Geothermal Energy Use, Country Update for Sweden

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ABSTRACT

This paper presents the status of geothermal energy use and market in Sweden by the end of 2024. Geothermal energy use in Sweden is dominated by shallow geothermal energy systems. Every fourth single-family house in Sweden is heated by a ground source heat pump system (GSHP) with a vast majority of the installed systems being vertical boreholes for space heating and domestic hot water. By the end of 2024, there were approximately 690’000 shallow geothermal energy systems in operation in Sweden, with an addition of roughly 15’000 new systems per year. GSHP systems provided some 28.4 TWh of heating in Sweden of which approximately 21 TWh is renewable heat from the ground. The total installed GSHP heating capacity was 8.1 GW_{th} by the end of 2024. In addition to the heating, approximately 1-2 TWh of direct cooling is provided from the ground.

1. INTRODUCTION

Sweden has more than a half century of experience and development of geothermal energy utilization. The first initiatives were largely triggered by the oil crises in the 1970s and 1980s, with a nationwide effort to achieve oil-independency in the energy system. Heat pump technology in general and ground source heat pumps (GSHP) in particular, developed rapidly by the Swedish industry during the 1990s. Sweden has since that time had a world-leading role in the GSHP research and industry. In the 2020 world geothermal survey (Lund and Toth 2020) Sweden is rated as top three world leading country in geothermal energy utilisation, in terms of installed capacity and extracted thermal energy.

The main focus of the geothermal energy market in Sweden is shallow geothermal systems, due to the favourable geology with widespread high thermal conductivity crystalline rock throughout the geography. Deep geothermal resources are less favourable and so far, only one geothermal district heating plant is in operation in the south of Sweden. It was established in 1985 and is still in operation (Aldenius 2017). Its moderate depth (700-800 m) and low extraction temperature (~20°C) do not meet the criteria for the EGC definition of deep geothermal district heating system, though in a Swedish context it is considered a “deep geothermal” energy plant.

2. GEOLOGY, HYDROGEOLOGY AND CLIMATE IN SWEDEN

The Swedish geology is characterized by the massive Baltic shield and its diverse crystalline eruptive and metamorphic rocks. In the southern parts of the country, sedimentary rock formations of significant thickness are found, (Figure 1).

Geothermal gradients in the Swedish bedrock vary in the range of 15-32°C/km. The higher value represents the sedimentary basin in SW Sweden while the lower values were found in deep boreholes in the Baltic shield region. In Table 1 measured temperatures and geothermal gradients from Swedish boreholes deeper than 1000 m have been summarized. Further information and references are given by Gehlin et al. (2023).

The basement consists mainly of solid granites, and gneisses. These rocks are favourable to drill with down-the-hole (DTH) hammer drilling and have generally a low groundwater yield. Shallow geothermal boreholes are occasionally drilled to a depth of 450-500 m, without significant problems, though common borehole depths are more in the range of 200-300 m.

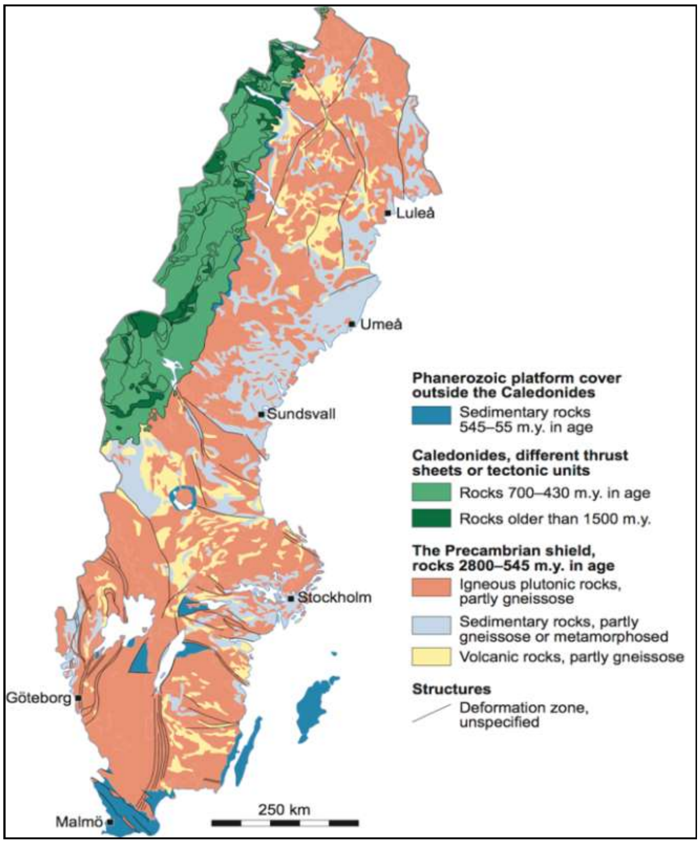

Figure 1: The bedrock geology of Sweden (© Swedish Geological Survey)

Table 1. Measured geothermal gradients in Swedish boreholes deeper than 1000 m

Borehole	Depth (m)	Bottom-hole temp. (°C)	Tempe-rature gradient (°C/km)	Reference
Gravberg-1	6957	116	14–18	Aldahan et al. (1991)
DGE-1	3702	85	22–24	Rosberg & Erlström (2019)
FFC-1	3133	84	7–24	Rosberg & Erlström (2021)
COSC-1	2496	55	20	Lorenz et al. (2015)
Bh32012 in Lake Vättern	1820	37	15–20	Sundberg et al. (2016)
KXL 02, Laxemar	1703	34	16.5	Andersson (1994)
Höllviken 1	2 050	67	26.8	Gustafson & Andersson (1979)

Groundwater reservoirs in the form of aquifers are mainly found in glaciofluvial deposits from the melting of the inland ice that covered Scandinavia some 10-20’000 years ago. These deposits with highly permeable gravel and sand are located along the river valleys where also the population is dense. Apart from their use for drinking water supply, these formations are also highly interesting for shallow geothermal open loop systems. A limited number of large aquifers are also found in the sedimentary rock, mainly located in the southernmost part of Sweden. It is the Mesozoic sandstones and limestones in particular that are used for shallow geothermal open loop systems.

Sweden has a climate that varies from north to south. The southern half is temperate continental while the northern half is continental. The variation in average high summer temperatures is small, with 21°C in the south and 20°C in the north. However, the variation during the winter season is more pronounced, with average temperatures varying from -3°C in the south to -14°C in the north (climatedata.eu 2019). The seasonal swing between summer and winter is generally favourable for seasonal underground thermal energy storage (UTES) systems. Ground temperatures at a depth of 100 m vary between +9°C in the south and +2°C in the north. The ground temperature features the annual mean temperature in the air at the location, but with an increase of 1-3°C in the north due to the insulating effect from snow cover in the winter.

3. DEEP GEOTHERMAL

The interest in using deep geothermal energy in Sweden began in the 1970s (Bjelm et al. 1977; Eriksson et al. 1978, Bjelm et al. 1979, Bjelm and Persson 1981). Focus was then on extraction of warm water from the sandstone aquifers in southern Sweden, and to apply the HDR-concept (Hot Dry Rocks) in other parts of Sweden where the geology is characterized by Precambrian crystalline rock.

The first geothermal well (Höllviksnäs-1) was drilled and tested in 1977-78. It indicated a large potential in the Bunter sandstone at 1800-2000 m depth (Gustafson et al. 1979). In the next step a full-scale geothermal district heating plant in the nearby village of Vellinge was designed but never realised (Andersson 1980).

The initial exploration projects resulted in the Lund Geothermal Heat Production plant, which has been operational since 1985 (see also section 3.1). In the early 2000s an attempt to explore deep geothermal in Lund was executed with the aim of finding hot water in fractured crystalline bedrock close to the Romeleåsen Fault Zone. Two wells were drilled, DGE-1, to a depth of 3702 m and DGE-2 to 1927 m depth. Around that time two wells were also drilled in Malmö, exploring the deep-seated sandstone aquifer within the Mesozoic succession. The borehole FFC-1 was 2110 m deep, and FFC-2 was 2801 m deep. However, none of these two projects were successful. Further information and references on these projects are given by Gehlin et al. (2023).

In 2016, the interest in EGS (Enhanced Geothermal System) applications in the crystalline basement increased. The well FFC-1 in Malmö was reopened, seeking to apply the EGS concept. The initial plan was to increase the depth of the well from about 2100 m to 4000 m, using air-percussion drilling. The drilling method was only used for around 90 m of the drilling, as it was found infeasible due to too high inflow of formation fluid. Further drilling was conducted with conventional rotary drilling to a depth of 3133 m. The drilling process took about two months to execute, with valuable information obtained from the uppermost one kilometer of the crystalline basement. Data acquired from the crystalline basement section during and after the drilling, as well as an overview of the drilling operation, is presented by Rosberg and Erlström (2021). The EGS exploratory project in Malmö is put on hold for now.

During 2023 and 2024, three exploration core drillings for CCS have been conducted by the Swedish infrastructure for scientific drilling, Riksriggen. Deep sandstone reservoirs have been explored on the island of Gotland and in Scania. This project, run by the Geological Survey of Sweden, has focus on CO_2-storage. However, the obtained information about the reservoirs, such as temperature, water chemistry and hydraulic properties, is also highly relevant and valuable for geothermal exploration purposes. The data interpretation is currently in progress, and promising temperatures, higher than expected, are measured in all the wells.

3.1 The Lund Geothermal Plant

In 2025 the Lund geothermal plant has been successfully operational for 40 years. It is the only geothermal heat pump plant in Sweden that can be classified as deep geothermal in a Swedish context, despite its being too shallow and too cold to qualify for the EGC 2025 criteria for deep geothermal district heating. The used geothermal resource is the highly permeable Cretaceous Lund Sandstone with a transmissivity of about $3 \cdot 10^{-3}$ m^2/s. The Lund geothermal plant consists of four production wells, initially extracting a flowrate of 450 l/s (1620 m^3/h) at an average temperature of 21°C. After heat extraction the water is reinjected into four, initially five, injection wells normally at a temperature between 4 and 7°C. The well depths vary between 654 and 768 m, and the average distance between the production wells and injection wells is on the order of 2.1 km. A more detailed description of the Lund geothermal plant is found in e.g. Alm and Bjelm (1995), Bjelm and Alm (2010), Aldenius (2017), Erlström and Rosberg (2022) and Gehlin et al (2023).

The development of the production temperature is shown in Figure 2. The two production wells (SK-1 and SK-2) located closest to the injection wells have been the most influenced by a thermal break-through caused by injecting cold water. The temperature has dropped around 6°C in SK-1 and around 9°C in SK-2 after 40 years of operation. The temperature drops in the two production wells, HA-1 and HA-2, located farther away from the injection wells, are less than 1.5°C after 40 years of production.

The geothermal fluid is used as the heat source for two heat pumps that have a combined capacity of 47 MW. During its first 20 years the plant provided more than 25% and up to 45% of the energy in the Lund district heating network (see Figure 3). Between 250 and 350 GWh of geothermal heat was produced annually during this period. The decrease in production since then is not much related to the geothermal well capacity, but rather a consequence of changes in the district heating production mix: Over the last decades an increased amount of waste heat and co-generation heat production has been introduced in other parts of the district heating system. The high electricity prices during the last years have clearly influenced the production. As an example, the geothermal heat pumps were shut down in December 2021 due to high electricity prices. The low production in 2022, seen in Figure 3, was also caused by a high electricity price. So far, the plant has produced approximately 8.3 TWh of heat over its 40 years operation.

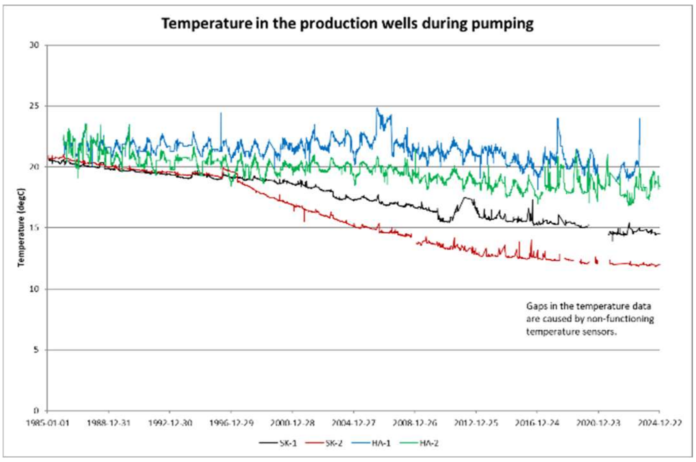

Figure 2. The variation of the temperature in the production wells after 40 years of production. The figure in Rosberg and Erlström (2022) is used and updated.

4. SHALLOW GEOTHERMAL

The typical shallow geothermal energy system in Sweden is a vertical groundwater-filled borehole drilled in crystalline rock. The borehole is connected to a ground source heat pump (GSHP), used for extraction of ground heat for space heating and domestic hot water (DHW) in a single-family house. The heat pump is typically electrically driven. A relatively small number of groundwater heat pumps (GWHP) and surface water heat pumps (SWHP) are also in use in areas where sufficient groundwater flow is easily accessed. Vertical boreholes in rock and groundwater wells are also used for direct cooling only, e.g. for cooling of telecom units and in the industrial sector.

The second most common GSHP system is a horizontal ground loop used for heat extraction for heating and DHW in a small domestic or commercial building. Horizontal ground loops require sufficient surface area with favourable soils. For this reason, these systems are mostly found in the Swedish countryside where enough space for the loops is more easily found than in urban areas.

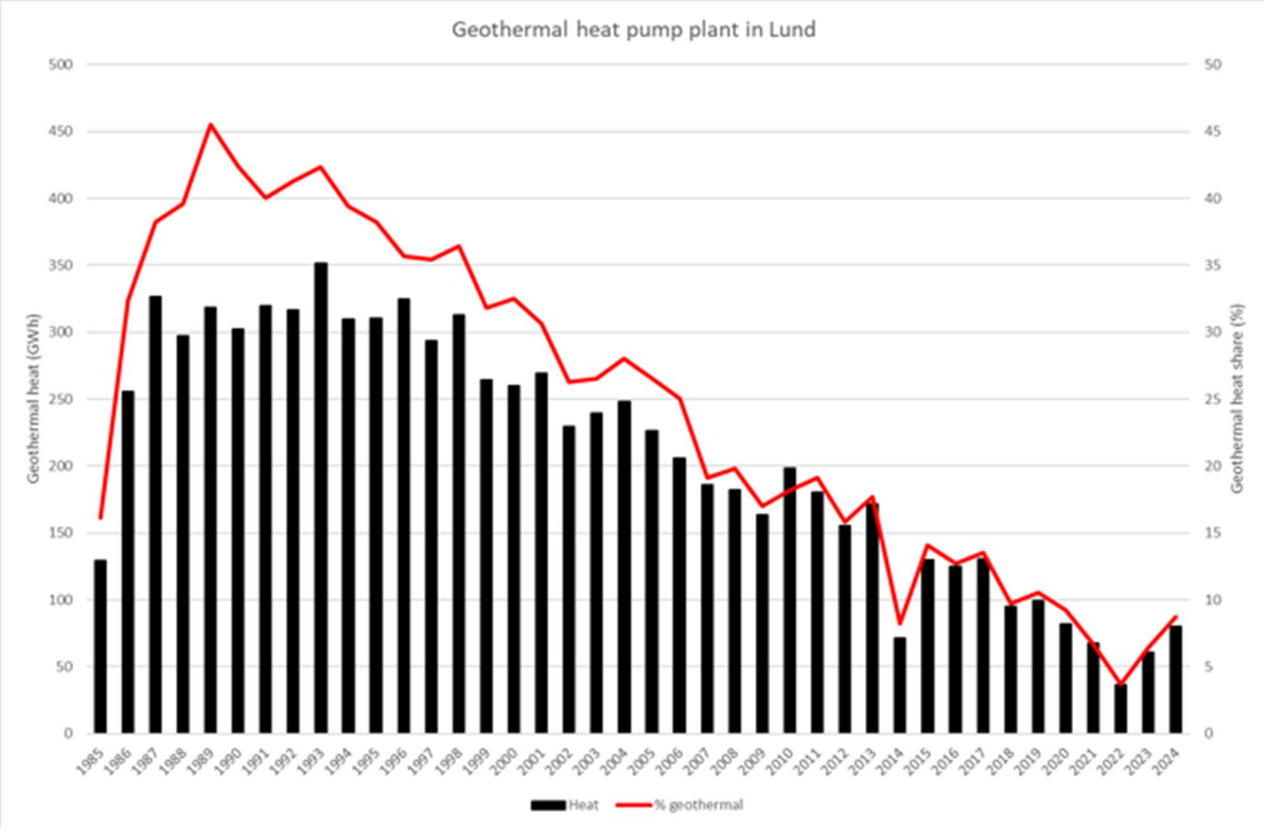

Figure 3. 40 years of geothermal heat production from the Lund Geothermal Plant and its share of the total heat demand in the Lund district heating system.

Shallow geothermal energy systems for larger buildings in Sweden occur both as GSHP systems and underground thermal energy storage (UTES). GSHP systems for larger residential buildings often require active recharge, such as solar heat or waste heat from exhaust air. Commercial buildings typically apply borehole thermal energy storage (BTES) or aquifer thermal energy storage (ATES) for extraction and storage of both heating and cooling (see chapter 5).

There are a handful of examples where boreholes are used in low-temperature applications without heat pumps for pre-heating and direct-cooling of ventilation air for commercial buildings, using the patented concept Skanska Deep Green Cooling (Skanska 2014, Liu and Zhang 2020). In these systems district heating is used as main heat source for space heating. A pre-heating concept called Geo-FTX where boreholes are used for pre-heating of ventilation air in residential buildings is used and developed by the Swedish housing company HSB (Kempe and Jonsson 2015, Kempe et al. 2021).

Figures 4 and 5 show trends in sales for GSHP units in Sweden between 2010 and 2024. Sales volumes for smaller fluid-to-fluid heat pump units (<10 kW) decreased between 2010 and 2020 with a small increase in 2021 and 2022, followed by a new peak in 2023. Sales volumes for larger GSHP units with a capacity >10 kW for residential and commercial buildings have grown steadily since 2012, quadrupling between 2012 and 2023 (Figure 5), with the biggest increase for heat pump units with a capacity between 11-25 kW. However, while 2023 was an all-time high record in GSHP sales in Sweden, it was followed by a dramatic market drop in 2024, caused by several factors such as general recession, high inflation, increased material prices and increased interest rates, which all struck the building sector hard.

By the end of 2024 approximately 690 000 ground source heat pumps have been installed in Sweden with roughly four out of five systems being vertical closed loop borehole systems and around 20% being horizontal loops in soil and lake sediments. Between 1-2% are open loop systems using groundwater or surface water as the heat source, with just a handful new installations per year. From 2012 and on, between 22’000 and 25’000 new GSHP units were sold annually in Sweden, increasing to 28’000 in 2023 and followed by more than 35’000 new units in 2023. In 2024 the sales dropped to less than 24’000 new GSHP units. An increasing number of these heat pump units are also replacement heat pumps for older heat pump units.

According to figures from the Swedish Heat Pump Association (SKVP 2025), a third of the annual total heat pumps sales (air-source heat pumps included) are now replacement heat pumps.

By the end of 2024 the calculated heating energy provided by GSHP systems in Sweden reached 28.4 TWh, of which 21 TWh is renewable heat from the ground. The total installed nominal capacity of all

GSHP systems in Sweden was 8.1 GW_{th} at the end of 2024. The calculations are based on the assumption of an average heat pump running time of 3500 hours/year, at an average COP of 3.8. In addition to this, ATES and BTES systems provide approximately 1-2 TWh direct cooling from the ground. The latter estimation is derived from an assumption that approximately 1000-2000 systems run with ~1000 full load hours of cooling on average. Commercial and institutional buildings often need cooling throughout the year and may reach 2000 full-load hours. Within the residential sector the need for comfort cooling is approximately 500 full-load hours annually. A small number of ATES and BTES systems are used for cooling only and may reach 4000 full-load hours per year.

The number of drilled meters per year, registered in the Swedish well database has been relatively stable over the past few years with around 3.5 million meters per year (SGU 2025). The overall average borehole depth in Sweden in 2024 was 200 m, which is the same average borehole depth as the last five years.

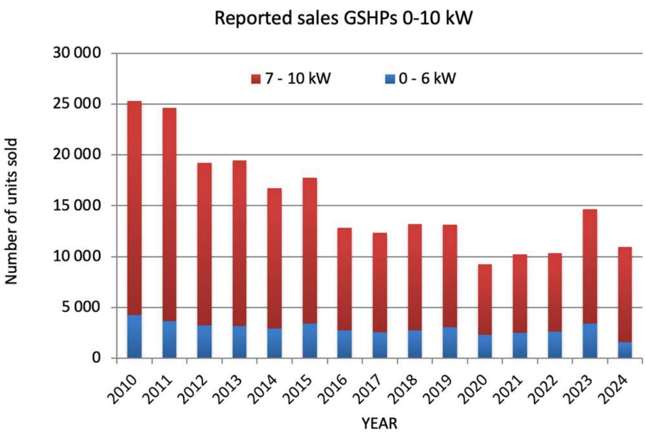

Figure 4: Reported sales of GSHPs up to 10 kW capacities in Sweden (SKVP 2025).

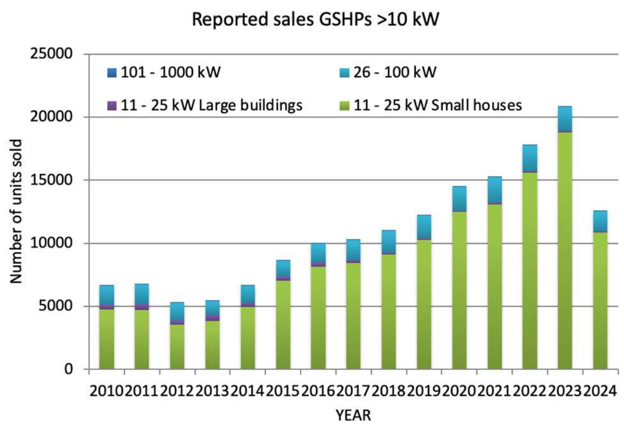

Figure 5: Reported sales of GSHPs >10 kW in Sweden (SKVP 2025).

5. UNDERGROUND THERMAL ENERGY STORAGE

Underground thermal energy systems (UTES) that combine heating and cooling are common applications for larger commercial and institutional buildings in Sweden, with Aquifer Thermal Energy Storage (ATES) and Borehole Thermal Energy Storage (BTES) being the main applications. A handful of Cavern Thermal Energy Systems (CTES), where heat or cold is stored in rock caverns, also exist in Sweden. In recent years the interest for such applications has increased, and two new CTES systems connected to district heating plants have been added in Västerås and Hudiksvall, and a third one is under development in Sundsvall.

5.1 Aquifer thermal energy storage (ATES)

ATES systems use groundwater for carrying the thermal energy into and out of an aquifer. The wells are normally designed with a double function – both as production and injection wells. Energy is stored in the groundwater and in the grains (or rock mass) that form the aquifer. Between 10-15% of the Swedish land area contains aquifers suitable for ATES, and approximately 25% of the population lives in these areas (Andersson and Sellberg 1992). The use of groundwater is strictly regulated in Sweden, making the real potential for ATES systems considerably smaller.

In previous EGC Country Updates for Sweden, the number of plants has been estimated with a growth factor based on real known ATES. As of 2016, an assessment according to SGU's well database has been added, which has turned out to be on the lower side. In order to better calculate which proportion of open loop systems that are ATES applications (heating and cooling) and which belong to the group GWHP (heat only), the methodology has been changed.

The revised way of calculating ATES numbers is still based on a reference list of known cases. This includes 88 open loop systems with a capacity of >100 kW. Of these, 53 are ATES, a few of which are only for heating or cooling. Based on SGU's well database, selecting the boreholes shorter than 100 m, the ATES systems have been added according to the criteria: (1) the systems must have at least 2 wells, (2) individual wells must have a flow capacity of at least 20 m^3/h, (3) growth rate according to the database for 2016-2024, (4) size distribution according to the upgraded reference list (2024). All the other open loop systems, including a thousand without a flow indication, are included in the GSHP system in the previous chapter.

The reference list contains 53 known ATES systems with a capacity of >100 kW. To calculate the total thermal capacity of these, the average values for each size category have been used equally for heating and cooling capacity. As several of the systems serve larger commercial and industrial facilities with year-round cooling needs, the production of free cooling has been assessed to have the same full load hours as heat, which has been estimated at 3,000 hours/year. This value multiplied with the mean value for heating and cooling capacity (0.6 MW_{th}) has been used for both heat and cold production in Appendix Table E2 (ATES). The number of units and their distribution by size is given in Table 2

Table 2: Estimated number and size distribution of ATES and GWHP plants

Capacity range (MW_{th})	Number of units	Total capacity (MW_{th})
0.1-0.99	640	320
1.0-5.0	45	70
>5.0	5	50
Sum	**690**	**440**

Typical ATES storage temperatures are 12-16°C on the warm side and 4-8°C on the cold side (Andersson 2007). Groundwater temperature for GWHP systems would commonly be within 5-10°C.

One of the largest ATES systems in Sweden is the Stockholm Arlanda Airport ATES plant. An esker is used for seasonal storage of heat and cold. The cold is used for air conditioning of the airport buildings, while the heat is used for pre-heating of ventilation air and for snow melting at some airport gates. Cold is stored at 2-3°C and heat at 20-25°C. The system has been designed for a capacity of 10 MW_{th} and uses no heat pumps (Andersson 2009). The system delivers 22 GWh of heat and cold annually (Arvidsson 2016).

5.2 Borehole thermal energy storage (BTES)

Swedish BTES systems typically consist of multiple closely spaced groundwater-filled boreholes of 150-300 m depth in crystalline rock. In later years the boreholes may even reach 350-450 m depth in some places. Single or double U-pipe borehole heat exchangers (BHE) are installed in the boreholes and the storage temperature typically ranges between +2°C in the winter and +8°C in the summer, though some systems with direct-cooling may reach +16°C in the summers. BTES systems have been in use in Sweden since the 1970’s and 1980’s (Gehlin 2016).

By the end of 2024 there were about 6300 GSHP and BTES systems with more than 1 000 borehole meters and around 2900 systems with 10 boreholes or more registered in the Swedish Geological Survey Well database (SGU Well database 2025).

The number of new large GSHP and BTES systems per year has been relatively stable over the past decade (Table 3 and Figure 6) with a drop in 2024 due to negative building market conditions. Data for 2023 and 2024 is incomplete due to delay in reporting to the well database. On average some 50 new systems with >20 boreholes are registered in the well database annually. As seen in Figure 6, GSHP and BTES systems with between 20 and 50 boreholes account for a major part of these systems.

The largest BTES system in Sweden is the BTES system at the Volvo Powertrain plant in Köping, constructed in 2015-2016, used mainly for cooling. The system has a total of 215 boreholes with average borehole depth of 270 m, and a total borehole length of 58’200 m (Svensk Geoenergi 2017).

Table 3: Number of new BTES systems of various sizes reported in SGU Database *(SGU Well database 2025)*

Year	Units (1-2 holes)	Units (3-5 holes)	Units (6-10 holes)	Units (11-19 holes)	Units (≥20 holes)
2015	14605	429	178	73	39
2016	10550	407	192	70	51
2017	10769	459	215	89	61
2018	10774	368	191	80	56
2019	10951	402	192	80	48
2020	9645	438	198	100	61
2021	9513	429	215	101	52
2022	10211	405	183	98	52
2023*	9033	361	177	75	42
2024*	6808	249	95	60	22

**Data for 2023 and 2024 is incomplete due to delay in reporting.*

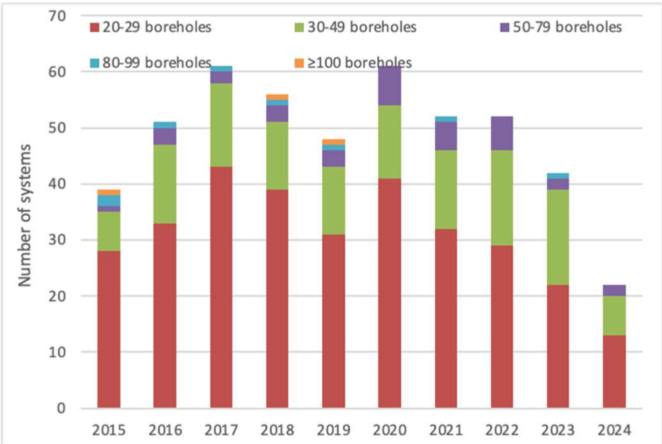

Figure 6: New large BTES systems 2015-2024 registered in the SGU Well Database. Data for 2023 and 2024 is incomplete due to delay in reporting. (SGU Well database 2025).

5.3 High temperature storage applications

There are two large-scale high-temperature seasonal storage technologies practiced in Sweden: storage in boreholes (HT-BTES) and storage in rock caverns (HT-CTES).

The first HT-BTES plant in Sweden, the Lulevärme project (Nordell 1994), is no longer operational. It stored industrial waste heat from a steel industry and was used for space heating of a university building in the northern city of Luleå in wintertime. This experimental plant was operational between 1981 and 1989.

The second HT-BTES installation is the Anneberg residential HT-BTES system that was taken into operation in 2002. This system is used for seasonal storage of solar heat for residential heating of 50 houses. It uses no heat pumps and has a measured solar fraction of 40% after 12 years in operation (Heier 2013). The future of the plant is uncertain since several major above-ground system components (solar collectors and control system) are reaching the end of their technical life and thus need replacement. One option is to decrease the storage temperature, replace the solar collectors with PV panels and install heat pumps.

The third HT-BTES installation is the Emmaboda Xylem HT-BTES system. This was installed in 2009-2010 and is used for seasonal storage of industrial waste heat, as well as for process cooling (Andersson and Rydell 2012, Nordell et al. 2016, Andersson et al. 2021, Andersson and Rydell 2024). Since the extraction temperature was too low, supporting extraction heat pumps were installed in 2018 and the storage temperature was decreased. The installation of heat pumps improved the system efficiency as was shown in the case study report from the IEA HPT Annex 52 project (Andersson et al. 2021) and in a later evaluation (Andersson et al. 2024).

In recent years, a new interest in HT-BTES is growing. Above all, it is the Swedish district heating plants that are looking for possibilities of storing excess heat from the summer operation. This applies in particular to the district heating plants with a high fraction of garbage combustion in their energy mix, especially the ones with cogeneration. Instead of fanning off the excess heat generated in summer, they now look for solutions to store this heat from summer to winter. There is also industrial waste heat that could be better utilized if stored seasonally. There are currently several ongoing feasibility studies on using HT-BTES for such applications. One of these studies is Tekniska Verken in Linköping, where a pilot plant was installed in 2023. The pilot plant uses fractured rock technology to improve the ground fluid flow and system efficiency (Energiforsk 2024).

During the 1980s, two HT-CTES were excavated for underground heat storage in Sweden: Avesta with a storage volume of 30’000 m^3, and Uppsala (Vreta) with a storage volume of 100’000 m^3. Both these CTES are still operational. A third application in Oxelösund consisted of a converted oil cavern that was chosen not to be remediated. For this reason it was taken out of use after only a couple of years. In recent times, the old oil caverns have come into focus again, however this time with remediated caverns. In the city of Hudiksvall the CTES volume is 180’000 m^3 and the heat storage capacity is 20 MW$_{th}$. This storage has been operational since 2018 (Energiforsk 2024). A similar CTES has recently been taken into operation in the city of Västerås. The storage consists of three chambers with a total storage volume of 300’000 m^3 (Mälarenergi 2025). In both cases the caverns are connected to district heating with a working temperature of 95/40°C.

6. FUTURE AND TRENDS

Since the previous country update (Gehlin et al. 2022) the market for small residential building GSHPs has experienced some market fluctuation. The pandemic in 2020-2021 caused a general building market decline and component shortage and in 2022 the Ukraine war shook the European energy market with big changes in prices for oil, gas, biomass and electricity. These energy price effects, combined with the clearly expressed promotion of heat pump technology in general and geothermal energy in particular from the EU parliament, caused a strong recovery of the Swedish GSHP market at the end of 2022 and in 2023, resulting in record GSHP sales these two years. However, the market clearly over-estimated the speed of the market development and the EU initiatives to stimulate geothermal in Europe. General economic recession, increased interest rates, and a declining building sector in Sweden resulted in a dramatic drop in GSHP sales in 2024, especially for small buildings. Lower inflation and decreasing interest rates at the end of 2024 gave indications of a slow recovery of the building market and GSHP sales.

Another factor that affects the GSHP sales market and to some extent also the drilling market is the increasing number of replacement heat pumps as the GSHPs installed around the millennium are now reaching the end of their technical life. These replacement heat pumps also raise new issues for the Swedish GSHP market. The GSHPs that were installed 20-25 years ago were on-off regulated heat pumps with a COP of around 3. The GSHP systems at that time were typically designed to cover 60% of the peak load, with the remaining load being covered by supplementary electric heating. For a typical Swedish single-family house this required a borehole depth of 100-120 m. These old heat pumps are now replaced by a new generation of efficient speed-controlled GSHPs with COP on the order of 4-5 or more, and many building owner want to minimize the need for supplementary electric peak heating. This means that building owners must make up their mind whether to choose a smaller heat pump that fits the depth of the existing borehole, or if they want to take advantage of the technology advancement and optimize the GSHP system based on the new and more efficient technology. In the latter case they will most likely need to add more borehole meters to meet the increased ground source load.

Recent analyses of house sales in Sweden show that buyers value GSHP systems in houses higher than any other heating solutions. This is indicated by significantly higher sales prices for small residential houses with GSHPs compared to houses with other heating solutions. On average, a single-family building with a GSHP was valued € 12’500 more than a house without a GSHP in 2024, and in the Stockholm region the added value for the GSHP was even higher: € 20’000.

Several Swedish district heating companies are now beginning to show interest in HT-UTES solutions and deep geothermal. This is caused by the rapidly increasing price for biomass, and an increased interest in using waste heat from cogeneration plants. Hence the district heating industry must look for new alternative heat sources, such as waste heat and large-scale heat pump solutions as well as HT-UTES and deep geothermal heat. A number of research and pilot projects are currently being executed.

There is growing interest in EGS (Enhanced Geothermal Systems) in the Swedish crystalline basement among the district heating industry, with several exploration projects and interest in new deep drilling projects and technology development.

7. CONCLUSIONS

Since decades, Sweden is the top geothermal energy using country in Europe, and the top three world leading country in geothermal energy utilisation according to the geothermal energy utilization world overview from World Geothermal Congress 2020 (Lund and Toth 2020). The Swedish market is so far completely dominated by shallow geothermal energy application, with no deep geothermal energy or geothermal power production within the definition of EGC. There is reason to believe that the Swedish GSHP and UTES market will remain strong over the coming decades, despite the fluctuations in GSHP sales in recent years. Increasing biomass and district heating prices due to increasing competition in biomass utilization, combined with increasing renewable electricity production in the Swedish energy system make geothermal energy and UTES competitive and feasible energy solutions. This applies both for individual buildings and as part of upgrading district heating networks. This is also indicated by the significant increase in real estate value for large and small buildings with GSHP and UTES solutions.

The growing interest in HT-UTES and deep geothermal in the Scandinavian crystalline bedrock indicates a shift in the view on geothermal, deep and shallow, among the strong district heating industry in Sweden, and opens up a new market for geothermal industry and research.

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Table A: Present and planned geothermal power plants, total numbers

There is no geothermal power production in Sweden.

Table B: Existing geothermal power plants, individual sites

There is no geothermal power production in Sweden.

Table C: Present and planned deep geothermal district heating (DH) plants and other uses for heating and cooling, total numbers

There is no present or planned deep geothermal DH plant in Sweden that meets the criteria of >25°C.

Table D1: Existing geothermal district heating (DH) plants, individual sites

There is no existing deep existing geothermal DH plant, nor individual ones, in Sweden that meets the criteria of >25°C

Table D2: Existing geothermal large systems for heating and cooling uses other than DH, individual sites

There are no existing large geothermal systems for heating and cooling in Sweden that meets the criteria of >25°C and >500 kW_{th}.

Table E1: Shallow geothermal energy, geothermal pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in the year 2024		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2024	690’000	8120	28’400	16’500	231	N/A
Of which networks *	N/A	N/A	N/A	N/A	N/A	N/A
Projected total by 2028	730’000	9000	31’400			

** Distribution networks from shallow geothermal sources supplying low-temperature water to heat pumps in individual buildings (“cold” DH, Geothermal DH 5.0 etc.)

Table E2: Shallow geothermal energy, Underground Thermal Energy Storage (UTES)

	Aquifer Thermal Energy Storage (ATES)			Borehole Thermal Energy Storage (BTES)		
	Number	Capacity (MW_{th}) Heat / Cold	Production (GWh_{th}/yr) Heat / Cold	Number	Capacity (MW_{th}) Heat / Cold	Production (GWh_{th}/yr) Heat / Cold
In operation end of 2024	690	H: 414 C: 414	H: 1242 C: 1242	815	H: 245 C: 245	H: 735 C: 295
New (additional) in the year 2024	20	H: 12 C: 12	H: 36 C: 36	35	H: 11 C: 11	H: 32 C: 13
Projected total by 2028	750	H: 450 C: 450	H: 1350 C: 1350	1015	H: 315 C: 315	H: 945 C: 375

Table F: Investment and Employment in geothermal energy

	in 2024		Expected in 2028	
	Expenditures * (million €)	Personnel ** (number)	Expenditures * (million €)	Personnel ** (number)
Geothermal electric power	0	0	0	0
Geothermal direct uses	0	0	0	0
Shallow geothermal	> 3000	> 10’000	>3000	>10’000
total	> 3000	> 10’000	>3000	>10’000

* Expenditures in installation, operation and maintenance, decommissioning

** Personnel, only direct jobs: Direct jobs – associated with core activities of the geothermal industry – include “jobs created in the manufacturing, delivery, construction, installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration”. For instance, in the geothermal sector, employment created to manufacture or operate turbines is measured as direct jobs.

Table G: Incentives, Information, Education

	Geothermal electricity	Deep Geothermal for heating and cooling	Shallow geothermal
Financial Incentives – R&D	none	none	Yes[1)]
Financial Incentives – Investment	none	none	TC[2)] DIS[3)]
Financial Incentives – Operation/Production	none	none	none
Information activities – promotion for the public	none	none	Yes[4)]
Information activities – geological information	none	none	Yes[5)]
Education/Training – Academic	none	none	Yes[6)]
Education/Training – Vocational	none	none	Yes[7)]

Key for financial incentives:

DIS	Direct investment support	FIT	Feed-in tariff	-A	Add to FIT or FIP on case the amount is determined by auctioning
LIL	Low-interest loans	FIP	Feed-in premium		
RC	Risk coverage	REQ	Renewable Energy Quota		
TC	Tax credits	O	Other (please explain)		

1) The Swedish Energy Agency runs the research programme TERMO from which geothermal energy research may be partially funded.

2) New GSHP installations for private residential buildings are partly deductible from tax, as is the case for a number of other types of renovation work.

3) Investment support for measures to reduce greenhouse gas emissions can be granted through The Environmental Protection Agency via their local investments program, called the Climate Leap initiative, granting subsidies of 20-65% of the investment.

4) The Swedish Geoenergy Center arranges courses, conferences/workshops, seminars, information activities, and issues the journal Svensk Geoenergi (Swedish Geoenergy).

5) Open access well database administered by the Swedish geological Survey (SGU).

6) Short courses and lectures at universities

7) Short courses in basic geothermal energy and EED training by the Swedish Geoenergy Center; two weeks education of new drillers once every year