

Geothermal District Heating Systems in Slovakia – Current Status and Plans

Oto Halás

Palisády 39, 81106, Bratislava, Slovakia

oto.halas@slovgeoterm.sk

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ABSTRACT

Slovakia, a small country situated in central Europe, belongs among European countries with above-average geothermal conditions. Most of the geothermal reservoirs in the country provide geothermal brine with temperature lower than 100°C which is insufficient for efficient power generation but optimal for district heating purposes (Halás 2009). Currently, there are three geothermal district heating systems in the country, one of them in operation for more than 18 years and two of them built within last five years. Experiences obtained over the years of operation prove significant geothermal heat production and natural gas savings while the heat price is lower and more stable than in case of conventional gas boiler plants. Positive environmental impact in form of decreased CO₂ emissions is encountered as well. As a response of the positive experiences, new geothermal district heating systems in different locations are in preparation phase and two of them are planned to be built soon.

1. INTRODUCTION

Extensive geological and hydrocarbon survey works financed by the state took place in the last three decades of 20th century and good knowledge of geological conditions was acquired. Geological and geothermal data were processed, “Atlas of Geothermal Energy of Slovakia” (Franko et al. 1995) was completed and prospective areas for geothermal energy utilization were selected and described (figure 1). Utilization of geothermal energy has quite long tradition in the country, the first applications for greenhouse heating and swimming pool purposes were built in the 70’s. However, there are only three geothermal district heating systems built in the country up to now, all of them situated in Danube basin. Geothermal energy represents a base load heat source in these systems and natural gas boilers are used as a peak and backup source. Positive results obtained over the years of operation verify the conception of the projects and stimulate further development of geothermal energy utilization in district heating systems in the country.

Mass housing development which was performed in the 70’s and the 80’s of the last century was typical with centralized heating systems. Therefore there is a district heating system in almost each town in Slovakia, absolute majority of them fired by natural gas. According to the location of the country, heating period takes in average 200 day per year with average ambient air temperature approximately 4°C. Extreme winter temperatures are around -10°C while summer days with more than 35°C are not exceptional. Nowadays the efficiency and technical state of many of the existing district heating system is on the edge of acceptance and it is necessary to start reparation and reconstruction process. Within the framework of district heating reparation the local possibilities of renewable energy resources utilization must be taken into account. In selected areas, geothermal energy appears to be one of the most convenient alternative energy resources. Utilizing of available geothermal energy in a district heating system represents obtaining of stable, economical and ecological renewable energy resource (Halás 2013).

The aim of this paper is to present overview of the current state, technical solutions, operational experiences and future plans in the field of geothermal energy utilization for the purposes of district heating systems in Slovakia.

2. GEOTHERMAL DISTRICT HEATING SYSTEM IN THE TOWN OF GALANTA

In the town of Galanta, as in the first town in Slovakia, geothermal water from two wells FGG-2 and FGG-3 has been utilized for district heating purposes since 1996. Geothermal heat is being supplied into apartment houses, public service buildings and a large hospital. Parameters of geothermal wells are stated in table 1.

Table 1: Parameters of geothermal wells in the town of Galanta

Well name	Depth (m)	Aquifer rocks	Flow rate by pumping (l/s)	Temperature on the well head (°C)	Total dissolved solids (g/l)
FGG-2	2100	sandstones, sands	15.7	78	3.7
FGG-3	2100	sandstones, sands	18.0	77	5.9

Geothermal water withdrawn by line shaft pumps passes through the cascade of five plate heat exchangers installed in “Energocentre”. Plate material is titanium. Three of the heat exchangers are used for heating water and two for hot tap water. Total installed thermal output of the heat exchangers is 10.5 MW. Natural gas boilers of total installed thermal output 13.1 MW are being used as a peak and backup source. Three separate heating loops with different temperature gradient are connected to Energocentre:

- 90/70°C – radiator heating loop in the hospital
- 77/52°C – radiator heating loop in apartment buildings and public service buildings

- 52/42°C – radiant ceiling heating loop in the hospital

Exploited geothermal water passes through the series of heat exchangers and therefore optimal utilization rate is achieved with respect to the current heat demand. As it can be seen on figure 2, absolute majority of annual heat production in Energocentre is produced by geothermal energy and only negligible part is covered by natural gas boilers (only 5.5% in average of the last five years). Annual natural gas savings achieved by geothermal energy utilization is in average approximately 2.5 million m³ which leads to CO₂ emission reduction by 4700 ton per year. The heat production is therefore very economical and the heat price is approximately 30% lower than in case of natural gas fired boiler plant in the other part of the town. Slight decrease of the heat production can be observed as well, which is in accord with the general trend in Slovakia caused by installing of additional thermal insulation on the buildings and energy saving effort of customers. Thermally utilized geothermal water is being drained via 7.6 km steel pipe into Vah river, the largest Slovak river.

After 18 years of operation, it can be stated that the conception of the project was proposed properly and the geothermal system produces heat in economical and environmental friendly manner. No significant fails were encountered except of common maintenance and the whole system works reliably.

3. GEOTHERMAL DISTRICT HEATING SYSTEM IN THE TOWN OF SALA

In the year 2011, almost 15 years after Galanta, operation of geothermal district heating system in the town of Sala was commenced. New geothermal well GTS-1 was drilled (parameters in table 2), pipelines were laid and heat exchanger station was built. Geothermal energy is being utilized in large boiler plant CK31, where four natural gas boilers of 20.7 MW total thermal output are installed. The installed capacity is strongly overdesigned in relation to recent heat consumption (massive installation of external thermal insulation on apartment houses takes place here as well) and significantly lower heat outputs are needed even in extremely cold period. Designed temperature gradient of heating loop is 100/50°C but most of the year lower return heating water temperature is being achieved. The distribution network supplies by heat 82 pressure independent heat exchanger stations situated in apartment and public service buildings. Geothermal well GTS-1 is located approximately 200 m west of the boiler plant. Geothermal water is transported via preinsulated pipeline to heat exchanger station placed in the boiler plant site. Two stages of direct geothermal water utilization via plate heat exchanger are implemented: in the first stage return heating water is being warmed up; in the second stage water of heat pump evaporator loop is being warmed up while the heat pump warms up the return heating water. Parameters of the mentioned devices are stated in table 3. Geothermal energy combined with heat pump presents base load heat source, while natural gas boilers are used as a peak load source or back up source. Thermally used geothermal brine is drained via 800 m long plastic pipeline into Vah river.

Table 2: Parameters of geothermal well in the town of Sala

Well name	Depth (m)	Aquifer rocks	Flow rate by pumping (l/s)	Temperature on the well head (°C)	Total dissolved solids (g/l)
GTS-1	1800	sandstones, sands	15	73	5.2

Table 3: Thermal outputs of devices installed in the boiler plant CK31 in the town of Sala

Site name	1 st stage geothermal heat exchanger (MW)	2 nd stage heat geothermal exchanger (MW)	Heat pump (MW)
CK31	1.3	0.5	0.6

As depicted on figure 3, with respect to the parameters of current district heating system and local geothermal conditions, geothermal energy covers in average 27.6% of overall heat production. Installed heat pump covers in average 6.0% and the natural gas boilers are still the most important heat source with contribution of 66.4% in average. However, annual natural gas savings by geothermal energy utilization in average of approximately 0.8 million m³ and subsequent CO₂ emission reduction of 1600 ton per year are notable.

4. GEOTHERMAL DISTRICT HEATING SYSTEM IN THE TOWN OF SERED

In the town of Sered, the advantage of geothermal energy is taken since 2012. New geothermal well SEG-1 was drilled (parameters in table 4). Geothermal heat exchanger station was built in medium size boiler plant K5, where four natural gas boilers of 8.7 MW total thermal output are originally installed. The installed capacity is similarly as in Sala overdesigned and substantially lower heat outputs are needed throughout whole year. Designed temperature gradient of heating water is 65/45°C. The distribution network supplies by heat 20 pressure dependent heat exchanger stations situated in apartment and public service buildings with more than 960 apartments. Geothermal well SEG-1 is located approximately 300 m south of the boiler plant. Geothermal water is transported via preinsulated pipeline to the heat exchanger station placed in boiler plant site. Two stages of direct geothermal water utilization are implemented: in the first stage return heating water is being warmed up; in the second stage water of heat pump evaporator loop is being warmed up while the heat pump warms up the return heating water. In addition, natural gas fired cogeneration unit producing heat for the network and electricity mainly for own consumption is installed. Parameters of the mentioned devices are stated in Table 5. Altogether four types of heat source are installed. Geothermal energy and heat pump present base load heat source, while the natural gas boilers are used as a peak load source or back up source. Thermally used geothermal brine is drained via 400 m long plastic pipeline into the Vah river.

Table 4: Parameters of geothermal well in the town of Sered

Well name	Depth (m)	Aquifer rocks	Flow rate by pumping (l/s)	Temperature on the well head (°C)	Total dissolved solids (g/l)
SEG-1	1800	sandstones, sands	8	66	5.1

Table 5: Thermal outputs of devices installed in the boiler plant K5 in the town of Sered

Site name	1 st stage geothermal heat exchanger (MW)	2 nd stage heat geothermal exchanger (MW)	Heat pump (MW)	Natural gas fires cogeneration unit (MW)
K5	0.6	0.5	0.6	0.25

Contribution of geothermal energy to the overall annual heat production in K5 boiler plant (figure 4) is in average 37.7%, the heat pump covers 26.6% and the cogeneration unit 11.0%. Rest of the annual heat production (27.0%) is supplied by the original gas boilers. Geothermal energy utilization enabled to achieve natural gas savings of 0.5 million m³ per year in average and adequate CO₂ emission reduction of 1000 ton per year.

5. PLANNED GEOTHERMAL DISTRICT HEATING SYSTEM IN THE TOWN OF VELKY MEDER

Vely Meder geothermal project counts with complex reconstruction of existing district heating systems consisting of union of two distribution networks, centralization of the heat source and replacement of distribution pipelines. New production geothermal well must be drilled, its expected parameters based on available geological data are stated in table 6. Since there is no river with sufficient flow in the vicinity, reinjection well has to be drilled too and all utilized geothermal water must be injected back to aquifer.

Table 5: Expected parameters of planned production geothermal well in the town of Velky Meder

Well name	Depth (m)	Aquifer rocks	Flow rate by pumping (l/s)	Temperature on the well head (°C)	Total dissolved solids (g/l)
VM-1	2500	sandstones, sands	10	85	10.0

Of actual annual heat production in existing boiler plants around 15000 MWh, up to 62% can be supplied by geothermal energy (9300 MWh). The rest will be covered by natural gas boilers. Natural gas savings of approximately 1.1 million m³ per year and CO₂ emission reduction of 2100 ton per year are expected.

Complete project documentation of the geothermal district heating system in the town of Velky Meder was elaborated and all required permissions were obtained. Drilling company was tendered and bank loan was arranged. Currently, final decision of the investor is being awaited to start the implementation of the project.

6. PLANNED GEOTHERMAL DISTRICT HEATING SYSTEM IN THE TOWN OF KOSICE

A substantial hydro-geothermal reservoir is situated in the neighborhood of the town of Kosice, the second largest town in Slovakia. Three geothermal wells drilled at the end of the last century confirmed very high potential of the location and brought geothermal water of temperature up to 135°C at flow rate of 55 l/s from each well. Due to high flow rates and chemical composition of the water, reinjection is the ultimate condition. Works on the project are in the process since the completion of the wells, however several unexpected complications, mainly of administrative character, were met over the years. Nowadays, drilling of five new wells in two geothermal centers is planned in order to supply geothermal heat to the extensive combined heat plant in the town of Kosice. Implementation of heat exchanger stations in the geothermal centers and main pipeline to Kosice must be carried out. Planned thermal output of geothermal resource is 60 MW and annual heat production of 250000 MWh is presumed in the first stage of the project. Possibility of power generation via binary power plants based on organic Rankine cycle is being examined too. Significant steps were done in recent time period and implementation of the project is expected in the nearest future.

7. CONCLUSIONS

Above-average occurrence of geothermal resources in Slovakia, their good exploration and existence of many extensive district heating systems represent good conditions for implementation of geothermal projects focused on space heating in the towns. Geothermal energy is environmentally friendly, local and stable renewable energy resource which is independent on climatic and market conditions. Implemented geothermal district heating systems prove expected natural gas savings and CO₂ emission reduction, while the heat price is favourable in comparison with conventional heat sources.

Rising prices of natural gas is a strong motivation for heat producers and for the municipalities to support and develop geothermal projects. Moreover, existing geothermal projects in Galanta, Sala and Sered confirm, that well designed and implemented projects are economically feasible without any subsidy. Hopefully, after good experience with the projects in operation, planned new geothermal district heating systems in Slovakia will be implemented soon.

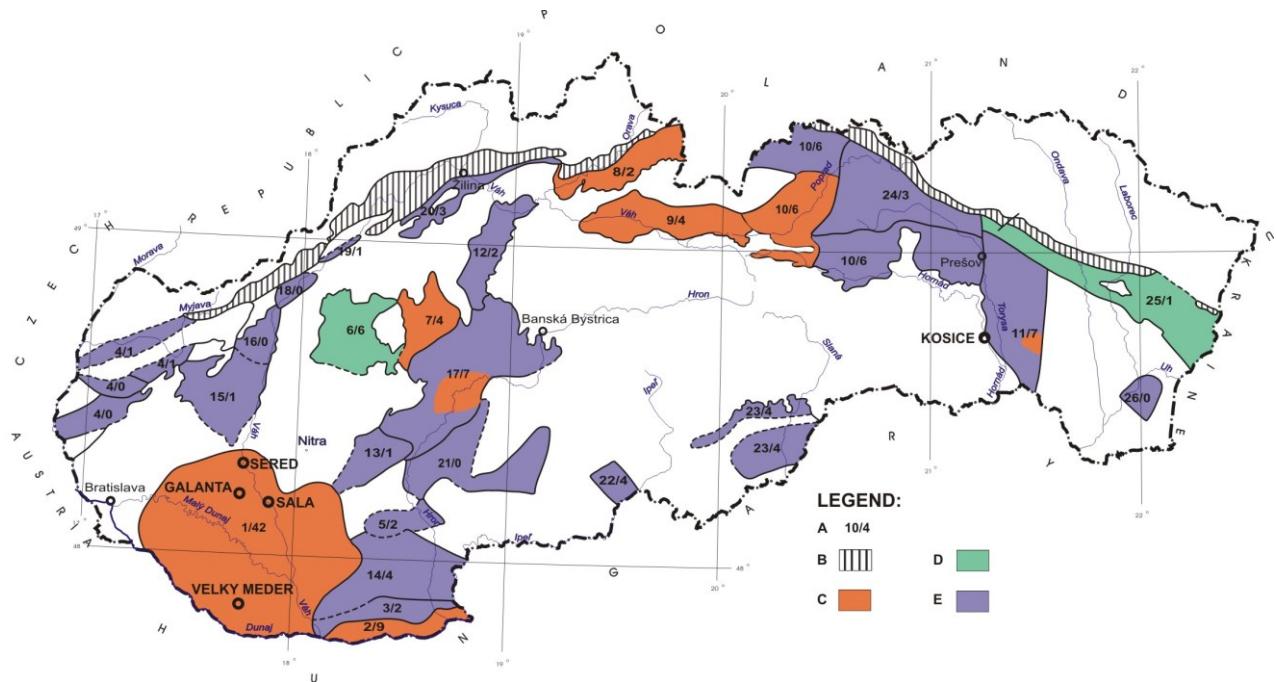


Figure 1: Prospective geothermal areas and structures in Slovakia. Towns with implemented or planned geothermal district heating systems are marked. Legend: 1 – serial number of the prospective area or structure/number of drilled geothermal wells, 2 – Klippen Belt, 3 – Prospective areas with geothermal water verified by wells, 4 – prospective areas geologically assessed for the purpose of prospecting and exploration of geothermal waters, 5 - prospective area with assumed occurrence of geothermal waters (based on general knowledge of geological conditions). (Fendek et al. 2005)

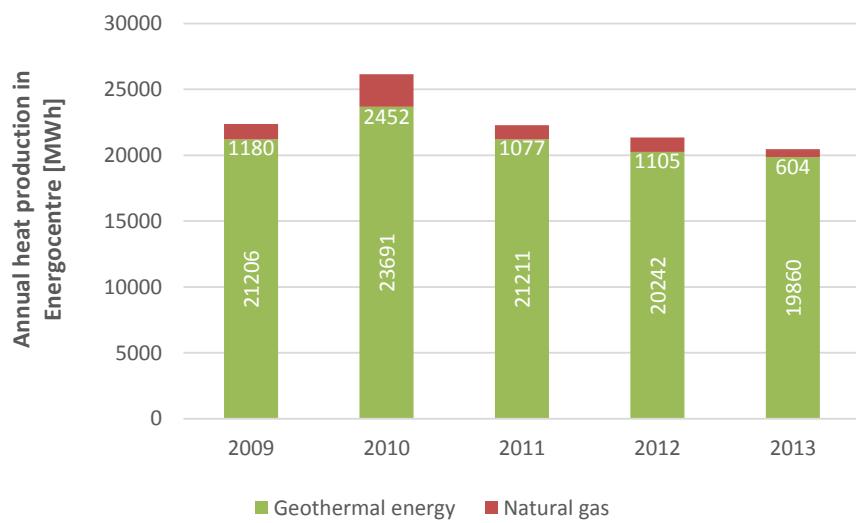


Figure 2: Chart of annual heat production in Energocentre in Galanta. Contribution of each of the heat source is distinguished and specified.

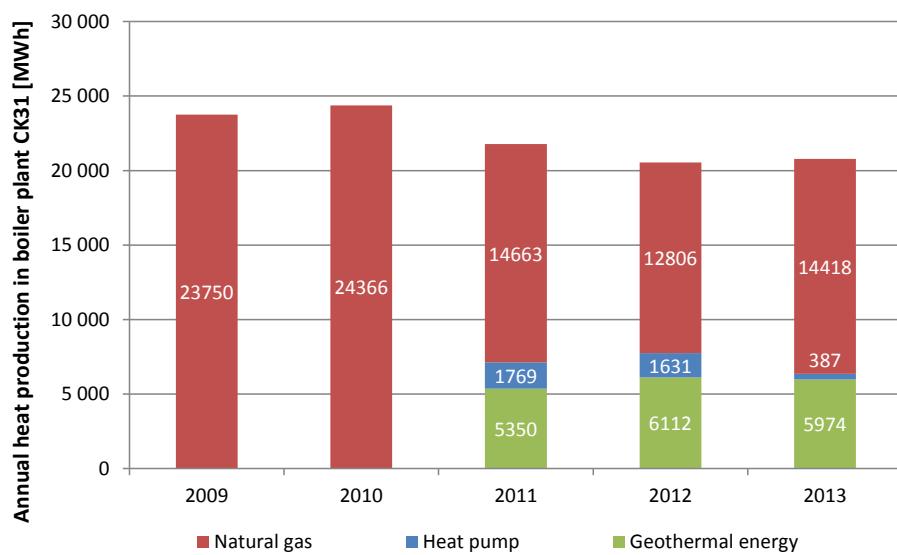


Figure 3: Chart of annual heat production in CK31 in Sala. Contribution of each of the heat sources is distinguished and specified.

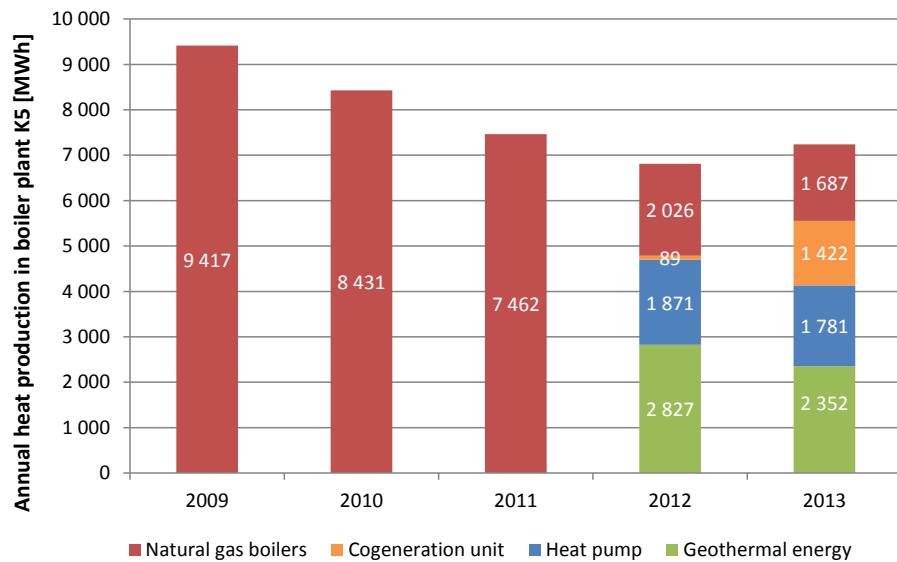


Figure 4: Chart of annual heat production in K5 in Sered. Contribution of each of the heat sources is distinguished and specified.

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