwater or a mixture of water and antifreeze, then the heat is transferred to the outside, transferred to a water supply or into the well (in the open system) or to the underground piping system (in the closed system). In some cases, part of this excess heat is also used to preheat the heated water [32, 33]. Unlike air heat pumps, ground-based pumps do not require a diverted cycle. Because the temperature of the earth is much more stable than the air temperature, and the heat pump device is generally located inside the building, so there are no problems with the formation of thrush [26, 30].

3.2.2.3. Types of Ground Thermal Pump Systems

In ground systems, the heat pump is connected to the ground by a plumbing system, causing heat exchange with the ground or water on the ground.

These systems are divided into two major types of open and closed systems. Therefore, unlike air thermal pumps, ground thermal pump systems require a well or a closed loop system to receive or give out heat to the ground [34, 35].

3.2.2.3.1. Open Loop Systems

An open system uses groundwater, for example in a typical well, as a heat source. Therefore, with the help of open systems, a huge source of energy is used. In accordance with Fig. 8.,

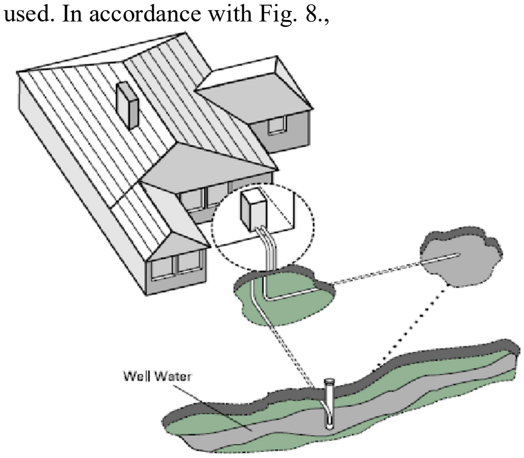

Fig. 8. The thermal pump with open system and groundwater source [33].

which shows the thermal pump with open system and the groundwater source, underground water is sent to the thermal pump to heat it out there, then the water consumed pours into a pond, pit, sewage, river or lake.Of course, this process is usually done in open discharge, which may not be possible in all areas. In open systems, groundwater acts as a source of heat, and is in fact the medium of transferring heat between groundwater and ground. The most important type of open systems is underground wells that receive or transfer water from underground layers [36]. Another method is to drain the water to a secondary well that returns water to the ground, and is called the water return well. A secondary well should accommodate all the water used in the thermal pump. This well is created by a well drill. In most cases, two wells are needed, one for water from the ground and one for water drainage, after use.Systems must be designed to prevent any damage to the environment. A thermal pump that transfers heat to the water does not produce any pollution. The only change that creates a small increase or decrease the water temperature is returned to the environment [37].

3.2.2.3.2. Closed Loop Systems

A closed loop system takes heat from the ground, using a continuous loop of special plastic tubes, located below the soil. While in an open system, water is drained into the well, in the closed system, the operating fluid in the pressurized tubes circulates again. Plumbing takes place in both the main vertical and horizontal modes. Fig. 9. shows the vertical arrangement of the closed loop system; this type of arrangement is more common for urban houses, because there is less space available.

The horizontal arrangement of the closed loop system is shown in the following figure. Horizontal arrangement is most commonly used in places with high space availability. Pipes, depending on their number, are placed in pits typically 1 to 1.8 m in depth. Usually, 100 to 150 meters of pipe is required per tonne of heat pump capacity. The most common form of heat exchanger used in the horizontal system is the two-tube converter, which is located in a pit alongside each other [38-40]. Another heat exchanger used in areas with limited space is a spiral type. In limited space, sometimes four or six pipes per well are also used. In systems that work with an antifreeze solution, plumbing should be at least 100 series of polyethylene or polybutylene pipes. With proper installation, these pipes can be used anywhere from 25 to 75 years. They are also not affected by soil chemistry and have good heat transfer properties [30]. Fig. 10. is a sample of thermal pumps with horizontal systems, a type of direct expansion. The operating fluid of the refrigerant thermal pump is directly circulating in the underground pipes.

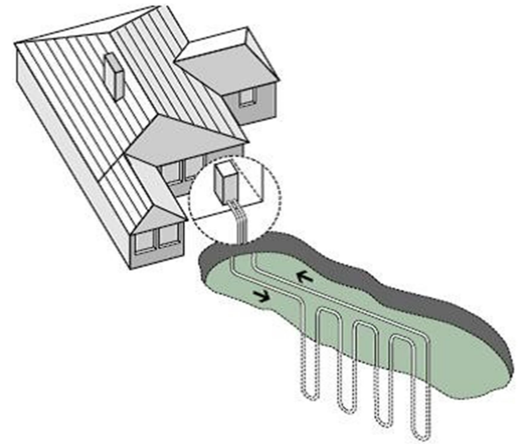

Fig. 9. Vertical arrangement of the closed loop system [41].

In other words, the evaporator of the thermal pump is spreading underground.

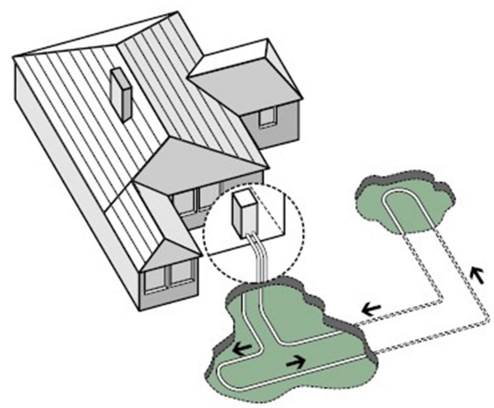

Fig. 10. Horizontal arrangement of closed loop system [38].

3.3. Application of Thermal Pumps

The thermal pump is used in homes, office buildings and commercial buildings, hotels, hospitals, industries, livestock centers, greenhouses, etc., and in different applications, they have a variety of models. Low-power thermal pumps in a range of kilowatts can be used to heat water in domestic use. In this case, especially in the summer, a thermal pump can provide high temperatures efficiently [26]. Thermal pumps with a power range of 12 to 20 KW are used for larger domestic uses, such as warehouses for storing goods and heating water in swimming pools.

Specific uses of thermal pumps include the following [26]:

- There are places where there is a heat source with a very low temperature to use the thermal pump and where there is a demand for thermal energy at the same time.
- In places where there is demand for both heating and cooling, this demand may change seasonally.

- In industrial sectors where there is a large energy stream and can be used by a thermal pump.
- In industrial facilities where there is a large heat production system and the use of a thermal pump can optimize it.

3.4. Geothermal Heating Advantages

When exploring geothermal heating, most homeowners are immediately turned off by the upfront costs. While they are higher than traditional heating, it is quite easy to recoup your costs through energy savings in just a few years' time, depending on utility rates. A geothermal heating system, when professionally installed, provides 30 to 60 percent savings on your heating and 20 to 50 percent on cooling when compared to traditional systems [42]. Other benefits include :
- Renewable energy (A geothermal heat pump utilizes renewable energy from the sun; therefore there are no dangerous emissions.)
- Installation (A geothermal system can be installed in new construction or in retrofit situations.)
- Quiet (The entire system is nearly silent. The interior unit is about as loud as your average refrigerator. The outdoor unit is buried underground, with no compressor or fan, so no noise.)

3.5. Environmental Benefits

One of the most important advantages of using thermal pumps is the reduction of its environmental degradation effects. Considering that the use of systems that use fossil fuels such as natural gas to provide environmental heating is one of the main factors in the production of environmental pollutants. Replacing a variety of new energies instead of fossil fuel systems can significantly reduce greenhouse gas emissions and pollutants [43-45].

4. Conclusions

Unfortunately, with the rapid advancement of human science and technology, attention has not been paid to the consequences of this development and its relationship with energy producers. Therefore, the use of less polluting and renewable energies is very important, in this way, geothermal energy can be considered less polluting than other energy sources. Today, this energy is one of the cleanest energy used either directly or indirectly in the world, it is also a valuable sustainable resource, and it will be an effective solution for heating and cooling systems and its production on a large scale, it can also significantly reduce per capita electricity consumption and help to save electricity in the electricity industry, and, on the other hand, help reduce greenhouse gas emissions and reduce air pollution.

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