Proceedings World Geothermal Congress 2023
Beijing, China, April 17 – 21, 2023

Geothermal Energy Use in Germany, Country Update 2020-2021

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Keywords: Geothermal development, power production, direct use, ground source heat pumps, Germany.

ABSTRACT

This country report update will give an overview of the geothermal energy use in Germany. It covers geothermal power production, direct use applications as well as geothermal heat pump units for heating and cooling.

At the end of 2021, about 190 geothermal installations for direct use of geothermal energy were in operation in Germany. This number includes facilities for district heating and thermal spas, the latter often in combination with space heating.

The installed geothermal capacity of these facilities amounted to 451.3 MW_{th} with a geothermal heat production of 6,480.2 TJ in 2021. District heating plants accounted for the largest portion of the geothermal capacity with 394.5 MW_{th} and a heat production of 4,771.1 TJ.

Geothermal electricity generation in Germany is based on the use of binary systems (Kalina cycle or ORC). This allows power production even at temperatures of 100°C. At the end of 2021, eleven geothermal plants with an installed capacity of 47.0 MW_{el} fed electricity into the German grid. The geothermal power production in 2021 summed up to a total of 207.7 GWh.

Due to favourable geological conditions, geothermal district heating and power plants are mainly located in the Molasse Basin in Southern Germany, in the North German Basin, or along the Upper Rhine Graben.

In addition to installations using "deep" geothermal energy, numerous small- and medium-sized decentralised geothermal heat pump units are in use for heating and cooling of individual houses and office buildings. In the last years, the sales figures of heat pumps have increased again. Over 150,000 heat pumps were sold in 2021, with a share of about 18% (27,000) for geothermal systems (brine and water systems). At the end of 2021, 435,000 geothermal heat pumps were running successfully in Germany and supply renewable heat mostly for residential buildings. All installed geothermal heat pumps had a thermal output of about 4,930 MW_{th} in total and provided 25,704 TJ of renewable heat in 2021.

1. INTRODUCTION

The majority of geothermal projects worldwide is located in geological systems with convection dominated heat transport such as magmatic arcs or large scale active faults (e.g. plate boundaries) (Moeck 2014). Germany, with its conduction dominated heat transport systems, lacks natural steam reservoirs which can be used for a direct drive of turbines. Thus, geothermal power generation is based on the use of binary systems, which use a working fluid in a secondary cycle (ORC or Kalina cycle). Hydrothermal reservoirs with temperatures and hydraulic conductivities suitable for power generation can be expected and are already utilised particularly in the Upper Rhine Graben as an active deeply rooting fault system and the Alpine Molasse Basin as an orogenic foreland basin (Agemar et al. 2014a, b; Moeck 2014).

However, the necessary implementation of the heat transition (referred to as *Wärmewende*) in Germany shifts the focus to geothermal heat production. In contrast to fossil fuels, geothermal heat in place can be used over a large depth and temperature range by a whole variety of technologies. Due to this scalability of geothermal applications, depending on the heat demand there is a huge potential for the development of geothermal utilisation. With the *Wärmewende* in Germany, we recognize the scalability of geothermal technology as the potential of geothermal use rather than individual geologic formations. Effectively, a broad range of the geothermal gradient from shallow to medium deep account for the installed geothermal capacity in Germany.

At the end of 2021, 31 geothermal plants for district heating and/or power generation were in operation in Germany and several new plants are under construction or in the planning phase. The discovery of deep hot aquifers has led to a vivid project development especially in Southern Germany. Current projects focus on the Bavarian part of the Alpine Molasse Basin, where karstified Upper Jurassic carbonates provide a suitable aquifer of several hundred meters thickness (Figure 1). Some projects are also in operation or under development in the Upper Rhine Graben, which is another region of elevated hydrothermal potential. Above-average geothermal gradients make this region especially interesting for the development of electricity projects.

This paper describes geothermal reservoirs and probable resources followed by the status of geothermal energy use in Germany. Different use categories such as district and space heating or thermal spas, as well as heat pumps and their contribution to the geothermal heat supply are allocated.

2. GEOTHERMAL RESOURCES

Geothermal resources applicable for geothermal power production and heat use in Germany were investigated in several studies and contributions to European geothermal atlases (Haenel and Staroste 1988, Hurter and Haenel 2002, Jung et al. 2002, Paschen et al. 2003).

In order to better understand the range of geologic settings hosting geothermal resources, subsurface data are collected, analysed, interpreted and provided by the Leibniz Institute for Applied Geophysics (LIAG) through the Geothermal Information System (GeotIS) since 2005 (Agemar et al. 2014a). GeotIS was funded by the German Government and the LIAG realised the project in close collaboration with several research partners.

The information system provides a variety of data collections on deep aquifers suitable for commercial geothermal exploitation. Furthermore, map and data compilations of regions with indicated hydrothermal resources and with inferred resources for enhanced geothermal systems (EGS) were published by Suchi et al. (2014) in a study about the competing use of the subsurface for geothermal energy and CO_2 storage. The resulting maps of that study are also available in GeotIS.

Besides the research focus, the practical relevance of GeotIS is to minimize the exploration risk of geothermal wells and to improve the quality of planning data for geothermal projects. GeotIS is designed as a digital information system which is available free of charge as an open-access data base (http://www.geotis.de).

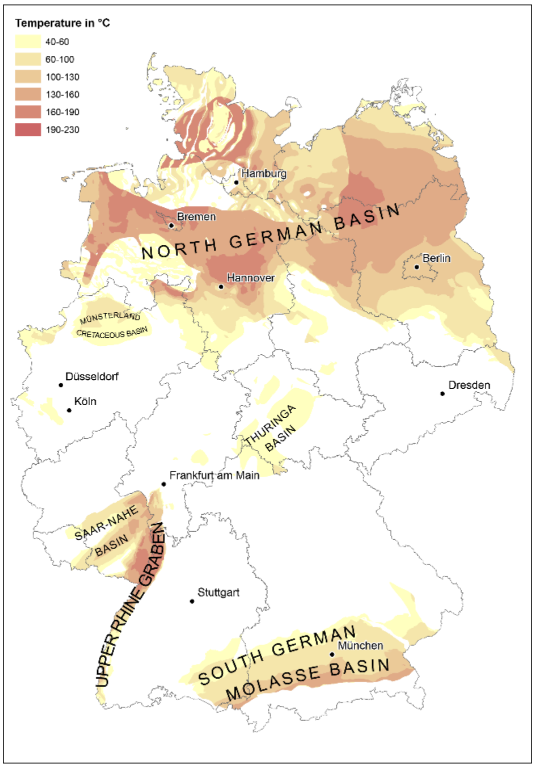

Figure 1: Regions with hydrothermal resources in Germany (inferred and indicated) and associated temperature ranges (map adapted from Suchi et al. 2014).

3. CURRENT TRENDS AT MEDIUM AND DEEP GEOTHERMAL PROJECTS

Before having a closer look on the installed geothermal capacities in Germany described in Chapter 4, the following section provides a short summary about recent developments and trends for medium and deep geothermal projects being recently installed, currently under construction or are in the planning.

3.1 Large-scale high temperature heat pumps

The increasing availability of commercial high temperature heat pumps (HTPHs) with a deployable possible temperature level of up to 100°C (Arpagus et al. 2018) is of high interest regarding medium and deep geothermal projects. Such HTHPs can play two potential roles regarding geothermal heating projects. Firstly, increasing the available thermal capacity of the geothermal project in case its capacity is (temporary) lower than the heat demand of the district heating system (DHS). If this is the case, the HTHP can further cool down the return temperature of the DHS while providing additional heat to the DHS supply side. Due to the lowered DHS return temperature, the geothermal brine can now be further cooled down, resulting in a higher thermal load provided by the geothermal project. Secondly, enabling the integration of geothermal sources, even if the brine temperature is significantly lower than the required DHS supply temperature. Thus, by lifting the temperature of the heat source by e.g. 30 to 60 K, HTHPs enable the utilization of geothermal reservoirs with temperatures below the required DHS supply temperature (Schäfer et al. 2019). A current commercial example for the application of such a large-scale HTHP system can be found in the geothermal heating project in Schwerin in the Northeast of Germany. The geothermal project utilizes a reservoir in a depth of 1200 m. The geothermal brine temperature of 55°C is not feasible to supply the existing local DHS, which is characterized by an average supply and return temperature of 80°C and 55°C, respectively. The planned HTHP system cools down the geothermal brine from 55°C to 20°C, while heating up the DHS from 55°C to 80°C with an overall thermal capacity of 6.9 MW_{th}. A special technical feature of the project in Schwerin is the number of heat pumps installed. Instead of having one single heat pump with a high temperature lift, the overall temperature increase takes place in four serial heat pumps. Due to the lower temperature lifts in each of these heat pumps, a higher overall Coefficient of Performance (COP) can be achieved. While this solution increases the investment costs and plant complexity, the significant reduction of the required electrical power demand compared to one single HTHP is favourable considering the long-term operational costs (Mathes 2022). The Stadtwerke München (SWM) plan to install a large HTHP system with a capacity of 21 – 30 MW_{th} at their envisaged project *Michaelibad* in the East of Munich in order to increase the thermal capacity of the geothermal heating plant with a conventional capacity of 45 to 107 MW_{th} (SWM Services GmbH 2021). Furthermore, future HTHPs may also be able to provide both process heat up to 200°C and process steam for industrial consumers (Bracke et al. 2022). While such high temperature ranges cannot be supplied by commercially available HTHP systems today, there is a strong research activity in this area. For example, the current *Kabel ZERO* project investigates the supply of process steam for a paper factory by a geothermal reservoir with 130°C and a HTHP.

3.2 Long-distance heat transmission pipelines

Regarding the utilization of geologically attractive regions, one limiting factor is that these regions are not always spatially overlapping with urban areas that have a high heat demand density. Thus, without heat transportation systems, rural geothermal heating project might not be economically due to the low local heat demand. While transporting heat from geothermal sources over a long distance is currently not applied in Germany, such concepts can be found for example in Iceland (Erlingsson and Porhallsson 2008). However, it has gained also increasing interest in the German geothermal sector during the last years. E.g. in 2020, a study by the Geothermal Alliance Bavaria demonstrated the high potential of large-scale heat transmission systems in the Southeast of Germany. By installing long distance heat transmission pipelines, a high share of the biggest heat demand clusters in the region (Munich, Augsburg, Rosenheim, etc.) could be supplied by geothermal projects in geological attractive (but rural) regions in the South and Southeast of Munich (Molar-Cruz et al. 2022). The SWM plan to install a heat transmission pipeline from their central DHS to three existing geothermal power plants (Kirchstockach, Dürnhaar and Sauerlach) in order to have their thermal capacity of around 120 MW_{th} available for heating purposes if required (Cröniger 2020; Kleinertz et al. 2021). Furthermore, in August 2022, the SWM have announced the plan of a new geothermal project in the South of Munich together with the local geothermal plant operator Erdwärme Grünwald (SWM 2022). Together, they want to realize one new geothermal heating project and a heat transmission pipeline is planned to connect the existing and new plants with the district heating system in Munich.

3.3 Cooling with deep geothermal energy by thermal driven absorption chillers

Against the background of the expected increasing cooling demand especially in urban areas, providing cooling will be a further relevant application case for geothermal energy next to heating and power generation. Currently, some buildings or district cooling systems (DCS) utilize shallow geothermal systems for this purpose (Epting et al. 2020). A further promising alternative are thermal driven ab- or adsorption chillers for cooling. Such sorption chillers can provide cooling by using heat as a main driving source for the cooling system, resulting in a significantly lower electricity demand compared to a conventional vapour compression cycle, which is currently the most common cooling technology. Depending on the required cooling temperature and the exact cycle configuration, sorption chiller can operate from a heat source level between 60 and 80°C on. Thus, medium and deep geothermal energy might be utilized for cooling in two ways: Using the heat of a geothermally driven DHS at the consumer with cold demand or by driving a DCS supplied by a central geothermal driven sorption chiller. In Unterföhring, the heat of the DHS is used to drive an absorption chiller with a cooling capacity of 200 kW in order to cool a large office building with more than 4500 m^2 since 2015 (Geovol 2015). In Munich, the SWM are installing a large-scale absorption chiller at their geothermal project in Sendling. If the geothermal heat is not required completely for supplying the DHS during the summer months, it can be used for cooling purposes resulting in a higher overall annual utilization of the geothermal project. The cold will be transported to a DCS in the city centre by a 5 km long pipeline (SWM 2021). Thus, the current projects in Unterföhring and Munich highlight the technical feasibility and growth potential of environmentally friendly cooling. The recently published roadmap on deep geothermal energy in Germany by Bracke et al. (2022) suggests an installed capacity of 1 GW for cooling systems driven by deep geothermal energy after 2040.

3.4 Current trends in recently installed and planned power generation projects

During the last years, only a low number of geothermal power plants have been installed. The two main projects were both located in the South German Molasse Basin: Holzkirchen and Garching a.d. Alz. The combined heat and power generation (CHP) project in Holzkirchen utilizes a geothermal brine temperature of 155°C, which is the highest temperature of all projects in the South German Molasse Basin so far. For power generation, a two-staged Organic Rankine Cycle (ORC) is installed. According to the manufacturer, their new two-staged ORC systems are utilizing an advanced four-staged turbine with two injection points on different pressure levels. Thus, the power generation of the two-staged ORC system can be realized within one turbine, resulting in a high efficiency also for low ORC mass flow rates during times with a high DHS heating demand (Duvia 2020). Also in Garching a.d. Alz, a CHP project is installed. In this project, the condensation system is a special feature. While the majority of the existing power plants are using air-cooled condensers, the project in Garching can use the cold water of an industrial channel next to the side for a water-cooled condenser (Friedlaender 2020). Thus, especially during the summer period, higher ORC efficiencies can be achieved due to the lower condensation temperatures compared with air-cooled condenser systems. In addition, the water-cooled system reduces the required investment costs and auxiliary power demand and displays lower noise emissions. However, such cooling solutions are limited to very few potential locations due to strong ecological restriction in case of using water from natural rivers. In summary, both recently installed power projects are CHP projects and have an installed capacity of a few MW_{el}, following the main characteristics of the already existing geothermal power generation projects in Germany (Eyerer et al. 2020). The geothermal project in Kirchweidach provides heat to local DHS and a greenhouse since several years. Currently, a large-scale ORC with around 4 MW_{el} is under construction (Duvia 2020). In addition, several standardized modular ORC systems by the German ORC manufacturer Orcan Energy have been installed. Six modules with a capacity of up to 200 kW_{el} are installed, resulting in an overall capacity of around 1 MW_{el} (ITG 2021). Thus, for the first time in Germany, such modular ORC systems have been installed at a geothermal project. While these modular systems display higher specific investment costs compared to an individually engineered large-scale ORC, they might enable an earlier starting of the power generation due to the significantly lower planning and construction times. Regarding currently planned geothermal projects in the South German Molasse Basin, there is a certain trend towards larger projects consisting of four wells, instead of the currently common doublets. E.g. all three planned projects in Tengling, Palling and Traunstein want to realize four wells. Thus, these projects would have an installed power plant capacity of 10 – 15 MW_{el} each, while still planning to provide heat to local municipalities.

The unsuccessful Kirchanschöring drilling, which was the most easterly well drilled in the South German Molasse Basin to date, represents a certain setback. However, the high level of activity in the region is still evident, as the drilling rig that was in use in Kirchanschöring is being used directly for the upcoming "Kirchweidach II" well (VGK 2022).

Furthermore, around 10 projects are currently in a planning phase in the Upper Rhine Graben. Next to power generation and heat supply, some of these projects are focusing also on the extraction of Lithium from the geothermal brine. According to Sanjuan et al. (2022), the Upper Rhine Graben is the most promising area for geothermal Lithium extraction in Europe. Another novel development is the current plan for the geothermal project in Geretsried, Bavaria. In 2018, the drilling for a conventional hydrothermal project was not successful due to a too low achievable brine flow rate. Currently it is planned to use the already existing well as a basis for realizing a deep closed-loop concept by a Canadian company, the so-called Eavor Loop concept. In Geretsried four such systems could be realized, resulting in a power capacity of around 9 MW_{el} (Gahr 2022). The drilling might start in 2023. Realizing such a large-scale deep closed-loop system for the first time in Europe might be an interesting and promising development regarding the utilization of the tremendous geothermal potential not only in geologically favourable hydrothermal hotspot regions.

4. STATUS OF GEOTHERMAL ENERGY USE

The German Government supports the development of geothermal energy by project funding, market incentives, credit offers as well as offering a feed-in tariff for geothermal electricity. However, progress in the development of geothermal energy lags behind the development of other renewables although there are good conditions for heating plants and also for power production at several locations (Fig. 1). For example, especially in southern Germany, a number of new projects have been realised and further developments are being planned.

Geothermal heat is utilised in about 190 larger installations using hydrothermal resources. Thermal spas are the most widespread form of deep geothermal heat utilisation. However, the number of larger district heating plants is growing continuously. They presently account for about 85% of the deep geothermal heat production, with an upward tendency.

Besides deep geothermal utilisations, numerous geothermal heat pumps for heating and cooling office buildings and private houses contribute the major portion to geothermal heat use in Germany.

4.1 Geothermal Power Production

Since the last WGC country update in 2020 two new geothermal power plants were commissioned in Germany: the 4.9 MW_{el} plant in Garching a. d. Alz and the modular ORC systems in Kirchweidach (for details see paragraph 3.4). In 2021, the installed geothermal capacity in Germany reached 47.0 MW_{el} and the electricity production amounted to 207.7 GWh.

4.2 Centralised Installations for Direct Use

In Germany, common deep geothermal utilisations for direct use are district heating plants or combined heat and power plants (CHP), thermal spas, and space heating. At present, about 190 geothermal installations of these types are in operation in Germany (Figure 2).

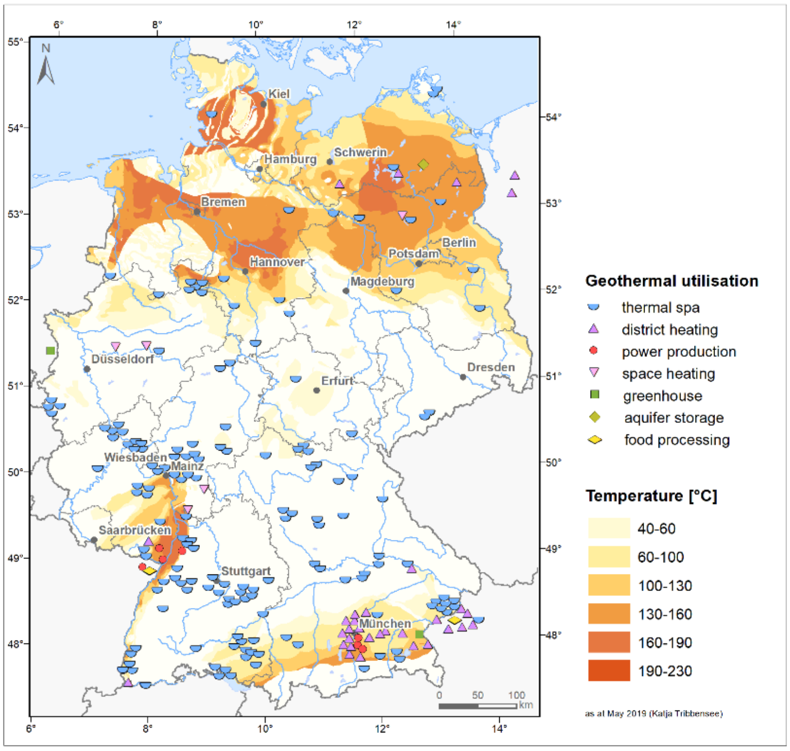

Figure 2: Sites of deep geothermal utilization in Germany and neighboring countries. The background colors represent predicted temperature ranges of the respectively deepest identified geothermal resources in sedimentary or volcanic rocks (map generated in GeotIS, 2019).

Furthermore, five deep borehole heat exchangers are in operation in Germany: Arnsberg with a total depth of 2,835 m heating a spa, Prenzlau (2,786 m, used for district heating), Heubach (773 m, providing heat for industry), Landau (800 m, for space heating) and Marl (700 m, for local heating). Also the use of mine water is becoming more and more interesting with regard to the heat transition in Germany.

At end of 2021, the geothermal installed capacity of direct heat use applications was 451.3 MW_{th} with a heat production of 6,480.2 TJ. 31 district heating and combined heat and power plants accounted for the largest portion of the geothermal capacity with about 394.5 MW_{th} and a heat production of 4,771.1 TJ.

4.3 Geothermal Heat Pumps

Heat pumps are a technology that has been established and ready for the market for decades for the sustainable provision of heating and cooling in residential and non-residential buildings in Germany. After an initial small boom at the beginning of the 1980s, heat pumps have become increasingly established in the German heating market since the turn of the millennium. As figure 3 shows, 2006 was the first year in which more than 30,000 units were sold per year. Thereafter the sales and installation numbers rose to around 80,000 heat pumps annually in the mid-2010s and to over 150,000 heat pumps in 2021.

There is a clear trend that the share of heat pumps sold is shifting from geothermal heat pumps to air-source heat pumps. While the percentage share of ground-source heat pumps was still more than 50% until 2016, the sales figures for air-source heat pumps have increased significantly in the recent past, so that the share of ground-source heat pumps fell to below 20%. These geothermal heat pumps use well systems, geothermal probes as well as geothermal collectors as a heat source.

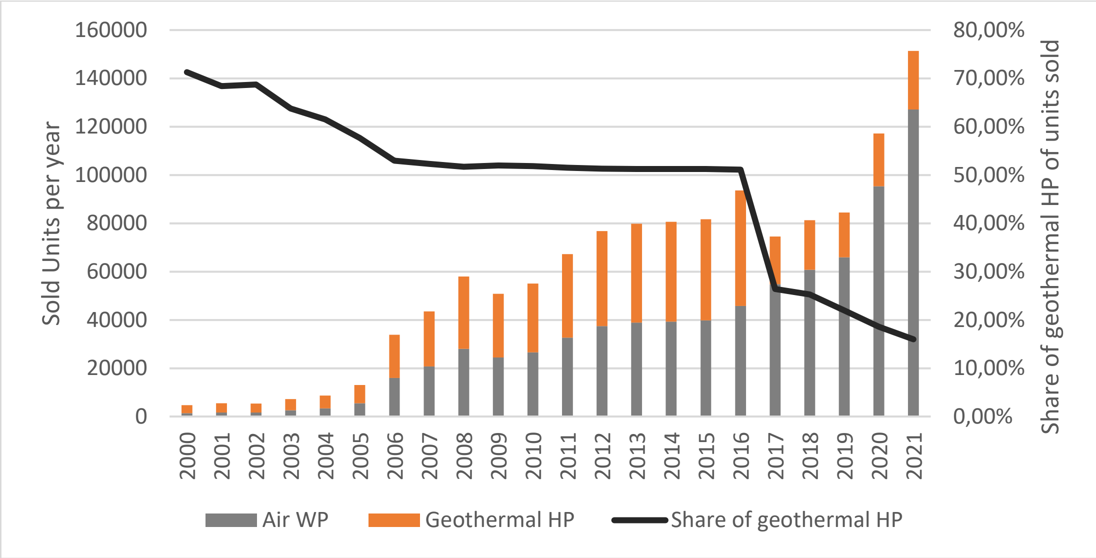

Figure 3: Development of sales figures for heat pumps in Germany (after annual data from BWP&BDH, 2013, 2017 & 2018, latest BWP&BDH, 2018).

Figure 4 shows the share of different heat sources - wells and probes/collectors - with geothermal probes being the dominant technology (Jensen and Pester 2019). Well systems in particular have been declining in importance in the past, with a share of less than 5% of systems sold in 2021.

Nevertheless, well systems in hydrogeologically suitable areas make a contribution to the heating and cooling supply.

Furthermore, the trend can be observed that mainly geothermal heat pumps of relatively small output classes are sold (outputs of less than 20 kW), as shown in figure 5. This is mainly due to the fact that heat pumps are currently mainly used in smaller residential buildings, and here mainly in new buildings.

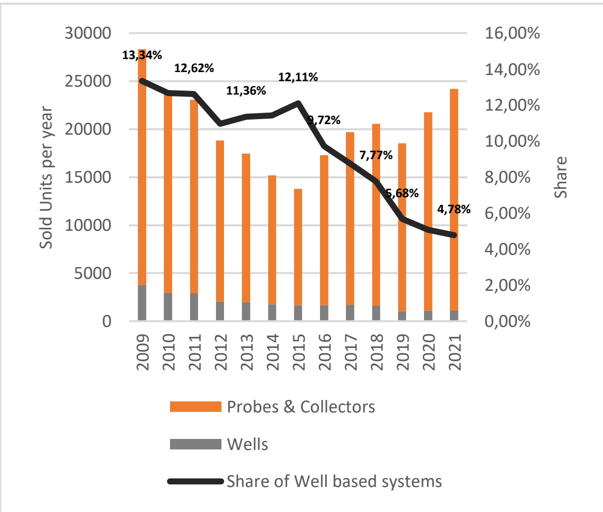

Figure 4: Share of different heat sources (after annual data from BWP&BDH, 2013, 2017 & 2018, latest BWP&BDH, 2018).

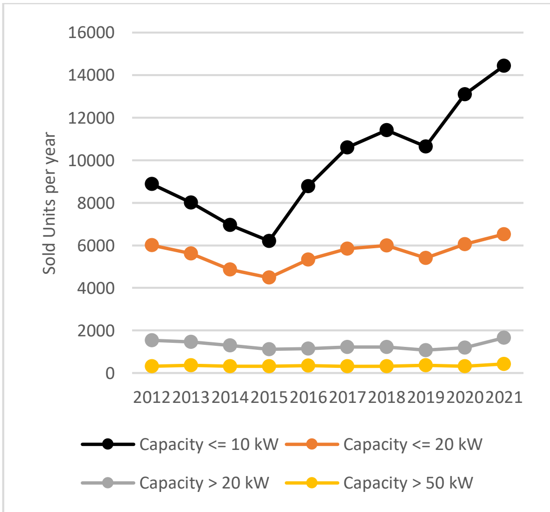

Figure 5: Capacity of sold geothermal heat pumps per year (after annual data from BWP&BDH, 2013, 2017 & 2018, latest BWP&BDH, 2018).

In 2020, heat pumps were installed in more than 50% of new buildings (55,544 air-source heat pumps and 10,257 ground-source heat pumps) (Statistisches Bundesamt 2021). In the same year, only 30,000 heat pumps were subsidised in existing buildings (BAFA 2021). Nevertheless, much larger systems (several hundred kW) represent the top of the market. In sum there was a field inventory of 435,000 successfully installed geothermal heat pumps in Germany end of 2021, see table 1.

Table 1: Field inventory of geothermal heat pumps

Year	Geothermal heat pumps
2016	340.000
2017	362.000
2018	382.000
2021	**435.000**

4.3.1 Calculation of Capacity, Usable Heat and Renewable Energy

The renewable heat that is provided by geothermal heat pumps in Germany based on the number of heat pump systems in operation (the field inventory), the average seasonal performance factor (SPF) of the heat pumps (in correlation of the year on installation), the average full load hours per year and the average capacity. The derivation of the data is methodologically based on the study Analyses of the German heat pump market (Born et al. 2017). The methodology was described in detail in the last Country Update 2018 (Weber et al. 2019). A continuation to 31.12.2021 was made.

In result the renewable heat that is provided by geothermal heat pumps in Germany is calculated in the following way.

The usable heat of all installed heat pumps is the product of the number of installed heat pumps multiplied by the average capacity and multiplied by the full load hours.

$$Q_{usable} = H_{HP} \cdot P_{rated} \quad (1)$$

where Q_{usable} is the estimated total usable heat delivered by heat pumps [GWh], H_{HP} are the equivalent full-load hours of operation [h] and P_{rated} is the capacity of heat pumps installed [GW]

$$P_{rated} = n_{hp} \cdot P_{avg} \quad (2)$$

where n_{hp} is the number of installed heat pumps and P_{avg} is the average capacity of all heat pumps [kW]

The renewable energy (E_{RES}, pure geothermal contribution) is the total useable heat minus the operating energy for the heat pump (electric energy) according to the average SPF.

$$E_{RES} = Q_{usable} \cdot (1 - \frac{1}{SPF}) \quad (3)$$

Table 2 shows the calculated values for the total installed capacity of all heat pumps P_{rated}, the total usable heat Q_{usable} and the pure geothermal contribution E_{RES} for the years 2016 to 2018 and 2021.

Table 2: Installed capacity, usable heat and renewable energy provided by geothermal heat pumps

	2016	2017	2018	**2021**
P_{rated} [GW]	3,88	4,09	4,40	**4,93**
Q_{usable} [TWh]	7,95	8,38	9,03	**9,83**
E_{RES} [TWh]	5,80	6,15	6,60	**7,14**

435,000 geothermal heat pump systems in Germany provide around 10 TWh of heat annually, which corresponds to approx. 1.3% of Germany's energy demand for space heating and domestic hot water in 2021.

4.3.2 Outlook – Potential of Geothermal Heat Pumps and Future Market Development

In 2022, the potential of geothermal heat pumps and the associated contribution margin for the provision of space heating and domestic hot water was determined for Germany for the first time (Born 2022). To determine the potential for the property-specific geothermal share, the characteristics of a property and the heat demand of the building stock, as well as the regulatory boundary conditions, were considered. The building data were intersected with the site-specific extraction capacities for geothermal probes (geothermal potential) based on the data sets (thermal conductivities) of the Geological Services and corresponding simulations. Finally, the proportionally developed property specific to each plot was offset against the building-specific demand and the geothermal potential. As a result, 75% of the demand for space heating and domestic hot water can be covered by geothermal heat pumps.

At the same time, a number of studies focus on the importance of heat pump technology for a sustainable heat supply in Germany in the future (Agora Energiewende 2021; BDI 2021; BWP 2021, dena 2017, Greenpeace 2022).

On average, the various scenarios (Figure 6) assume that six million heat pumps must be installed in Germany by 2030, and twelve million by 2045, in order to achieve the greenhouse gas reduction targets. Against the background of the current gas crisis, the sharply rising prices for natural gas and the conflict in Eastern Europe, the German government also declared in June 2022 that 500,000 heat pumps must be installed annually (BMWK 2022a). In these medium- and long-term installation targets, no or only insufficient distinction is currently made between air-source heat pumps and ground-source heat pumps. A shift in market share in favour of ground source heat pumps is to be expected in the future, especially for supplying larger existing units, solutions for urban regions and heat grids, as well as for meeting the increasing demand for cooling.

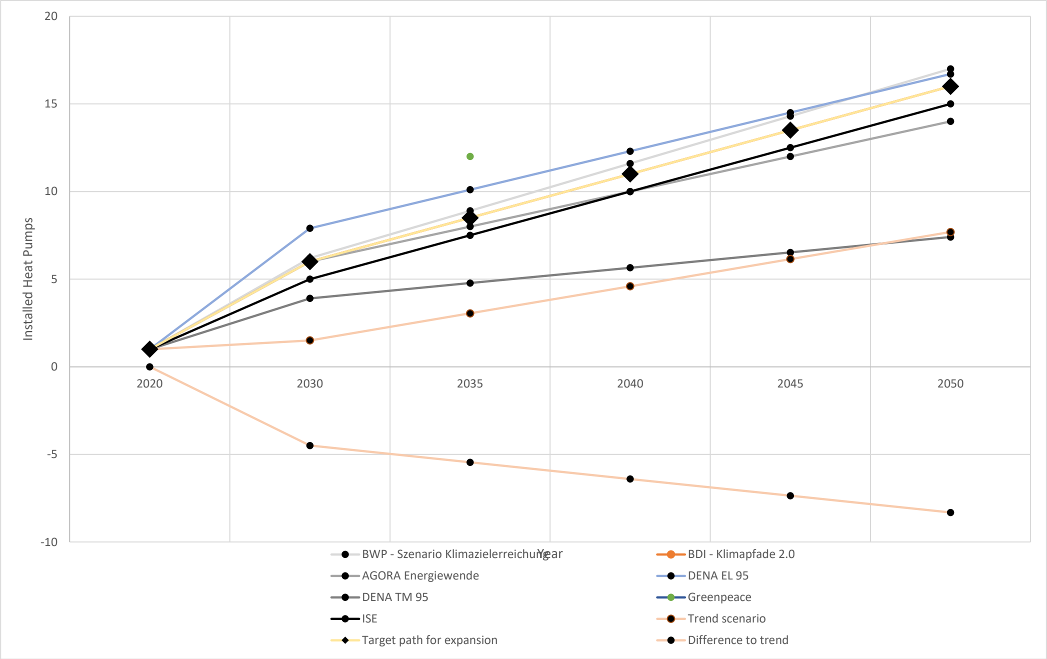

Figure 6: Scenarios for the Heat Pump field inventory by 2050 (Agora Energiewende 2021; BDI 2021; BWP 2021, dena 2017, Greenpeace 2022 and own calculations)

The decision for a geothermal heat pump systems in comparison to alternative fossil fuel heat generators is always also an economic decision. While the investment costs, especially for the drilling for heat source development, are still higher than for fossil heating systems, the developments for the operating costs, the electricity and gas prices, have been positive in the recent past. For the end customer, a kWh of electrical energy will only be ~3 times as expensive as a kWh of natural gas at the beginning of 2022, see figure 7. Heat pumps with a seasonal performance factor of three are just as economical in operation as fossil heating systems.

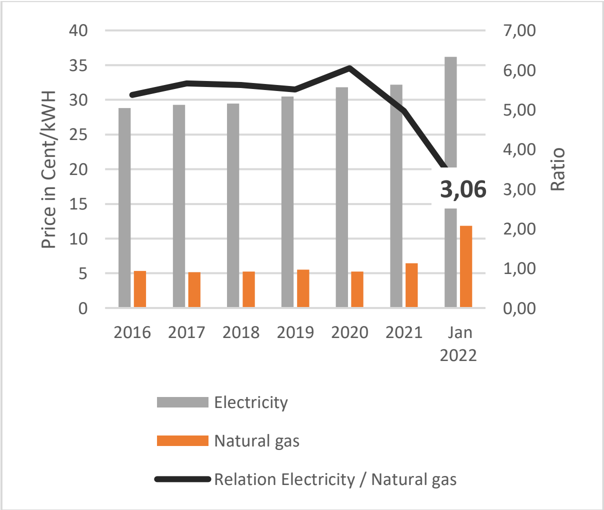

Figure 7: End customer price for electricity and natural gas in Germany (BDEW 2022)

In order to compensate for the higher investment costs, there is a nationwide subsidy for the installation of heat pumps in Germany via the Federal Subsidy for Efficient Buildings (BEG). The scope of the current subsidy range is 35% to 50% of the total investment costs (BAFA 2022).

5. OUTLOOK

In Germany, about 75% of the current heat supply for district/space heating and hot water are covered by the fossil fuels oil, natural gas and coal (BMWK 2022b).

In view of rising energy prices, geothermal energy which has an enormous potential for expansion along with low land requirements has to become a key pillar in German heat supply. The geothermal gradient can be used in all scales resulting in a whole variety of geothermal applications. In many areas of heat generation fossil fuels such as coal, oil and natural gas can be substituted by geothermal energy.

Besides deep geothermal energy utilisation there is also a large growth potential for shallow and medium-deep geothermal resources, through the utilisation of ground source heat pumps, especially for new buildings, or by using high temperature heat pumps, respectively.

In the case of shallow geothermal energy utilisation, it will be necessary above all to expand and strengthen human resources for all the steps required to set up a geothermal heat pump plant in order to be able to implement the enormous numbers of new plants that will be needed on the market in the coming years.

This includes the skilled trades of installers and drillers, who are already suffering from the increasing shortage of qualified workers in Germany, as well as the planning engineers and the licensing authorities. (BIBB 2021, KOFA 2021, prognos 2018)

Furthermore, a change in the regulatory framework is urgently needed. In order to strengthen the use of geothermal heat pumps, a ban on the installation of new fossil heating systems in the short term and a ban on existing systems in the medium term would be an important step.

Geothermal heat pumps for heating and cooling purposes and for domestic hot water heating in individual buildings as well as in larger heating networks are an established technology for sustainable energy supply in Germany, whose extensive potential must be used much more extensively in the short term.

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