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on Direct Application of Geothermal Energy

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GEOTHERMAL ENERGY FOR HEATING GREENHOUSES IN SERBIA

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1. INTRODUCTION

The surface of Yugoslavia is relatively small (about 80.000 km^2) but its geological and tectonic structure are very complex. Because of that, geothermal characteristics of its territory are interesting. On two thirds of Yugoslav territory values of the heat flow density are greater than average values for the continental part of Europe and on the half of the territory they are around 100 mW/m^2 (Mlivojevic, 1989). Consequently, on the territory of Yugoslavia there are more than 60 hydrogeothermal low-temperature convective systems (T<150°C) as well as enormous hydrothermal conductive system in the Yugoslav part of Pannonic basin.

The development of geothermology in Yugoslavia was established in the last century by S. Radovanovic, the first Serbian hydrogeo-logist who can be considered as the father of Serbian hydrogeology and geothermology (Radovanovic, 1897, Milivojevic, 1997).

The examining of thermal springs, which are 196 in Yugoslavia, was started more than 150 years ago. First hydrogeothermal researches were conducted between The First and Second World War in the areas of the most knownspas. First preliminary evaluation of geothermal potential was completed in 1975 (Milivojevic et al., 1975. Since then the sudden development of geothermal researches in Yugoslavia had started and lasted until 1988 when the evaluation of geothermal resources was completed (Milivojevic, 1989).

In the period of time between 1991 and 1995 geothermal researches were completely broken off due to the economic crisis caused by UN embargo. The last geothermal well was bored in the year 1991. In the last three years a lot of effort is put into continuing geothermal resear-ches but the progress is very small. Thus, since the OLTN embargo was rescinded in 1995 not a single well has been bored yet. The reasons for this are: economic crisis, the beginning of the transit process, 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 YUGOSLAVIA

In Yugoslavia geothermal energy is scarcely used in regard to her geothermal potential. The use of geothermal waters is mainly done for balneological purposes. In Yugoslavia there are 60 spas where geothermal waters are used for balneology, sports and recreational purposes. Other fields of direct uses are presented in the table I(Milivojevic et at., 1995).

The total installed energy use is 74 MWt out of which 36 MW, in balneology, and 38 MWt for other ways of energy use. According to Freeston (1995) Yugoslavia takes 17 th place in the world as far as the use of geothermal energy is concemed. That makes just about 10% of its real potential, which is estimated to about 800 MWt.

3. THE USE OF GEOTHERMAL ENERGY FOR THE HEATING OF GREENHOUSES

Ten years ago former Yugoslavia (SFRJ) was the second in Europe (not including former SSSR), just behind Hungary in the surface of the greenhouses heated by geothermal energy (Popovski, 1987), and in the year 1990 it was the fifth in the world in installed power of 111 MWt (Andrejevski, 1995). In former Yugoslavia the heating of greenhouses by geothermal energy was mostly applied in practice in 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, 1997).

Nowadays, geothermal energy is used for the heating of greenhouses only in three locali-ties in Yugoslavia: Vrnjacka Banja, Srbobran and Knjazevac (Fig. 1). The biggest greenhouse is in Vranjska Banja, and the smallest in Knjazevac. 8 ha is heated by geothermal energy while the whole surface of other greenhouses heated by crude oil and gas occupies around 64 ha.

3.1. Geothermal Energy Use for the Heating of the Greenhouses in Vrnjacka Banja

Vmjacka Banja is one of the most well-known geothermal localities in Yugoslavia for its natural geothermal resources that have the temperature of 80 - 92°C and its yield around 80 l/s. The flowing of geothermal waters is done from gneiss and granodiorite from Neogene. The spring are captured and geothermal water is taken to its users through the covered concrete canal.

Fig.1. Geographical position of greenhouses heated by geothermal energy

The users of geothermal energy are disposed in a row so that the water can be used firstly for the heating of hotels, the buildings for baineotherapy, schools, kindergartens, health centres and poultry farms and finally it can be used for the heating of two complexes of greenhouses.

The complex of greenhouses "Cvece". The surface of the greenhouses in this block is 7 ha. Its owner is the 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 temperature 75°C.

Geothermal water from is flown from the canal into the water tank. Then it is flown out of the tank into heating installations of the "old" part of the complex of greenhouses.

Transferring of geothermal water to the greenhouse is carried out through asbestos-cement pipes insulated by glass wool and the pipes are placed into a covered concrete canal. Thermal water first reaches the tank of 50 m^3. 15,2 MW is total thermal power necessary for the heating of the whole greenhouse complex which occupies around 7 ha.

With the aid of circulation pumps, thermal water is forced into the heating installlations in the "old" part of the greenhouse and drawn out of the tanks. In that way direct heating is achieved. In the "new' part of the greenhouse carried out toward a plate heat - exchanger.

Temperature of the water which en-ters

the exchanger is 75°C but when it goes out of the exit 44°C. The water which becomes colder is heated once again and after that it can be used for heating.

The system of heating is combined: soil heating installations and airal heating, i.e. aerial steel pipe heating system. Soil heating is put into effect through the polyethylene pipes of diameter 1/2" dug in the depth of 30 cm.

The regulation of temperature is mechanical i.e. by opening windows, and automatic.

Movement of the air in the greenhouse is natural and artificial caused by ventilators.

The construction of the greenhouse is of Belgium origin. Plant growing is combined on a plantation and on the benches.

Trimed flowers in flowerpots, 600.000of them in total are produced in greenhouses. The value of the whole production is around $3 * 10^6$ DEM per year.

The greenhouse Complex "Rasadnici". The surface of this greenhouse is 1,2 hectare. Their owner is the firm with the same name "Rasadnici" from Vrnjacka Banja. This green-house was the oldest greenhouse heated by geothermal energy inSerbia.

It was built in the year 1954. This is the place where the first greenhouse vegetable production (of tomato) in former Yugoslavia started.

The greenhouse is heated by geothermal water which is taken from the canal covered with concrete. That is "waste" geothermal water which comes out after having been used in the complex of greenhouses "Cvece".

Temperature of geothermal water which enters the greenhouse i from 37 to 40°C and the amount of water around 36 l/s.

Heating is performed through aerial pipes of diameter Ø 100 mm. This heating system is opened i.e. thermal water circulates through the pipes with the aid of circulation pipes directly from the canal and without an exchanger (because of that, there are certain problems with corrosion). Finally, it reaches an exit canal for the further use. In the greenhouse with this heating

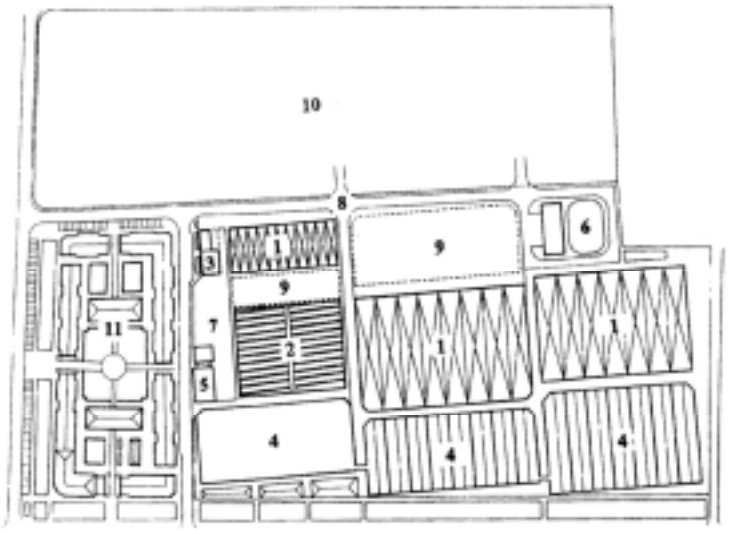

Fig. 2. The greenhouse Complex "Rasadnici (1. greenhouse, 2. nursery plant, 3. offices, 4. greenhouse first stage, 5, 6. workshop, 7, lawn, 8. road, 9. greenhouse second stage, 10. free space for future projects, 11. agro-business center).

and with outside temperature of - 10°C, inside temperature reaches 8-10°C. When outside temperature is lower than -10°C the temperature in the greenhouse is maintained by the use of heating oil. From 40 to 60 tons of heating oil are consumed during cold winters. The circulation of air in the greenhouse is natural.

The complex of greenhouses consists of differently constructed greenhouses (Fig. 2.).

The first type of construction is Russian production. It occupies 0,2 ha. The span of this construction is 6 m and its length 30 m.

The second type of construction is made by Holland and it was produced in 1964. The span of this construction is 12 m

and its length 50 m. It occupies the surface of 1 ha.

The regulation of temperature is mecha-nical. There are no problems with condensation. The hardening of glass surfaces is performed during the summer. Plant growing is combined: on a plantation and on the benches. The season starts in October, 10 and lasts until April, 15 of the next year.

Trimmed flowers and in flowerpots are grown here. The production of flowers is about 90% of the total production. 300.000 of trimmed flowers and 30.000 flowers in flowerpots are produced per year. The production is complete: from seeds to flowers. Apart from flowers, there is also a production of vegetables: 5 - 10 tons of cucumbers and 20 - 30.000 hot peppers. The total value of this production is around 350,000 DEM.

The complex of greenhouses "Elan".

This complex of greenhouses is situated next to the town called Srbobran, 100 km north of Belgrade (Fig. 1). Its owner is "Elan", the plant in Srbobran. It consists of 6 ha of the greenhouse heated by gas from the nearby gas field and 0,5 ha of the plastic building heated by geothermal water from the nearby well Sr - I /H.

The geothermal plastic building is built in the year 1982. Its producer was "Agrostroj", the finn from Ljubljana (Slovenia). Heating is carried out by 11,7 l/s of geothermal water that has temperature of 610C. The total mineralization of geothermal water is 3,67 gr/l According to its chemical composition geothermal water is HCO_3 - Na - Cl having NaCl of 1,46 gr/l. Geothermal water has a lot of gas (CH_4 and $C0_2$) i.e. 1,37 m^3 of gas/1 m^3 of water. Aquifer of geothermal water is the sand from Neogene.

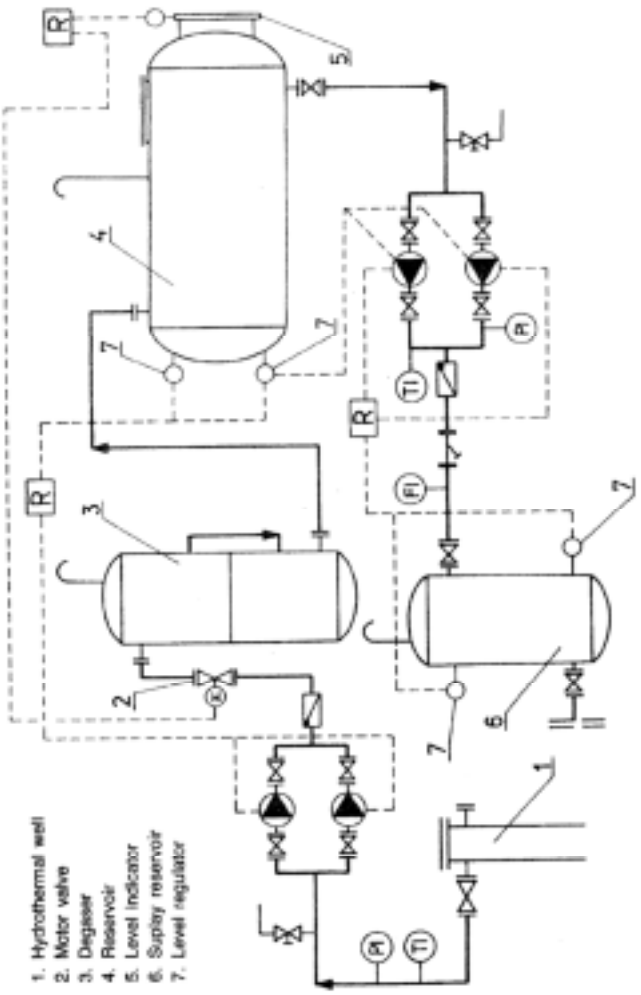

Fig.3. Well connection of the greenhouse geothermal heating system in Srbobran (“Elan”)

Because of the high percentage of gas geothermal water is degased before use (Fig.3.). The scheme of the system for taking water i. e. of its degasification is presented on picture 3. Being degassed, geothermal water is flown through the pipeline of 200 m long toward the plastic building. The circulation of geothermal water is done by pumps. 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 aluminia pipes and through a convector with 60/35°C regime and 2) by soil heating through poly-ethylene pipes with 35/25'C regime. By using this heating system when outside temperature measures -20°C we reach the temperature of 0ºC above soil. At the end, geothermal water is used for reheating of cold water from 12 °C to 20°C, which is used for watering in the, plastic building. The regulation of temperature in the plastic building is automatic. The movement of air is carried out by ventilators which are the part of calorifer. Used geothermal water is flown out of the plastic building through the opened canal into sewerage system.

The construction of the plastic building is latticed with aluminia pipes. The plastic buil-ding is 90 m tong, 48m v;ide and 3m high. Corrosion and incrustation are not apparent.

The nursery plants of cucumbers, tomatoes and lettuce are produced in this plastic building. 3 workers work in it. Total value of the production is around 30.000 DEM per year.

The complex of greenhouses in Knja-zevac. The owner of this complex is the firm named "Standard" from Knjazevac. This town is about 300 km away from Belgrade. The complex was built in 1981 and it consists of the green-house that occupies 0,027 ha and the plastic building of 0,024 ha. The manufacturer of the greenhouse was "Agroalumina", a firm from Stip (Macedonia). Karst geothermal water from upper crust limestone is used for heating. The temperature of geothermal water is from 28 to 30°C and it is drawn from a dug vertical well 14,8 m deep.

Geothermal water has the same chemical composition as drinking water (the total mine-ralization is about 0,5 gr/l, HCO_3 - Ca type) so there are no problems with corrosion and in-crustation.

Soil and aerial pipe - heating system are used. The circulation of geothermal water is done by pumps. Water is reheated by thermal pump type WTC 12 - 12 kW power which was inbuilt in 1989. The producer of this thermal pump was LTH - the firm from Skofija Loka (Slovenia). In addition to this way of air reheating they have furnaces which use solid fuel. Temperature in the greenhouse and also in the plastic building is mechanically regulated. The average temperature in the greenhouse during the winter is 10°C and in the plastic building from 15 - 18 °C. After being used geothermal water is flown into the sewerage system.

The flowers in flowerpots, about 3.000 of them and the nursery plants intended for parks, about 50.000 per year are produced in the greenhouse and in the plastic building on the plantation and on the benches. Total value of this production is around 30.000 DEM a year. 6 workers are employed here.

4. CONCLUSION

We have a satisfactory experience with geothermal energy use for the heating of greenhouses and plastic houses here in Yugo-slavia. Although that surfaces of geothermal greenhouses and plastic buildings are very small, just about 8 ha on 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 on gas or liquid fuel. However, the lack of money for building new and modem complexes of greenhouses as well as for the revitalisation of existing ones prevents the development and enlarging of these buildings. Because of the fact that geothermal resources can be immediately used if the financial problem could be solved, the surfaces of geothermal greenhouses and plastic buildings in Yugoslavia could be several hectares larger.

5. REFERIENCES

1. 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 Re-public Macedonia (Ed, K. Popovski), MAS, Skopje, 17 - 22, (in Macedonian).
2. Basic, Dj., Milosavljevic, S. and Vidovic, S.,1988. The Use of Geothermal Water of

Law Temperature and Rich in Gas, Adana (Turkey).
3. Ceman, J. and Vidovic, S., 1993. Study, Analysis and Technical Solution of Energetic Efficiency of Geothermal Water from the well Sr- I/H, NIS - Naftagas, Novi Sad, I - 56.
4. Freeston, D.H., 1995. Direct uses of geother-mal energy 1995 (preliminary review):In: Proc. World Geothermal Congress 1995, 18. 31. May, Florenz, Bd. I., S. 15 - 25, Auckland, 1995.
5. Milivojevic, M., 1989. Assessment of Geothe-rmal Resources of Serbia Excluding Autono-mous Provinces (PhD thesis), University of Belgrade, Belgrade, 458, (in Serbian).
6. Milivojevic, M. 1997. "Ground Waters" the first Book in Serbian Text - book of Hydro-leology and Geoterology by Svetolik Radova-novic. In: 100 Years of Hydrogeology in Yugoslavia (Ed. Z.Stevanovic). RGF, Belgra-de, 21 - 29.
7. 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, 20 - 34, (in Serbian).
8. Milivojevic, M. and Martinovic, M., 1995. Geothermal energy possibilities, exploration and future prospects in Serbia. World Geothermal Congress 1995, 18. - 31. May, Florenz. Unpublished.
9. Popovski, K., 1987. Draft state of the art on geothermal energy use in agriculture of Euro-pean countries. FAO/CNRE Workshop on Geothermal Energy Use in Agriculture, Skopje.
10. Popovski, K., Andrejevski, B., Dimitrov, K. and Popovska - Vasilevska, S., 1997. Geo-thermal Energy Use in Agriculture - Justifi-cation, Difficulties, Perspectives and Mea-sures for the Further development. In Geo-thermal Energy in Macedonia: Yes or No? MGA, Vinica, 66 - 80, (in Macedonian).
11. Radovanovic, S., 1897. Ground Waters: aqui-fers, springs, wells, thermal and mineral waters. Serbian Books Association 42, Belgrade, 152, (in Serbian).
12. Vidovic, S., 1995. State-of-the art and Per-spectives of Geothermal Research and Use in Serbia, DIT, Zrenjanin, 56 67, (in Serbian).