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The New Geothermal Atlas For Austria - Uncovering The Geothermal Resources For Heating and Cooling

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ABSTRACT

The Geothermal Atlas of GeoSphere Austria enables precise analyses and optimized planning for shallow geothermal energy systems in Vienna. It highlights resources, indicates possible limitations of use and pre-assesses available thermal capacity and annual heat and cold production of individual systems. A web map viewer shows geological and hydrogeological spatial data needed for planning of groundwater heat pumps and borehole heat exchangers in the city of Vienna. Based on this underground data, a location specific tool allows to calculate the available thermal capacity, annual heat and cold production, as well as the demand coverage of individually configured borehole heat exchanger fields, with the results being summarized in a PDF report. This tool is available nation-wide for Austria and uses an estimation of underground specific data for outside of Vienna, which the user can adapt directly. The results serve as first-level estimation and do not replace detailed design. With its user-friendly design, it supports professionals in implementing shallow geothermal solutions and makes a significant contribution to the decarbonization of heat supply.

1 INTRODUCTION

In the context of Austria's commitment to climate neutrality by 2040, shallow geothermal energy (SGE) presents a key opportunity for decarbonizing the heating and cooling sector. Despite its technical maturity, the application of SGE remains limited. One key barrier has been the lack of accessible, harmonized geoscientific data and planning tools that support strategic energy planning across diverse regions. The Geothermal Atlas Austria was developed to address these challenges through the provision of a harmonized, nationwide information platform. This web-based system integrates geological, hydrogeological, and technical data to enable evidence-based spatial energy planning, foster stakeholder engagement, and support decision-making processes at local, regional, and national levels.

The motivation for this platform aligns with broader governance models of adaptive and cyclical resource management, such as the framework proposed by García-Gil et al. (2020). This model promotes integrated planning, monitoring, and iterative control of shallow geothermal systems to ensure long-term technical and environmental sustainability. By embedding SGE into established spatial planning tools, the Geothermal Atlas also enhances visibility and accessibility of shallow geothermal technologies, which helps to include them as viable alternatives in Austria’s energy mix.

The datasets and analytical methodologies behind the Geothermal Atlas were established in the Green Energy Lab – Spatial Energy Planning (GEL-SEP) project. In this framework, GeoSphere Austria developed harmonized approaches for assessing geothermal resources and possible limitations of use (Steiner et al. 2021). The chapter 2. Methodology of this study explains the basic foundations leading to the creation of the resource and possible limitations data sets for groundwater heat pumps (GWHP) and borehole heat exchangers (BHE) for the city of Vienna. These resulting data sets are implemented already in the Geothermal Atlas. Data for Salzburg and Styria have also been prepared and their integration is work in progress. Chapter 3. Results describes the two key functionalities, which integrate the spatial datasets: (1) A web map viewer for spatial comparison featuring the above-mentioned information about resources and possible limitations. The shown data sets feature geological and hydrogeological properties, which are used in planning processes, and thermal capacity and annual energy yield for fixed operation scenarios giving a rough estimation about the available geothermal resources. (2) A

location specific query on property level for an individual assessment of borehole heat exchanger fields including coverage of heating and cooling demand.

2 METHODOLOGY

This section describes the methodology used to create the spatial datasets of Vienna integrated into the web map viewer of the Geothermal Atlas. Steiner et al. (2021) outlines the methodology, which was developed in GEL-SEP, in detail. Aim of the harmonized methodology was to deliver a consistent, area-wide first-level assessment of resources and possible limitations for SGE systems. The resulting data sets support planners, engineers, and public authorities in evaluating SGE feasibility. SGE systems addressed for Vienna are GWHPs and BHEs. The methods in general are harmonized to support both urban areas with dense data coverage and rural regions with sparse data availability. This ensures comparability of results across federal states and allows integration into regional spatial planning instruments.

2.1 Possible limitations of use

A comprehensive set of possible limitations of used was compiled, independent from the assessment of the geothermal resources. They were combined into traffic light maps in vector data format, separately for GWHP and BHE, and provide a quick, intuitive overview of site suitability based on regulatory and technical constraints. The traffic light map holds three colors, representing the following suitability categories:

Green: Use is generally possible.

Yellow: Use is potentially feasible, but requires additional site-specific investigation

Magenta: Use is generally not possible

The underlying constraints differ by technology (GWHP vs. BHE) and include factors such as groundwater protection areas, nature protection zones, areas with confined groundwater, geological formations susceptible to karstification, contaminated sites, and proximity to critical infrastructure or other existing underground uses. It is planned to update the traffic light maps regularly based on inputs from relevant federal and municipal authorities. The current version holds the traffic light maps with the status of 2021. Some parameters that were identified “good to know about” in the planning phase, but they do not pose a general limitation. As such, they were not included in the traffic light map. Instead, individual data sets of this “additional information” were created, including groundwater chemistry, multiple aquifer storeys, confined/artesian aquifers and shallow gas deposits. Aim of them is to provide information about conditions, that when considered properly in the planning, installation and operation phase, still enable the use of SGE at the given location.

2.2 Resources for groundwater heat pumps

Main idea behind the methodology is to first develop raster data sets with a resolution of 25 m of key hydrogeological parameters and use them to calculate site-specific hydraulic and thermal capacity as well as energy yield of the GWHP. These calculations were therefore only applicable for productive aquifers, with a good data basis available, which were delineated beforehand and are part of the data set outline of suitable aquifers. The overall workflow for the groundwater heat pumps is shown in Figure 1.

Outline of suitable aquifers: Existing delineations of shallow groundwater bodies were revised based hydrogeological research conducted by Wiener Gewässer Management (WGM), particularly regarding the alluvial boundaries of the Liesingbach and Danube valley. The GEL-SEP project classified the areas into two categories: Zones with productive groundwater resources and known elevations of groundwater level and bottom, which allow quantitative estimates of hydraulic and thermal capacity and annual energy yield. These aquifers are found in gravel and sand deposited by the River Danube. Areas where these sediments are hydraulically connected to either underlying Miocene sediments or to older terraces are also included in the delineation of productive aquifers. The remaining porous aquifers contain either only local or limited groundwater, or data for advanced resource calculations was mostly missing.

The following parameters characterize the productive aquifers

2.2.1 Depth to water table

The vertical distance between the land surface and the groundwater level acts as insulator of heat transport from the land surface to the groundwater. It is also crucial for estimating drilling depth and pump installation requirements. The data set was derived from groundwater level maps of the lowest level (provided by MA45 – Vienna Water Management) to ensure conservative estimates.

2.2.2 Aquifer thickness

This refers to the thickness of the saturated zone, which is calculated from the difference between the groundwater level and the elevation of the bottom of the Danube gravels and connected Miocene gravels, where applicable. The aquifer thickness is directly proportional to the groundwater quantity. The mentioned sedimentary deposits represent the most productive uppermost aquifer in Vienna, which had been already well described (Pfleiderer et al 2004). The Vienna Water Management provided the according input data sets of the bottom of the aquifer.

2.2.3 Hydraulic conductivity

The hydraulic conductivity reflects the ease with which groundwater can flow through the aquifer, therefore impacting the water quantity that can be pumped. Input data for the generation of this data set were values from over 40 pumping tests taken from digital archives, and numerical modeling results from prior projects.

2.2.4 Groundwater temperature

Minimum, maximum and mean annual groundwater temperatures are interpolated from time series recorded at 255 observation wells between 1982 and 2021. Before interpolation, the temperature data from the observation wells were fitted to sinusoidal temperature models to adjust for long-term trends. These temperature data sets are critical for estimating the thermal capacity and energy yield.

Based on the above-mentioned input data, several operation-related parameters are calculated:

2.2.5 Hydraulic capacity

The pumping rate of a well pair (with one abstraction and one reinjection well) is estimated using the Dupuit-Thiem formula for unconfined aquifers. The standard system configuration assumes a 50 m distance between both wells. The hydraulic capacity is constrained by aquifer properties (conductivity, thickness) and chosen usage thresholds. The calculation allows a maximum water level change (drawdown or increase) of 5 m or of one-third of the aquifer thickness, whichever is lower. Additionally, the usable aquifer thickness is capped at 20 m and the depth to water level has to have a minimum of 3 m.

2.2.6 Thermal capacity

The hydraulic capacity, a temperature difference and the specific heat capacity of water determine the thermal capacity. The temperature difference between abstraction and reinjection well was taken from the calculations described below for the annual energy yield of balanced mode and was set to a maximum of 5 K.

2.2.7 Annual energy yield

The calculation of the annual energy yield is based on the thermal storage capacity of the aquifer. This is determined by the specific heat capacity of the aquifer, its saturated thickness, and the usable temperature difference between abstraction and reinjection well. In case of balanced operation, the entire thermal storage content can be used annually for heating and cooling. Here the average groundwater temperature remains stable over the year. In heating- or cooling-dominated operation, the thermal storage content is spread over the total life span of the system (set to 20 years). However, due to the temperature change, induced by an unbalanced use, additional heat flow occurs from ground surface and from below the aquifer, and recuperates the thermal storage of the aquifer. The usable temperature difference for heating depends on the minimum groundwater temperature during winter season and the lower discharge limit (set to 5 °C) for reinjected groundwater. The usable temperature difference for cooling is determined by the maximum groundwater temperature during summer season and the upper discharge limit (set to 18 °C). For balanced mode, the minimum value of the two mentioned temperature differences was chosen. The set temperature limits correspond to the threshold values defined in the Austrian guideline ÖWAV Rule Sheet 207 (ÖWAV 2009). For further methodological details, refer to the projects GEL-SEP (Steiner et al. 2021) and GeoPLASMA-CE (Görz et al. 2019).

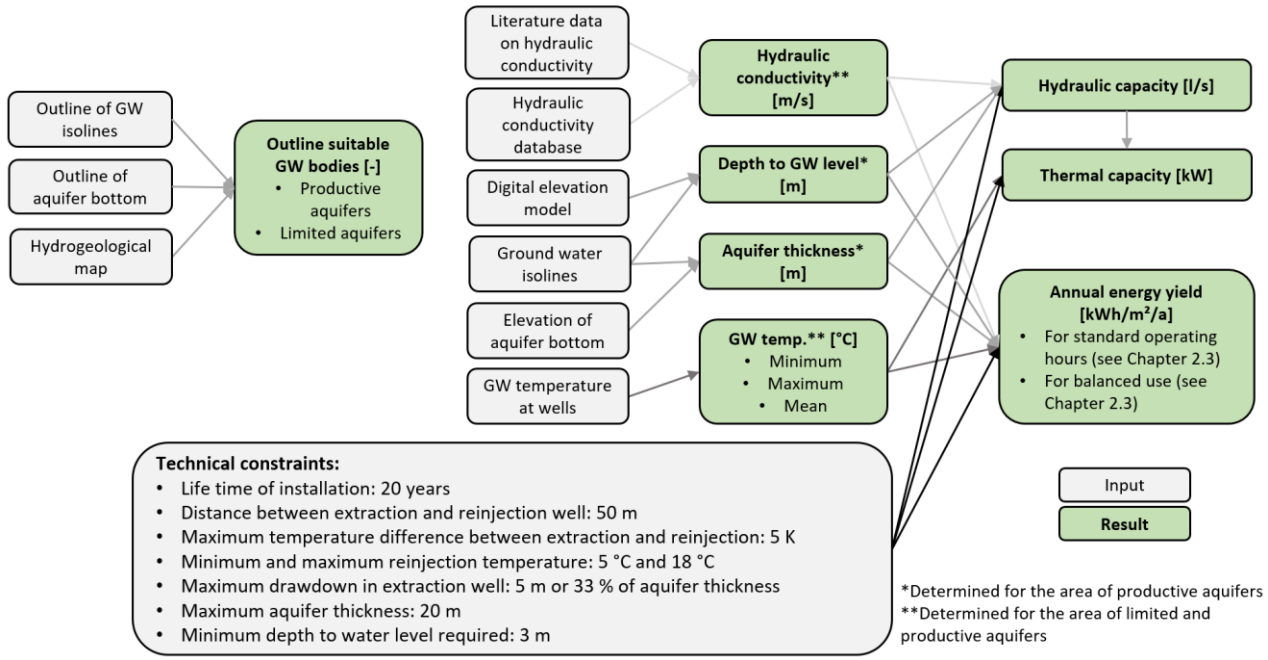


Figure 1. Workflow for deriving results to describe the resources of groundwater heat pumps (GW – ground water).

2.3 Resources for borehole heat exchangers

Instead of the availability of aquifers, the thermal capacity of BHEs depends on location-specific subsurface parameters (usable temperature difference and thermal conductivity), the coupling between the BHE and the ground (borehole thermal resistance), the geometry of the system (borehole radius, depth, field size and spacing), and its operation mode (operation hours for heating and cooling, heating/cooling energy balance). Geometry and operation mode are collectively represented through g-functions. GeoSphere Austria elaborated location-specific subsurface parameters as input data sets for the resource calculations within GEL-SEP (Steiner et al 2021). All depth-dependent resource data sets target a depth of 100 m, which reflects the average installed depth of BHEs registered in Vienna and Salzburg up to April 2021. Figure 2 shows the workflow used to derive the resources for borehole heat exchangers in raster format with a resolution spanning from 25 m to 100 m.

2.3.1 Thermal conductivity

Mean thermal conductivity values were taken from the WC-33 project (Fuchsluger 2016), where they have been derived from borehole lithology profiles. The values reflect purely conductive heat transfer.

2.3.2 Land surface temperature

Land surface temperatures were based on the Europe-wide model developed by Metz et al. (2014), using MODIS satellite data. The dataset represents average annual temperatures with a resolution of 250 x 250 m. It was validated in the GeoPLASMA-CE project against ground temperature measurements at meteorological stations and found to be consistent with soil temperatures at 10 cm depth for the city of Vienna. For Austria as a whole the temperatures in the mountainous regions were found to be lower than soil temperature measurements. This is due to the isolating effect of snow on the snow-covered ground, which leads to an underestimation of the land surface temperatures via satellite. Therefore the temperatures of the original land surface temperature data set were adapted accordingly in the mountainous regions.

2.3.3 Underground temperature

Subsurface temperature profiles were obtained from thermal response tests (TRTs). Since their low spatial distribution does not allow for interpolation, they were used to determine the geothermal gradient of five hydrogeological clusters. The geothermal gradient was then combined with the actual surface temperature derived from satellite data and, where applicable with the mean groundwater temperature (see chapter 2.2). This yielded individual temperature profiles for each cell, covering the full depth of 100 m.

2.3.4 Standard operating hours

Assumptions regarding heating full-load hours were made, based on Swiss standard SIA 384/6 (2010), which provides an estimation of operating hours for single family houses. The elevation dependency of the full load hours of the SIA was modified and recalculated based on the dependency of land surface temperature. 200 hours were added to account for domestic hot water demand. For cooling hours a linear model was set to start at surface temperatures of 8 °C and increase up to 13.5 °C, reaching a maximum of 1 000 full-load hours.

2.3.5 Thermal power and energy yield

To calculate the thermal power and energy yield, in GEL-SEP a Python cool was created, which uses the finite line source theory and g-functions described by Eskilson (1987). The g-functions are calculated analytically by using the Python Plugin "pygfunction" (Cimmino 2022). With the help of g-functions it was possible to incorporate a simple operation function that consists of the phases heating and cooling with passive regeneration in-between, over a 20 year time frame. The operation function was determined using the standard operating hours for heating and cooling described above. Additionally, a scenario of a balanced use for heating and cooling was developed to showcase the use of BHEs for thermal storage. Based on the input parameters, thermal conductivity, underground temperature, operational function (for the two operating modes standard operating hours and balanced use) and field geometry, the Python based tool calculates the specific thermal power (W/m) of a single 100 m deep borehole. For the energy yield (kWh/m^2/a), two BHE field layouts were defined. They cover one BHE field with 4 x 4 probes and 10 m spacing in-between (standard operating hours), and one with 7 x 7 probes and 5 m spacing in-between (balanced use). All technical constraints used in the calculation are listed in figure 2. The resulting thermal capacity and energy yield give the available energy coming from the underground, excluding additional heat from the heat pump. The user-defined calculation of the location specific indicates the share of both.

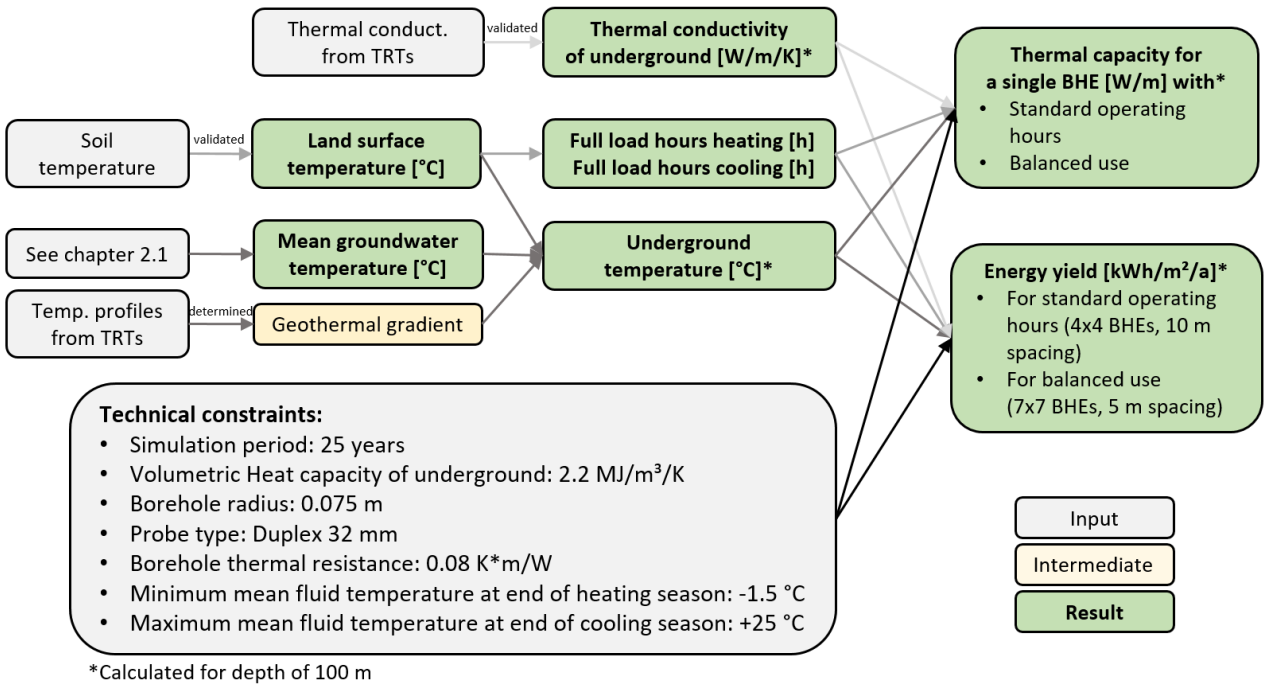


Figure 2. Workflow for deriving results to describe the resources of borehole heat exchangers.

3 RESULTS

The Geothermal Atlas for Vienna contains traffic light maps for borehole heat exchangers and groundwater heat pumps. They summarize 10 possible limitations of use. Five data sets of "additional information" were created to accompany the traffic light maps. The data sets including a more detailed description are provided in the data publication of Steiner (2023a). The resources of borehole heat exchangers are described in 9 data sets and of groundwater heat pumps in 11 data sets. The resource data sets are published as well (Steiner 2023b and Steiner 2023c). The Geothermal Atlas of Vienna displays those data sets and uses them for property specific resource estimates.

Goal of the resulting user tools in the Geothermal Atlas is to provide free access to data, which is relevant for planning of SGE installations and gives a first overview of available resources at locations, selected by the user. The following sub-chapters describe the functionalities of the tools. The resulting data sets of the methodology described in the previous chapter are provided in the Geothermal Atlas (https://geothermieatlas.geosphere.at/) as raster-based web map services, hosted on an ArcGIS Enterprise platform. The base topography is supplied by basemap.at, a unified nationwide mapping initiative of the Austrian federal states. The two tools, a web map viewer and a location specific query, are accessible via two separate sub-pages, one for groundwater heat pumps and one for borehole heat exchangers. The original version of the Geothermal Atlas is in German, however, the automatic website translation works well. Only any PDF reports are restricted to German.

3.1 Web map viewer

Per default, the traffic light map is shown on the map viewer, all other data sets can be activated and deactivated via a sidebar. In the sidebar menu, the traffic light maps are displayed under “Possible Limitations” and all other datasets are grouped together under “Resources”. The web map viewer includes all data sets indicated as results in figures 1 and 2.

To select a specific location the user can enter the address in the “Search address” field or by directly navigating with the mouse. Selecting a location opens a location specific report that lists all values of the data sets at the specific location, including all possible limitations, including the “additional information” parameters and resources (see figure 3). A textual description was chosen to increase clarity for the users.

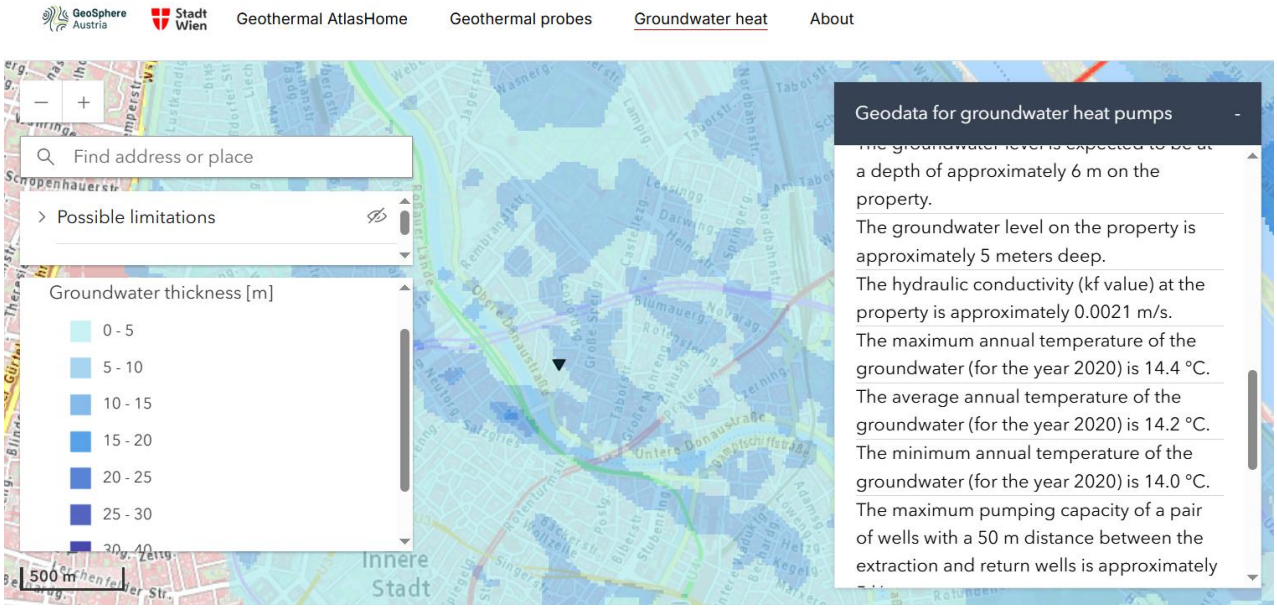


Figure 3. Screenshot of the web map viewer for groundwater heat pumps in the Geothermal Atlas with automatic website translation into English.

3.2 Location specific query

The location specific query tool is designed to provide an initial estimate of the heating and cooling resources of BHEs on a specific property. Parcel geometries are provided by the Austrian Federal Office of Metrology and Surveying (BEV). Based on this underlying parcel geometry and the topography, an initial BHE field layout is suggested after selecting a land parcel by clicking on it or drawing an outlining polygon of the BHE field. The first suggestion automatically excludes buildings, however, it is possible to position BHEs in these areas individually afterwards. The user can interactively adjust the layout by deleting, repositioning, or adding boreholes. To keep the calculation time feasible, the maximum number of BHEs was set to 300. The configuration of the BHE field also includes adjustments for the borehole spacing and the borehole depth. For the city of Vienna the necessary geological and climatological data is taken from the data sets as described above. This is done simultaneously with the first selection of the parcel. In regions outside of Vienna the adapted land surface temperature is used in the calculations. Austrian wide data sets for the thermal conductivity and the underground temperature are not available and the user has to adjust the provided default values. For thermal conductivity the default values is set to 2 W/m/K. The default value for the underground temperature is automatically calculated using the land surface temperature at that point and a fixed geothermal gradient.

Subsequently, the operation mode has to be set. Three options are available for the heating supply temperature. Selection of floor heating with a supply temperature of 35 °C induces a Coefficient of performance (COP) of 4.74, choosing the radiator with a supply temperature of 55 °C results in a COP of 2.8 and for the user-defined input in the range of 30 – 65 °C the COP will be calculated separately. The COPs are included in the calculation accordingly.

The provided default values for the annual full-load hours for heating and cooling can either be simply kept, which are determined using the workflow described in the chapter above, or changed. Setting the operating hours completes the mandatory inputs. If the heating and cooling demand in kW is known, this can also be entered and will be used to calculate the percentage coverage of the demand. A pure heating or cooling mode can be considered by setting one of the two operating hours and demand to zero.

The technical constraints used are similar to the ones used for the data sets described in chapter 2.1 (see figure 2), with the following adaptions. The simulation time is 20 years and the maximum mean fluid temperature at the end of the cooling season is 28 °C.

After completing the input in the calculation menu on the left side of the tool, the data is transferred to a dedicated server, where the Python-based calculation script is executed to estimate the resources. The results are returned to the application and a short version of the calculation results is shown in a separate window. The text description also includes a Senky diagram indicating the energy flow of the warm and cold side of the heat pump and the BHE field. A more detailed report can be downloaded as PDF. A screenshot of the location specific query at a random location in Vienna is shown figure 4.

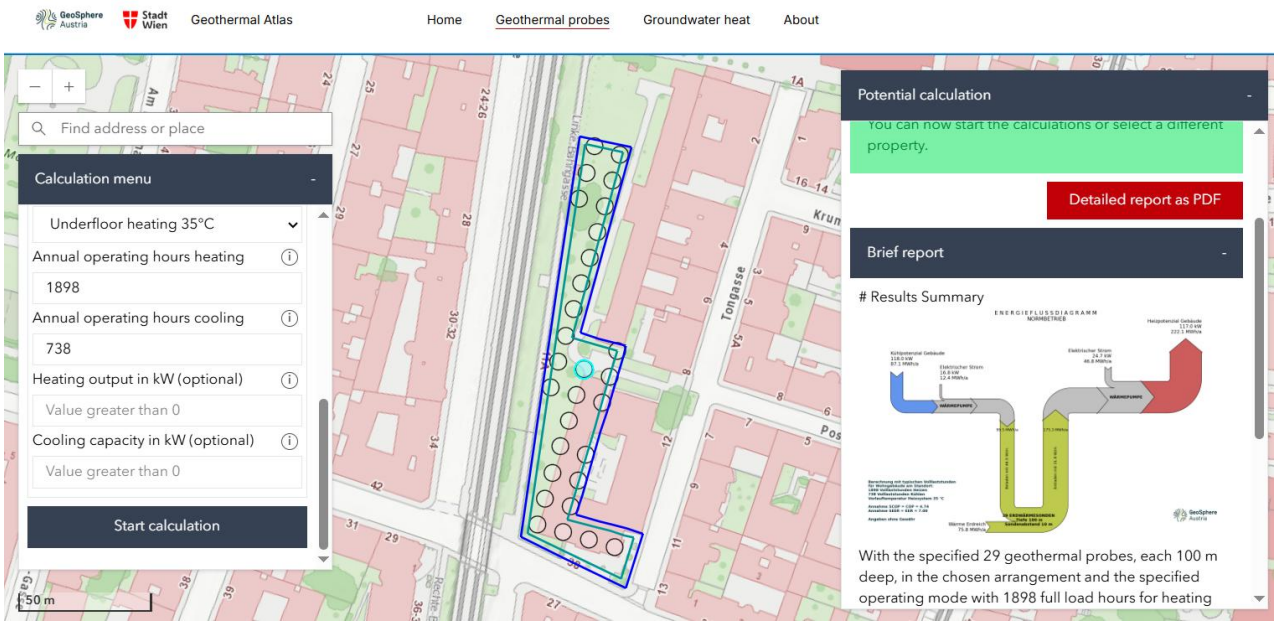


Figure 4. Screenshot of the location specific query for borehole heat exchangers at a random location in Vienna with the calculation menu on the left, located borehole heat exchangers in the center and the resulting Senky diagram on the right.

The first section of the PDF report includes a list of the used input parameters for the calculation as provided in the calculation menu and taken from the geological and climatological data sets.

Then follow the results for thermal capacity and energy yield. Without a given demand, the maximum heating and cooling capacity is calculated with the given operating hours in a way, that both temperature limits (-1.5 °C in heating mode and 28 °C in cooling mode) are reached. If a heating and/or cooling demand is provided, the calculation differentiates between the scenarios "No demand side (heating and cooling) is fully covered (< 100 %)" - (1), "Demand of either heating or cooling is fully covered (< 100 %)" - (2) and " Both demand sides are fully covered (> 100 %)" - (3).

1) The BHE field is too small for the given demand. The tool calculates the maximum possible potential for heating and cooling. The report indicates that neither of the demand can be met and additional heating and cooling sources are required. Fluid temperatures reach the defined upper and lower limits.

2) In this scenario, one of the two potentials meets or even exceeds the demand and is therefore capped at 100 % of the demand. The remaining potential of the uncovered demand side is then calculated based on the energy balance that results from the capped usage. This is relevant because the achievable potential on one side depends on how intensively the other is used. Higher cooling usage lads to better thermal regeneration and thus a higher heating potential. The report notes that one demand cannot be fully met, and that the other potential is not fully utilized. In the temperature simulation, the fluid temperature on the capped side remains within limits, confirming the underutilization.

3) Here the BHE field is large enough to meet or even exceed the specified heating and cooling demands, without necessarily reaching the temperature limits. The heating and cooling ratio remains as given, leading to the same coverage of demand for both sides. In case of a demand coverage > 110 %, the report denotes that the BHE field can be decreased to still meet the demand.

For certain cases, e.g. if the number of BHEs > 6 and the annual energy yield is not balanced (including a tolerance of 10 %), the tool also calculates the potential for an automatically determined balanced use of the BHE field. Therefore, the heating and cooling ratio is optimized, and the operating hours of either heating or cooling are adapted. The heating and cooling potential are always fully used in this automatically balanced mode.

4 CONCLUSIONS

The Geothermal Atlas provides a harmonized and structured basis for evaluating the technical feasibility of groundwater heat pumps and borehole heat exchangers in the city of Vienna. It supports strategic and individual-use planning by displaying possible limitations of use, hydrogeological and geological information as well as thermal capacity and annual energy yield, and by a property specific query. The tools allow a first-level assessment of heating and cooling potential, incorporating realistic site-specific subsurface parameters. However, it is essential to emphasize that the Geothermal Atlas is not a design tool. It does not replace detailed planning or system dimensioning. Critical aspects such as existing underground infrastructure (e.g. pipelines, cables, basements) are not considered in the resource calculations and my severely limit practical installation possibilities. Furthermore, the energy-related datasets were calculated based on standard operating hours derived for single family homes. This must be taken into account whenever the actual building demand substantially differs from that assumption. Currently, the operation mode of free cooling is not implemented in the Geothermal Atlas. By incorporating this highly efficient cooling mode, the flexibility of the location specific query would be enhanced.

Mutual thermal interference between boreholes within a given field is accounted for in the energy related data sets as well as in the query tool via g-functions. However, thermal interaction with neighbouring systems is not currently considered. Existing shallow geothermal systems were not included in the calculation of the resource data sets. Including these systems would be valuable, for assessing cumulative impacts as well as for considering already-used geothermal resources. The in 2026 finalized GeoBOOST project analysed the current market for SGE (Schnabl 2024) and established a template for which data should be collected and reported about existing systems (Brancher and Steiner 2024). This offers an opportunity to enhance the Geothermal Atlas. By integrating the installation records collected within GeoBOOST, the system could be expanded to show existing installations as another important input for planning, and improve potential estimates and sustainable energy planning.

To further support sustainable system planning, the location specific query also demonstrates how a balanced use of heating and cooling can enhance both system performance and underground resource sustainability. Injecting waste heat into the ground during the cooling season regenerates the underground and increases the heating potential, while heat extraction during the heating season support cooling performance in summer. For borehole fields with more than five boreholes, the tool automatically provides an additional balanced operation scenario.

In this current form, the Geothermal Atlas supports professionals in implementing shallow geothermal solutions and makes a significant contribution to the decarbonization of heat supply, mainly in Vienna. An incorporation of additional federal states of Austria is work in progress.

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Europe project GeoBOOST, the future development of the Geothermal Atlas will be able to integrate existing shallow geothermal installations, building on the monitoring and data standards established across Europe.

REFERENCES

Brancher, M., and Steiner, C.: Reporting and monitoring geothermal heat pumps in Europe, Deliverable D2.2. LIFE project GeoBOOST (2024).

Cimmino, M. and Cook, J.C.: pygfunction 2.2: New features and improvements in accuracy and computational efficiency. In Research Conference Proceedings, IGSHPA Annual Conference 2022 (pp. 45-52). International Ground Source Heat Pump Association. DOI: https://doi.org/10.22488/okstate.22.000015, (2022).

Eskilson, P.: Thermal Analysis of Heat Extraction Boreholes. Ph.D. thesis. University of Lund, (1987)

Fuchsluger, M.: Projekt WC-33 Potenzialkarte für die integrative Planung thermischer Grundwassernutzungen in Aspern Nord. Geologische Bundesanstalt, Wien, (2016).

García-Gil, A., Goetzl, G., Kłonowski, M. R., Borovic, S., Boon, D. P., Abesser, C., Janza, M., Herms, I., Petitclerc, E., Erlström, M., Holecek, J., Hunter, T., Vandeweijer, V. P., Cernak, R., Mejías Moreno, M., and Epting, J.: Governance of shallow geothermal energy resources. Energy Policy, 138, 111283, https://doi.org/10.1016/j.enpol.2020.111283, (2020).

Görz, I., Heiermann, M., Götzl, G., Steiner, C., Ciapala, B., and Hofmann, K.: EVALUATED GUIDELINES ON HARMONIZED WORKFLOWS AND METHODS FOR URBAN AND NON- URBAN AREAS. Project GeoPLASMA-CE - Interreg CENTRAL EUROPE, (2019).

Metz, M., Rocchini, D. and Neteler, M.: Surface temperatures at the continental scale: Tracking changes with remote sensing at unprecedented detail. Remote Sensing, 6(5), 3822–3840, https://doi.org/10.3390/rs6053822, (2014).

ÖWAV: ÖWAV-Regelblatt 207 Thermische Nutzung des Grundwassers und des Untergrunds - Heizen und Kühlen. Wien: ÖWAV (2009).

Pfleiderer, S., Hofmann, T., Wien, D. S., Kultur, W., & Hofmann, M. T.: Digitaler angewandter Geo-Atlas der Stadt Wien Projekt WC 21 HYDRO-Modul (Pilotphase) Endbericht, (Geol. Bundesanstalt), (2004).

SIA: SIA 384/6 - Erdwärmesonden. Schweizerischer Ingenieur- und Architektenverein (SIA), (2010).

Schnabl, P.: Ground Source Heat Pumps in Europe: An analysis of the Geothermal Heat Pumps market, Deliverable D2.1, LIFE project GeoBOOST (2024).

Steiner, C.: Mögliche Einschränkungen für die Nutzung der oberflächennahen Geothermie in Wien. Tethys RDR, GeoSphere Austria, Wien (https://doi.org/10.24341/tethys.223), (2023a).

Steiner, C.: Ressourcen für die Nutzung von Erdwärmesonden in Wien. Tethys RDR, GeoSphere Austria, Wien (https://doi.org/10.24341/tethys.222), (2023b)

Steiner, C.: Ressourcen für die thermische Nutzung des Grundwassers in Wien. Tethys RDR, GeoSphere Austria, Wien (https://doi.org/10.24341/tethys.221), (2023c).

Steiner, C., Turewicz, V., Götzl, G., Fuchsluger, M., Nyeki E., Brüstle, A., and Hoyer, S.: Projekt GEL-SEP Wien „InformationsSystem Oberflächennahe Geothermie für Wien“ Endbericht. Geologische Bundesanstalt, Wien (2021).