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Country Update for Sweden 2020

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ABSTRACT

In this paper the current status of geothermal energy use and market development in Sweden is presented. Geothermal energy in Sweden is dominated by low temperature, shallow geothermal energy systems, and >95 percent of the installed geothermal energy systems are ground source heat pump systems for space heating and domestic hot water heating for single-family buildings. Over the last decade there has been an increase in the market for larger residential and non-residential shallow geothermal energy systems, often providing both heating and cooling. There are today two high-temperature borehole thermal energy storages (HT-BTES) in operation in Sweden, one residential and one industrial application. More large-scale high-temperature storages connected to district heating plants are under consideration or investigation. The geological conditions in Sweden are not favourable for deep geothermal in sedimentary rock. Since the mid 1980's there is one low-temperature geothermal heat production plant in operation in Lund in the southern part of Sweden, providing heat pump supported geothermal heat to the district-heating network. Lately there has been an increasing interest in deep geothermal exploration in Sweden, raised by the development of the neighbouring deep geothermal project in Espoo in Finland. In 2019, shallow geothermal energy systems provide approximately 17.1 TWh (62 400 TJ) of heating from the ground (no heat pump electricity included). The installed heating capacity is 6 680 MW.

1. INTRODUCTION

Development of geothermal energy utilization in Sweden was triggered by the oil crises in the 1970's and 1980's, when nationwide efforts were made to achieve an oil-independent energy system. Following these national efforts, heat pump technology was promoted by the government, and largely funded through the Swedish Council for Building Research. The development was further favoured by the national power production strategy based on nuclear power and hydropower, which provided for secure, clean and inexpensive electricity for heat pumps. During the 1990's the heat pump technology in general and ground source heat pump (GSHP) technology in particular, developed rapidly in Sweden. Sweden became a world-leading nation within GSHP research and industry. At the end of the 1990's the Swedish Council for Building Research was closed and the responsibility for funding of energy related research was taken over by the Swedish Energy Agency. In 2013 the Swedish Geoenergy Center (Svenskt Geoenergicentrum) was established, to meet the need for information raised by an overall increasing interest in geothermal development. Over the last decade, funding for shallow geothermal research and development has slowly increased, and a renewed interest in deep geothermal exploration in Sweden, is seen from the Swedish Energy Agency and the industry.

One of the main scientific bodies in Sweden for the exploration and utilization of deep geothermal energy resources is the Engineering Geology department at Lund University, where deep geothermal research has been going on since 1977. The Geological Survey of Sweden (SGU) is the expert agency for issues relating to bedrock, soil and groundwater in Sweden, and is responsible for providing geological information, and groundwater protection. In 2016 SGU issued a report on the geological information provided by SGU, related to the geothermal energy potential in Sweden (Erlström et al, 2016).

The majority of geothermal development in Sweden relates to shallow geothermal systems, with over a half million installed GSHP systems by 2019. Some activities related to deep geothermal resources were seen in the 1980's and early 2000's, so far resulting in one geothermal district heating plant utilizing a geothermal resource at moderate depth (600-800 m) and temperature level (<22°C) in the south of Sweden. The plant was established in the 1985, and is still in operation (Aldenius 2017).

2. GEOLOGY BACKGROUND

The Swedish geology, in short, 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, spot-wise containing porous sandstones at considerable depth and with decent hydraulic properties allowing for potentially feasible use. The crystalline rock consists mainly of granites and gneisses. 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 is slightly higher in the north due to the insulating effect from snow cover in the winters. Geothermal gradients reach approximately 30°C/km in the south and seldom more than 15°C/km within the Baltic shield regions (NE 1980:7). Lately, higher temperature gradients have been reported as well, Rosberg and Erlström (2019) presented gradients between 22-24°C/km for a deep well located in the Fennoscandian basement and Lorenz et al. (2015) presented a gradient of 20°C/km for a deep well in the Swedish Caledonides.

Groundwater in the form of aquifers is mainly found in the glaciofluvial deposits from the melting of the inland ice that covered Scandinavia some 10-20 000 years ago. Eskers with highly permeable gravel and sand deposits are located along the river valleys. A limited number of large aquifers are also found in the sedimentary rock, mainly located in the southernmost part of Sweden.

3. GEOTHERMAL RESOURCES AND POTENTIAL

3.1 Deep geothermal resources and potential

The crystalline eruptive and metamorphic rocks of the Baltic shield, covering most of Sweden, provide little potential for deep geothermal exploitation. The moderate geothermal gradient, would require very deep boreholes to reach sufficiently high geothermal temperatures. Deep sedimentary formations with porous sandstones and hydraulic properties suitable for geothermal exploitation are only found in the southernmost parts of the country. In the southwest of the province of Skåne the geothermal gradients in the sedimentary succession are between 28 and 32°C/km (Erlström et al. 2018). However, the thickness of the sedimentary succession is not enough to reach temperatures above 100°C. The first deep temperature logging in the southwest of Skåne was carried out in 1955 in a 2270 m deep borehole at Ljunghusen 1 (LTH 1977). The measured temperature gradient at that location was close to 35°C/km. In 1977 a former oil exploration borehole was reconstructed to a geothermal well in Höllviksnäs 1, close to Ljunghusen 1. This well, with a screen completion in the Bunter sandstone at approx. 2 000 m showed a gradient of 30°C/km and a production capacity of 90 m^3/h (Gustafson et al. 1979). Further investigation of the potential for geothermal energy in Skåne was reported by a research group at Lund University (Bjelm et al. 1977, Bjelm et al. 1979), and for Sweden as a whole by Eriksson et al. (1979). The municipalities of southwest Skåne (SSK) issued a special report for a broad exploration the geothermal resource (Andersson 1982). Apart from SW Skåne, the potential for semi-deep geothermal heat extraction in sedimentary bedrock may also be found on the island of Gotland and in the Siljan area in the middle parts of Sweden (Erlström et al. 2016). A comprehensive study of the deep geothermal potential in SW Skåne and the Öresund region has recently been published (Erlstöm et al. 2018). The only geothermal plant in Sweden, operational since the 1980's, is located in Lund (see section 4.1).

Table 1: Deep geothermal exploration projects in Sweden

Location	Year	Total drilling depth	Notes	Reference
Ljunghusen 1	1955	2270 m	First deep temperature loggings in Sweden	LTH, 1977
Höllviksnäs 1	1977-79	2 605 m Screen at 1860-2050 m	First geothermal well, logged and pump tested	Gustafson el al 1979
Lund 1 (4 production wells, 6 injection wells)	1983-85	550-700 m (production zone)	First commercial application	Aldenius 2017
Fjällbacka	1984-1995	500 m	HDR project	Wallroth et al. 1999
Lund 2 (2 wells)	2002-2005	3702 m 1927 m	Both deep-seated sandstone layers and the crystalline basement were tested.	Bjelm 2006, Bjelm and Rosberg 2006, Rosberg and Erlström 2019
Malmö (2 wells, one deviated)	2002-2003	2110 m 2801 m MD or 2120 m TVD	Triassic sandstone	DONG 2006a, DONG 2006b, Malmö Stad 2007, Erlström et al. 2018
Birka	2005	1000 m	Impact crater	Henkel et al. 2005
Siljan	2010-2013	500-600 m	Impact crater, shallow geothermal sandstone aquifer.	IGRENE, 2016

In 2009 the Swedish Research Council awarded Lund University a grant for purchasing and implementing a national infrastructure for scientific core drilling. The so-called Riksriggen is capable of drilling to a depth of 2500 m in NQ size (hole size 76 mm and core size 47.6 mm). The drill rig in combination with the Luleå Technical University stress trailer is a useful tool for geothermal exploration in Sweden (Ask et al. 2017). In addition, valuable information about thermal gradients and geothermal properties are obtained from the deep scientific drilling projects were often one of the scientific sub-tasks is related to geothermal research.

Despite the moderate geothermal gradients in the Swedish geology, the interest in deep geothermal energy in Sweden has increased in the last few years, to some part related to the development in Finland with the EGS pilot project in Espoo, where drilling started in 2015 (Kallio 2016). The possibility to produce geothermal power in Sweden is non-existent, considering the low geothermal gradients. It is conceivable that geothermal resources at depths down to 5-7000 m, may in the future be utilized for heat pump aided district heating applications.

3.2 Shallow geothermal resources and potential

While the predominant crystalline rock in the Baltic shield provides little potential for deep geothermal exploitation, it provides the more potential for shallow geothermal energy use. The granites and gneisses are normally solid with a generally low groundwater yield, which makes them favourable for drilling holes down to 200-300 m or more without technical problems.

The Cretaceous formations in Skåne are, at many locations, suitable for GSHP or ATES applications, often in large scale. In other areas with less or none groundwater it has become common to drill boreholes for closed system. The limestone and chalk is easily drilled to depths of 300 m or more. In these deep boreholes, commonly pipe sizes DN45 or DN50 are used in borehole heat exchangers. In the northwest part of the Skåne province, the rock consists of Jurassic shale with poorly consolidated beds of silt- and sandstones. The latter ones limit the depth of geothermal boreholes to approximately 200 m at the best. The sedimentary rocks in the rest of Sweden consist mainly of Precambrian and Cambrian sandstones, Ordovician limestones and Silurian shales with a total thickness of 300 m or less. These are covering a minor part of the surface area. On the islands of Gotland and Öland the limestones are commonly used for closed GSHP applications.

Using groundwater from shallow aquifers as thermal source for heat pumps has a vast potential in those areas where either eskers or sandstone and limestone formations are present. Between 10-15% of the Swedish land area contains aquifers suitable for shallow geothermal energy utilization, and approximately 25% of the population lives in these areas (Andersson and Sellberg 1992), However, using groundwater is strictly regulated making the real potential for shallow geothermal groundwater utilization considerably less.

All in all, the potential for ground source heat pump (GSHP) systems throughout Sweden, using the ground (rock or soil) or groundwater as heat sources, is very good. The vast majority of the Swedish shallow geothermal energy systems are vertical boreholes in hard rock, serving as heat source for heat pumps to single-family houses. There are around two million single-family houses in Sweden, and approximately 20-25% of these houses are today heated with a GSHP. Market development for these small systems has been very strong for several years, however over the later years the number of new installed small systems has stabilized. Instead there is a steady growth of larger GSHP systems for residential as well as commercial buildings. Also the market for underground thermal energy storage (UTES) for large facilities is steadily growing. The two main UTES categories used are Aquifer Thermal Energy Storage (ATES) and Borehole Thermal Energy Storage (BTES), and are used for both heating and cooling purposes, preferably combined. Geothermal energy is considered an environmentally friendly technology by the general public and tends to increase the commercial value of a building. Geothermal energy has played a major part in replacing fossil fuels in the heating of the Swedish building stock, especially for small residential buildings.

4. GEOTHERMAL UTILIZATION

4.1 Deep geothermal utilization

There is no geothermal power production in Sweden, and the only geothermal plant in Sweden that meets some of the criteria for a deep geothermal plant is the Lund geothermal heat pump plant in Lund. It has been operating since the mid 1980's. The geothermal resource at the well site Värpinge consists of a set of very porous sandstones at 400-800 m depth. The formation belongs to the Campanian of Upper Cretaceous located at the border zone of the Danish basin known as the Sorgenfrei Tornquist zone. The sandstone aquifer is highly permeable with a transmissivity of about $3x10^{-3}$ m^2/s. The four production wells initially produced 450 l/s (1 620 m^3/h) at a production temperature of 22°C. The temperatures in the production wells closest to the injection have been influenced by the injection of cold water for more than 30 years, but the wells farthest away are more or less unaffected. The temperature has decreased around 10 °C. The gravel pack in the injection wells tends to clog and has therefore been subject to air-lift treatment several times. In addition, a hydro-jetting method was introduced for cleaning the wells in 2011, and resulted in significantly improved specific capacity (Andersson and Bjelm 2013). The geothermal fluid is used as the heat source for two heat pumps. These heat pumps have a combined capacity of 47 MW. After >30 years run-time, the geothermal plant was re-evaluated by Aldenius (2017). At its peak in 1993, the plant produced 350 GWh of heat, providing 40% of the energy in the Lund district heating network. Between 2015 and 2018 the heat production was between 95 and 131 GWh/year. The decrease in production is mainly due to an increased amount of waste heat and co-generation heat production in other parts of the district heating system, and is not related to the geothermal well capacity. In total the plant has produced 7.7 TWh of heat since its operation started in the 1980's.

4.2 Shallow geothermal utilization

The typical Swedish shallow geothermal energy extraction system is a groundwater filled vertical closed loop GSHP system, drilled in crystalline rock, used for heat extraction only. The heat pump is typically electrically driven and is used for both space heating and domestic hot water (DHW) heating. These systems, mainly used for small to medium size systems for heating of residential buildings, are sometimes recharged with heat from exhaust air or solar. About 20-25% of all shallow geothermal energy systems in Sweden are horizontal ground loops in soft ground material at about 1 m depth below the ground surface. These systems are typically, in Sweden, only used for heat extraction, and will freeze the moisture in the ground around the ground loops, thus taking advantage of the phase change energy. Horizontal ground loops work best in finely grained soil with high porosity and moisture content. These are most common in the south of Sweden where the ground temperature is higher and thick layers of soil cover the hard rock. The market for underground thermal energy systems (UTES), where heat and cold is actively stored, has been continually growing over the last decades. The two commercial systems are Aquifer Thermal Energy Storage (ATES) and Borehole Thermal Energy Storage (BTES).

Sales figures from the Swedish Heat Pump Association show that currently some 590 000 ground source heat pumps are installed in Sweden, of which approximately 140 000 are horizontal loop systems, and an estimated number of 10 000 are open groundwater or surface water heat pump systems. Many of the open systems, small and large, were installed in the 1980's. Today between 5-10 new such installations, mainly large systems (>100 kW), are added each year. The total number of sold ground source heat pump units in the capacity range 3 kW-1 MW over the last five-year period is approximately 140 000 units, of which about half are new GSHP systems, and the rest are replacement heat pumps in older GSHP systems. Over the last five years, an average of 14500 new GSHP systems have been installed per year, with a slightly decreasing trend. In 2019 around 12000 new GSHP systems will be installed. It is the market for small units that has shown a decreasing trend these last few years, as the market for single-family buildings is becoming saturated. On the other hand, the market for larger systems is growing. Vertical boreholes in rock and ground water wells are also used for comfort cooling and free-cooling, for instance in the telecom and industrial sectors. There are also some large ground source heat pumps in operation in district heating networks around Sweden. In 2012 these plants provided some 0.65 TWh to the Swedish district heating network (Trad 2014). More recent figures for the amount of heat provided by ground sources to the Swedish district heating network are not available.

BTES systems in Sweden typically consist of several closely spaced boreholes with a depth of 150-300 m. The boreholes are typically groundwater-filled and fitted with single or double U-pipe borehole heat exchangers (BHE). The storage temperature typically ranges between +2°C in the winter and +8°C in the summer. Sweden was one of the early adopters of BTES systems in the late 1970's and 1980's, and built several pilot plants (Gehlin 2016). After a rather slow period during the 1990's, the market for BTES systems is now growing in Sweden.

The number of registered BTES systems (SGU Well database 2019) with 10 000 m or more total borehole length has almost quadrupled from 21 in 2015, to 76 systems in 2019.The currently registered number of GSHP and BTES systems with 1 000 borehole meters or more, is 3970, and there are 1701 registered systems with 10 boreholes or more. This is an increase with almost 40% since 2015, when these numbers were 2883 and 1238 respectively. An estimate of 720 systems with more than 10 boreholes are true BTES applications used for both heating and cooling, while the rest are applied for heating only in the residential sector.

The largest BTES system in Sweden is currently the BTES system at the Volvo Powertrain plant in Köping. This system comprises a total of 215 boreholes with average borehole depth of 270 m, giving a total borehole length of 58 200 m (Svensk Geoenergi 2017). The system was constructed in 2015-2016.

An estimate of some 190 ATES plants with a capacity of 100 kW or more are installed in Sweden, as of 2019. This estimate is based on the number of boreholes that are classified as "energy wells" in the SGU well data base, and are not deep enough to belong to the closed system category. The larger systems (>1 MW) are fairly well known from engineering reports, articles etc. Systems larger than 100 kW nominal capacities are estimated to represent a total of some 180 MW. In addition to these ATES plants, there is an estimate of approximately 320 installed groundwater-source heat pumps with an average capacity of 50 kW, probably used only for heat extraction within the residential sector. The growth rate has been quite steady the last decade at approximately 5% annually. The larger systems typically have a capacity ranging between 500-5000 kW.

The largest ATES system in Sweden is the Stockholm Arlanda Airport ATES plant, used for free-cooling and pre-heating of ventilation, and for de-icing of gates. It has been designed for a capacity of 10 MW and uses no heat pumps (Andersson 2009). The system delivers 22 GWh of heat and cold annually (Arvidsson 2016). Typical ATES system storage temperature levels are 12-16°C on the warm side and 4-8°C on the cold side (Andersson 2007). The very largest ATES plant in Sweden was designed in 1998 for short-term storage of cold. It is connected to the district cooling system for Stockholm City, and was designed for a cooling capacity of 25 MW for peak shaving during hot summer days. Due to well problems it is working at approximately 15 MW capacity. The working temperature is +3/+14°C and when fully charged it holds around 1 000 MWh of cold (Andersson 2007).

Table 2: Estimated number and size distribution of ATES plants with a capacity >100 kW by the end of 2019

Capacity size (MW)	Number of units	Total capacity (MW)	Heat production (GWh)	Cold production (GWh)
0,1-0,49	115	35	122,5	20
0,5-0,99	45	35	122,5	40
1,0-5,0	25	70	245	210
>5,0	5	40	140	160
Sum	190	180	630	430

5. DISCUSSION

The statistics on number and size of shallow geothermal applications in Sweden suffer from lack of officially proven data. The figures given in this paper are based on two main sources, (1) annual heat pump unit sales figures in the capacity range 0-1000 kW (i.e. units for single and multi-family buildings), collected by the Swedish Heat Pump Association from 1982-2019, and (2) recorded boreholes for energy utilization in the open well database at the Swedish Geological Survey (SGU) over the period 1980-2019. Other sources, especially for larger projects, are various engineering reports, reference lists from drilling contractors and HVAC installers, articles in newspapers and magazines, etc.

In the heat pump sales figures reported by the Swedish heat Pump Association, only sales from the member manufacturers are included, however, the members account for 90% of the total sales, and this has been accounted for in the statistics. The sales figures do not include all large heat pumps, hence many large heat pumps (>80 kW nominal capacity) are missing. On the other hand, several heat pump units may be installed in one system to cover the capacity need. This means that the number of GSHP systems may be either underestimated or overestimated by some percent. Replacement heat pump sales have been accounted for in the statistics by estimating the technical life of the sold heat pumps to 20 years, and only adding the difference between total sold heat pump units and the estimated number of replacement heat pumps each year.

Although it has been obligatory since 1978 to register all drilled wells in Sweden, it is a well known and proven fact that far from all drilled boreholes and wells drilled for shallow geothermal have been registered in the database. The Swedish Geological Survey has estimated the fraction of un-reported boreholes to be between 20-40%. The fraction of registered wells and boreholes is believed to increase over the latter years as a result of fruitful information campaigns and improved tools for reporting.

Another uncertainty is the amount of geothermal energy (heat or cold) provided by the geothermal systems. The estimates are based on theoretical analyzes in which it is assumed that the major parts of installed GSHPs are designed to cover 60% of the building load the coldest day of the year. The result is an average full load running time for the system of 3500 hours during a normal year. This figure includes production of domestic hot water. Due to differences in climate zones over Sweden, the number of full load hours will be lower in the south and higher in the north. In addition to that, newer buildings tend to have considerably lower heating demand than older buildings, and the heat pumps installed in newer buildings are normally designed to cover the entire building heating demand.

The Swedish energy policy goal is that the used energy mix shall contain at least 50% renewables in 2020. Furthermore, the use of energy shall be 20% more effective 2020 compared to 2008, and 50% more effective 2030 compared to 2005. (Swedish Energy Agency 2019b). It is evident that geothermal energy in all forms already significantly contributes to these goals, and has the potential of doing so to an even greater extent in the future. This is, however, yet far from well understood by Swedish politicians in general, as they tend to focus more on power production from wind, and in later years also on solar energy.

6. FUTURE DEVELOPMENT AND INSTALLATIONS

Beginning around 2012, the market for small residential building GSHPs has leveled out around 12-15000 new GSHP systems per year. At the same time, the market for larger GSHPs and UTES systems is growing, and these systems tend towards larger system size and deeper boreholes. Another market trend is the new interest in industrial high-temperature UTES systems, in particular as part of district heating plants or networks. In the last few years three pilot projects on large-scale high-temperature BTES for district heating have been investigated at Linköping, Helsingborg and Gothenburg. In Gothenburg the system is under construction, while the projects at Linköping and Helsingborg are still at the investigation stage. Also low-temperature thermal networks with integrated BTES for universities and hospital campus have been developed at several locations in Sweden.

In 2016 two strategic documents on geothermal energy development (Räftegård and Gehlin 2016) and heat pumping technology and thermal energy storage (Ölén 2016) in Sweden were compiled on behalf of the Swedish Energy Agency. These documents have contributed to the recent launching of a new research program TERMO (Swedish Energy Agency 2017) on heating and cooling technologies. The research program specifically promotes development of deep and shallow geothermal applications as well as thermal storage, combined with district heating and small to medium scale thermal networks. Several research and development projects related to geothermal energy have started in 2018 with funding from the TERMO program. These include studies of new high-temperature ground heat exchangers, and high-temperature underground thermal energy storage applications. A four-year long-term GSHP system performance monitoring project comprising 17 Swedish case studies is also partly funded by the TERMO program, as part of IEA HPT Annex 52. A geothermal road de-icing pilot project is carried out at Chalmers University in cooperation with the Swedish Transport Administration (Johnson 2017), and indicates a rising interest in geothermal energy use for infrastructural applications.

No new deep geothermal projects have been planned in Sweden since the first and only such plant was constructed in the 1980's, although occasional prospecting has been undertaken. With the increasing interest in renewable energy resources, new technical development, and changing energy market prices, the last few years have given rise to a renewed interest in deep geothermal resources also in Sweden. It is unlikely that geothermal power production could ever be done in Sweden, but would the results from the on-going deep geothermal heat production pilot project in Ootaniemi in Finland (Kallio 2016), be promising, this may lead to similar pilot studies in Sweden.

7. CONCLUSIONS

Sweden has more than 30 years of experience from geothermal energy utilization, almost entirely based on shallow geothermal energy. The market for shallow geothermal systems and in particular GSHP systems with vertical boreholes in hard rock peaked around 2009, and has since levelled out. With around a quarter of all single-family houses in Sweden being heated with some sort of ground source heat pump system, it is not surprising that the residential GSHP market is becoming saturated. Larger GSHP and UTES applications for commercial, institutional and multi-family buildings are however growing. While ATES applications are suffering from comprehensive permit processes that lower the growth rate, still a number of large-scale systems are under construction. BTES applications, on the other hand, tend to be designed with increasing size, with deeper boreholes and higher heating and cooling capacities. Several newly started R&D projects open up for new applications and system combinations that may even further boost the general geothermal energy market, particularly regarding high-temperature storage and borehole storage as part of thermal networks.

Although the geological conditions in Sweden are non-favourable for deep geothermal power and heat production, there is currently a budding interest in deep geothermal energy for district heating, following an on-going deep geothermal pilot project in Finland.

Geothermal energy, shallow and (moderately) deep, significantly contributes to the Swedish energy goals for 2020 and 2030, and has the potential of contributing to an even larger extent in the future.

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APPENDIX – STANDARD TABLES

TABLE 1. Present and planned production of electricity (Swedish Energy Agency 2019a). (*Denotes contribution from wind power and **Denotes biomass)

	Geothermal		Fossil		Hydro		Nuclear		Other renewables *)Wind **) Biomass		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2017 (the latest statistical figures)	-	-	No info	5 000	16 300	64 600	8 600	63 000	6 600* 3 000**	17 600* 15 300**	38 851	160 000
Under construction in Dec 2019	-	-	No info	No info	No info	No info	No info	No info	No info	No info	No info	No info
Funds committed, Not yet under construction in Dec 2019	-	-	No info	No info	No info	No info	No info	No info	No info	No info	No info	No info
Estimated total projected use by 2020	-	-	No info	No info	No info	No info	No info	No info	No info	No info	No info	No info

TABLE 2. Utilization of geothermal energy for electric power generation as of 31 December 2019

There is no existing or planned geothermal electricity production in Sweden.

TABLE 3. Summary of geothermal direct heat use as of 31 December 2019

There is no existing or planned geothermal direct use in Sweden.

TABLE 4. Geothermal (ground-source) heat pumps as of 31 December 2019 (V=vertical; H= horizontal; W= groundwater)

Locality	Ground or Water Temp (°C)	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type	COP	Heating Equivalent Full Load Hr/year	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
Lund geothermal	17	47 000	2	W	3.3	6 000	470	-
Sweden (small V)	-2/8	5-10	440 000	V	3-5	3500	44 500	-
Sweden (small H)	-5/+5	5-10	140 000	H	3-4	3500	11 100	-
Sweden (small W)	4-8	7-25	10 000	W	4-5	3500	1 500	-
Sweden (ATES)	4-16	100-5000	190	W	5-8	3500	2 400	1 550
Sweden (BTES)	2-8	50-500	720	V	3-5	3500	2 500	1 600
TOTAL			591 000	V W H	3-8		62 400	3 150

TABLE 5. Summary table of geothermal direct heat uses as of 31 December 2019

Use	Installed Capacity (MWt)	Annual Energy Use (TJ/yr =10^{12} J/yr)	Capacity Factor
Individual Space Heating	-	-	-
District Heating	-	-	-
Air Conditioning (Cooling)	-	-	-
Greenhouse Heating	-	-	-
Fish Farming	-	-	-
Animal Farming	-	-	-
Agricultural Drying	-	-	-
Industrial Process Heat	-	-	-
Snow Melting	-	-	-
Bathing and Swimming	-	-	-
Other Uses (Specify)	-	-	-
SUBTOTAL	-	-	-
Geothermal Heat Pumps	6 680	62 400	0.29
TOTAL	6 680	62 400	0.29

TABLE 6. Wells drilled for electrical, direct and combined use of geothermal resources from January 1, 2015 to December 31, 2019 (excluding heat pump wells)

There are no wells drilled for electrical, direct and combined use of geothermal resources during this period, in Sweden.

TABLE 7. Allocation of professional personnel to geothermal activities (restricted to personnel with university degree)

Year	Professional Person-Years of Effort						
	Gov.	Publ. ut.	Universities	Paid For. Cons.	For. Aid prog.	Priv. ind.	Total
2015	1	2	5	-	-	30	38
2016	1	2	6	-	-	35	44
2017	1	2	7	-	-	40	50
2018	1	3	7	-	-	45	55
2019	1	3	8	-	-	50	62

TABLE 8. Total investment in geothermal energy (2019) in USD

Period	Research & Development Incl. Production	Field Development Incl. Production	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million USD	Million USD	Million USD	Million USD	%	%
1995-1999						
2000-2004	22.2					
2005-2009	0.5					
2010-2014	1				60	40
2015-2019	3				60	40