Low-Temperature Sensible Heat Storage

Storage Principle

In sensible heat storage, thermal energy is stored in a temperature change of the heat storage medium. The amount of stored heat is directly proportional to the change of the temperature.

Water is one of the most common mediums used in low-temperature thermal energy storage (TES). The range of low-temperature sensible heat storage can thus be generally defined as the temperature interval in which water exists in the liquid state at barometric pressure (0 °C – 100 °C). Most of the materials used for low-temperature sensible heat TES are inexpensive, non-toxic and recyclable.

Low-temperature sensible heat TES systems have generally very high Technology Readiness Levels (TRLs). Some of the technologies have been in use for decades. The most common methods of low-temperature sensible heat TES are heat storage tanks, water pit storage, aquifers and boreholes. The thermal mass of building structures can be utilized for heat and cold storage in built environments.

Power to heat has become another important application of low-temperature sensible heat TES given the rapid development of renewable power generation.

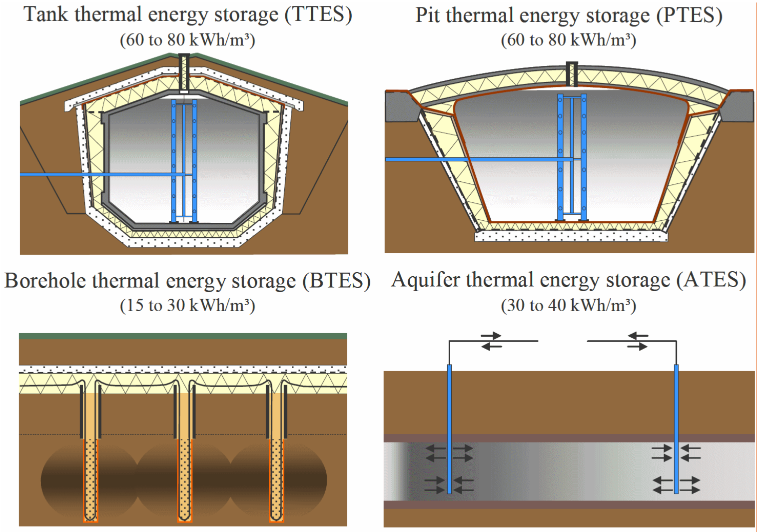

Figure 1. Methods of sensible heat thermal energy storage [1]

Figure 2. Thermal energy storage tank under construction [2]

Technical Characteristics

Power range (MW): 0 to > 20

Feasible size (MWh): small-scale (kWh-range) to over 10,000

Energy density (kWh/m^3): 15 – 80[1]

Response time (min.): < 1

Technical lifetime (y): > 20

Temperature range (°C): 0 - 100

Maturity

Worldwide use: widespread

Installation costs (€/kWh): as low as 0.5

Technology readiness level: 9

Challenges in development

- Reduction of heat losses
- More efficient heat exchangers
- Improvement of lifespan

Potential of technology

- High TRL
- Low capital costs per kWh
- Affordable and safe storage media
- Versatility and flexibility

Barriers

- Low energy density
- Suitable locations for large-scale TES

Common Applications

- Domestic hot water heating
- District heating and cooling
- Solar thermal heating plants
- Building heating and cooling systems
- Industrial process applications

Figure 3. Chilled water storage tank [3]

Example Applications

1. District heating and cooling

It is estimated that by 2050 more than 80 percent of Europe's population will live in urban areas [4]. Urban areas are particularly suitable for installation of district heating and cooling networks. Since the demand for heating and cooling changes during the day and throughout the year, thermal energy storage will have to be integrated with these systems for energy-efficient operation. Water heat storage tanks, water pit storage as well as aquifer and borehole storage are suitable for use in district heating and cooling systems.

Figure 4. District heating CHP plant with 5500 m^3 water heat storage.

2. Low-temperature solar thermal systems

Most solar thermal systems need TES to operate efficiently. Small residential solar thermal systems mostly employ water tank TES. Packed rock beds can be used in solar air heating systems. A variety of TES system exists for central solar plants. These include water tanks, pit storage, aquifers and boreholes. A new world's largest solar heating plant is commissioned almost every year and thus the demand for low-temperature sensible heat storage in solar thermal systems is increasing.

Figure 5. Solar heating plant and pit storage [5].

3. Buildings

Due to the number of TES system installations, the building sector represents the most common application of low-temperature sensible heat TES. Water tank storage systems are used in domestic hot water heating, hydronic space heating and chilled water air-conditioning systems. The thermal capacity of building structures can also be employed for TES. Boreholes under a building can be used for rejection of heat from air-conditioning systems in summer and as a heat source for heat pumps in winter.

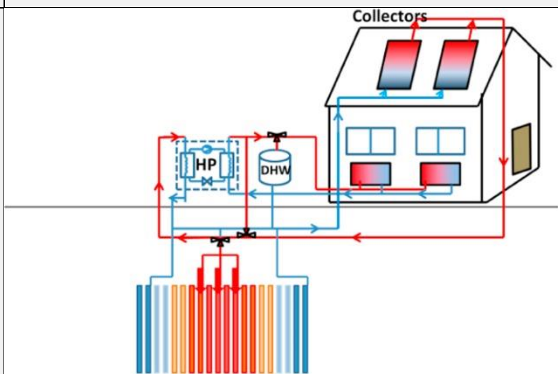

Figure 6. Borehole thermal energy storage [6].

References

1. D. Mangold & T. Schmidt, 2009.
2. Austin Energy, accessed July 2018.
3. Araner, accessed July 2018.
4. United Nations, 2015.
5. Ramboll, accessed July 2018.
6. A, Hesaraki et al., 2015.

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