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4.3 Prospective directions of the use of geothermal resources in Ukraine

Introduction

In the current economic conditions of Ukraine in order to achieve energy independence it is necessary to actively introduce renewable energy sources and, first of all, geothermal energy resources into the energy cycle.

For the effective development of geothermal resources, we should rely on the previous positive experiences of Ukraine and other countries of the world - the leaders in the development and use of the latest technologies for the extraction and utilization of geothermal energy (USA, Iceland, China, France, Turkey).

The large-scale use of geothermal resources in various countries of the world has led to the sophistication of hydrothermal extraction technologies, the development of new high-performance well designs, the need for forced extraction of geothermal fluid, the stimulation of low-permeability hydrothermal collectors, the widespread implementation of geothermal circulation systems (GCS) and equipment for the efficient extraction of thermal energy from igneous intrusive rocks.

Literary data analysis [135] and previous developments [136], made it possible to adjust the general and technically possible potential of geothermal energy of Ukraine and to determine the most promising directions for the development and implementation of geothermal energy, as well as to establish a list of the most effective modern technologies for achieving a positive result. According to expert assessments, the theoretically possible energy potential of geothermal energy in Ukraine is more than 40 GW in terms of capacity, and the economically feasible potential is about 10 GW [2]. The most promising regions for the development of geothermal energy in Ukraine are Zakarpattia, Prykarpattia, Sumy, Chernihiv, Kherson, Donetsk, Luhansk and Poltava regions.

Objective. The scale of thermal and electrical energy production at a specific deposit depends on many factors, such as the geology of the area, the average annual temperature of the surrounding environment, the flow rate and temperature potential, the quality of the geothermal fluid (mineralization, chemical composition, gas saturation, hardness, acidity and corrosive activity in relation to structural materials). The infrastructure in the area of geothermal heat energy complex construction and the distance to perspective energy consumers are also important. Therefore, taking into account the above, the main direction of application of geothermal energy in Ukraine is small power generation, within which it is possible to create local geothermal energy complexes for the production of electric and thermal energy, the extraction of useful mineral compounds, as well as the use of thermal waters in the social sphere and balneology.

In this case, the main consumer of energy of local geothermal energy complexes will be heat and electricity supply enterprises of housing and communal services, agro-industrial complex and industrial enterprises of local importance.

Figure 1 presents the energy potential of geothermal energy in Ukraine, promising areas of use and the necessary temperature potential of geothermal fluid in various technologies.

At a thermal water temperature of 20°C and above it can be used in combination with heat pumps; at temperatures of 30…50°C – in the underfloor heating system; at a temperature of 55…70 °C – in hot water supply. At a thermal water temperature of more than 80 °C, it is widely used in the agro-industrial complex (dryers, greenhouses). At the temperature of 100…120°C thermal water can be used to produce electricity and obtain artificial cold using absorption chillers.

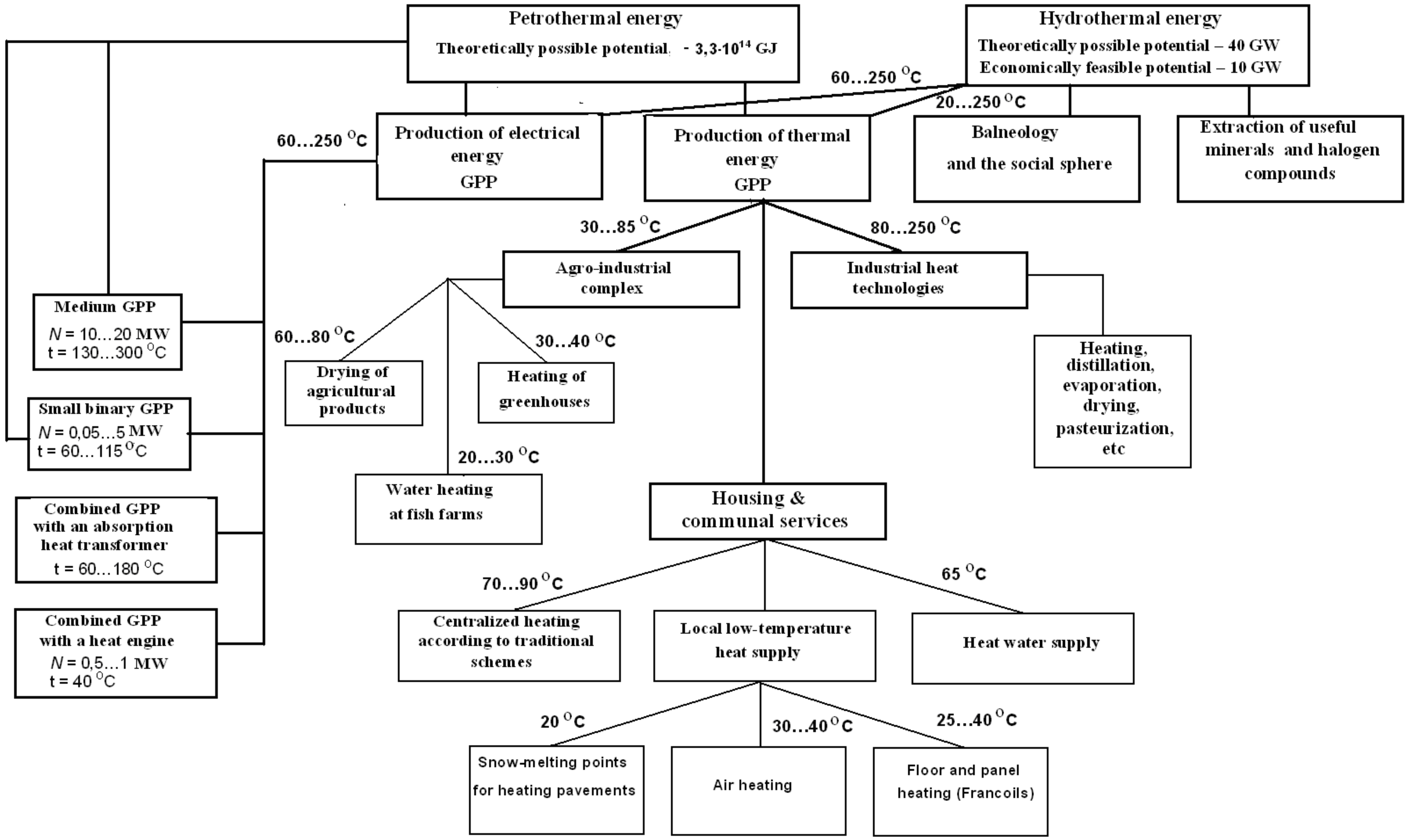

Figure 1. Energy potential of geothermal energy of Ukraine and prospective directions of its use**.**

Methods. In order to determine the areas of priority development of geothermal resources, it is necessary to establish indicators or selection criteria that will allow performing technical and economic calculations, as a result of which the capacity of the geothermal energy complex, the cost of its products and the payback period will be established.

The main criteria for the selection of objects for priority development of geothermal resources, including with the help of inactive wells in oil and gas fields, are:

1. The real scale of reserves of geothermal fluid, its energy potential, thermal energy and physicochemical properties of geothermal fluid, and characteristics of the rocks of the water-bearing horizon, which were determined during experimental pumping of the well. The number and location of inactive and preserved wells.

2. The presence and distance of potential consumers of thermal and electrical energy from the deposit, the scale and technical characteristics of their needs.

3. The possibility of introducing modern technologies for the extraction and utilization of hydrothermal energy and a share of the thermal energy of rocks of the framework of the aquifer at the given deposit, as well as the possible feasibility of extracting combustible gases and hydrocarbon compounds dissolved in the geothermal fluid.

4. Technical condition and construction of wells.

5. List and methodology for determining the technical and economic indicators of the proposed methods and means of extraction and utilization of geothermal energy.

When determining the feasibility of arranging the industrial production of geothermal energy and its use in the electricity and heat supply systems of housing and communal services, the agro-industrial complex or in other areas, it is necessary to identify the list of possible consumers, their distance from the deposit and wells that are expected to be used in the project, as well as the value of the maximum thermal and electrical loads, the temperature schedule, the nature and terms of consumption of thermal loads.

The list of modern technologies, which are successfully used in the world, and which, in our opinion, should be used in Ukraine should include:

- introduction of geothermal circulation systems (GCS) technologies with injection of spent (cooled) geothermal fluid into the aquifer;

- introduction of technologies of two-circuit systems of geothermal energy supply using corrosion-resistant heat exchangers and pre-insulated pipelines made of high-strength composite materials;

- implementation of GCS technologies using downhole coaxial heat exchangers of the "pipe-in-pipe" type;

- development of technologies for the construction of high-throughput wells with horizontal or inclined shafts in the aquifer;

- transfer of a significant number of individual inactive wells of oil and gas fields to the production of geothermal energy with the help of deep coaxial heat exchangers of the "pipe-in-pipe" type and the creation of a circulation circuit with an intermediate coolant;

- implementation of modern binary medium and small power Geoelectric Power Stations based on serial energy modules, for example "Obcom Powerbox", Sweden or "Ormat", Israel and production of such equipment in Ukraine;

- introduction of heat pump technologies to increase the temperature potential of the heat carrier based on vapor compression heat pumps or absorption thermotransformers;

- development and implementation of complex technologies for utilization of geothermal energy and extraction of useful hydro-mineral resources.

Results.

In Ukraine, the vast majority of geothermal resource deposits are highly mineralized, where the content of mineral compounds exceeds 40 g/l, and in the deposits of the Dnipro-Donetsk Basin (DDB) it reaches 150...300 g/l [137]. Considering the ecological aspect, there is no alternative to the introduction of geothermal circulation systems with the injection of spent highly mineralized thermal waters into the aquifer.

Geothermal circulation systems are designed to deliver geothermal fluid from an aquifer to the surface of the earth, extract heat and forcibly return it to the reservoir, i.e. create a closed circulation circuit: aquifer – extraction well – heat exchanger – pump – injection well. The simplest scheme of the GCS is presented in fig. 2.

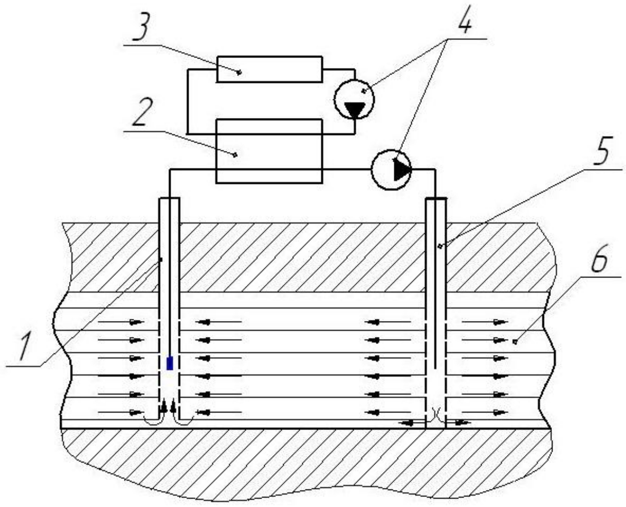

Figure 2. Technological scheme of the circulation system (GCS):
1 – production well with a submerged pump; 2 – geothermal energy heat exchanger;
3 – thermal energy consumer; 4 – circulation pumps;
5 – injection well; 6 – aquifer**.**

Thanks to the organization of such contours, almost all the heat of the geothermal fluid is removed, as well as part of the heat of the earth's interior, which refers to petrothermal energy reserves. In addition, as a result of the circulation of the geothermal fluid in the formation, a constant pressure is maintained, which allows to significantly (by 2.5...3 times) increase the flow rate of the well and, accordingly, the amount of extracted thermal energy [138].

The next step on the way to increase the productivity of geothermal production is the creation of a GCS with several wells that are drilled at a small distance from each other and have an oblique direction of the shaft in the opposite direction with the location of the bottom of the wells in one aquifer, thus increasing the drainage surface of the productive layer, which leads to an increase in the flow rate of the well due to an increase in the area of the active bottom, and a significant reduction in capital costs for the installation of a geothermal heat point. Such systems have a successful history of operation in the geothermal heat supply system of one of the industrial districts of Paris.

The scheme of the GCS with obliquely directed wells is shown in fig. 3.

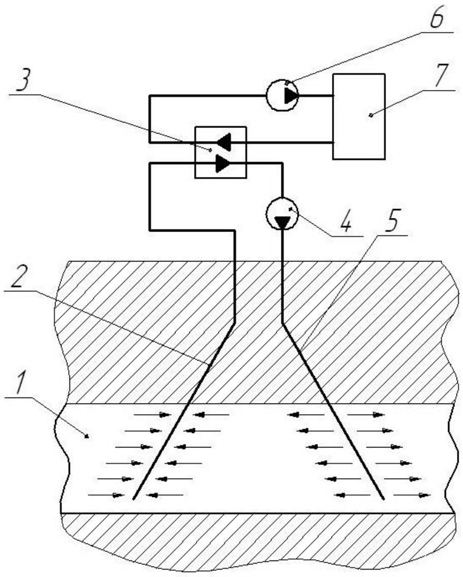

Figure 3. The scheme of the GCS with obliquely directed wells:
1 – productive layer; 2 – production well; 3 – heat exchanger; 4 – GCS pump;
5 – injection well; 6 – circulation pump; 7 – consumer.

It is possible to increase the debits of individual wells by creating a horizontal well shaft along the aquifer. The length of the horizontal shaft can be several hundred meters, which allows you to increase the drainage area tenfold and significantly increase the productivity of the well.

A promising method of improving the technical and economic indicators of geothermal energy production is the technology of double-circuit heat supply with GCS and borehole heat exchangers of the "pipe-in-pipe" type, presented in fig. 4.

Borehole heat exchangers of the "tube-in-tube" type are easy to manufacture, reliable in operation, and the capital costs for their installation do not exceed the costs of shell-and-tube heat exchangers manufacturing. Smaller-diameter wells are lined with a production column of pipes from the wellhead to the bottom. An intermediate column is lowered into the gap between the large-diameter pipes and the operating column, which does not reach the bottom of the heat exchanger. The outer column of heat exchanger pipes simultaneously performs the function of a conductor, which serves to overlap unstable upper rocks.

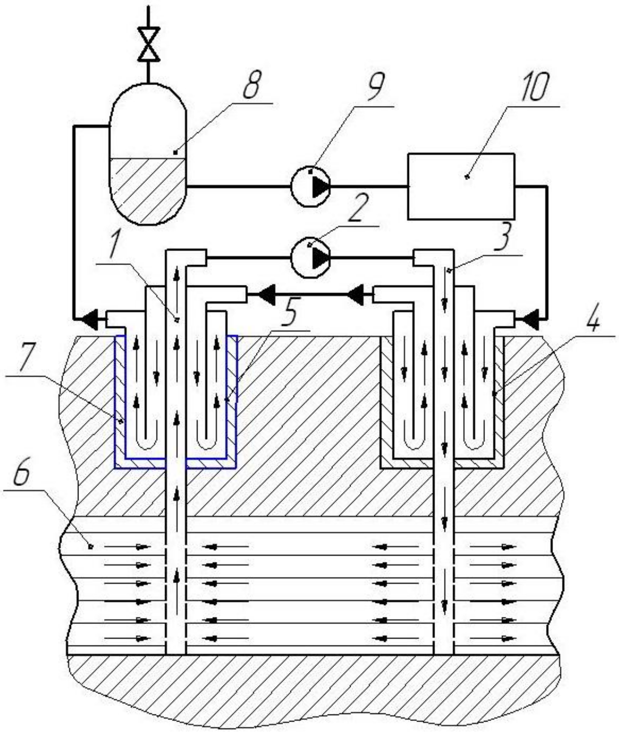

Figure 4. Schematic diagram of a two-circuit system of geothermal heat supply with a closed GCS and internal borehole heat exchangers:
1 – production well; 2 – injection pump; 3 – injection well; 4, 5 – borehole heat exchangers of the "pipe-in-pipe" type; 6 – water-saturated layer;
7 – cementation zone of the annular space;
8 – battery tank; 9 – circulation pump; 10 – consumer**.**

The disadvantages of the above-mentioned technologies are the rather high energy consumption of the process of pumping spent geothermal fluid into the water-saturated layer and a possible drop in the temperature potential of the deposit, the start of which is determined by the thermophysical properties of rocks and the volume of geothermal fluid reserves.

An alternative technology of geothermal energy production is the creation of deep well heat exchangers in individual inactive wells of oil and gas condensate fields. The depth of these wells in Ukraine is in the range of 2...6 km with layer temperature

90…250 °C. The technological scheme of a single-well geothermal heat point with a built-in deep heat exchanger is presented in Fig. 5.

The creation of a deep well heat exchanger involves the installation of an additional central riser pipe in the production column, which does not reach the cemented end of the production column. The intermediate cooled coolant is fed into the intertube space of the coaxial heat exchanger by pump 5. Having reached the lowest point, the coolant enters the lower opening of the riser pipe and rises to the surface due to the thermal lift and circulation pump. Thus, a closed circuit of the intermediate heat carrier is created, circulation in which is carried out with the help of circulation pump 5, the energy consumption for the drive of which should cover only the energy losses due to hydraulic resistance, consisting of hydraulic losses due to the friction of the liquid against the walls of the heat exchanger, local losses when the movement of the heat carrier changes and the hydraulic resistance of the surface heat exchanger 6, which transfers the extracted thermal energy to the consumer.

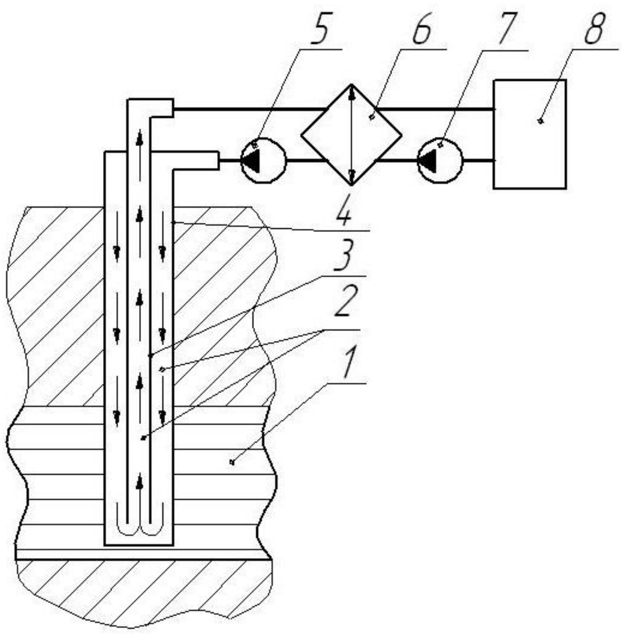

Figure 5. Technological diagram of a single-well geothermal heat point with a built-in deep heat exchanger:
1 – productive layer; 2 – deep heat exchanger; 3 – lifting pipe; 4 – production column; 5 – pump; 6 – heat exchanger;
7 – circulation pump of the heat supply system; 8 – consumer.

The disadvantage of this technology is the lack of circulation of the geothermal fluid in the heat extraction zone, which can lead to a gradual decrease in the temperature of the coolant at the exit from the well. To eliminate this phenomenon, it is necessary to switch to a seasonal period of well operation: autumn-winter - heat consumption; spring-summer is the season of renovation of the temperature of the borehole zone due to the heat of the Earth.

When implementing all the above technologies, modern corrosion-resistant materials should be used for the manufacture of heat exchangers and pipelines from composite materials and modern heat-insulating materials.

In the case when the geothermal fluid has high gas saturation and mineralization, the volumes and list of components of the geothermal fluid to be extracted and disposed of, as well as methods and means of disposal, should be determined based on the actual flow rate of the well. First of all, attention should be paid to the combustible gases extracted from the geothermal fluid when the pressure changes, and useful chemical compounds that can be used in industry.

Conclusions

The subsoil of Ukraine contains large reserves of geothermal energy, distributed over almost its entire territory. Prospective regions for the development of geothermal energy in Ukraine are Zakarpattia, Prykarpattia, Sumy, Chernihiv, Kherson, Donetsk, Luhansk and Poltava regions. According to experts, the possible energy potential of geothermal energy in Ukraine is more than 40 GW in terms of capacity, and the economically feasible potential is about 10 GW.

A significant reserve of geothermal energy production are conserved wells on the territory of gas fields; there are several thousand of them in the territory of Ukraine. Depleted oil and gas fields, even after their complete closure for hydrocarbon extraction, remain an important energy resource, primarily for the regions where they are located, and when developing state policy and relevant measures at the state level, and a resource for the entire fuel and energy complex of Ukraine.