Danube Region Geothermal Strategy and information system to support the decarbonisation of the heating sector

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ABSTRACT

A joint transnational strategy elaborated together by 6 countries (HU, SLO, HR, BH, SRB and RO) supporting the enhanced use of the existing, however still largely untapped deep geothermal energy resources in the heating sector is one of the key-outputs of the DARLINGe project working at the S-ern part of the Pannonian Basin. The Strategy is based on the comprehensive assessment and SWOT analysis of detailed investigation of state-of-art conditions (including technical and non-technical themes) performed on the entire project area. This paper summarizes two key areas of the entire Strategy focussing on methods and results of matching the resources with heat demands; and dissemination of results on the Danube Region Geothermal Information Platform (DRGIP), a web-based interactive portal with the ultimate goal to show all evaluated and processed technical and non-technical information in a user-friendly way, demand-tailored to stakeholders needs.

1. INTRODUCTION

The Pannonian Basin extending across nine countries in Central and Eastern Europe is well-known of its positive geothermal anomaly (heat flow density with a mean value of 90-100 mW/m^2, geothermal gradient of about 45°C/km) (Hurter and Haenel, 2002; Lenkey et al., 2002; Horváth et al., 2015) coupled with favourable geological-hydrogeological conditions (e.g. extensive and productive aquifers at depth of 1000-2000 m) and long-lasting thermal water production history. This could make the region - especially its S-ern part where geothermal conditions are the best - attractive for investors. Nevertheless so far relatively little attention was paid to these areas at global levels, which is partly due to the lack of international publications and information available from this region. Furthermore the enhanced use of geothermal energy could have a significant role in the decarbonisation of the heating sector in the region, which is mostly fossil based (coal and gas) at the moment, fed by import sources, thus making these countries' energy supply vulnerable.

The DARLINGe project (http://www.interreg-danube.eu/approved-projects/darlinge) is a milestone in making up this deficiency with the ultimate goal to provide the very first time a comprehensive assessment (both the technical and non-technical aspects) of the existing, however still largely untapped deep geothermal resources at the S-ern part of the Pannonian basin in order to raise the decision makers' awareness on the advantages of its enhanced utilization. The 95,000 km^2 large project area covers southern Hungary (southern Transdanubia and southern part of the Great Plain), northeastern Slovenia (Pomurska and Podravska), northern Croatia (Slavonia), the northern parts of Bosnia and

Herzegovina, northern Serbia (Vojvodina) and western Romania (Crisana and Banat) (Fig. 1).

Figure 1: Location of the DARLINGe project area at the S-ern part of the Pannonian Basin. Bright green areas refer to three cross-border pilot areas

The Danube Region Transnational Strategy jointly elaborated by the six participating countries is based on the key results of detailed investigations that were performed on the entire project area covering key topics, such as the assessment of the geothermal potential with a strong emphasis on transboundary reservoirs, evaluation of current thermal water uses and some best practices (including their technical-operational issues), overview of the national energy strategies and regulatory frameworks, available financial incentives, as well as heat market analyses and data policies. Based on a broad consensus and discussion with key stakeholders, the Strategy is considered as an important step towards the Danube Region's transformation into a low-carbon economy.

The full Strategy (Nádor et al. 2018b) contains many statements that are generally valid for the entire geothermal sector in Europe, therefore in the following we focus only on those key conclusions that are specific for the studied region.

1. POLICY FRAMEWORK

Conclusions are based on the detailed overview of the national (renewable) energy policies (Medgyes et al. 2017) and of the regulatory frameworks of the partner countries with a strong focus on licensing procedures (Balan and Nádor 2018). These studies revealed that at national level all DARLINGe countries have common goals regarding the aims of their energy strategies (mostly addressing security of supply, competitiveness, sustainability / environmental protection, increasing energy efficiency and the share of renewables). Nevertheless geothermal energy per se is either not mentioned at all when speaking of the increasing role of renewables in the heating and cooling sector (e.g. Serbia, Bosnia and Herzegovina) despite the favourable potentials, or the NREAP target numbers are growing slower, than expected. Biomass and wind (and solar in some cases) are the preferred RES in this region.

Regarding the regulatory framework of geothermal energy utilization in the DARLINGe countries, a strength is that geothermal resources are state owned and their use is well regulated (harmonized with EU legislation) and is possible only based on licences issued by various authorities. Nevertheless the main weakness is that all countries lack a comprehensive geothermal regulatory framework, the licensing procedures are complex, lengthy and far too administrative (like in most European countries). Laws are often changing, in many cases they are far from real situations, so it is impossible to apply them efficiently, and contain many exemptions which make possible their vague and different interpretation by different authorities. Furthermore laws are adapted slowly, and the changing political support, as well as the passivity of decision makers often impedes the uptake of geothermal (renewable) projects.

The depicted future vision is in line with many recommendations already made at European level (e.g. EGEC 2015). At first place we must emphasize the importance of a responsive policy environment. The essential role of geothermal energy in the European /Danube Region energy transition has to be recognized: a clear political objective and structural reforms are necessary to move forward replacing natural gas and/or coal with geothermal energy that should have a more articulated role in the national energy strategies. A robust and reliable governance framework, including sound planning and steady deployment trajectories is needed.

It is important to ensure that streamlining and improving a time-effective permitting granting processes is performed in accordance with existing EU legislation. The establishment of a competent authority integrating or coordinating all permit granting processes ('one-stop-shop') should reduce complexity, increase efficiency and transparency of licensing procedures. Administrative procedures for geothermal licensing have to be fit to purpose - they should be streamlined wherever possible and the burden on the applicant should reflect the complexity, cost and potential impacts of the proposed geothermal project. However the more efficient administrative procedures should not compromise the high standards for protection of the environment and public participation.

Transparency is still an issue in many DARLINGe countries, so it is recommended that information should be publicly available on the licensed objects [names of wells and springs, location (at least the nearest settlement if not coordinates), purpose of use, licenced quantity]. It is also recommended that the official time for a decision on granting the licence after the submitted application is complete should be shorter than 2 months.

2. GEOTHERMAL RESOURCES AND UTILIZATIONS

Although the Pannonian basin is cited as one of the regions with best geothermal potentials in Europe, there are many exaggerating estimations on its resources without sound verifications, which might result in unrealistic expectations. Another important gap is that geothermal potential assessments generally exist at national levels and do not take into consideration the transboundary character of most of the geothermal reservoirs (bordered by geological structures cut-cross by country borders).

A science-based approach and novel methodology based on the combination of the bounding surfaces of the respective geological units and a set of isotherms showing the subsurface temperature distribution has been developed earlier to delineate and characterize such transboundary reservoirs in the Pannoninan basin (Rotár Szalkai et al. 2017). These methods have been further improved and applied in the DARLINGe project territory, by identifying 2 main types of reservoirs: (1) geothermal aquifers within the thick porous basin fill sedimentary sequence (called “basin fill – BF reservoirs”), and the (2) geothermal aquifers associated with fractured, karstified zones of the carbonate and crystalline rocks forming the basement of the Pannonian sedimentary basin (called “basement – BM reservoirs”). The major progress was achieved in developing a simplified conductive model for the entire region and in elaborating a method for quantifying the exploitable heat represented by the heat content of the fluids stored in the effective pore space (“moveable fluid”), calculated by a Monte Carlo method (Rotár-Szalkai et al. 2018, Nádor et al. in press). The results of these methods are suitable for regional assessments, i.e. differentiating between non-prosperous and prosperous areas and as a method can serve an example for other territories. The delineated reservoirs and their calculated heat content underpin the project area’s great potential for space and district heating, especially in the temperature interval of 50-75°C.

However such regional assessments covering territories of more than one country can be done only on the basis of harmonized geoscientific data and their joint interpretation. During DARLINGe work it was found that there is a large number of geological, hydrogeological and geothermal data (drillings, seismic sections, etc.) available in the project area, also partly deriving from the long-lasting hydrocarbon exploration in the region, which assures a good level of geological knowledge, therefore a relatively low-level of exploration risk. Nevertheless it has to be highlighted, that many of these data are old (more than 30 years), acquired by old methods, therefore their reliability has to be handled with great care. Furthermore, a large heterogeneity characterizes the project area (i.e. areas with extremely dense data compared to “white spots”).

Thermal water exploitation have long-lasting traditions at the S-ern part of the Pannonian basin, which was also proven by identifying 767 geothermal objects (mostly thermal water wells) on the project area, of which 51% have outflow temperature higher than 50 °C (Rman et al. 2017). Although the natural recharge conditions of this large sedimentary basin are very good, concentrated areas with thermal water abstraction coupled with insufficient reinjection lead to overexploitation in certain regions - to pressure drops and lowering of the hydraulic heads. As the project area is characterized by large-scale regional (thermal) groundwater flow systems, the unfavourable effects may impact distant areas as well.

Unfortunately reinjection is a rare practice in the DARLINGe region, therefore fostering its application is one of the project’s key messages. As reinjection has some technical limits in porous aquifers / basin fill reservoirs (e.g. clogging of the pore spaces) DARLINGe recommendations consider reinjection very good if at least 80% of the used water is reinjected into the same aquifer, and good if this ratio is above 60%. In fractured (mostly basement) reservoirs a 100% reinjection rate is technically feasible and recommended (Nádor et al. 2018a).

The long-lasting and voluminous thermal water abstraction warns for the need of a science-based management of the geothermal aquifers to assure sustainable production levels. DARLINGe recommendations for such key indicators are the critical water level (below which water level should not decrease during production compared to the original pre-exploitation potential), or the maximum allowed amount of abstracted fluid. The concrete values for these measures (which can vary from region to region depending on the local geological-hydrogeological conditions) can be defined by regional transient hydrogeological models calibrated on the water level of monitoring wells further from the production sites. These measures are important indicators to alarm for overexploitation.

Monitoring and appropriate reporting is essential to follow the productions and their effects, According to DARLINGe recommendations active monitoring (reported by the users to the relevant national authorities) should include the regular measurements of the cumulative quantity of the abstracted water, the discharge rate, the piezometric level, the outflow water temperature, as well as chemical analyses. This should be complemented by passive monitoring which exists only in Hungary and Slovenia at the moment among the DARLINGe countries. A passive monitoring network is composed of wells drilled or adjusted for the purpose of monitoring, where the wells are placed sufficiently far away from the active production zones to observe the background and boundary conditions of the regional thermal water system. Measurements and reporting are done by the relevant authorities, state organizations.

In addition to the above summarized aspects concentrating on the good status and long-term productivity of the geothermal aquifers / reservoirs, the other group of recommendations are focused on utilisation efficiency. Similarly to the basic principles of energy savings ("the cheapest energy is that one which is not used"), the more efficient use of the already exploited geothermal fluids makes unnecessary to produce additional amounts of thermal water, thus avoiding overexploitation.

At the moment the lack (low number) of cascade uses and the high outlet temperature of the used thermal water underpin the general existence of non energy-efficient systems in the DARLINGe countries. According to our recommendations cascade use is considered very good, if there are at least 3 successive stages of energy extraction, the water is not mixed with cold water prior to use (e.g. when letting into pools) and there is no surplus of unused heat at the end of the utilisation chain: waste water temperature is close to the ambient fresh groundwater temperature (12 °C) (Nádor et al. 2018a).

Cascade systems or individual uses should be assessed by their thermal efficiency and utilisation efficiency. Thermal efficiency is related to the ratio of the temperature difference between the outflow and waste water temperatures, and the temperature difference between the outflow and the ambient temperature (12 °C). According to DARLINGe recommendations thermal efficiency is considered good above 60% and very good above 70%. This can be achieved – among others – by maximizing the extraction of heat (by heat pumps) even from each energy extraction stage (temperature interval).

Utilisation efficiency describes the ratio of the average annual water production to the maximum water quantity that could be theoretically produced (i.e. the licenced allowed maximum production). DARLINGe recommendations for a good utilisation efficiency are above 45%, whilst for the very good category above 60%.

3. HEAT DEMANDS AND HEAT MARKETS

It does not matter how rich geothermal resources are available, as heat cannot be transported on longer distances, if there are no sizeable heat markets near to the resource, there is no real potential to develop direct use projects. Therefore DARLINGe put special emphasize on heat market studies in order to match the resources and the demands.

In the project area all six countries have some similarities in their geographical, geological, economic and social parameters. The southern part of the Pannonian Basin is sparsely populated compared to the western regions of Europe, and its economy as well as its infrastructure is also less developed. The heat demand of the population is mainly covered by the burning of non-renewable energy sources, mostly coal and natural gas. Renewables have a low share in production, biomass burning, water power plants and solar collectors cover about 10% of the total energy needs, whilst the contribution of geothermal is minimal.

In terms of heat market conditions, the DARLINGe project area has several strengths and opportunities to build on. There are a significant number of cities and towns accommodating nearly two-third of the area's total population, which represent a considerable heat demand. On the project area there are 92 cities which have population above 15 000. Inherited from the communist era, when district heating was extremely popular, altogether 74 settlements were identified on the DARLINGe area with existing DH infrastructure although much of them are obsolete and need renovation / modernization. Nevertheless they represent a potential future market (where suitable reservoirs area available) to switch to geothermal.

The towns, especially the smaller ones are also suitable (in case of available resources) for "thermal water town heating" systems, where a specially established thermal water pipeline provides the heat for the main buildings in the city centres (e.g. Town Hall, school, hospital, library, etc.). On the DARLINGe project area several such heating systems already exist and serve as good examples for other municipalities willing to invest into RES / geothermal projects.

Another important segments of the potential heat market are those cities – altogether 46 on the project area – where thermal water is already in use, e.g. for balneology. In these areas the additional use of thermal energy for heating of nearby buildings is a significant unexploited potential. The other advantage of such sites is that the resource is already proven (well is drilled), which eliminates a major part of cost and risk of project development.

Finally we have to highlight that on the DARLINGe area altogether 58 settlements signed the Convenant of Mayors committing themselves to significant CO_2 reductions. In their SECAP-s many of these cities/villages articulate the role of geothermal energy as an option to make their settlements greener.

As large territories of the DARLINGe project are typical agricultural regions, these areas also represent potential heat markets for a wide range of application of geothermal heat (e.g. greenhouses, plastic tents, stables, drying of products, hatcheries, soil heating, fish farming, etc.).

Regarding costs and economics, we can conclude that developing geothermal projects in this region is cheaper compared to other parts of Europe due to lower costs (cheaper drilling-, labour-, service costs).

It is necessary to supervise the currently existing pricing of geothermal heat production in the DARLINGe countries. Thermal water production – if it happens for direct heat purposes – often suffer double taxation, i.e. the user has to pay water fee after the abstracted amount of water and mining royalty for the exploited heat amount from the same fluid. Furthermore if the spent geothermal water is not reinjected, the wastewater fee is also higher. These costs put extra burden on thermal water producers for energy purposes (in comparison to balneological use) and should be terminated.

As it has been stated many times, the main financial barrier of geothermal projects is the lack of capital for drilling the first well in a phase when there is still a reasonable chance of complete failing of the project. The combination of high upfront investment cost and the geological risk in the same time makes almost impossible to finance these projects on pure market conditions. This is especially true for the DARLINGe countries, which represent juvenile geothermal markets. Some regularly available direct investment subsidies exist in each country, but they cannot solve the major problem above, because they are repayable if the project is unsuccessful. The establishment of a European geological risk mitigation scheme for geothermal projects has been a key issue for several years and now is addressed by the ongoing GeoRISK project. GeoRISK has strong links to DARLINGe and the potential establishment of a regional risk mitigation scheme for the Pannonian Basin is an option with the advantage of pooling resources by a larger number of projects from several countries, therefore fragmenting the risk.

4. DATA POLICY AND THE DANUBE REGION GEOTHERMAL INFORMATION PLATFORM (DRGIP)

Rich information in the form of various scientific and technical datasets, publications are available in general on the geothermal energy potential and its utilisation in the DARLINGe countries. However these are fragmented in terms of contents, formats and their geographical coverage, and most often available only in national languages, seldom accessible to the public. Data accessibility in general varies a lot in the DARLINGe countries: due national regulations, different levels of digital maturity as well as IPR and confidentiality issues data availability vary from data provider to data provider, who often has their own data sharing concepts and services, and hence each designs and builds its own information system independently. Some organisations focus more on data protection rather than on data use and reuse.

Only a few systematic databases exist and most of the data are scattered, so an organized collection on any segment of geothermal energy use in this geographical area is a big challenge. Furthermore as the INSPIRE Directive focuses on the Member States, it remains difficult to find comparative data and statistics covering the candidate countries and countries in accession (in DARLINGe this is the case for Serbia and Bosnia and Herzegovina).

Therefore creating harmonised / cross-border datasets which is one of the ultimate goal of the DARLINGe project still remains a matter of pilot activity rather than a full-scale implementation.

However the utilisation of state-of-the-art technologies in combination with user-guided implementation and present-day advances in data standardisation and interoperability is a big opportunity in maximizing use of data for better policy making.

In the past few years several EU funded projects aimed to provide pooled knowledge and data sharing services where geothermal information can be accessed, retrieved and queried to support geothermal projects development. One of the pioneering work was the concept of the European Geothermal Information Platform- EGIP (http://egip.igg.cnr.it/) prepared in the frame of the Geothermal ERANET project in 2013, which was designed as a distributed system: each (national) data provider delivers its data according to a common standard data model and services (INSPIRE compliant).

Inspired by EGIP, one of the main aims of the DARLINGe project was also to establish an entry point to advance collaboration, and facilitate exchange of methods and ideas between those working in the field of geothermal energy in the Danube Region, to integrate and harmonise geological, hydrogeological, geothermal- and to some extent other technical information and services. This is called the Danube Region Geothermal Information Platform - DRGIP, which can be also considered as a pilot of the EGIP. In short, the DRGIP is a data infrastructure that provides data- and information services, as well as core services allowing discovery, access, validation and download of data and information and maintenance of the system. It follows an open-access policy, meaning that no user authentication is required and that the content enabled by DARLINGe is accessible by accepting only the general terms and conditions of the data providing institutions.

DRGIP has two main parts: a web-map viewer where all spatially referenced data are visualized, such as identified geothermal objects (767, most of them are wells) together with their data (coordinates, depth, utilization, outflow temperature, basic chemistry, etc.), contours of identified geothermal reservoirs (all types and categories), as well as characteristic geological cross sections. It also contains the thematic of heat demand showing cities in the following categories:

- potential cities (cities where thermal water is already used, i.e. geothermal resources are confirmed, and there is a potential for future additional use
- cities where geothermal district heating systems are in operation
- cities where district heating infrastructure is available
- cities that joined the Covenant of Mayors

• cities with inhabitants more than 15 000 people

During the interactive visualization the different city categories summarized above can be combined with the extension of the potential geothermal reservoirs of different temperature categories, thus the target audience (especially mayors and project developers) can see the best places for future development. The module makes possible all different queries.

In addition to this main part DRGIP also comprises so called “thematic modules” such as the following:

LEGISLATION – the module provides an easy overview (“traffic light system” approach) on the geothermal legislation of the 6 countries by comparing answers to 25 questions on geothermal legislation, where countries having the same answer appear in the same colour. In addition this module provides flow charts on licensing procedures for each country, complemented by the contact information of the relevant authorities.

BENCHMARKING – this module provides a graphical comparison of 12 individual benchmark indicators describing various management, technology and energy, as well as environmental and social aspects of thermal water uses tested on 3 cross-border pilot areas. The module makes possible an interactive comparison of:

• indicators within a pilot area

• indicators among countries

• countries within a pilot area according to different indicators

• any individual comparisons according to interest

DECISION TREE – this module takes the interested end-users through the steps of project development in four key areas: (1) resources (exploration), (2) licencing, (3) market and (4) funding opportunities, showing all decision gates (based on yes-no answers) till the successful realization of a geothermal project.

RISK MITIGATION – this module summarizes all possible risk events, amending activities, mitigation measures and timing characteristic for deep geothermal direct use projects on the DARLINGe area.

GLOSSARY – this module explains briefly the most commonly used technical terms in the field of geothermal energy for the general public

LIBRARY – this module is a systematic collection of geothermal literature in the DARLINGe countries (at the moment contains 189 items), continuously expanding, also with a functionality for search for certain geographical regions.

The DRGIP portal is accessible at: www.darlinge.eu and will operate with full functionality from September 2019.

5. CONCLUSIONS

The DARLINGe project’s ultimate objective has been to improve energy security and efficiency in the Danube Region by promoting the sustainable utilization of the existing, however still largely untapped deep geothermal resources in the heating sector at the S-ern part of the Pannonian Basin, covering areas of Hungary, Slovenia, Croatia, Serbia, Bosnia and Herzegovina and Romania.

The presented Danube Region Transnational Strategy aims to provide a firm science-based policy support for the decarbonisation of the heating sector by fostering the use of the rich geothermal energy assets of the area. The focus was put on matching the resources and the demand. Novel methods were elaborated for the delineation and potential assessment of large transboundary geothermal reservoirs, which were than coupled with the main heat demand centres, represented by various categories of cities.

Different indicators were elaborated and recommendations were made for the sustainable use of the reservoirs, especially to avoid overexploitation, which is an existing threat due to the large number of the already existing uses.

Regarding data policy in the region, one can conclude that although a lot of data exist on geothermal energy in various national repositories, they are fragmented and hard to access as Open Data policy is still underdeveloped.

All results are summarized on the Danube Region Geothermal Information Platform (DRGIP), which is an open access interactive web-portal with a map viewer and several thematic modules making a wide range of queries and visualizations possible.

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