Open indirect district heating system on the territory of Bogatic - DARLINGe project pilot area

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ABSTRACT

With the aim of increasing energy efficiency and sustainable development of geothermal energy along with the tendency toward increasing the share of geothermal resources primarily within the heating sector in a way that would reduce the dependence on the fossil fuels with the good benefits to the environment, the realization of the DARLINGe project (Danube Region Leading in Geothermal Energy) is taking place. Within the Project area there are three defined pilot areas which actually represent transboundary geothermal reservoir areas, and it is envisaged to test in the areas now tools that would increase the use of geothermal energy and help the development of energy efficient cascade systems in general. One of these three areas is Bogatic pilot area and here is formed a transboundary geothermal reservoir within the Triassic limestones. The entire pilot area includes western parts of Macva (SRB) and eastern parts of Semberija (B&H). In this pilot area the realization of the district heating system is currently under way, projected in the variant of bivalence as indirect, open geothermal system with cascade use. The installed thermal power of the district geothermal heating system is 2.1 MW. The estimated thermal potential of the resource at the exit point from the collecting pipeline is about 2.8 MW.

1. INTRODUCTION

The main principle of using geothermal energy for the sake of heating system, just like with any other renewable energy source, is to meet the baseload, whereas the consumption peaks can be met by using fossil fuels. According to the experiences of both Central and Eastern Europe, within geothermal systems 60% of heating needs in the course of heating season is met out of geothermal sources (Eliasson et al., 2003), whereas the remaining part is covered by using fossil fuels or some other renewable energy source.

Thanks to technologies development, geothermal district heating (GeoDH) systems in Europe are on an ascending path. Among 5,000 district heating systems in Europe, 240 are geothermal DH (GEODH) with great potential for developing, using both high enthalpy resources as well as shallow geothermal resources. Serbia, especially northern part of the country, which belongs to Pannonian basin, has favourable geothermal conditions that can be used for heating. The total heat capacity of all geothermal wells in Serbia is assumed on about 188 MWth, out of which 80.3 MWth are in Pannonian basin. Most of the thermal waters are used for balneological purposes in spas (55.6MWth installed capacity and 258,4 GWth/y production). The direct heat use in agriculture (16,95 MWth/82,88 GWth/y) and for space heating with heat exchangers and heat pumps (53,64 MWth/231,25 GWth/y) are considerable, however there are significant still untapped resources (Oudech & Djokić, 2015).

Actions for "pushing" geothermal energy use forward are absolutely necessary, taking into consideration some of indicators as disproportion between potential and usage. According to Milenic et al. (2016) total geothermal potential of Serbian part of Pannonian basin is about to be 243 Mtoe, while current usage is reaching about 0.001 Mtoe. Despite of good geothermal potential and good technical preconditions for GeoDH (19 cities on the territory of the Serbian part of Pannonian basin have district heating systems with installed capacity of 1.200 MW) geothermal resources are not used in that kind of systems yet. DARLINGe project (Figure 1) main objectives are very based on resolving forementioned issues: to promote sustainable utilization of the existing, untapped deep geothermal resources; to contribute to energy security by increasing the use of geothermal energy in the heating sector and to help the penetration of energy efficient cascade systems.

The optimization of the system for the production of heat energy out of geothermal resources is an approach with multiple benefits both on the side of resources as well as on the side of potential investors and end users. One of the ways to increase the efficiency and cost-effectiveness of the system is the application of the cascade use concept which implies several stages of usage which are conditioned by different temperature degrees and according to that by different end users with different temperature requirements. The principle of multi-stage geothermal energy exploitation has been applied to the study example of the district heating system of public utility buildings in Bogatic where it is envisaged to use geothermal resources of low enthalpy within the open indirect system. At the same time, this is the first geothermal district heating system built ever since in Serbia.

Figure 1: DARLINGe project area with three cross-border pilot zones

2. METHODOLOGY

2.1 Geological and geothermal characteristics

The area of Bogatic is located in the border area of central Serbia, within the region of Macva. The entire pilot area includes western parts of Macva (SRB) and eastern parts of Semberija (B&H), and these are recognized as some of very potential areas in terms of geothermal energy and this is additionally indicated by high values of terrestrial heat flow (95-112 mW/m^2), as well as by the results of the geothermal wells drilled up to now.

The geothermal reservoir is formed within the basin basement formations, called “basement reservoirs” (BM) and in the territory of Bogatic it is represented by karstified limestones and dolomites of Triassic age with rather good hydraulic features. The upper layer of the reservoir is represented by Tertiary sediments (Bogatic and its wider surroundings), Upper Cretaceous marl, clay and sandstone, meta-sandstone and meta-alevrolites which have an insulating role. In certain areas, in this part of the reservoir, there is also Upper Cretaceous limestone (BiH). The bottom of the reservoir is built of Paleozoic shales. The thermal source is represented by Tertiary granitoids. The temperature of the surface of the reservoir ranges within the scale from 35 to 78 ^{0}C. Due to lithostratigraphic and hydraulic characteristics, this joint geothermal system can be seen as a complex (Figure 2), especially in terms of geothermal reservoir management in the future. One of the main challenges is sustainability in exploitation under different conditions from both sides of this transboundary reservoir.

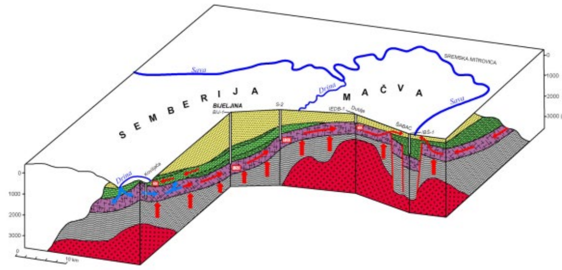

Figure 2: Hydrogeothermal model sheme od the transboundary geothermal aquifer (after Martinovic, 2008)

2.2 Mehodology and Concept of the Geothermal District heating in Bogatic

The formation of the concept and methodology of research was directly linked with the subject issue of constructing a geothermal district heating system in the area of Bogatic, and this conditioned an integrated approach as well as parallel conduction of researches in terms of defining the available amount of energy, energetic requirements of the facilities and the means of transportation of the resource to its end users. Projecting the geothermal district heating system is based on the already existant geothermal wells in the area of Bogatic which have never been exploited up to now.

Potential users were analysed within the frame of public utility facilities whereas the residential and other purpose objects were not subjected to this analysis. Overall, seven objects were analysed and the analysis included: the location of the object in comparison to other objects which are the subject of the analysis, whether there are interior installations and what kind they are, temperature regime of heating and heat losses (needs in terms of thermal energy). Table 1 is showing the main calculations of the necessary heating power of the chosen public utility facilities in the area of Bogatic.

Table 1: Thermal power calculation for the selected public buildings in Bogatic

Object	Installed capacity (kW)	estimated capacity (kW)	$t_{inl.}$ (^{0}C)	$t_{out.}$ (^{0}C)	Q (kW)	Q (l/s)
No.1	200	152	70	50	152	1.8
No.2	880	668.8	70	50	669	8.0
No.3	440	334.4	70	50	334	4.0
No.4,5	800	486.4	70	50	486	5.8
No.6	18	14.4	70	50	144	0.2
No.7	700	448	70	50	448	5.3
Total	**3038**	**2104**				**25.1**

The district heating system was projected in the variant of bivalence as indirect, open geothermal system with cascade use. The installed thermal power of the district geothermal heating system is 2.1 MW.

The system will supply with thermal energy seven public utility objects in the following regime: primary 75/55°C; secondary 70/50°C.

The choice of the pipes for the future heating system route of the geothermal district heating system in Bogatic has been performed in such a way as to meet the main condition, which is the reliability and safety in terms of temperature and resource amounts losses. The supply pipeline is built out of pre-isolated pipes from networked polyethylene (Figure 3). Thanks to their longitudinal firm mechanically connected components, these pipes are self-compensating. The structure of the pipes, which is longitudinally watertight, locally restricts the water leaks at the damaged pipe covers. In that way, heat losses are locally restricted. At the supply route with the length of 2.5 km, the expected heat losses do not exceed 1°C. At the exit point of the collecting pipeline, the expected water temperature is 50°C with the yield of 25 l/s. The estimated thermal potential of the resource at the exit point from the collecting pipeline is about 2.8 MW.

Further (cascade) use of the resource is envisaged for various purposes such as heating the central square and supplying the future residential/commercial zone with thermal energy. The condition for a cascade system is the existence of objects which use low-temperature installations (floor heating, wall heating, or fan-coil devices).

Figure 3: Construction of the GeoDH system in Bogatic; operation on the well head; pipe line

3. CONCLUSIONS

In the area of Bogatic geothermal district heating system is projected in the variant of bivalence as indirect, open geothermal system with cascade use. Geothermal resources are formed within Triassic limestones, distributed beyond state borders, representing typical transboundary aquifer. The installed thermal power of the district geothermal heating system is 2.1 MW. The estimated thermal potential of the resource at the exit point from the collecting pipeline is about 2.8 MW, ready for various purposes such as heating the central square and supplying the future residential/commercial zone with thermal energy.

The turnover period for the investment is 4-5 years, depending on the relevant year for which the calculations are made, that is the duration of the heating season and the amount of spent fossil fuels. By substituting fossil energy sources with geothermal energy, there will also be savings of the CO_2 emissions, of at least 1000 t per year.

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