UDC (UDK) 620.91:550.361]:631.1

Lazar RUŽIČIĆ,
Ljiljana KOSTADINOVIĆ, Kosta GLIGOREVIĆ and Mićo OLJAČA[1]

THE APPLICATION OF GEOTHERMAL ENERGY IN AGRICULTURE

SUMMARY

In order to protect the environment and natural resources for energy production, in the world are increasingly advocating the use of unconventional or alternative energy sources. One of the necessary usages of alternative energy source is geothermal energy, generated in the Earth's crust slow decay of radioactive elements, chemical reactions, or friction in the movement of tectonic masses. The amount of this energy is so great that it can be considered almost inexhaustible, and thus geothermal energy is a renewable source of energy. This type of energy has many advantages over traditional sources of energy based on fossil fuels, and most are as clean and safe for the environment. In addition, geothermal energy is virtually inexhaustible. The simplest and most promising way of utilizing geothermal energy in direct use of heat for various purposes in tourism, agriculture, industry and communal heating. Use may be alone or in combination. Can be combined with other (conventional) methods of heat production or the production of electric energy from geothermal sources. World capacities for the direct use of geothermal energy are estimated at 15 GWt installed capacity and 191 PJ of heat used per year. Direct application in agriculture is the largest for heating greenhouses, barns and other farm buildings, for use in kilns and ponds where termelni source close. Each region has its own characteristics, depending not only on the geothermal potential but also on many other factors. The paper reviews the technological possibilities of geothermal energy in agriculture.

Keywords: geothermal energy, agricultural production, technical solutions.

INTRODUCTION

Intensive development of energy production and consumption in the world, which has still been realized through conventional, mainly non-renewable energy sources, in many countries obtrudes a need for long-term planning, finding and using new energy sources. Thereby it is taken in account that those sources are renewable and do not pollute environment. Beside solar, wind and tidal energy, geothermal energy takes more and more important place in human efforts to find appropriate solution for a problem of providing sufficient energy quantities,

[1] Lazar Ružičić, Ljiljana Kostadinović, Kosta Gligorević, Mićo Oljača (corresponding author: omico@agrif.bg.ac.rs), University of Belgrade, Faculty of Agriculture, Department of Agricultural Engineering, 11080 Belgrade-Zemun, Nemanjina 6, Republic of Serbia.

which beside food and raw materials, belongs to vital existential problems of human population in general Ružičić et al (2011).

Geothermal energy is heating energy which is made within the Earth crust by decomposition of radioactive elements, chemical reactions, crystallization and solidifying of dissolved materials or by friction on moving of tectonic mass. Quantity of such energy is so big that it can be considered as the endless one. Geothermal energy is a resource, which can be found in different concentrations in all the countries as well as in all the continents. It includes heating content in rocky complexes, and fluids – waters, steams, melts which appear in different depths under the earth surface Krmpotić et al (2006).

Using thermal energy means using energy accumulated in the inner part of the Earth in forms of hot water and steam or in dry rocks. By that, it is very important the temperature difference between the land surface and the inside of the Earth. Temperature gradient, that is increasing temperature according to the kilometre of the depth, is the biggest close to the surface, and with the increasing of the distance from the surface, it becomes lower. By lowering from the outer layer of the Earth, that is through the land crust temperature increases approximately 17 °C to 30 °C per the depth kilometre (50 – 87 °F per the depth mile). Under the crust, there is a soil layer compounded by partly dissolved rocks and the temperature of that layer is between 650 and 1250 °C (1200 – 2280 °F). In the core itself of the Earth, the temperatures could be, according to some evaluations, between 4000 and 7000 °C (7200 – 12600 °F). Knowing that the temperature is always transmitted from warm places to cold ones, the heat from the inside of the Earth is transmitted toward the surface and that transmission of the heat is the main starter of the tectonic plates Stevanović et al (2003).

The potential of the geothermal energy is huge, there are 50000 times more of it than all the energy which could be provided from the oil and gas all over the world. There are three general groups of geological mediums where geothermal appearance appears:

1. Complexes of volcanic rocks, made of Pliocene to date in the rocks of nowadays active volcanoes. Geothermal fluids, waters and hot steams, temperatures up to 230 °C, rarely more, are tied to lava and different pivoclastic materials, and fractures in those formations.

2. The regions which are situated in the zones of breakout and crimp. Big cracks are used as roads along which geothermal fluids come up to the surface. That way there are waters emerging, usually with the temperature of 80° C to 90° C (ex. central Africa).

3. Thick sediment complexes in the pools of different size, within the continents, consist of hot water reservoir. Those waters are often under high pressure, mixed with gases and steams and could be exploited in economic terms Nedović et al (2008).

RESULTS AND DISCUSSION

Geothermal sources in the world

By the term geothermal sources is meant sources of geothermal mediums, waters from underground layers which could be without water supply (feed) from the surface or with natural or artificial supply from the surface which then passes through underground layers. Areas which have the highest number of geothermal sources are in the same time those which are geologically very active ones, that is which have still active volcanoes or inside where very often there are quakes. Those are areas around the Pacific Ocean (so called Pacific circle of fire: west parts of the USA and Canada, Middle America, north coasts of the South America, New Zealand, Indonesia, Japan and east Siberian), medium Atlantic ridge (Iceland), mountains ranges like Alps and Himalaya, east Africa, central Asia and some islands in the Pacific Ocean.

There are four groups of geothermal energy sources:

- Hydro geothermal energy from hot water sources
- Hydro geothermal energy from water steam sources
- Hydro geothermal energy from hot water in big depths
- Petro thermo energy – energy from hot and dry rocks

Sources of geothermal energy are used in different areas of human acting, and among them, more and more for producing electricity. The biggest effort are made in this direction, because apart from being deficit this type of energy is convenient for transporting to big distances International Energy Agency (2007).

Energetic potentials of geothermal resources in Serbia

Researches show that Serbia has important possibilities for using geothermal energy and that in future higher participation of it in energetic balance should be planned. Existing results show that with intensive program of geothermal resources development could increase until 2015 enough to replace at least 500.000 tons of imported liquid fuels a year. In Serbia, geothermal energy is just used symbolically, that is about 86 MW, although according to the geothermal potential it is one of the richer countries Lambić (2003).

Exploitation of geothermal energy in Serbia has to become more intensive, as there are several factors forcing toward that: tension of oil – energetic imbalance, inevitable transition on market economy, permanent increase of deficits of fossil and nuclear fuels, aggravation of ecological situation and increase of costs for environmental protection. The biggest importance for Serbia will have direct using of geothermal energy for heating and heating system of rural and urban settlements and development of agriculture and tourism Ružičić et al (2011a).

Geothermal characteristics of the territory of Serbia are very interesting, That is due to suitable geological compound of the terrain and suitable hydrological and geothermal characteristics of the terrain. Density of the geothermal course is the main parameter in according to which it is evaluated geothermal potential of a region. It is the quantity of geothermal heat, which every second through the surface of 1 m^2 comes from the Earth inside to its

surface. On the biggest part of the territory of Serbia, density of geothermal heating stream is higher than its average value for the continental part of Europe, which is about 60 mW/m^2. The highest values are more than 100 mW/m^2 in Panonski basen, central part of south Serbia and in Central Serbia.

On the territory of Serbia apart from Panonski Basen there are 160 natural sources of geothermal waters with the temperature more than 15°C. The highest temperature among them have waters from the source in Vrnjacka Banja (96°C), then in Josanicka Banja (78°C), Sijerinska Banja (72°C) and so on. Total bounty of all natural geothermal sources is about 4.000 l/s Lambić (2003).

According to current knowledge, there are about 60 findings of geothermal waters with the temperature higher than 15°C up to the depth of 3000 m on the territory of Serbia. Total amount of heat, which is accumulated in findings of geothermal waters in Serbia up to the depth of 3 km, is twice bigger than equivalent heat energy, which could be produced by burning all types of coals from all the coal findings in Serbia. Bounty of 62 artificial geothermal sources that is geothermal drill holes, in the area of Vojvodina is about 550 l/s, and heat power is about 50 MW, and in the rest part of Serbia from 48 drill holes 108 MW Mihajlović, Đordenski (1979).

On the territory of Serbia beside suitable possibilities for exploiting heat energy and other geothermal sources from geothermal waters, there also favourable possibilities for exploiting geothermal energy from dried rocks, that is from rocks, which do not consist of free underground water. In that case, water is pumped into underground hot rocks where it is heated. By pumping out such heated water, energy transition is realised from the hot rocks.

Exploitation of energy from this resource will not begin in certain time taking into consideration current minimal usage of natural sources of hot and curative water although those technologies for that application are already developed in the world Mihajlović, Đordenski (1979).

Usage of geothermal energy

The most common using of geothermal energy is realised by convective transition of heat by fluids, which is usually hot water or mixture of hot water and steam, with the presence of different additions (plins, salts, minerals). Heating energy of geothermal layers consisted in geothermal fluid at certain pressure and temperature, is used for heating or transformation into electricity. Possibility of using geothermal energy depends on working temperature of geothermal fluid. Basic division is based on usage of heating energy and on transformation of heating into electric energy http://geotermika.com.

1. Direct usage of geothermal energy

Geothermal water that is its heat nowadays is mainly used directly worldwide, what means without transformation into some other energy type, and less for production of electricity. Direct usage of heating energy replaces energents, which pollute air and environment. Geothermal energy can be applied

for different purposes. Direct usage of geothermal energy for heating, for industrial processes or for any other purpose always consists of the system with the three basic components http://gradjevinarstvo:

1.Production drill hole – for supply of hot water onto the surface;

2.Mechanical system – includes pumps, heat exchangers and controlling elements, in order to bring the heat to a place or a process;

3.Injection hole – for accepting chilled geothermal fluid.

2. Application of geothermal energy for electric energy production

Geothermal fluid in form of hot water or steam, temperatures over 120 °C, its latent heating energy change into mechanical work, that is electric energy. Depending on thermo dynamic features of geothermal fluids, it is possible to apply several technological processes for exchanging heating energy into the electric one. Selection of processes depends on quantity of fluid, pressure and temperature, ratio between hot water and steam, content of non-condensate gasses. Equipment of a very small capacity of 100 to 1000kW is also produced, of independent binary unit for modular usage in distant areas, which are very profitable and applicable. Some of the basic processes in production of electric energy Mihajlović and Đordenski (1979):

Simple process: This way electric energy is produced from the layers of hot water steam. Water steam is brought under pressure directly from geothermal source onto blades of turbine and after short expansion at atmospheric pressure of 1 bar, instead of condensate pressure of 0,04bars it blows out air. This is the simplest and the most economical process of production of electric energy from geothermal sources.

Clausius – Rankine process: Mixture of water, water steam and large particles which come from the production of holes firstly come into centrifugal separator with packs of thin tins for drying and separating steam. Such received dried saturated steam is brought to steam turbine together with following gasses, such as carbon and sulphur dioxide. For chilling condensations the same water is used which already passed working process, but previously it is chilled in chilling tower. Following gasses with two levels compression are firstly raised to atmospheric pressure, and afterwards are pushed out into surrounding.

Flash process: Residue of hot water, which is separated in separator, can be partly transformed again into steam by so-called "flash separator", under lower pressure. Such received additional steam is taken to central level of the turbine and the process flows further in the same way as at Clausius-Rankine cycles.

Binary process: Binary process is applied in cases of middle temperature of geothermal sources and beside that, it contains more quantities of undesirable following gasses. In this process geothermal fluid in heat exchanger transmit heat to secondary easy liquid fluid which moves blades of the turbine, and geothermal fluid is again back into the land through the injection drill hole.

Stirling process: Binary cycles, which use helium as a working medium, also can work according to Stirling cycles, especially after Japanese success with low temperature motor. This motor was shown in the International Congress on Stirling motors in Tokyo in 1955 and on the same Congress in Ancon in 1997 but significantly better and adjusted to application.

Equipment for exchanging geothermal heating energy into the electric one, delay in outer fluid important quantity of heat (Qiz), and that is why outlet temperature (Tiz) compared to the temperature of the surrounding (To), and so the usage of those and such equipment is relatively small compared to heating capacity of geothermal fluid. Economical point of the process of exchanging heating into electrical energy is increased by increasing working temperature and the amount of flow of geothermal fluid, combined outlet temperature in direct application for different types of heating Lambić (2003).

Price of produced electric energy in geothermal electric plants depend on temperature of geothermal drill hole, quantity of in-flow of fluid and cost of building the drill hole. Those three parameters mainly determine economic valorisation of geothermal resources. For big geothermal electric plants profitability, that is ration between economic benefit of output and input costs, it limits their physical size. That means that in current moments upper limits of profitability of size, for geothermal electric plant on steam, is 135 MW, and for geothermal electric plant on hot water it is 55MW. Beside that, nowadays are regularly produced small geothermal electric plants, capacity of 5 to 10 MW, of modulator type of plant for usage on distant, inaccessible areas that is like start-up equipment during developing geothermal sources. Equipment of very small capacity of 100 to 1000KW is also produced, independent binary units for modular usage in distant areas, which are very profitable and applicable.

Advantages of using geothermal energy in production of electric energy are Stevanović et al (2003):

- **Ecology**. Geothermal electric plants, as well as electric plants on wind and solar electric plants, have not got burning of fuels for producing steam, which moves turbines. Production of electric energy by geothermal energy saves non-renewable, fossil energents. By decreasing the usage of fissile fuels their damage emission is also decreased, the one which pollutes the atmosphere.
- **Reliability**. Geothermal electric plants are designed for plants over 24 hours a day, almost whole year around. They belong to top source of fuel, because there is no cease of production due to weather conditions, natural disasters or political influences, which could prevent transport of other types of fuels.
- **Economy**. There is no need for spending money to import fuel, because geothermal electric plants are always built on geothermal sources. Saved money stays with population of compounding areas, and that way they do not have sudden changes of fuel prices.
- **Development**. Geothermal projects enables all above mentioned advantages with in the same time development of the country and energetic

increase, but without environmental pollution. Even installed objects in distant areas can raise living standard by taking electricity to population who are far away from electrified settled centres.

Usage of geothermal energy in agriculture

In agriculture, geothermal energy can be used for different methods of heating greenhouses (heating of rooms through radiators, radiator heating of land and air, heating of land and/or air by ventilation and similar) either direct or through heat exchanger alike at heating rooms. Thermal water of lower temperature and mineralization can be successfully used for watering and/or heating cultivated surfaces on planting Mihajlović and Đordenski (1979).

By using thermal energy in greenhouses, the production costs are becoming lower and that is up to 35% in total cost of production.

There are four basic physical conditions, which play main role in creating climate of greenhouses, and those are:

- Sun rays
- Air in greenhouses
- Plant mass
- Temperature

Physical parameters, which are controlled during the process of growing plants in greenhouses, are:

- Light
- Temperature
- Concentration of CO2
- Air moving
- Water flowing, watering
- Heating installation
- Chilling installation

Factors influencing selection of solutions for heating greenhouses are:

- Types which are planted in glass-greenhouses (controlled climate through the months and all year)
- Role of heating installation (if it is additional or total heating of greenhouse)
- On drill hole type (if it is eruptive or lifting by pump)
- Chemical characteristic of thermal fluid
- Limitations which are settled by some other users of geothermal water

Systems of heating greenhouses

System for heating soil. The main task of this way of heating is heating of root part of plants. Such system of heating can only cover needs for heating and can be used without other systems of heating only in the areas with milk climate. Such system of heating is economic at the cultures which need certain regulation of temperature of root system or in combination with some other system of heating greenhouses http://geotermika.com.

System for heating air and land in the greenhouses. Such way of heating is made so that pipes for heating are set on the land. This way both land and air are heated. Regular instalment of heating elements enables optimal transfer of heating to the plant and the smallest loss of heating in the surrounding. Such system of heating is excellent for covering all heating needs in the areas with mild climate, or to cover basic needs for heat in the areas with continental or sharp climate http://geotermika.com.

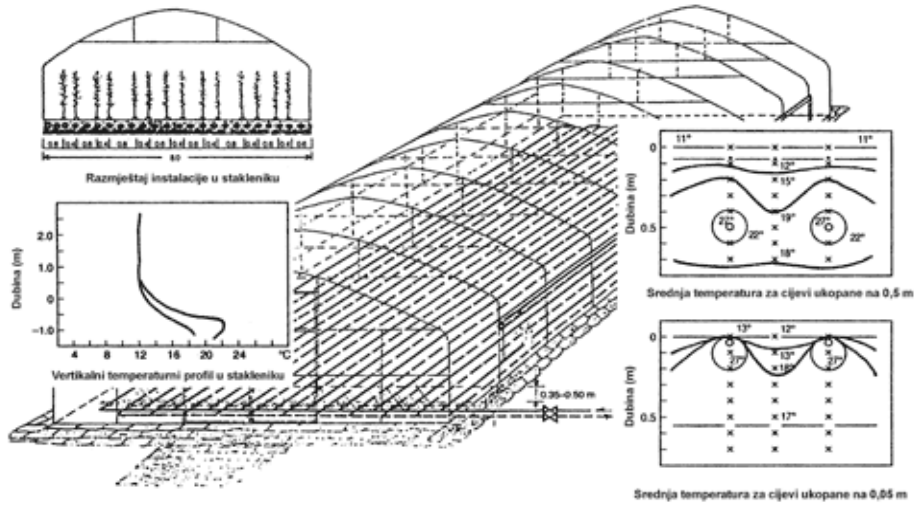

Figure 1. The system for heating soil in greenhouses

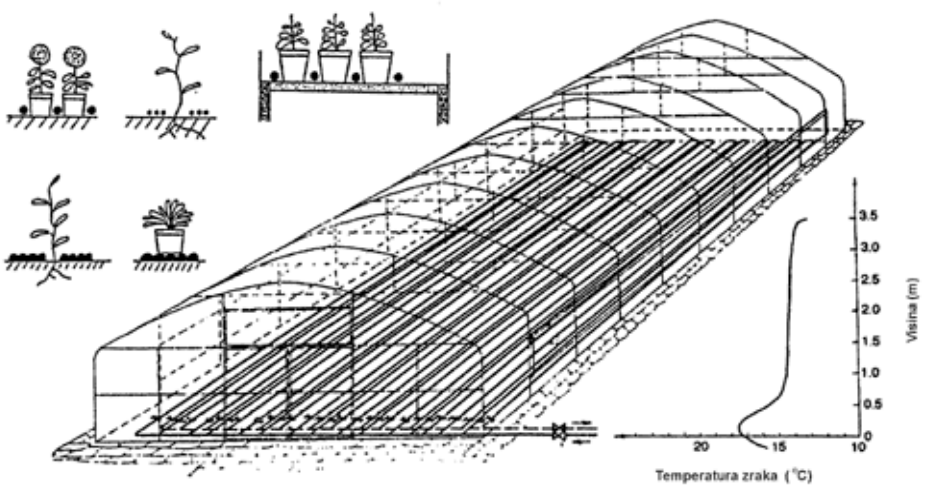

Figure 2. The system for heating air and land in the greenhouses

System for heating air. At such way of heating metal pipes or heat exchangers above the land surface are used. The advantage of such heating system is because it enables fast and precise regulation of heating and it can independently be used in the areas with continental and sharp climate. The lack of such system is that coefficient of transmitting heat at low temperature fluids very low and bigger surface of heaters are needed to be used, what can decrease surface of light dispersing and damage conditions of plants growing http://geotermika.com.

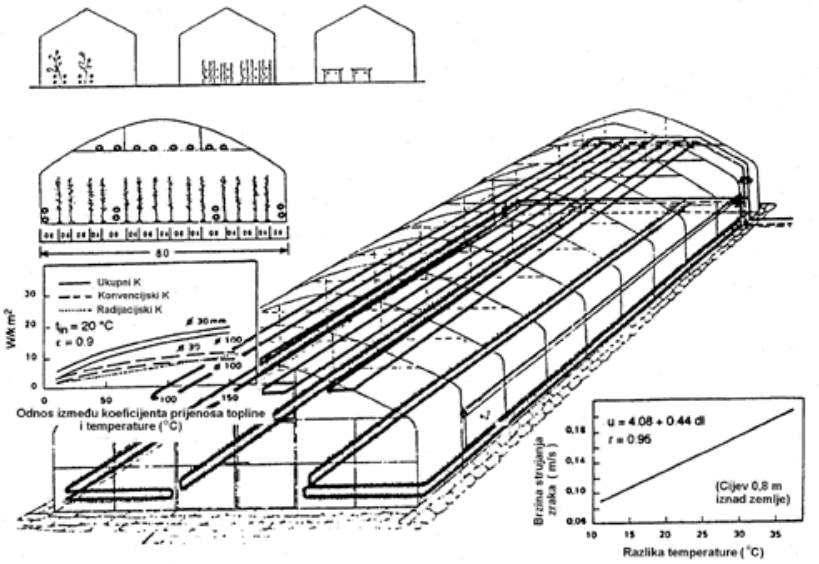

Figure 3. The system for heating air in a greenhouse

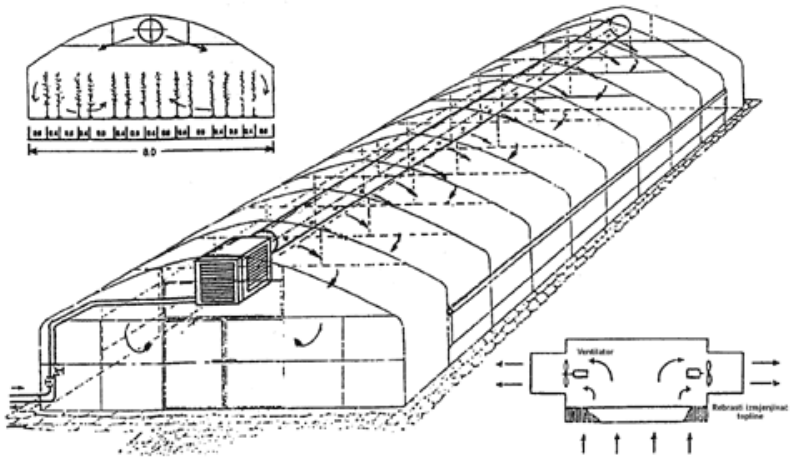

Figure 4. The heating system with fan heat conduction

Systems with heat transmission. By introducing into a system of using fans, the coefficient of heat transmission can be increased significantly, even at

low temperature fluids systems. Such way of heating greenhouses is very simple, cheap and suitable for automatic regulation and it enables fast system reaction on the change of outer temperature **http://geotermika.com**.

Other systems for heating greenhouses In the figure 5 the system for heating greenhouses by geothermal fluid with the high level of dissolved minerals is shown. This system for heating is made of cheap polyethylene material, which can be replaced after one or two production seasons http://geotermika.com.

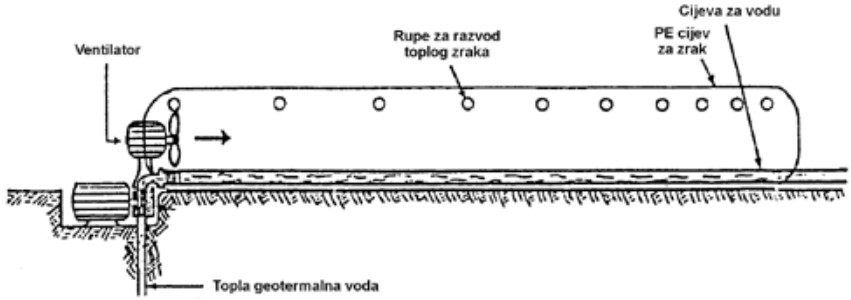

Figure 5. The system for heating air and land with "aggressive" geothermal fluid

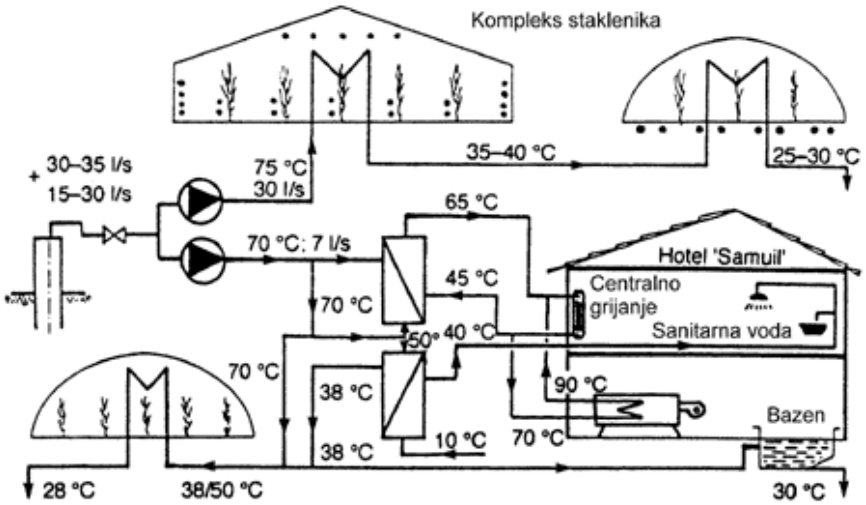

Figure 6. Geothermal system "Bansko" (Macedonia) consisting of heating a greenhouse, and other various hotel customers

Combined application of geothermal energy

One of the main lacks of using geothermal waters in greenhouses is high investment, knowing that it is used during a short period of a year. Solution for this problem is in finding other consumers of geothermal waters, what would decrease costs of heating greenhouses. In the figure 6, schematic show is given on combined usage of geothermal energy for heating greenhouses on different

temperature levels, areas and hot sanitary water. This way the factor of using total system for using geothermal energy is increased http://geotermika.com.

Beside usage in agriculture, geothermal energy can be used in other purposes, such as http://www.beodom.com:

Balneology – usage in pools for recreation or therapeutic purposes either directly or through heat exchangers.

Industrial usage – using geothermal heating energy in different industrial heating processes (pasteurisation, drying, dehydratation and so on).

Fisheries – usage of heating energy in the processes of fish fry and similar.

Heating pumps are special form of direct application of geothermal energy.

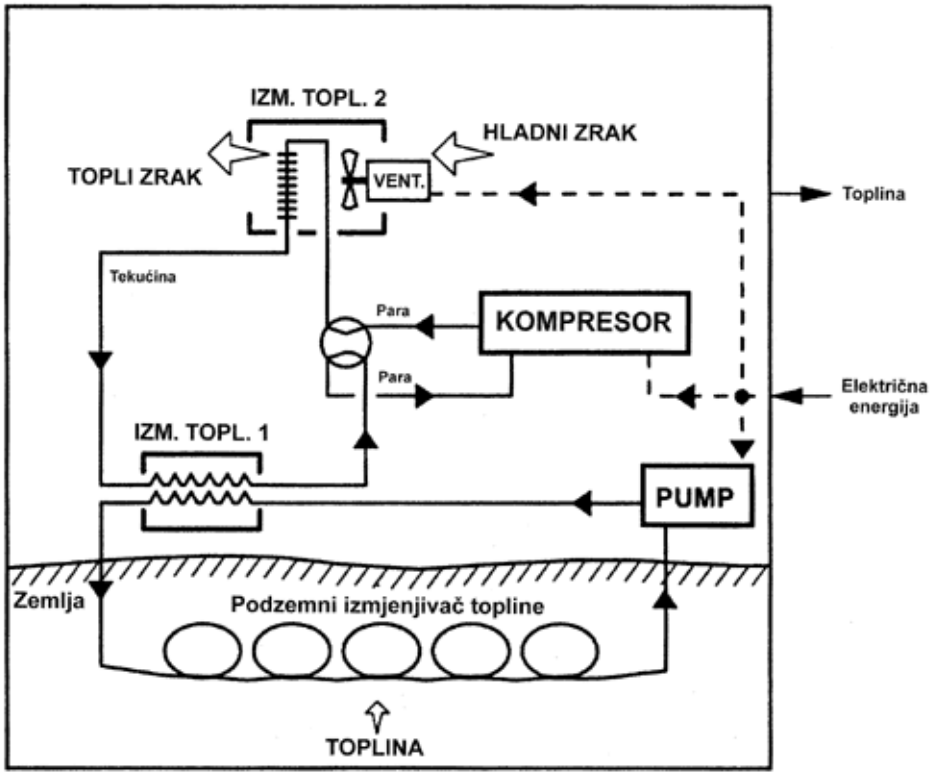

Figure 7. Geothermal heat pump

Geothermal heating pumps, in the world are known as GHP (Geothermal heat pumps), have wide application in many countries of Europe and the USA. Heating pumps spend electric energy for circulation of geothermal (open circle) or some secondary fluid which takes heat from the earth (closed circle) through pipes. This way geothermal heat is brought to households, wher it is mainly used for heating, then for chilling and preparation of hot water. By using geothermal pumps, electric energy consumption is being decreased significantly. Typical

scheme of geothermal pump is shown on figure 7 www. toplotnepumpe-solari.com.

Heat which comes out of heating pump can be used for heating rooms and for preparation of hot sanitary water. There are two basic systems for using geothermal energy by heating pumps. The first system does not use directly geothermal fluid, but by the system with dug-heat-exchange unit take heat from the land crust or geothermal fluid from the drill hole by so-called drill-hole-heat-exchange unit. The other system uses geothermal water which is produced from the drill hole, and after transmitting heat to secondary circle it either is pressed back into the layer, or is released in water flows or drainage systems www.esco.rs/toplotne-pumpe.html.

For all the systems with heating pumps the following is important (depending on if it is applied for chilling or heating) :

- If geothermal heating pump is used for heating, then brought heat from underground is transmitted through laid pipes, it is transmitted to the fluid in them and is brought to a user.
- For chilling, heating pumps are used that way that circulating fluid within pipes of a building or apartment, takes out, that is "collects" heat which is transmitted to it and than it is pressed into the ground.

Advantages of using geothermal heating pumps are: economy, (decreasing heating and chilling costs in living and business buildings for 50%), continuation (duration of geothermal heat pumps is longer than conventional systems, due to appropriate protection from weather disasters; mechanical part of the system is situated in closed area, and pipes for bringing geothermal energy are under the ground), low maintenance costs (underground pipes have predicted duration without maintenance of about 50 years), ecological aspect (geothermal pumps almost do not pollute environment, and so are important factor in decreasing atmosphere pollution, different from fissile fuels), geothermal pumps do not make noise, and so are suitable for using in households or in business offices; they are used both in hot and cold periods (in summer for chilling, in winter for heating; geothermal systems can supply different types of consumers by heating energy www.esco.rs/toplotne-pumpe.html.

CONCLUSIONS

Geothermal energy is all under us. Somewhere it is easily accessible, or comes to the land surface by itself in the form of hot water or steam, and somewhere it is on high depth and practically inaccessible. Knowing that the total amount of geothermal energy is evaluated, the one which could be used, it is significantly bigger than the whole amount of energetic sources based on oil, coal or gas, and geothermal energy should be paid more attention. Especially if it is taken into account that it is cheap, renewable source of energy which is in the same time ecologically acceptable. Knowing that geothermal energy is not always and everywhere easily accessible, it should be used at least in the places where it is easily reachable (edges of tectonic plates) and that way partly

decrease the pressure on fissile fuels and so help the Earth to recover from damage gasses which cause effect of greenhouse and cause global worming and climate changes.

Geothermal energy in Serbia is symbolically used, only with 86 MW, although according to geothermal potential it counts into richer countries. Researches showed that Serbia has significant possibilities for using geothermal energy and that in future its higher participation in energetic balance should be planned. Existing results show that with intensive program of geothermal resources development could increase until 2015 enough to replace at least 500.000 tons of imported liquid fuels a year.

REFERENCES

International Energy Agency (2007): Obnovljivi izvori u svetskom snabdevanju energijom. Podaci međunarodne agencije za energiju, OECD, p.3.

Krmpotić,T., Brasić, M., Kiš, T., Vekić, Lj., Bošković, J. (2006): Ekonomija resursa i energetika biofarme. Megatrend univerzitet, Fakultet za biofarming, Beograd.

Lambić, M. (2003): Energetika. Tehnička knjiga, Beograd.

Mihajlović, L., Đordenski, Đ. (1979): Ekonomika poljoprivrede sa zadrugarstvom. Novi Sad.

Nedović, B. (2008): Ekologija ivotne sredine. Univerzitet za poslovne studije u Banja Luci.

Ružičić, L., Kostadinović, Oljača, M., Gligorević, K., Fišter, S., Jurišić, B., Bojat, N. (2011): Alternativni izvori energije i zaštita životne sredine, 1st Sympozium of Natural Resources Management, Zaječar, 177-185.

Ružičić, L., Bošković, J., Kostadinović, Lj., Bojat, N., Milenković, S., Oljača, M., Gligorević, K. (2011a): Trendovi zaštite životne sredine na početku trećeg milenijuma. Prvi naučni skup „Zaštita životne sredine“, maj 2011, Univerzitet Educons, Sremska Kamenica (predavanje po pozivu), 20-26.

Stevanović, B., Knežić, L., Čikarić, S., Ilić-Popov, G., Karaman, G., Nedović, B., Todić, D., Vukasović, V., Vujošević, M., Stojanović, B., Tošović, S., Božović, B., Mijović, D., Angelus, J., Pantović, M., Stefanović, Đ. (2003): Životna sredina i održivi razvoj. Knjiga tačnih odgovora. Ecolibri: Beograd/Zavod za udžbenike i nastavna sredstva. Srpsko Sarajevo.

http://geotermika.com

http://gradjevinarstvo.rs

http://www.toplotnepumpe-solari.com/usluge.html

http://www.esco.rs/toplotne-pumpe.html

http://www.beodom.com/sr

Lazar RUŽIČIĆ,
Ljiljana KOSTADINOVIĆ, Kosta GLIGOREVIĆ, Mićo OLJAČA

PRIMENA GEOTERMALNE ENERGIJE U POLJOPRIVREDI

SAŽETAK

U cilju zaštite životne sredine i prirodnih resursa, za dobijanje energije u svetu se sve više zagovara korišćenje nekonvencionalnih, odnosno alterantivnih izvora energije. Jedan od neophodnih načina koriščenja alterantivnih izvora energije je geotermalna energija, koja se stvara u Zemljinoj kori sporim raspadanjem radioaktivnih elemenata, hemijskim reakcijama ili trenjem pri kretanju tektonskih masa. Količina takve energije je tako velika da se može smatrati skoro neiscrpnom, pa je prema tome geotermalna energija obnovljivi izvor energije. Ova vrsta energije ima brojne prednosti pred tradicionalnim izvorima energije baziranim na fosilnim gorivima, a najveće su što je čista i sigurna za životnu okolinu. Osim toga, geotermalna energija je praktično neiscrpna. Najjednostavniji i najperspektivniji način iskorištavanja geotermalne energije predstavlja direktno korištenje toplotne energije za različite namene u turizmu, poljoprivredi, industriji i komunalnom grejanju. Korišćenje može biti samostalno ili kombinovano. Može se kombinovati sa drugim (konvencionalnim) načinima proizvodnje toplotne energije ili s proizvodnjom električe energije iz geotermalnih izvora. Svetski kapaciteti za direktno korišćenje geotermalne energije procenjuju se na 15 GWt instalirane snage i 191 PJ korištene toplote godišnje. Direktna primena u poljoprivredi je najveća za zagrevanje staklenika, štala i drugih poljoprivrednih objekata; za primenu u sušarama i ribnjacima tamo gde je termelni izvor blizu. Svaka regija ima svoje specifičnosti, zavisno ne samo o geotermalnom potencijalu već i o brojnim drugim faktorima. U radu je dat pregled tehnoloških mogućnosti primene geotermalne energije u poljoprivrednoj proizvodnji.

Ključne riječi: Geotermalna energija, poljoprivredna proizvodnja, tehnička rešenja