# High Temperature Tank Thermal Energy Storage (HT-TTES)

## GENERAL DESCRIPTION

### Mode of Energy Intake and Output

- Heat-to-heat
- Power to heat

### Summary of the Storage Process

Tank Thermal Energy Storage (TTES) encompasses a wide range of systems designed for storing and retrieving heat using tanks. The focus of this factsheet is the implementation of large scale sensible TTES with water as its medium, starting at 100 MWh total capacity. Some other notable innovative forms of heat storage with tanks are: molten salt heat storage, phase change material storage, thermochemical storage.

TTES is often used for hourly or daily cycles, but recent developments also allow for large tanks to be used for seasonal storage, mainly for residential buildings. Most often tanks are installed above ground, as it limits investment costs and makes for easier maintenance. The tanks can also be installed below ground. Despite the higher cost, it can be a viable alternative, as the space above the tank can then be used for a different purpose, and it has a limited to no visual impact.

The most common internal design is where the storage medium is directly extracted from the tank. This allows for high flow of the medium at its highest available temperature. The natural stratification of the water will allow for a relatively long extraction period at temperatures close to the loading temperature. To maintain good stratification, the diffusers need to provide laminar inlet flow and the tank needs to be sufficiently high.

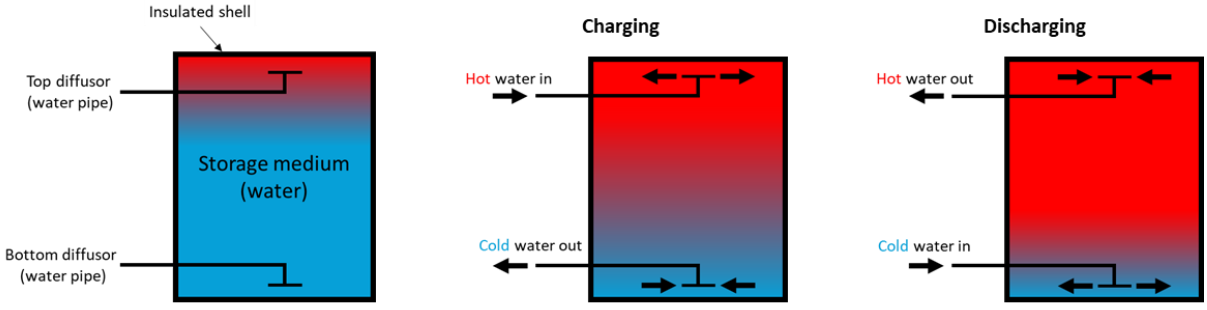


Figure 1: Illustration of a TTES charging and discharging process.

For specific applications, it is also possible to transfer heat in and out of a tank with heat exchangers, spread out over the height of the tank. This kind of compromise is made when mixing of the storage medium and the secondary medium is undesirable, for example when there are issues with pressure, or chemical composition. The thermal cost will be a drop in temperature between loading and unloading between 8°C and 10°C. Some tanks can be equipped with a heating element when the higher temperatures are required.

Figure 2: Inside of large 55.000 m³, 200 MW tank for Vattenfall heating network in Berlin

### Suitable Fields of Application:

There is a very wide range of applications. Tank storage is the most mature of all large thermal storage technologies. Here is a short, but not exhaustive list of possible applications:

- Day/night buffering for large district heating systems
- Seasonal storage for small scale residential networks
- Balancing buffer when there is a local excess of sustainable electricity
- Versatile applications in power plants for load balancing and grid stability
- Industrial processes requiring variable temperature heat inputs

### Technology-Readiness-Level (TRL):

9

### State of Development/Commercial Availability

TTES has been commercially used in various applications, including district heating, greenhouses, power plants and industrial processes (TRL = 9).

Ongoing research and development efforts focus on diverse niche applications, like tanks for pressurized high temperature networks, or for local seasonal heat storage.

### TECHNICAL SPECIFICATIONS

These technical specifications are derived from projects that either already exist, or projects that have considered feasible by experts.

| | HT-TTES |
|---|---|
| Temperature range | 10°C – 120°C |
| Maximum output power range | 10 – 1000 MW |
| Operating range | 10% – 100% |
| Storage size | 100 – 3.000 MWh |
| Discharge Time | Hourly – daily - seasonal |

| | |
|---|---|
| Service life | Multiple decades |
| Response Time | minutes |
| Storage efficiency | 65-95% |
| Specific energy storage density | 40 – 100 kWh/$m^3$ |

## ECONOMIC SPECIFICATIONS

The specific costs range between 2 and 20 €/kWh.
The specific investment costs for tank storage vary strongly, depending on the requirements of the application. Temperatures, pressures, required power, total volume and location all can significantly affect the costs.

### Operating and maintenance costs

This depends strongly on the type of storage and the application. The relative annual O&M costs are between 0,5% and 5% of the investment costs.

## FURTHER INFORMATION


- Mather DW, Hollands KGT, Wright JL. Single- and multi-tank energy storage for solar heating systems: fundamentals. Sol Energy 2002;73(1):3–13; https://doi.org/10.1016/S0038-092X(02)00034-8
- Dickinson RM, Cruickshank CA, Harrison SJ. Charge and discharge strategies for a multi-tank thermal energy storage. Appl Energy 2013;109:366–73. https://doi.org/10.1016/j.apenergy.2012.11.032