HEATSTORE
Feasibility assessment & design for demonstration projects – learnings of an international workshop

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Please cite this report as: Hahn, F. et al., 2019: Feasibility assessment & design for Demo Projects – minutes of international workshop, GEOTHERMICA – ERA NET Cofund Geothermal. 22 pp.

This report represents HEATSTORE project deliverable number D 4.1

HEATSTORE (170153-4401) is one of nine projects under the GEOTHERMICA – ERA NET Cofund aimed at accelerating the uptake of geothermal energy by 1) advancing and integrating different types of underground thermal energy storage (UTES) in the energy system, 2) providing a means to maximise geothermal heat production and optimise the business case of geothermal heat production doublets, 3) addressing technical, economic, environmental, regulatory and policy aspects that are necessary to support efficient and cost-effective deployment of UTES technologies in Europe.

This project has been subsidized through the ERANET cofund GEOTHERMICA (Project n. 731117), from the European Commission, RVO (the Netherlands), DETEC (Switzerland), FZJ-PtJ (Germany), ADEME (France), EUDP (Denmark), Rannis (Iceland), VEA (Belgium), FRCT (Portugal), and MINECO (Spain).

About HEATSTORE

High Temperature Underground Thermal Energy Storage

The heating and cooling sector is vitally important for the transition to a low-carbon and sustainable energy system. Heating and cooling is responsible for half of all consumed final energy in Europe. The vast majority – 85% - of the demand is fulfilled by fossil fuels, most notably natural gas. Low carbon heat sources (e.g. geothermal, biomass, solar and waste-heat) need to be deployed and heat storage plays a pivotal role in this development. Storage provides the flexibility to manage the variations in supply and demand of heat at different scales, but especially the seasonal dips and peaks in heat demand. Underground Thermal Energy Storage (UTES) technologies need to be further developed and need to become an integral component in the future energy system infrastructure to meet variations in both the availability and demand of energy.

The main objectives of the HEATSTORE project are to lower the cost, reduce risks, improve the performance of high temperature (~25°C to ~90°C) underground thermal energy storage (HT-UTES) technologies and to optimize heat network demand side management (DSM). This is primarily achieved by 6 new demonstration pilots and 8 case studies of existing systems with distinct configurations of heat sources, heat storage and heat utilization. This will advance the commercial viability of HT-UTES technologies and, through an optimized balance between supply, transport, storage and demand, enable that geothermal energy production can reach its maximum deployment potential in the European energy transition.

Furthermore, HEATSTORE also learns from existing UTES facilities and geothermal pilot sites from which the design, operating and monitoring information will be made available to the project by consortium partners.

HEATSTORE is one of nine projects under the GEOTHERMICA – ERA NET Cofund and has the objective of accelerating the uptake of geothermal energy by 1) advancing and integrating different types of underground thermal energy storage (UTES) in the energy system, 2) providing a means to maximize geothermal heat production and optimize the business case of geothermal heat production doublets, 3) addressing technical, economic, environmental, regulatory and policy aspects that are necessary to support efficient and cost-effective deployment of UTES technologies in Europe. The three-year project will stimulate a fast-track market uptake in Europe, promoting development from demonstration phase to commercial deployment within 2 to 5 years, and provide an outlook for utilization potential towards 2030 and 2050.

The 23 contributing partners from 9 countries in HEATSTORE have complementary expertise and roles. The consortium is composed of a mix of scientific research institutes and private companies. The industrial participation is considered a very strong and relevant advantage which is instrumental for success. The combination of leading European research institutes together with small, medium and large industrial enterprises, will ensure that the tested technologies can be brought to market and valorised by the relevant stakeholders.

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1 Introduction

During the 1st Annual Meeting of the HEATSTORE consortium, which was held at the TNO offices in Utrecht on 3-4 July 2019, The Netherlands the current status of the feasibility assessment and design for demonstration projects was presented and discussed by all participating partners. This deliverable summarizes these findings of the above mentioned international workshop in a compact bullet point manner.

In detail all demonstration projects shared their feasibility assessment and their current design status of their project sites and case studies. Important lessons learned from the discussions were the following:

- Thorough understanding of the local geology and hydrogeology is required before making a preliminary design of a storage project to review business opportunities and technical challenges.
- Therefore exploration drilling and testing is strongly advised and should be performed in the projects to get a better understanding of local geological and hydrogeological circumstances.
- Smart setting of the storage site is highly important from both subsurface as surface points of view. This applies to location specific limitations (buildings, protected areas, geological anomalies, etc.), to opportunities from heating grid point of view (end of distribution, temperature levels, sources and demand nearby, etc.) and to legal challenges (ownership and legal framework).

2 Azores case study – Caldeiras da Ribeira Grande area

- ***Previous highlights***

Sparse geochemical data (soil CO_2 flux data, gas analyses from fumaroles, soil temperature) exist for the studied site, but these have never been integrated and used to formulate a model supporting future geothermal drilling/exploitation in the area. This site (Caldeiras da Ribeira Grande area) is located on the northern flank of Fogo Volcano, where the local geothermal enterprise already drilled some wells, which are not under production due to several operational issues and to the fact that a refinement of the modelling in the area is strongly required.

- ***Current status***

Gas analyses from the springs and fumaroles allowed to apply several geothermometers (e.g., Sr/K^2, quartz, H_2/Ar, H_2S/Ar) that show feeding temperatures in the reservoir up to 260 °C; detailed soil radon (^{222}Rn) and soil carbon dioxide (CO_2) flux measurements showed values above the background for non-volcanic areas for these two gases. These results highlight the volcanic-hydrothermal origin of the gas emissions, which seem to be controlled by tectonic structures that do not show surface expression as they are probably covered by the thick pumice deposits existing in the area; soil temperature surveys, together with the soil CO_2 flux values and the gas analyses, also allowed to estimate the thermal energy of the area (approximately 30 MW). The first model of the area based on geochemical and geological data (acquired by the IVAR - University of the Azores) is ongoing in cooperation with the ETH Zurich). The simulation utilizes the ETH's CSMP++ computing platform and as first approach evaluates possible flow patterns based on the Digital Elevation Model and the Geology of the site.

- ***Foreseen challenges***

Future activities include the definition of the mineralogy of the rock samples from the cores obtained in one of the wells drilled in the area. The rock samples belong to the local geothermal enterprise, which only very recently released the authorization to IVAR researchers to use them for research purposes. The material will be delivered to the IVAR laboratories in November 2019. This information will be integrated with the other geochemical data and then included for the model implementation.
A detailed tectonic map of the area will be also produced through the interpretation of aero photos and satellite images and possibly corroborated by field surveys.

3 Danish case study

- ***Previous highlights***

Denmark currently has six HT-UTES in operation, one BTES and five PTES and an initial screening for identification of areas with a potential for UTES based on available existing subsurface data and heating/energy infrastructure data has been carried out in the national project "EUDP, 1887-0017, Evaluation of the potential for geological heat storage in Denmark".

Experience from the Danish UTES systems, which are all shallow applications, has, together with other international experience, contributed to a description of lessons learned so far with UTES. For deeper UTES applications current experience from geothermal heat production in Denmark has been used to describe tools and workflows for simulating subsurface dynamics to be used for HT-ATES scenarios.

Approx. 400 local district heating companies/heat producers have been invited to participate to a survey of specific interests for UTES and about 80 of them have responded. A first yearly national knowledge sharing workshop for stakeholders has been conducted to support the development of UTES in Denmark.

- ***Current status***

The characteristics of selected Danish district heating networks with UTES have been described together with a review of the applied business models as well as the planned/actual monitoring activities.

A description of the national screening of the potential for UTES in Denmark is currently being produced for further use in the HEATSTORE project.

Based on the initial screening and the survey of specific interests for UTES that has been conducted, more detailed characterization of the subsurface conditions will be carried out in selected areas. The activities will include: detailed characterization of the subsurface conditions based on existing data and 3D geological modelling in specific areas of interest.

- ***Foreseen challenges***

New codes and modelling workflows for modelling subsurface dynamics for deep HT-ATES developed in HEATSTORE will be tested on a selected Danish case based on existing information from geothermal heat production.
Models and tools for system integration and optimization as well as business case models developed in HEATSTORE will be also tested on Danish district heating networks with existing or planned UTES systems.
GIS maps of the technical future potential for UTES in Denmark will be updated with a more detailed characterization of selected areas based on the survey of specific interests.

4 Iceland seasonal injection case study – Reykir geothermal system

- ***General info***

The water for the district heating system in Reykjavík and its neighbouring communities comes from two different sources. On one hand there is heated cold groundwater produced along base load electricity production in the Hengill area and on the other hand there is geothermal water from low temperature fields in the city´s vicinity. There is seasonal excess of the previous but shortage of the latter. These waters are kept separate in the distribution system due to precipitation risk from mixing the two that have different chemical composition. In search of better ways to use the resource, the idea of possibly injecting the seasonal excess water from the Hengill area into a low temperature system came up. This would mean storing the heat underground for later usage. Modelling the effect of such injection is the subject of this study within HEATSTORE.

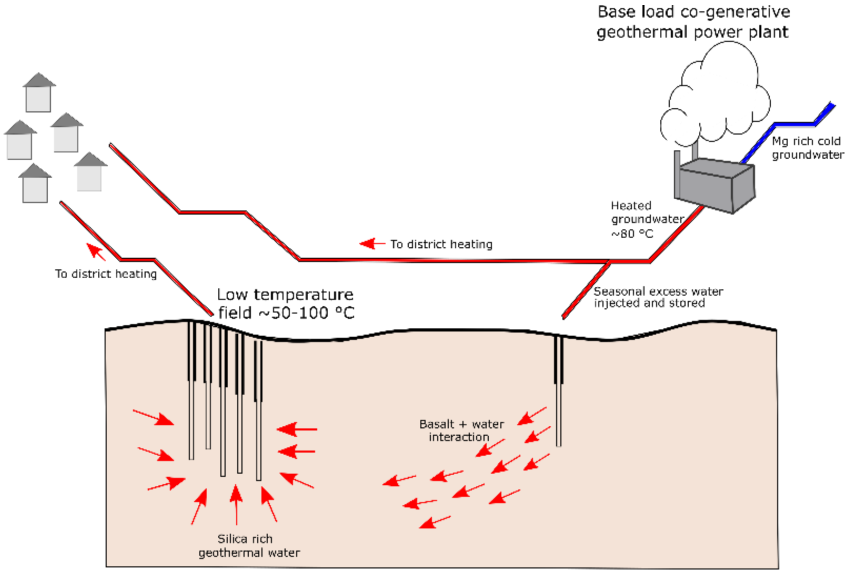

Figure 1. Schematic for seasonal injection of excess heat from the Hengill area.

- ***Current status***

A flow model of the Reykir/Reykjahlíð low temperature system has been developed within this study. The simulator TOUGH2 is used. The model has been calibrated against formation temperature profiles and production history – i.e. pressure draw-down and temperature of produced fluid. Calibration of the model to available data shows that the system is very permeable. From current calibration runs, the horizontal permeability values for the geothermal system rock types range from $5 \cdot 10^{-13}$ to $1 \cdot 10^{-12}$ m^2 and the vertical permeability from $3 \cdot 10^{-14}$ to $7 \cdot 10^{-14}$ m^2. With a functional numerical model, different production and injection scenarios are being simulated. These for example include injection at the system periphery while maintaining normal summer production (Fig. 2), injection at the system periphery with decreased summer production in Reykir and injection into the center of the system with decreased summer production in Reykir.

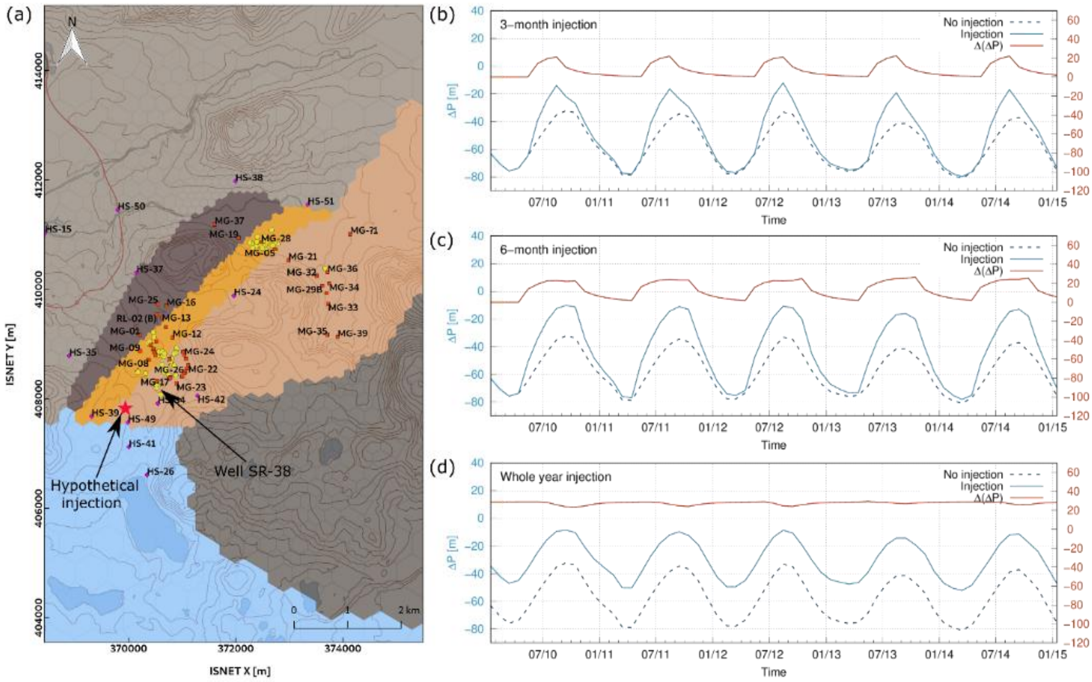

Figure 2. (a) The location of one hypothetical injection location and the location of monitoring well SR-38, different colors represent different model rock types, (b-d) Comparison between simulated draw-down when no injection takes place (dashed line) and when injection takes place (solid blue line) and the difference between the two (orange line). (b) is for three month long seasonal injection, (c) is for six month long seasonal injection and (d) is for constant injection (Tómasdóttir et al., 2020).

- ***Next steps***

The results from these simulations will give indications of flow regimes that can be used to build smaller scale models including chemical reactions to explore the effects of mixing of the two water types in the subsurface. This is the next step along with further injection scenario simulations.

References:

Tómasdóttir, S., Gunnarsson, G. and Aradóttir E.S.P, 2020. *Possible seasonal injection of surplus hot water from the Hengill Adrea into a low temperature system within Iceland´s capital area.* World Geothermal Congress 2020. Reykjavik, Iceland: Submitted for publication.

5 Iceland superhot case study – Hengill geothermal area

- **General info**

Heat sources in high temperature geothermal systems (<200 °C at 1 km) and their vicinity are still to some degree an enigma. In recent years, work has been ongoing to drill deeper into existing production fields in Iceland in order to increase the exploitable part of the resource downwards and to reach formations at higher temperature where conditions might be supercritical. Drilling of such a deep well (< 4km) is planned in the Hengill area within the next few years. To this day, most wells in the Hengill area are drilled down to approximately 2.5 km. The current field scale simulation model only reaches that depth and cannot handle supercritical conditions. It is critical to develop modeling tools to simulate deep conditions and proximity to heat sources before the drilling of this well commences. The Hengill case study within HEATSTORE aims to use academic research codes developed at ETHZ to develop a state-of-the-art process model of conditions at greater depths and subsequently incorporate the results from that model into the industrial field scale model of the area. Furthermore, the project seeks to model different production or injection scenarios for the deep well.

- **Current status**

The TOUGH2 field scale model of the Hengill area has been recalibrated with new data and revised to better represent the permeability structure of the system. Existing data on temperature distribution, pressure conditions, well paths, surface features, volcanic fissures etc. has been collected and reviewed with Thomas Driesner and Benoit Lamy-Chappuis at ETHZ to increase the understanding of possible heat sources and to set up scenarios to model. Following that, Benoit constructed a preliminary model that reached an 8 km depth with uniform permeability and performed simulations with and without intrusions. This was done to identify what kind of thermal structures would evolve with time and whether they would be similar to the pattern seen at Hengill (Fig. 3a). Following those models, the setup was changed to be able to include the permeability structure in Hengill as well as intrusions (Fig. 3b-c). The current plan is to simulate different emplacement scenarios in that model; different shapes, sizes, depths and emplacement times to try to reproduce the temperature field data observed in Hengill.

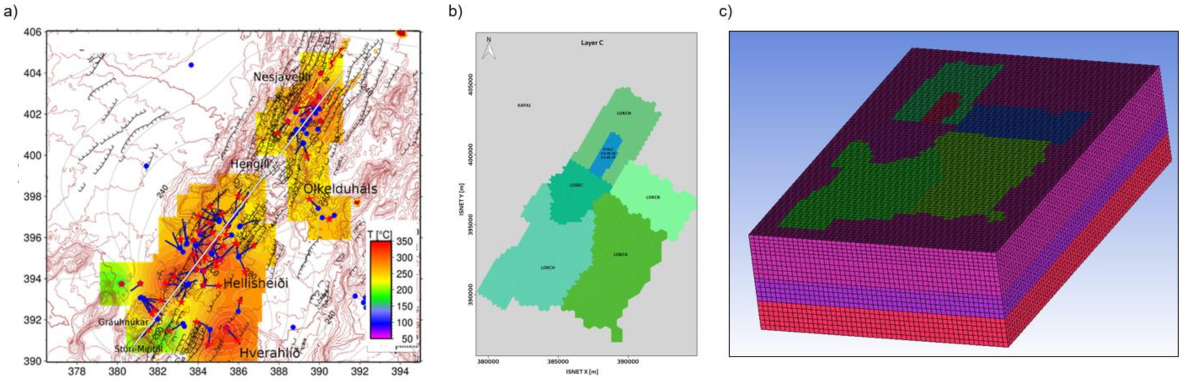

Figure 3 a) Formation temperature in the Hengill Area at 1000 m b.s.l., b) snapshot of rocktypes in the field scale TOUGH2 model at 100 m b.s.l., c) snapshop of the CSMP++ mesh.

- **Next steps**

In the later phases of the project we will explore how the CSMP++-based results from those simulations can be implemented in the TOUGH2-based current model. A variety of approaches are possible that need to be evaluated as the first results are obtained. Currently the most plausible version is based on the idea that CSMP++ based-models naturally generate "correct" flow and thermal patterns that are mainly a function of the permeability distribution. If we succeed to obtain in this way a virtual geothermal field with the main characteristics of the Hengill system, then slices can be cut through that model that allow deriving boundary conditions that can later be used in the TOUGH2 model.

6 The Netherlands: HT-ATES case study at NIOO

NIOO is the Netherlands Institute of Ecology, based in Wageningen. The buildings and facilities at this research institute are designed based on the 'cradle-to-cradle' principle. This has resulted in a number of facilities that help closing the water-, waste- and energy cycles. The High Temperature (HT) ATES system that stores heat at 45 ºC is one of these systems. Below, an update on the HT-ATES system of NIOO is provided.

- ***Previous highlights***
  - The HT-ATES system was realized in 2010 and is still operational.
  - Consistent monitoring in and around the HT-ATES system has resulted in a unique, extensive (nine-year) series of temperature and groundwater composition data. The monitoring activities were performed in accordance with the pre-defined monitoring plan.
  - In 2018 – 2019 additional monitoring activities were carried out within the HEATSTORE case study project.

- ***Current Status***
  - The available data is collected and the evaluation of this case study within the HEATSTORE research program is in progress.
  - The data allows for interpretation on the physical, chemical and microbiological processes that play in and around the HT-ATES system, in the (relatively deep, saline and anoxic) subsurface.
  - No water treatment was applied during operation
  - The system does not perform conform design. The solar collectors deliver insufficient power to charge the hot well with the aimed amount of heat. Also, no detailed insight in the subsurface at depth of the HT-ATES system (200 – 300 mbgs) was present in 2010 (no test drilling was performed). The bulk of the water is produced from the top part of the well filters, as these are located in a different (more permeable) formation than the deeper part of the filters. The absence of a solid confining (e.g. clay) layer allows part of the injected heat to move upward. This, together with the smaller than expected storage volume, results in low storage efficiencies.
  - NIOO plans to add more solar collectors in order to increase heat supply to the HT-ATES.
  - NIOO, together with IF Technology, organized sessions with the authority (Province of Gelderland) to decrease the obligations and regulations taken up in the permit.

- ***Foreseen challenges***
  - NIOO would like to change the permit, because many (costly) parameters are obligatorily measured even though not all of them are useful in interpreting risks or subsurface processes. Provinces are reservedly in this, because in-depth knowledge and understanding of the processes playing in the subsurface is at the basis of a permit change.
  - Net water was pumped from the cold to the hot well. The resulting upward displacement of the fresh-brackish groundwater interface (150 mg Cl-/l) at the hot well may, over time, cause implications for the HT-ATES system, because in the regulations this displacement is limited to a defined depth. Exceeding this regulation does not pose any threats for nearby stakeholders, but contact with the authorities is advised.
  - The absence of a clear confining layer will expectedly suppress the increase in storage efficiency over time.

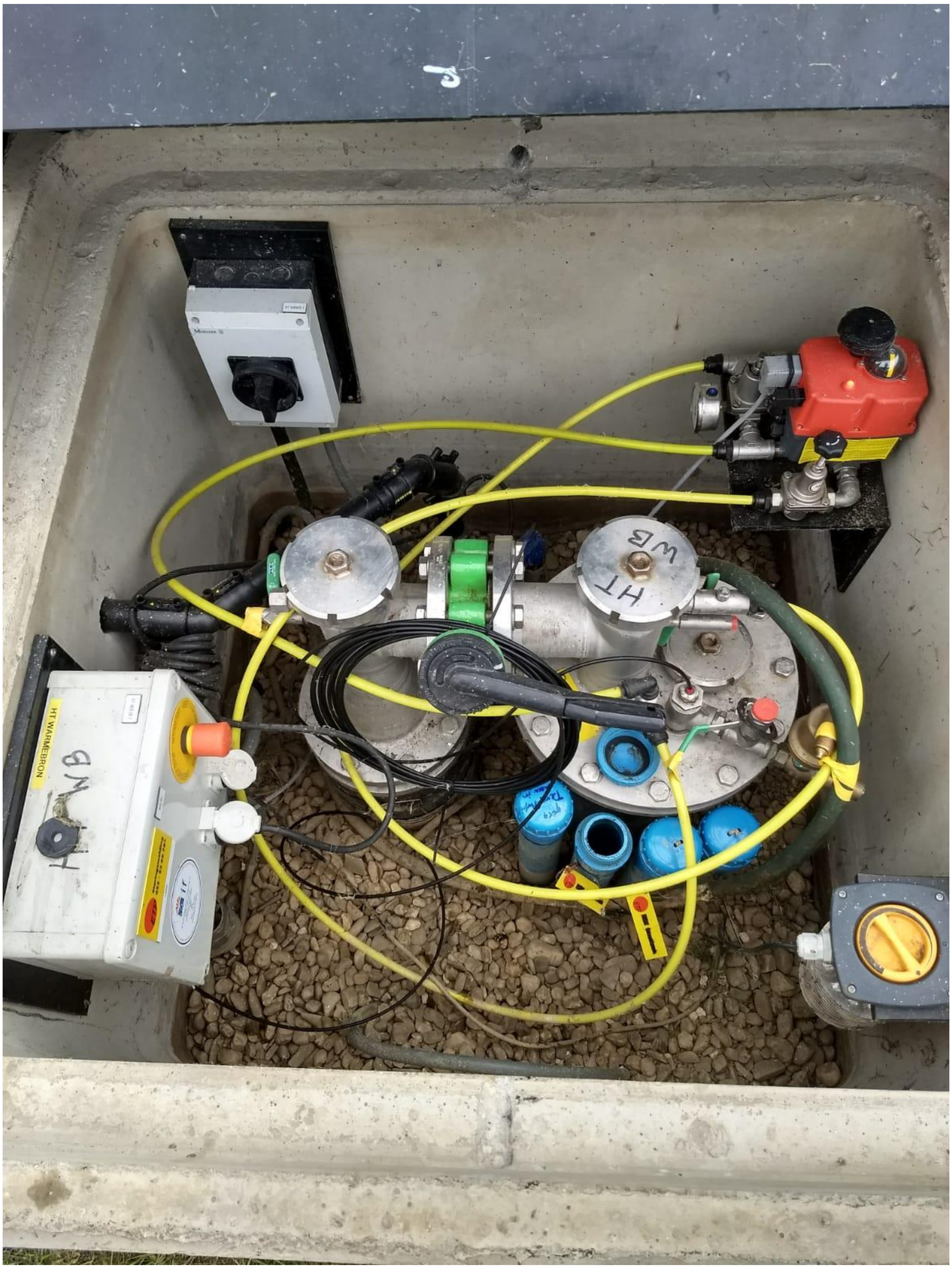

Figure 4: Picture of the hot well. The 4 sampling wells (blue) are installed in the gravelpack and allow for temperature and groundwater composition monitoring at several depths along the well.

7 The Netherlands - HT-ATES case study at Koppert-Cress

Koppert-Cress is a horticulture company situated in the western part of the Netherlands. To provide sustainable heating and cooling, an ATES system was installed with 4 warm and 4 cold wells with filters in two aquifers up to ±170m depth (Figure 5). As part of a Dutch research project the normal ATES was converted to a HT-ATES pilot (Bloemendal et al., 2019). For research purposes one of the warm wells is intensively monitored.

- ***Previous Highlights***
  - Upgrade ATES to HT-ATES (infiltration temperatures from 25°C up to 45 °C)
  - Installation of 2 (shallow) Distributed Temperature Sensor (DTS) monitoring locations
  - Sampling of groundwater quality

- ***Current status***
  - In September 2019 work was done[1] to improve the monitoring system that is in place at the ATES system of Koppert-Cress. Two new (deep) DTS locations and a monitoring well (to extract heated groundwater) close to the injection well were drilled (Figure 5**Error! Reference source not found.**). This is operational since the end of September. Currently a model is being developed to simulate the distribution of the stored heat.

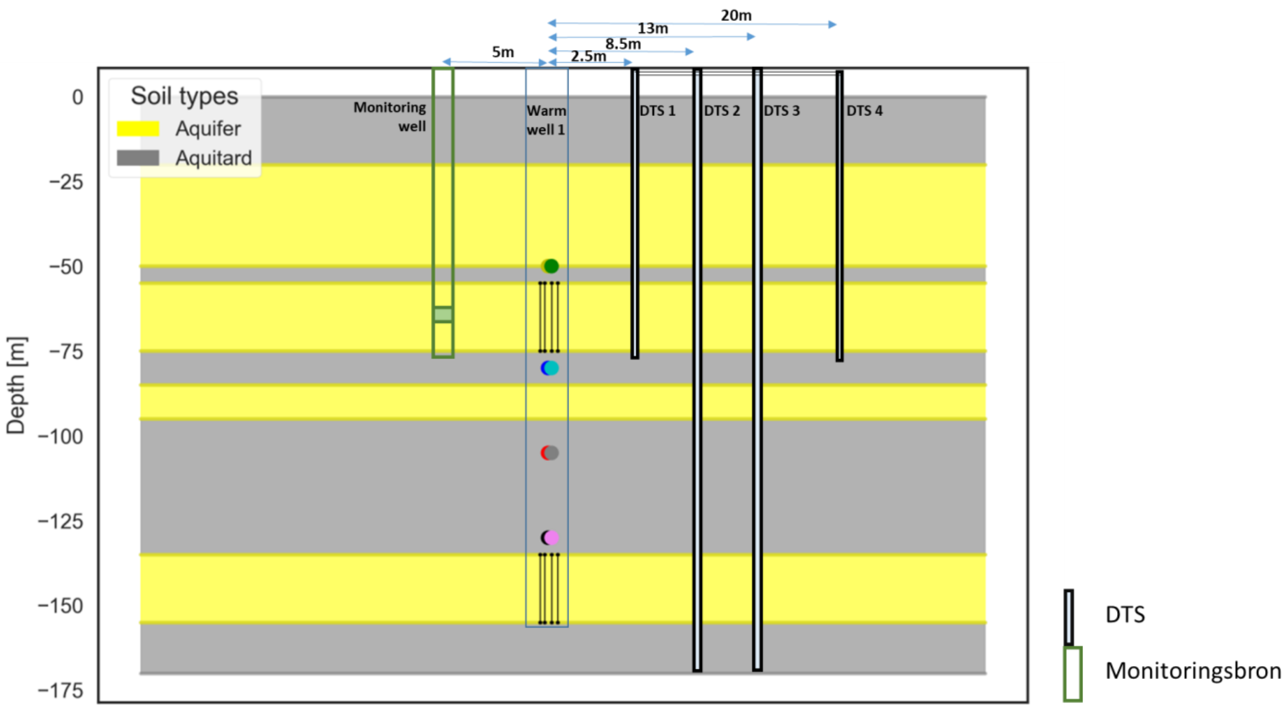

Figure 5: Current monitoring approach at warm well 1 – Koppert-Cress, September 2019.

- ***Foreseen challenges***
  - Measuring the water quality of the stored ground water; take sample at the right moment to sample affected groundwater and measure changes in water quality
  - establish a model and use the heat distribution measured with the DTS to calibrate the model.

[1] More info: https://www.kwrwater.nl/actueel/monitoring-of-the-aquifer-thermal-energy-storage-system-at-koppert-cress/

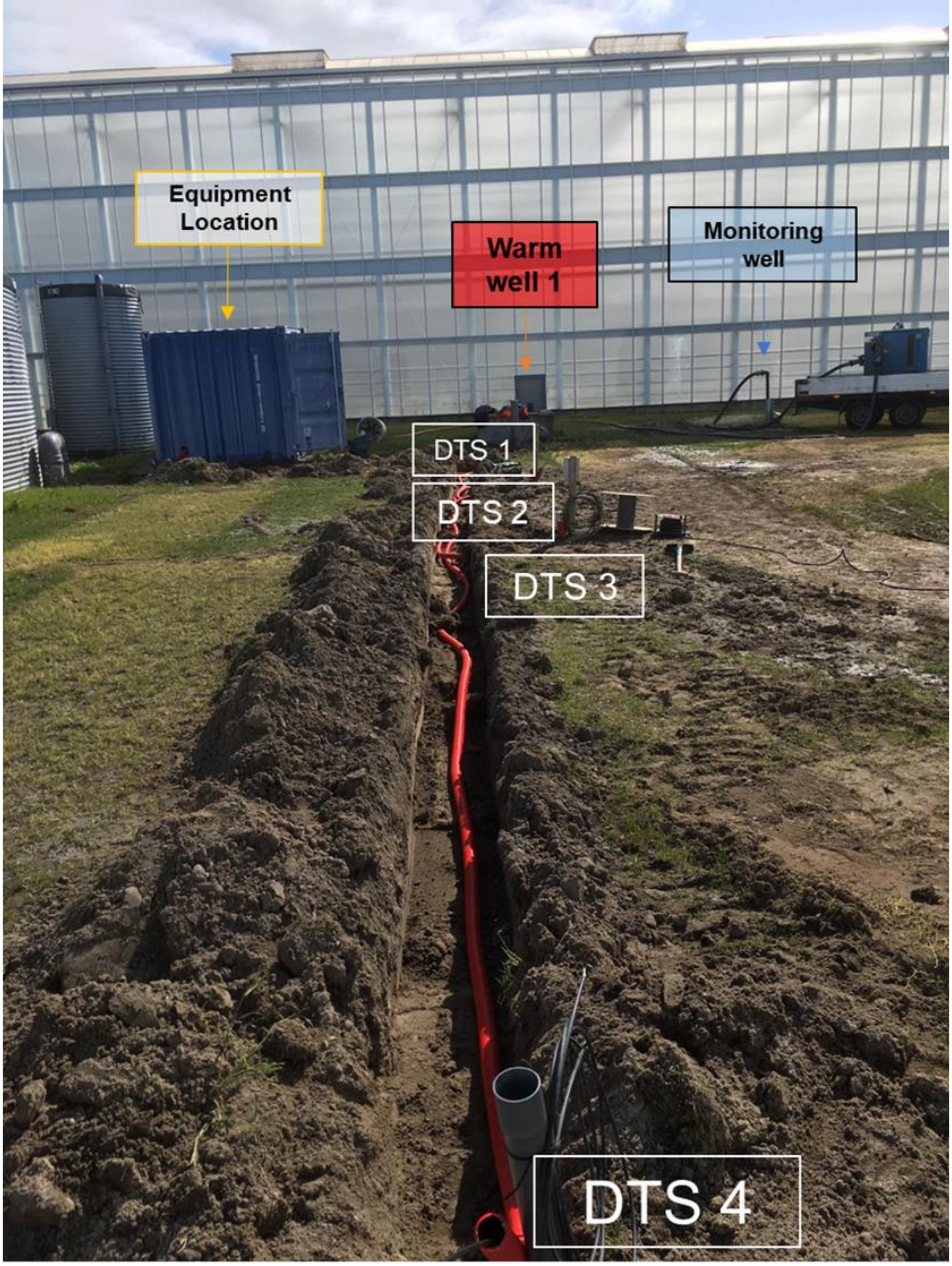

Figure 6: Overview of the monitoring facilities around 'warm well 1'. New locations (Sept 2019) are: DTS 2 (deep), DTS 3 (deep) and the monitoring well. (When compared to figure 4, the viewpoint is from right to left).

References:

Bloemendal, M., Beernink, S., Hartog, N., & Van Meurs, B. (2019). Transforming ATES to HT-ATES. Insights from Dutch pilot project. Paper presented at the European Geothermal Congress EGC, Den Haag.

8 Switzerland – Geneva pilot site

- ***Previous highlights***
  - The Geneva subsurface has been investigated in the past via geophysical surveys (2D seismic and gravity) and 2 deep wells (Humilly 2 and Thonex-01) have been drilled in the 70s and 90s for hydrocarbon and geothermal exploration. However, the data available were too scarce and limited to define the underground heat storage potential in the Geneva area.
  - Very few groundwater geochemical data were available over the whole Geneva basin and thermal properties of the reservoir rocks were available only from literature data.
  - A regional 3D static model from GEOMOL project was available but the resolution was inadequate for the goal of this project
  - No petrophysical and dynamic reservoir models were available
  - Geomechanical characterization of reservoir units was not investigated
  - Site selection, design and permitting of small scale analog has been done by UniNe
  - No energy system scenario including seasonal and deep heat storage was developed
  - The Swiss legal framework was vague in terms of deep subsurface valorization for geothermal developments
  - No business model was developed for heat storage projects

- ***Current status***
  - Data from the GEo-01 well, which was drilled by SIG in 2018 in the framework of the Geothermie 2020 program for geothermal exploration, are now used to better constrain fault architecture, rock typing, petrophysical conditions in the study area.
  - Production tests at GEo-01 will be operated by SIG and will start in Q4 2019
  - Geochemical sampling over the Geneva area has been carried out by UniGe in Q4 2018 and data are now under interpretation
  - Mineralogical and petrographic characterization of GEo-01 cuttings were performed by UniGe
  - Petrophysical characterization of GEo-01 cuttings has been performed by UniGe
  - 3D Static model at GEo-01 has been developed aby UniGe and provided to ETHZ
  - Geomechanical characterization of GE-01 has been performed by UniNe
  - Rock samples have been delivered to UniBe for water/rock interactions laboratory experiments
  - Preliminary TH modelling at GEo-01 has been performed by ETHZ
  - Preliminary THM modelling at GEo-01 has been performed by ETHZ
  - GEo-02 well drilling pad is ready
  - Preliminary Energy System Integration scenarios at local scale were defined by UniGE and SIG
  - Business modelling workflow has been defined by SIG and UniGe

- ***Foreseen challenges***
  - Drone topographic surveys are planned to be executed by UniGe and SIG during pumping tests at GEo-01 to monitor ground deformations
  - GEo-02 drilling operations will start in Q4 2019
  - The workflow for subsurface characterization developed for GEo-01 will be applied to GEo-02
  - Drilling shallow wells to perform injection tests in analogue conditions to GEo-01 and GEo-02 wells are expected to be performed by UniNe in Q4 2019-Q1 2020
  - Detailed TH modelling will be performed by ETHZ
  - Detailed THM modelling will be performed by ETHZ
  - Water-rock interactions laboratory experiments will be performed y UniBe
  - THC modelling will be performed by UniBe
  - Validation of scenarios and after TH, THM, THC models results and geo-localisation integration studies.
  - Energy system scenarios at GEo-02 will be defined by UniGe and SIG
  - Business modelling workflow defined for GEo-01 will be adapted and applied to GEo-02
  - The results will help providing solutions to improve the current Swiss legal framework

9 Switzerland – Bern pilot site

- ***Previous highlights***
  - Phase 0 (pre-drilling): done
  - Phase 1A (minimal scope of work): delayed by 18 months
  - Phase 1B (optional for heatstore): delayed by 18 months
  - Lab testing: ongoing, on track
  - Permitting (completed in Nov 2018) and funding (completed in May 2019) took longer than expected, public tendering will start in Nov 2019.

- ***Current status***
  - Planned drilling Phase 1A is scheduled for July 2020
  - Phase 1B has been labeled only "optional" in the Geothermica Heatstore proposal. This part will be completed only after the end of the Heatstore project.

- ***Foreseen challenges***
  - No operational phase has been scheduled for Geothermica Heatstore

10 The Netherlands: pilot project at ECW site Middenmeer

- ***General description of the Dutch HT-ATES demonstration***
  - Geothermal heat stored in summer and to be used in winter
  - HT-ATES results in higher redundancy of heat supply in winter
  - Continues and constant production of the geothermal wells in summer is highly preferred because of technical reasons
  - One Geothermal doublet generates ca. 15 MWth.
  - Goal of this project: one HT-ATES generates 5 MWth extra

- ***Previous highlights (as in project plan)***
  - Water treatment: Within the agricultural business there is a supply chain for CO2 available. In theory it is possible to use CO2 for water treatment, instead of the more common hydrochloric acid. One of the goals is to have a more in depth theoretical research on water treatment with CO2 and to monitor the results of the application of CO2 injection.
  - Material selection: ATES has a different technical characterization from geothermal well. So instead of using the same materials as for the geothermal well, it might be possible to identify cost reducing materials for making the wells and pipes. Pump selection: Past experience shows that pump selection is an important aspect. Attention will be made to select the right pump to increase lifetime, while keeping total cost of ownership as low as possible.
  - Storage efficiency: Groundwater models can predict the storage efficiency. Do they predict this right? By monitoring the ATES system the storage efficiency models can be verified to a better use in future projects.
  - Insulation of well: Does insulation of the ATES wells help prevent environmental impact. And does it also contribute to storage efficiency?

- ***Current status***
  - It is still a valid option to use CO2. TNO is performing lab test with the soil and the groundwater. Results are expected soon.
  - Final design is still to be made, the idea has not changed yet. We will try to make this an ATES as much as possible. When needed we will select other materials
  - Based on the test well (Figure 7) the design and the models will be adjusted to calculate the new expected storage efficiency and optimize its performance. A monitoring program has been designed.
  - It seems that insulation will not really upgrade the storage efficiency. In the final design decision will be made.

- ***Foreseen challenges***
  - The timeline is getting critical, we aim for installing in April and operating in May/June 2020.
  - As a result of the test well we will make changes to the final design of the HT-ATES wells. This also means we have to make changes to the permit.
  - Costs are higher than in the project plan.

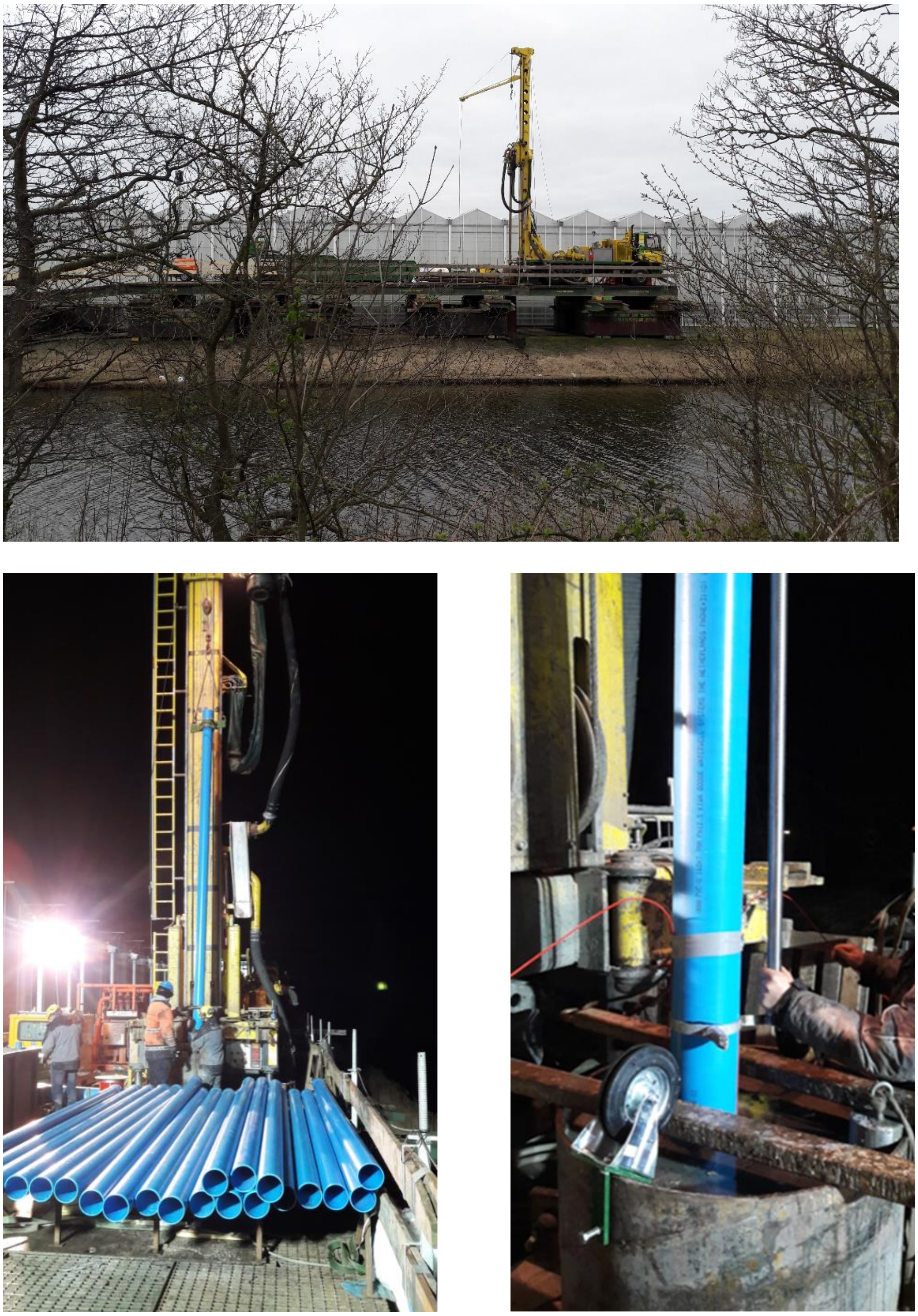

Figure 7: Drilling the test well at the Dutch demonstration site.

11 Belgium pilot site

- ***Previous highlights***

The district heating system at the VITO and SCK site in Mol (Belgium) was connected to the new geothermal power plant in 2018. Geothermal heat will be used as the base heat source for heating the office buildings, lab infrastructure and sport facilities. In addition, the renovated residential area in the north of the VITO site will also be connected to the district heating system in 2021, building renovation works already started in 2019. Located at a distance of approximately 5 kilometers to the east, the European school and European Commission's Joint Research Centre are two interesting additional clusters for connecting to the district heating system since they have a high heat density and are currently heated by fossil fuels (natural gas). This potential thermal network expansion is currently being investigated further by KWB and SPIE.

Figure 8: Rendering of the renovated residential area

The current operational strategy of the district heating system however is not optimized for integrating geothermal heat. First, in order to maximize the share of renewable heat from the geothermal power plant, thermal energy storage is needed. Second, the current return temperature of the district heating system is relatively high and should be reduced to maximize the thermal output from the geothermal wells and to increase overall efficiency of the thermal network. This will be achieved by implementing a smart self-learning controller (STORM-controller) which optimizes the heat load of the buildings in favor of the renewable heat sources that provide heat to the thermal network.

- ***Current status***

The controller was implemented in the summer of 2019, it controls 5 buildings with a combined peak heat load of approximately 2MW (+/- 15% of the total peak heat load). The system is online since the beginning of September 2019. Next, response tests were performed in these buildings to verify whether the control-actions have the desired impact on the building's HVAC systems. As soon as there is enough monitoring data available and the heat load forecasting is accurate, the system will operate autonomously.

Figure 9: On-line data monitoring platform

- ***Foreseen challenges***

The STORM controller provides a lot of detailed monitoring data on the operational behavior of the buildings HVAC system and the district heating system in general. It can therefore reveal many suboptimal settings, failures and even design faults in the system that were not recognized or identified before. In order to achieve significant gains in terms of system efficiency, reduction of the return temperature and heat source optimization it is possible that additional actions have to be taken e.g.:

- Replacing hardware (actuators, pumps, …)
- Adapting the BMS settings
- Changes in the HVAC systems (piping, valves, …)

The first weeks of testing already revealed malfunctioning hardware in one of the building substations. This also limits the impact of the STORM controller in that building. Due to the age and the conditions of the hardware, the building substation will be completely renovated after next heating season. Therefore, the malfunctioning hardware will not be replaced in the short-term.

12 German pilot site

- ***Previous highlights***
  - Numerical modelling of thermal energy storage within the small coal mine.
  - Setting up monitoring system within seven groundwater monitoring wells.

- ***Current status***
  - Setting up liability agreement with previous mine owner.
  - Tendering of CSP plant.
  - Design set up of the surface part of the pilot plant within the framework of the GZB drilling site (Figure 10).

- ***Foreseen challenges***
  - Implementation of exploration wells into the mine layout.
  - Performing pump test and confirming storativity values.
  - Setting up license agreement with previous mine owner.

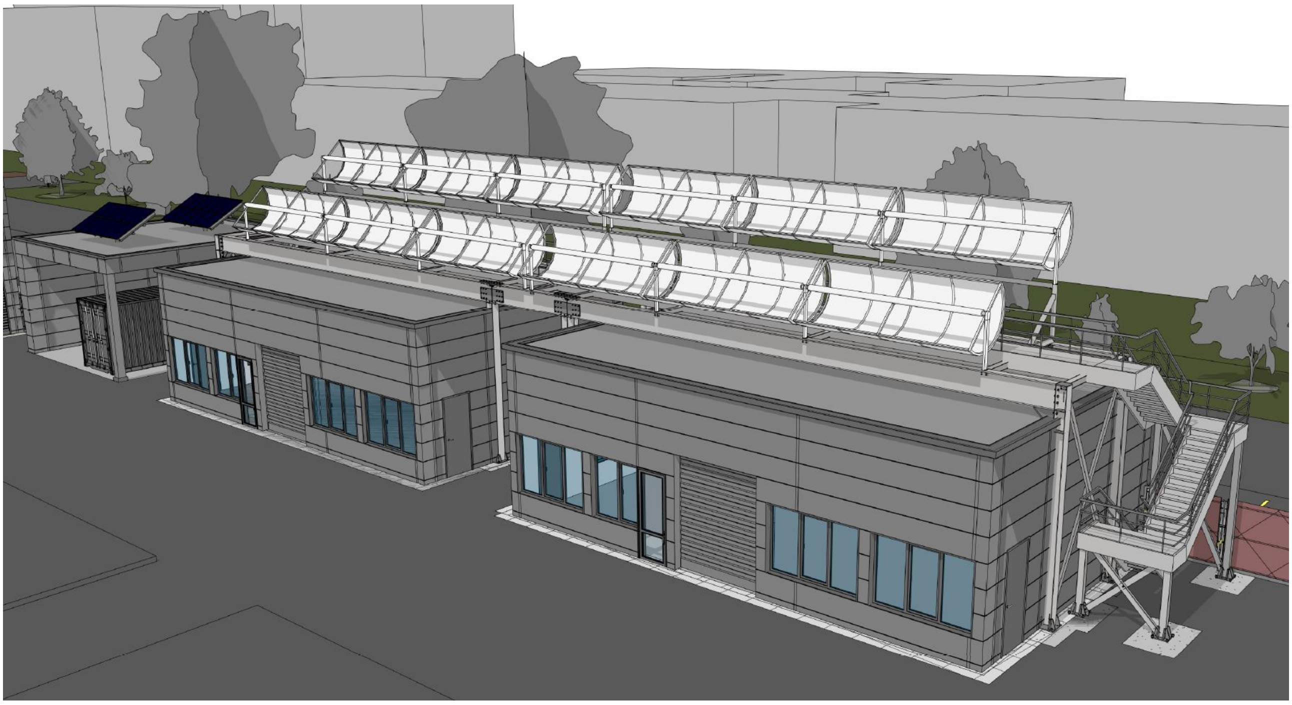

Figure 10: CSP set up at GZB site.

13 French pilot site

Despite all efforts to maintain the costs of BTESmart to a reasonable level, it appears that they are significantly higher than the initial budget. Indeed the BTESmart project at Chemery, due to its location within a gas storage site, felt under the COMAH (Seveso) regulations. It induces significant additional costs and operational constraints to the project compared to similar BTES projects.
Therefore, the management of partner Storengy decided to withdraw the planned BTESmart demonstration project at Chemery from the HEATSTORE project.

Alternative locations are currently assessed in order to implement the BTESmart technology. Despite best all efforts, this new site will not be ready within the timeframe of Heatstore project.