Assessment of thermal water utilization in the southern part of the Pannonian basin

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ABSTRACT

The paper presents the current exploitation practice of thermal waters with outflow temperature above 30 °C in the wider Pannonian basin region, in the six neighbouring countries. As much as 767 geothermal sources are identified, highlighting the great potential for even more extensive geothermal heat production. However, lack of reinjection is evident and, currently, it is difficult to treat existent practice as sustainable. The comparison has showed that observed variations in exploitation are also a consequence of different legislation procedures, requirements and supports in these countries, and much can be done to enhance the geothermal heat production in the next years simply by promoting the sustainable use of existing wells.

1. INTRODUCTION

The Pannonian transboundary sedimentary basin has a huge geothermal potential for direct use of thermal water (Horváth et al. 2015, Nádor et al. 2012, Tóth et al. 2016, and many others). Many utilization sites have been reported (Rman et al. 2015) but with prevalent use in bathing and balneology. Quantification of worldwide use of geothermal energy is prepared every five years at the World Geothermal Congress (Lund et al. 2016) and in recent years such overview is prepared also for the European Geological Congress. However, this summary approach does not account for reservoir properties or distinguishes among their hydraulic potentials, therefore it is not sufficient when preparing strategies for enhanced exploitation of geothermal aquifers. The most recent activities for evaluation of the current thermal water exploitation in the wider Pannonian basin region were performed in the year 2018 within the Interreg Danube Transnational Programme project DARLINGe. A reliable quantification of current situation is presented in this paper, to set ambitious yet reliable targets in action plans which will be developed using the Transnational Danube Region Geothermal Strategy in 2019.

2. METHODOLOGY

We assessed various utilisation practices between countries and reservoirs, which may reduce operational issues for new investments. The sandy intercalations possessing high permeability represent the main geothermal aquifers in the region (Nádor et al. 2012), referred to as the Pannonian-Pontian or Upper Pannonian clastic aquifer. This 100-300 m thick sandy sequence occurs at depths to about 2 km in the deepest parts of the basin, where the temperature reaches up to 90 °C. The second important type of geothermal aquifers occurs in the karstified Paleozoic-Mesozoic carbonates and fractured zones of the crystalline rocks in the basement of the sedimentary basin. They are characterized by high secondary porosity where the reservoir temperature can exceed 100-120 °C due to greater depths. Some minor Miocene sandstone and carbonate geothermal aquifers capping the basements highs are also known. In this paper, the term "basin-fill reservoir (BF)" stands for Lower and Upper Pannonian reservoirs with intergranular porosity, while the term "Basement reservoir (BM)" stands for all fissured, fractured, karstified and dual porosity basement and Middle-Miocene reservoirs.

Utilization data on thermal waters were collected from the N-ern parts of Bosnia and Herzegovina, Serbia and Croatia, S-ern parts of Hungary, W-ern parts of Romania, and NE-ern parts of Slovenia, altogether from an area of about 99,347 km^2. The selection criteria were: i) Outflow water temperature of 30 °C and above, ii) Active production or reinjection of thermal water, even if no exploitation permit is granted, iii) Inactive wells were included if they had an exploitation permit or belonged to a national monitoring network. We also evaluated discrepancy among actual and licenced production rates in order to assess environmental and legislative risks for new investments. The reference year for which data was collected was mostly 2015, but if available, more recent information was accounted for.

3. RESULTS

The overview identified 767 geothermal sources (only a few springs, Table 1), resulting in an average distribution density of 7.7 sources per 1000 km^2.

Table 1: Geothermal objects by countries

Country	No. of objects
BA	10 wells
HR	6 springs and 21 wells
HU	606 wells
RO	55 wells
RS	1 spring and 24 wells
SI	44 wells
TOTAL	767 objects

In total, 93% of these are intended for thermal water production (Figure 1) and, of these, at least 29% are being exploited for thermal water, 14% are inactive, while no information on the activity of the remaining 56% was available. About 5% of sources are reinjection wells. The average well depth is approximately 1145 m.

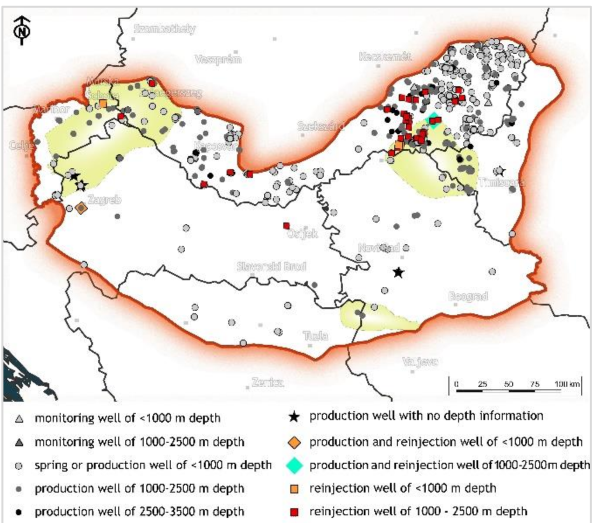

Figure 1: Objects' drilling purpose and operational depths for 767 objects

About 13% of wells are younger than 10 years, with an additional 17% aged under 30 years, while 26% are over 50 years old (Figure 2). The lifespan of geothermal wells is usually about 30 years and only about 29% of wells are younger than this. This indicates that a large capital investment needed to drill such wells is acceptable from a long-term perspective, but also that some of the wells may be approaching their final stages of operation. The number of new wells put in operation has been decreasing in the region since 2008, which alarms for new support to investors and maintenance of the existing ones. These facts indicate that it will be necessary to promote new investments into geothermal wells in order to retain total capacity in the region in long-term.

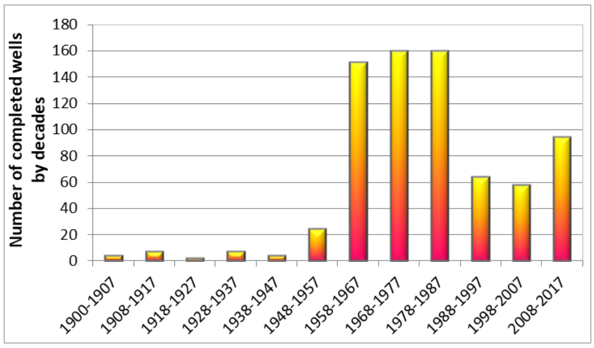

Figure 2: Number of completed wells by decades

The average outflow temperature shows that 36% of the sources have temperatures below 40 °C while 50% of the sources have temperatures below 50 °C (Figure 3). The highest measured temperature reached 101 °C in Hungary. This means that half of the listed sources are more than favourable for geothermal heat production. The temperature range is 30-75 °C in Bosnia and Hercegovina, 32-97 °C in Croatia, 25 °C (originally 30 °C)-101 °C in Hungary, 29-85 °C in Romania, 25 °C (originally 31 °C) -72 °C in Serbia, and 30-75 °C in Slovenia. The highest temperatures of above 80 °C are mostly reported in Hungary, and to a lesser extent in Croatia and Romania. This confirms a very favourable potential for geothermal heat production.

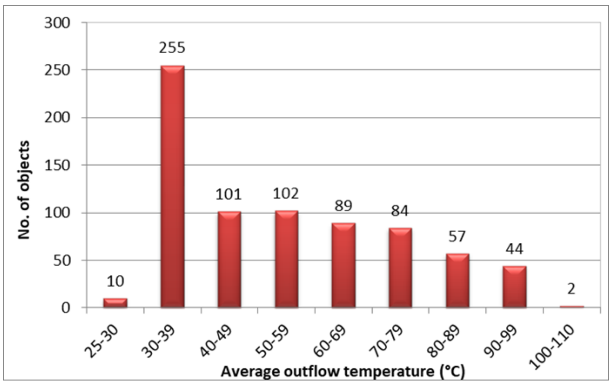

Figure 3: Distribution of average outflow temperatures of 744 geothermal objects

Among reservoir types, the porous basin-fill and the Pannonian delta slope reservoirs significantly predominate over the fissured/karstified basement (Figure 4), Badenian and Sarmatian reservoirs, as almost 6 times more sources produce thermal water from these types of sources. It should be noted that there are some wells in the Badenian, Sarmatian and Lower Pannonian, too, which were attributed to both types and will be further classified and described within the pilot area study.

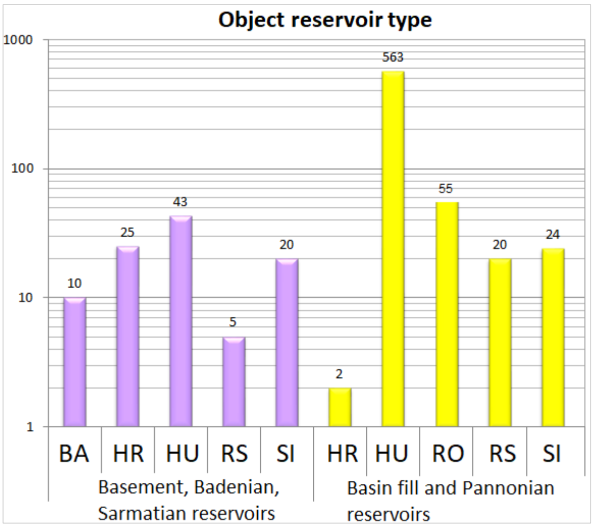

Figure 4: Identified reservoir types for 767 objects with the numbers of object in each type

Bathing and balneological use is prevalent with 24% of all geothermal sources; however, only 15% of these have also heating systems applied (Figure 5). Next, 16% of all sources are those with different types of heating, of which a total of 13 wells produce water for district heating and 3 for individual space heating. An additional 9% are intended for agricultural use, dominantly (greenhouse) heating. The 5% appertains to reinjection wells. Mostly in Hungary, drinking water (17%), industrial use (5%) and monitoring wells (2%) are also common.

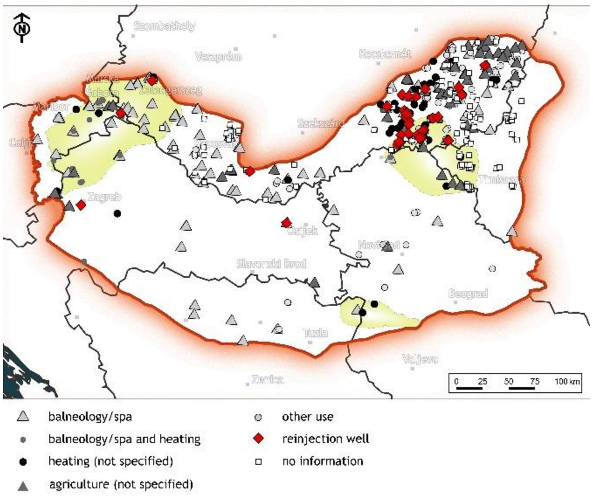

Figure 5: Generalised utilisation types for 668 active sources or sources with no information on activity. Heating includes district heating, sanitary water heating and individual space heating. Agriculture includes also heating of greenhouses. Other use stands mostly for industrial use and monitoring wells.

Regarding granted permits, water rights prevail in Croatia, Hungary, and Slovenia, geothermal rights in Serbia, and mining rights in Bosnia and Hercegovina and Romania. In total, 72% have water rights, 18% have no information on permits, 6% have mining rights, 2% geothermal rights, and 1% have no rights granted.

Production information was only available for 62% of the sources, and it amounted to (at least) $40 \cdot 106$ m^3 per year, of which 85% was exploited from basin-fill and Pannonian reservoirs. In total, 72% of the sources have been granted water rights, 6% mining rights, 2% geothermal rights, 1% no rights, while for the rest no information on permits is available. The licensed maximum annual production gives even higher quantities – $62.3 \cdot 106$ m^3 per year (55% of the data available), of which 70% may be produced by basin-fill and Pannonian reservoirs. No precise data is available for licenced reinjection quantities except for a well in Slovenia with a granted amount of $1 \cdot 106$ m^3 per year for reinjection.

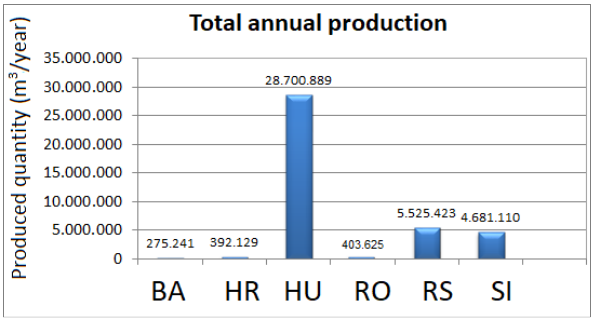

Figure 6: Annual production quantity per countries. Notice that 90% of the objects had production information in BA, 19% in HR, 55% in HU, 96% in RS, 29% in RO and all in SI.

3. CONCLUSIONS

In general, it was very difficult to collect up-to-date production information from official databases, if they even existed. In most countries, the exploitation data is reported per-partes to several authorities (e.g. environmental, economy, financial, energy… agencies) and therefore it is not possible to get a fast and reliable overview on actual production characteristics of geothermal wells and their impacts on the environment.

There is also a general issue of public inavailability of the concession information. Whereas, for example, well's names, coordinates, licenced production rates and purpose of water use are public information in

Slovenia, it is very hard to get the information whether a concession was even granted in some countries.

Which is most important is that this overview confirmed the large geothermal potential of the Pannonian basin and pointed out that a significant development in geothermal heat use can be achieved already by using the existing geothermal objects and flow rates, also by applying a higher efficiency of heat abstraction.

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