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Shallow Geothermal in the Danube Region: Serbia's Priorities and Actions

Davor Končalović, Vladimir Vukašinović, Dušan Gordić, Mladen Josijević, Filip Nastić, Dubravka Živković

Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia

Abstract **-** Heating and cooling account for nearly half of Europe's final energy consumption, with approximately 75% still relying on fossil fuels. Decarbonisation of this sector is therefore critical for the continent's climate neutrality. This paper analyses the obstacles and possible pathways to broader implementation of shallow geothermal energy (SGE) utilisation in Danube region and in Serbia. The research was conducted for the purpose of producing a document titled Transnational Action Plan (TAP), which was developed within the framework of the Interreg Danube GeoHeCo project. Two major types of shallow geothermal energy exploitation are examined: (i) closed-loop and open-loop ground source heat pump systems exploiting shallow geological layers up to 400 m depth, and (ii) wastewater heat recovery systems using high-temperature water source heat pumps without additional drilling. Based on national geological, regulatory, and market data, the paper identifies structural barriers and proposes targeted measures for accelerating the deployment of this source of energy. All proposed measures are divided into 5 priorities: Resources and regulations; Technology and design; Education and training; Financing and Awareness raising.

Index Terms – Shallow geothermal energy, Renewable energy sources, Energy transition, Danube region

I INTRODUCTION

Heating and cooling represent approximately 50% of total final energy consumption in Europe, with fossil fuels dominating the sector [1]. Serbia reflects this European pattern, with a high share of coal and natural gas in both electricity generation and district heating systems. Cooling relies almost entirely on electricity.

Space heating in individual households with their own heat source the situation is even more carbon intensive than average. The main sources of heating energy are wood biomass (64.2%), electricity (17.3%), gaseous fuels (12.6%), and other sources (3.8%), which include coal, fuel oil, wind, solar, and geothermal energy [2]. On top of that, it is unofficially known that citizens in Serbia also use various types of solid waste, such as waste oils, textiles, etc. is illegally used as an energy source, especially in the case of low-income households [3]. Furthermore, the stoves and boilers used in the households category are often outdated, unmaintained, or inadequately maintained, with efficiency estimated under 40% [4]. It should also be noted that this combination of used fuels and combustion inefficiencies, in addition to carbon intensity, also results in a very high level of local pollutants emitted (particles, VOCs, soot, heavy metals, etc). Correspondingly, Serbia was ranked as the 5th most polluted country in Europe in 2019 [5], whose capital city's annual mean PM2.5 concentration is almost 4 times higher than World Health Organization's limit [6].

The above leads us to the conclusion that, in the case of Serbia, the energy transition is an imperative both, from the standpoint of local pollution levels, and from the climate emergency standpoint. Furthermore, the focus, should certainly be on the combination of space heating and space cooling, since both are carbon-intensive and with adequate combination of technology and energy efficiency measures could be improved simultaneously. The mentioned Western Balkan countries (including Serbia) are making progress when it comes to policy and law framework toward energy transition, but unfortunately without significant results [7].

When considering technologies that are mature, widely available, and suitable for large-scale decarbonisation of the heating sector, heat pumps in general and especially shallow geothermal energy (SGE) are the technologies that cannot be ignored [8]. In addition to the listed, the mentioned technologies can be characterized as technologies that:

- Have potential to reduce our dependence on fossil fuels [9];
- Can reduce greenhouse gas emissions, (GS)HP combined with renewable energy sources (RES) is practically the only (non-passive) technology available on the market that can be used for the decarbonisation of cooling [10];
- Can improve energy efficiency and save on heating/cooling bills;
- Have a long life and will work well independently of daytime and weather circumstances;
- Are applicable for industry and district heating systems.
- If widely used, it will result in job creation.

There are also shortcomings or challenges of GSHP, such as:

- Relatively high upfront cost;
- Requires adequate geological circumstances (high thermal conductivity and diffusivity);
- Requires an available area for the placement/drilling of geothermal probes;
- The problems with overcooling of the ground in case of heating without cooling can arise;
- A water-sourced heat pump requires a stable, high-yield source of groundwater or surface water;

- A water-sourced heat pump may face environmental restrictions, relatively high upfront investment costs due to underground water piping, and, in the case of a cold-water-based system, drilling of production and reinjection cold-water wells.

In the framework of Interreg Danube GeoHeCo, the following two applications of this technology have been considered:

- Exploitation of geothermal energy stored in shallow geological layers requiring geothermal heat pump systems. Such shallow layers are from 1.5 m up to 400 m depth and can be utilised with closed-loop ground source heat pump (GSHP) and open-loop groundwater heat pump (GWHP) systems for heating and cooling.
- Utilisation of geothermal waste heat without additional extraction of thermal water and with no need for drilling geothermal wellbores. In this case, a special open-loop water source heat pump (high-temperature WSHP) system is necessary to exploit the heat potential.

Within the Danube region, SGE represents a locally available and technically mature renewable solution. The Transnational Action Plan (TAP) developed within the scope of the Interreg Danube GeoHeCo project provides a coordinated framework for accelerating its uptake. This paper reviews Serbia's specific geological, regulatory, and market conditions developed within the TAP, thus proposing applicable measures.

Although Serbia possesses favourable geothermal gradients and extensive hydrogeological resources, shallow geothermal energy deployment remains limited and fragmented [11], so we can look at this technology as one whose mass expansion is yet to come.

The specificity of the Republic of Serbia is the low share of renewable energy sources (excluding hydropower) in the overall energy mix and the relative delay in the energy transition compared to other countries participating in the project. On the other hand, the lack of transparency in the implementation of certain renewable energy projects in the recent past in the Republic of Serbia has repeatedly caused public distrust, resistance, and outrage. Hence, the authors believe that the wider use of geothermal energy at the state level should be approached with special caution, as transparently as possible, and with strict compliance with legal regulations. Otherwise, the sustainability of projects that are yet to come could be jeopardized.

At the level of the countries participating in the project, it was proposed that coordinated regulatory simplification, demonstration projects, financial instruments, and institutional strengthening are required to unlock its potential, while taking extensive care of (control) mechanisms that should provide transparency, compliance with legal norms, and genuine, not formal, care for the environment.

II State of Shallow Geothermal Energy in Serbia

A Geological potential

Northern Serbia lies within the Pannonian Basin, characterised by above-average geothermal gradients between 0.04 and 0.07 °C/m. Numerous hydrogeothermal wells exist, mainly drilled for balneological or agricultural purposes, with outlet temperatures typically between 20°C and 40°C. Terrestrial heat flow map of Serbia indicates that under most of Serbia values of heat flow are higher (100-120 mW/m^2) than the average of 60 mW/m^2 for the rest of Europe [12]

The mentioned Country Report for Serbia confirms:

- More than 60 hydrogeothermal systems are currently in use (mainly spas, greenhouses and recreational facilities);
- Significant underutilised shallow potential for heat pump-based applications;
- Absence of a comprehensive national shallow geothermal database;
- Since there is no comprehensive geothermal database, as well as possible existence of projects that were carried out without proper permits, sources on the number of installed geothermal heat pumps vary significantly, depending on publishing date and the data available to the authors. For example, number varies between 775 in 2016 of which closed loop vertical systems make up 2% and water-source units 98% according to [13] and 1005 in 2022 according to [14]. Other sources and various EU projects implemented in the previous decade are reporting different numbers of installed geothermal units in the Republic of Serbia [15–17];
- The technical potential for SGE in Serbia significantly exceeds current utilisation levels.

Shallow geothermal systems in Serbia are legally defined up to 400 m depth under the Mining and Geological Exploration Act [18]. Applications primarily rely on ground and water-sourced heat pumps, which extract stable ground or groundwater temperatures for heating and, less often, for cooling.

When observing the state of the existing market, we can notice:

- Dominance of small-scale private investments and mid- to large-scale company/corporate investments;
- Absence of large public demonstration projects;
- No SGE-based district heating network.

Compared with countries from the Danube region, such as Austria and Slovenia, where heat pump deployment is strongly supported by subsidy schemes and regulatory simplification, Serbia remains in an early development phase.

B Closed-loop systems

Within the installed SGE capacities in Serbia, the heat pump equipped with closed-loop borehole heat exchangers is the dominant technology. Typical borehole depths for residential and commercial buildings range from 80 to 150 m. Ground temperatures in shallow layers remain stable at approximately 11–13°C, enabling yearlong efficient operation.

These systems are technically well-suited for:

- Both heating and cooling for residential, public buildings (schools, healthcare facilities), and commercial/office buildings;
- Combination with (existing) district heating.

However, the combination of high upfront cost (drilling) and relatively low price of electricity and/or natural gas limits wider market uptake by giving priority to cheaper technologies with

lower efficiency and/or higher environmental footprint, such as:

- Air source heat pumps (combined with PV solar energy);
- Natural gas boilers combined with a split air conditioner (also potentially combined with PV solar energy);
- Other sources of heating energy that are often completely unacceptable from an environmental perspective, such as unsustainably harvested wooden biomass, different kinds of waste, etc.

C Open-loop and wastewater systems

Open-loop groundwater heat pumps demonstrate high efficiency, particularly in the Pannonian Basin, where hydrogeological conditions are favourable.

The Serbia Country Report, developed within the mentioned Interreg project, highlights significant but largely unused potential for wastewater heat recovery in urban centres such as Belgrade and Novi Sad, and other cities. Wastewater temperatures in municipal systems remain sufficiently high year-round to enable efficient heat pump operation, yet no large-scale wastewater heat recovery projects are currently implemented.

III The structure of the proposed Transnational Action Plan (Priorities and Interventions)

The TAP priorities are organised by thematic areas (Figure 1), each addressing a specific challenge with proposed solutions implemented through defined actions. These actions include both transnational and national components involving all project partner countries.

The TAP defines five strategic priorities, each directly relevant to Serbia: Resources and regulation; Technology and demonstration; Education and training; Financing mechanisms; and Awareness raising. Each strategic priority has a certain number of Areas of Intervention (AOI). Each AOI has one or more Strategic Actions (SA).

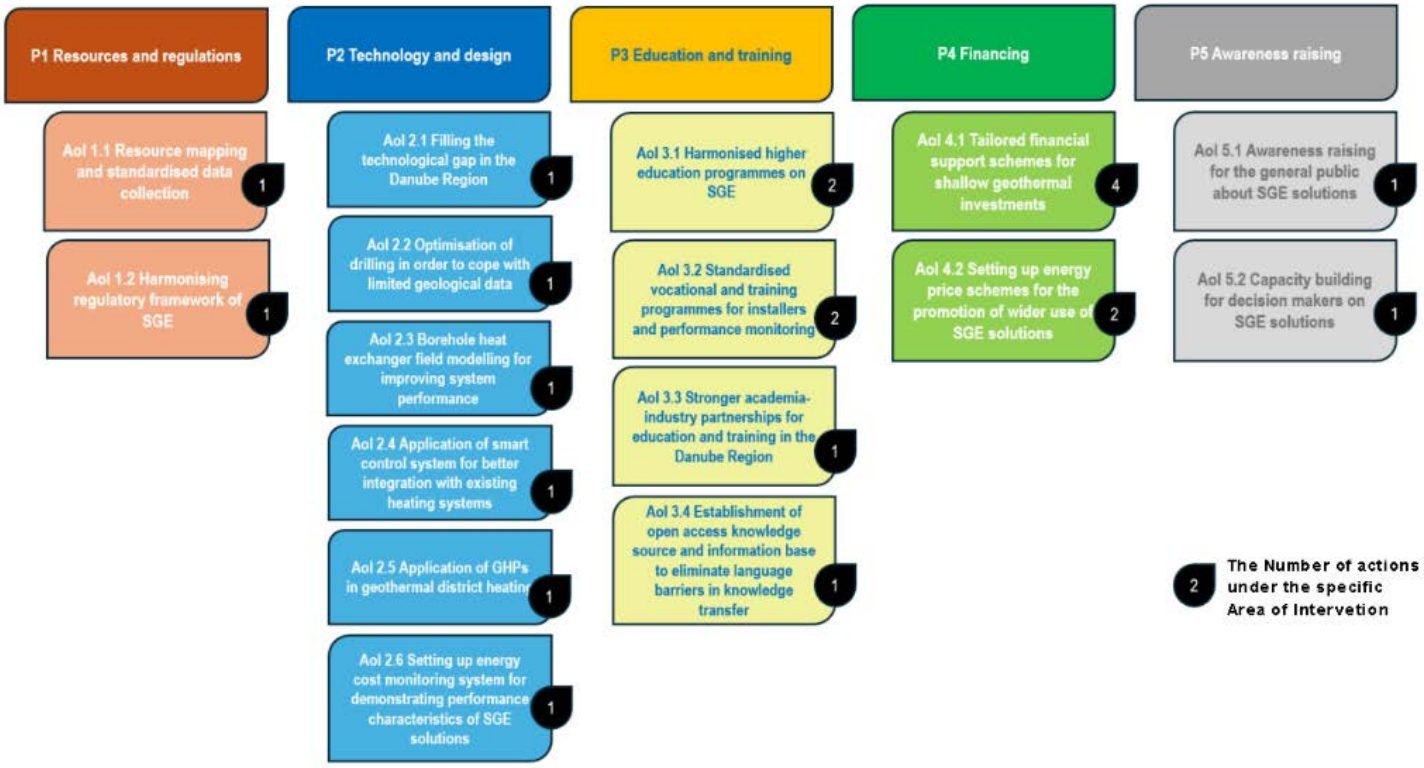

Figure 1. The structure of the proposed Transnational Action Plan

Each Strategic Action outlines activities, key stakeholders, potential funding sources, expected outputs, and an estimated budget. The implementation period runs from 2026 to 2035, with some SA starting immediately, some concluding by 2030, and others beginning in the next programming period (2028) and continuing until 2035.

In the following text, all five strategic priorities will be explained in more detail.

A. Resources and Regulation

AOI 1.1: Resource Mapping and Standardized Data Collection

One of the identified obstacles to the SGE expansion in the Danube Region is the lack of consistent, high-resolution resource data. Available data are often outdated or fragmented across different national bodies. This intervention aims to bridge this gap by implementing transnational standardization of data collection related to geological, operational, and energy performance metrics in accordance with the FAIR (Findable, Accessible, Interoperable, and Reusable) principles. For Serbia, which is in part located within the geologically favourable Pannonian Basin, this action is particularly significant. Proposed activities include research into local hydrogeological conditions and the development of national geothermal zoning maps for the

classification of soil and rock types. By providing structured, geological data, the plan facilitates more accurate feasibility assessments for SGE development, thereby reducing the research risks related to the implementation of the SGE in the region.

AOI 1.2: Harmonising the regulatory framework of SGE

Regulatory administrative complexity and heterogeneity represent significant non-technical barriers to the adoption of SGE, often resulting in lengthy and/or non-straightforward permitting processes. This intervention focuses on harmonizing the regulatory framework by establishing a transnational working group to develop a common vocabulary and a policy document containing concrete recommendations for the standardization of licensing procedures. In the Serbian context, this intervention highlights the necessity of harmonizing national legislation with the EU regulatory framework. Such alignment has been identified as a prerequisite for Serbia to access specialized EU funds and to ensure the operationalization of cross-border energy cooperation. The proposed intervention advocates a gap analysis of the existing Serbian legislation in order to adopt missing regulations and clarify institutional responsibilities, potentially through specific bylaws for SGE.

B. Technology and Design

AOI 2.1: Filling the technological gap in the Danube Region

Despite the technical/geological potential of the region, there is a significant gap in design practice, performance monitoring, and the application of modern modelling tools. This intervention proposes a “quadruple helix” cooperation model – involving the public sector, academia, innovative enterprises, and NGOs – to launch joint research and development projects focused on tailored technical solutions, such as large-scale heat pumps and life cycle assessment (LCA) methodologies. For Serbia, the plan highlights the use of pre-accession funds to support these technological developments. Key activities include the procurement of advanced design software/tools, which will enable the universities to perform accurate simulation and planning. Furthermore, the establishment of national pilot projects, with one specifically designated for each partner country, including Serbia, will serve as a demonstration of hybrid and bivalent energy-emission systems for different building types, stimulating local innovation and technical competence.

AOI 2.2: Optimisation of drilling in order to cope with limited geological data

Suboptimal well sizing due to insufficient high-resolution geological mapping often leads to poor system performance and increased installation costs. This AOI addresses these challenges by promoting hybrid drilling techniques that combine rotary and percussive methods, particularly adapted to the heterogeneous soils – including clay, gravel, and sand – prevalent in the Danube Basin. Serbia, as a partner country, is participating in the development of a Transnational Guideline on Shallow Geothermal Drilling and the creation of a digital platform for the exchange of drilling case studies. To accomplish this, AOI is proposing the establishment of regional drilling laboratories at universities to test new materials and methodologies. What could be relevant for the Serbian market is that these efforts aim to provide drilling companies and designers with the optimized tools necessary to improve the cost-effectiveness and long-term reliability of borehole heat exchanger systems, even in areas where subsurface data is currently limited.

AOI 2.3: Borehole heat exchanger field modelling for improving system performance

In densely populated urban areas, the risk of thermal interference between adjacent SGE systems can seriously compromise long-term efficiency. This intervention prioritizes the implementation of transnational modelling and optimization for BHE fields to ensure sustainable heat extraction and injection. The plan specifically identifies Belgrade as one of the key urban centres where high-density heating demand requires sophisticated modelling to prevent thermal depletion of the ground. Proposed activities include standardization of thermal response tests (TRT) and development of a common framework for modelling that accounts for urban heat islands and specific hydrogeological conditions. By enhancing the capacity for precise field modelling, this action ensures that large-scale SGE installations can be integrated into the urban areas without compromising the performance of existing or future geothermal infrastructures.

AOI 2.4: Application of smart control system for better integration with existing heating systems

A major technical barrier is the incompatibility of many existing building infrastructures with SGE technologies, which often leads to suboptimal hybrid operation. This AOI focuses on the application of Building Energy Management Systems (BEMS) and the technical retrofitting of internal distribution networks to lower required water temperatures, making them suitable for SGE integration. The intervention involves developing a common methodology for retrofitting existing buildings and establishing a transnational database of best practices for hybrid SGE-solar or SGE-fossil systems. In Serbia, where many public and residential buildings rely on legacy heating systems, these activities are vital for enabling geothermal retrofits. The plan supports the implementation of transnational workshops and the training of Serbian engineers in the design of "low-temperature ready" buildings, thereby facilitating the transition of existing infrastructure towards renewable-based geothermal solutions.

AOI 2.5: Application of GHPs in geothermal district heating

This intervention addresses the potential for integrating geothermal heat pumps (GSHP) into existing district heating and cooling (DHC) networks to improve overall efficiency and use of low-temperature return water. In the Danube region, existing geothermal district heating systems are often bivalent, combining fossil fuels with geothermal sources. This action promotes the use of GSHP to increase the temperature for end users while maximizing heat recovery. Serbia’s potential involvement includes participation in a transnational working group focused on the integration of SGE in DHC systems and the identification of potential pilot sites. Activities include the development of common technical guidelines for large-scale applications of heat pumps and the implementation of pilot investments in Serbian district heating plants. This strategy aims to reduce the carbon intensity of Serbian district heating networks by using shallow geothermal resources as a reliable baseload component.

AOI 2.6: Setting up an energy cost monitoring system for demonstrating performance characteristics of SGE solution

The lack of transparent data on the actual operating and maintenance costs of SGE systems often deters potential investors. This area of interest proposes the establishment of a comprehensive operational cost model based on technical performance data and economic information collected from demonstration sites. The system will enable transparent life cycle cost analysis, providing a benchmark for optimization and informed decision-making. Serbia is foreseen as a key participant in these demonstration efforts, with activities focused on collecting data at the national level and testing an online evaluation framework. By monitoring the installations of renewable energy generation in Serbia, the intervention aims to confirm the cost-effectiveness of the technology and provide a robust evidence base for Serbian investors and public authorities. This data-driven approach is essential to demonstrate (especially the long-term) economic benefits of SGE generation compared to conventional fossil fuel-based heating and cooling systems.

C. Education and Training

AOI 3.1: Harmonised higher educational programmes on SGE

The education sector has been identified as one of the weakest links in the renewable energy generation value chain due to fragmented and outdated curricula. This intervention aims to establish a harmonized regional framework for accreditation and certification for higher education, facilitating credit transfer and academic mobility through the Erasmus+ programme. A Danube Regional Curriculum Working Group will be established to jointly develop modular courses covering geology, drilling, and mechanical engineering. In Serbia, the plan foresees the integration of these modules into at least one national university, which will then become part of a transnational network of excellence in geothermal education. This network will offer joint postgraduate and Erasmus Mundus-type mobility programmes, ensuring that engineering graduates in Serbia possess the specialised competences required for the design and implementation of complex geothermal systems in line with international standards.

AOI 3.2: Standardised vocational and training programmes for installers and performance monitoring

In addition to academic education, there is a critical need for standardised vocational training for installers and operators who are the technical backbone of SGE implementation. The AOI focuses on the development of a harmonised VET framework aligned with European standards, such as GeoTrainet. Activities include the creation of a Danube working group for the joint development of modular training content and the publication of a Transnational Guide for Vocational Training in the field of SGE. For Serbia, the AOI foresees the establishment of national training centres where installers can receive certified training in the installation of borehole heat exchangers and the maintenance of heat pumps. By aligning Serbian vocational standards with those of the wider Danube region, the intervention ensures cross-border recognition of skills, which is essential for a mobile and skilled workforce capable of scaling up geothermal energy deployment across the region.

AOI 3.3: Stronger academia-industry partnerships for education and training in the Danube Region

Effective technology transfer requires close cooperation between the education sector and the industry/companies. This intervention aims to strengthen partnerships between academia and the private sector by establishing a Regional Network of Geothermal Innovation and Training Centres. These centres should serve as demonstration sites, training grounds, and incubators for small and medium-sized enterprises (SMEs). In Serbia, the implementation of such a centre could facilitate dual vocational education programs where students can gain practical experience through internships with geothermal system integrators and equipment manufacturers. The plan also aims to develop innovative geothermal energy solutions adapted to local Serbian conditions. By bridging the gap between theoretical knowledge and practical application, these partnerships have the potential to accelerate communication and professionalization of all participants in the field of geothermal technologies.

AOI 3.4: Establishment of an open-access knowledge source and information base to eliminate the language barrier in knowledge transfer

To ensure the broad distribution of geothermal energy expertise, this AOI proposes the creation of a transnational open-access knowledge platform. This platform will contain a repository of technical documentation, design guidelines, and real-world case studies, translated into national languages to ensure accessibility for all regional stakeholders. For Serbia, this includes the introduction of technical English curricula and the translation of over 200 technical documents into Serbian. The platform will also feature Massive Open Online Courses (MOOKs) specifically designed for the Danube Region, with at least two to three modules adapted to the Serbian context. By providing a centralized, bilingual resource for geothermal energy knowledge, the plan empowers Serbian experts, students, and policymakers with the information necessary to advance the local geothermal sector, supported by gamified learning tools to engage a wider audience.

D. Financing mechanism

AOI 4.1: Tailored financial support schemes for shallow geothermal investments

The high initial drilling and installation costs remain a major deterrent for potential users of GSHP/WSHP. AOI focuses on the design and launch of national financial support programs tailored to ground-source heat pumps (GSHP) and water-source heat pumps (WSHP). The plan advocates upgrading existing Serbian renewable energy programs to include efficiency criteria that favour more complex and efficient closed and open loop solutions. Specific activities include the creation of targeted subsidies for thermal response tests (TRT) and borehole drillings up to 150 meters. Furthermore, the intervention explores the integration of GSHP/WSHP into mainstream European funding streams, such as the Just Transition Fund and the Modernization Fund. For Serbia, the goal is to establish dedicated co-financing mechanisms that could shorten long payback periods typical for

GSHP/WSHP projects.

AOI 4.2: Setting up energy price schemes for the promotion of wider use of SGE solutions

Traditional energy pricing often does not take into account the unique operational characteristics of large-scale generation (SGE) systems, such as their potential for load shifting and demand management. This intervention aims to develop a methodology for capacity-based pricing and introduce preferential electricity tariffs for SGE users. For Serbia, this includes formulating recommendations for a policy of bonuses for cogeneration when SGE is combined with solar photovoltaic systems or waste heat recovery. The plan also supports the financing of digital metering and control units to enable time-of-use incentives, which is a key for improving grid compatibility. By introducing these innovative pricing models, the efficient use of locally produced renewable energy can be incentivized, while overall operating costs for SGE system owners can be reduced. Awareness-raising actions, such as the publication of cost comparison reports and energy cost calculators, could further support end-users in understanding the financial benefits of these new tariff structures.

AOI 4.3: Innovative business models for energy as service

The adoption of SGE can be accelerated by implementing innovative business models that reduce financial risk for end-users, such as Energy as a Service (EaaS) or third-party financing through Energy Service Companies (ESCOs). This intervention focuses on developing transnational guidelines for SGE business models and establishing a network of financial intermediaries specialized in geothermal investments. Activities include the creation of standardized contract templates for performance-based contracting of SGE and training Serbian financial institutions on risk assessment of geothermal projects. By fostering a more sophisticated financial ecosystem in Serbia, these innovative models can overcome the barrier of high capital outlays, allowing Serbian users to benefit from geothermal heating and cooling through manageable operational payments.

E. Awareness raising

AOI 5.1: Awareness raising for the general public about SGE solutions

General public awareness of SGE is often limited or blurred, and misconceptions regarding drilling safety, environmental impacts, and perceived high costs exist. This intervention proposes coordinated, transnational campaigns to present SGE as an accessible, low-risk, and cost-effective solution. For Serbia, this involves adapting a transnational awareness-raising package into the local language, with real-life stories from pilot sites in Serbia. The campaign will use digital tools to illustrate long-term savings and involve local multipliers such as schools and community organizations to build trust in Serbian communities. By focusing on simple, understandable communication formats, the plan aims to work on the skepticism of local actors in order to adequately present SGE as an energy resource and a sustainable alternative to conventional energy sources. Joint promotion of pilot projects will further provide Serbian citizens with tangible evidence of the benefits of the technology in their local environment.

AOI 5.2: Capacity building for decision-makers and institutional stakeholders on SGE solutions

Widespread scepticism among institutional stakeholders and decision-makers often hinders the integration of energy resources into local and regional planning. This AOI focuses on building knowledge and commitment through high-level briefings and transnational policy workshops. In Serbia, the plan targets at least 400 decision-makers across the region for specialized training and advocates for at least 16 bilateral policy dialogues between partner countries. A key output is the publication of transnational policy guidelines for the integration of energy resources into spatial planning, which will be used to update national and regional energy strategies in Serbia. By engaging representatives of Serbian institutions, the intervention ensures that SGE is recognized as a strategic priority in national programs for the promotion of energy efficiency and renewable energy sources. This “top-down” approach is necessary to create an enabling policy environment that facilitates the implementation of large-scale shallow geothermal energy projects throughout Serbia.

IV Proposed 2026-2035 Roadmap for Serbia

Despite favourable geothermal gradients and extensive hydrogeological resources, Serbia’s shallow geothermal deployment remains underdeveloped. The primary barriers are not geological but institutional, financial, and administrative.

The Serbia Country Report confirms that market stagnation results from regulatory fragmentation, the absence of financial stimuli, and the lack of coordinated policy prioritisation. As Serbia progresses towards EU integration and aligns with European Green Deal objectives, shallow geothermal energy represents a low-risk and scalable solution for heating/cooling sector decarbonisation.

Particular strategic value lies in:

- Electrification of heating;
- Lower cooling load on the distribution network;
- Hybridisation of district heating systems;
- Urban wastewater heat recovery.

Without targeted intervention, however, deployment will likely remain limited to small-scale private and corporative systems.

Based on Serbia-specific findings, the following actions are proposed:

- Establish a National Shallow Geothermal Coordination Platform to ensure institutional coherence.
- Develop a National Shallow Geothermal Atlas and Registry.
- Introduce fast-track permitting procedures for closed-loop systems below 200 m.
- Launch 2–3 large-scale public demonstration projects by 2028.
- Initiate a wastewater heat recovery pilot project(s) in conjunction with centralized wastewater treatment plant development.

- Introduce a dedicated financial incentive scheme for geothermal heat pumps.
- Create a Geothermal Competence and Training Centre within a Serbian technical university.

Estimates are that the implementation of proposed or similar measures could significantly increase SGE market penetration by 2035.

V Conclusion

Serbia possesses significant shallow geothermal potential, particularly in the Pannonian Basin region. However, utilisation remains modest compared to neighbouring Danube countries.

Findings from the Serbia Country Report indicate that regulatory complexity, institutional fragmentation, and insufficient financial incentives are the primary barriers. The Transnational Action Plan provides a structured framework to overcome these challenges.

Through coordinated regulatory simplification, pilot projects, financial mechanisms, and institutional capacity building, Serbia can substantially increase shallow geothermal deployment between 2026 and 2035. Such development would contribute to greenhouse gas reduction, energy security, and alignment with European climate policies.

Implementation of the TAP is a complex process that requires the coordinated action of various bodies as stakeholders on local/regional, national and transnational level. Implementation technicalities are influenced by the responsibilities and conditions laid down in the subsidy contract of the Danube GeoHeCo project and the institutions of energy policy governance in the partner countries.

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Authors

Davor Končalović – redovni profesor, Fakultet inženjerskih nauka Univerziteta u Kragujevcu, davor.koncalovic@kg.ac.rs, ORCID 0000-0003-1207-2653

Vladimir Vukašinović – vanredni profesor, Fakultet inženjerskih nauka Univerziteta u Kragujevcu, vladimir.vukasinovic@kg.ac.rs, ORCID 0000-0001-6489-2632

Dušan Gordić – redovni profesor, Fakultet inženjerskih nauka Univerziteta u Kragujevcu, gordic@kg.ac.rs, ORCID 0000-0002-1058-5810

Mladen Josijević – vanredni profesor, Fakultet inženjerskih nauka Univerziteta u Kragujevcu, mladenjosijevic@gmail.com, ORCID 0000-0001-9619-0897

Filip Nastić – istraživač saradnik, Fakultet inženjerskih nauka Univerziteta u Kragujevcu, filip.nastic@uni.kg.ac.rs, ORCID 0000-0002-2164-6658

Dubravka Živković – docent, korespondirajući autor, Fakultet inženjerskih nauka Univerziteta u Kragujevcu, dubravka@uni.kg.ac.rs, ORCID 0000-0002-0266-456X

Plitka geotermalna energija u Dunavskom regionu - Prioriteti i mere za Srbiju

Rezime - *Grejanje i hlađenje čine skoro polovinu konačne potrošnje energije u Evropi, pri čemu približno 75% ove energije i dalje dolazi iz fosilnih goriva. Dekarbonizacija ovog sektora je stoga ključna za klimatsku neutralnost kontinenta. Ovaj rad analizira prepreke i moguće puteve ka široj primeni korišćenja plitke geotermalne energije zemljama Dunavskog regiona sa osvrtom na R. Srbiju. Istraživanje je rezultat izrade dokumenta pod nazivom Transnacionalni Akcioni Plan (TAP), koji je razvijen u okviru projekta Interreg Danube GeoHeCo. U fokusu se dva osnovna pristupa u korišćenju plitke geotermalne energije: (i) sistemi toplotnih pumpi zemlja-voda i to zatvorenog i otvorenog tipa, a koji koriste plitke geološke slojeve do dubine od 400 metara i (ii) sistemi za rekuperaciju toplote otpadnih voda korišćenjem toplotnih pumpi bez dodatnih bušotina. Na osnovu nacionalnih geoloških, regulatornih i tržišnih podataka, rad identifikuje strukturne barijere i predlaže ciljane mere za ubrzavanje ekspanzije ovog izvora energije. Sve predložene mere su podeljene u 5 prioriteta: Resursi i propisi, Tehnologija i dizajn, Obrazovanje i obuke, Finansiranje i Podizanje svesti.*

Ključne reči - *Plitka geotermalna energija, obnovljivi izvori energije, energetska tranzicija, Dunavski region*

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