
BobSol
Bobach
Solutions
- Engineering for a sustainable future -
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Bobach Solutions

- Consultancy and Engineering services
- Specialties within:
  - Renewable Energy Systems – Simulation, Planning, Design
  - Large Scale Thermal Energy Storages – Product Development, Simulation, Planning, Design, Implementation
  - Large Scale Solar Thermal Plants
  - Large Scale Heat Pumps
  - District Heating Systems
  - Project Management
- Company Fundamentals:
  - High Proffesionality
  - Quality
  - Trustworthy

Company Introduction

Morten Vang Bobach – Founder, Engineer MSc

- Extensive experience
  - 6 years as mechanical design engineer at production company
  - 6 years as project engineer and project mangager at consultant company
  - 6 years as technical specialist and manager at engineering and construction company
- Selected projects:
  - Planning and/or design and implementation of several pit thermal energy storages
  - Planning and design of borehole thermal energy storage
  - Planning and design of heat pump projects for district heating
  - Development, certification and implementatin of new cover technology for pit thermal energy storage

PTES (Pit Thermal Energy Storage):

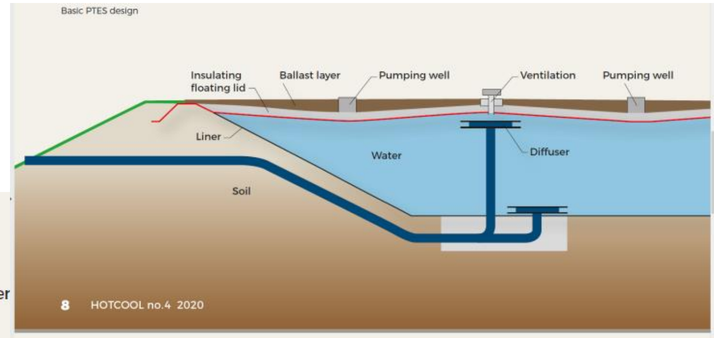
DTU:	500 m3	1983
Ottrupgaard	1.500 m3 / 43,5 MWh	1995
Marstal Sunstore 2	10.000 m3 / 638 MWh	2003
Marstal Sunstore 4	75.000 m3 / 6.960 MWh	2012
Dronninglund Sunstore 3:	60.000 m3 / 5.570 MWh	2013
Gram:	122.000 m3 / 11.300 MWh	2015
Vojens:	203.000 m3 / 18.800 MWh	2015
Toftlund:	70.000 m3 / 6.500 MWh	2017
Langkazi, Tibet	15.000 m3 / 1.000 MWh	2018
Høje Tåstrup	70.000 m3 / 3.300 MWh	2021

BTES (Borehole Thermal Energy Storage):

Brædstrup:	19.000 m3 soil = 5.000 m3 Weq	2012

ATES (Aquifer Thermal Energy Storage):

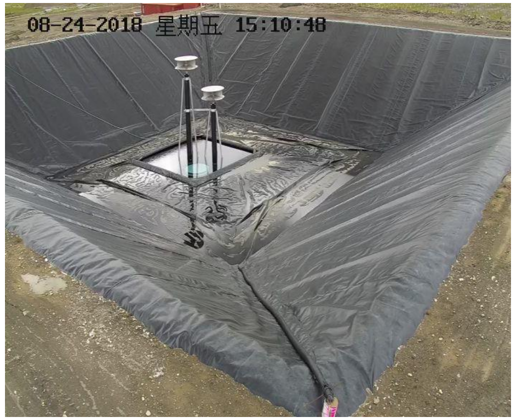
Bjerringbro:	5.200 MWh	2013

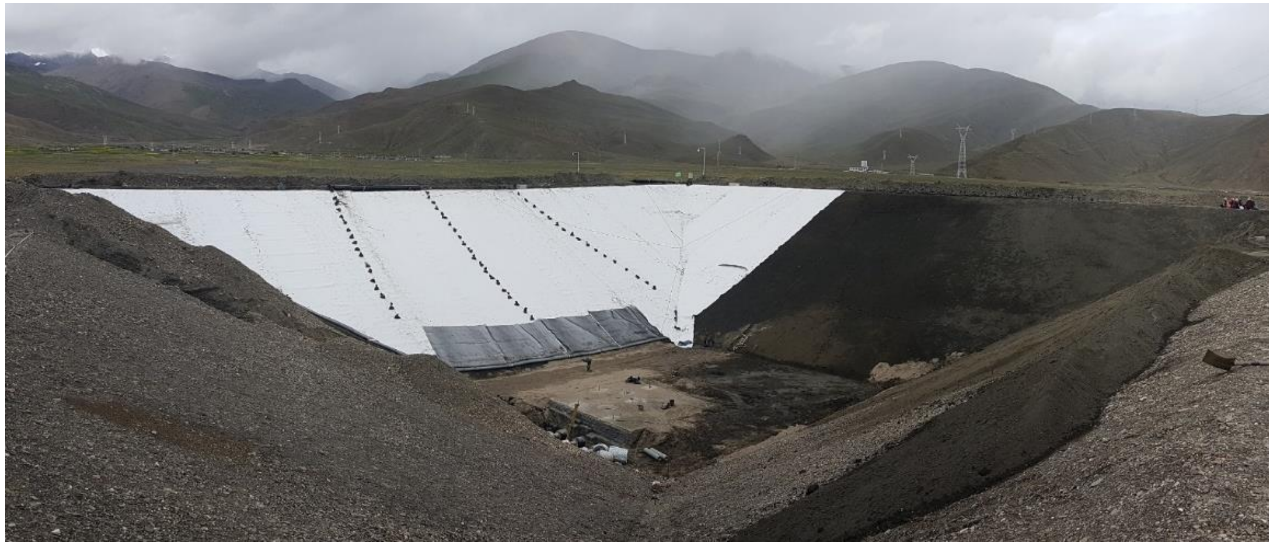


Projects – Morten Vang Bobach

75,000 m3 PTES in Marstal, DK (cover replaced 2019-2020)

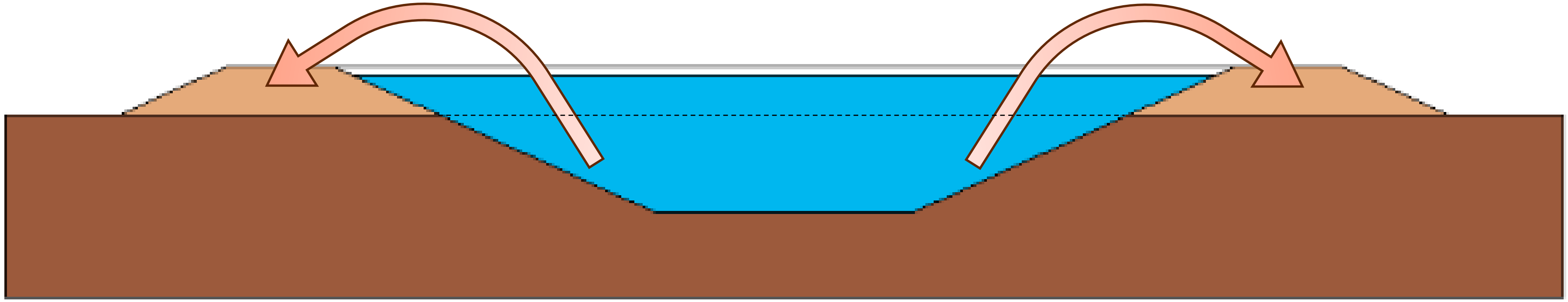
15,000 m3 PTES in Langkazi, Tibet (2018)





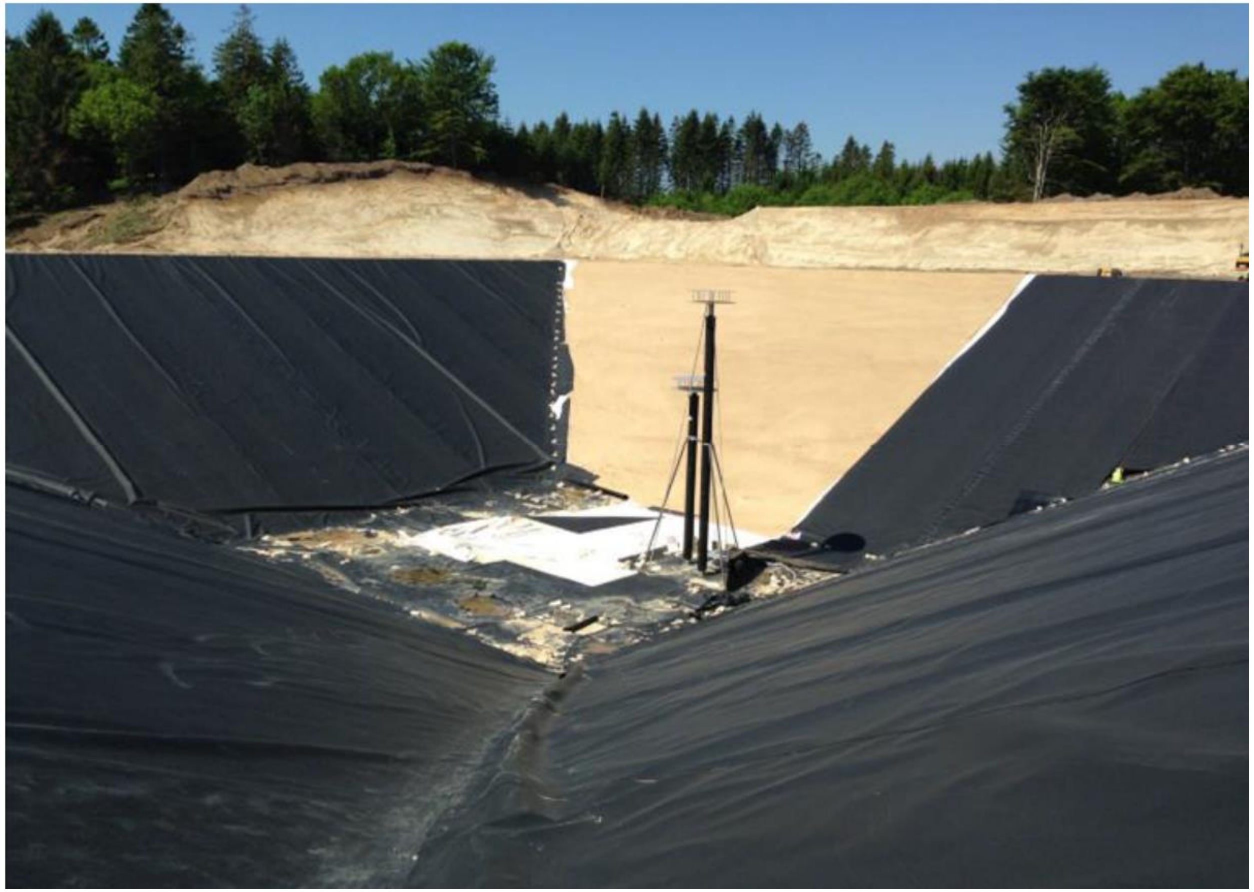
PTES General Overview of Construction

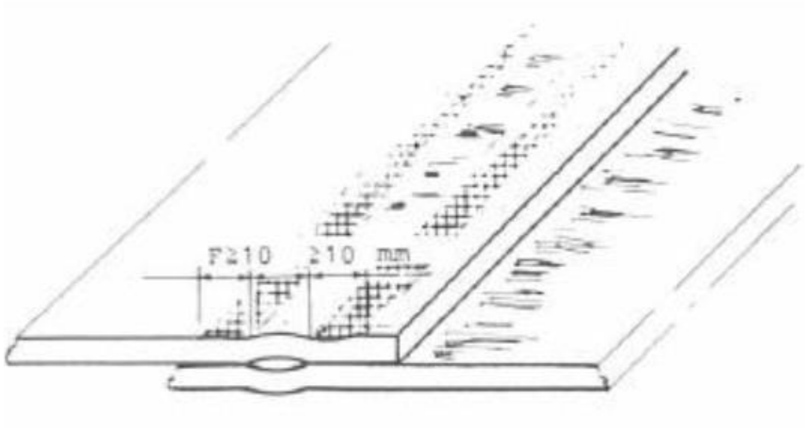
- Geometry and excavation



PTES General Overview of Construction

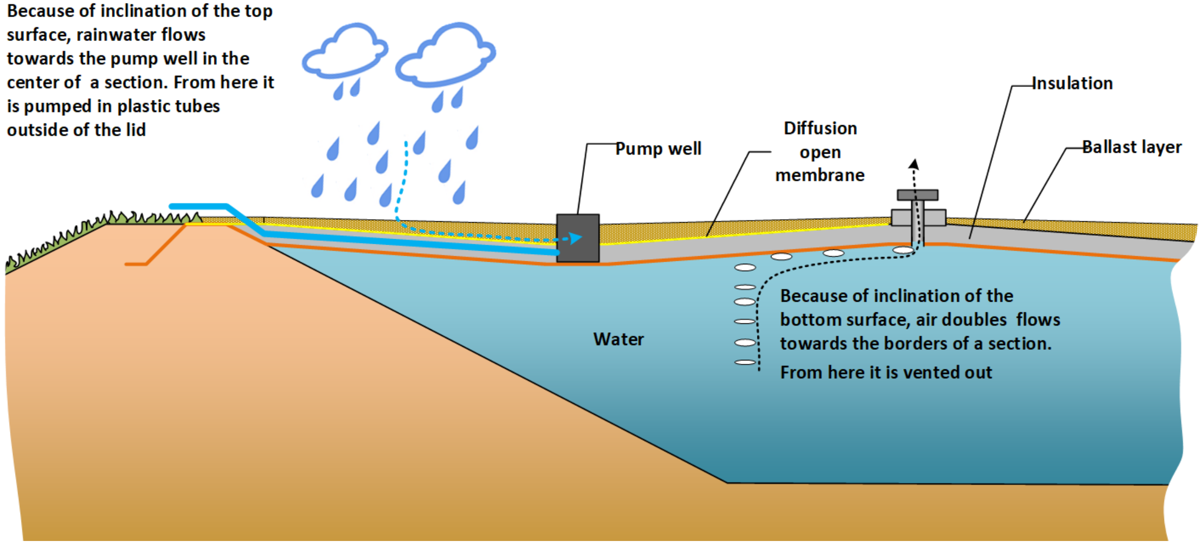
- Liner / Water tightness





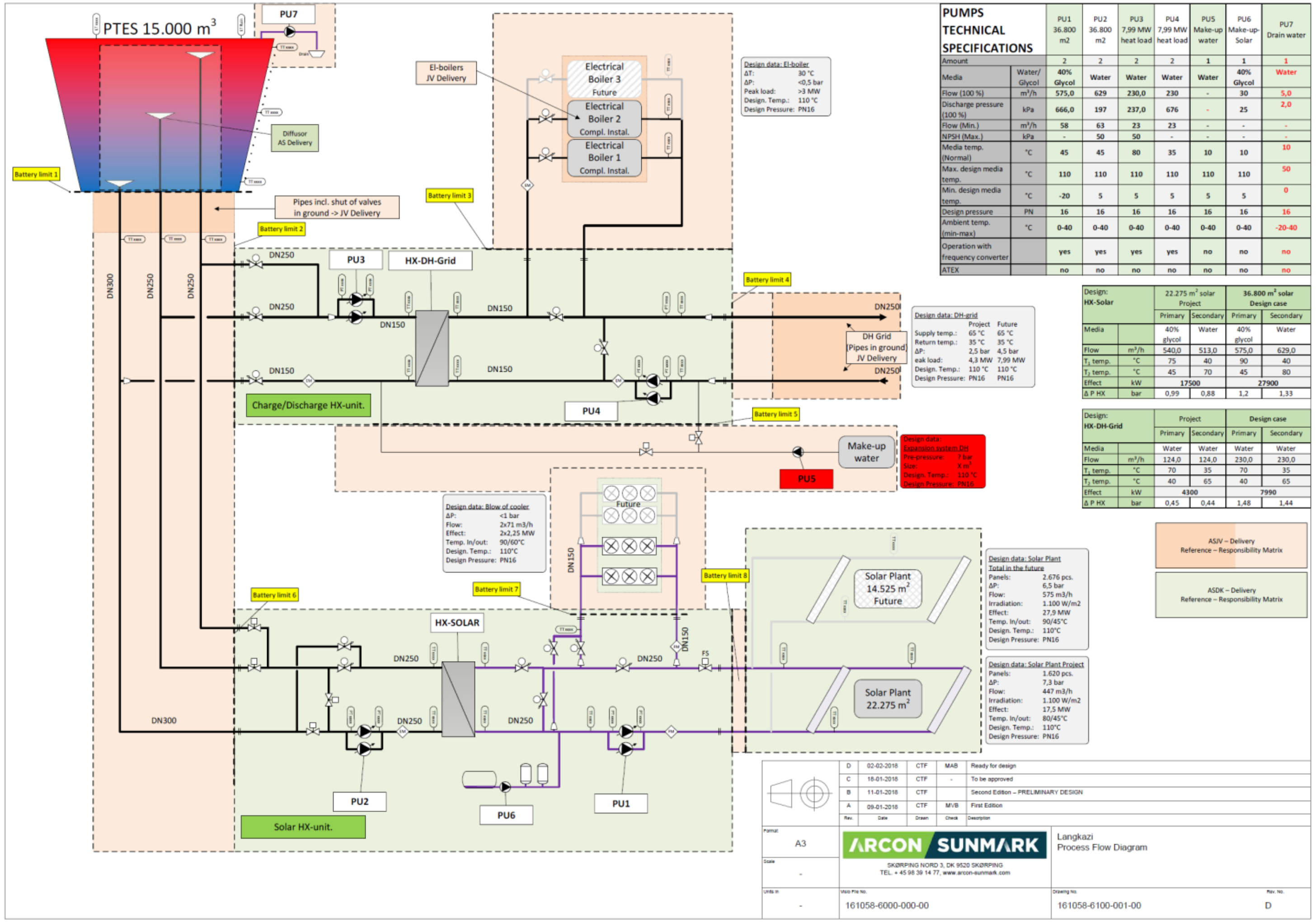
PTES General Overview of Construction

- Insulated floating cover



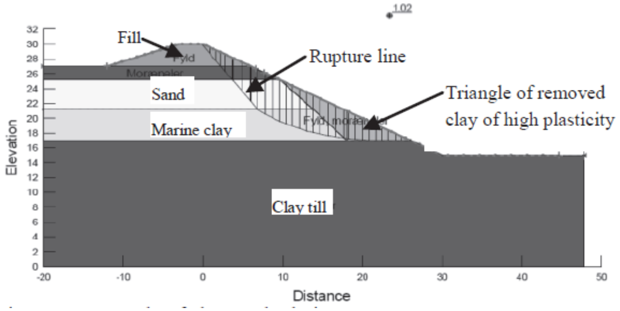
PTES General Overview of Construction

- Diffusers, Pipe Connections and Heat Exchangers

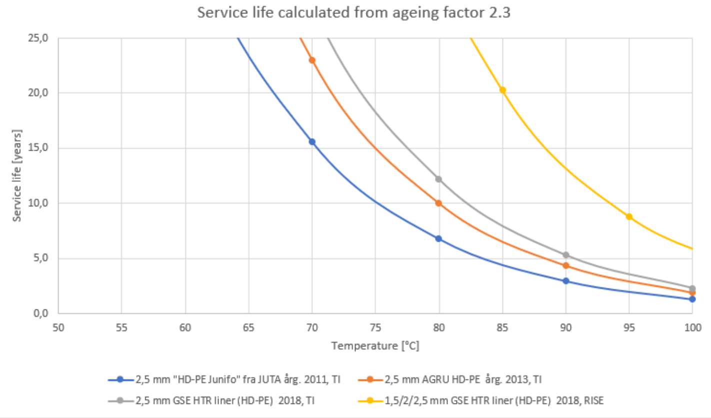


Attention Points for Project Implementation

- Geology and Ground Water Table



- Temperature Expossure vs. Service life



- Water Quality and Corrosion Resistance

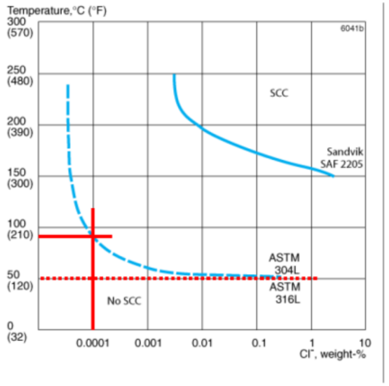
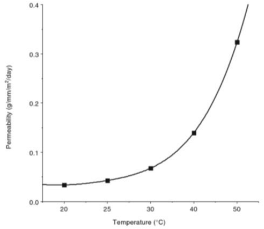


Figure 7: Resistance to stress corrosion cracking in neutral water with app. 8 ppm oxygen [Appendix A]

- Weather Impact on Installation – Planning and Coordination of Subcontractors

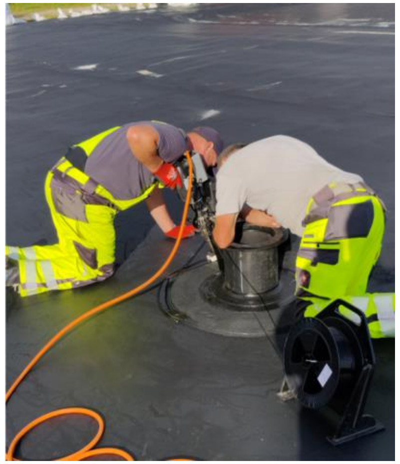
- Insulated Cover – Temperature – Rain water – Air bubbles – Water Vapour Diffusion



Water vapour permeability as a function of temperature for a typical HDPE liner [3]

Materials – Liners for PTES

- Two Main Liner Materials (HDPE and PP)
  - HDPE (HTR)
    - Pros:
      - High experience from testing as well as real life applications (All existing PTES except Høje Taastrup)
      - High durability at all temperatures
    - Cons:
      - Low service life at permanent high temperatures (less than 20 years at 85°C)



  - PP (HTR)
    - Pros:
      - High temperature resistance (service life potentially more than 25 years at 95°C)
    - Cons:
      - Less experience from testing and real life experince (Only one PTES project realized – Høje Taastrup 2022
      - Brittle at low temperatures (special precautions needed during installation)

Materials – Diffusers and Water Quality

- Stainless steel:
  - Dronninglund (2013)
  - Langkazi (2018)



- Black Steel
  - Marstal (2012)
  - Høje Taastrup (2021)



- Coated Black Steel
  - Gram (2015)
  - Vojens (2015)
  - Toftlund (2017)



Materials – Diffusers and Water Quality

- Water quality:

*Table 2: Minimum required water quality for PTES with stainless steel diffuser system. Maximum chloride content is adjusted according to the requirements from temperature (95°C) and steel grade (AISI 304/316). Maximum conductivity is adjusted as well. *Conductivity increase as a result of pH adjustment by sodium hydroxide is accepted.*

Appearance		clear and colourless
Odour		odourless
Solid particles	mg/l	<1
Oil and grease content	mg/l	free of oil and grease
Residual hardness	°dH	<0.01
Conductivity at 25°C	µS/cm	<20 before pH adjustment / <50 after pH adjustment*
Chlorides, cl^-	mg/l	<1
Sulphates, SO_4^{--}	mg/l	<0.2
Total iron, Fe_{total}	mg/l	<0.005
Total copper content, Cu_{total}	mg/l	<0.01
pH		9.8±0.2

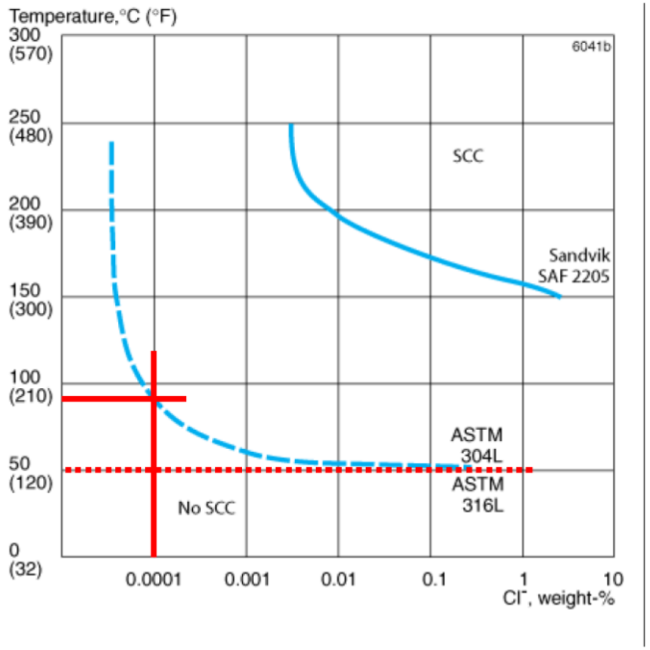


Figure 7: Resistance to stress corrosion cracking in neutral water with app. 8 ppm oxygen [Appendix A]

Weather Impact on Installation - Planning and Coordination

- Coordination of Excavation and Liner Installation:

- Liner Installation Heavily Depending on Temperature, Moisture and Wind (Installation not possible during winter)

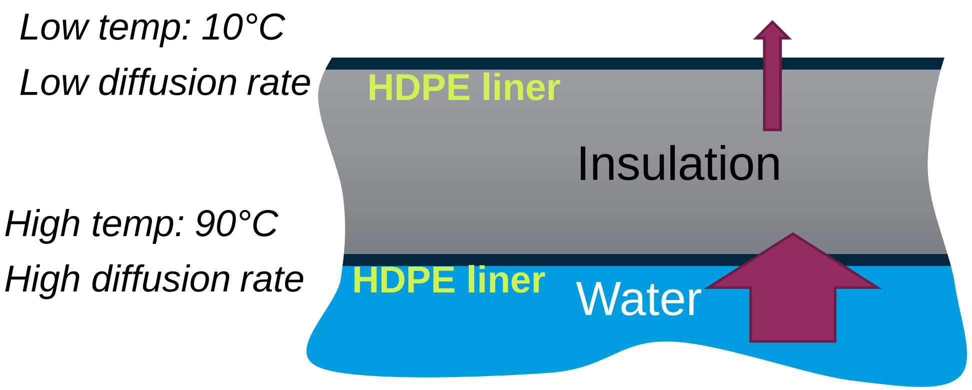
Insulated Cover

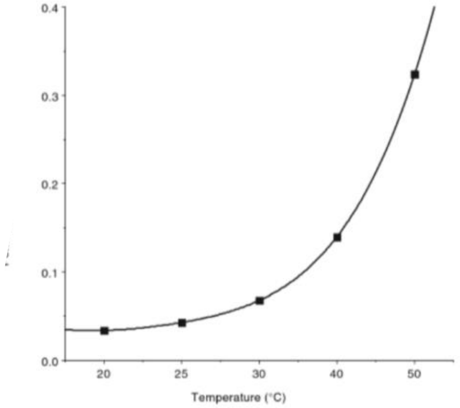
- Two main problems has been identified at older PTES installations. R&D project started 2017 resulting in new lid design

A- Water accumulation in insulation

Water diffusing through the floating liner accumulate inside the insulation.

Water accumulation reduce efficiency of the insulation.





Water vapour peri eability as a function of temperature for a typical HDPE liner [3]

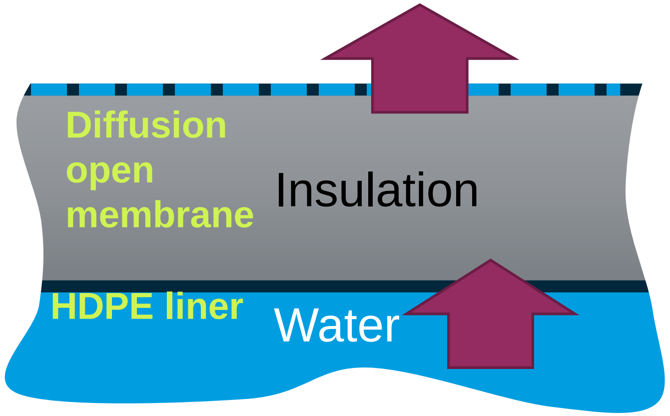
B - Rainwater ponding on top

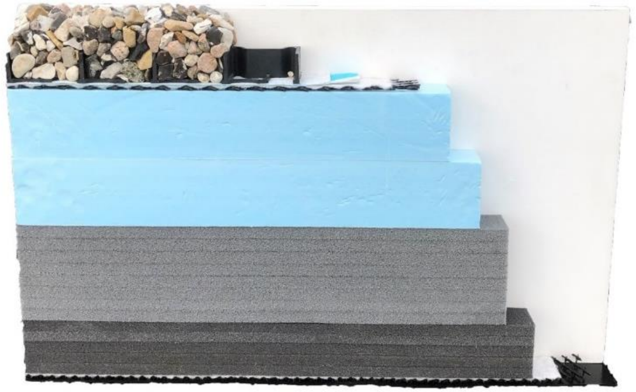
Because of the flexible nature of the floating lid, rainwater will form ponds at the lowest points. Ponds increase in size over time. The load from water ponds can damage the insulation.

Insulated Cover

- Water accumulation inside insulation cause increased heat loss
  Diffusion open top membrane to avoid water accumulation

A- Water accumulation inside insulation
The top liner of the lid is replaced by a diffusion open membrane. This type of membrane is known from roof design in buildings and allow water to diffuse out of the insulation. Membrane prevents water accumulation.

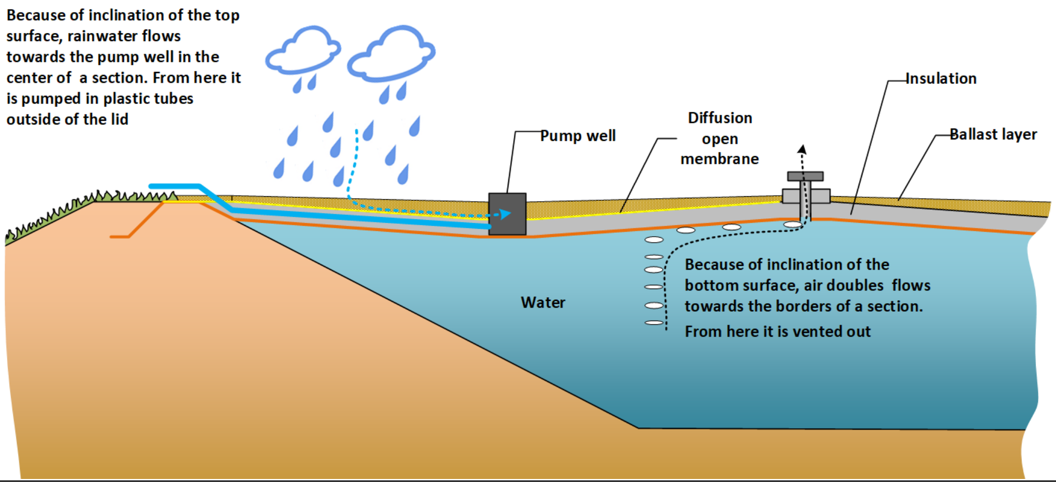




Insulated Cover

- Water ponding on top of lid, cause local load/damage of insulation
  Sectionized lid design with built in drain system for rainwater.

B- Rainwater ponding on top
The top cover is divided into sections, each with own drain system. On top of each section a ballast layer forms a slope shape of the surface allowing water to be pumped away from the surface



Measuring Results and Performance - Dronninglund

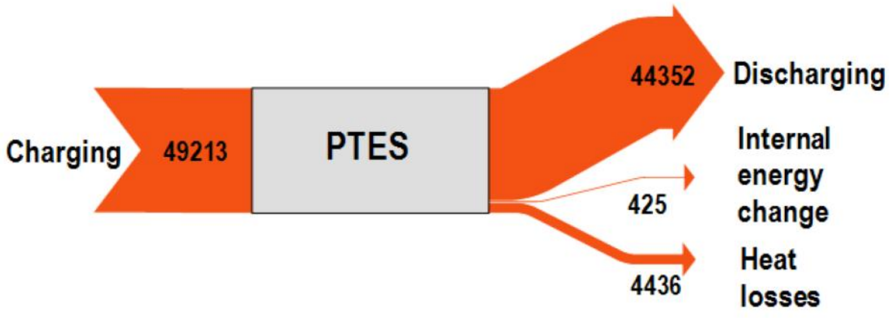


***Figure 21.** Heat balance diagram for the Dronninglund PTES for the period 2014-2017, numbers in MWh.*

- Capacity: 5,500 MWh
- Average Efficiency: 91%
- Average number of Storage Cycles: 2.0

Project title	Follow up on large scale heat storages in Denmark
Project identification (program abbrev. and file)	64014-0121
Name of the programme which has funded the project	EUPD2014

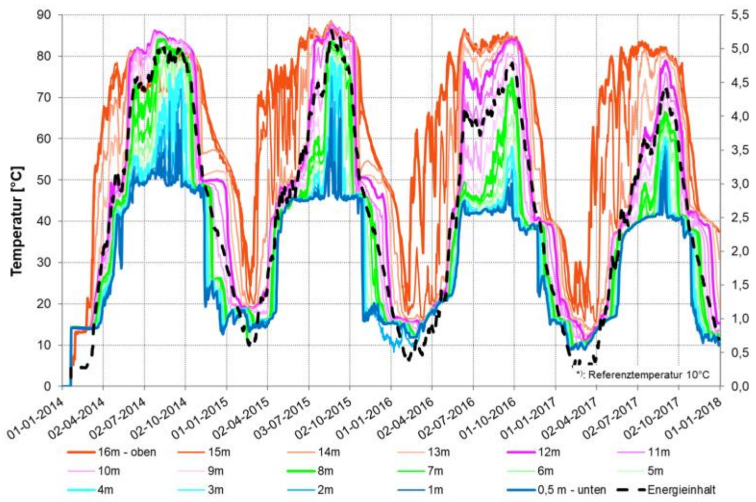


***Figure 22.** Temperature distribution and energy content in the storage from 2014 to 2017.*

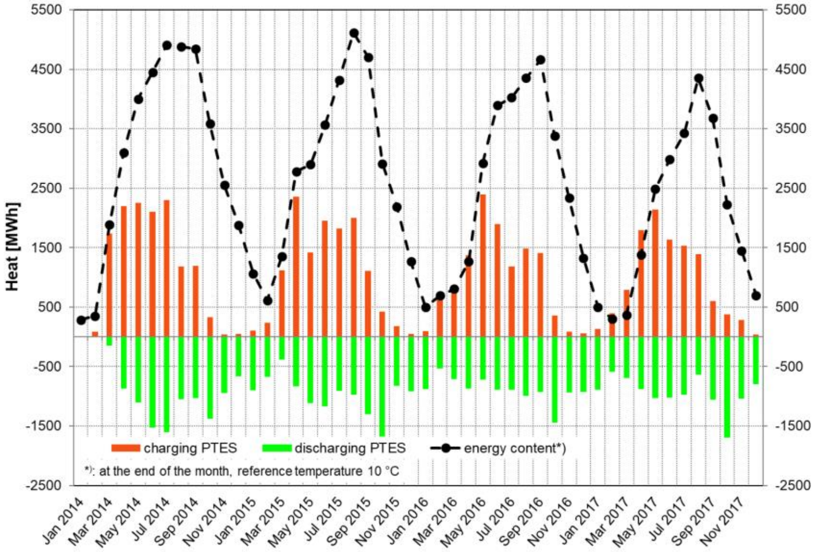


***Figure 23.** Monthly overview of charging and discharging of the PTES in Dronninglund from 2014 till 2017.*

PTES Prices

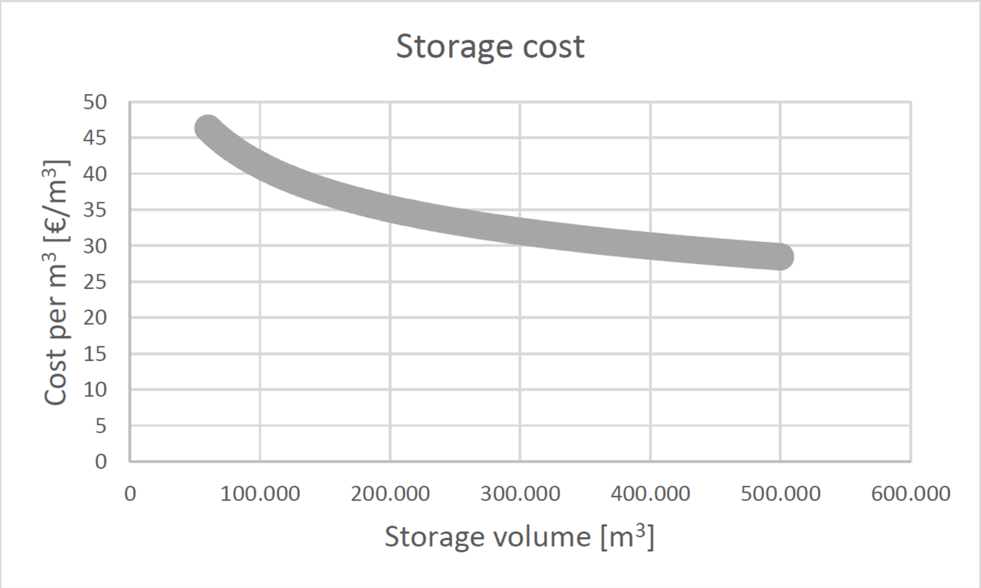


Figure 15. Estimation of the costs for a pit heat storage as a function of the size of the storage. Source: PlanEnergi.

Subject:	Seasonal pit heat storages
Date:	21 October 2020
Description:	Guidelines for design of seasonal pit heat storages. (Updated version of IEA SHC TECH SHEET 45.B.3.2 Seasonal storages – Water pit heat storage – Guidelines for materials & construction)
Author:	Original version: Morten Vang Jensen, PlanEnergi 2014. Updated by Jan Erik Nielsen, PlanEnergi 2020.
Download possible at:	IEA SHC Task 55 website: https://task55.iea-shc.org/fact-sheets

- Recent price calculation (2022) - 600,000 m^3 (uncomplicated conditions):

  38€/m^3

- Minimum 30% above chart

- Significant increase in raw material prices 2020-2023

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