HEATSTORE
Monitoring data availability of the UTES demonstration projects and case studies, status 2021

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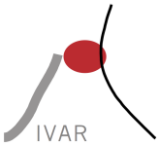
Please cite this report as: Oerlemans, P.J.A. (ed.) 2021: Monitoring data availability status of the UTES demonstration projects and case studies 2021. HEATSTORE project report, GEOTHERMICA – ERA NET Cofund Geothermal. 12 pp.

This report represents HEATSTORE project deliverable number D5.2.



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.

Document Change Record

This section shows the historical versions, with a short description of the updates.

Version	Short description of change
2021.10.08	Final overview in draft
2021.10.18	Final version
2021.10.25	Final edited version

Table of Content

1 Introduction

Status overview of the available Monitoring data from UTES systems
The monitoring activities that were originally planned at the HEATSTORE UTES Case studies and Demonstration projects were described in report D5.1 (Hahn et al., 2019). Since the start of HEATSTORE, monitoring activities have been performed at the Case studies, and the Demonstration projects have (partially) been realized and monitored. Over the last three years this has resulted in several monitoring datasets from the various UTES systems.
This document offers an overview of the monitoring data that has become available at the various UTES sites of the HEATSTORE project, up to the summer of 2021. For future research to UTES systems, one can see in this overview which monitoring data is planned or has already become available over the last years, which may contribute to the research objectives.

Contributors
The HEATSTORE partners that contributed to the data are listed in the appendix.

More in-depth reports on monitoring
Note that the data itself is not included in this report. However, also within work package 5.2, two individual reports have been delivered, reporting on the monitoring data acquired at two HEATSTORE sites:
1. The HT-ATES Case Study at NIOO in Wageningen, the Netherlands;
2. The HT-ATES Demonstration site in Geneva, Switzerland.

Additionally, monitoring data on environmental effects of the HEATSTORE case studies on the subsurface, as well as modelled predictions for some Demo projects, are described in greater detail in HEATSTORE report D6.6.

All of these reports can be found on the HEATSTORE website (www.heatstore.eu).

2 Monitoring data availability status

Below, the status of the monitoring data availability is shown in tables for the various UTES sites. For each project, the upper row describes the original monitoring plan (according to D5.1) and the second row shows the data that has actually become available up to the summer of 2021.

2.1 HT-ATES systems

HT-ATES systems		Pressure		Temperature		Flowrate		Water analysis		Bacteria		Monitoring well(s)		Specific tests	InSAR	Micro seismic	Other monitoring	Notes
Koppert-Cress (NL)	Plan (D5.1)	Y	hourly	Y	hourly	Y	hourly	Y	3-months	N		Y	Temp-profile		N	N	n.a	n.a
	Data available 2021?	N	-	Y	5min	Y	5min	N	-	N	-	Y	3hrs	-	-	-	-	-
NIOO (NL)	Plan (D5.1)	Y	8 min	Y	8 min	Y	8 min	Y	6-months	Y	Analysed every 6-months	Y	Temp-profile		N	N	n.a	n.a
	Data available 2021?	Y	8 min	Y	8 min	Y	8 min	Y	6monthly + extra samples	Y	6monthly + extra samples	Y	Temp-profile, water samples				Camera-inspection of wells	All available monitoring data was discussed in the separate 'NIOO Case Study Report' (D5.2)
ECW (NL)	Plan (D5.1)	*Monitoring plan of HTATES at ECW was not described in D5.1*															n.a	n.a
	Data available 2021?	Y	8 min	Y	8 min (wells), Daily (monitoring well)	Y	8 min	Y	3 months	Y	REF, yearly	Y	Temp-profile, water samples	pH, CO2-dosing, well tests, sand production tests			Continuous monitoring of pH	
Geneva (SWI)	Plan (D5.1)	Y		Y		Y		Y		N		Y		Well test	Y	Y	n.a	n.a
	GE0-01		real time during production tests		real time during production tests		real time during production tests		some months, depeding on advancement of production tests			Y	T-P measures before and during ongoing production tests		Y	Y	Ground deformation (GPS-Tilt meters)	This status applies to well 'Geo-01'. For well 'Geo-02', data is available upon request.
Bern (SWI)	Plan (D5.1)	Y	min/hr	Y	min/hr	Y	min/hr	Y	Regularly	Y	Regularly	Y	Temp-profile	Well test	Y	N	n.a	n.a
	Data available 2021?	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	drilling delayed due to safety shortfalls at drilling company.

2.2 LT-ATES systems

Although delivering monitoring data from LT-ATES systems was originally not included in D5.1 and D5.2, GEUS has provided the status of the monitoring data availability of various LT-ATES systems in Denmark, as shown below.

LT-ATES systems		Pressure (Waterlevel)		Temperature		Flowrate		Water analysis		Bacteria		Monitoring well(s)		Specific tests	InSAR	Micro seismic	Other monitoring	Notes
Bjerringbro (ATES A/S)	Plan (D5.1)																	
	Data available 2021?	Y	2 sec	Y	2 sec	Y	2 sec	Y	Yearly	N		N			N	N	n.a	n.a
Rambøll, Ørestad (Rambøll/ISS)	Plan (D5.1)																	
	Data available 2021?	Y	2 min	Y	2 min	Y	2 min	Y	Yearly	N		Y	Waterlevel and temp (hourly)	Conductivity	N	N	n.a	n.a
Crown Placa Hotel (Enopsol)	Plan (D5.1)																	
	Data available 2021?	Y		Y		Y		N		N		N		Energy balance	N	N	n.a	n.a
Bispebjerg Hospital (Enopsol)	Plan (D5.1)																	
	Data available 2021?	Y		Y		Y		N		N		N		Energy balance	N	N	n.a	n.a

2.3 MT-ATES systems and Geothermal Doublets

HT-MTES systems		Pressure		Temperature		Flowrate		Water analysis		Bacteria		Monitoring well(s)		Specific tests	InSAR	Micro seismic	Other monitoring	Notes
Markgraf II (DE)	Plan (D5.1)	Y	min/hr	Y	min/hr	Y	min/hr	Y	3-months	N		Y	Temp-profile	Well test & tracer test	N	Y	n.a	n.a
	Data available 2021?	Y	30 min	Y	30 min	Y	Not in Digital Format (5.8 m^3/h constant flow rate during heat injection)	Y	monthly	Y	before/after heat injection	Y	Y	Y			Full Chemical water analyis of the MTES Wells before and after heat injection;	dataset of fiber optic cable in the MTES Boreholes (46.556 measurements available); also data from drilling and geophysical logging

Deep doublet		Pressure		Temperature		Flowrate		Water analysis		Bacteria		Monitoring well(s)		Specific tests	InSAR	Micro seismic	Other monitoring	Notes
Mol (BE)	Plan (D5.1)	Y	min/hr	Y	min/hr	Y	min/hr	Y	Regularly	N		N		Well test & tracer test	N	N	n.a	n.a
	Data available 2021?	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Hengill area (IS)	Plan (D5.1)	Y	2 weeks	Y	2 weeks	Y	2 weeks	Y	2 weeks	N		Y	Temp-profile	Well test & tracer test	N	Y	n.a	n.a
	Data available 2021?	Y	10 min	Y	6 months	Y	6 months	Y	6 months	N		Y	Temp/pressure profile	Well test & tracer test	N	Y		The table refers to individual well measurements. The every six months measurements are tracer fluid tests that give information about enthalpy and flow, they are used to construct and improve productivity curves so that the flow in each well can be continuously estimated from the pressure which is measured every 10 min.
Reykir area (IS)	Plan (D5.1)	Monitoring plan of Reykir area was not described in D5.1																
	Data available 2021?	Y	2 weeks	Y	2 weeks	Y	2 weeks	Y	Yearly	N		Y	10 min interval measurements for water level in 3 monitoring wells plus hourly values for water level in 2 additional wells	Quality control measurements (H_2S and O_2) in distribution system every 2 weeks	N	N		The table refers to individual well measurements.

2.4 PTES systems

HT-PTES systems		Collector pressure		Temperature			Flowrate		Profile		Water level in storage	Other monitoring	Notes
Marstal (DK)	Plan (D5.1)	Y	10 min	Y	30 min	Various locations : inside & outside	Y	Heatflux : 10 min	Y	Every 0.5 m	Y	n.a	n.a
	Data available 2021?	N		Y	60 min	In/oulet to top/mid/bottom pipes	Y	60 min	Y	Every 1m (16 sensors, but top one not always in water)	N		Data available from 30/05/2020 12:00 to now (the new measured data is available from the moment where the new lid solution has been installed and properly connected), with a missing set from 30/04/2021 12:00 to 14/07/2021 16:00 (lightning strike shut down the SCADA system)
Dronninglund (DK)	Plan (D5.1)	Y	10 min	Y	30 min	Various locations : inside & outside	Y	Heatflux : 10 min	Y	Every 0.5 m	Y	n.a	n.a
	Data available 2021?	Y	10 min	Y	10 min	Inside + air temperature	Y	10 min	Y	Every 0.5 m	N	Flow and temperatures in the pipes to the 2 solar collector fields and the transmission lines to the city	Data available until 01/04/2021 00:00

2.5 BTES systems

HT-BTES systems	Collector pressure			Temperature			Flowrate		Monitoring well(s)		Humidity in cover	Solar radiation	Air temp.	Wind speed	Other monitoring	Notes
Braestrup (DK)	Plan (D5.1)	Y	10 min	Y	30 min	each line & global	Y	Heatflux : 10 min	Y	Temp-profile (probes) : 30 min	Y	Y	Y	Y	n.a	n.a
	Data available 2021?	N		Y	5 min	Inlet-outlet to BTES	Y	5 min	Y	5 min	N	N	N	N	N	Data (probably) available but not usable since the BTES is not in operation
BETSmart (FR) Site changed to Annecy	Plan (D5.1)	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	n.a	n.a
	Data available 2021?	N		Y	15 min	Inlet-outlet to BTES	Y	15 min	Y	20 min	N	N	Y	N	N	No data available yet. First boreholes drilled in August, data expected Autumn 2021 .

3 References

For more detailed information on the monitoring results at the various studied UTES sites, it is referred specifically to the reports delivered within D5.2 and D6.6, which can be found on the HEATSTORE website (www.heatstore.eu).

4 Appendix

UTES Type	Research type	Site name	Location	HEATSTORE Partners involved
HT-ATES	Case Study	Koppert-Cress	Monster, the Netherlands	KWR
HT-ATES	Case Study	NIOO-KNAW	Wageningen, the Netherlands	NIOO-KNAW
HT-ATES	Demonstration site	ECW	Middenmeer, the Netherlands	ECW Energy, IF Technology, TNO
HT-ATES	Demonstration site	Geneva Geo-01 and Geo-02	Geneva, Switzerland	UniGe, UniBe, UniNe, ETHZ, SIG*
HT-ATES	Demonstration site	Geospeicher Forsthaus	Bern, Switzerland	UniBe, ETHZ, UPC*
BTES	Case Study	Braestrup	Braestrup, Denmark	GEUS*
BTES	Demonstration site	BTESmart	Annecy, France	STY*, BRGM
MTES	Demonstration site	IEG colliery	Bochum, Germany	Fraunhofer IEG (former GZB)
PTES	Case Study	Marstal	Marstal, Denmark	GEUS*, PlanEnergi
PTES	Case Study	Dronninglund	Dronninglund, Denmark	GEUS*, PlanEnergi
Geothermal	Case Study	Reykir	Hengill, Iceland	OR*
Geothermal	Demonstration site	Vito	Mol, Belgium	VITO*
Geothermal	Case Study	Caldeiras da Riberia Grande	Azores, Portugal	IVAR*

* for some partner names, a (non-official) abbreviation was used within the HEATSTORE program: SIG = Services Industriels de Geneve, Switzerland. UPC = Universitat Politècnica de Catalunya, Spain. GEUS = Geological Survey of Denmark and Greenland, Denmark. STY = Storengy, France. OR = Reykjavik Energy, Iceland. VITO = Flemish institute for technological research, Belgium. IVAR = de Investigação em Vulcanologia e Avaliação de Riscos, Portugal.