Managing Urban Shallow Geothermal Energy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166

Webinar

"Novel approaches in shallow geothermal resource mapping"

Short summary

Date and location of the workshop: 10th of May 2021, 3 pm – 4:30 pm (CET, Vienna – Berlin-Paris), digital event

Link to the webinar recordings

The webinar is shown on the GeoERA MUSE YouTube cannel at: https://youtu.be/okN065GKWzM

Program

3 pm*	***Opening of the webinar and welcome address***
	Adela Ramos Escudero (University of Cartagena) & Burkhard Sanner (UbeG GbR): Large scale, pan-European resource mapping – results from the EU project GEOCOND" adela.ramos@edu.upct.es, b.sanner@ubeg.de
	Martin Fuchsluger & Cornelia Steiner (Geological Survey of Austria): The application of g-functions in shallow geothermal resource mapping for the project GEL-SEP (Austria) Martin.Fuchsluger@geologie.ac.at, cornelia-steiner@geologie.ac.at
	Q&A round and joint discussion
4:30 pm	***End of the webinar***

*all times in CET (Vienna – Berlin – Paris)

Summary of the workshop

Context: Mapping shallow geothermal resources is an important but still challenging exercise when it comes to spatial resolution and adaptability of information provided to end-users. Policy makers prefer large scale maps, which deliver information in an easy digestible format, anticipated by non-geoscientists as well. Energy planners need to have resource maps translating geoscientific parameters into technical ones. This has partly been achieved for single installations (e.g. borehole heat exchangers - BHE) at typical operational schemes for single buildings. However, appropriate mapping workflows are still lacking when it comes to large scale BHE fields operating at a combined heating and cooling mode.

GEOCOND presentations: The project aimed at improving the operational efficiency of Borehole Heat Exchanger (BHE) systems by optimizing the materials of the individual components (pipes and grout), configurations and the overall setup. The work performed also included the assessment of the limiting factors (e.g. thermal conductivity of the surrounding subsurface rocks) as well as the set-up of sandbox testing of prototypes. Focus was put on the reduction of the thermal resistance of BHEs (pipes and grouting) and a reduction of 20% was confirmed by the end of the project in prototype installations. GEOCOND concluded that the required thermal conductivity (TC) of the grouting is determined by the one of the surrounding rocks and that pipe materials should fulfil a minimum TC

of 1 W/m/K. In order to upscale the findings of Geocond, pan European maps regarding the geoscientific requirements were created in the project. These maps, among others, covered the thermal conductivity of the surrounding rocks as well as the mean annual surface temperature. Geostatistic analyses, performed on the calculated maps revealed that there is a significant gap between the areal and residential distribution of geoscientific conditions. In most cases the requirements on the grouting is lower in heavily populated areas, as these are located in soft rock basin requirements. Taking this into account, the quality of the grouting is sufficient to allow for efficient BHE systems in most households when reaching TC values of 2.0 – 3.0 W/m/K. In addition to the work performed in GEOCOND, the presented PhD thesis of Adela Ramos Escudero addressed multi-variant resource and decision support maps on a pan-European scale based on 6 geoscientific and socio-climatic attributes. The study aimed at comparing these different attributes and identifying favourable conditions for the use of BHEs in a European context. This resulted in a qualitative suitability raster map based on weighted criteria. A dedicated scientific article about the work presented in the webinar can also be accessed at this link: https://www.sciencedirect.com/science/article/pii/S0960148120318309

GEL-SEP / g-functions presentations: The Austrian national project Green Energy Lab – Spatial Energy Planning (GEL-SEP) aimed at introducing multi-level decision support to promote the use of renewable or waste heat in heating and cooling in communities. Along with other sources, shallow geothermal energy use (groundwater heat exchangers, horizontal collectors and BHEs) was considered in a digital ENERGYatlas tool addressing energy planners as well as the lay public. Resource and limitation of use mapping, linked to shallow geothermal energy use, was achieved in 3 different levels of details and complexity: 1) providing a map based overview without taking into account the heat demand of consumers; 2) location specific data query tool focusing on land properties and matching the available resources with the currently existing demand for heating and cooling; 3) regional query on community basis for upscaling of tool 2). At all levels, the operational conditions of BHEs (pure heating / cooling or alternating heating and cooling) was considered as well as mutual effects of multiple BHE fields. In order to do so, a pre-existing Python based script (pygfunction) was applied and modified in order to use g-functions for semi-analytic calculations for different BHE patterns and operational modes. The use of g-functions enables a higher degree of flexibility and accuracy on the one hand and short processing times on the other. Moreover, the calculations directly lead to outputs, which can directly be used in energy supply estimations (specific heat transfer rate in W/m). The newly developed resource matching tool “BHEseppy” will be published soon and is available for adaption. The Austrian ENERGYatlas tool, covering the national states Vienna, Salzburg and parts of Styria will be online from autumn 2021 on.

Q&A round and concluding statements

GEOCOND presentations	
Question and comments	**Answer by the speakers**
You mentioned that you could not account for the water content in the maps existing in EGDI - which kind of maps would be helpful to improve the TC prediction?	For future studies, pan-European maps showing the water table would be helpful.

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Are the maps available as shape files somewhere?	The maps will be available at the EGDI platform of EuroGeoSurveys (http://www.europe-geology.eu/) from autumn 2021 on including data download.
Were the climate maps also filtered by the population density? This would be helpful for policies discussions	Climate maps filtered by population can be found as well in the performed analyses
How were the weighting factors selected - based on stakeholder surveys?	Weighting factors considered were those previously spatially studied. All of them were considered as they somehow affect the final SGE efficiency.
Did you check your predictions of ground thermal conductivity and temperature against Thermal Response Test (TRT) data? *These maps are a real important starting point for pan-European geothermal mapping, thank you Burkard and Adela. But what about mapping improvement and refining for each country with real thermal conductivities data adding to thermal conductivity VDI 4640-created maps?*	The maps have not been calibrated or evaluated by TRT measurements to lack of access to such data.
In some areas such as salt it may be unacceptable to install CL - is this situation represented in maps? Water protection areas can also been an issue. Have you included these in your study?	No, only outcropping lithologies were considered. And superficial water protection areas were considered as long as the country itself consider these areas as protected area.
You mention the use of annual thermal amplitude. How did you define the amplitude that is needed to make GSHPs more efficient than ASHPs?	In the analysis, there is no range values defining the efficiency. What the results want to show is that in those areas with wider amplitudes, GHSP technology is considered more adequate than ASHP, than in areas with narrower amplitudes.

GEL-SEP / g-functions presentations	
Question and comments	**Answer by the speakers**
Are the BHEs distributed in a raster or to maximize the space?	In tool 1 and 3 the BHE fields have a square base and in tool 2 the BHEs are distributed in the most compact form possible, depending on the demand.
(How) is groundwater flow considered in your tool #1, e.g. to assess system's thermal footprint / interference risks etc.?	Groundwater flow is not considered in our tools, neither are existing SGE systems. It is planned to consider groundwater flow in a further release of the thermal conductivity maps to include an estimation of the advective part.
How there the tools designed? Through discussions with designers and planners?	They are a result from the need of the project itself and our considerations. Relevant attributes and expected outcomes had been discussed with stakeholders (e.g. planners, authorities) in dedicated workshops.
Are the tools publicly available?	Unfortunately not yet, because we are still working on the project. The ENERGYatlas will be online in fall this year. The g-function tool can be tested upon request to GBA.
If I understand correctly your script does not take into account any BHEs on neighboring properties?	There were efforts to include thermal plumes of existing BHE at the underground temperature map, but the monitoring information is missing and many existing BHE are not even in the administration database. So we decided, that neighboring effects are

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	not included in the maps and location query. At least, the neighboring BHEs should be listed in the query (tool 2) as a hint for the detail planning. Furthermore, the range of influence of BHEs is limited due to the hydrogeological conditions and moderate level of BHE densities in the investigated regions in Austria.
How realistic are your heating demand data? Was it possible to correlate it to actual demand data (i.e. natural gas consumption)?	The heating demand data was provided to GBA by the project team. They have calculated the heating demand based on an extensive building model and calibrated it with actual demand data.
If the BHE is 2m from the edge of the property, is it then 4m from the nearest BHE on the neighboring property?	Yes, in the worst case. This may play a role in urban areas with high building density and small free spaces. But then, there is also much buffer due to the areas of the buildings and roads
How does your determination of possible heat extraction compare to the activities and assessments in Switzerland concerning high density of BHE and the need of regeneration?	Our maps clearly show the positive effect of regeneration. We decided to use two modes of operation: 1) heating and cooling with standard operational hours and 2) heating and cooling with balanced load (act as a storage). We consciously do not show maps with "heating only" or "cooling only" to motivate the user to use the cooling and regeneration opportunities.
The Salzburg examples nicely illustrates the population density shift in usable ground thermal conductivity!	
Could you share the link to the Cimmino g-function toolbox?	https://github.com/MassimoCimmino/pygfunction
If the valley sediments are thin but bedrock is high TC it's not so bad in reality? You can include superficial thickness in future assessments?	Our thermal conductivity maps are results from geological modelling. Our colleague has modelled the bottom of the sediment basins, which were included in the TC-calculation; the TC models distinguish between full sediment fillings up to 100 meters depth, border zones with sediment thicknesses below 100 meters and hard rock zones
To try to find greater usability to the GIS layers that we develop in the ICGC (Geological survey of Catalonia) by end-users, and that we now have published in a GISweb viewer, we are developing an App like standalone that will be able to downloaded from our website, which will consume these GIS layers and the user will make a pre-calculation of the demand and the field array of facilities up to 70 kW, and assess the economic analysis of the system comparing it with other thermal sources. Always with the warning that it is a pre-calculation and for any specific case, a specific study will have to be made, as has been pointed.	
How fast is the processing routine based on g-functions	One pygfunction needs few seconds, with polynomial approximation for maps in Milliseconds. For example, the calculation of all maps for Salzburg need about 2 hours, as there are about 1 Million grid points and 6 maps to calculate.

About GeoERA-MUSE

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GeoERA MUSE addresses managing shallow geothermal energy use in European urban areas. The projects, organized under the GeoERA umbrella of EuroGeoSurveys investigates novel approaches covering the entire management circle including resource and limitation of use mapping, legal procedures and licensing, operation and monitoring for supporting a so called integrative and adaptive management approach in cities. Web based GIS maps at local scale represent the central interface between these steps and offer vital instruments for authorities and decision makers. GeoERA MUSE represents a collaboration of 15 national Geological Survey Organisations inside EuroGeoSurveys for harmonizing and testing methodologies and approaches concerning mapping and management in 14 different European urban areas.

For more information on GeoERA MUSE please visit **https://geoera.eu/projects/muse3/**.

About GEOCOND

The GEOCOND project operated from May 2017 to February 2021 with the main objective to develop new and enhanced materials for BHE pipes and grout. Through a cooperation of material scientists, industry and shallow geothermal specialists, substantial improvements in both fields have been made, and the efficiency gains made possible by the advanced materials have been confirmed in a test field and some full-size installations. Mapping on a European scale was key to define the optimum target values for the new materials, and examples of regional mapping in Spain contribute to site design support. GEOCOND was supported by the European Union's Horizon 2020 research and innovation programme under grant agreement No 727583.

For more information on GEOCOND please visit **https://geocond-project.eu/**.