Alternative energy source from Earth's core, combined accumulation of solar energy – downhole heat exchangers with heat pump

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***Abstract*—The article offers new technical solutions for solar energy accumulation around the vertical downhole heat exchangers (DHE) in the surface of Earth's crust (depth of up to 100 m). In order for the Vertical DHEs to be more efficient and reach surplus thermal energy from the Earth's core in greater quantities, its length should be from 300 to 400 m instead of 120 m. These measures could fully support heat pumps and improve their coefficient of performance (COP) with an excellent value far above 6. Thus granting a rational solution in using a completely renewable ecological energy source and can be applied on bigger scale for heating and cooling large industrial facilities, resorts and even major cities. Dangerous energy sources like nuclear power and fossil fuels can absolutely be avoided from being use. Furthermore, implementing these solutions is exceedingly important reason as to avoid volcanic eruptions, tectonic plate shifts, earthquakes and ravaging tsunamis by reaching and intensively using the so-called "surplus" power of the thermal energy of the Earth's core.**

I. Introduction

At the beginning of twentieth century, heat pumps have been developed as a technical solution and since then they are in use only individually but never for the whole village or town. Presently, heat pumps had been improved with a coefficient of performance (COP) of even more than 5.

The principle of heat pump consists in the fact that they absorb thermal energy from one place and transfer to another (Fig.1). The thermal energy is taken from the ground (Earth's crust) thus use mostly the downhole heat exchangers (DHE) that is a few tens of meters deep (60-120 m). Another way to use thermal heat from the ground is by burying pipes or from the water in the streams, lakes and the sea. Groundwater-source heat pumps are not environment - friendly and are rarely practiced in EU as well as other developed countries. [6], [7]

Heat pumps are the perfect technical solution, but the quality of thermal energy exploited from the ground thru heat exchangers is a big problem that needs yet to be improved.[2] The difficulty restricts the possibility to use heat pumps for even a small community with less than 10,000 inhabitants.

Earth's crust is composed of materials like clay, stone, sand, water, with their own thermodynamic parameters with different coefficient of thermal conductivity k (Table I.).The overall heat transfer coefficient U (W/m^{2}K) depends on coefficient of thermal conductivity k (W/mK):

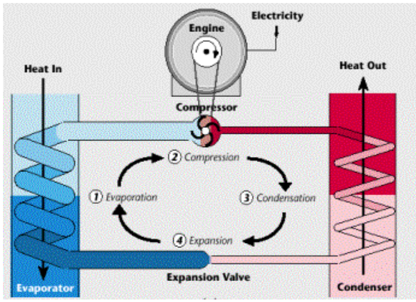

Figure 1. The operating principle of the heat pumps [8]

$$k = \frac{\Delta Q}{\Delta t}\frac{1}{A}\frac{d}{\Delta T}, \qquad (1)$$

where:

$\Delta Q/\Delta t$ - rate of heat flow

A - total cross sectional area of conducting surface,

ΔT - temperature difference,

d - thickness of conducting surface separating the two temperatures.

$$U = \frac{1}{\frac{d}{k}}. \qquad (2)$$

Since d is the thickness of the layers of soil around the heat exchangers, the expression for the overall heat transfer coefficient U takes on a very small value:

$$d \to \infty \Rightarrow U \to 0. \qquad (3)$$

Practically this means a large heat transmission resistance R (m^{2}K/W) from the surrounding soil to the heat exchangers.

$$R = \frac{d}{kA} \qquad (3)$$

TABLE I.
THE AVERAGE VALUE OF THERMAL CONDUCTIVITY COEFFICIENT FOR MOST FREQUENT MATERIALS IN THE EARTH´S CRUST

Components	Material			
	Clay	Sand	Stone	Water
Coefficient of thermal conductivity (k)	0,8 - 1,3	0,58 - 1,3	1,2 - 3,3	0,83

Based on the thermal conductivity coefficient (k) values for the materials in the Earth's crust, in Table I., it can be concluded that these values are not high and these materials in the Earth's crust – in which immersed the heat exchangers of the heat pump – are heat insulating barrier for the thermal energy of the surrounding environment.

Exploiting the heat from the earth is a particular problem as the geometrical characteristics of DHEs are thin in cross section with a small surface area and are practically one line in the longitudinal section. In recent time DHEs are typically made from materials that are polymer based for better corrosion resistance plus with lower value of thermal conductivity coefficient *k* and with meager heat conduction.

Thus, during function it often happens that the heat in the ground around the DHEs is not completely recovered. As a result, in this zone, the temperature falls down, which also means a decrease in heat capacity of the heat exchangers (Fig. 2). After a few years it is possible for the DHEs to malfunction.

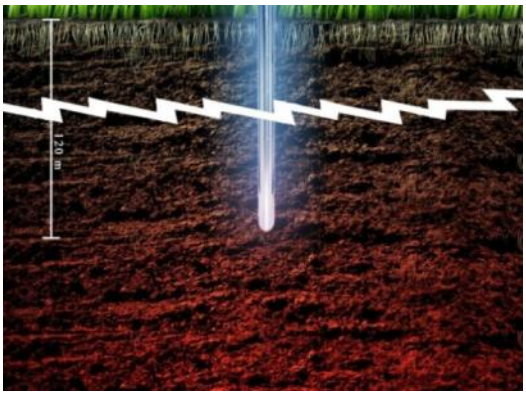

Figure 2. Cooling of the Earth around the heat exchangers

An event from Sweden is a proof in where the temperature of the soil in the early period of utilization was +8 ºC. [3] After twenty seven years of exploitation, a decrease in heat from +8 ºC to +1 ºC was noticed. Every year, due to the inactiveness of the ground, through the insulating properties of the earth manifested by the thermodynamic coefficient of thermal conductivity (k) and the dense installation of DHE, the heat was not restored completely to its previous degree after the heating season. Thus, a fall in the temperature of the Earth of only 0,26 ºC was noticed each year and increased to 7 ºC after 27 years.

Another practical evidence for this claim of heat energy accumulation is the possibility in the earth is from distant history. Romans were digging combustion furnace into the ground to a depth of several meters and hot air from the furnace passes through enclosed areas under floor and inside the walls, after flowed out in the roof – a system known as "hypocaust". At start they had higher heat energy losses, then later on when the heat were already accumulated around the fireplace, with a significantly lesser fuel they could hold the temperature inside the rooms, and afterwards it would be needed in the case when the furnace and the air-flow channels would not be buried. (Fig. 3).

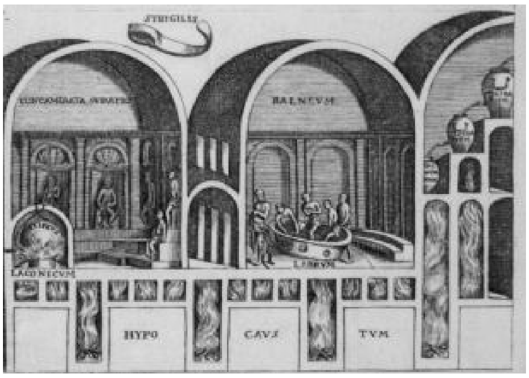

Figure 3. Way of heating at the time of ancient Rome with the aim of accumulation of heat in the ground around the furnace[11]

All of this clearly indicates that the DHEs depth of heat pumps have a number of deficiencies that must be improved so that the solution could be applicable not only individually but also for the largest cities in the world with millions of inhabitants:

1) DHEs length of 120 m is not enough – but rather should be at least 300 m length to be able to take excess energy from the Earth's core.

2) Around DHEs in the surface area of Earth's crust (to depths of 100 m), solar energy should be accumulated using solar collectors.

3) The heat exchangers should be made of metal or a material with a dominant share of metal content in the volume to achieve higher value of coefficient of thermal conductivity (k) and enhanced overall heat transfer coefficient (U)

4) Cementing the boreholes around the DHEs should be done with materials that are hygroscopic and using water (moisture) heat exchange would be faster

II. A NEW TYPE OF DHES AS PASSABLY SUPPORTING SOLUTION FOR EXPLOITATION OF THERMAL HEAT WITH HEAT PUMPS

Earth's core temperature is between 4000 and 7000 ^{0}C. Such high temperature is the result of thermonuclear processes initiated during the formation of the Earth itself. Controlled drawing of energy from the Earth's crust could give positive effects as more energy is produce than is released by layers to the surface in the Earth's core. Preventing the release of heat energy from Earth's core creates more pressure inside itself. That pressure is transmitted on the layers around the core, which starts to tighten and that time comes to form new cracks, usually at the place of old ones. This particularly occurs in zones of tectonic disturbances, which are described as movements of tectonic plates. (Fig. 4).

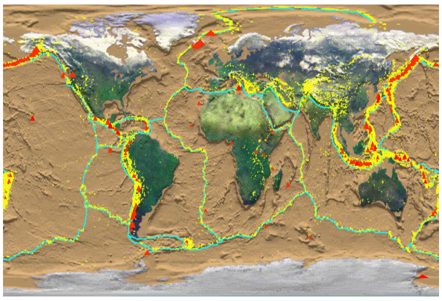

Figure 4. Tectonic plates with fault lines and areas with frequent occurrences of volcanoes and related phenomena - earthquakes and tsunamis [9]

Movements of tectonic plates usually occur because of the existence of volcanoes on the seabed. Another way of releasing energy and pressure within the Earth's core are volcanic eruptions that occur on land. In both cases, especially if we have volcanoes in the sea, a devastating earthquake can evoke tsunamis (Fig. 5). Earth itself naturally regulates the pressure and temperature inside its core. Volcanoes and tectonic plate movements are "safety valves" that Earth itself conditions. Unfortunately, catastrophic consequence happens to humanity itself. If this is true, and the physical logic suggests that it is, then people with artificial interventions should seek solutions in the sense to consume excessive heat from the Earth's core and thus reduce the internal pressure around the core. This would avoid the catastrophic consequences of earthquakes, volcanoes, tsunamis, and at the same time humanity would get the much needed natural renewable energy without burning fossil fuels and CO_2 emissions.

Instead of 120 m, the DHEs should have a length of 300 to 400 m, so that besides the use of solar energy in the upper part (up to 100 m depth), the thermal energy from the Earth's crust can be used more rigorously at the bottom of DHE. The depth from 300 to 400 m, the temperature of the Earth's crust ranges from +40 to +50 ºC.

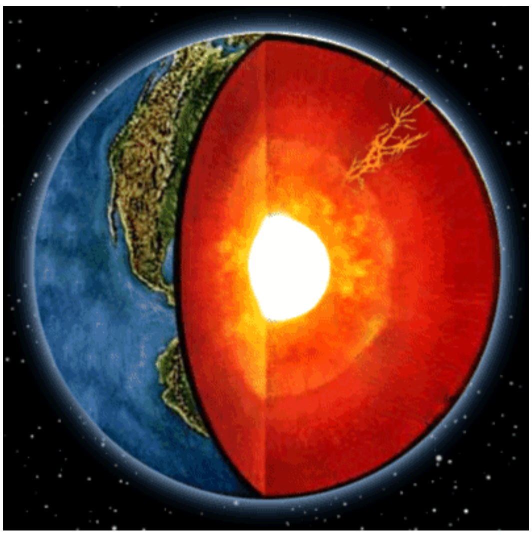

Figure 5. Slice of the Earth from core to cosmic space with spots of Earth´s "valves" - volcanoes and tectonic plate faults

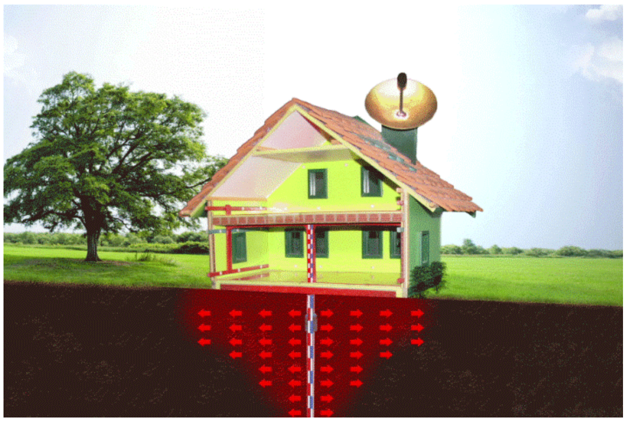

Figure 6. A technical solution to transport solar energy from solar collectors to the vertical DHE

One logical solution in regard to all mentioned problems is to restore the thermal energy in the surface layer of the Earth's crust by constant, intense and renewable solar energy, especially in areas of large consumers such as industrial plants and cities.

Based on the low value of heat transfer coefficient (k) in the ground around the DHE, it can be concluded that the Earth's crust would be a much better accumulator, than a conductor of heat. This leads to the idea that a cheap storage of solar energy could be made, that almost throughout the year, with solar collectors can be transported into the ground, around the DHEs[4].

It is entirely feasible technically in the manner as shown in Figure 6.With solar thermal collectors (flat plate collectors or concentrators) solar energy is transported by liquid medium known as glycol in case of temperatures that is up to +100 ºC, or thermal oil if the temperatures are higher than +100 ºC. Heat-transport fluid transferring the thermal energy into the ground by thin tubes made from stainless steel (Ø = 15 mm) which are spirally wrapped around the vertical DHE [5].

The heat transfer starts from a lower point (approx. at 1/3 of its length) and so DHE is wrapped with thin stainless steel tubes starting from below (from 100 m depth and up) Fig. 7.

These thin tubes must be made of materials resistant to chemical aggression and simultaneously must have a high coefficient of thermal conductivity (k) in order to deliver energy easier and faster.

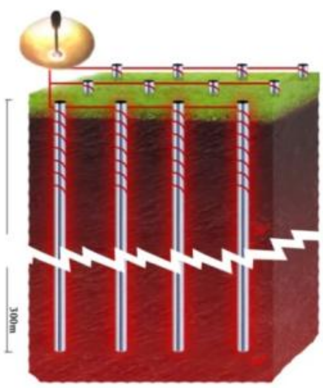

Figure 7. Technical solution of vertical DHE using solar energy accumulated in the surface layer and the excess heat of the Earth's core

If the walls of the DHEs are made of aluminum, or composite materials containing aluminum in its structure, the coefficient of thermal conductivity's value would be k = 200 W/mK or as a composite material with value of k = 50 W/mK and if such is the case, could easily warm and transform the thermal energy to liquid medium (glycol) inside the DHE and finally heat pumps. Under such circumstance might subtract heat from the ground between 10 and 20º C, which is several times more energy than using the current methods of exploitation. It is important to emphasize that DHE system would be stable in terms of heat capacity and it could reach 0,15 to 0,35 kW/m^2. In other words, a 300 m long DHE could give at least 30 kWh of energy to heat pumps with the assurance that energy will be renewed continuously. The quantity of exploited thermal energy depends on the surface area of the DHE, temperature conditions of the ground, the coefficient of thermal conductivity (k) of the material around the probe, the material from which the probe and the liquid media (water or glycol) are made of. The DHEs depth of up to 15 m can be insulated from the outside and cannot exchange heat with the external environment. During one heating season under above mentioned conditions, temperature around DHE can deliver about 100 MW of thermal energy from ground, which is several times more than today's conventional results.

If the boreholes would be secured with technology of cementing, it should be done with materials that would be hygroscopic. Namely, hygroscopic materials would draw moisture - water and thus the thermal energy would be faster drained in this case, since the c coefficient of thermal conductivity of water is, k = 0.83 W / m K and the specific heat capacity of water is c = 4190 J / kgK. Water is, indeed, the best medium for the transfer of thermal energy and this property can be utilized in the Earth's crust using DHEs.

In order to quickly and easily drill deeper (300 to 400 m), it is necessary to develop an entirely new type of heat exchanger that could be use simultaneously for drilling and later on settle and ensure the borehole itself. Filling of the boreholes could then be omitted if such pipes can take the pressure. Within these probes after the completion of drilling, pipes are lowered with glycol, which transports the heat taken by the heat pump.

III. CONCLUSIONS

This paper offers new technical solution using a combination of two thermal energy sources: the Sun and the Earth's core. (Figure 8.)

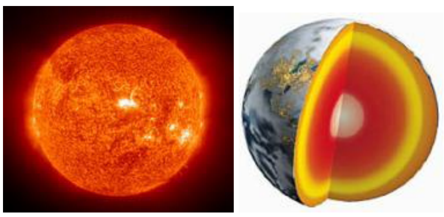

Figure 8. The sun and the Earth´s crust - inexhaustible sources of cheap and environmental-friendly renewable energy for life on Earth [10]

Figure 9. Benefits of changes - no icy roads and sidewalks in large cities

The general belief of physicists for a long time and even until today is that the accumulation of heat in the Earth's crust is not possible because of its large mass and relatively high coefficients of thermal conductivity (k) for material; Earth's crust is built up (Table 1). These presumptions are even more theoretically wrong since these materials have thick layers. Consequently it is not so important that the coefficients of thermal conductivity of these materials in Earth's crust have higher values than usual insulation materials. Heat resistance during heat transfer will definitely be more loaded in view of the large width (d) of layers. After all it can be clearly concluded from (2).

Specifically, this impossibility of fast (equalization) inflow of thermal energy by the thermodynamic laws, in which limits the capacity and service life of heat pumps as well as demonstrating clearly that the Earth's crust could be a better conductor for heat rather than an accumulator. We had also stated 2 evidences for this claim: the example of heat pumps with DHEs from Sweden and the well known Roman system of underfloor heating that had been proven for centuries. All this suggest that it could be possible to accumulate thermal energy in the earth and most likely it can be accomplished easier with solar energy - as with an inexhaustible source.

Accumulation of solar energy around the vertical DHE on the surface of the Earth's crust (depths up to 100 m) is almost possible all year. Furthermore, a DHEs length of 300 to 400 m instead of 120 m is proposed in order to be more efficient and reach the surplus thermal energy from the Earth's core in greater quantities. These measures could fully support heat pumps, and even improved their coefficient of performance (COP) with an excellent value far above 6. Through this a rational solution of using a completely renewable ecological energy source would be granted which is applicable on bigger scale for heating and cooling large industrial facilities, resorts and even major cities (Fig.9.). A high class energy efficiency of A$^+$ can also be achieved. Buildings in average, the leading consumers of energy in the world, use 50% of the total produced energy. The consumption can enormously be reduced up to 15% using the described solution. Dangerous energy sources like nuclear power as well as fossil fuels can be completely avoided from being use. There is a possibility with deeper boreholes of up to 1500 m and by thermal oil as a medium for heat transfer, and to build electric power plants of few hundred MW. DHEs can even supply steam turbine by taking a part of the Earth's core heat and a fraction from the large solar collector-concentrator, which would raise the heat around the DHE to a temperature of up to 200 ºC(Fig.10).

Figure 10. Solar energy captured by solar collector-concentrator of several 10 MW would be transported in the ground around the 1500 m length vertical DHEs[12]

In addition to obtaining cheap and environmentally renewable energy, by implementing these solutions there is a real opportunity to avoid volcanic eruptions, tectonic plate shifts, earthquakes and devastating tsunamis through reaching and intensive use of the Earth's core thermal energy, a so-called "surplus" energy. These surplus energies causes the increase of pressure within the core and stress-tension in the layers of the Earth's crust that crack in places of previous cracks and lines of moving tectonic plates (Fig. 5). And similarly lead to volcanic eruption, which together with dislocation of tectonic plates can cause the onset of devastating earthquakes and tsunamis. Earth on a natural behavior performs the regulation of pressure and temperature inside the core. Instead of Earth itself uncontrollably activating its "safety valves", volcanic eruptions and tectonic plate movements, it is logical for us people to use the surplus of environmental and renewable energy in a natural manner and satisfy humanity, concurrently avoiding catastrophic devastation. The issue of Earth's over-heating and melting of ice at the poles does not only need to be due to the "greenhouse-effects".[1] The reasons for this may exist even in the Earth's crust, where surplus thermal energy "arrives" from the Earth´s core.

ACKNOWLEDGMENT

The work reported in this paper is a part of the investigation within the research project III 42012 "Energy efficiency enhancement of buildings in Serbia and improvement of national regulative capacity for they are certification", supported by the Ministry for Science and Technology, Republic of Serbia. This support is gratefully acknowledged.

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