GEOTHERMAL ENERGY IN ROMANIA : AN UNCONVENTIONAL, CLEAN AND RENEWABLE ENERGY SOURCE

ENERGIA GEOTERMALĂ ÎN ROMÂNIA: O SURSĂ DE ENERGIE NECONVENȚIONALĂ, CURATĂ ȘI REGENERABILĂ

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Abstract: *Geothermal energy is thermal energy generated and stored in the Earth. Water and/or steam carry the geothermal energy to the Earth's surface. Temperature variability in the depth of the earth's crust is known as the geothermal gradient. The natural heat of the Earth's core is due to the various physical and chemical processes that occur inside. Depending on its characteristics, geothermal energy can be used for heating and cooling purposes or be harnessed to generate clean electricity.*

Keywords: The Earth, geothermal energy, geothermal gradient, thermal energy, clean and renewable resource.

Rezumat: *Energia geotermală este energia termică generată și stocată în Pământ. Apa și / sau aburul transportă energia geotermală la suprafața Pământului. Variabilitatea temperaturii în ceea ce privește adâncimea scoarței terestre este cunoscută sub numele de gradient geotermic. Căldura naturală a miezului Pământului se datorează diferitelor procese fizice și chimice care apar în interior.În funcție de caracteristicile sale, energia geotermală poate fi utilizată în scopuri de încălzire și răcire sau poate fi valorificată pentru a genera electricitate curată.*

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Cuvinte cheie: Pământ, energia geotermală, gradientul geotermic, energia termică, resursă curată și regenerabilă.

1. Introduction

Geothermal resources lie in abundance beneath our feet, waiting to be exploited. At present, geothermal energy is a practically inexhaustible energy source and, until now, it has not been sufficiently studied and exploited.

The paper aims to highlight the possibilities of harnessing the geothermal energy potential in the development of the country (geothermal projects offer all the benefits to contribute, without pollution, to the development of the country; facilities in remote locations can exceed quality standards of life, bringing distance electricity in people's homes).

Drilling of geothermal wells is a complex of works for crossing, consolidating and isolating the rocks crossed.

The purpose of geothermal drilling works is to make boreholes in which ground geothermal wells can be placed, which can capture the energy of the earth, later distributing it further to the heating system. These works are performed with the help of special drilling rigs for geothermal wells.

The directional drilling of the wells, *-in a direction other than the vertical one-*, is imposed by certain surface conditions or certain technical-economic conditions. [1], [2], [3], [4]

2. General aspects [1]

Geothermal energy is a form of renewable energy obtained from the heat inside the Earth. The Earth's temperature rises considerably as it approaches its center (see Figure 1).

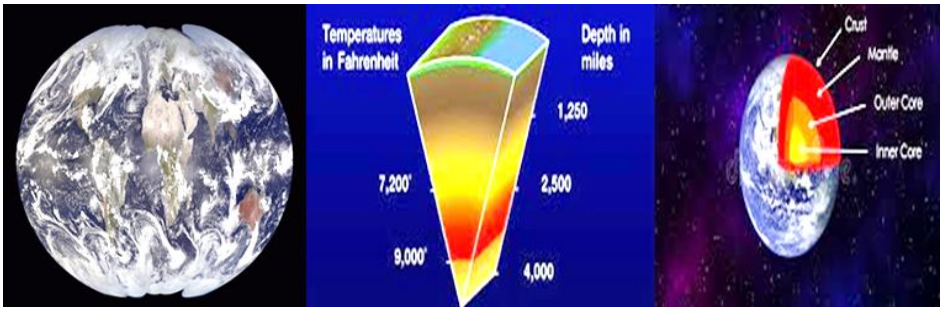

Figure 1. TERRA (*temperature and energy inside the Earth*) [1].

It is known that the core of our planet is incredibly hot, according to the latest research it is estimated that the temperature exceeds 5,000° C, obviously, the earth's temperature varies greatly, and geothermal energy is usable for a wide range of temperatures (from room temperature to over 300° F ≅ 150° C). [1]

The high temperature at the center of the Earth is explained by the origin of the Earth, by the existence of radioactive isotopes of uranium (^{238}U), thorium (^{232}Th) and potassium (^{40}K) in the Earth (see Figure 2).

The term geothermal comes from the Greek word geothermal, derived from *"Geos (γη)" = earth and "thermos (θερμος)" = heat*, so geothermal energy involves the exploitation of heat inside the earth.

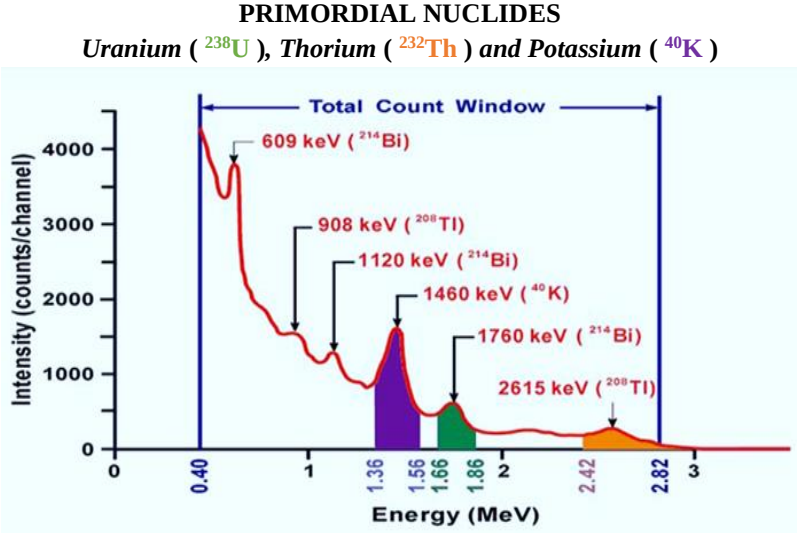

Figure 2. Typical Gamma - Ray Spectrum [1], [12].

Experimentally, with the help of the MAESTRO program and in accordance with the reference standards IAEA 312 and IAEA 375, the researchers analyzed the peaks corresponding to gamma energies, obtaining the following values: 609 keV, 1120 keV and 1760 keV for ^{214}Bi; 908 keV and 2615 keV for ^{208}Ti and 1460 keV for ^{40}K.

Geothermal energy is the heat accumulated in rocks and in the fluids that fill their pores.

Geothermal energy exists in different forms all over the Earth (by steam vents, lava, geysers, or simply dry heat), and there are different possibilities for extracting and using this heat (for example, in Iceland,

almost 90% of the country's people use geothermal heating resources. Iceland also relies on its natural geysers to melt snow, warm fisheries, and heat greenhouses). [1]

3. The geothermal energy potential on the Romanian territory

Theoretically, Romania has a remarkable potential in terms of geothermal energy, being considered the third country in Europe, after Greece and Italy.

Figure 3 represents the map with the temperature distribution on the Romanian territory. The map illustrates the areas with geothermal potential of Romania at a depth of 3,000 m. [1], [3]

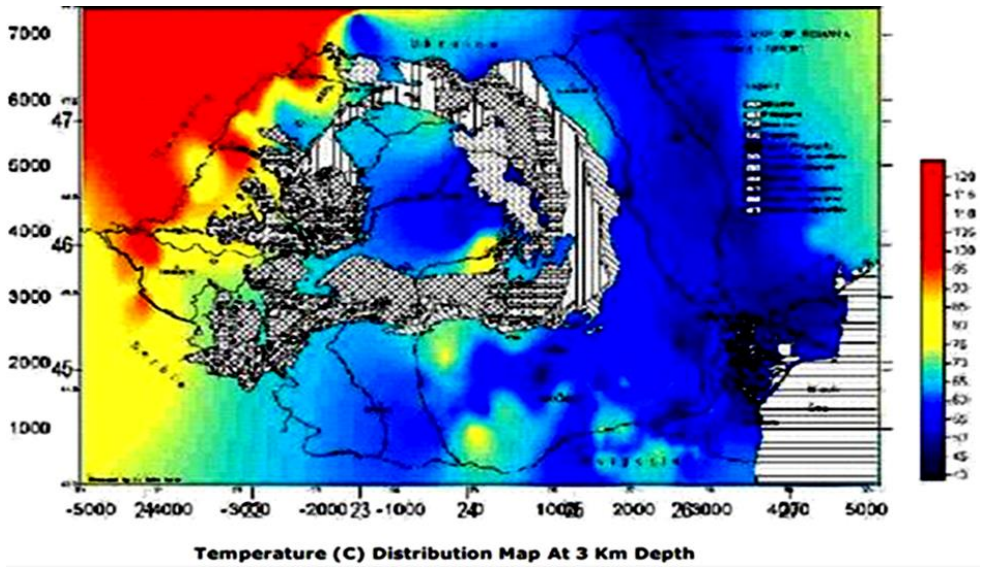

Figure 3. Areas with geothermal potential of Romania at a depth of 3,000 m, after to the EBRD study [1], [12].

On the Romanian territory, in most drillings performed for hydrocarbons, low and medium enthalpy geothermal resources were found at depths between 800 m and 2,500 m with temperatures between 40 ÷ 120ºC.

Experimental exploitation of approx. 100 drillings, in the last 25 years, allowed the realization of some evaluations of the energetic potential of this type of resource (see Figure 4).

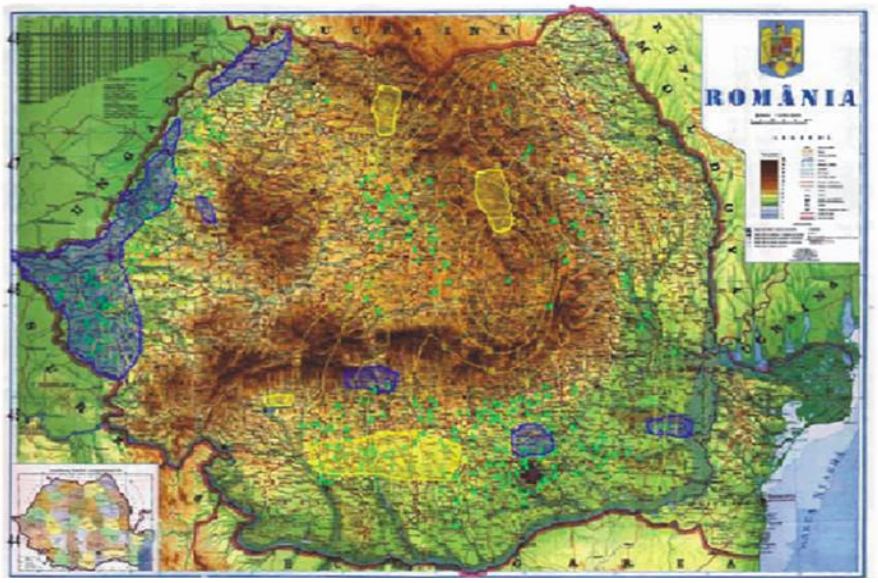

Figure 4. Map with favorable areas for the concentration of geothermal resources in Romania [1], [12].

Observations:

1) Geothermal source, by point of view economically, it must be accessible by drilling to depths not exceeding 3,000 m (under favorable conditions this depth can increase up to 6,000 m);

2) The geothermal source must have a sufficiently high potential (both quantitative and qualitative) to result in its exploitation in advantageous economic conditions. [1]

Table 1 and Figure 5 show the main areas with geothermal energy potential in Romania. [1]

Table 1. **The main deposits with geothermal energy potential in Romania [1]**

Deposit area	Surface [km^2]	Depth [km]	Drilled wells	Use wells	Temperature [°C]	Flow wells [l/s]	Installed power [MW]
Oradea	75	2,2 ÷ 3,2	14	12	70 ÷ 105	4 ÷ 20	58
Bors	12	2,4 ÷ 2,8	6	5	115	10 ÷ 15	25
Campia de Vest	2,5	0,8 ÷ 2,1	88	37	50 ÷ 85	4 ÷ 18	210
Valea Oltului	28	2,1 ÷ 2,4	3	2	92 ÷ 96	12 ÷ 25	18
Otopeni	300	1,9 ÷ 2,6	11	5	58 ÷ 75	22 ÷ 28	32

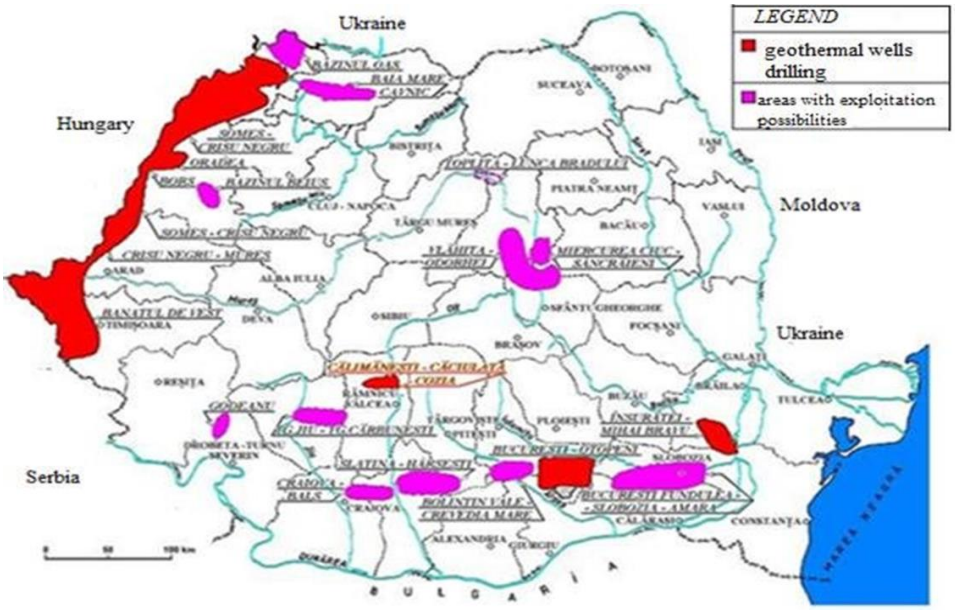

Figure 5. The main areas with geothermal energy potential in Romania [12].

4. Drilling of geothermal wells

Drilling of geothermal wells is a complex of works for crossing, consolidating and isolating the rocks crossed. [1]

The purpose of geothermal drilling works is to make boreholes in which ground geothermal wells can be placed, which can capture the energy of the earth, later distributing it further to the heating system. These works are performed with the help of special drilling rigs for geothermal wells.

The directional drilling of the wells, *-in a direction other than the vertical one-*, is imposed by certain surface conditions or certain technical-economic conditions (see Figure 6). [4]

A geothermal exploitation requires two wells (see Figure 6.1):

1) one of production, which allows the extraction of hot water and,

2) one an injection, which allows the reinjection of cold (used) water into the layer.

The second borehole must be drilled so that its extremity is placed at an optimal distance from the first borehole, in order to avoid a too rapid drop in the temperature of the exploited water. [1]

The practical realization of this system consists in drilling two boreholes.

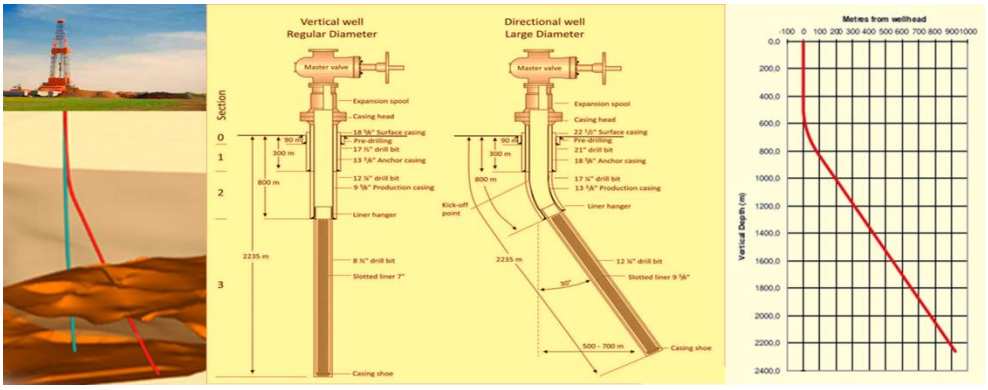

Figure 6. Drilling of geothermal wells [4] [5].

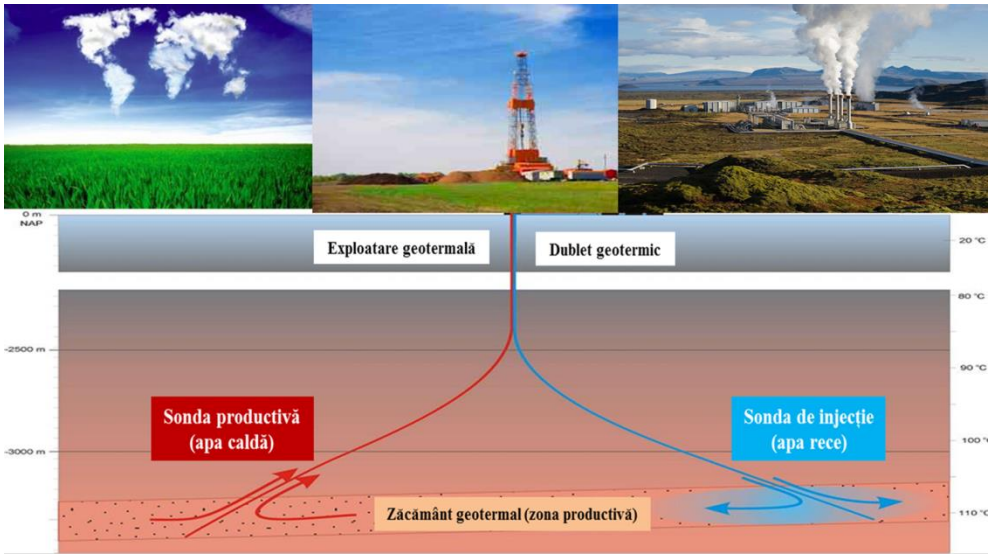

Figure 6.1. Drilling and exploitation of geothermal wells [1].

In principle, the geothermal energy from the earth is extracted with the help of the productive probe, from the established depth (depending on the heat demand and the existing geological conditions).

The natural heat of the earth is extracted at the surface of the productive well, then taken over by a system of local pipes through which the thermal water or special thermal agent circulates (for example: water + antifreeze) and transported to the main pipe system for heating and / or air conditioning of production spaces, offices and private homes with the help of heat pumps. [7] [8]

4.1. Factors in the Cost of Geothermal Wells

There are four factors common to geothermal drilling that result in increased cost when compared to oil and gas drilling. These four factors are lost circulation, high temperature, hard rock, and corrosive fluid.

A complete program to reduce the cost of drilling should contain elements targeted at reducing costs and problems in each of these areas.

If we define drilling problems as being only those situations or events that require interruptions in the normal drilling and completion processes; then, of the four factors listed the previous, only lost circulation is a drilling problem. [1], [6]

Other examples of drilling problems are well kicks or blowouts, stuck pipe, broken or twisted drill strings, materials or tools lost in the hole, incomplete cementing, and unusual bit wear resulting in under-gauge cutting or premature failure. The primary figure of merit for any tools or procedures developed to attack drilling problems is the time necessary to return to normal drilling and completion processes. [1], [2]

The high temperatures encountered in geothermal wells directly affect instrumentation and testing capabilities. Long term flow and draw-down tests, common in oil and gas wells, cannot be conducted with down-hole instrumentation in geothermal wells due to the inability of electronic instruments to withstand the temperatures. The resultant lack of long-term pressure, temperature, and flow data from geothermal wells limits our knowledge of geothermal reservoirs and restricts our ability to predict reservoir behavior. Because of the inability to operate at high temperature, bond logs and cement evaluation tools can be run only after cooling the well, with the resultant dangers associated with thermal cycling. Instrumentation developed to operate for longer periods at higher temperatures could alleviate these shortcomings. [4], [6]

High temperatures cause changes in fluid properties. The ability of the drilling fluid to remove cuttings, control formation fluids, and stabilize the well bore is decreased at elevated temperatures. Also, cementing problems are encountered at high temperatures. Not only are retardants necessary to prevent premature setting, but special additives must also be employed to prevent the cement slurry from dehydrating at high temperature. [1], [2], [10]

The hard, abrasive rock encountered in geothermal drilling causes accelerated wear on bits and drill string components due to both the increased

abrasiveness of the rock itself and to the increased forces necessary to cut the rock.

5. Use of geothermal resources

The use of geothermal energy depends on the thermal parameters of the resource. For resources with geothermal fluids exceeding 150 ° C they can be used for electricity production, being fully technically and economically justified (the current minimum threshold for electricity production is 97 ° C). Below this temperature, geothermal energy is used in direct processing technologies, most of which are built as cascade systems (see Figure 7). [1]

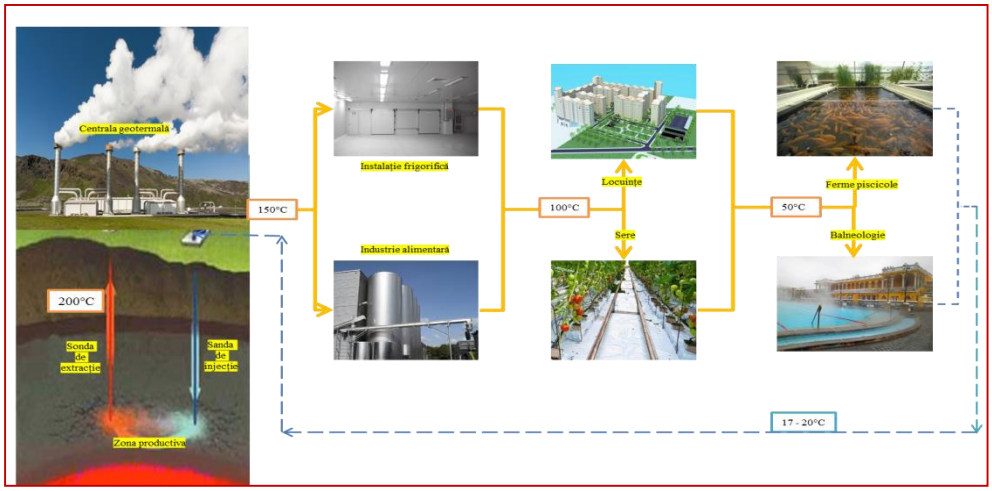

Figure 7. Use of geothermal energy in the waterfall system [1].

A wide efficient use of geothermal energy, in cascade system, can be in [1]:

– Industry (*heating*, *drying*) at a temperature of 100 - 90° C;

– District heating (*heating homes*, *hospitals*, *institutions etc*.), at a temperature of 90 - 60° C;

– Agriculture (*greenhouses*, *heating crops*), at a temperature of 70 - 60° C;

– Hot water preparation (*fish farms*, *balneology*, *housekeeping*) temperatures below 60° C.

5.1. Advantages and Disadvantages to using geothermal energy

Advantages [1], [9], [11]

There are many advantages to using geothermal energy either directly or indirectly:

– Geothermal energy is renewable; it is not a fossil fuel that will be eventually used up. The Earth is continuously radiating heat out from its core, and will continue to do so for billions of years;

– Some form of geothermal energy can be accessed and harvested anywhere in the world;

– Using geothermal energy is relatively clean. Most systems only emit water vapor, although some emit very small amounts of sulfur dioxide, nitrous oxides, and particulates;

– Geothermal power plants can last for decades and possibly centuries. If a reservoir is managed properly, the amount of extracted energy can be balanced with the rock's rate of renewing its heat;

– Unlike other renewable energy sources, geothermal systems are "baseload." This means they can work in the summer or winter, and are not dependent on changing factors such as the presence of wind or sun. Geothermal power plants produce electricity or heat 24 hours a day, 7 days a week;

– The space it takes to build a geothermal facility is much more compact than other power plants (for example, wind energy or a solar photovoltaic center);

– Geothermal energy systems are adaptable to many different conditions. They can be used to heat, cool, or power individual homes, whole districts, or industrial processes;

Disadvantages [1], [5], [9], [11]

Harvesting geothermal energy still poses many challenges:

– The process of injecting high-pressure streams of water into the Earth can result in minor seismic activity, or small earthquakes;

– Water that flows through underground reservoirs can pick up trace amounts of toxic elements such as arsenic, mercury, and selenium. These harmful substances can be leaked to water sources if the geothermal system is not properly insulated.

6. Conclusions

This article highlights aspects regarding the **geothermal energy** on the Romanian territory, - ***an unconventional, clean and renewable energy source*** -, with special emphasis on drilling geothermal wells.

The Earth has been emitting heat for about 4.5 billion years, and will continue to emit heat for billions of years into the future because of the ongoing radioactive decay in the Earth's core. So, Geothermal energy is a renewable resource.

Geothermal energy is one of the alternatives that can meet human need for energy, minimizing the impact on the environment.

The resulting pollution level is very low, - it tends to zero - and by using this form of alternative energy in the future we can give up other more polluting forms of energy.

Geothermal energy, at national level, in addition to being a clean and beneficial energy source for the population, is expected to be exploited to its full potential.

Consequently, Romania has a remarkable potential in terms of geothermal energy, being considered the third country in Europe. Unfortunately, the degree of capitalization of energy sources of geothermal origin is low, - *today, only a small part of the geothermal potential is used (greenhouses, balneology and leisure)* -, the main cause being determined by the lack of adequate financial support, which does not favors the development of this energy sector with superior economic and financial effects. [1]

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