Utilization of geothermal energy in Serbia

M. Milivojevic[1)] and M. Martinovic[1)]
[1)] Faculty of Mining and Geology, Geothermal Research Laboratory, Belgrade
E-mail: martin@eunet.yu

Abstract

In Serbia, there are more than 60 hydrogeothermal low-temperature convective systems ($T<150^oC$), as well as a large hydrogeothermal system in the Serbian part of the Pannonian basin. Estimated energy reserves of geothermal resources are about 800 MWt, but utilization of this is low, only about 80 MWt. Utilization of geothermal energy is mostly of the cascade type, with a few examples of integrated utilization. Integrated utilization combines the use of gas, oil, and electric power for heat pumps. According to the installations already built, utilization of geothermal energy is mostly for balneological purposes and tourism. From an energy point of view, utilization of geothermal energy is mostly for heating of greenhouses. Geothermal energy is now used for the heating of greenhouses only in three localities in Serbia. Eight ha. are heated by geothermal energy while the total area of other greenhouses heated by crude oil and gas totals around 64 ha. According to the potential of geothermal resources, near future development should focus on cascade and integrated utilization of geothermal energy.

Keywords: *geothermal resources, Serbia, utilization, balneology, greenhouse, heat pump.*

1 Introduction

Serbia is relatively small (about 80,000 km^2), but her geological and tectonic structures are very complex. Because of that, geothermal characteristics are interesting. On two-thirds of Serbian territory, values of the heat flow density are greater than average values for the continental part of Europe; and on half of its territory they are around l00 mW/m^2 (Milivojevic, l989). The development of geothermology in Serbia was established in the last century by S. Radovanovic, the first Serbian hydrogeologist, who can be considered as the “Father” of Serbian hydrogeology and geothermology (Radovanovic, l897; Milivojevic, l997). The examination of thermal springs (total of 196 in Serbia), was started more than 150 years ago, but the first modern hydrogeothermal research projects were conducted between the First and Second World War in the areas of the most well-known spas. The first, preliminary evaluation of geothermal potential was completed in 1975 (Milivojevic et al., 1975). Development of geothermal research in Serbia was at its peak between 1975 and 1988, when the evaluation of geothermal resources was completed (Milivojevic, 1989). In the period of time between 1991 and 1995, geothermal research stopped completely due to the economic crisis caused by the OUN embargo. The last geothermal well was drilled in 1991. In the last three years, a lot of effort has been put into continuing geothermal research, but the progress is very slow. The reasons for this are: economic difficulties; energetic focus on the import of oil and gas; as well as the fact that people are not conscious about the necessity of increasing energy efficiency and energy rationalisation.

2 The use of geothermal energy

In Serbia, use of geothermal energy is very low compared to the geothermal potential. The use of geothermal waters is mainly for balneological purposes. In Serbia, there

are 60 spas using geothermal waters for balneology, sports and recreational purposes. Other fields of direct uses are presented in Table 1 (Milivojevic et al., 2000). The total installed energy use is 74 MW_t, out of which 36 MW_t are in balneology, and 38 MW_t for other types of uses. According to Freeston (1995), Serbia takes 17th place in the world as far as the direct use of geothermal energy is concerned, using only about 10% of its real potential, which is estimated to be about 800 MW_t.

Table 1: State-of-the art on geothermal energy use in Serbia (Milivojevic, 2000).

Type of Use	**Installed Thermal Power[(1)] MW_t**	**Energy Use[(2)] TJ/yr**
Space heating	18.5	575
Bathing and swimming	36.0	1150
Agricultural drying	0.7	22
Greenhouses	8.4	256
Fish and other animal farming	6.4	211
Industrial process heat	3.9	121
Snow melting	-	-
Air conditioning	-	-
Other uses	-	-
Subtotal	74.0	2335
Heat pumps	6.0	40
Total	80.0	2375

[(1)] Inst. thermal power (MW_t) = Max. water flow rate (kg/s) x (Inlet temp. (^{o}C) - Outlet temp. (^{o}C)) x 0.004184

[(2)] Energy use (TJ/yr) = Annual average water flow rate (kg/s) x (Inlet temp. (^{o}C) - Outlet temp. (^{o}C)) x 0.1319

At most localities in Serbia utilization of geothermal energy is cascade and integral. Localities of this kind of utilization are shown in Table 2.

3 The use of geothermal energy for the heating of greenhouses

Fifteen years ago, the former Yugoslavia (SFRJ) was the second in Europe (not including former SSSR), just behind Hungary in the area of greenhouses heated by geothermal energy (Popovski, 1987). In the year 1990, it was fifth in the world in installed power of 111 MW_t (Andrejevski, l995). In the former Yugoslavia, the heating of greenhouses by geothermal energy was mostly applied in the Yugoslav ex Republic Macedonia. The block of greenhouses in Bansko (Macedonia) was the first commercial block of greenhouses heated by geothermal energy in the world (Popovski et al., 1997). Geothermal energy is now used for the heating of greenhouses only in three localities in Serbia: Vranjska Banja, Srbobran and Knjazevac (Figure 1). The biggest greenhouse is in Vranjska Banja, and the smallest in Knjazevac. Eight ha. are heated by geothermal energy while the total area of other greenhouses heated by crude oil and gas totals around 64 ha.

3.1 Cascade utilization of geothermal energy in Vranjska Banja

Vranjska Banja is one of the most well-known geothermal localities in Serbia. Its natural geothermal resources have temperatures of 80-92°C and a yield around 80 1/s. The flow of geothermal water is from gneiss and granodiorite. The age of these

formations is Neogene. The geothermal water is collected from the springs and conducted to the users through a covered, concrete channel or conduit. The use of geothermal energy is of the cascaded type, so that the water can first be used for the heating of hotels, then the buildings for balneotherapy, schools, kindergartens, health centres and poultry farms. Then, finally, it can be used for the heating of two complexes of greenhouses.

Table 2: Utilization of geothermal energy for direct heat.

		Annual Utilization			
Locality	**Type [1]**	**Flow rate**	**Temperature °C**		**Energy use [2]**
			Inlet	**Outlet**	
		kg/s			
Kanjiza - 1	C(D/B)	20.0	72	26	121.35
Kanjiza - 2	C(D/)B	14.0	65	26	72.02
Prigrevica	I+C(D/B/HP)	21.0	54	25	80.33
Srbobran	I(G/Gs)	11.7	63	24	60.18
Becej	I(D/B/Gs)	19.4	65	24	104.91
Vranjska Banja	C(Ip/F/D/B/G)	77.0	96	50	467.20
Sijarinska Banja	C(D/B)	7.4	76	25	49.78
Josanicka Banja	C(D/B)	17.0	78	40	85.21
Lukovska Banja	C(D/B)	12.0	67	35	50.65
Kursumlija	C(D/B)	20.0	68	25	113.43
Palanka	C(B/W)	13.0	56	25	53.16
Ribarska Banja	C(D/B)	37.0	44	25	92.73
Palic	I+C(D/B/Gs)	17.0	48	25	51.57
Bujanovacka Banja	C(D/B/W)	7.0	43	24	17.54
Gamzigrad	C+I(D/B)	10.0	42	24	23.74
Ovcar Banja	C(D/B)	50.0	38	27	72.54
Vrnjacka Banja	C(B/W)	5.0	36	25	7.25
Niska Banja	I+C(D/B/HP)	60.0	37	25	94.97
Klokot	C(B/W)	15.0	34	25	17.80
Koviljaca	C+I(B/O)	130.0	30	24	102.88
Bukovicka Banja	C(B/W)	15.0	34	28	11.87
Prolom Banja	I(B/HP)	15.0	31	24	13.84
					2335

[1] Type of Use: C=Cascade, I=Integrated (Ip=Industrial process heat; A=Agricurtural drying; F=Fish and other animal farming; D=District heating; B=Bathing and swimming; G=Greenhouses; W=Bottled water; HP=Heat pump; Gs=Gas)
[2] Energy use (TJ/yr) = Annual average water flow rate (kg/s) x (Inlet temp. (°C) - Outlet temp. (°C)) x 0.1319

"Cvece" greenhouse complex: The area of the greenhouses in this block is 7 ha. Its owner is a company called "Simpo" from Vranje. The complex consists of two parts: the "old" and "new" one. The "old" part of the complex occupies 2 ha and is built in the year 1970; and the "new" one in 1985. The amount of geothermal water used for heating is 45 l/s and the temperature 75°C.

Geothermal water is flowing from the conduit into a water tank. From the tank it goes into heating installations of the "old" part of the complex of greenhouses. Transfer of geothermal water to the greenhouses is through asbestos - cement pipes insulated by glass wool with the pipes placed in a concrete-covered conduit. Thermal

water first reaches a tank of 50 m^3. The total thermal power necessary for heating the whole greenhouse complex, which covers around 7 ha., is 15.2 MW_t.

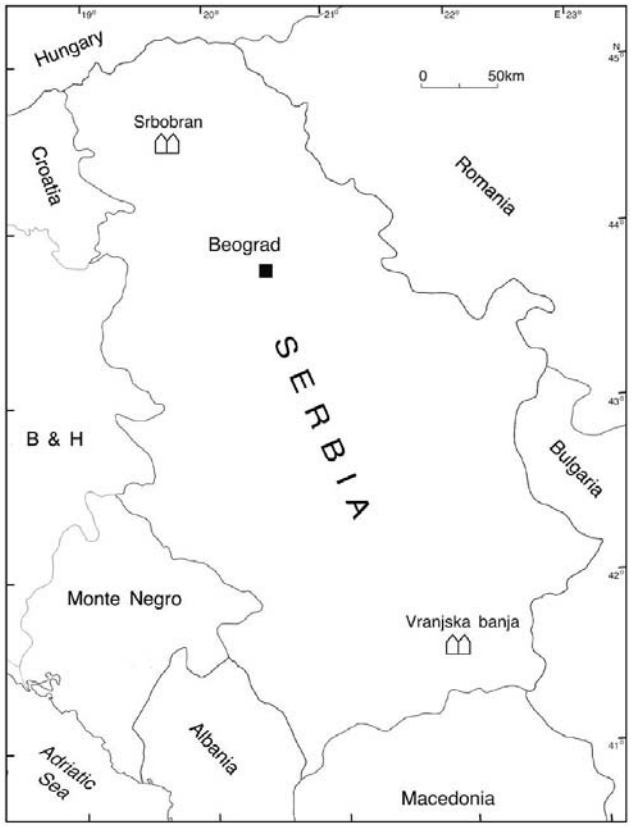

Figure 1: Geographical position of greenhouses heated by geothermal energy.

Thermal water is sent from the tanks into the heating installations in the "old" part of the greenhouses with the aid of circulation pumps. In that way, direct heating is achieved. In the "new" part of the greenhouses, heating is carried out with the help of a plate heat exchanger. Temperature of the water, which enters the exchanger, is 75°C, but 44°C at the exit. The return water is heated once again and, thus, it can be used for heating. The system of heating is combined: soil heating installations and aerial heating, i.e. aerial steel pipe heating system. Soil heating is put into effect through polyethylene pipes of ½" diameter dug to a depth of 30 cm (Milivojevic et al., 1998).. The regulation of temperature is mechanical i.e. through windows, and automatic. Movement of the air in the greenhouses is both natural and artificial with the help of ventilators. The construction of the greenhouses is of Belgium origin. Plant growing is both on the ground and on benches. Trimmed flowers in flowerpots, 600,000 of them in total, are produced in the greenhouses. The value of the whole production is around $1.5 * 10^6$ € per year.

"Rasadnici" greenhouse complex: The area of these greenhouses is 1.2 ha. This greenhouse complex has the oldest greenhouses heated by geothermal energy in former Yugoslavia. It was built in the year 1954. This is the location of the first vegetable production greenhouse (of tomatoes) in former Yugoslavia.

The greenhouses are heated by geothermal water that is taken from a concrete-covered conduit. This is "waste" geothermal water, which is coming from use in the "Cvece" complex of greenhouses. Temperature of the geothermal water that enters the greenhouses is from 37 to 40°C, and the amount of water is around 36 l/s.

Heating is performed through aerial pipes with 100 mm diameter. The heating system is open, i.e. thermal water circulates through the pipes directly from the conduit and without a heat exchanger (because of that, there are certain problems with corrosion). Finally, it reaches an exit conduit for further use. With this heating system, and with an outside temperature of minus 10°C, inside temperature in the greenhouses reaches 8-10°C. When outside temperature is lower than -10°C, the temperature in the greenhouses is maintained by the use of oil for heating. During cold winters, 40 to 60 tons of heating oil are consumed. The circulation of air in the greenhouses is free.

The complex of greenhouses consists of differently constructed greenhouses. The first construction was a Russian product, which occupies 0.2 ha. The span of this construction is 6 m and its length 30 m. The second type of construction was made in Holland and produced in 1964. The span of this construction is 12 m and its length 50 m. The regulation of temperature is mechanical. There are no problems with condensation. The hardening of glass surfaces is performed during the summer. Plant growing is both on the ground and on benches. The season starts on October 10 and lasts until April 15 of the following year.

Trimmed flowers and flowers in flowerpots are grown here. The production of flowers is about 90% of the total production, with 300,000 of trimmed flowers and 30,000 flowers in flowerpots produced per year. The production is complete, from seeds to flowers. Apart from flowers, there is also production of vegetables: 5-10 tons of cucumbers and 20-30,000 hot peppers (annually). The total value of this production is around 175,000 €.

3.2 Integrated utilization of geothermal energy use in Srbobran

The “Elan” complex of greenhouses is situated next to the town called Srbobran, 100 km north of Belgrade (Figure 1). It consists of 6 ha of the greenhouses heated by gas from the nearby gas field and a 0.5 ha plastic building heated by geothermal water from the nearby geothermal well.

The geothermal plastic building was built in the year 1982. Heating is by 11.7 l/s of geothermal water that has a temperature of 61°C. The total mineral content of the geothermal water is 3.67 g/l. According to its chemical composition, the geothermal water is of HCO_3-Na-Cl type, having NaCl of 1.46 g/l. The geothermal water has a lot of gas (CH_4 and CO_2), 1.37 m^3 of gas/1 m^3 of water. The aquifer of the geothermal water is sand from the Neogene period. Because of the high gas content, the geothermal water is degassed before use (Ceman, 1993). After being degassed, the geothermal water flows through a 200 m long pipeline toward the plastic building. Pumps are used to controll the circulation of geothermal water. The use of geothermal water in the plastic building is direct, i.e. without heat exchangers. The plastic building is heated in two ways: 1) by aerial heating through finned aluminium pipes and through a convector with a 60/35°C regime; and 2) by soil heating through polyethylene pipes with a 35/25°C regime. Using this heating system, and with outside temperature measuring -20°C, a temperature of 0°C is reached above soil. Finally, the geothermal water is used for heating cold water from 12 to 20°C, which is used for irrigation. The regulation of temperature in the plastic building is automatic. The movement of air is carried out by ventilators, which are a part of a calorifer. Used geothermal water flows out of the plastic building through an open conduit into the sewage system.

The construction of the plastic greenhouse is lattice type with aluminium pipes. The plastic greenhouse is 90 m long, 48 m wide and 3 m high. Corrosion and

incrustation are not apparent. Nursery plants of cucumbers, tomatoes and lettuce are produced in this plastic building.

4 Conclusion

We have satisfactory experience with cascaded geothermal energy for the heating of greenhouses and plastic houses here in Serbia. Although the area of geothermal greenhouses and plastic buildings is quite small or just about 8 ha in three locations, their owners want to enlarge them since economic indicators show that the production of flowers and vegetables in geothermal greenhouses is better than in those heated by gas or liquid fuel. However, the lack of money for building new and modern complexes of greenhouses as well as for renovating existing ones prevents the enlargement and further development of these buildings. If the financial problems can be solved, the geothermal resources are available to increase the area of geothermal greenhouses and plastic buildings in Serbia by several hectares.

5 References

Andrejevski, B. (1995). Present state-of-the art and strategy for development of geothermal energy in the world at the end of the XX Century. In: *Geothermal Energy: State-of-the-art and Perspectives in the Republic Macedonia* (Ed, K. Popovski), MAS, Skoplje, pp. 17-22 (in Macedonian).

Ceman, J. and Vidovic, S. (1993). Study, analysis and technical solution of energetic efficiency of geothermal water from the well Sr- 1/H, NIS - Naftagas, Novi Sad, pp. 1-56.

Freeston, D.H. (1995*).* Direct uses of geothermal energy 1995 (preliminary review): In: *Proc. World Geothermal Congress 1995*, 18. - 31. Mai, Florenz, Bd. 1, S. 15-25, Auckland.

Milivojevic, M. (1989). *Assessment of geothermal resources of Serbia excluding autonomous provinces.* Doctoral thesis, University of Belgrade, Belgrade, 458 p. (in Serbian).

Milivojevic, M., Milovanovic, M. and Peric, J. (1975*).* Geothermal potential and utilisation of geothermal resources in central part of Serbia and Kosovo. In: *Proceedings of Symposium of Geothermal Energy*, Belgrade, pp. 20-34 (in Serbian).

Milivojevic, M. (1997). "Ground Waters" the first book in Serbian text - book of Hydrogeology and Geoterology by Svetolik Radovanovic. In: *100 Years of Hydrogeology in Yugoslavia* (Ed. Z. Stevanovic). RGF, Belgrade, pp. 21-29.

Milivojevic, M., Martinovic, M. and Vidovic, S. (1998). State-of–the-Art of heating greenhouses with geothermal enegry in Yugoslavia. In: *Heating Greenhouses with Geothermal Energy* (Ed. Kiril Popovski & Ana Catarina Rodriges) Inst. For Innov. Tech. of Azores INOVA, Ponta Delgada (Azores, Portugal), pp. 413-424.

Milivojevic, M. and Martinovic, M. (2000*).* Geothermal energy possibilities, exploration and future prospects in Serbia. *Proceedings World Geothermal Congress 2000*, Japan, May 28-June 10, pp. 319-226.

Popovski, K. (1987). Draft state of the art on geothermal energy use in agriculture of European countries. *FAO / CNRE Workshop on Geothermal Energy Use in Agriculture*, Skoplje.

Popovski, K., Andrejevski, B., Dimitrov, K. and Popovska - Vasilevska, S. (1997). Geothermal energy use in agriculture - justification, difficulties, perspectives and

measures for the further development. In: *Geothermal Energy in Macedonia: Yes or No?* MGA, Vinica, pp. 66-80 (in Macedonian).

Radovanovic, S. (1897). *Ground Waters: aquifers, springs, wells, thermal and mineral waters*. Serbian Books Association 42, Belgrade, 152, (in Serbian).