Occurring Challenges in the Development Process of Geothermal Mine Water Projects and Possible Solutions

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Abstract

In the context of the ongoing energy transition, characterized by a shift from fossil fuels towards renewable energy sources, it becomes imperative to present local energy suppliers with technically and ecologically viable solutions. In regions formerly dedicated to coal mining, the utilization of warm mine water and its geothermal application can play a significant role in the energy transition, functioning as a heat source and a heat reservoir. The implementation's feasibility has been thoroughly investigated by various studies, particularly within the Ruhr region of Germany, elucidating the pertinent challenges and the development of solutions for addressing them, which will be subsequently presented.

Keywords: Mine water, legal challenges, geothermal, post-mining exploitation

Introduction

In the context of the transformation of the heat supply in Germany, away from fossil fuels towards renewable energies, geogenic energy sources play a vital role, as they offer the advantage of providing energy locally and thus secure independence from external energy sources. In the former coal mining regions, mine water can represent a part of these locally available heat sources and can be compared with the other heat sources in terms of technical and economic feasibility. In the course of conducting various feasibility studies on the implementation of geothermal mine water systems, challenges that need to be overcome for numerous reasons and using diversified methods quickly come to light. Recognizing and compiling these important findings is essential in order to create a more profound basis for future projects, so that obstacles that arise again can be dealt with more effectively using the lessons learned. In the following, typical problems that emerged in recently completed or in-progress case studies are highlighted, and respective solutions and/or circumventions are discussed.

Technical challenges

As part of three feasibility studies on the conversion of heating networks for a local energy supplier serving three municipalities in the eastern part of the Ruhr area, mine water was investigated as a regenerative heat source in addition to other energy sources. In the three areas that were investigated, a comprehensive evaluation was conducted to ascertain the requirements and conditions for implementing geothermal mine water utilisation. It was observed that each of the three supply areas presented distinct possibilities for mine water utilisation, accompanied by a range of challenges.

The northernmost areas of the former "Königsborn" coal mine are located directly below the smallest of the three district heating grids that were the focus of the study. The location of the heat network and the former underground parts of the mine are shown in Fig. 1. The existing underground data was overlaid with a buffer zone representing a larger area around the original data points. This buffer serves to anonymise the specific location of the data by adding an extra spatial margin around it, according to legal restrictions.

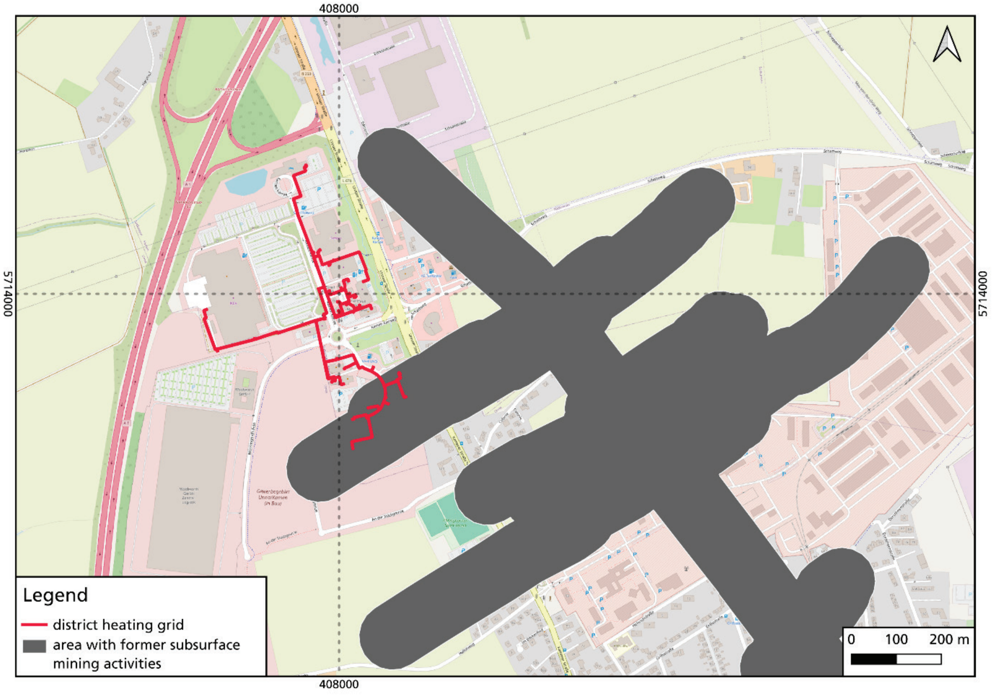

Figure 1 *District heating network (red) with a representation of the former underground structures of a coal mine (grey, due to restricted permission anonymised).*

The former drifts and crosscuts of the colliery lie at a depth of -200 to -300 meters below sea level, while the upper edge of the site is at a level of +70 meters above sea level. The mine workings are part of a mine that is isolated from the central mine water drainage system that often dominates the mine water levels in the Ruhr area and is therefore completely flooded. With a current measured mine water level of just over 45 meters above sea level (Bürgerinformationsdienst, 2025), this results in a pumping height of just under 25 meters at an expected temperature of 18 °C. Based on these facts alone, especially the low head and the perfect location of the mine below the current network, the use of mine water as a geothermal source seems obvious and logical. However, there are two major obstacles that make technical implementation problematic: the age of the mine and its location within the mine. The part of the mine below the heating network is one of the oldest parts of the mine and was created around 1890. At that time the mine was mainly built with wooden beams, and discussions with experts from the responsible mining company suggest that these beams have barely survived the last 130 years intact, leaving only a small residual mine void volume from the former workings. This means that only a small part of the former cavity is likely to be available for geothermal use. The second obstacle to the development of the mine is the location of the existing drifts in relation to the rest of the mine. The drifts are very isolated areas in terms of their location and are only connected to the rest of the mine by a single drift. This makes it difficult for the mine water to exchange with the rest of the mine, which means that the mine workings would cool down more and more over time. For these two reasons, the use of mine water for the existing local heating network was not the preferred option for the project.

As the underground conditions cannot be changed retrospectively, a different solution must be found for the utilisation of mine water for this project, which relates to the surface. One possible solution, which was discussed and developed with the energy supplier and grid operator, would be a possible extension of the grid to the south.

This would allow the network to move into areas of the mine that were created much later and therefore offer more residual mine void volume and at the same time open up areas of the mine that allow better exchange of the mine water to prevent the mine water from constantly cooling down. By creating a mine model and simulating the underground thermal-hydraulic situation, the influence of larger residual cavity volumes can be modeled and well estimated. The mine water can then once again become a valuable geothermal heat source for a future expansion of the heating network.

Legal Challenges

The second and largest heating network of the energy supplier is located in proximity to one of the six central mine water dewatering sites, with the future intention of permanently pumping mine water from this location to ensure a constant mine water table in the mine water province. These pumping sites offer a high potential for the geothermal utilisation of mine water, as the necessary infrastructure has already been established to bring the water to the surface. The existence of this infrastructure greatly enhances the economic viability of the project and facilitates expeditious and technically uncomplicated execution.

While technical implementation at this location can be very straightforward, the legal and contractual challenges here are more complex and need to be clarified in advance. First of all, the water law in Germany issues had to be clarified, as these can have an influence on the subsequent operator model. In principle, the energy from the mine water can be transferred to three locations. (1) at the surge chamber of the mine drainage system, (2) behind a heat exchanger and finally (3) behind a high-temperature heat pump. Each of these three options offers advantages and disadvantages for both the operator of the mine dewatering system and the operator of the heating network.

In the case (1) of a transfer downstream of the surge tank, the mine water management operator would lose control over its own water and would transfer responsibility for the extracted mine water to the network operator, and thus also the potential problems associated with this. The advantage of this variant would be that the supplier could plan everything from a single source and that no additional costs would be incurred by the mine water management company. In variant (2), the operator of the mine water drainage system would continue to have sovereignty over its own mine water, but would have to pay for the investment and operation of the heat exchanger. The network operator would avoid problems with the mine water and would have lower investment costs, but these would probably be offset by a slightly higher price for the heat provided. Option (3) would save the supplier the large investment for a large heat pump, but the potential margin from refining the heat would also be lost. The mine water operator could offer the heat at grid temperature in a complete package and thus increase its own margin, but this would come with high investment costs as well as the responsibility of becoming an energy supplier. After constructive discussions with both stakeholders, it became clear that variant (2) turned out as the most practicable option for the time being, as a clear separation of responsibilities is evident for both sides and, above all, the legal issues relating to the ownership of the mine water are clearly resolved.

Another legal obstacle that can be encountered in the implementation of mine water geothermal projects is the exploration fields for the use of geothermal energy. At the present time in North Rhine-Westphalia, these legally cover the areas of medium-depth and deep geothermal energy as well as the use of mine water for geothermal purposes from a level of less than 100 meters. As part of the "Act to speed up the approval procedures for geothermal systems, heat pumps and heat storage facilities", the lowering of the limit to 400 m is currently being examined, which may offer more scope for implementation in the future (BMWK, 2024). This means that if such a field was to be used by the owner for the exploration of deep geothermal energy, the realization of projects that want to use thermal energy from mine water could be hindered. Here too, an agreement would have to be reached with the owner of the field in order to find a joint legal solution. Alternatively, such a problem could also be solved technically. If the mine workings and the conditions above ground are suitable for use as a mine heat storage facility, consideration could be given to adapting the concept into a storage concept. The storage of heat is not covered by the rights of the exploration fields for geothermal energy and therefore a possible legal obstacle could be circumvented here by adapting the technical layout.

Conclusions

The challenges that can arise during the planning, development and implementation of mine water projects are multiple and complex. For some, there are direct solutions that ideally only require intensive and constructive discussions among the stakeholder and can often be resolved with a contract. These are mainly issues that have either a legal, social or contractual dimension. Although these problems can be solved, the processes can be extremely delayed, as it is not always clear who is responsible, which areas are affected and which other stakeholders may need to be involved in finding a solution. As this can take a very long time, it is important to address these issues at an early stage of the project, to avoid further delays during the actual implementation.

Problems that are based on geological, chemical or technical reasons can be much more complex, due to the many different aspects, but can often be solved or circumvented with the right methods and approaches. However, if this is not the case, an alternative solution must be sought or the expansion must be postponed to a later stage, when the framework conditions for the successful implementation of a geothermal mine water utilization are more favorable.

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