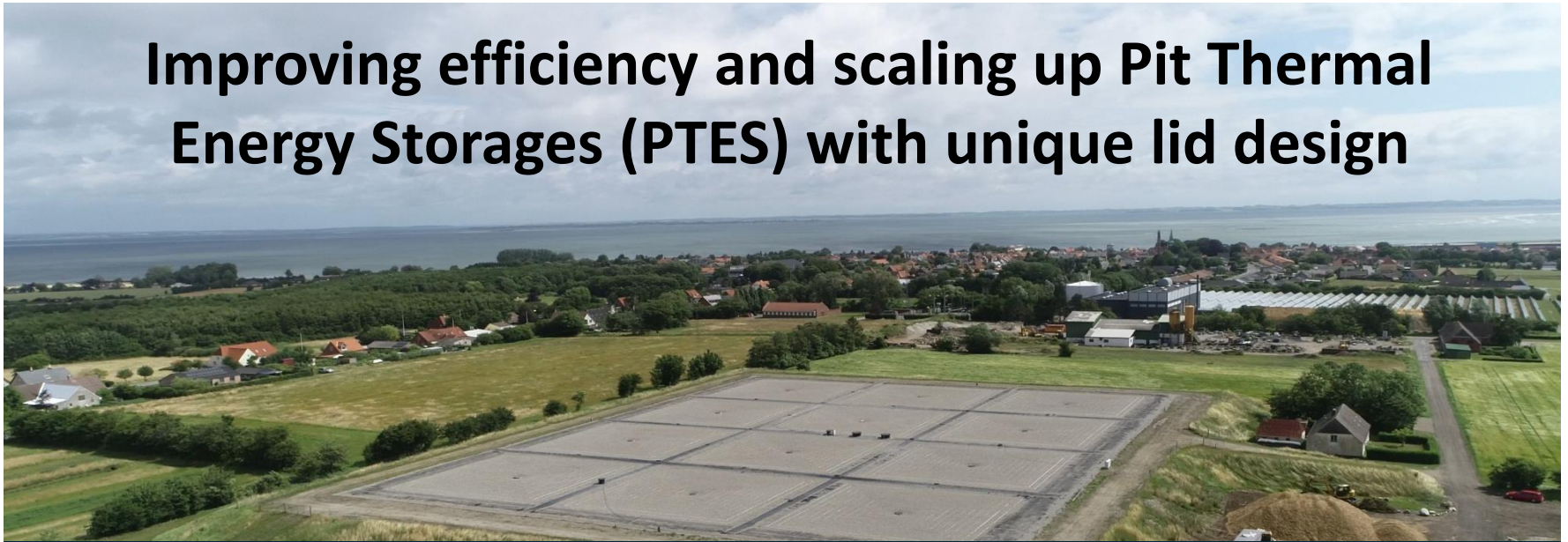


Heat storage and monitoring results
October 27, 10-16, Aalborg CSP, Hjulmagervej 55, 9000 Aalborg

Improving efficiency and scaling up Pit Thermal Energy Storages (PTES) with unique lid design



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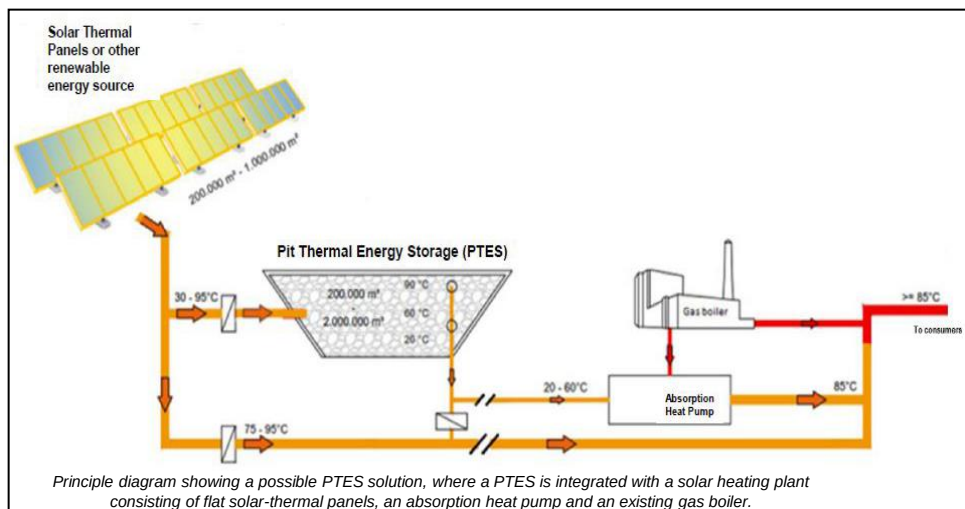
AALBORG CSP
- Changing Energy

heatstore
High Temperature
Underground Thermal Energy
Storage

PTES, Pit Thermal Energy Storage

The next generation of storing energy in a green future

- A flexible energy system that will enable the conversion from conventional fossil fuel energy to fluctuating renewable energy sources requires large scale energy storage.
- The PTES technology is a low-cost energy storage for thermal energy up 90°C. Energy is simply stored in pure water.
- PTES enables storing of excess energy for later use in district heating networks resulting in increased flexibility and efficiency of the heat production. This includes:
 - excess heat from solar heating plants, power plants or industrial processes
 - excess electricity produced by wind or PV stored as heat
- Collecting waste heat/power and using it for district heating later helps lower energy loss and reduces our carbon footprint.



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

Danish PTES installations

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	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	2022

A- Water accumulation in insulation

Water diffusing through the floating liner accumulate inside the insulation.

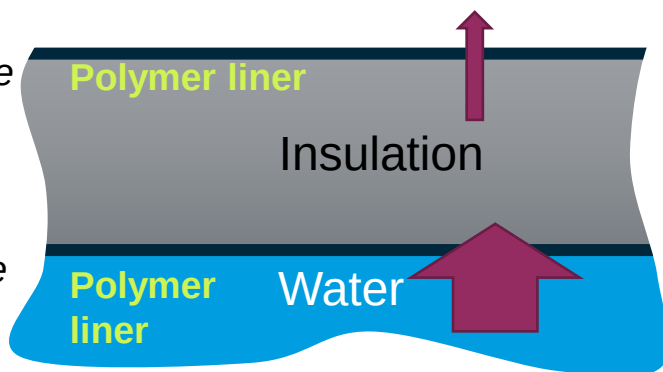
Water accumulation reduce efficiency of the insulation

B - Rainwater ponding on top

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

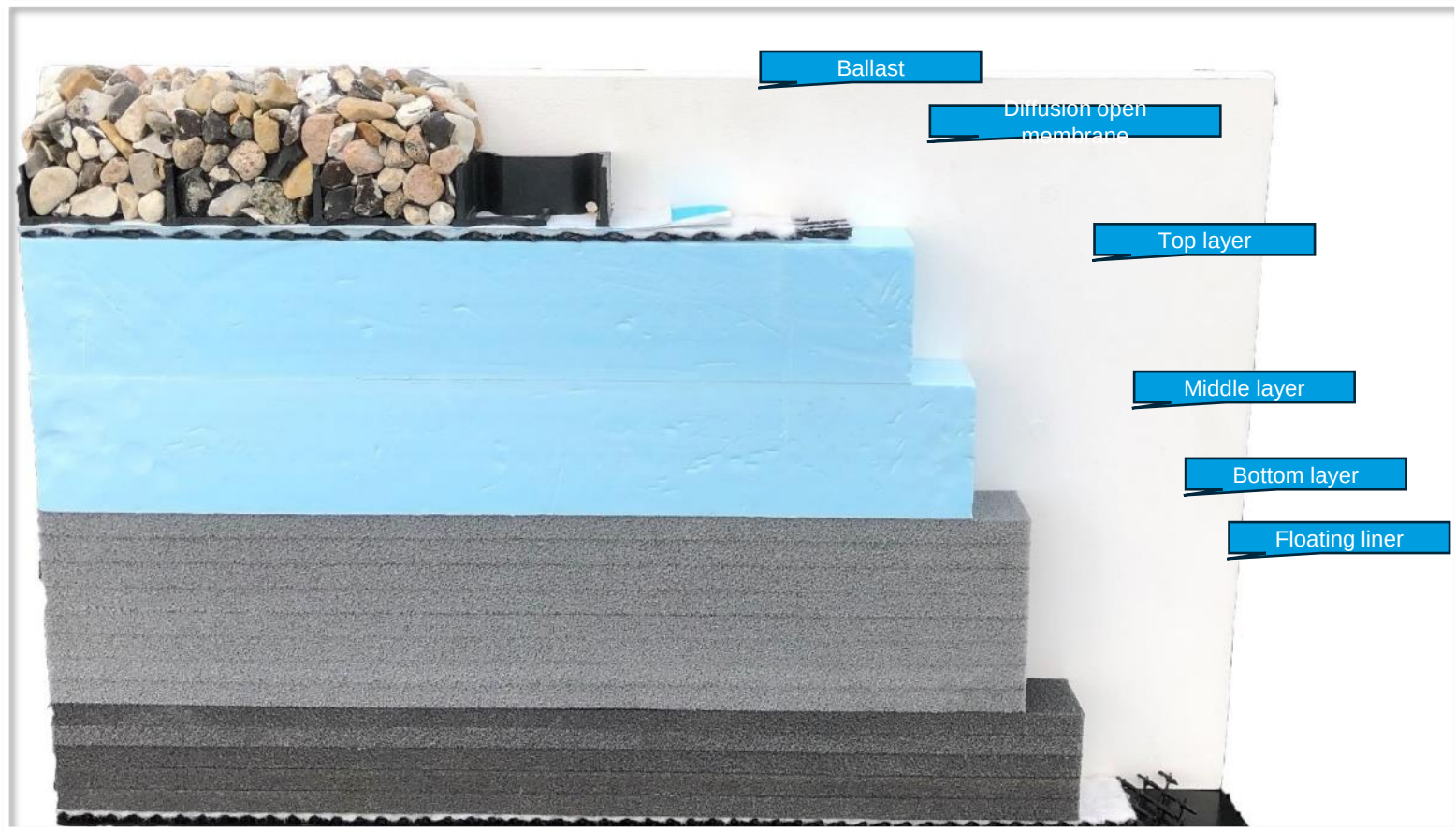
Low temp: 10°C
Low diffusion rate

High temp: 90°C
High diffusion rate



The technology and functionality of PTES

Insulating lid cover build up of layers of tested and proven material

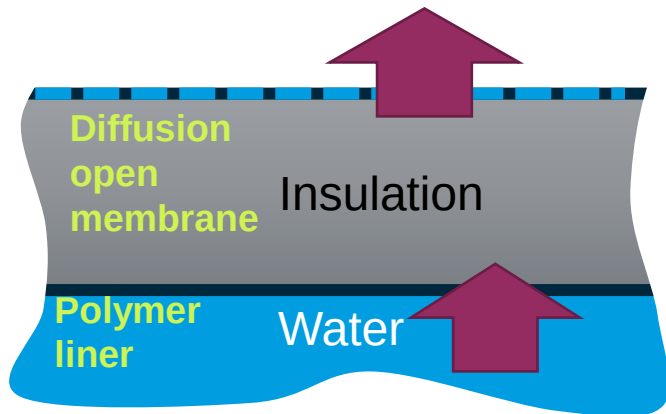


Water accumulation inside insulation cause increased heat loss Diffusion open top membrane to avoid water accumulation

Patented

A- Water accumulation inside insulation.

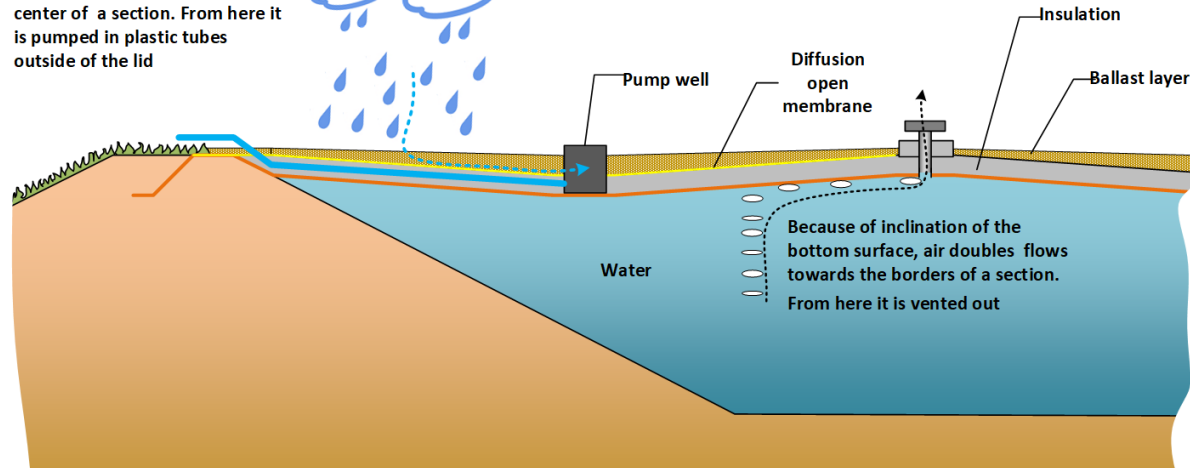
The top liner of the lid is replaced by a diffusion open membrane. This type of membrane is known from roof design in buildings and allow water to diffuse out of the insulation. Membrane prevents water accumulation.



Insulation
water.

Patented

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



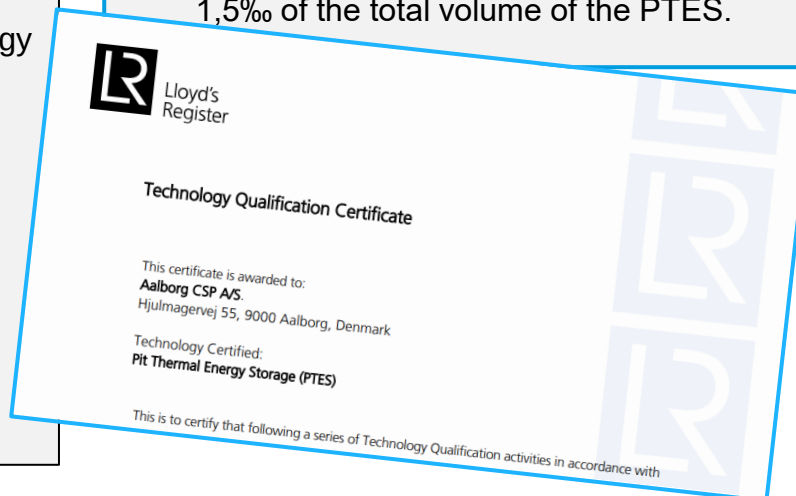
New lid design with improved efficiency, service life and PTES technology ready for implementation

New lid design for PTES technology

- Solving problems from previous projects.
- Lid design protected by two patents
 - Diffusion open top cover construction to avoid water accumulation inside insulation material
 - Top cover surface is built in sections, each with own drain system for surface water. Each section is centered around a pumping well with an inward fall towards it allowing water to be led away from the surface and insulation layer easily.
- Improving lifetime and reliability.
- Reduced service costs.
- During the entire design phase, the technology has been reviewed by Lloyd's Register, resulting in a Technology Qualification Certificate
- Large scale installation in Marsal (10.000 m² surface area) . Running since April 2020.
- Easy scalable due to sectionized design
- Technology is ready

Claims listed in Technology Qualification from Lloyd's Reg.

1. The lifetime of the PTES is at least 25 years.
2. The efficiency of the PTES is at least 90%
3. The PTES is capable of storing heat up to maximum 90°C
4. Reliability: Service and maintenance can be carried out without interfering with normal operation. This gives an availability factor of 100%
5. Charging and discharging power is minimum 90MW
6. Once installed and operating the PTES requires a minimum of operational resources
7. At least 90 % of the components of the PTES are recyclable.
8. The maximum yearly required amount of make-up water is 1,5‰ of the total volume of the PTES.



PTES future from AalborgCSP's perspective

- Installation in Dronninglund ongoing
- Installation in Høje Taastrup 2022
- Continuously work on improving technology. Materials, system, installation process,,
- Interest from DK and European projects



THANK YOU FOR YOUR ATTENTION

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