Design Aspects for Large-Scale Aquifer and Pit Thermal Energy Storage for District Heating and Cooling

Pit Thermal Energy Storage (PTES)

Per Alex Sørensen
PlanEnergi, Denmark
Investment cost analysis presented in review report

**Investment cost** per m³ water equivalent [€/m³ WE]

**Storage volume in water equivalent** [m³ WE]

---

**Graph: Solites**
The Danish PTES Storage concept

**Original objective:** To develop cheap thermal storages >50,000 m³ for high solar thermal fractions. That means:

- Soil balance
- Polymer solutions
- Floating lid
- Insulation only in lid
- Water as storage medium

**Present objective:** to use the storages at 90 °C constantly in 20-30 years
Why use the Danish PTES concept?

**Advantages:**
- Quick charging and discharging. Can be used as peak shawer
- Can be utilized also as short time storage
- A closed construction
- Water as storage medium means good stratification and high thermal capacity/m$^3$
- The same storage can be used as hot water and cold water storage at the same time because it is possible to have cold water in the bottom and hot water in the top due to the inherent stratification
- Relatively low construction cost where suitable ground conditions exist

**Disadvantages:**
- Land area required can be difficult to find in urban centres
- Lifetime of liner material and lid construction still being demonstrated
- Higher construction costs in areas having high ground water levels and where excavated soil is not suitable for use in the bank construction
- Maximum temperature 90 °C, due to liner material properties.
PTES Project Example Dronninglund, Denmark

Name of the project: Sunstore 3. In operation from 2014
Location: 9330 Dronninglund, Denmark
Owner: Dronninglund Fjernvarme
Size of storage: 60,000 m³
Smart District Heating combining heat generation with solar thermal, CHP and heat pumps

Graph: PlanEnergi

Photo: Dronninglund Fjernvarme
Monitoring results 2018-19

\[ Q_{in} \%: 90 \quad \text{Sum} \%: 100 \quad -Q_{out} \%: 94 \]

\[ -dQ \%: 10 \quad -Q_{loss} \%: 6 \]
Temperature stratification 2018-19

Dronninglund 2018-2019
Temperatures - monthly mean values

°C


Tbottom  Ttop  Tmean  Linear (Tbottom)
Data for Dronninglund

- Volume: 60,000 m³ water
- Max capacity: 5,400 MWh ($T_{\text{max}}$ 89 °C and $T_{\text{min}}$ 12 °C)
- Thermal losses/capacity: 19 % (Thermal losses 1020 MWh in 2016, capacity 5,400 MWh)
- Investment: 2.3 mio. € or 38 €/m³
- Investment/capacity: 0.43 €/kWh
- Max charge/discharge capacity: 27 MW
- Investment/max charge capacity: 85 €/kW
Design aspects, polymer liners

Polymer liners (PP or HDPE). Be aware of:

- Moisture diffusion
- Oxygen diffusion
- Lifetime exposed to water and to air
- Price for liner and mounting
- Welding and testing procedures for leakages during mounting
- Guarantees
- Repairs during operation period
Design aspects, insulation

Insulation material. Be aware of:

- Moisture resistance and possible regeneration from wet
- Thermal expansion
- Pressure resistance
- Price for insulation and mounting
- Guarantees
- Possible to repair during operation?
Design aspects, lid

Lid. Be aware of:

- How to get rid of rain water and avoid ponds on the lid
- How to get rid of air produced when heating up PTES water
- Moisture ventilation
- Oxygen diffusion to PTES
- Thermal expansion
- Price for materials and mounting
- How to repair during operation
Design aspects, water quality and in- and outlet

Water quality and quality of in- and outlet. Be aware of:

• Water must be softened
• Salts must be removed (reverse osmosis)
• Water quality (salts, oxygen, conductivity) must be frequently monitored and
• In- and outlet must be in non-corrosive materials if water contains oxygen (stainless steel was used in Dronninglund)
New projects in Denmark. 90 °C constantly

Høje Taastrup 70,000 m³
- Liner work in Høje Taastrup is expected to be finalized in July 2020 and the storage will be ready 1st September 2021

Aalborg
- Call for tender September 2020. 2x 500,000 m³

Odense
- Call for tender end of 2020. 450,000 m³ and 550,000 m³
Thank you for your attention!

Contact: Per Alex Sørensen
pas@planenergi.dk
www.planenergi.dk