High Temperature Borehole Thermal Energy Storage (HT-BTES)

GENERAL DESCRIPTION

Mode of energy intake and output

- Heat-to-heat
- Power to heat

Storage process

Borehole thermal energy storage is typically used at lower temperatures, somewhere between 4°C and 20°C, to provide heating and/or cooling at smaller scales. Ground source heat pump can use these lower temperatures to provide heating more efficiently than air source heat pumps. High-Temperature Borehole Thermal Energy Storage (HT-BTES) makes use of the same technology to store much higher temperatures, up to 95°C.

HT-BTES is designed more specifically for large-scale heat storage applications. It consist of a network of boreholes drilled into the ground, each serving as a thermal energy charging and recovery point. A tube in each borehole allows heat transfer fluid to store and release thermal energy as needed. Water is typically used as a heat transfer fluid for HT-BTES. The boreholes are typically between a few dozen up to 150 meters deep. Deeper holes can be drilled, but the thermal losses would increase as the relative surface area of the heated soil increases.

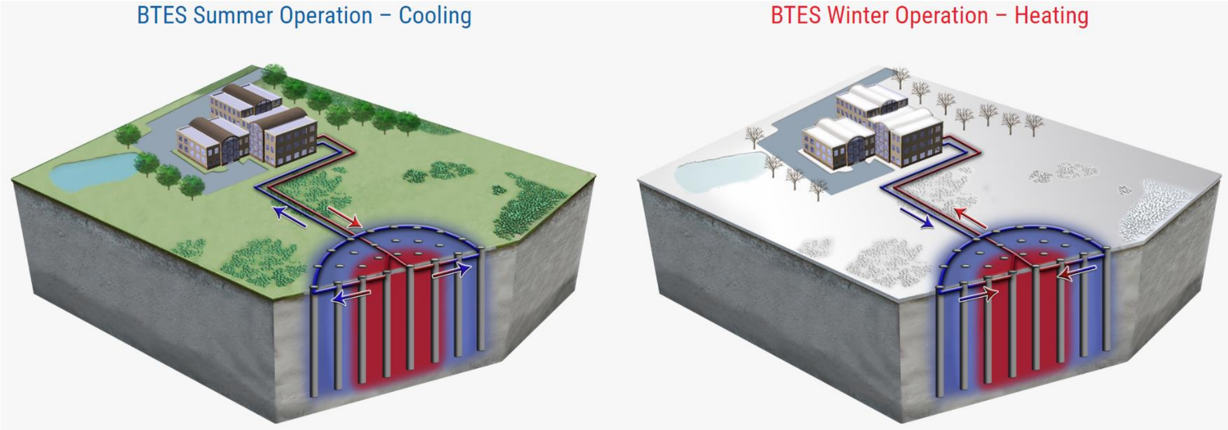

Figure 1: Schematic impression of HT-BTES

The efficiency of HT-BTES evolves over time, with a startup process lasting 3–4 years. During this initial period, the storage efficiency is comparatively low as the surrounding ground material requires time to reach optimal thermal conditions, contributing to enhanced long-term performance.

The successful implementation of HT-BTES depends on the local geological conditions. The ground must be drillable, possess high heat capacity, and high thermal conductivity. Additionally, low hydraulic conductivity and minimal natural groundwater flow are essential for optimal system performance.

Figure 2: Building site of BTES system at the municipality of Drammen, Norway

An important benefit of HT-BTES is that the surface above it can be used after implementation of the borehole system. It does however limit the use of the subsurface in that particular area.

Fields of application

HT-BTES is typically used where there is a seasonal source of excess heat, typically in summer months. Possible sources are for example waste heat, solar collectors, power to heat, and geothermal heat.

A HT-BTES can also function as a balancing buffer when there is a local excess of sustainable electricity.

Technology readiness level (TRL)

4-9

State of development / commercial availability

HT-BTES has successfully been applied for decades. It is however more costly than fossil alternatives and it therefore has only come up as a commercially viable alternative heat source in recent years.

Topics with demand for R&D (TRL 4 and above) are cost reduction, increasing efficiency, and implementation in various heating networks. Medium-deep storage systems of 500 – 1,000 m depth for increased storage temperatures, smaller surface foot print and reduced impact on shallow groundwater are being tested currently, but require cheaper drilling technologies as well.

TECHNICAL SPECIFICATIONS

	HT-BTES
Temperature range	5°C – 97°C
Maximum output power range	100 – 1.500 kW
Operating range	10% – 100%
Storage size	100 – 2.100 MWh

Discharge Time	Daily - seasonal
Service life	Multiple decades
Response Time	minutes
Storage efficiency	40-90%
Specific energy storage density	10 – 70 kWh/m^3

ECONOMIC SPECIFICATIONS

Specific investment costs of HT-BTES systems are between 0,6 and 3 €/kWh

Operating and maintenance costs

The operating and maintenance costs are between 2% and 8% of the total investment costs.

FURTHER INFORMATION

- Giordano N, Comina C, Mandrone G, Cagni A. Borehole thermal energy storage (BTES). First results from the injection phase of a living lab in Torino (NW Italy). Renew Energy 2016;86:993–1008. https://doi.org/10.1016/j.renene.2015.08.052
- Gao L, Zhao J, Tang Z. A review on borehole seasonal solar thermal energy storage. Energy Procedia 2015;70:209–18. https://doi.org/10.1016/j.egypro.2015.02.117
- Walch A, Mohajeri N, Gudmundsson A, Scartezzini J-L. Quantifying the technical geothermal potential from shallow borehole heat exchangers at regional scale. Renew Energy 2021;165:369–80. https://doi.org/10.1016/j.renene.2020.11.019