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GEOTHERMAL RESOURCES AS ALTERNATIVE ENERGY

Abstract. Necessity of non-renewable energy sources preservation and environmental situation requires using of alternative energy sources. Using of geothermal energy becomes urgent especially for detached modern houses. Thus exactly geographical and climatic conditions define the use different kinds of energy.

Keywords: energy resources, renewable energy sources, geothermal energy, geothermal power station, heat exchanger, alternative energy, sustainable construction

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ГЕОТЕРМАЛЬНЫЕ РЕСУРСЫ КАК АЛЬТЕРНАТИВНАЯ ЭНЕРГЕТИКА

Аннотация. Необходимость сохранения невозобновляемых источников энергии и экологической ситуации требует использования альтернативных источников энергии. Использование геотермальной энергии особенно актуально для отдельно стоящих современных домов. Таким образом, именно географические и климатические условия определяют использование разных видов энергии.

Ключевые слова: энергетические ресурсы, возобновляемые источники энергии, геотермальная энергия, геотермальная электростанция, теплообменник, альтернативная энергетика, устойчивое строительство

Introduction

Humanity came within touching distance of fuel shortage and ecological crippling (global warming, air pollution, water contamination) because of uncontrolled exploitation and wasteful use of exhaustible energy.

Experts predict we will completely use up the reserves of natural energy resources (gas, oil, coal) in the next fifty years.

Nowadays much attention is given to renewable natural resources, for example, geothermal energy resources.

Geothermal energy is heating energy producing from the earth. The research has shown that the temperature at the core of the Earth is 3000–6000 °C. And the temperature is decreasing with distance from the center. Eruptions, earth layer movement and macroseisms indicate an energy action of the Earth. The volume of the planet is about 1085 billion cubic meters and everything except the thin layer of the earth's crust has a very high temperature [1].

The earth emits 42·1012 W of heat, of which 2 % is absorbed in the crust and 98 % — in the mantle and core. Modern technologies do not allow to reach diggings, which is allocated too deeply, but also 840 000 000 000 W (2 %) of available geothermal energy can provide needs of mankind for long time. The use of geothermal energy is only possible in areas of seismic and volcanic activity, because the crust in such areas is much thinner. Now geothermal energy is effectively used by many countries: USA, Italy, Iceland, Mexico, Japan, New Zealand, Russia, Philippines, Hungary, El Salvador. Here the heat rises from the ground to the surface in the form of hot water and steam with temperatures up to 300 °C and often breaks out in the form of geysers, for example, the famous geysers of Yellowstone Park in the United States, geysers of Kamchatka, Iceland [2, 3].

Geothermal energy types

There are several main types of geothermal energy:

- normal surface heat of the Earth at a depth of several tens to hundreds of meters;
- hydrothermal systems, i. e. hot or warm water tanks, in most cases self-draining;
- thermal system — field of steam and water mixture;
- geothermal zone or heat dry rocks;
- magma (heated to 1300 °C molten rocks).

In 2014, the total capacity of geothermal power plants in the world was about 9 million kW, and geothermal heat supply systems was about 20 million kW (heat).

According to the forecasts of the Geothermal power may be about 20 million kW, and electricity generation is 120 billion kW per hour.

There are several ways of producing energy in geothermal power station:

1) Direct circuit: steam is piped to turbines connected to electric generators.
2) Indirect circuit: like the direct one. Difference is cleaning of gases, that cause the distraction of pipes, before entering the system.
3) Combined circuit: like the direct one, but after condensation the water is removed from the non-dissolved gases.
4) Binary circuit: the working medium is not thermal water or steam, but a low boiling point liquid. Thermal water is passed through a heat exchanger where the steam is generated from another liquid used for rotating the turbine [4].

The technology of converting geothermal energy into electricity depends mainly on the parameters of the heating agent. High-energy geothermal water, which ensures the flow of high-pressure steam to the geothermal power plant, makes it possible to direct such a heat conductor directly to the turbine blades. In this case, the generator part of geothermal power plant is not fundamentally different from traditional thermal power plants using hydrocarbon fuel. Mechanical impurities and gases contained in geothermal water or steam are purified by filters and separators. With a significant amount of impurities, which are often aggressive, a two-circuit system with a heat exchanger is used. The secondary circuit contains water chemically treatment and deaeration.

Mutnovskaya geothermal power plant can be an example of such system. It is located 140 km from Petropavlovsk-Kamchatsky at the foot of the active volcano Mutnovsky. Now, it is difficult to imagine that industrial geothermal energy will be able to replace traditional energy sources. First, due to the complexity of deep drilling and the limited thermal zones. Today, there are many other available sources of energy, but geothermal energy has an important place among the various ways to produce electricity and heat. Geothermal energy, based on the distribution of low-temperature sources heat, has great aspects. This type of energy does not require special zones with superheated water or steam. Heat pumps are becoming more and more popular and are actively installed in modern homes (Fig. 1).

Low-temperature heat of the Earth can be used in various types of buildings and structures in different ways: for heating, hot water supply, air conditioning (cooling), heating tracks to prevent icing, heating fields in open stadiums, etc.

Low-temperature energy sources

Buildings at the Central and North European countries, as at the United States and Canada, require heating; air cooling, even in summer, is relatively rare. Therefore, unlike the United States, heat pumps in European countries operate mainly in the heating mode. In the US, heat pumps are more often used in air heating systems combined with ventilation, which allows both heating

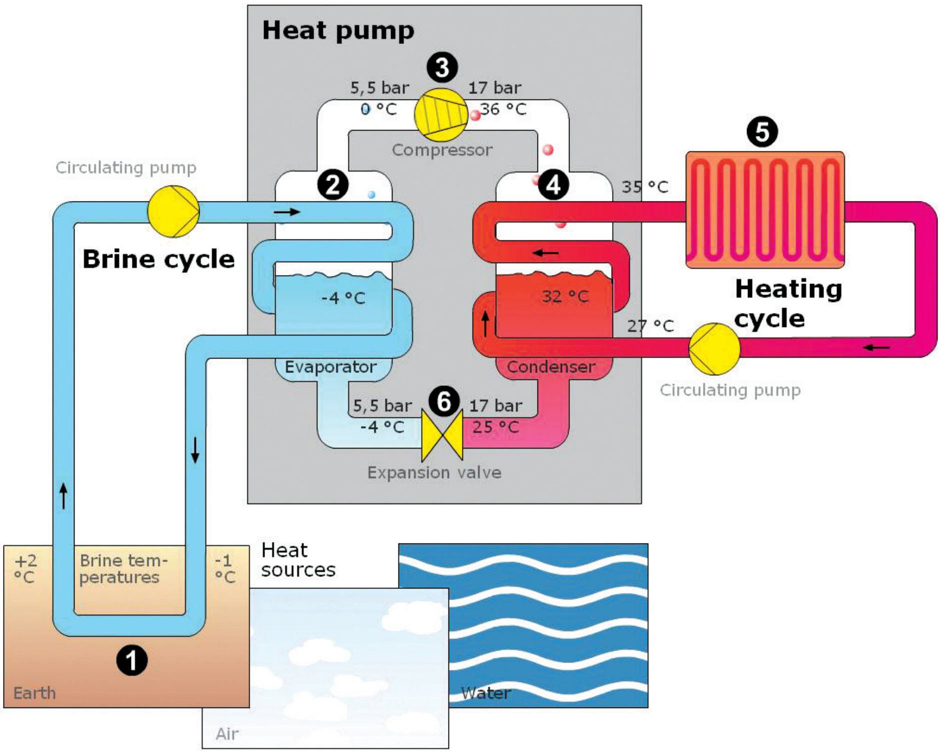

Fig. 1. The layout of heat pump

and cooling the outside air. In European countries heat pumps are usually used in water heating systems. Since the efficiency of heat pumps increases with decreasing temperature difference between the evaporator and the condenser, floor heating systems are often used for heating buildings, in which the coolant circulates relatively low temperature (35–40 °C).

Most heat pumps in Europe, designed to use the low-grade heat of the Earth, are equipped with electrically driven compressors (Fig. 2).

Over the past ten years, the number of heat pumps systems using low-temperature heat from the Earth has increased significantly. The largest number of such systems is used in the United States. A large number of such systems operate in Canada and Central and Northern Europe: Austria, Germany, Sweden and Switzerland.

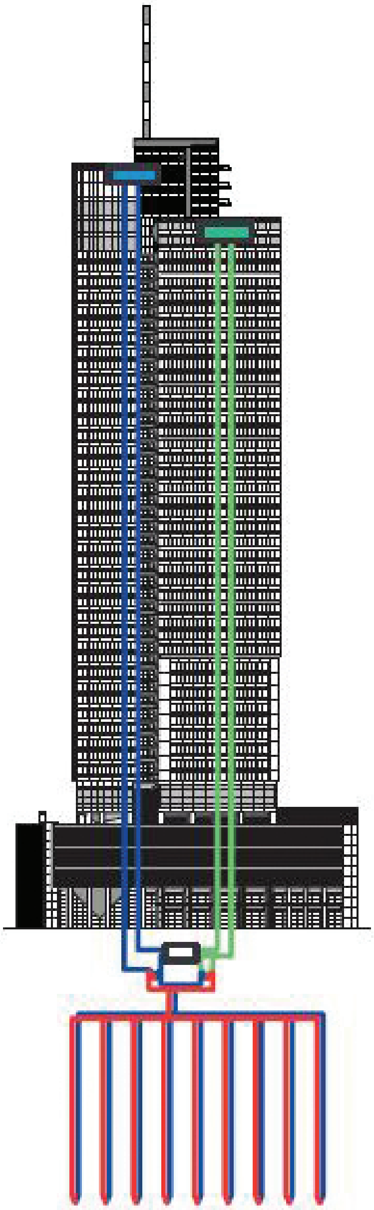

Fig. 2. The heating system of "Main Tower" (Germany)

Switzerland leads in the value of using low-grade thermal energy of the Earth per capita.

As a source of low-temperature heat energy can be used groundwater with a relatively low temperature or soil surface (depth up to 400 m) layers of the Earth. The heat content of the soil mass is generally higher. The thermal regime of the soil of the surface layers of the Earth is formed under the influence of two main factors — the solar radiation falling on the surface and the flow of radiogenic heat from the earth's interior. Seasonal and daily changes in the intensity of solar radiation and the temperature of the outside air cause fluctuations in the temperature of the upper layers of the soil. The depth of penetration of daily fluctuations in the temperature of the outside air and the intensity of the incident solar radiation, depending on the specific soil and climatic conditions, ranges from several tens of centimeters to one and a half meters. The depth of penetration of seasonal fluctuations in the outside air temperature and the intensity of the incident solar radiation does not exceed 15–20 m.

The temperature behaviour of the soil layers located below this depth ("neutral zone") is formed under the influence of thermal energy coming from the earth's interior and practically does not depend on seasonal, and even more daily changes in the parameters of the external climate. As the depth increases, the soil temperature also increases according to the geothermal gradient (approximately 3 °C per 100 m). The magnitude of the flow of radiogenic heat coming from the earth's interior varies for different localities. For Central Europe this value is 0.05– 0.12 W/m^2.

In addition, the temperature schedule of the upper layers of the soil is influenced by the moisture of precipitation and groundwater.

Thus, at a relatively small depth from the surface there are layers of soil, which have the temperature potential in the cold season much higher than the outside air. It cannot but mention that the maximum temperature in the soil observed in the coldest period of the year at some depth from the surface.

Geothermal installation

Thus, geothermal energy is actively developing in its "small" forms. The main element here is the heat pump, which includes two circuits at the same time. The internal circuit is a traditional heating system consisting of a pipeline and radiators.

And external circuit is a large heat exchanger, which is placed under the ground at a shallow depth or under the water. The operating principle of the geothermal installation is that the liquid (which is composed of cold-proof coolant) circulates inside the heat exchanger. Refrigerant is the working substance of the geothermal installation, which in the process of expansion or evaporation takes heat from the cooled object (earth) and then after compression in the compressor transmits it to the cooling medium (heating circuit). In the evaporator, the refrigerant passes into a gaseous state, takes heat from the environment (earth) and cools it. In the condenser, the refrigerant again turns into a liquid state, transferring heat to the house [5].

Consider the types of geothermal installations:

1. Horizontal heat exchanger. This type is often used in houses. In its application, the pipes are placed in specially made stripping lines to a depth slightly higher than the level of freezing of the soil cover. However, this system has one drawback — you need a large area to position the collector. Also, if trees grow on the territory of the house, the equipment must be placed at a distance of 1.5 meters from the plants.
2. Vertical heat exchanger. This mechanism is more compact but is more expensive at the same time. For the equipment of geothermal heating of the house with such device, you do not need a large area, but it is necessary to have equipment for drilling. Since in this case the required depth of the well — from 50 to 200 meters.
3. Water-displaced heat exchanger. This type is the most economical, as it works due to the heat of the water. The system must be installed no further than 100 meters from the pond. The pipeline circuit is laid out on the bottom in the form of a spiral at a depth of 3 meters or less. It is important to note that the area of the reservoir should not be less than 200 square meters.

Installation of geothermal equipment is much more expensive than installation of electric, gas, diesel boiler or Central air conditioning system. However, the heat pump consumes less energy, that is, significantly saves the homeowner money during operation. On 1 kW of the spent electric power the heat pump returns 3–5 kW of thermal energy and it is slightly less in the mode of conditioning [6].

Conclusions

In connection with the exhaustion of traditional energy resources, the question arises about the energy efficiency of facilities, and the use of additional or alternative energy sources. It is necessary to consider the cultural environment, geopolitical and topographic features, geographical and climatic conditions of the regions that determine the use of an alternative energy: solar or geothermal, wind or water energy. Only taking into account all these factors, we can save the exhaustible resources on the planet and come to ecological sustainable construction.

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