WP4

MID-TERM REVIEW REPORT HEATSTORE

ERANET cofund GEOTHERMICA project n. 731117

10 December 2019

HEATSTORE (170153-4401) is one of nine projects under the GEOTHERMICA – ERA NET Cofund aiming 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.

Mid-term review report

1. Identification of the project and report

Project title	High Temperature Underground Thermal energy Storage
Project ID	731117
Coordinator	TNO – Dr. Holger Cremer
Project website	www.heatstore.eu
Reporting period	M1-18 – 1 May 2018 – 31 October 2019

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2. Short description of activities and intermediate results

General progress of activities and results achieved

HEATSTORE is generally carried out according to the proposed work plan. A compact activity description per work package is found below. However, the project has to consider one serious drawback: in October 2019 the consortium was informed by partner Storengy that the demonstration of a Borehole Thermal Exchanger Heat Storage (BTES Smart) project at Chemery (France) cannot be realized; see chapter 3 below for more information on the reasons and consequences.

HEATSTORE achieved high visibility in the scientific community and the energy storage sector by its media performance and topical contributions on several scientific and sector conferences and workshops (see chapter 6).

WP 1 Specifications and characterization for UTES concepts (Lead: GEUS – Thomas VANGKILDE-PEDERSEN)

The objective of WP1 is to provide general design considerations and recommendations for UTES technologies (ATES, BTES, PTES, MTES) under different geological settings, heating demands and heat sources as well as to provide screening of the national sub-surface potential for UTES. Together with the results of WP 2, 3 and 5, this will feed into the demonstration projects in WP4 and the recommendations for market uptake in WP6.

The first WP1 activity has been a thorough analysis of existing UTES projects and collation of lessons learned based on a literature study of available international experience. Subsequently, the lessons learned have formed the basis for providing general specifications for ATES, BTES, PTES, MTES. The work was initiated prior to a common WP1/WP3 workshop in Bochum in Germany, November 2018.

The following deliverables were finalized within the first reporting period:

- D1.1 Analyses of existing UTES systems and lessons learned was finalized 28/4-2019 and the public report "Underground Thermal Energy Storage (UTES) – state-of-the-art, example cases and lessons learned" is available on the HEATSTORE website https://www.heatstore.eu/downloads.html
- D1.2 General specifications for UTES systems was finalized 20/9-2019 and the public report "Underground Thermal Energy Storage (UTES) – general specifications and design" is available on the HEATSTORE website https://www.heatstore.eu/downloads.html

The following milestones were passed within the first reporting period:

- M1.1 Collection of existing experience in participating countries
- M1.3 Workflow for fast-track re-processing of existing seismic data

In the second reporting period, the work in WP1 will focus on

- Screening of the national potential for UTES in selected countries with respect to subsurface geology and existing infrastructure feeding into WP6.1 looking at possibilities to include UTES in exiting energy networks in Europe
- Synthesizing the lessons learned and general specifications in D1.1 and D1.2 as well as the experience gained from the demonstration projects in WP4 in a set of best-practice guidelines for developing large scale UTES systems

WP 2 Tools and workflows for modeling the subsurface dynamics (Lead: ETHZ – Thomas DRIESNER)

WP2 focuses on numerical modelling of water flow, heat transfer, and interactions (thermal, mechanical, chemical) between the storage formation and water in the subsurface, which is a key method for planning, designing, and optimizing HT-UTES systems. It allows prediction of storage efficiency, operating conditions and potential problems as well as testing pre-drilling design scenarios to be used in decision making, dimensioning and assessing possible grid-integration.

However, there exists a plethora of modelling tools, workflows are often created on the fly by a single person, and documentation of procedures, assumptions and simplifications as well as of the actual model parameters often remains patchy at best. WP2 aims at keeping the advantages of a diversity of approaches but at the same time establishing best practices and demonstrating the value of employing well-documented workflows.

Accordingly, the four main objectives are:

- Establish modelling workflows and software tools as integral part of HT-UTES project development
- Transfer advanced academic/research codes to real world HT-UTES application.
- Demonstrate that such academic/research codes have potential to add significant value and innovation to geothermal plays beyond HT-UTES
- Increasing reliability and credibility of modelling workflows as an integral and crucial technology for project development by benchmarking and enable further validation with real data.

These objectives are approached by three tasks and WP2 has put significant efforts into designing coherent paths for the work to be executed in all of these as detailed in the following subsections.

Task 2.1 Modelling toolsets and workflows for optimal and efficient HT-UTES of different types

Task 2.1 is set out as a comprehensive umbrella task in which the individual partners develop and apply their choices of workflows and software to the respective demonstration sites (UniGE, ETHZ , UniNE & UniBE for Geneva, UniBE & UPC for Bern, KWR/TNO for NL, VITO for B, DH for D, GEUS for DK, IVAR & ETHZ for Azores, OR & ETHZ for Iceland). An obvious advantage is that this allows testing and comparing a broad variety of approaches on a diversity of HT-UTES concepts.

In order to facilitate the development of reproducible and well-documented workflows we defined the only deliverable D2.1 as a comprehensive "Report on tested and validated tools and workflows for different types of HT-UTES, with input from WP5 on validation (Month 6: interim/Month 35: final)" with the interim version accomplished in late spring 2019 and built on a fruitful exchange during a full-day WP2 meeting in April 2019 in Geneva.

For D2.1 we defined a detailed and standardized template for the individual chapters, each addressing modelling for one demo site. Different approaches may apply to each site (e.g., for thermo-hydraulic vs. thermo-hydraulic-mechanical or thermo-hydraulic-chemical aspects) and are collected in the respective chapter. The template has been laid out such that the complete workflow from description of the HT-UTES type, through the conceptualization for numerical modelling, pre-processing (e.g., computational mesh generation), model set-up, computational approach and software, to model and result analysis is covered and follows the same structure for each site.

All partners provided high-quality inputs to D2.1 that will then be updated towards the end of HEATSTORE. Our current vision is that by using this template approach and having a high-quality first version already in place, updating it with results and analysis near the end of the project can efficiently be achieved and the individual chapter be submitted as manuscripts to a special issue of a peer-reviewed journal such that the results of Task 2.1 receive widest reception and visibility in the community.

D2.1 also documents the progress of each partner in late spring 2019. Afterwards, modelling work has largely progressed according to plan; we here refrain from a review of the individual achievements since then in order to keep the respective space limitations.

Task 2.2: Integrating advanced academic simulation codes into diverse geothermal project development workflows

As laid out in the document of work some of the HEATSTORE demo sites encounter complex geologic situations or require environmental impact assessments (e.g. surface uplift due to poro- and thermo-elastic effects when injecting into the urban subsurface) that cannot routinely be dealt with when applying commercial software. Task 2.2 deals with bringing a number of academic / research code platforms that do not have these limitations to application in real-world HT-UTES projects. Some of the most advanced of these are of European origin (whereas most commercial ones are not).

The main demo sites for this have been the two Swiss sites (with CSMP++/Nexus and MOOSE frameworks being employed by ETHZ at Geneva, and CODE_BRIGHT/Retraso by UPC and PFLOTRAN by UniBE at Berne), one Dutch site (KWR using SEAWAT at Koppert-Cress) as well as two non-HT-UTES projects to demonstrate the value of using such advanced modelling approaches in geothermal plays beyond HT-UTES (ETHZ applying CSMP++ to modelling for medium to high enthalpy resource characterization with sparse data on the Azores and for pre-drilling project development for a superhigh temperature resource in Iceland.

Analogous to D2.1 we defined a report on "UTES-type-/site-specific simulators based on academic/research codes (Month 18: interim/ Month 35: final)" as deliverable D2.2 with a template that allows reproducible documentation of the adapted simulation codes to the individual demo sites. D2.2 has been completed in time and is in the final stages of fine-polishing as of the writing of this report.

Work progress has been very significant and a large number of non-standard simulations have performed to assess site-specific problems that cannot routinely be dealt with commercial, industry-standard software:

- Geneva site: ETHZ performed comprehensive sensitivity study (several hundred simulations with thermo-hydraulic processes only) on how geologic and design parameters relevant to the project (inclination of aquifers, thickness, permeability, presence of fractures, well layout …) affect the possible performance of heat storage in the Geneva underground. The computationally much more challenging possible poro- and thermo-elastic uplift effects were studied for some key scenarios.

- Bern site: UniBE and UPC provided first scenarios of how chemical reactions in the targeted aquifers may lead to mineral precipitation. UPC also performed first models of thermo-hydro-mechanical impacts.
- Koppert-Kress, NL: KWR performed a series of operation scenario simulations for the Koppert-Cress demo site, including the effects of ambient groundwater flow and temperature-dependent viscosity and density.
- Azores: no advanced simulations have been performed so far but ETHZ and IVAR have developed the conceptual model to be studied. A few simplistic reconnaissance simulations showed that the intended approach of simulating the full geothermal system under Fogo Volcano may indeed add significant value to understanding the size and character of the resource, which currently modelled with an industry-standard model that comprises only the drilled extent of the field.
- Iceland: ETHZ and OR have succeeded in performing the first-ever 3D simulations of a high-geothermal filed with magmatic heat sources explicitly included. The model is currently refined for the purpose of aiding in selection of the best site for the upcoming IDDP-3 well.

Task 2.3: Benchmarking, and improving models of subsurface heat storage dynamics

While the HT-UTES concepts in HEATSTORE are very diverse and the applied workflows and softwares are as well, the underlying physics of water flow, heat transfer, poro- and thermo-elasticity and chemical reactions between water and rock formation are very similar. We therefore proposed to use the chance of this large consortium to perform benchmarking and validation of a selection of simulation codes on typical problems to be encountered in the context of HT-UTES.

We defined a series of benchmarks on thermo-hydraulic (TH), thermo-hydraulic-mechanical (THM) and thermo-hydraulic-chemical (THC) problems that are each inspired by HEATSTORE demo sites. The benchmark descriptions have been confirmed and refined by the respective partners, results are collected and shared on HEATSTORE's file sharing platform.

The deliverable D2.3 "Report on synthetic benchmarks and results" is due only in month 24 but several of the benchmark comparison tests have already been done and partially to largely completed. Good to very good agreement has been shown in the TH problems. The THC benchmarks showed reasonable to good agreement between UniBE and UPC while the exercise led to the discover of a bug in BRGM's simulation approach that is currently being fixed, attesting to the value of such a comparison exercise. THM results are in the process of being completed.

Conclusion and Outlook

WP2 is progressing largely to plan and, in hindsight, we feel that our initial definition of Tasks and Deliverables has been shown to work very well.

We see that having requested every participant to do report their workflows and software approaches in a common, comprehensive format will allow high-quality and reproducible documentation and assessment of the work performed. If we succeed to indeed convert the final version of D2.1 to a special issue of a journal, the experiences and developments made in WP2 will provide valuable outcomes that will serve a broader community after completion of the project.

<u>WP 3 Heating System integration and optimisation of design and operation (Lead: VITO – Koen ALLAERTS)</u>

WP3 aims to assess the performance of UTES systems, Demand Side Management (DSM) and other flexibility options in an integrated local heat network. The main objectives are to determine optimal design and operational strategies for the UTES systems and DSM, and to develop models for evaluating the impact of UTES and DSM on the profitability of geothermal heating networks.

The following deliverables were finalized within the first reporting period:

- D3.1 Minutes of the first workshop on design and system integration. This workshop was held at GZB in Bochum on 2018.11.23. The meeting minutes and presentations are available for all project partners on the SCIEBO drive.
- D3.2 Technical report on the characteristics of the heat demand and supply at the demonstration sites. This report was finalized on 2019.05.25 and gives an overview on the local conditions and the thermal characteristic of the different demonstrators. It's a confidential deliverable as it also contains more detailed design information.
- D3.4 Business models for the demonstration cases. This report was finalized on 2019.11.08. In this report the business models used at the demonstrators are described more in detail and the report also gives more background on specific investment and operational costs for the technologies considered in Heatstore as well as more general background on business models used at district heating systems where thermal energy storage is applied.

Remark: Due to unforeseen circumstances related to local geological conditions and excessive investment costs for certain equipment and works at the French demonstrator site (natural gas storage site), Storengy decided not to continue with the construction of the BTES system. Given the exceptional conditions Storengy decided not to share financial information as it is not representative for the rest of France.

<u>WP 4 Demonstrations and case studies: Detailed design and implementation in practice (Lead: International Geothermal Centre – Florian HAHN)</u>

The overall objective of WP4 is to develop demonstration projects on a European level focusing on innovative methods and technologies for investigation, design and implementation of heat storage facilities. The following activities and intermediate results are based on the D4.1 report. Due to the complexity and non-standard regulatory framework conditions of the proposed pilot sites, the majority of the demonstration projects face a delay compared to the original timeline. In order to quickly comprehend this circumstance, the following deviation table is included below.

Country	Status			Explanation of delay
Netherlands				Demonstration project at ECW site: test drilling done, results and data are currently evaluated and will lead to an updated design. In Dec. 2019, planned realization of the project is as follows: Q1/Q2 2020: drilling HTO source and set up technical installations; Q3 2020: first loading of heat; Q3 2020/Q1 2021: monitoring. Totally, a delay of c. 6-8 months.
France				The French demonstration project at the Chemery site cannot be realized, due to its location within a gas storage site and resulting significantly higher budget costs.
Switzerland (Geneva)				Permitting (completed in Nov 2018) and funding (completed in May 2019) took longer than expected, public tendering will start in Nov 2019.
Switzerland (Bern)				The delay with respect to the planned begin of operations is associated to long administrative activities which ended with the approval by the authorities in July 2019.
Germany				The demonstration project is delayed by several months, due to an extended setup of the liability agreement with the previous mine owner and the Fraunhofer legal department.
Belgium				The demonstration project is ready to start. Response tests at the different buildings already started in October.

The Netherlands

Previous activities

- 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?

Intermediate results

- 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 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, a decision will be made.

France

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, 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.

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 at the European level but the principle of a time extension at the national level to allow one year of monitoring has been agreed upon with the French national agency, the ADEME. The national conventions Storengy/ADEME and BRGM/Ademe will be updated once the new demo site location will be identified. As a consequence, there is no change of scope for the tasks impacted by the French demo site: Task 4.2, Task 5.2, Task 5.3 and Task 5.4. These tasks will be postponed at the French national level for the parts related to the French demo site.

Task 4.3 (The demonstrator synthesis and best practice guidelines for replication) remains unchanged in scope and in timing, the French team will contribute based on the experience acquired on the different demo sites, including France, even if the French demo site is not yet in exploitation: the feedback will be based on the design and construction phases.

Switzerland – Geneva

Previous activities

- 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 model was available
- No dynamic reservoir model was 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

Intermediate results

- 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 has been 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 have been defined by UniGE and SIG
- Business modelling workflow has been defined by SIG and UniGe

Switzerland – Bern

Previous activities

- 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.

Intermediate results

- 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.

Switzerland - Concise

In complement to the demonstration activities in the deep exploration wells of Geneva, the University Neuchâtel is developing a shallow analog site at which THMC well test protocol for ATES in fractured media will be developed and tested. The analog site is located in Concise (Switzerland) and currently three 50 m boreholes are being drilled. Detailed THMC test design will follow drilling completion.

Germany

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

Intermediate results
- 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.

Belgium

Previous activities

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.

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 favour of the renewable heat sources that provide heat to the thermal network.

Intermediate results:

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. In the next weeks response tests will be 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.

WP 5 Monitoring and validation to assess system performance and workflow (Lead: Storengy – Marc PERREAUX)

The overall objective of WP5 is to bridge the gap between the data collected on the demo site and the results of the modelling work for all the demo-sites, in order to adjust and validate our models to facilitate the development of future HT-UTES (ATES, BTES, MTES,PTES) projects.

The Task 5.1 (Monitoring plan demonstrations and cases studies) objective was to design and develop monitoring plans and strategies for HT-UTES demonstration projects. The related deliverable D5.1 Design and develop monitoring strategies for HT-UTES demonstration projects has been completed and delivered on schedule. This work was performed with a high level of exchanges between the different partners involved in the demo-sites of HEATSTORE, each partner bringing its own experience from its specific background and past experience on different projects.

The information to be collected on the demo-sites was also shared with the simulation teams in order to ensure that the monitored data will allow to properly constrain the models to make them predictive and adapted for the design of future HT-UTES at a larger scale.

A compilation of the monitoring plans was conducted in the different projects. One very good point illustrated from this work is that all the projects gather or will gather the minimum amount of data to enable assessing both the efficiency of the energy systems and their impacts on the environment.

HT-ATES systems	Pressure		Temperature		Flowrate		Water analysis		Bacteria		Monitoring well(s)		Specific tests	InSAR	Micro seismic
Koppert-Cress (NL)	Y	hourly	Y	hourly	Y	hourly	Y	3-months	N		Y	Temp-profile		N	N
Geneva (SWI)	Y		Y		Y		Y		N		N		Well test	Y	Y
Bern (SWI)	Y	min/hr	Y	min/hr	Y	min/hr	Y	Regularly	Y	Regularly	Y	Temp-profile	Well test	N	N
HT-MTES systems															
Markgraf II (DE)	Y	min/hr	Y	min/hr	Y	min/hr	Y	3-months	N		Y	Temp-profile	Well test & tracer test	N	Y
Deep doublet															
Mol (BE)	Y	min/hr	Y	min/hr	Y	min/hr	Y	Regularly	N		N		Well test & tracer test	N	N
Hengill area (IS)	Y	2 weeks	Y	2 weeks	Y	2 weeks	Y	2 weeks	N		Y	Temp-profile	Well test & tracer test	N	Y

HT-BTES systems	Collector pressure		Temperature			Flowrate		Monitoring well(s)		Humidity in cover	Solar radiation	Air temp.	Wind speed
Braestrup (DK)	Y	10 min	Y	30 min	each line & global	Y	Heatflux : 10 min	Y	Temp-profile (probes) : 30 min	Y	Y	Y	Y
BETSmart (FR)	Y	min / hourly	Y	min/hourly	each line & global	Y	flow and heat : min/hourly	Y	Temp-profile (probes) : hourly / daily	N	N	Y	Y

HT-PTES systems	Collector pressure		Temperature			Flowrate		Profile		Water level in storage
Marstal (DK)	Y	10 min	Y	30 min	Various locations : inside & outside	Y	Heatflux : 10 min	Y	Every 0.5 m	Y

Figure 1. Compilation of the monitoring plan (from D5.1).

It is also interesting to observe that some projects will test innovative or advanced techniques like DTS (optic fibers), repeated InSAR, microseismic which will be helpful to investigate their added value and potential for future application in other, future sites.

As a consequence the associated **Milestone M5.1** Finalization of the monitoring plans as been passed.

The **Task 5.2** (Monitoring results), **Task 5.3** (Model validation for Subsurface dynamics) and **Task 5.4** (Model validation for system integration and optimization) will be completed once the data on the different demo-sites will be collected at the end of the monitoring period and the corresponding deliverable D5.2 (Report on analyses of gathered data of demonstration sites and show cases), D5.3 (Report on the results of the model validation of the demonstration sites) and D5.4 (Validation report of system integration modelling) are respectively planned for Month 35 (April 2021), 36 (May 2021) and 34 (March 2021).

Task 5.5 Uncertainty management has already been initiated with constructive exchanges around the presentations made by BRGM and Storengy at the 1st Annual Meeting organized at the TNO office in Utrecht on 3-4 July 2019. A theoretical framework for the representation of uncertainties is currently being defined in order to pass the **Milestone M5.5 (**Theoretical framework for the representation of uncertainties) planned for month 20 (January 2020). To date, this milestone is planned to be passed in time.

The milestones corresponding to data acquisition and analysis (M5.2, M5.3 and M5.4) were not passed formally after respectively 15 months (August 2019), 24 months (May 2020) and 36 months (May 2021).

<u>WP 6 Fast-track market uptake in Europe & dissemination (Lead: TNO – Joris KOORNNEEF)</u>

WP6 establishes the requirements necessary to move UTES and demand side management in heating networks from demonstration phase to commercial deployment, within 2 to 5 years on the European market after HEATSTORE completion, and provide an outlook towards 2030 and 2050. To achieve this, WP6 will:

- Identify favourable conditions for the replication of the developed technologies in Europe (EU-28 with a focus on countries within HEATSTORE-Geothermica)

- Share these outcomes with relevant stakeholders in policy, science, industry and the general public. address the fundamental technical, economic, environmental, societal, regulatory and policy aspects to support the efficient and cost-effective deployment of underground heat storage in Europe.
- Help promoters in implementing of this technology by providing them adapted business models and appropriate regulatory frameworks.
- Yield a roadmap to provide a clear strategy for the immediate (2-5 years) and long term (2035-2050) actions that need to be undertaken to implement the demonstrated and studied concepts within HEATSTORE.

This work package is focussed on integrating lessons learned and providing outlook for UTES technologies in Europe. The majority of the research efforts and dissemination activities are scheduled for the second term (coming 1.5 years) of the HEATSTORE project.

Up to the mid-term of the project a few milestones and deliverables were planned. Herewith we provide a brief update of the main activities:

- The website (www.heatstore.eu) was launched in the months after start of the project and has a clear overview of all national projects and allows for downloading all public reports and deliverables.
- D6.5.1 Plan for communication and dissemination was finalised later than planned. It contains the basic communication strategy for the HEATSTORE project.
- Dissemination and engagement. In the past year and a half significant media attention has been generated on the HEATSTORE project both in printed as online social media channels. The most active social media presence is on LinkedIn (see Link) where HEATSTORE project partners post their activities and progress. Also the HEATSTORE partners have presented their work on conferences and (international workshops). More details are provided in section 4 and 6.

In the next phase of the project the work withing WP6 will be intensified. Although the deliverables are scheduled for month 32-36, the partners will have intensive meetings in Q1 2020 to already define the scope of these deliverables and work towards draft reports. This allows for a proper dissemination of lessons learned in the other work packages in national and international workshops and events.

WP 7 Project management (Lead: TNO – Holger CREMER)

WP7 includes all project management activities: operational, legal, and financial matters. It includes also reporting to the GEOTHERMICA office and to the national funding agencies.

After a positive evaluation procedure of the project and receipt of the invitation letter to prepare the contract, the implementation agreement between TNO as Coordinator and the GEOTHERMICA office was signed on 19 Apr. 2018 (TNO) and 3 May 2018 (GEOTHERMICA representative), respectively.

The final version of the Consortium Agreement, signed by all 23 consortium partners and being effective from 1 May 2018, was concluded on 12 June 2018.

The official kick-off meeting was organized on 17-18 Sept. 2018 at TNO in Utrecht. The kick-off had 34 attendants, 3 of them being representatives of the national funding agencies.

The 1st Annual Meeting with almost 50 participants was again organized at the TNO office in Utrecht on 3-4 July 2019 (meeting report is available). Meeting participants critically discussed the demonstration projects and case studies with a focus on the business cases and legal, operational and technical challenges. All given presentations were shared with the consortium partners via the SCIEBO exchange platform.

Operational control on the project was maintained by the Executive Board and Project Management Team (EB-PMT) which regularly had skype meetings of approximately 1.5 h duration. The EB-PMT consists of the Coordinator, the 9 National Leads, and the WP Leads (5 National Leads are also WP Lead), altogether 11 members. Until November 2019, a total of 12 EB-PMT meetings were held. The EB-PMT in their meetings discussed the operational progress, challenges and possible solutions, the status of the deliverables and workshops/meetings to be organized. Meeting minutes including an action list were always prepared by the Coordinator and made available to the consortium partners through the project's exchange platform on SCIEBO.

Operational activities also included the organization of topical workshops. In the first reporting period, two workshops have been organized. Meeting reports are available of both workshops.

- Workshop at GZB in Bochum on 22-23 Nov. 2018 with 26 participants. Topics of the workshop included MTES (Mine Thermal Energy Storage) and activities and challenges in WP1 and WP3.
- Workshop at Univ. of Geneva in Genève on 7-8 April 2019 with 32 participants. This workshop focused on activities and discussion of activities and results WP2: modelling concepts for the demonstration projects.

The mandatory traffic light reports to GEOTHERMICA office, to be provided every 6 months, were sent on 9 Nov. 2018 (1 May 2018 – 31 Oct. 2018), 16 May 2019 (1 Nov. 2018 – 30 Apr. 2019) and 7 Nov. 2019 (1 May 2019 – 31 Oct. 2019).

<u>Specific reports of the national leads</u>

Belgium (Lead: VITO – Koen ALLAERTS)

National lead of the Belgian consortium partners is Mr. Koen Allaerts (koen.allaerts@vito.be).

The Belgian consortium partners have regular operational skype meetings to discuss progress and challenges on the Belgian demonstrator and deliverables.

An intermediate status report was sent to VEA on 25 January 2019, covering the major part of the first year.

A number of <u>national workshops</u> among Belgian partners was held:

- 2019.06.25: Technical workshop on specific tasks of KWB and SPIE (participants: VITO, KWB, SPIE).
- 2019.07.05: Technical workshop on content and planning WP3, deliverable 3.4 (participants: VITO, SPIE).

Denmark (Lead: GEUS – Thomas VANGKILDE-PEDERSEN)

The decision letter of the national funding agency (EUDP, Energy Technology Development and Demonstration Program of the Danish Energy Agency) was received on 23 May 2018.

National lead of the Danish consortium partners is Mr. Thomas Vangkilde-Pedersen (tvp@geus.dk).

The Danish consortium partners GEUS and PlanEnergi have face-to-face meetings, skype meetings or telephone conversations on an ad-hoc basis when necessary to discuss the planning, progress and challenges of the project.

The 1st yearly report of the Danish partners was sent to EUDP by the end of June 2019, covering the period 1 May 2018 – 30 June 2019.

Germany (Lead: GZB – Florian HAHN)

The decision letter of the national funding agency (FZJ-PtJ, Project Management Jülich) was received on 20 Jul. 2018.

National lead of the German consortium partners is Mr. Florian Hahn (florian.hahn@hs-bochum.de).

The German consortium partners have regular telephone conferences to discuss progress and challenges of the German demonstration project.

The 1st Progress Report of the German partners was sent to PTJ on 8 Feb. 2019, covering the first project mid-year (1 Aug. 2018 – 31 Jan. 2019).

The 2nd Progress Report of the German partners was sent to PTJ on 8 Aug. 2019, covering the second mid-year (1 Feb. 2018 – 31 Jul. 2019).

France (Lead: Storengy – Marc PERREAUX)

The French national contract was signed on the 2nd of July, 2018 with the French national funding agency (ADEME - Environmental and Energy Management Agency). The French consortium consists in Storengy and the BRGM.

The National lead of the French consortium partners is Mr Marc Perreaux (marc.perreaux@storengy.com).

The French consortium partners have a bi-weekly regular operational skype meeting to discuss the progress and challenges linked to the on-going activities.

The 1st Annual Progress Report of the French partners was sent and presented to ADEME at their Sophia-Antipolis offices on the 5th of June, 2019, covering the first project year (1 May 2018 – 30 Apr. 2019).

<u>Important update on French demonstration site:</u>

Storengy SAS cannot proceed with a BTESmart site as a demonstrator within Heatstore project.

BTESmart project contemplates to implement a Borehole Thermal Exchanger Heat Storage project on Storengy main gas storage site, Chemery, located in the Centre - Val de Loire region of France.

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

Storengy is currently assessing alternative locations to implement BTESmart technology. Despite Storengy best efforts, this new site will not be ready within the timeframe of Heatstore project.

As a consequence, Storengy SAS cannot proceed with a BTESmart site as a demonstrator within the GEOTHERMICA time frame, but a time extension will be confirmed at the national level once a new site has been identified. Storengy SAS expresses its sincerest apologies for the impact of this decision on HEATSTORE project as whole and on the activities of our partners.

Iceland (Lead: OR – Edda Sif ARADÓTTIR)

The Iceland National Contract between OR and Rannís was signed on the 18th of June 2018.

National lead of the Icelandic projects is Edda Sif Aradóttir (edda.sif.aradóttir@or.is), Head of Innovation and strategic planning and the R&D department at Reykjavík Energy. The main researchers involved in the project are Dr. Gunnar Gunnarsson and Sigrún Tómasdóttir. Sigrún serves as deputy national lead manager. Reykjavík Energy is the only Icelandic participant in Heatstore and participates with two case studies; one on possible seasonal heat storage of excess hot water in a low temperature system and another one on superhot resource exploration in the Hengill area.

Regular meetings are held inhouse at Reykjavík Energy (monthly) where progress in reservoir simulations is discussed along with other matters such as deadlines and reporting. The superhigh-temperature Hengill case study is a collaboration project with Thomas Driesner and his team at ETHZ.

The first progress reporting to the Icelandic funding agency, Rannís, was delivered on the 31st of May 2019 and covered the first year of the project. It consisted of two deliverables; one on conceptual models and another one on heat storage schemes to be simulated and a more compact summary on project progress, plans and finances. The reporting was approved by Rannís on the 7th of June 2019.

Workshops:

7th of September 2018– Meeting at RE and field visit to the Hengill area with Tomas Driesner and Alina Yapparova from ETHZ.

10th of January 2019 – Presentation on the Heatstore low temperature case study at a workshop at RE on possible reinjection into low temperature areas in Reykjavík.

9-10 April 2019 – workshop at ETHZ with Thomas Driesner and Benoit Lamy-Chappuis on heat sources in Hengill, this was following a WP2 workshop in Geneva.

2nd of July 2019 – workshop in Utrecht with Thomas Driesner on the Hengill superhigh temperature project – prior to the HEATSTORE annual meeting.

6th of December 2019 - Presentation on the Hengill reservoir model and the HEATSTORE high temperature case study collaboration on the Hengill workshop 2019 which included participants from Reykjavík Energy, The Iceland Geosurvey and the University of Iceland.

The Netherlands (Lead: TNO – Joris KOORNNEEF)

The decision letter of the national funding agency (RVO, Netherlands Enterprise Agency) was received on 26 April 2018.

National lead of the Dutch consortium partners is Mr. Joris Koornneef (joris.koornneef@tno.nl).

The Dutch consortium partners have a tri-weekly regular operational skype meeting to discuss progress and challenges of the Dutch demonstration and case studies.

The 1st Progress Report of the Dutch partners was sent to RVO on 22 May 2019, covering the first project year (1 May 2018 – 30 Apr. 2019).

A number of national workshops among Dutch partners was held:

- 30 July 2019: Workshop on WP3 with TNO and ECW on 30 July 2019.
- 3 October 2019: Workshop on the ATES demonstration at the ECW site Middenmeer.

Specific legal matter: Partner ECW Geomanagement B.V. requested a transfer of all rights and obligations to the new consortium partner ECW Projects B.V. After all HEATSTORE partners have indicated by mail to agree to this transfer, the Coordinator has formally submitted this request to the national funding agency of the Netherlands (RVO). Approval by RVO of the request was given on 16 May 2019. Consequently, the Consortium Agreement has been amended accordingly.

Specific financial matter: Partner TNO requested a financial modification in WP4: to split the allocated budget of 60,000 Euro on subcontracting for chemical analyses into three parts, namely 36,000 Eur for personnel costs of TNO to carry out chemical experiments in its own labs.

Portugal, Azores (Lead: IVAR - Fátima VIVEIROS)

The learning agreement between the IVAR, University of the Azores and the national funding agency (FRCT) was signed on the 2nd May 2018.

The national lead of the Azores project is Fátima Viveiros, professor at the University of the Azores (maria.fb.viveiros@azores.gov.pt).

Three-monthly face-to-face meetings have been carried between all the participants in the project to program the activities for the following period and to show/discuss the results obtained in theprevious months. The meeting usually accomplishes with the presence of six researchers involved in the project.

In the period between 9th and 13th September 2019 several meetings between IVAR researchers and Thomas Driesner (ETH Zurich) were carried out in the Azores University in order to discuss the progress of the project and program the activities that will be carried out by the two institutions in what concerns modelling the geothermal reservoir. During that period, visits to the study site (Caldeiras da Ribeira Grande area) and to the geothermal power plants settled in the island were also carried out.

Three meeting were also carried out between IVAR researchers and the local geothermal company (EDA Renováveis S.A.) to agree for the delivery to IVAR of the rock samples cores from a geothermal well drilled up to 1000 m. These samples should be available in the end of November 2019, what caused some delay on the development of the tasks related with the rock geochemistry. Nevertheless, a plan to recover from this delay was already settled and it should not compromise the development of the project.

The 1st Progress Report of the Portuguese (Azorean) partner was sent to the FRCT on 30th October 2019, as required in the learning agreement and it covers the first half of the project (1 May 2018 – 30 Oct. 2019).

Spain (Lead: UPC – Sebastia OLIVELLA)

The final decision for granting the project HEATSTORE to the UPC by the Spanish Ministry of Economy was made 23 May 2019 (reference PC12018-092933).

Since June 2019, a researcher is hired for working on the project in the framework of a PhD study.

No national meetings are necessary as the UPC is the only national participant.

Switzerland (Lead: Univ. Genève – Luca GUGLIELMETTI)

The Swiss National Contract was signed on 29 September 2019.

National Lead of the Swiss consortium is Dr. Luca Guglielmetti – University of Geneva (luca.guglielmetti@unige.ch)

The Swiss Consortium as regular updates at 2 semestral meetings plus work packages meetings.

The 1st progress report covering the activities carried out in the period May 2018 - May 2019 was delivered to the Swiss Federal Office of Energy on 8 July 2019.

The Swiss consortium organized the HEATSTORE WP2 workshop on 8 April 2019.

Additionally national workshops were held:

2018.10.08Swiss Consortium Meeting

2019.10.03. WP2 meeting

2019.01.10. WP2 meeting

2019.02.11. WP2 meeting

2019.04.08. WP2 meeting

The next Swiss Consortium meeting will be held on 22 November 2019.

Financial progress

The tables below present an overview of financial progress (total budget spent) per partner and per work package.

TNO	**Costs (Euro) made until 31.10.2019**			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1	40,755	1,957		**42,712**
2	16,431			**16,431**
3	51,915	946		**52,861**
4	64,138	560		**64,698**
5	2,456			**2,456**
6	3,621	24		**3,645**
7	193,473	20,305		**213,778**
Total:	**372,789**	**23,792**		**396,581**

IF Technology	Costs (Euro) made until 31.10.2019			
WP	Personnel	Direct costs (e.g. travel, materials, other)	Subcontracting	Total
1	31,565			**31,565**
2*	26,660			**26,660**
3	11,690			**11,690**
4*	168,920			**168,920**
5	11,018			**11,018**
6				
7				
Total:	**249,853**			**249,853**

*Realized costs for these work packages are significantly higher than initially calculated costs. Contact with Dutch National Funding Agency RVO necessary to find a solution for this challenge.

KWR Water	Costs (Euro) made until 31.10.2019			
WP	Personnel	Direct costs (e.g. travel, materials, other)	Subcontracting	Total
1				
2	153,812			**153,812**
3				
4	18,923	8,605		**27,528**
5	4,998			**4,998**
6	2,403			**2,403**
7				
Total:	**180,136**	**8,605**		**188,741**

ECW	Costs (Euro) made until 31.10.2019			
WP	Personnel	Direct costs (e.g. travel, materials, other)	Subcontracting	Total
1 t/m 7	7,092	506,519		**513,611**
Total:	**7,092**	**506,519**		**513,611**

Univ. Geneva	Costs (Euro) made until 31.10.2019 (1 Euro = 1.11 CHF)			
WP	Personnel	Direct costs (e.g. travel, materials, other)	Subcontracting	Total
1	307,330			**307,330**
2				
3	37,412	2,837		**40,249**
4	22,994		38,190	**61,184**
5	15,843	40		**15,883**
6	31,686	9,291		**40,978**
7	56,157			**59,782**
Total:	**471,422**	**15,794**	**38,190**	**525,406**

ETHZ	Costs (Euro) made until 31.10.2019 (1 Euro = 1.12 CHF)			
WP	Personnel	Direct costs (e.g. travel, materials, other)	Subcontracting	Total
1				
2	215,568	2,590		**218,158**
3				
4	10,487			**10,487**
5	20,974			**20,974**
6				
7				
Total:	**247,029**	**2,590**		**249,619**

Univ. Neuchâtel	Costs (Euro) made until 31.10.2019 (1.0 Euro = 1.05 CHF)			
WP	Personnel	Direct costs (e.g. travel, materials, other)	Subcontracting	Total
1	13,837			**13,837**
2				
3				
4	124,533	4,316	37,586	**166,435**
5				
6				
7				
Total:	**138,370**	**4,316**	**37,586**	**180,275**

Univ. Bern	Costs (Euro) made until 31.10.2019			
WP	Personnel	Direct costs (e.g. travel, materials, other)	Subcontracting	Total
1				
2	85,893	1,066		**86,959**
3				
4	28,341	6,544		**34,885**
5				
6				
7				
Total:	**114,234**	**7,610**		**121,844**

SIG	Costs (CHF) made until 31.10.2019			
WP	Personnel	Direct costs (e.g. travel, materials, other)	Subcontracting	Total
1	70,554			**70,554**
2				
3	85,948	263,425	2,902,911	**3,252,283**
4	11,545			**11,545**
5				
6				
7				
Total:	**168,047**	**263,425**	**2,902,911**	**3,334,382**

EWB	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1				
2	2,924			**2,924**
3				
4	2,521		134,737	**137,258**
5				
6				
7				
Total:	**5,445**		**134,737**	**140,182**

BRGM*	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1	14,888			**14,888**
2	41,097	1,648	5,457	**48,202**
3	5,996	1,591		**7,587**
4				
5				
6		3,861		**3,861**
7				
Total:	**61,981**	**7,099**	**5,457**	**74,538**

*Numbers until 30 Sept. 2019.

Storengy	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1	30,133			**30,133**
2	91,691			**91,691**
3	18,080			**18,080**
4				
5	19,587			**19,587**
6				
7	12,053	5,101		**17,154**
Total:	**171,544**	**5,101**		**176,645**

HS Bochum - IGC	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Investment costs**	**Total**
1	9,620	1,868		**11,488**
2				
3 and 4	82,655	15,964	13,687	**112,306**
5				
6				
7				
Total:	**92,275**	**17,832**	**13,687**	**123,794**

GEUS	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1	50,915	4,902		55,817
2	23,489	1,303		24,792
3				
4	7,914	2,471		10,385
5	8,855			8,855
6	5,432	400		5,831
7	10,704			10,704
Total:	107,310	9,075		116,385

PlanEnergi	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1	12,021	536		12,557
2	2,610			2,610
3	20,379	397		20,776
4	5,276	1,110		6,386
5	5,903			5,903
6	8,147			8,147
7				
Total:	54,337	2,043		56,380

VITO	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1				
2	11,472			**11,472**
3	17,526	2,090		**19,616**
4	15,933		46,150	**62,083**
5	14,021			**14,021**
6	4,780			**4,780**
7	1,912			**1,912**
Total:	**65,644**	**2,090**	**46,150**	**113,884**

Univ. Azores	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1				
2	7,000	1,591	1,066	**9,657**
3				
4	6,216			**6,216**
5				
6				
7	1,441	1,126		**2,567**
Total:	**14,657**	**2,717**	**1,066**	**18,440**

OR Iceland	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1				
2	228,291	9,878		**238,169**
3				
4				
5				
6				
7	2,846			**2,846**
Total:	**231,137**	**9,878**		**241,015**

UPC	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1				
2	75,555	1,833		**77,388**
3				
4				
5				
6				
7				
Total:	**75,555**	**1,833**		**77,388**

Delta-h	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1				
2	42,680	1,018		**43,698**
3				
4				
5				
6				
7				
Total:	**42,680**	**1,018**		**43,698**

SPIE Belgium	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1				
2				
3	14,400	200		**14,600**
4				
5				
6				
7				
Total:	14,400	200		**14,600**

Kempens	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1				
2				
3	19,800	100		**19,900**
4				
5				
6				
7				
Total:	19,800	100		**19,900**

NIOO	Costs (Euro) made until 31.10.2019			
WP	**Personnel**	**Direct costs (e.g. travel, materials, other)**	**Subcontracting**	**Total**
1	5,234			**5,234**
2				
3				
4	5,234			**5,234**
5	75,530	303	4,477	**80,310**
6	1,837			**1,837**
7				
Total:	**87,835**	**303**	**4,477**	**92,615**

3. Problems/ challenges/ deviations from proposal/work plan

Tables below describe deviations and delays and their consequences. Most deviations are in fact delayed delivery of reports and/or milestones. However, all deliverables scheduled to be delivered in the first half of the HEATSTORE project were achieved until mid-December 2019.

The single serious deviation so far is the withdrawal of the BTESmart demonstration project at the Chemery site in France (see specific national lead reports above).

What	Title	Lead partner	Due	Explanation/solution
BTES-Smart project at Chemery (France)	Implementation of a Borehole Thermal Exchanger Heat Storage project	Storengy	30-04-2021 **NEW DATE:** **-**	**Current status of deliverable/milestone/task** Despite all efforts to maintain the costs of the project to a reasonable level, it appears that they are significantly higher than the initial budget. The BTESmart project, due to its location within a gas storage site, falls under the COMAH (Seveso) regulations. This induces significant additional costs and operational constraints compared to similar BTES projects. As a consequence, Storengy SAS to stop the BTESmart project at Chemery within the Heatstore project. The Storengy management has provided a formal memo that is offered to the project partners and the French funding agency ADEME. **Reasons for the withdrawal** Significant projected cost increase of the planned BTESmart project. **Impact on other tasks, deliverables, milestones** All activities connected to the BTESmart project at Chemery cannot be carried out. Storengy is

What	Title	Lead partner	Due	Explanation/solution
				currently assessing alternative locations to implement BTESmart technology in cooperation with ADEME. The new site will not be ready within the timeframe of Heatstore project – Storengy discusses with ADEME potential extension of the French HEATSTORE activities to make a realization of BTESmart at the new site possible. **Expected changes in time-line** French activities in WP4 and WP5 delayed, potentially after the official deadline of HEATSTORE in 04/2021. **Budgetary impact** To be sorted out in detail by Storengy and French partners.

What	Title	Lead partner	Due	Explanation/solution
D1.1	Analyses of existing UTES systems and lessons learned	GEUS	31-10-2018 **NEW DATE: 30-04-2019**	**Current status of deliverable/milestone/task** The Deliverable has been finalized with the publication of the public report: "Underground Thermal energy Storage (UTES) – state-of-the-art, example cases and lessons learned" **Reasons for the delay** The start of project activities was delayed in the beginning of the project due to signatures of national contracts **Impact on other tasks, deliverables, milestones** The start of Task 1.2 was equally delayed **Expected changes in time-line** No further impact **Budgetary impact** No

What	Title	Lead partner	Due	Explanation/solution
D1.2	General specifications for UTES systems (ATES, BTES, PTES, MTES)	PlanEnergi	30-04-2019 **NEW DATE: 30-09-2019**	**Current status of deliverable/milestone/task** The Deliverable has been finalized with the publication of the public report: "Underground Thermal energy Storage (UTES) – general specifications and design". **Reasons for the delay** The start of project activities was delayed in the beginning of the project due to signatures of national contracts. **Impact on other tasks, deliverables, milestones** No **Expected changes in time-line** No **Budgetary impact** No

What	Title	Lead partner	Due	Explanation/solution
MS1.1	Collection of existing experience in participating countries		31-07-2018 **NEW DATE: 30-11-2018**	**Current status of deliverable/milestone/task** The Milestone was passed with a few months of delay **Reasons for the delay** The start of project activities was delayed in the beginning of the project due to signatures of national contracts **Impact on other tasks, deliverables, milestones** The finalization of D1.1 and start of Task 1.2 was equally delayed **Expected changes in time-line** No further impact **Budgetary impact** No

What	Title	Lead partner	Due	Explanation/solution
MS1.2	Survey of specific interests for UTES and description of screening process		31-10-2018 **NEW DATE: 31-12-2019**	**Current status of deliverable/milestone/task** The Milestone was partly passed August 2019 with the completion of a survey of specific interests for UTES among Danish district heating companies and with initiation of description of national screening process and will be fully passed by the end of 2019 **Reasons for the delay** The start of project activities was delayed in the beginning of the project due to signatures of national contracts and the initiation of this work was further delayed due to practical/planning reasons **Impact on other tasks, deliverables, milestones** The first part of this Milestone is specifically for work carried out in Denmark and the delay will not cause any impact on further work while the second part is related to work in the end of the project and hence the delay will not cause any impact here either **Expected changes in time-line** None **Budgetary impact** None

What	Title	Lead partner	Due	Explanation/solution
MS1.3	Workflow for fast-track re-processing of existing seismic data		28-02-2019 **NEW DATE: 05-11-2019**	**Current status of deliverable/milestone/task** The Milestone was passed with some months of delay **Reasons for the delay** The start of project activities was delayed in the beginning of the project due to signatures of national contracts. **Impact on other tasks, deliverables, milestones** None **Expected changes in time-line** None **Budgetary impact** None

What	Title	Lead partner	Due	Explanation/solution
MS5.1	Finalization of monitoring plan	GZB	01-05-2019 **NEW DATE: 27-06-2019**	**Current status of deliverable/milestone/task** Milestone has been checked with the publication of the following public report: "Monitoring plans: demonstration projects and case studies" **Reasons for the delay** Due to delay in realization of demonstration project **Impact on other tasks, deliverables, milestones** **Expected changes in time-line** **Budgetary impact** no

What	Title	Lead partner	Due	Explanation/solution
MS4.3	Best practice sharing for UTES and DSM project realization on international HEATSTORE events	BRGM	01-05-2019 **NEW DATE: 01-05-2020**	**Current status of deliverable/milestone/task** Best practices can only be evaluated on the results of the demonstration projects, which still need to be elaborated. **Reasons for the delay** Due to delay in realization of demonstration project **Impact on other tasks, deliverables, milestones** **Expected changes in time-line** **Budgetary impact** no

4. Progress on project impact (TNO – Holger CREMER/Joris KOORNNEEF)

In the first reporting period of HEATSTORE, the project has already created significant impact. A differentiation has been made between scientific, technical, economic and societal impact – all of these are briefly commented below.

<u>Scientific impact</u>

Scientific relevance of HEATSTORE is proven by the high visibility of project partners at various conferences and knowledge sharing events. These include scientific conferences as DECOVALEX, but also sector events as the European and World Geothermal Congresses or the recently held European Workshop on Underground Energy Storage. HEATSTORE partners are involved in these conferences with oral and poster contributions and, if applicable, provide a contribution for the conference proceedings. HEATSTORE partners have submitted 6 and 11 conference proceedings papers for the European and World Geothermal Congresses, respectively.

<u>Technical impact</u>

HEATSTORE studies various processes of the entire underground thermal energy storage (UTES) value chain. It looks at processes in the subsurface as well as above surface. Research questions and technical development generally follow the HEATSTORE roadmap Design – Demonstrate & Monitor – Replicate & Upscale. The learning curve is fed by both theoretical considerations but moreover by experiences from the planning and design of the planned demonstrations and case studies. Results of technical research and developmental questions – mostly related to one of the demonstration pilots or case studies – are described and in most cases published in the deliverable reports and publications (see chapter 6). Key publications already provide an overview of the state of the art of UTES and design considerations (see deliverable D1.1 and D1.2).

Economic impact
Underground Thermal Energy Storage projects must be beneficial and profitable in order to have a role in the future heat supply system. HEATSTORE is challenged not only to develop technically high-standing workflows and tools but solutions that are affordable. In cooperation with the project partners who operate the planned demonstration projects, HEATSTORE supports in optimizing the business case of the various demonstration projects. Examples include for example the GeoToolBox developed by partner VITO to optimize the impact of UTES for district heating networks or the CHESS model developed by TNO to support the integration of stored heat into heat grids. In the next phase of the project new business models will be identified and developed to further improve the economic viability of UTES technologies.

Societal impact
Stakeholder awareness and perception is key for technology adoption. Stakeholders including the general public should be informed on UTES technologies and their properties. In the HEATSTORE project activities have been executed to increase awareness.
The growing societal significance of heat storage and specifically the HEATSTORE project is indicated by the large number of news items in various media of all participating countries (see list below in chapter 6). Reports include contributions in regular newspapers, industry publications, sector media, and university websites. HEATSTORE is also reported in international media like the ThinkGeoEnergy Newsletter. And, HEATSTORE is mentioned in the Dutch National Climate Agreement which underlines the attention energy storage receives on governmental level. Large scale underground heat storage in relatively new to society – the significant attention of the topic in all kinds of media shows the necessity and willingness of societies to develop concepts for the storage of excess industrial heat for periods when heat demand usually increases. Up to this point no negative public/stakeholder perception has been identified on the (to be) demonstrated UTES technologies.

5. Collaboration and coordination within the Consortium (TNO – Holger CREMER)

Project governance
The coordination of the HEATSTORE consortium occurs on three levels: international consortium, national consortium, and individual partners.
On international consortium level, operational and technical progress is managed by the Executive Board/Project Management Team (EB-PMT) which consists of the coordinator, the national leads from each country, and the WP leads (note, that 5 of the national leads are also WP lead). The EB-PMT meets regularly every 5-6 weeks or on request for a skype meeting of 1.5 hours to discuss progress and challenges. Minutes including discussed matters and an action point list are prepared by the coordinator of each meeting.

Table 1. Composition of the HEATSTORE Executive Board and Project Management Team.

Company	Name	Role	EB vote
TNO	Cremer	Coordinator	1
TNO	Koornneef	National lead NL, WP6 lead	1
GEUS	Vangkilde-Pedersen	National lead DK, WP1 lead	1
ETHZ	Driesner	WP2 lead	0
UNIGE	Guglielmetti	National lead SUI	1
VITO	Allaerts	National lead BEL, WP3 lead	1
GZB	Hahn	National lead GER, WP4 lead	1
STORENGY	Perreaux	National lead FR, WP5 lead	1
OR	Tómasdóttir	National lead ISL	1
UPC	Saaltink	National lead ESP	1
IVAR	Viveiros	National lead POR	1

The national consortia are managed by the national lead who focuses on country specific aspects of HEATSTORE and is also the main contact point for the coordinator. Reporting to the coordinator occurs regularly during the EB-PMT meetings.

Likewise, work package leaders share in the EB-PMT the progress and specific challenges of the WP work. Particular attention goes to the status of the planned demonstrations and case studies, and to the status of the deliverables.
On the individual partner level each partner organization has nominated one or two contact points for partner-specific operational matters.

The coordinator and the national leads are the main contacts for any information flow to and from the GEOTHERMICA office and the national funding agencies, respectively.

The described 3-layer governance structure with clearly distributed operational tasks has proven to be very efficient and effective as project progress, challenges and issues become evident rather quickly. The clearly organized tasks and mandating guarantees a quick handling of

Document sharing among consortium partners
Documents are shared within the HEATSTORE consortium through the SCIEBO exchange platform. SCIEBO is a non-commercial cloud storage service for research and teaching which is run jointly by 27 universities in the German state North Rhine-Westphalia. The SCIEBO cloud section for HEATSTORE was set up and is maintained by partner GZB at the Hochschule Bochum.

HEATSTORE meetings/workshops on consortium level

2018.09.17-18.	Kick-off meeting. Organized by TNO, Utrecht, 33 participants.
2018.11.22-23.	Workshop on MTES (Mine Thermal Energy Storage) and activities and challenges in WP1 and WP3. Organized by GZB, Bochum, 26 participants.
2019.04.07-08.	Workshop on activities and results of WP2: modelling concepts for the demonstration projects. Organized by Univ. Geneva, Geneva, 32 participants.
2019.07.03-04.	1st Annual meeting. Organized by TNO, Utrecht, 50 participants.

HEATSTORE meetings/workshops on national level

Azores (Lead: IVAR - Fátima VIVEIROS)

2019-09.09 Meeting between IVAR researchers and Thomas Driesner (ETH Zurich) to discuss the integration of the Azores study case on WP2. Field visits to the study site and to the geothermal power plants were done. Organized by IVAR, University of the Azores. Cooperation also of the local geothermal company (EDA Renováveis S.A.).

Belgium (Lead: VITO – Koen ALLAERTS)

2019.06.14	Technical workshop on BMS system at the Belgian demonstrator site (participants: VITO, Siemens)
2019.06.25	Technical workshop on specific tasks of KWB and SPIE (participants: VITO, KWB, SPIE)
2019.07.05	Technical workshop on content and planning WP3, deliverable 3.4 (participants: VITO, SPIE)
2019.10.03	Workshop on BMS adaptations and updates of the control systems at the Belgian demonstrator site (participants: VITO, Siemens)

Monthly status meetings with Wissenskapital Energie GmbH (former Noda GmbH).

Regular status phone calls with Belgian partners according to the project planning and deliverable deadlines.

Denmark (Lead: GEUS – Thomas VANGKILDE-PEDERSEN)

2019-06-18	National knowledge sharing workshop for external stakeholders in Denmark

The Netherlands

2019.07.30.	Technical workshop on specific challenges in WP3 (Participants: TNO, ECW).
2019.10.03.	Technical workshop on the Dutch demonstration at Middenmeer/ECW (Participants: TNO, IF, ECW, RVO).

Germany (Lead: GZB – Florian HAHN)

A number of national meetings with corresponding parties/institutions were held:

- 03 Sep. 2018: Meeting E.ON regarding the boundary conditions of a liability agreement.
- 22 Mar. 2019: Meeting with Taberg regarding geotechnical evaluation of Markgraf II mine.
- 29 Mar. 2019: Meeting with Ministry of Economic Affairs, Innovation, Digitization and Energy (MWIDE) of the State of North Rhine-Westphalia regarding the regulatory framework of MTES.
- 26 Apr. 2019: Second meeting with E.ON regarding the liability agreement.
- 17 Oct. 2019: Second meeting with MWIDE regarding the regulatory framework of MTES.

France (Lead: Storengy – Marc PERREAUX)

Bi-weekly meetings between Storengy and BRGM.

Iceland (Lead: OR – Edda Sif ARADÓTTIR)

2018.09.07	Meeting and field visit at Reykjavík Energy HQ and in the Hengill area with Thomas Driesner and Alina Yapparova from ETHZ to discuss Icelandic HEATSTORE case studies
2019.01.10	Presentation on the HEATSTORE low temperature case study at a workshop at Reykjavík Energy on possible reinjection into the companies low temperature areas in Reykjavík
2019.04.09-10	Workshop at ETHZ with Thomas Driesner and Benoit Lamy-Chappuis on heat sources in Hengill, following a WP2 workshop in Geneva
2019.07.02	Workshop in Utrecht with Thomas Driesner on the Hengill superhigh temperature project – prior to the HEATSTORE annual meeting
2019.12.06	Presentation on the Hengill reservoir model and the HEATSTORE Icelandic high temperature case study collaboration on the Hengill workshop 2019 which included participants from Reykjavík Energy, The Iceland Geosurvey and the University of Iceland.

Spain (Lead UPC – Sebastia OLIVELLA)

No national meetings were necessary as the UPC is the only national participant.

Swiss consortium lead (Lead: Univ. Genève – Luca GUGLIELMETTI)

International

2019.04.08	WP2 workshop (Geneva)

National

2018.10.09	Swiss Consortium Meeting
2019.10.03.	WP2 meeting
2019.01.10	WP2 meeting
2019.02.11.	WP2 meeting
2019.04.08.	WP2 meeting

The next Swiss Consortium meeting will be held on 22 November 2019.

6. Dissemination activities (including list of publications where applicable)

The HEATSTORE project, concept and results are shared with stakeholders and various user groups via a number of different channels. These include the project website on which deliverable reports are published, scientific publications and conference contributions. HEATSTORE is prominently represented with various contributions from all work packages on two of the biggest geothermal conferences: the European Geothermal Congress (The Hague, June 2019) and the World Geothermal Congress (Reykjavik, April 2020). HEATSTORE also gained significant media attraction in various newspapers and branch magazines in at least some countries. The complete overview is found below.

HEATSTORE website
www.heastore.eu (maintained by TNO).

Deliverables for consortium-restricted use only (confidential)

D2.1: Driesner, T. (ed.) (2019) Initial report on tools and workflows for simulating subsurface dynamics of different types of High temperature Underground Thermal energy Storage. HEATSTORE project report, GEOTHERMICA – ERANET Cofund Geothermal. Unpublished report, 143 pp.

D3.1: Allaerts, K. (2019) Minutes of the first workshop on design and system integration. HEATSTORE project report, GEOTHERMICA – ERANET Cofund Geothermal. Unpublished report, 3 pp.

D3.2: Allaerts, K. (ed.) (2019) Technical report on the characteristics of heat demand and supply at the demonstrator sites. HEATSTORE project report, GEOTHERMICA – ERANET Cofund Geothermal. Unpublished report, 56 pp. + appendices.

D3.4: Vanschoenwinkel, J. et al. (2019) Design and execution of business case models for the demonstration sites. HEATSTORE project report, GEOTHERMICA – ERA NET Cofund Geothermal. Unpublished report, 41 pp + appendices.

D6.5.1: Sørensen, P.A., Koornneef, J. (2019) HEATSTORE Plan for communication and dissemination. HEATSTORE project report, GEOTHERMICA – ERANET Cofund Geothermal. Unpublished report, 7 pp.

Deliverables published on project website (www.heatstore.eu)

D1.1: Kallesøe, A.J., Vangkilde-Pedersen, T. (eds.) (2019) Underground Thermal energy Storage (UTES) – state-of-the-art, example cases and lessons learned. HEATSTORE project report, GEOTHERMICA – ERANET Cofund Geothermal. 130 pp. + appendices.

D1.2: Nielsen, J.E., Vangkilde-Pedersen, T. (eds.) (2019) Underground Thermal energy Storage (UTES) – general specifications and design. HEATSTORE project report, GEOTHERMICA – ERANET Cofund Geothermal. 58 pp.

D2.2: Tómasdóttir, S. & Gunnarsson, G. (eds.) 2019: HEATSTORE – Interim report on UTES-type/site-specific simulators based on academic/research codes. GEOTHERMICA – ERA NET Cofund Geothermal. 55 pp.

D3.6: Werkman, E. et al. (2019) Incorporation of a new generation smart energy management algorithm (HeatMatcher) in CHESS. GEOTHERMICA – ERANET Cofund Geothermal. 21 pp.

D4.1: Hahn, F. et al. (2019) Feasibility assessment & design for demonstration projects – learnings of an international workshop. GEOTHERMICA – ERANET Cofund Geothermal. 22 pp.

D5.1: Hahn, F. (ed.) (2019) Monitoring plans: demonstration projects and case studies. HEATSTORE project report, GEOTHERMICA – ERANET Cofund Geothermal. 29 pp.

Conference proceedings papers

European Geothermal Congress 2019, The Hague, The Netherlands, 11-14 June 2019

Beernink, S., Hartog, N., Bloemendal, M., van der Meer, M. (2019) ATES systems performance in practice: analysis of operational data from ATES systems in the province of Utrecht, The Netherlands. Proceedings European Geothermal Congress 2019, The Hague, The Netherlands, 11-14 June, 2019.

Bloemendal, M., Beernink, S., Hartog, N., van Meurs, B. (2019) Transforming ATES to HT-ATES, insights from Dutch pilot project. Proceedings European Geothermal Congress 2019, The Hague, The Netherlands, 11-14 June, 2019.

Drijver, B., Bakema, G., Oerlemans, P. (2019) State of the art of HT-ATES in The Netherlands. Proceedings European Geothermal Congress 2019, The Hague, The Netherlands, 11-14 June, 2019.

Hahn, F., Jagert, F., Bussmann, G., Nardini, I., Bracke, R., Seidel, T., König, C. (2019) The reuse of the former Markgraf II colliery as a mine thermal energy storage. Proceedings European Geothermal Congress 2019, The Hague, The Netherlands, 11-14 June, 2019.

Koornneef, J., Guglielmetti, L., Hahn, F., Egermann, P., Vangkilde-Pedersen, T., Aradóttir, E.S., Allaerts, K., Viveiros, F., Saaltink, M. (2019) HEATSTORE: high temperature underground thermal energy storage. Proceedings European Geothermal Congress 2019, The Hague, The Netherlands, 11-14 June, 2019.

Koumrouyan, M., Sohrabi, R., Valley, B. (2019) Geomechanical characterization of geothermal exploration borehole for Aquifer Thermal Energy Storage (ATES) development in Geneva, Switzerland. Proceedings European Geothermal Congress 2019, The Hague, The Netherlands, 11-14 June, 2019.

World Geothermal Congress 2020, Reykjavik, Iceland, 26 April -2 May 2020 (all listed contributions are submitted to the conference secretariat)

Birdsell, D., Saar, M. (2020): Modelling Ground Surface Deformation at the Swiss HEATSTORE Underground Thermal Energy Storage Sites. Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26-May 2, 2020.

Eruteya, O., Guglielmetti, L., Makhloufi, Y., Moscariello, A. (2020): 3-D Static Model to Characterize Geothermal Reservoirs for High-Temperature Aquifer Thermal Energy Storage (HT-ATES) in the Geneva Area, Switzerland. Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26-May 2, 2020.

Ferreira de Oliveira, G., De Haller, A., Guglielmetti, L., Makhloufi, Y., Moscariello, A., (2020): Application of Chemostratigraphy and Petrology to Characterize the Reservoirs of the Mesozoic Sequence Crossed by the GEo-01 Well: Potential for Direct Heat Production and Heat-Storage. Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26-May 2, 2020.

Guglielmetti, L. and 22 others (2020) HEATSTORE SWITZERLAND: New opportunities of geothermal district heating network sustainable growth by High Temperature Aquifer Thermal Energy Storage development. Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26-May 2, 2020.

Hahn, F., Jagert, F., Bussmann, G., Nardini, I., Bracke, R., Seidel, T., König, C. (2020) The reutilization of a small coal mine as a Mine Thermal Energy Storage. Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26-May 2, 2020.

Kallesøe, A.J., Vangkilde-Pedersen, T., Nielsen, J.E., Bakema, G., Egermann, P., Maragna, C., Hahn, F., Guglielmetti, L., Koornneef, J. (2020) HEATSTORE – Underground Thermal Energy Storage (UTES) – State of the Art, Example Cases and Lessons Learned. Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26-May 2, 2020.

Koornneef, J., Guglielmetti, L., Hahn, F., Egermann, P., Vangkilde-Pedersen, T., Aradóttir, E.S., Allaerts, K., Viveiros, F., Saaltink, M. (2020) HEATSTORE Project Update: High Temperature

Underground Thermal Energy Storage. Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26-May 2, 2020.

Mindel, J.E. & Driesner, T. (2020) HEATSTORE: Preliminary design of a High Temperature Aquifer Thermal Energy Storage (HT-ATES) system in Geneva based on TH simulations. Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26-May 2, 2020.

Rey, C., Maragna, C., Egermann, P., Perreaux, M. (2020) Modelling of an innovative HT-BTES(smart) design with lateral recovery boreholes to reduce heat losses : development and preliminary result. Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26-May 2, 2020.

Sohrabi, R., Valley, B. (2020) Thermo-Hydraulic-Mechanical (THM) Experiments and Numerical Simulations to Quantify Heat Exchange Characteristics of Fractured Limestone Reservoirs for Aquifer Thermal Energy Storage (ATES). Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26-May 2, 2020.

Tómasdóttir, S., Gunnarsson, G., Aradóttir, E.S.P. (2020) Possible seasonal injection of surplus hot water from the Hengill Area into a low temperature system within Iceland's capital area. Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, April 26-May 2, 2020.

<u>Conference visits</u>

European Geothermal Congress 2019, The Hague, The Netherlands, 11-14 June 2019

Beernink, S. et al. (2019) ATES systems performance in practice: analysis of operational data from ATES systems in the province of Utrecht, The Netherlands. Oral presentation.

Bloemendal, M. et al. (2019) Transforming ATES to HT-ATES, insights from Dutch pilot project. Poster presentation.

Drijver, B. et al. (2019) State of the art of HT-ATES in The Netherlands. Oral presentation.

Hahn, F. et al (2019) The utilization of the former Markgraf II colliery as a mine thermal energy storage. Oral presentation.

Koornneef, J. et al. (2019) HEATSTORE: high temperature underground thermal energy storage. Oral presentation.

*DECOVALEX 2019 Symposium – **DE**velopment of **CO**upled models and their **VAL**idation against **Ex**periments, Brugg, Switzerland, 4-5 November 2019.*

Birdsell, D.T., Saar, M.O. (2019) Coupled Thermo-Hydro-Mechanical Model of Ground Surface Deformation at Swiss Heat Storage Sites. Oral presentation.

European Workshop on Underground Energy Storage, Paris, France, 7-8 November 2019

Koornneef, J. et al. (2019) HEATSTORE – High Temperature Underground Thermal Energy Storage. Oral presentation.

De Oliveira Filho, F. et al. (2019) District heating and thermal energy storage. Oral presentation.

Vangkilde-Pedersen, T. et al. (2019) Lessons learned from existing and past underground thermal energy storage systems. Oral presentation.

World Geothermal Congress 2020, Reykjavik, Iceland, 26 April -2 May 2020 (all listed contributions are submitted to the conference secretariat)

Guglielmetti, L. et al. (2020) HEATSTORE SWITZERLAND: New opportunities of geothermal district heating network sustainable growth by High Temperature Aquifer Thermal Energy Storage development. Oral presentation.

Hahn, F. et al. (2020) The reutilization of a small coal mine as a Mine Thermal Energy Storage. Oral presentation.

Kallesøe, A.J. et al. (2020) HEATSTORE – underground Thermal Energy Storage (UTES) – State of the Art, Example Cases and Lessons Learned. Oral presentation.

Koornneef, J. et al. (2020) HEATSTORE Project Update: High Temperature Underground Thermal Energy Storage. Oral or poster presentation, to be determined.

Mindel, J.E. & Driesner, T. (2020) HEATSTORE: Preliminary design of a High Temperature Aquifer Thermal Energy Storage (HT-ATES) system in Geneva based on TH simulations. Oral or poster presentation, to be determined.

Rey, C. et al. (2020) Modelling of an innovative HT-BTES(smart) design with lateral recovery boreholes to reduce heat losses: development and preliminary result. Oral or poster presentation, to be determined.

Sohrabi, R., Valley, B. (2020) Thermo-Hydraulic-Mechanical (THM) Experiments and Numerical Simulations to Quantify Heat Exchange Characteristics of Fractured Limestone Reservoirs for Aquifer Thermal Energy Storage (ATES). Oral or poster presentation, to be determined.

Tómasdóttir, S. et al. (2020) Possible seasonal injection of surplus hot water from the Hengill Area into a low temperature system within Iceland's capital area. Oral presentation.

Media visibility

This section summarizes news reports in the media per country.

Europe

European Association for Storage of Energy website report entitled *Underground thermal energy storage facilitates the low-carbon transition of the heating and cooling sector* published on 1 Jan. 2018 about the HEATSTORE project (Link).

Belgium

www.energiesparen.be website report entitled *Extra steun voor onderzoek naar diepe aardwarmte* on 15 June 2018 (in Dutch; Link).

www.architectura.be website report entitled *Zomerwarmte opslaan om in de winter te gebruiken* published on 10 October 2018 (in Dutch; Link).

Denmark

www.energiforskning.dk website report entitled *Højtemperatur varmelagring i undergrunden* (in Danish; https://energiforskning.dk/da/project/heatstore-hoejtemperatur-varmelagring-i-undergrunden).

www.planenergi.dk website report entitled *PlanEnergi deltager sammen med GEUS i EU GEOTHERMICA projektet HEATSTORE* (in Danish; http://planenergi.dk/arbejdsomraader/internationale-arbejdsomraader/heatstore/).

www.geus.dk website report entitled *Grøn omstilling: Snart kan vores varme være geotermisk* (in Danish; https://www.geus.dk/om-geus/nyheder/nyhedsarkiv/2018/dec/geotermi/).

Germany

Geothermische Energie journal report (ed. 93) by the "Bundesverband Geothermie" published in Sep. 2019 (in German).

The Netherlands

Energeia published an online article entitled *Ondergrondse thermosfles vor seizoensopslag aardwarmte tuinders* on 30 Oct. 2019 (in Dutch, Link).

In **Noordhollands Dagblad** an article entitled *Project grootschalige opslag warmte van ECW in Middenmeer grootste in Europa* published on 23 Oct. 2019 (in Dutch, Link).

In the **ThinkGeoEnergy** Newsletter of 9 Sept. 2019, the HEATSTORE deliverable report 'Underground Thermal energy Storage (UTES) – state-of -the-art, example cases and lessons learned' is discussed and promoted.

HEASTORE is mentioned in the **Dutch national climate agreement** (in Dutch: Het Klimaatakkoord), released on 28 June 2019. In Chapter C1.11 'More sustainable heat' under d) Development & innovation agenda, the report says: "Additionally to the European project HEATSTORE, the heat sector engages in the development of seasonal high temperature storage".

Cobouw website report entitled *TNO: 'Prijs warmtenetten halveren met bodenwarmte'* published on 11 Oct. 2018 (in Dutch; Link).

Engineeringnet website report entitled *Europees consortium demonstreert ondergrondse seizoensopslag zomerwarmte* published on 11 Oct. 2018 (in Dutch; Link).

Utilities website report entitled *Doel: 20 procent minder kosten voor opslag en gebruik zomerwarmte* published on 4 Oct. 2018 (in Dutch; Link)

FluxEnergie.nl website report entitled *Schaalvergroting voor bodemopslag warmte in Kop van Noord-Holland* published on 4 Oct. 2018 (in Dutch; Link).

Vlaanderen is energie website report entitled *Extra steun voor onderzoek naar diepe aardwarmte* published on 15 June 2018 (in Dutch; Link).

Portugal

IVAR website reports the HEATSTORE project highlighting the main objectives of the national project (in Portuguese; http://www.ivar.azores.gov.pt/Paginas/all-projects.aspx?cy=:).

IVAR website reports that *IVAR participa em projet europeu que pretende desenvover tecnologias para armazenar calor no subsolo*, published on 10 October 2018 (in Portuguese; http://www.ivar.azores.gov.pt/noticias/Paginas/20181010-geothermica.aspx).

Correio dos Açores newspaper reports *Os Açores vão ser caso de estudo de criação de tecnologias para armazenar calor no subsolo*, published on 11 October 2018 (page 9, in Portuguese).

Switzerland

Geotermia Svizzera website report entitled *Stockage thermique à haute température dans les aquifères profonds*, published on 10 October 2018 (in French, Link).

Geothermie Suisse website report entitled *Le premier rapport HEATSTORE à été publié*, published on 24 September 2019 (in French, Link).

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