Impact of high-temperature heat storage on groundwater

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In a recently launched project, the aquatic research institute Eawag is investigating how the use of borehole thermal energy storage (BTES) affects the surrounding soil, the groundwater and the microorganisms living in it. In collaboration with Empa and its Demonstrator Energy Hub (ehub), a project is being developed in a unique setting on the campus in Dübendorf.

In winter, conventional geothermal heat pumps draw heat from the ground to heat buildings. The borehole heat accumulators installed on the Empa and Eawag site are geothermal probes that can not only draw heat to the surface in winter, but also store the heat from the summer months in the ground so that it is available in the colder months of the year. The maximum temperature that can be fed into the reservoir is 65 degrees Celsius – a record in Switzerland and therefore unique in the country. As a result, temperatures of up to 50 degrees Celsius can be reached locally in the ground on average.

So far, however, little is known about how the subsurface reacts to these high-temperature reservoirs. The regular heating and cooling of the probes at depths of up to 100 metres can affect the chemical components in the groundwater as well as the microbial communities in the soil and water. Exactly how and to what extent is now being investigated as part of the ARTS (Aquifer Reaction to Thermal Storage) research project at the aquatic research institute Eawag.

A unique setup

Three such boxes are now installed on the Empa/Eawag campus, each equipped with sensors and a mass spectrometer. The groundwater pumps run 30 and 70 metres below them (Photo: Eawag, Joaquin Jimenez-Martinez).

144 geothermal probes were “sunk” on the Dübendorf campus. They run up to 100 metres deep and converge in a basement next to the new car park. They are monitored and controlled by the Empa/Eawag site’s energy control system (GAMS), as the probe field is hydraulically integrated into the campus energy system. The measured values of the storage reservoir are then stored in the database of the NEST building of Empa and Eawag and are available to the researchers.

Three new holes were drilled into the ground: Eawag’s groundwater observation points. Over the next three years, water samples will be pumped to the surface from underground to provide information on how the microbiology of the environment reacts to the probes and to what extent the chemical composition of the groundwater is affected.

The researchers use five pumps to extract groundwater samples from the three boreholes before, during and after it comes into contact with the geothermal probes. In the first few years of the project, only two of the three monitoring stations will be relevant, as comparisons can be made just a few months after the probes are commissioned. However, it may take several years for the groundwater from the immediate vicinity of the probes to reach the third station further away – that’s how slowly the water flows through the subsurface.

Miniature mass spectrometer

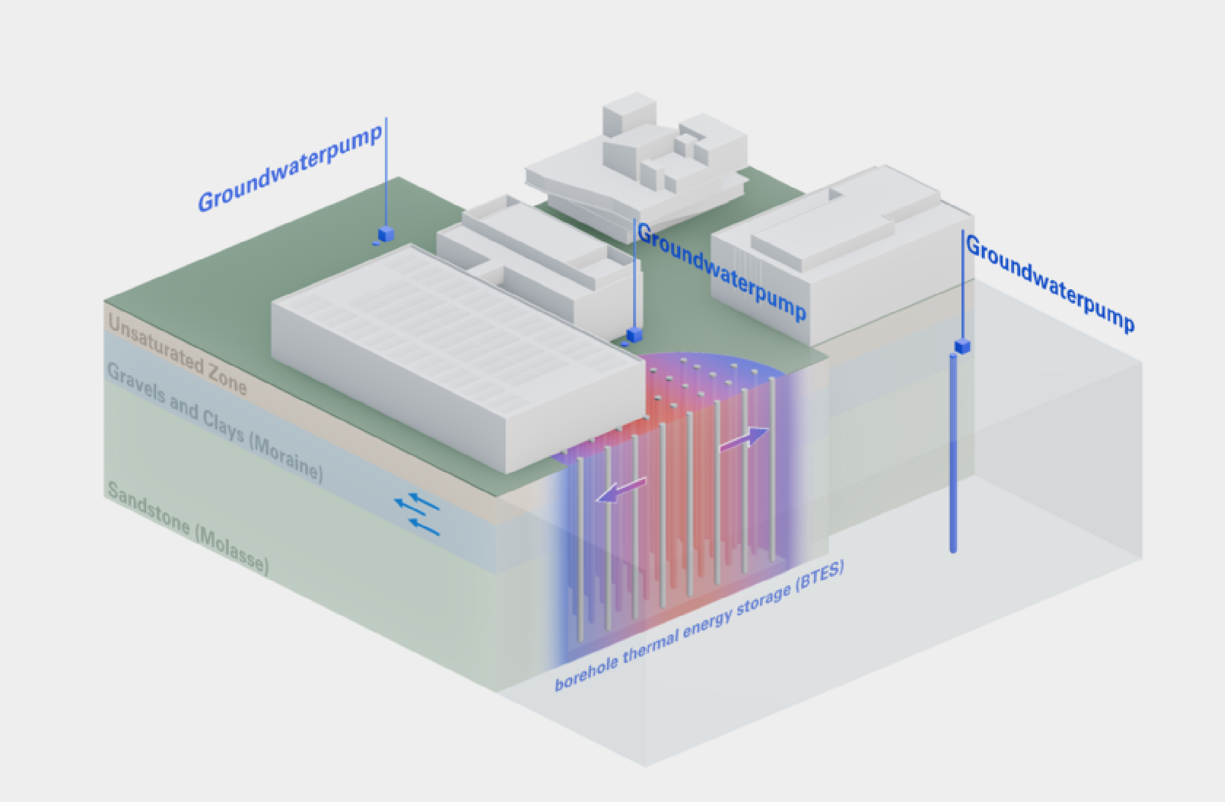
The aim of the project is to gain insights into the reactions triggered by this type of heat storage in the groundwater. This includes not only hydrogeochemistry and microbiology, but also the analysis of gases such as oxygen, methane or carbon dioxide produced by the effects of heat in the ground. Such gases are mainly consumed and produced by bacteria underground – depending on the effects of heat and cold. For this purpose, the water in the pump flows into the GE-MIMS mass spectrometer (also known as miniRUEDI) developed at Eawag. “For the next three years, miniRUEDI devices will measure the dissolved gases in the groundwater every hour, while 2.4 litres of water are pumped through the mass spectrometer every minute,” explains Joaquin Jimenez-Martinez, head of the project and researcher in Eawag’s Water and Drinking Water Department.

The sampled water is also regularly analysed in the laboratory by researchers from Eawag’s Environmental Microbiology and Aquatic Ecology Departments. They focus on the question of how microbial diversity changes under the influence of temperatures of this magnitude. DNA traces (known as eDNA) can also be used to determine which organisms populate the groundwater and whether their numbers and distribution change as a result of the geothermal probes.

The sensors are located in the box on the surface together with the mass spectrometer (miniRUEDI) (Photo: Eawag, Joaquin Jimenez-Martinez).

Great interest from the federal government and cantons

Switzerland already has the highest density of geothermal probes per unit area in the whole of Europe, which is why the project is attracting a great deal of interest from the cantons and the federal government. The demand for new possibilities for energy generation and seasonal storage has also increased as part of the energy transition. The effects of temperature input on the groundwater as an overall system are also of interest. ARTS is therefore supported by the Swiss Federal Office of Energy as well as the Cantons of Zurich, Aargau, Thurgau, Zug and Geneva and is run in cooperation with Empa and Eawag. Employees from the environmental offices of Zurich and Thurgau also contribute to the understanding of hydrogeological questions. Collaboration at this scale is uncommon and the speed at which the project was developed is unprecedented. “It only took ten months from the initial idea in a corridor at Eawag to the drilling of the holes on campus for the sensors,” says Jimenez-Martinez. This shows how pressing the issue is.



The high-temperature borehole heat exchangers under the campus reach down to a depth of 100 metres. Three groundwater pumps bring the groundwater to the surface at three different locations. Illustration: Eawag

Cover picture: Our soil consists of several layers. It is porous and loose near the surface, but compact like concrete at depth. Pictured: soil from the boreholes for the necessary groundwater pumps (Photo: Eawag, Joaquin Jimenez-Martinez).

Financing / Cooperations

Eawag Empa Bundesamt für Energie (BFE) Kanton Zürich Kanton Aargau Kanton Zug Kanton Thurgau Kanton Genf

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Borehole Thermal Energy Storage (BTES)

Empa News

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