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The Multifaceted Challenges of Refitting Legacy Geothermal District Heating Systems in Hungary

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ABSTRACT

Geothermal district heating (GDH) is a cost-effective and environmentally friendly way to heat and cool both residential and commercial properties. GDH systems align well with the EU's decarbonization roadmap, as they hold significant potential for delivering clean, sustainable, and efficient heating across Europe. In Hungary, geothermal district heating and thermal-water heating cascade systems are established, but still have room to grow in terms of their total number and improved efficiency.

Some of these district systems are partial GDH, where geothermal energy supplements a natural-gas dependent district heating infrastructure. In these cases, geothermal energy contributes between 30% to 100% of the heat supply. This article serves as an instructional case, highlighting the challenges and difficulties of retrofitting a legacy district heating system in Mátészalka, Hungary. The project's goal was to improve an outdated system by installing industrial high-temperature heat pumps to take better advantage of the geothermal water used as the heat source. In Hungary, the challenges to implementing these system upgrades are primarily administrative, political, and related to investment, rather than technical. These issues will persist until relevant stakeholders are convinced that geothermal energy is an effective solution for providing heating, cooling, and electricity.

1 INTRODUCTION

The use of geothermal as a source for district heating (DH) is not new; it dates back to Roman times, as seen in the ruins of city homes and baths heated via natural hot water catchments and piping Cataldi et al. (1999).

With the help of modern technology, and partly due to the oil crises of the 1970s, more and more DH projects began to utilize geothermal resources with temperatures at or above the 50-60°C range. This upswing halted in the 80s and 90s when the oil and gas industry developed better directional drilling methods, which again made fossil fuels more competitive Lund and Tóth (2021). Now, after thirty years of slower development, the GDH market is experiencing renewed momentum, notably due to the war in Ukraine, higher oil and gas prices, new technological advancements, and growing concerns over energy dependency and sustainability. Every year, the European Geothermal Energy Council (EGEC) publishes its Geothermal Market Report, which analyzes market trends and developments in the European geothermal sector. There are approx. 6,000 DH systems in Europe, ranging from small, local networks to large-scale systems that supply heat to entire cities Tóth et al. (2025).

Geothermal district heating plays a rapidly growing and strategic role in Hungary's energy transition, particularly for urban areas seeking to reduce their reliance on imported natural gas and lower greenhouse gas emissions. In Hungary, geothermal district-heating and thermal-water heating cascade systems represent a significant portion of direct use, and are available in 28 towns, which collectively have an installed capacity of 283.38 MWth and an annual production of 758,4 GWht/yr, as reported by Nádor et al. (2025). These are partly geo-DH systems, where geothermal energy contributes to the already existing district heating infrastructure (operated otherwise by gas) with a 30 to 100% share, and partly so-called "thermal water heating cascade systems", where the gas-based heating of some public buildings (town halls, libraries, schools, hospitals, etc.) is replaced by geothermal. These local systems are commissioned based on a water license and are often operated by local municipalities or municipality-owned service providers. This contrasts with the district-heating systems, where heat is provided by a separate commercial entity on a contract basis, regulated by the Hungarian Energy and Public Utility Regulatory Authority.

Hungary published its renewed Energy Strategy and National Energy and Climate Plan in 2020. These documents highlight the role of geothermal energy, in agriculture and especially in the heating and cooling sector, with the particular goal of making district heating more sustainable and environmentally friendly. Although the anticipated growth of geothermal in the heating-cooling industry is 58% (84.6 ktoe – 2020, 116.6 ktoe – 2030), this will only slightly increase the overall share of geothermal within the total RES, which will remain around 5%.

Hungary is committed to doubling its geothermal energy capacity by 2030 and aims to reduce the share of natural gas in district heating to 50% by that year, primarily through the expansion of geothermal and other renewable energy sources MBFSZ (2021).

Mátészalka is among 28 Hungarian towns with operational geothermal heating systems. This district heating system is classified as a small-scale porous sandstone sediment geothermal project. It delivers an installed capacity of about 2.5 MW thermal, serving residential and some communal buildings. This article describes the challenges, difficulties, and solutions involved in developing cascade geothermal heat pump applications, which increased the system's green heating capacity by 16,000 GJ per year (a 67% increase), currently accounting for approx. 40% of the district heating system's supply.

2 AN OVERVIEW OF DISTRICT HEATING IN HUNGARY

Hungary has a developed district heating system, much of which was built in the 1950s and 1970s in large housing estates. The first largest-scale district heating build-out began around 1958 in Budapest, when the Kelenföld coal based power plant and other municipal plants started supplying heat for residential uses rather than only industry, driven by the construction of large prefabricated apartment estates that required central heat, and by policy to reduce polluting coal stoves in the inner city. During the 1960s–1980s the system shifted from coal and oil to increasing use of natural gas and combined heat-and-power (CHP) generation to raise efficiency and reduce emissions; a simultaneous national program in the 1970s converted much of the city from town gas to natural gas and replaced or converted household appliances, which affected the balance between direct gas heating and district heat connections. As of 2022, Hungary has 213 district heating systems operational across the country. These systems are predominantly in urban areas and serve a significant portion of residential and commercial heat demand Talamon and Kujbus (2024).

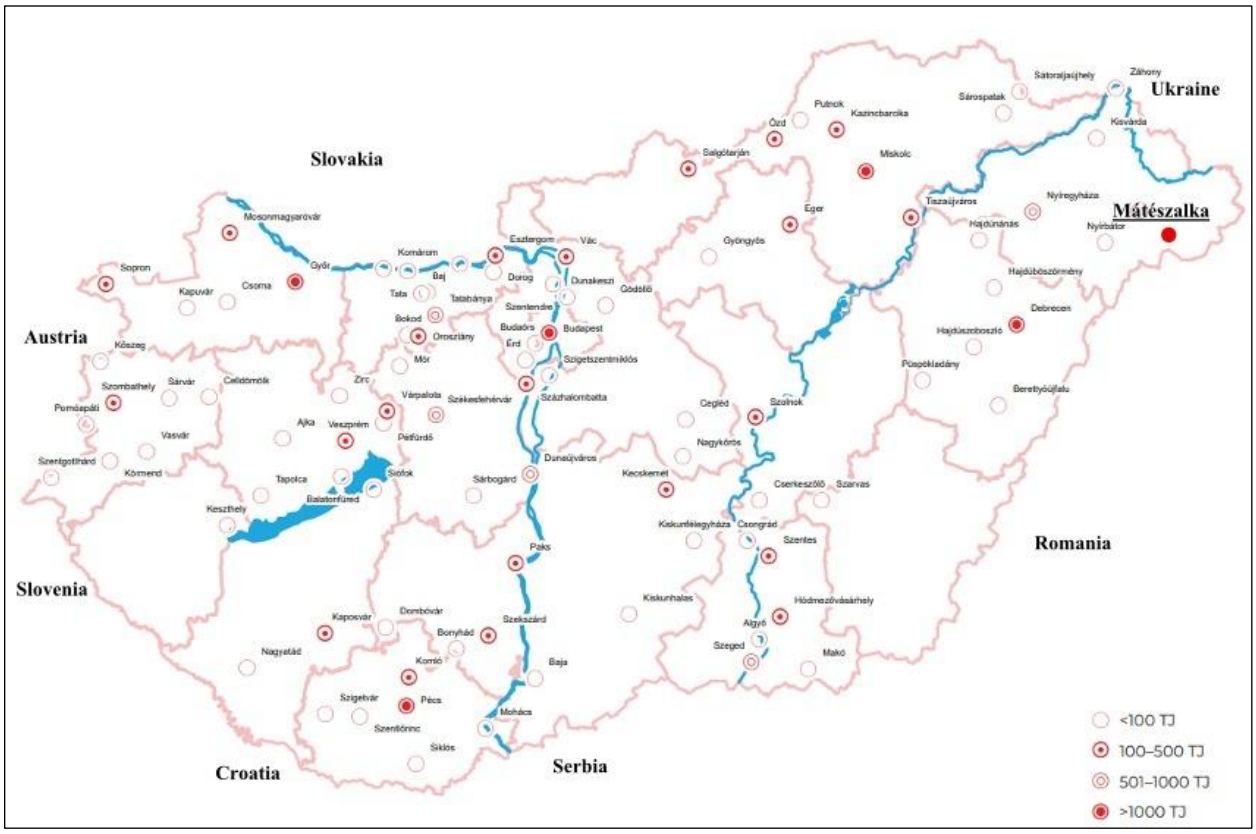


Figure 1. District heating systems in Hungary, Talamon and Kujbus (2024).

2.1 Mátészalka and its district heating system

Mátészalka is a town in northeastern Hungary, with a population of 15,157. Like many Hungarian towns, its favorable geothermal situation was mostly evident from the popularity of its local thermal bath. The town also has a strong agricultural base and associated food-processing activities. Its proximity to the Romanian border has helped make it an attractive location for large corporations such as the Danish owned FrieslandCampina

(milk processing factory and dairy production plant), as well as the German optical giant Zeiss and the Japanese-owned Hoya corporation. A more efficient GDH system stands to benefit both these companies and their local employees.

Mátészalka's district heating system began in the early 1970s, as larger housing estates were being built in the city. Originally, the system was based on a petroleum-fed (heavy fuel oil - HFO) boiler. It primarily serving large apartment blocks, public institutions and schools.

The first district heating permit was issued in 1973 and currently provides heat for approx. 1,800 apartments and 32 public institutions. Only in the 80s did the district heating system switch to natural gas-based heat production. In the 90's, the first combined heat and power plant began operation, using natural gas primarily for electricity production. Since 2001, the district heating system has operated a 5 MW biomass boiler at the central site. At the end of the 2000s, the outdated and uncontrollable single-pipe heating system was eliminated in apartment buildings. All residential radiators were re-equipped with control valves, cost-sharing devices, and individual hot water meters, enabling accurate individual billing.

Perhaps the most significant change was that which occurred began in 2017, when the geothermal system project was launched. The system began operation in 2020 and has been stably serving the city's population's heat production needs ever since.

The Mátészalka district heating service company is committed to utilizing renewable energy sources and modern technology. Since 2022, the town's usable hot water supply is provided almost entirely by renewable energy sources, except during the coldest months (April-October).

Over the past five years, the district heating service provider has modernized its pipe network (more than 6 km long), replacing its outdated system with plastic, pre-insulated pipes. These have significantly reduced heat and water losses.

3 THE APPEARANCE OF GEOTHERMAL ENERGY IN THE CITY

In 2017 the municipality initiated a collaboration with EU-FIRE Ltd. to undertake research and commercial activities designed to improve the district heating system's geothermal heat production.

3.1 Geological background

The region is located in the northeastern part of the Pannonian Basin, one of Europe’s most favorable areas for geothermal utilization due to its thinned continental crust and anomalously high heat flow. Regional heat-flow measurements indicate values in the order of 90–100 mW/m^2, with corresponding geothermal gradients typically ranging between 45-65°C/km. These conditions provide a basin-wide framework that promotes the accumulation and sustainable extraction of low- to medium-enthalpy geothermal resources Horváth et al. (2015).

Fig. 2 shows that 50°C rock temperature can be reached at the 700-900 m depth almost everywhere in Hungary. This temperature is high enough to be used in panel radiators, a traditional way to heat houses in Hungary. 50°C is also warm enough to be a thermal source for a large-scale district heating system, if combined with heat pumps.

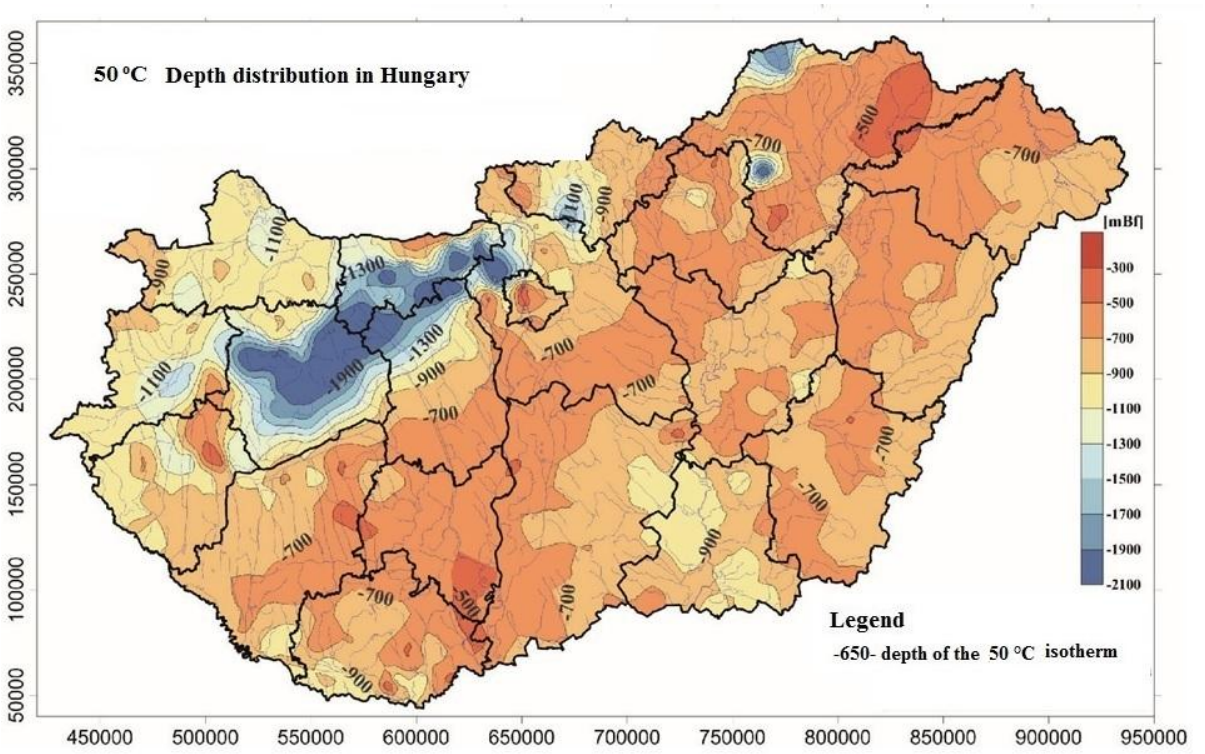


Figure 2: Geo-isothermal map 50C rock temperature Tóth (2017)

3.2 Technical activity and the use of a heat pump to boost an outdated system's production

The geothermal application in Mátészalka represents a low-enthalpy system with a wellhead temperature of 61 °C and a flow rate of 60 m^3/h. The system's peculiarity lies in its surface installation, not coupled to the primary pipeline of the local district heating service, but to the secondary system in each heating center. This application provides a redundant heating system for the primary conventional system, offering the benefit of increased supply security, but at the disadvantage of higher CAPEX requirements due to the more complex and extensive surface system: the geothermal pipeline is routed to all heating centers, and there are heat exchangers in each.

Despite the system's low enthalpy and direct capacity, the successful installation of a novel heat pump coupling manages to enhance the system's cascading efficiency in 2024, increasing system capacity by 67% and allowing the local district service to completely eliminate natural gas consumption. This use of a heat pump, described in detail below, could offer a straightforward way for towns with either geothermal or natural gas-based systems to significantly reduce reliance on natural gas.

3.3 Financial and economic background

EU-FIRE Ltd. successfully implemented the development of the Mátészalka geothermal system in 2020, within the 2021-2027 framework of Hungary's KEHOP grant program (“Környezeti és Energiahatékonysági Operatív Program Plusz” or Environmental and Energy Efficiency Operational Programme Plus.) It is part of Hungary’s use of EU Cohesion Policy funds aimed at supporting projects that promote environmental protection, energy efficiency, and climate action. Key objectives include funding residential and public building renovations for energy efficiency, supporting renewable energy investments, advancing energy communities, raising awareness, and fostering sustainable development across less-developed regions. EU-FIRE Ltd. benefited from this fund as it received the non-repayable grant of HUF334 million (approx. USD 988K), which covered 48 % of the total project budget of HUF 696 million (approx. USD 2,059K). As a result, the company received its district heating production license from the Authority.

3.4 The first GDH in Mátészalka

Geotherm FIRE Ltd., a member of the EU-FIRE Group, implemented a local geothermal energy-based district heating producer plant and system in Mátészalka in 2020. The geothermal energy (hot water) is obtained from a geothermal well drilled in the Upper-Pannonian sandstone reservoir, with a true vertical depth (TVD) of 1,200 meters (the lowest casing shoe). The geothermal sandstone reservoir is sealed to prevent solid particle inflow and open-hole degradation. An ESP (Electrical Submersible Pump) unit was installed in the tubing at a depth of

150 meters, providing a flow rate of 60 m^3/h with a wellhead temperature of 61-62 °C. Fig. 1 demonstrates the well schematic of the geothermal well MGT-1.

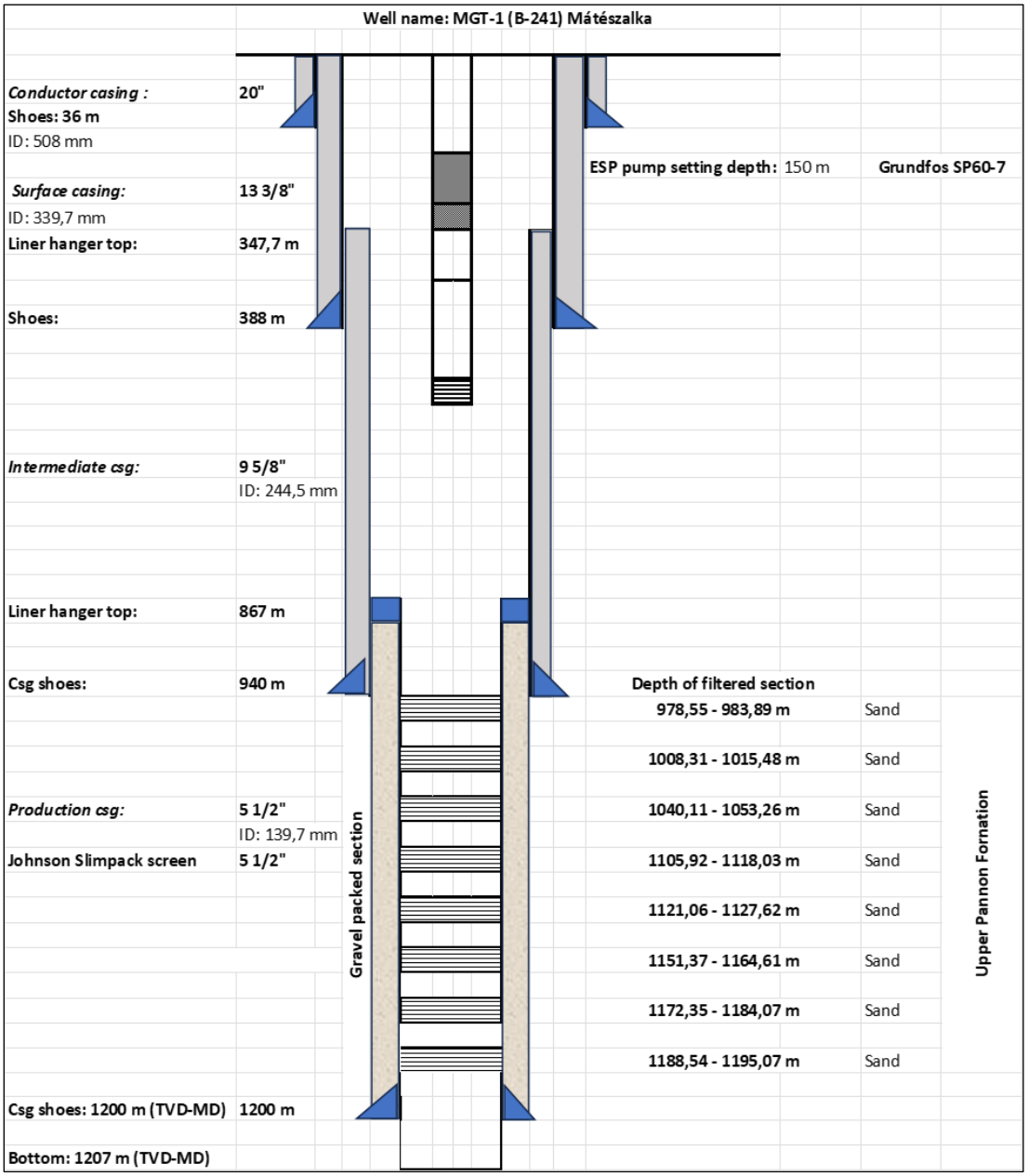


Figure 3: Well Schematic of MGT-1

The produced thermal water flows through the wellhead into the gas separation buffer tank, releasing the dissolved gases into the atmosphere after the air pressure drops. The buffer tank level provides the indication (LI) to the variable speed drive (VSD) controller of the electrical submersible pump's motor, allowing it to control the level based on the production rate. From the buffer tank, the hot water is subsequently pumped into the heating centers (7).

The primary driver of heat transfer between systems is the temperature difference, which determines the limits and capacity of a geothermal heating system in principle. Since the wellhead temperature is not high enough for a centralized heat exchanger to heat the primer district heating system (where the temperature scales of the supply and return media vary between 85/55 and 90/60 °C), two parallel heating systems — geothermal and conventional natural gas-based — are installed in the heating centers.

After it comes through the return line from the customers (the secondary network of the district heating system), the water is routed to the geothermal heat exchangers first and then to the conventional heat exchangers. Directly heating the secondary system of the district heat provider's system with geothermal energy makes the energy transfer more efficient, as the temperature in the secondary system is lower than in the primary system;

therefore, the temperature difference between the geothermal and the heated side is more significant. The same path can be identified for the usable hot water system. In this construction, the conventional heating system fills the gap between the temperature level reached by the geothermal system and the actual required temperature. It provides surplus energy to the secondary system over the geothermal level only. Much less conventional fossil-based energy is needed to heat the district heating system as the existing geothermal system provides a significant portion: ~ 24,000 GJ out of a total of ~ 80-85,000 GJ.

As the thermal water flows from one heating center to another, its enthalpy — the temperature of the thermal water — is reduced due to the heat transfer into the recirculation line serving consumers (heating and usable hot water). Each heating center contains two plate heat exchangers (with a capacity of 1 MWth) to heat both the heating recirculation loop and the fresh supply of usable hot water, which is distributed to customers (apartments, municipal buildings, etc.).

In February 2021, Geotherm FIRE Ltd. was awarded the district heating producer permit. Following the initial period of operation, further enhancements to the system's efficiency were implemented, resulting in an additional 3,000-4,000 GJ of heat energy for the town annually. The improvement involved connecting not only the original supply but also the recirculation loop of the usable hot water to the geothermal heat exchangers in the heating centers.

3.5 Characteristics of the GDH

Since 2020, EU-FIRE Ltd. has continuously supplied Mátészalka's heating and domestic hot water needs with environmentally friendly, renewable geothermal energy, thereby replacing approx. 1 million cubic meters of natural gas annually. The produced thermal water ranges from 360,000 to 415,000 cubic meters annually, which is converted to 24-25,000 GJ of heat energy for the GDH. It satisfies ~ 35% of the total district heating needs, with the rest covered by biomass and natural gas. Based on the experience of the initial operational period, an additional investment was made in May 2022 to improve efficiency, thanks to which geothermal energy now provides the entire domestic hot water supply, except for the coldest months from April to October.

During the ongoing energy crisis, which began in 2021 and peaked in 2022, the crisis-resistant strength of geothermal energy has become increasingly evident, underscoring the growing justification for investment in the sector. Between November 2020 and March 2023, GDH delivered a total of 56,146 GJ of geothermal heat energy to the town (Table 1).

Table 1: Heating prices and the supplied heat (1$=340 Ft - Hungarian currency)

Terms	Nov. 2020 - March 2021	April 2021- Sept. 2021	Oct. 2022 - Dec. 2022	Jan. 2023 - March 2023
Natural gas-based heat price	10.2 $/GJ	10.2 $/GJ	126.8 $/GJ	61.3 $/GJ
Geothermal heat price	9.4 $/GJ	10.2 $/GJ	14.3 $/GJ	15.1 $/GJ
Savings	0.79 $/GJ	-	112.5 $/GJ	46.2 $/GJ
Supplied heat	12,048 GJ	29,850 GJ	5,903 GJ	8,345 GJ
Sum of savings	9,462 $	-	663,832 $	385,497 $

As a result, a significant portion of heating was supplied with geothermal energy instead of natural gas, which saved the Hungarian State nearly HUF 356 million (approx. USD 1,053K). The non-repayable KEHOP grant of HUF 334 million (approx. USD 980K) allocated to the Mátészalka geothermal development has therefore already been paid off to the State "with interest" in 2023, with many more future years of fuel savings remaining under the contractual heat supply term ends in 2039. Table 1 presents the heat prices and the supplied heat amounts during the heating periods of 2020-2023.

4 THE NEWEST DEVELOPMENT

In the existing geothermal system, the thermal water loses its direct heating capacity due to the decreased temperature (~ 42 °C). Although the cooled-down thermal water is useless for direct heating purposes, it still

represents a significant amount of energy that could be utilized but was previously released and therefore wasted. The careful choice and installation of a heat pump has captured much of that wasted heat.

4.1 Engineering approach

The concept applied in Matészalka utilizes residual geothermal energy by incorporating an industrial high-temperature water-to-water heat pump that draws its source from ~42 °C cooled thermal water and discharges into the district-heating primary return, preheating boiler feed. The tie-in at heating center V2 has the advantage of being only 10–15 m from the main header, which minimizes piping and costs. Because the brine contains chloride, ammonia, fluoride, and has a high TDS, both source and condenser circuits are isolated by plate heat exchangers, creating closed demineralized loops (approx. 2 °C source penalty) and protecting water quality. Controls maintain source/sink temperatures and flows for performance. Key parameters: source flow ≈60 m^3/h, source inlet ≈40 °C (post-HEX), sink flow 60–104 m^3/h, sink inlet 55–60 °C; the sink outlet is set by heat-pump capacity.

The system process flow diagram, a visual representation of the geothermal system, is shown in Figure 4. As presented, the geothermal system begins at the production well and ends at the heat pump system, after which the used thermal water is released into the lake near the town's swimming pool. The last heating center is V2, as described above.

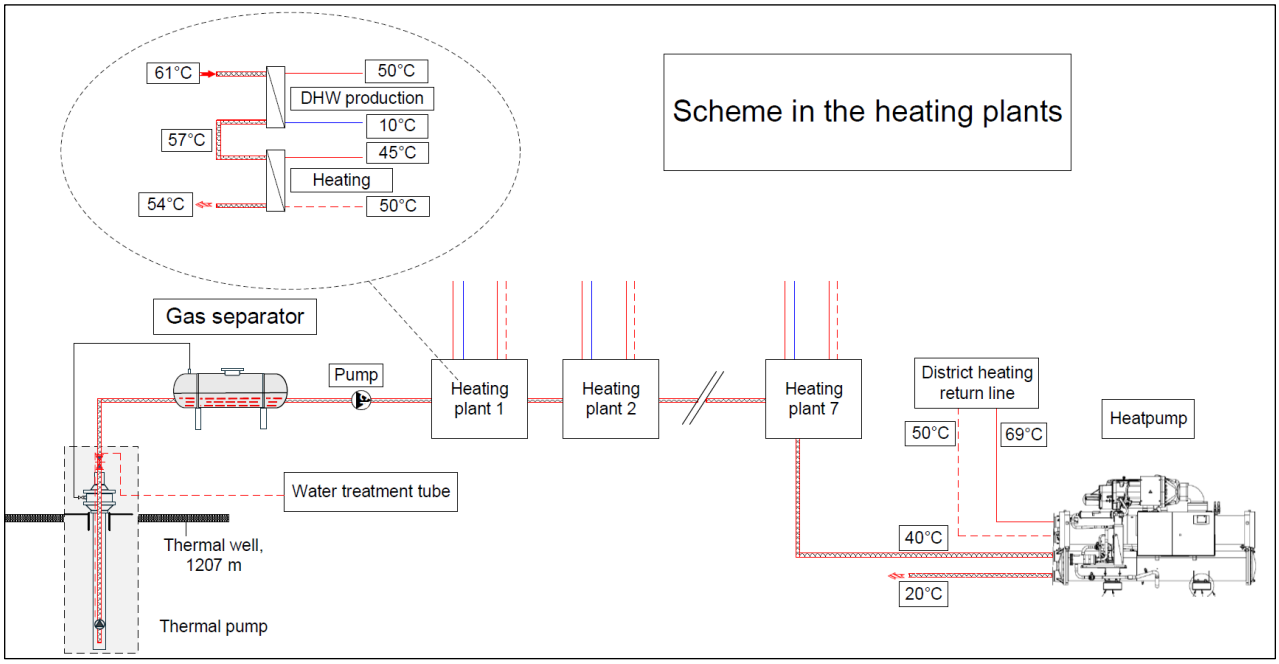


Figure 4: PFD of the geothermal heating system

4.2 Financial and economic background - the Swiss Fund

Since 2006, the Swiss Contribution has supported 2004 EU entrants, including Hungary. Through the Swiss-Hungarian Cooperation Programme, Switzerland provides CHF87.6 million in grants, with Hungary's co-financing, so that the total will exceed CHF103 million (approx. USD 128.75 million) through 2029. Funds focus on four aims: stimulating growth and social partnerships, reducing youth unemployment, strengthening social security, and advancing environmental/climate protection while providing effective migration management and ensuring public safety. The environment pillar reduces gas reliance by scaling renewables, especially geothermal energy, through modernized or repurposed wells, adding surface engineering to increase efficiency, and connecting sources to district-heating networks for reliable, low-emission heat.

4.3 System Performance

As the investment was executed in the summer of 2025, no historical performance data is available yet. Therefore, the performance of the heat pump system is demonstrated based on engineering design and model calculations. During the engineering design, two scenarios (No. 1 [Best case] and No. 3 [Worst case] in Table 2) were considered to represent the boundary conditions of heat production, where the reality (Scenario No. 2) is assumed to lie between 1 and 3.

Table 2: Heat production scenarios

Scenario	Sink In (°C)	Sink Out (°C)	Mass flow rate (kg/h)	Flowrate (l/s)	Q (GJ/h)	Q (MW)	COP	Energy (GJ)
1	55,0	70,0	66339	18,9	4,17	1,16	4,7	21014
2	55,0	69,0	58266	16,6	3,42	0,95	4,9	17226
3	60,0	73,5	58266	16,6	3,30	0,92	4,5	16611

In terms of the amount of produced heat energy, the best (55 °C heat sink temperature with 68 m^3/h) and worst (60 °C heat sink temperature with 60 m^3/h) scenarios were considered to compute and model the geothermal-based heat production. Another crucial boundary condition is the system's coefficient of performance (COP), which must be equal to or greater than 4.5, as specified by the application. Based on the system capacity provided by a reputable heat pump vendor (Carrier), the estimated outcomes in Table 2 can be achieved.

The calculation considers the water's heat capacity (isobaric specific heat capacity, cbw) of 4.19 kJ/kg°C and the 975 kg/m^3 water density specified at 74 °C and atmospheric pressure, representing the worst-case scenario, i.e., conditions that underestimate the performance of the system. The last column, heat energy produced, represents the seasonal (annual) heat production over 5040 operational hours (7 months, 30 days, and 24 daily hours), which corresponds to the duration of the heating season based on the local district heating service operation. The capacity of the heat pump installation, and consequently, the amount of heat transferred into the district heating system, is calculated by the well-known heat transfer equation:

$$Q = c_{bw} \cdot \dot{m} \cdot \Delta T \tag{1}$$

where Q is the capacity or the heat energy per unit time transferred (kJ/h); c_{bw} is the isobaric specific heat of hot water at the above-defined conditions (constant, 4.19 kJ/kg°C); $\dot{m}$ is the mass flow rate at heat sink side (kg/h); and ΔT is the temperature difference between sink inlet and outlet (°C).

In Table 2, scenario No. 2 represents an assumed, more realistic case where the capacity and energy produced are lower than in the best case (scenario No. 1); however, its 4.9 COP is relatively high compared to the others. As indicated, even in the worst-case scenario (Scenario No. 3), 16,611 GJ of heat energy can be transferred into the district heating network annually.

Figure 4 illustrates the schematic hydraulic connection of the heat pump system (Scenario No. 1), where two high-temperature industrial heat pumps are arranged in series to increase the enthalpy incrementally. An additional heat exchanger was installed on the heat source side to prevent corrosion and scaling problems in the heat pump system. The thermal water contains chloride, ammonia, and fluoride, with a TDS content of 1,600 mg/L and an electrical conductivity of 1,562 µS/cm. Additionally, a buffer tank was included to balance the system operation and ensure stable operation conditions. In Figure 4 the dashed and solid lines represent the suction (input) and discharge (output) lines, respectively.

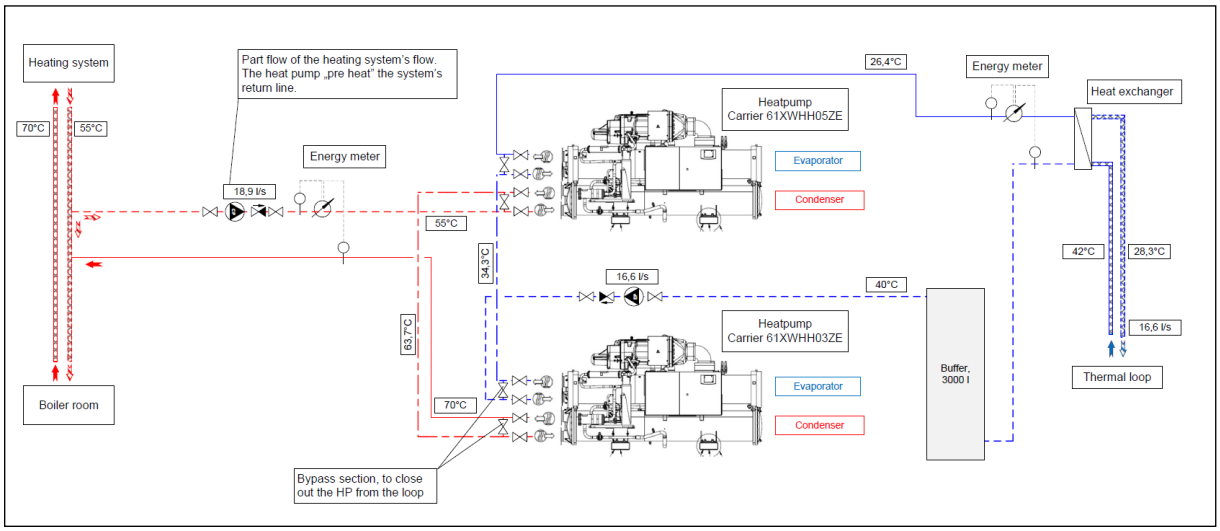


Figure 5: Schematic of HP system installation (Scenario No. 1)

Two heat pumps are installed and connected in all scenarios to achieve the capacity defined above. In scenario No. 1 – seen in Figure 5 –, equipment with a 678 kW heating capacity (called Carrier 61XWHH05ZE) and another one with a 486 kW heating capacity (called Carrier 61XWHH03ZE) are connected with a declared system capacity of 1163 kW. In scenarios Nos. 2 and 3, the same machines (Carrier 61XWHH03ZE) are connected with a declared system capacity of 943 and 923 kW, respectively. In this way, the temperature increase is performed in two stages.

If COP is considered, one of the most relevant parameters is the outlet temperature achieved by the equipment. The higher the temperature, the lower the COP with the same conditions. Therefore, the same capacity can produce the same amount of energy with a higher COP in case of a higher mass flow rate and lower temperature (see the heat transfer equation above). Since the coefficient of system performance is a crucial indicator, the higher capacity construction option (Scenario No. 1) was excluded to enhance the installation's efficiency, as the lower capacity may result in less energy being produced. Still, the higher flow rate could further increase the system's efficiency (COP) in scenarios No. 2 and 3.

A detailed temperature and flow rate schedule in the relevant section (where the return header is connected to the heat pump application) was provided by Szalkatávhő Ltd. to model the phenomenon better and approx. the reality with a more realistic characteristic of the return header of the primary side of the district heating system, representing the heat sink of the heat pump system.

Table 3: District heating system characteristics

Month	Return Temp. (°C)	Return Flowrate (m3/h)	Heat Energy (GJ)
January	60	80	2478
February	60	70	2243
March	60	60	2470
April	55	60	2426
October	55	60	2507
November	60	60	2391
December	60	70	2484

The system COP varies between 4.5 and 4.91 under different operation conditions, as Table 3 defines. The condition with a return temperature of 60 °C and a flow rate of 60 m3/h represents the least efficient condition.

The weighted average COP under these conditions is 4.675, and the heat energy transferred into the district heating system during the period above is 16998 GJ, as shown in Table 2.

5 REGULATORY ENVIRONMENTAL FRAMEWORK

The geological conditions in Hungary are particularly favorable for utilizing geothermal heat. Geothermal energy can support the country's long-term energy sovereignty within a predictable and fruitful regulatory framework. By exploiting Hungary's geothermal potential on a large scale, the country's energy exposure can be reduced by up to 1–1.5 billion cubic meters of natural gas annually by 2030. For conventional geothermal heat supply projects, thermal water can typically be provided by drilled wells with a depth of approx. 1000–2500 meters.

To achieve the above goal, the legal regulation of geothermal energy extraction underwent significant changes as of March 1, 2023. According to the previous regulation, if geothermal energy was extracted by extracting groundwater, it had to be permitted by the water authority, and the mining supervision authority acted as a specialized authority in the procedures. In practice, this technology is commonly used in cases involving higher-temperature media (above 30 °C), representing, alongside low-temperature, shallow-depth heat pump systems, the backbone of geothermal energy utilization.

With the change in legal regulations, as of March 1, 2023, mining supervision will still permit the exploration, extraction, and utilization of geothermal energy in cases involving the extraction of groundwater, except for the extraction of thermal water for primary medical or agricultural purposes. In addition to the Mining Law, the implementation and detailed rules have also been amended. According to the new regulations, after exploring geothermal energy, the holder of the exploration permit may apply for the establishment of a protective structure, which provides the exclusive right to extract geothermal energy. They may then begin the extraction and utilization of geothermal energy based on a contract concluded with the Authority.

Professional authorities also participate in the procedures for permitting geothermal energy research and establishing the Wellhead Protection Area (WHPA). In the case of the former, the Geothermal Energy Committee, led by the Ministry of Energy, also provides an opinion on the applications (Government Decree 178/2023. (V. 12.)). Since the available underground water resources play a key role in terms of utilization, the asset management consent of the competent water management directorate is also required for permitting research and establishing WHPA. To maximize the benefits of geothermal energy, research may be permitted for the purpose of supplying heat to a property or a group of connected properties, even if the research area overlaps with another research area or an already established protective barrier.

The change in regulations appears to have had a significant positive impact on the domestic utilization of geothermal energy -- the Authority received more than 50 research permit applications on the day it came into effect.

6 THE HUNGARIAN BUSINESS MODEL

As indicated in Chapter 1, the utilization of geothermal energy is widespread in the district heating sector. This sector represents a regulated market that entails predefined cash flows for interested parties, as determined by the Hungarian Energy and Public Utility Regulatory Authority (HEPURA), and the Hungarian Ministry of Energy. The regulated economic environment ensures predictability and obviously sets limits regarding the payback periods of projects.

In brief, a district heat producer supplies heat energy to the local district heating service provider, which then distributes the heat energy to residential buildings and various public institutions within the district. I.e., it delivers energy to the local district heating service provider for compensation. The suppliers of a district heat producer ensure the normal operation of the heating plant, which involves activities such as chemical dosing, maintenance, and daily operation.

Simplified, the regulation implies a cost-based pricing strategy. The interested companies, district heating producers, and service providers administer all information regarding operations. Therefore, HEPURA owns all the data to calculate the operational expenditure (OPEX) of the company. It is essential to note that depreciation is also included as an approved cost. The regulated pricing also applies to CAPEX. It determines different rates of return on investment (ROI) depending on the source of heat production; for example, the corresponding ROIs are 2% and 4.5% for fossil-based and geothermal district heat producers (investments before 2025), respectively. For geothermal-based district heat producers, the 4.5% ROI is adjusted for investments made after December 31. The ROI is adjusted to the current market environment, with both upper and lower limits, and will be introduced accordingly. The ROI will be determined in relation to the arithmetic average of the reference yield

of government securities with a nominal maturity of 10 and 15 years published on the last working day of March of the relevant year, which will be increased by an additional 2.5 percentage points, with the result that the value thus obtained must be at least 4.5%, but may not exceed 9%. When the costs are acknowledged, the sum is divided by the planned produced heat energy (based on the heat produced in the previous year), and a unit price is published by the Hungarian Ministry of Energy at the beginning of the heating period (October) annually. This strategy aims to ensure predictability, but it also implies risk for the parties, as the predefined costs and amount of heat energy may differ during the period due to unexpected circumstances or a simple malfunction.

7 CHALLENGES

Key challenges of the Matészalka project were the following.

7.1 Funding.

Funding was the binding constraint: although the concept was technically mature for years, the upfront CAPEX and risk profile prevented a final investment decision. Feasibility was unlocked when the Swiss–Hungarian Cooperation Programme (Swiss Contribution) provided non-refundable support, including USD 9.35 million dedicated to this project, which closed the equity/loan gap. The grant improved lender metrics (DSCR, covenant headroom), shortened payback periods, and lifted the project's IRR above internal hurdles, despite low heat energy prices and electricity price volatility. Crucially, the funding aligned with the program’s environmental goals, and did not crowd out private capital.

7.2 Supply Chain & EPC

Securing a reliable EPC required a vendor able to supply high-temperature Carrier water-to-water heat pumps guaranteed at ≥4.5 COP under site conditions (42 °C source, 55→70 °C sink) and one who fit the assumed performance/liquidated-damages risk matrix. Tight, low-ΔT integration demanded precise hydraulic design—plate heat exchangers sized for minimal approach temperatures, VFD-controlled primary/secondary pumps, hydraulic separation, and control logic that maximizes temperature lift while preserving source COP. The EPC scope also covered water chemistry management (anti-scaling, filtration, corrosion-resistant alloys), N+1 critical components, winterization, acoustics, and SCADA integration with the existing system for real-time telemetry and dispatch. Finally, constrained tie-in windows and brownfield interfaces required detailed method statements, factory acceptance tests, and a commissioning plan aligned to heating-season operations.

7.3 Strict schedule delivery

The overall project schedule was highly compressed, allowing only 11 months for project execution from initiation to commissioning and SU, with a critical two-month construction window following the end of the heating season in May 2025. Because the geothermal and district-heating systems had to remain operational during winter, all major tie-ins, hydraulic modifications, and heat-pump installations were deferred to this brief post-season period. Detailed coordination was required between contractors, suppliers, and Szalkatávhő’s operations team to synchronize equipment delivery, site access, and safety procedures. Meanwhile, the operator implemented control and boiler-room upgrades in parallel, ensuring the integrated system could enter testing and full heating service by September 2025 without delay.

7.4 Partner collaboration

Securing grid access posed a significant challenge, as the local distributor, OPUS Titász CJSC, typically requires nearly two years to deliver a 3×600 A high-capacity connection. Because the application could only be filed after the grant award in December 2024, less than nine months remained to design, permit, and build the electrical feed. Intensive collaboration with OPUS Titász enabled accelerated transformer sizing, protection configuration, and phased energization, all fully compliant with grid codes. Equally vital was the resilience and cooperative attitude of Szalkatávhő, whose prior experience with our conventional geothermal system’s design, construction, and operation ensured smooth coordination and readiness for commissioning of this HP system in September 2025.

8 CONCLUSION

The experience of this pilot project in Mátészalka shows that even 42 °C geothermal tailwater still holds value when coupled to a high-temperature water-to-water heat pump, in this case raising the local district heating service's primary return from 55 °C to 70 °C at a 4.5 COP or greater. Since Mátészalka represents only one of Hungary's 28 heating districts, there is a good chance that many if not all of those other heating districts could benefit from the approach used successfully in Matészalka. The heat harvesting done for this project uses technology which has been long applied elsewhere in Europe, so it should not be very difficult to replicate

elsewhere in Hungary. Assuming the continued support of Hungary's national government, the key to further progress on this front is to find a reliable investor and qualified partners to carry out a project with well-defined and realistic goals, on behalf of local stakeholders who see the benefit in improving their community's energy infrastructure.

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