Danish Energy Agency

Technology Brief

New chapter on Long term energy storage in the Technology Catalogue

(Feb 2025)

The Danish Energy Agency has published an updated chapter on Large thermal energy storage as part of the energy storage Technology Catalogue. The chapter has undergone an overhaul, based on recent projects. It has been renamed from seasonal heat storage, to reflect the new role it has been seen to play in the energy system.

The updated chapter provides an updated economic and technical data on one technology, PTES, as well as more examples different technologies.

This chapter provides a detailed overview and comparison of large-scale thermal energy storage (LTES) technologies, particularly for district heating applications. It focuses on four types of thermal storage: Pit Thermal Energy Storage (PTES), Borehole Thermal Energy Storage (BTES), Aquifer Thermal Energy Storage (ATES), and Tank Thermal Energy Storage (TTES). It also includes key data for eight PTES projects completed in Denmark between 1995 and 2022, as well as three for BTES, and one ATES project.

Major changes in the datasheet for PTES

The datasheet on PTES contains important changes:

- Input and output capacity are expected to increase for future installations, up to 200 MW, rather than remaining static at 30 MW.
- Round trip efficiency increased from 70% to 80%.

80% is the total efficiency during a one year cycle, including losses during the storage period, which is very depended on the operation of the storage. E.g. if the yearly efficiency is 80% with one cycle, the same storage will have a yearly efficiency of 90% with two cycles. There are examples of 70% efficiency for seasonal storage without heat pump, up to 90% seasonal with heat pump, and up to 95% efficiency in the short term.

- Specific investment increased by around 90%, based on five projects, including the realized prices from the completion of the site in Høje Taastrup. This is primarily due to higher quality and lifetime.

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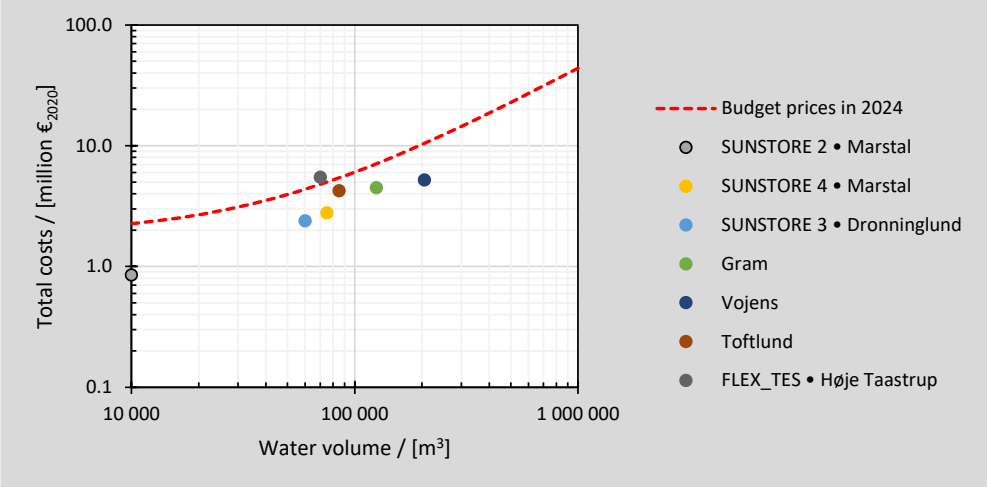
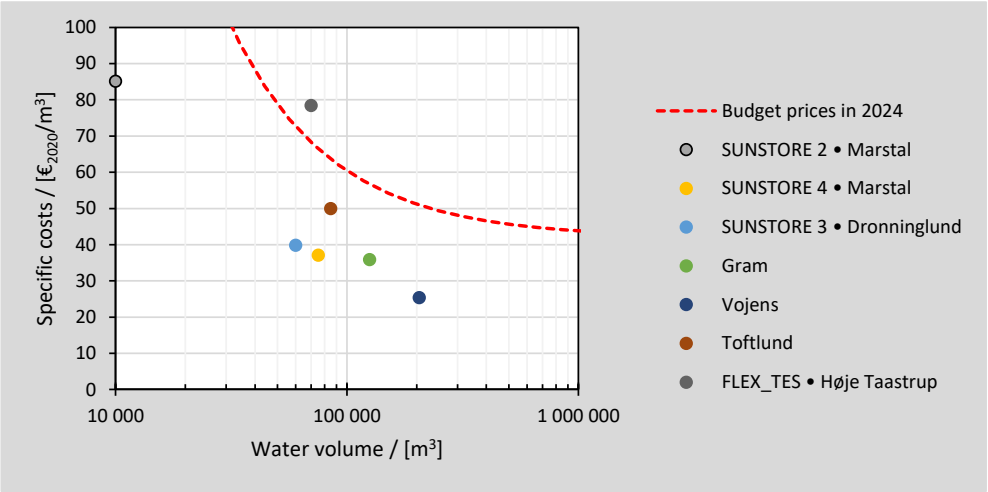
- Fixed O&M down 19%, based on observed data from new projects. This is set according to capacity of the energy storage specified in the data sheet, corresponding to approximately 28,000 €/facility/year for e.g. divers for inspection, repairing possible leakages and minor fixes.

The construction time has been increased to 2 years, excluding extensive planning phase with possible Environmental Impact Assessment etc. Careful timing of steps is necessary. Depending on the storage size the steps of excavation, building, installation of liners etc. can be done within one summer. For very large volumes, the water filling phase can take several months (depending on the filling speed) and filling should preferably be scheduled during the winter. A construction time of approx. 2 years for very large storages is not unrealistic.

Economies of scale

PTES are characterized by a significant effect of economy of scale as illustrated in the figure below. The economy of scale is due to the fact that the volume (and therefore the energy capacity) scales with the linear dimensions to the power of 3, whereas the materials and the installation of these only scales with the surface area, which have linear dimensions to the power of 2. The soil works scales with the linear dimensions to the power of approx. 2.8.





Current and Future Development

- PTES has a proven track record and is in widespread use in Denmark, with improvements expected in the development of high-temperature-resistant liners and other components.
- BTES is in the early demonstration phase but shows potential for use in Denmark.
- ATES is well-established in countries like Sweden and the Netherlands but remains a niche technology for district heating in Denmark.
- Ongoing work is focused on improving materials like liners for PTES, expanding the use of ATES in district heating, and improving modeling techniques for more accurate system planning and integration.

Conclusion

Large-scale thermal energy storage offers a range of options depending on site conditions, temperature requirements, and desired efficiency. PTES, in particular, stands out for its scalability and cost-effectiveness, especially in Denmark, while ATES and BTES offer specialized solutions with their own unique advantages and challenges. Research is ongoing to improve efficiency, expand capacity, and reduce costs.