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Opening new paths into geothermal energy

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Abstract

The European heating market is undergoing a structural transition toward decarbonisation, with heat pumps increasingly replacing fossil-fuel-based systems. In new residential buildings, air-to-water heat pumps dominate due to their low investment costs and ease of installation. In contrast, ground source heat pumps maintain a low and in some regions declining market share, despite their higher efficiency, longer lifetime, greater reliability, and positive impact on electricity grid stability. Market data from Germany, Switzerland, and across Europe show that high upfront costs, space limitations, and regulatory constraints, particularly related to drilling requirements, remain the main barriers to wider adoption of geothermal systems.
This paper highlights the need for technological innovation to unlock the untapped potential of geothermal energy. It presents the separatus split-pipe technology, which significantly reduces borehole diameter, drilling costs, and space requirements while maintaining high thermal performance. A case study from Brussels demonstrates the successful application of this approach under highly constrained urban conditions. The results illustrate how innovation in geothermal access can enable wider deployment of ground source heat pumps and support a more efficient, resilient, and sustainable heat supply in the building sector.

1. Introduction: The market for heating systems is on the move

The heating transition in the building sector is noticeably underway. The decarbonisation of heating technology is progressing and fossil fuels are increasingly being replaced by heat pumps.
In recent years, the market for heating systems in new residential buildings with one to two residential units in Germany has shifted significantly [Fig. 1]. The steep rise in air-to-water heat pumps is particularly striking. While their share of completed residential buildings was 38% in 2019, their share rose to over 60% by 2023. This technology has quickly become the standard solution for new buildings in Germany. By contrast, the market share of ground source heat pumps has remained consistently low for years, despite their superior efficiency, longer lifetime and greater operational reliability over air-to-water heat pumps.

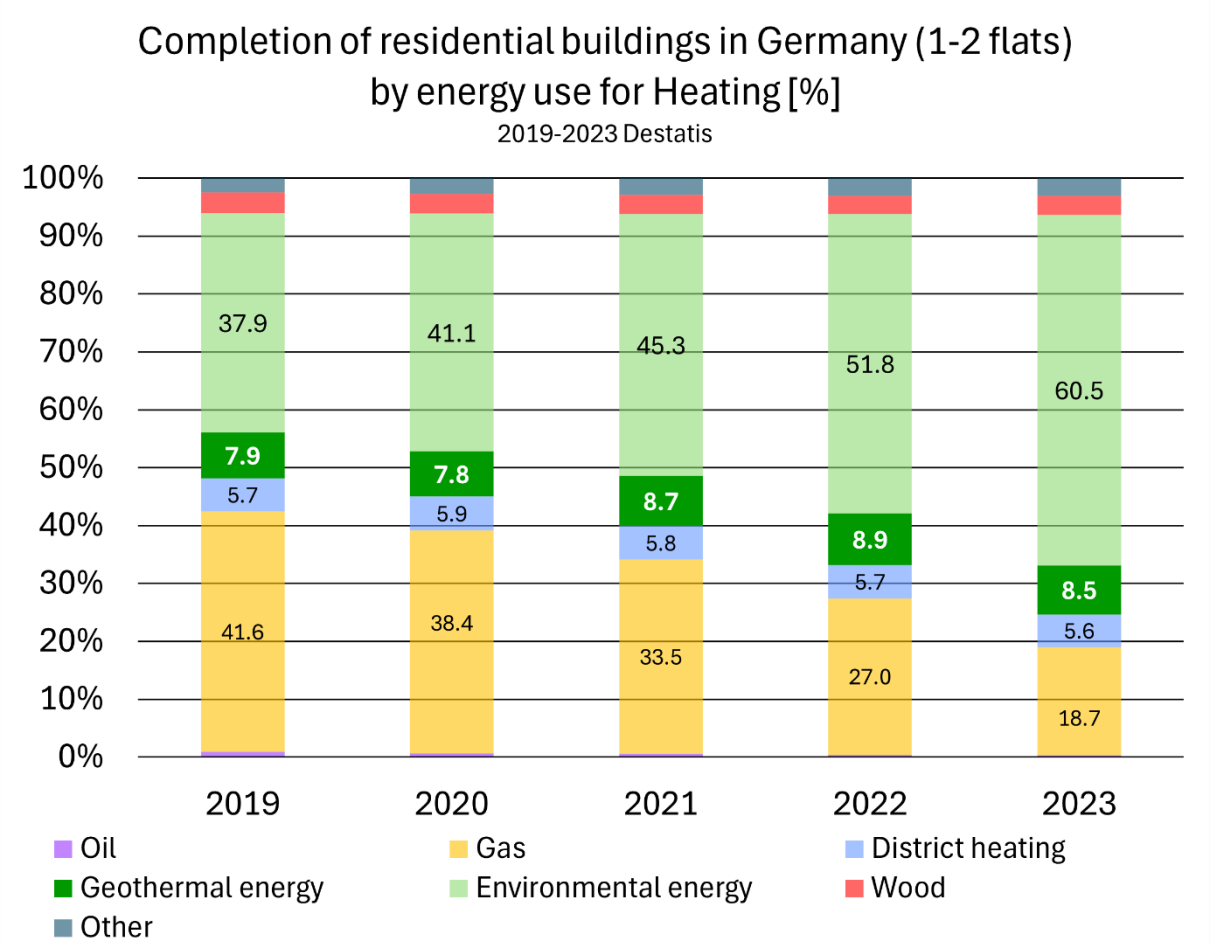


Fig. 1: Completion of residential buildings with 1-2 apartments in Germany, sorted by energy use for heating. Source: Federal Statistical Office of Germany (2025).

Examining the change of heating systems in existing residential buildings in Switzerland and Germany reveals a clear trend towards renewable technologies [Fig. 2]. In Switzerland, the decline in the use of heating oil is particularly striking. While almost 60% of residential buildings were heated with oil in 1990, this figure had fallen to around 37% by 2023. Since then, the proportion of gas heating systems has shown a slight increase. During the same period, the use of heat pumps has increased significantly. Their share rose from 4.1% in 2000 to over 21% in 2023. Despite this positive trend, the overall share of fossil-fuelled heating systems in Switzerland remains high.

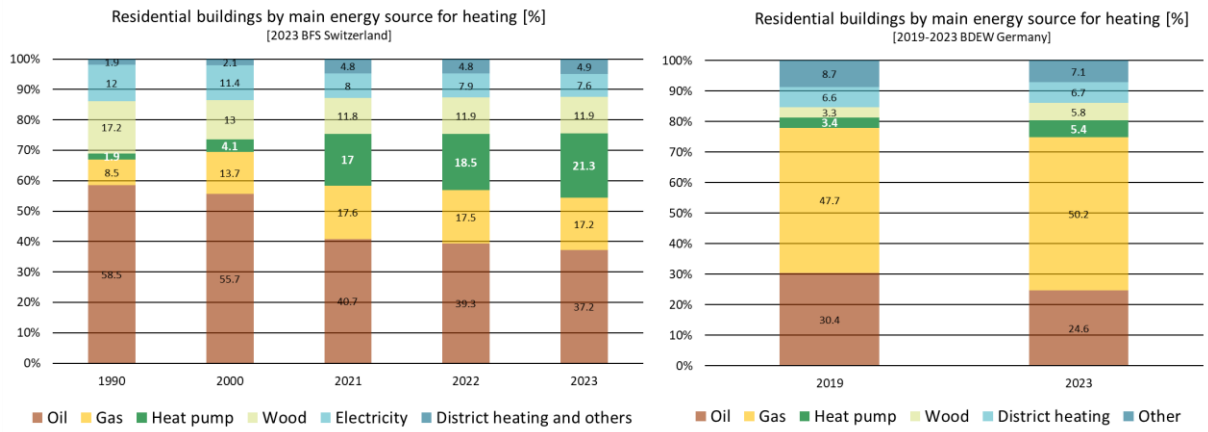


Fig. 2: Existing residential buildings by main energy source for heating in Germany and Switzerland. Sources: FSO (2024) & BDEW (2023)

The trend towards decarbonising existing buildings is also evident in Germany, albeit at a slower pace than in Switzerland. Since 2019, the proportion of gas heating systems has increased slightly, while the proportion of oil heating systems has decreased. Overall, however, fossil fuels continue to dominate. Between 2019 and 2023, the share of heat pumps only increased from 3.4% to 5.4%, which demonstrates that there is still considerable potential for the expansion of renewable heating technologies, especially geothermal heat pumps.

A closer look at the sales statistics from the German heat pump association for the years 2023 & 2024 in Germany corroborates these observations (BWP 2025). In 2023, 356,000 heat pumps were sold in Germany. Remarkably, air-to-water heat pumps accounted for an overwhelming 93% of the market, while ground source heat pumps accounted for just 7%. This share increased to 8% in 2024.

According to the annual statistics & market figures from FWS for the years 2023 & 2024 in Switzerland, ground sourced systems account for a significantly larger market share of around 26%. Although air-to-water heat pumps clearly dominate with 73 %, the gap is smaller. Most heat pumps sold in Switzerland have an output of less than 20 kW. This can be deduced from their widespread use in detached and semi-detached properties.

This market development is consistent across Europe as a whole. The annual sales of heat pumps peaked in 2022 and have declined ever since. A closer look at the EHPA's data from the Market Report 2025 shows that ground source heat pumps still have a small market share and are declining somewhat. In 2012, sales were divided as follows: 57% air/air, 22% air/water and 13% ground source. By 2024, these figures had changed to 41% air/air, 40% air/water and 4% ground source. Therefore, the market share of geothermal energy has decreased by almost 10 percentage points.

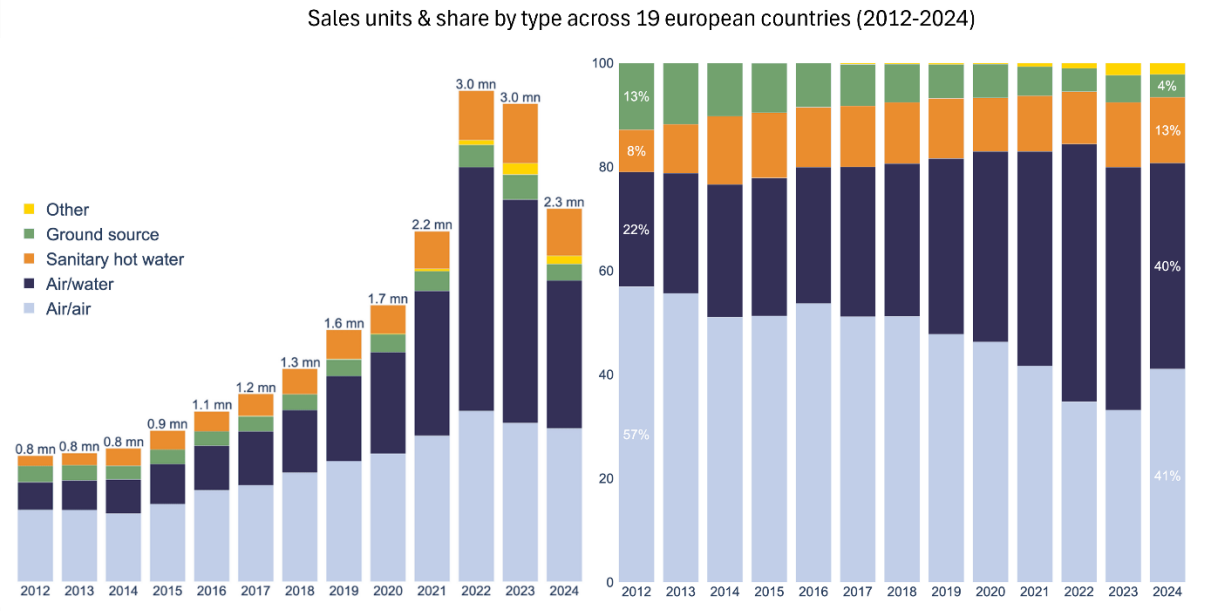


Fig. 3: Annual sales of heat pumps in units across 19 European countries. Source: EHPA (2025)

Overall, air-to-water heat pumps currently dominate the market due to their simple installation, low investment costs, and high feasibility. However, they are demonstrably inefficient and shorter-lived than ground-sourced systems, and they also present a noise problem. Furthermore, ground source heat pumps contribute significantly to grid stability due to their lower energy consumption compared to air source heat pumps, and they save even more electrical and primary energy.
Meanwhile, the potential of efficient geothermal systems has remained largely untapped, despite growing political and economic pressure to decarbonise the building sector and stabilise the electricity grid. Technical, economic and regulatory hurdles have held back this enormous potential for geothermal energy. Innovations are needed, to facilitate new ways of accessing geothermal energy and thus significantly expand its use. To make geothermal energy more accessible and economically attractive, it is essential to find a more cost-effective way of drilling.

2. Without innovation no comeback for geothermal energy

Geothermal energy offers numerous advantages for a modern heat supply. It provides reliable heat at low outside temperatures and contributes to grid stability thanks to its consistently high efficiency, especially in winter when air-to-water heat pumps are much less efficient. The ground is a reliable source of energy that is available all year round. The use of renewable geothermal energy is particularly sustainable and, in combination with green electricity, CO_2-neutral. Minimal maintenance and wear and tear costs are incurred, and operating costs remain low. Geothermal systems are durable and enable passive or active cooling in addition to heating and hot water generation. This makes geothermal energy not only efficient and climate-friendly, but also the future-proof technology that enables a largely self-sufficient heat supply.
Despite its high efficiency and reliability, it has not yet been able to gain market shares in the construction sector. Most households still rely on fluctuating gas or oil prices for heating, or face high electricity costs for air-to-water heat pumps. Above all, building owners want independence and manageable investment and operating costs. When it comes to renovations, they also want to minimise disruption or damage to their grounds.
One of the main reasons for rejecting geothermal energy is the high initial investment cost, even though the costs over the systems' lifetime are much lower than those of air-to-water systems. In

addition, people are concerned about potential damage to gardens and pathways, or the system is not feasible at the location due to water law constraints. Another argument against is the limited space on site, particularly in the case of renovations. Using geothermal systems in existing single-family homes is often difficult using conventional methods.
The main driver of the investment costs for geothermal energy is obtaining access to the soil. Several factors play a role. Poor thermal ground conditions mean that more metres of drilling are required to achieve the necessary thermal output. Costs increase further in difficult geology where boreholes must be extensively cased.
However, the drilling diameter always has the greatest influence on the cost of accessing the ground. A larger drilling diameter brings additional technical and economic challenges. Heavier drilling equipment with higher energy requirements is needed, which increases fuel consumption, worsens the carbon footprint and causes greater damage to land. At the same time, space requirements increase, which limits feasibility, particularly in densely built-up areas. Material costs increase significantly: drill heads, pipework, and other equipment need to be larger, resulting in higher purchase and maintenance costs. In addition, increased volumes of drilling mud are produced, which must be disposed of properly. A larger borehole requires more backfill material.
In some European countries, regulations unnecessarily increase the required drilling diameter due to minimum distance requirements between probe tubes and the borehole wall. Safety concerns relating to the correct grouting of the borehole are cited as the reason for this, however the quality of the work carried out on site is the decisive factor, not the diameter. Countries without such regulations demonstrate that safe, high-quality installations can be achieved without these requirements.
In dense areas, the large space and cost demands of large-diameter boreholes hinder the use of geothermal energy’s potential, despite its technical suitability. This restricts building owners' freedom of choice. As the market overview shows, air-to-water heat pumps are steadily gaining market share, while geothermal heat pumps are stagnating despite their advantages.
This is where the separatus system with its patented splitpipe technology comes in. Flow and return are integrated into a single pipe, with a 2.5 mm wall separating them. With a diameter of just 51 mm, this pipe significantly reduces the borehole diameter and, consequently, the drilling costs. The system can reduce the costs of a geothermal system by up to 30 %. At the same time, the space required can be reduced by up to 60 %. This opens the use of geothermal energy in places where it was previously technically or economically unviable, allowing geothermal heat pumps to regain market share.



Fig. 4: separatus splitpipe-technology. Source: separatus

3. separatus in practice: a new access to geothermal energy

A practical example that illustrates the philosophy of separatus can be found in Belgium. Despite the extremely limited space, a geothermal system was successfully implemented in a terraced house in a densely built-up neighbourhood in Brussels. In such circumstances, many installers and HVAC consultancies would probably have opted for a short-sighted solution, such as an air-to-water heat pump, without giving it any closer scrutiny. Not so in the case of this project. This project was realised by the licensed separatus installation partner BruDrill from Brussels. They drill geothermal boreholes in densely populated areas where conventional drilling equipment is ineffective. They make closed-loop geothermal systems for heating and cooling possible almost everywhere, thanks to the slim probe design of separatus.
The geological profile of the subsoil consists of a topsoil layer, followed by several alternating layers of clayey sand. At depths between 65 and 95 metres, a continuous clay layer is present, followed by another layer of sand. Groundwater is located around 19 metres below terrain.
A Beretta T41 with a weight of just 3.2 tonnes was used to drill three boreholes, each with a minimum diameter of 85 millimetres. Two of these were fitted with coaxial stainless-steel probes, the outer diameter of which was 54 mm, and an inner tube with a diameter of 32 mm. The third borehole was equipped with a separatus geothermal probe with an outer diameter of 51 mm.
All boreholes have an inclination angle of between 5 and 25 degrees. Two boreholes were drilled in front of the garage entrance. A particular highlight was drilling the third borehole: the drill pipe was guided from the street through a small window into the basement, where drilling into the ground commenced.

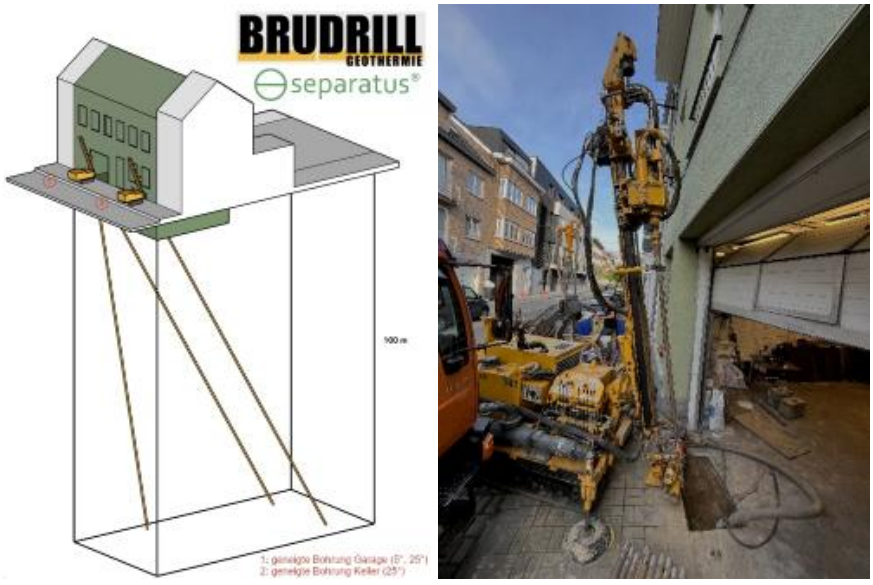


Fig. 5: Diagram of the drill holes and drill rig in use in front of the garage. Source: BruDrill

As part of the project, thermal response tests (TRTs) were carried out on the separatus as well as the stainless-steel coaxial probes. The results showed that the performance of the stainless-steel geothermal probe was only around five per cent higher than that of the separatus geothermal probe. This impressive result demonstrates the efficiency and power of the separatus system.



Fig. 6: Construction site installation in confined spaces. Source: BruDrill



Fig. 7: Drilling an inclined hole through the basement window. Source: BruDrill

4. Conclusion: Potential meets pioneers

Although geothermal heat pumps are more efficient and reliable than air-to-water heat pumps, their market share has remained consistently low for years and continues to decline acrossEurope. In some countries, regulations concerning the minimum required borehole diameter make boreholes more expensive than necessary. However, given ambitious climate targets and the growing demand for stable, renewable heating solutions, geothermal energy could play a pivotal role in the building sector in the future. Because its potential to contribute to security of supply, grid stability and lower operating costs is often overlooked today, a substantial untapped market opportunity for geothermal energy remains.
This project in Brussels is a prime example of how technological innovation and practical implementation can be successfully combined. It demonstrates that geothermal energy can be

realised economically, even in challenging conditions. The key is the reduction in drill diameter and easy installation, thus massively cutting costs.
If the geothermal industry wants to advance the market and drive growth, it will require both innovation and long-term vision. This requires courageous and forward-looking drillers and HVAC engineers that are prepared to break new ground. In Switzerland, Austria, and Belgium, for example, such partners are already working successfully with separatus. Separatus is actively looking for partners who want to help shape the change and elevate geothermal energy to a key market player.

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