Feasibility, design, tender ing, and monitoring for 70,000 m³ PTES in Høje Taastrup, Denmark

Per Alex Sørensen

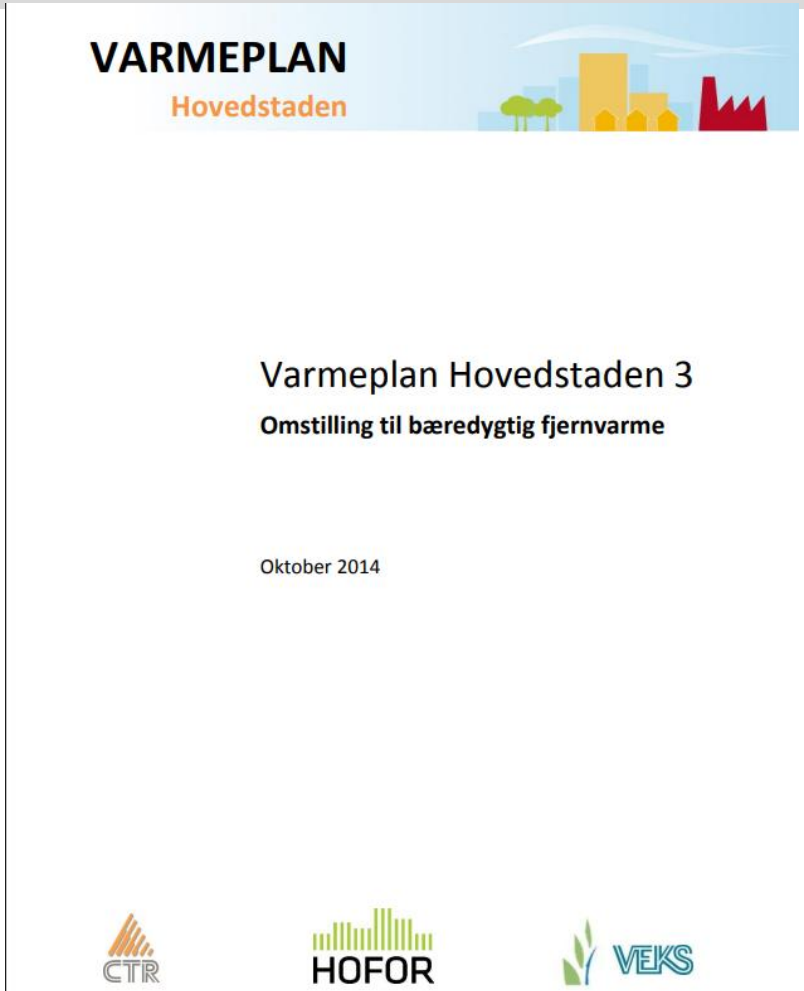
PlanEnergi

pas@planenergi.dk

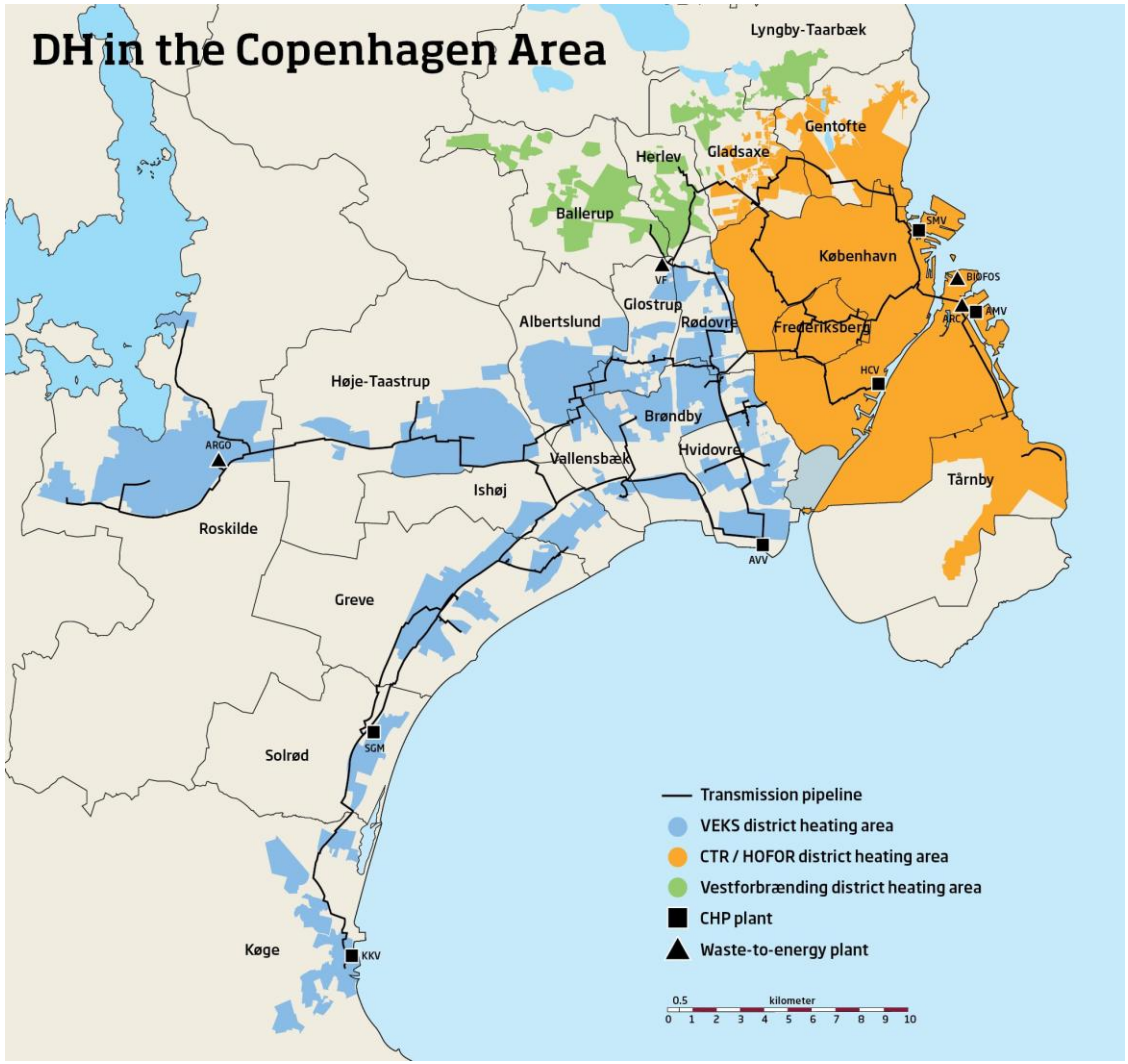
Opportunity – heat planning

In Heat Plan Greater Copenhagen 3 from 2014, which was prepared by the transmission companies CTR, HOFOR and VEKS, the following is stated about heat storage:

"Heat Plan Greater Copenhagen 3 demonstrates a large economic potential for investing in heat storage in the metropolitan area. The next step is to find suitable locations for the establishment of heat storages in relation to grid connection and space for thermal plants and to assess when the heat storage is best established over the next 20 years."



The heating system in Copenhagen

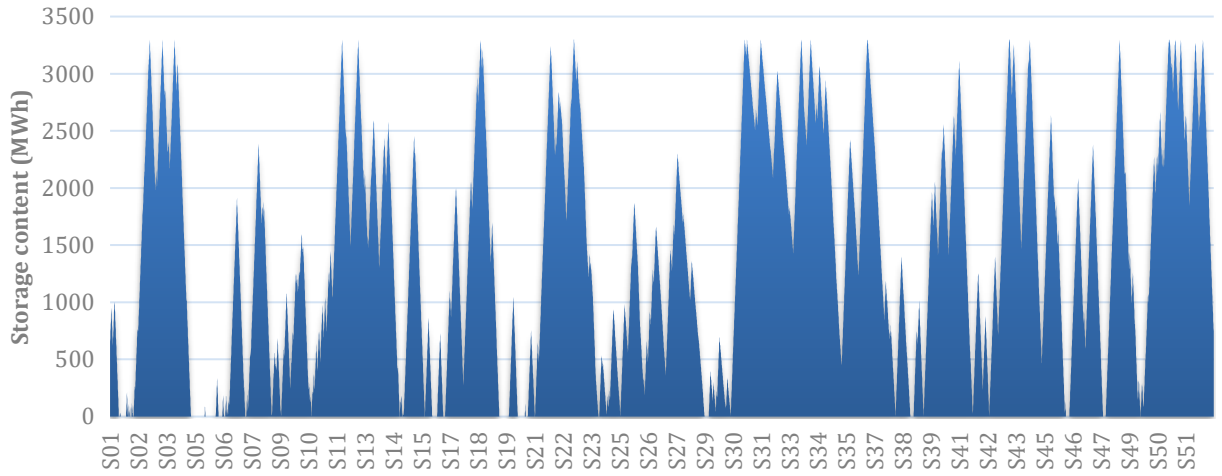


Heat suppliers:
Four CHP plants of a total of 2,050MW. The plants are owned by three different companies: Ørsted, HOFOR and VEKS.
Three waste-to-energy facilities of a total of 400MW
Reserve and peak load plants of a total of 1,900MW
Two heat accumulators of a total of 660MW

Economical feasibility

Subsequent analyses showed that a 70.000 m^3 heat storage could be profitable already with the existing heat production system. Høje Taastrup Fjernvarme (HTF) found a suitable site, and VEKS and HTF decided to begin the process before the Final Investment Decision (FID).

The preliminary budget showed a total investment of DKK 74.1 million and an expected income (operational benefit) in 2025 of DKK 6.3 million. The income came from 1) a better optimisation of production in relation to the electricity market, 2) increased production at cheaper units (CHP plants and heat pumps) especially in peak hours in the overall heat production system in Copenhagen and 3) increased production at waste incineration plants in the summer.



Feasibility – sustainability mainly connected to site

- Ground water conditions?
- Protected areas? Natura 2000 or other protected areas?
- Protected fauna?
- Historical and cultural landscapes?
- Utilization of ground water (report of district heating waters influence on ground water was annexed)?
- Needs for getting rid of waste/water?
- Changes in traffic?
- People affected?
- Is the area environmental vulnerable?
- Reduction in greenhouse gas emissions?

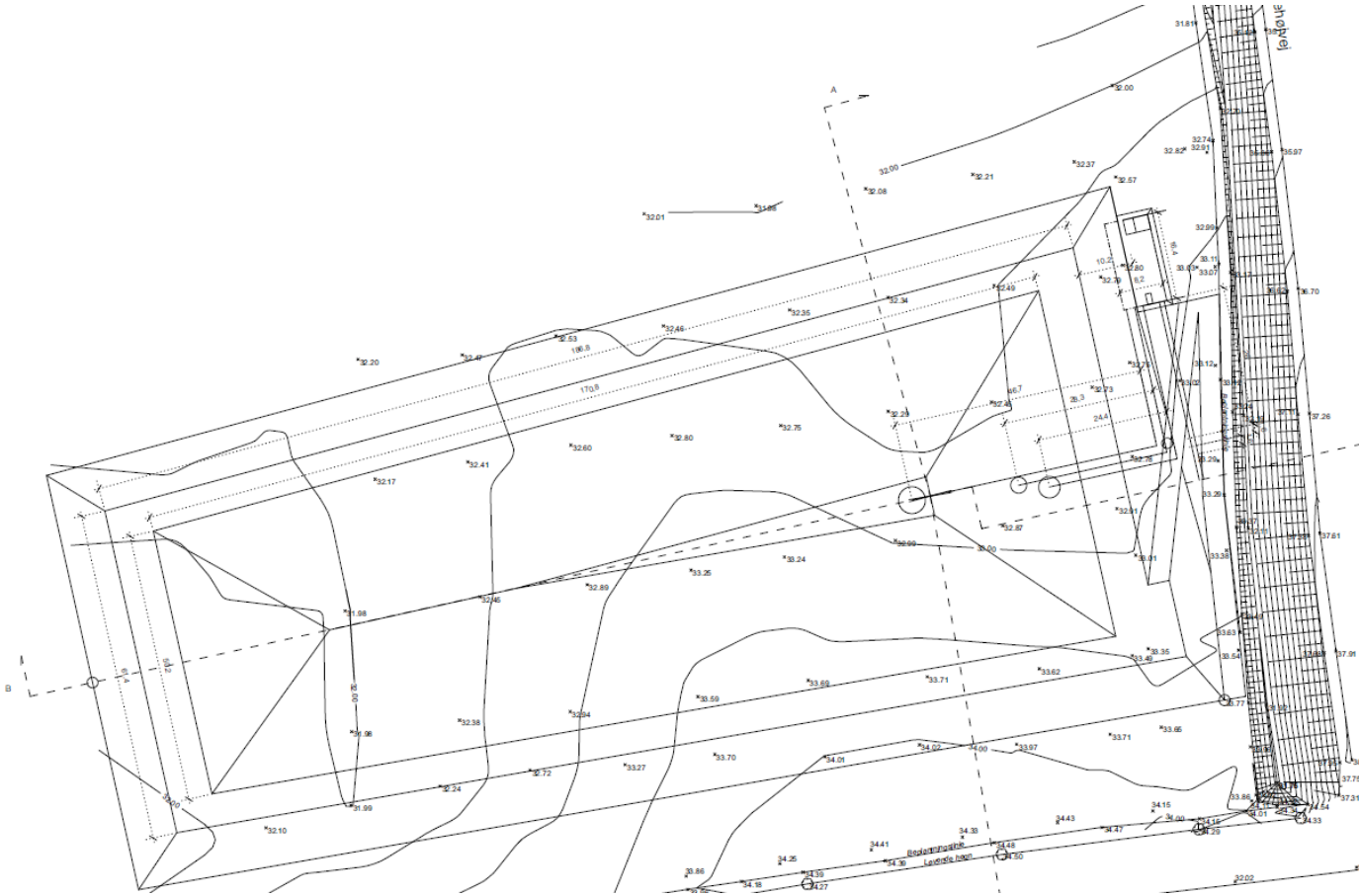
Serious environmental consequenses?

Are consequenses reversible?

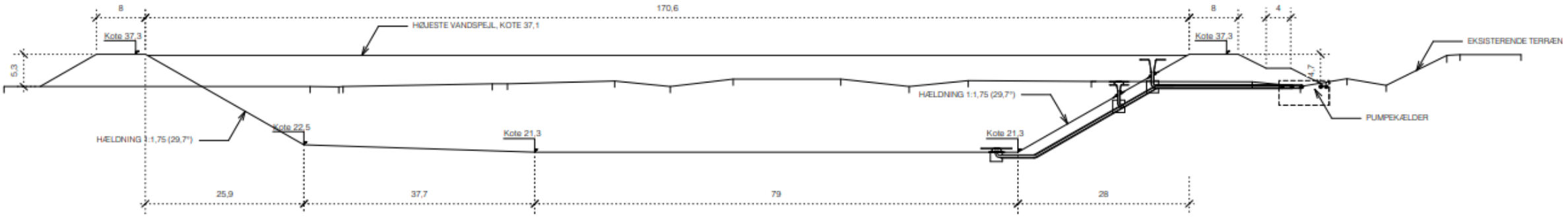
Result: The project is feasible and can be implemented without Environmental Impact Assessment Report

Design – excavation, in- and outlet, concrete work and pipe work

- Storage geometry and amounts of soil to be removed
- Details for penetrations of liner
- Details for in- and outlet
- Details for pump cellar
- Drainage details
- Principal diagram



Design - Longitudinal section of the PTES



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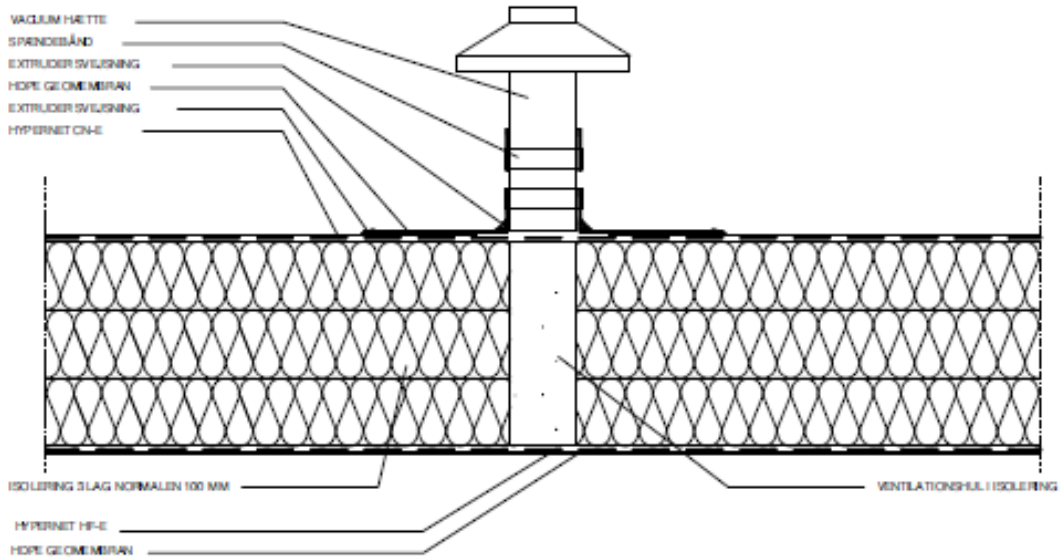
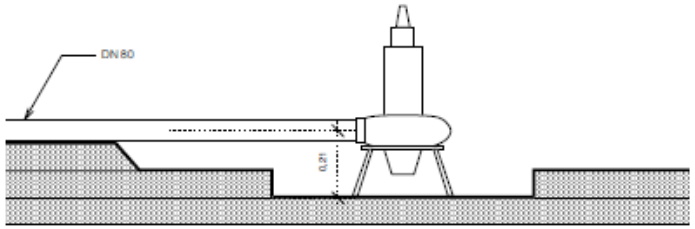
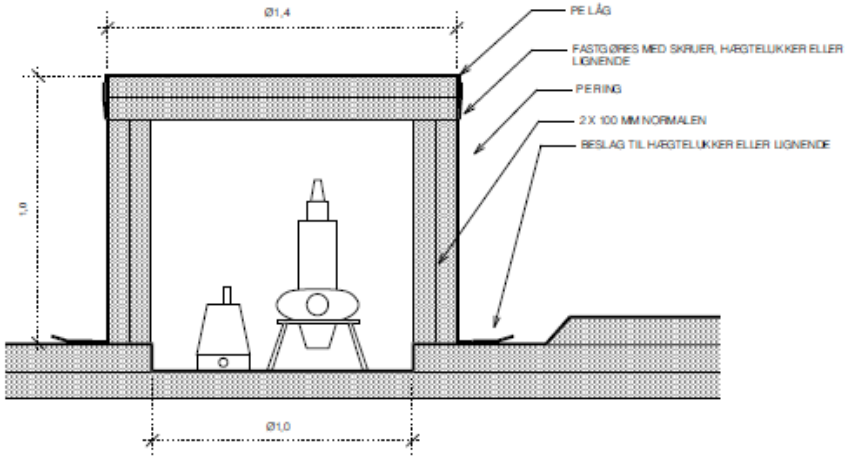
Design – Linerwork incl. lid

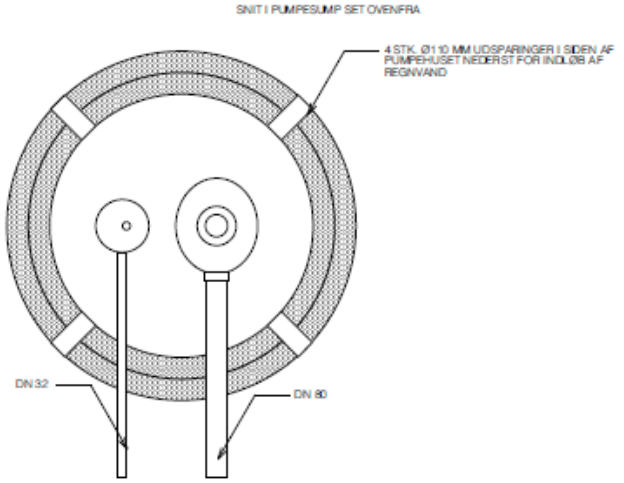
- Storage geometry and amounts of liner to be welded
- Details for penetrations of liner
- Details for lid construction
- Details for dewatering of lid
- Principal diagram



Design – Pump sump







Tendering

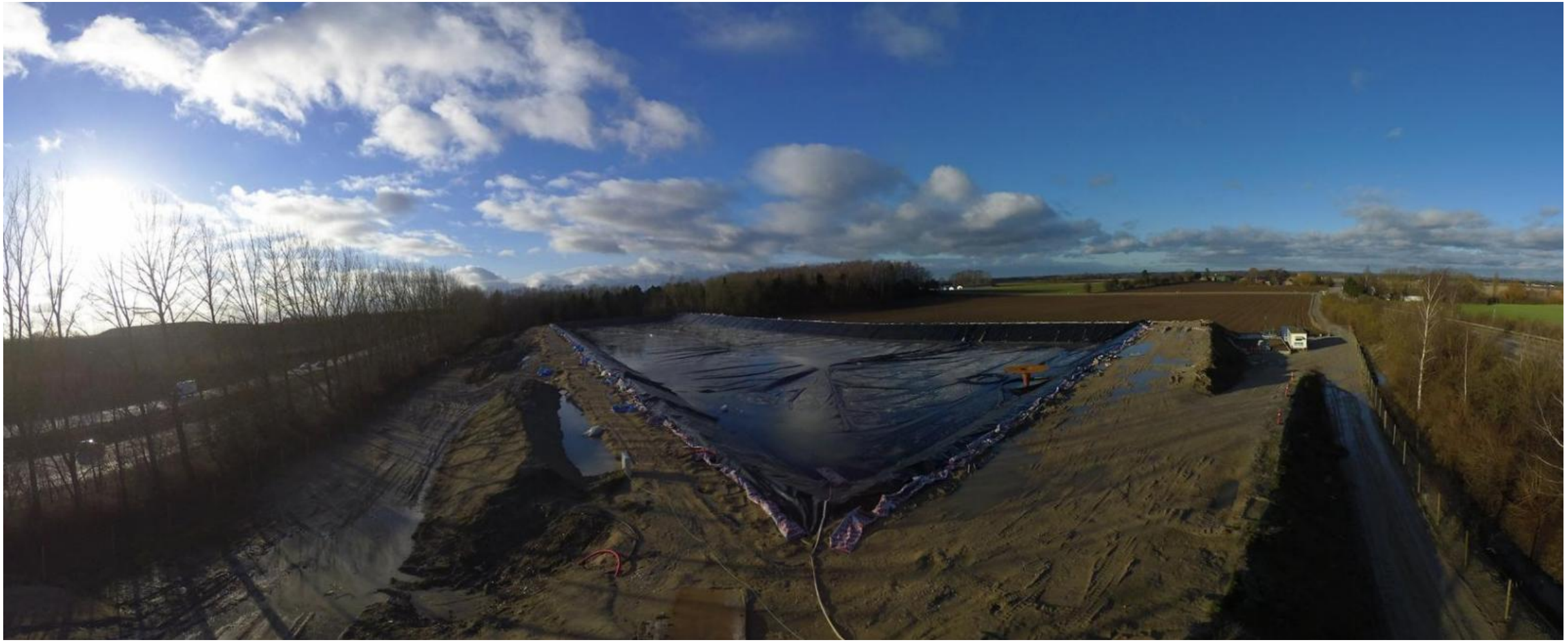
- Two turnkey contracts: A) Excavation, in- and outlet, concrete work and pipe work and B) Liner and lid
- Each turnkey contractor must be responsible for all deliveries, building permits, detailed design, coordination with other contracts, the client's own deliveries, installation, establishment and operation of the construction site, temporary measures, commissioning, handover, warranty conditions, etc., which are related to the contract in question and necessary for a complete and functional facility.
- Contract A: Demand specifications for soilwork, dewatering, pump cellar, in- and outlet
- Contract B: Demand specifications for membrane work, implementation of lid and roof membrane. Membranes and insulation will be delivered by the client
- Time schedule, description of interfaces between entrepreneurs

Construction Phase, earthworks and sealing system

Source: HTF Denmark

Construction Phase, before water filling started

Water Filling with District Heating Water



Construction Progress Floating Liner

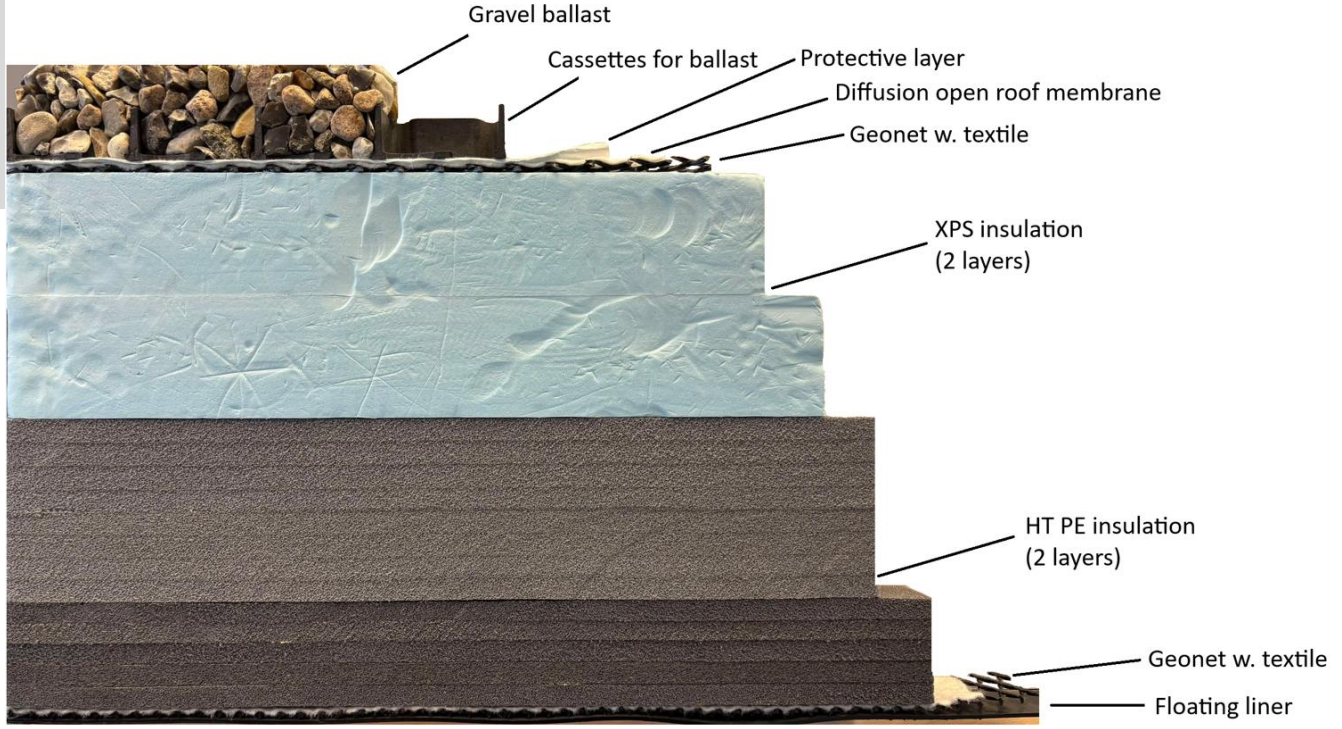
Implementation of **geomembrane** made of **high temperature resistant Polypropylene**

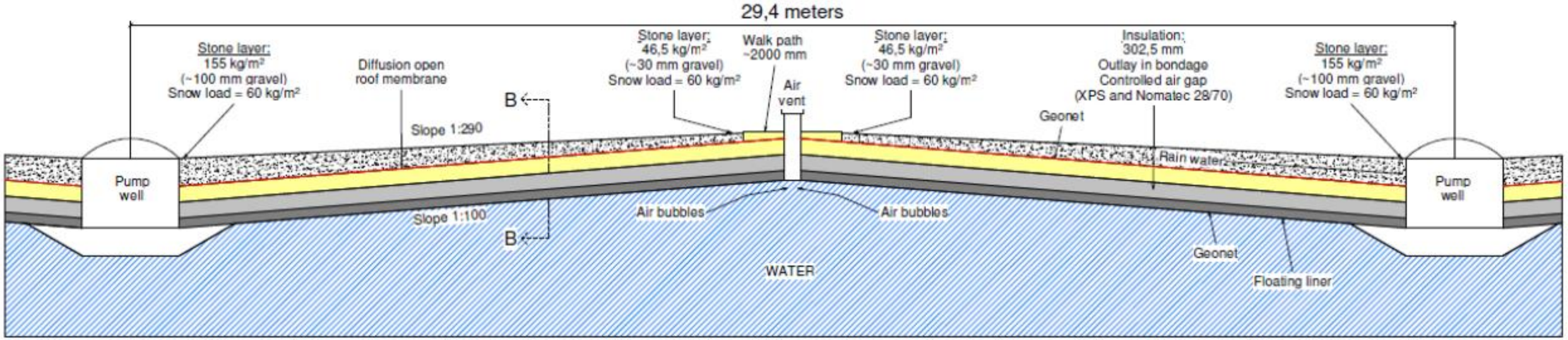
also applied for sealing system of bottom and sides of the PTES

Construction Progress Lid Cover

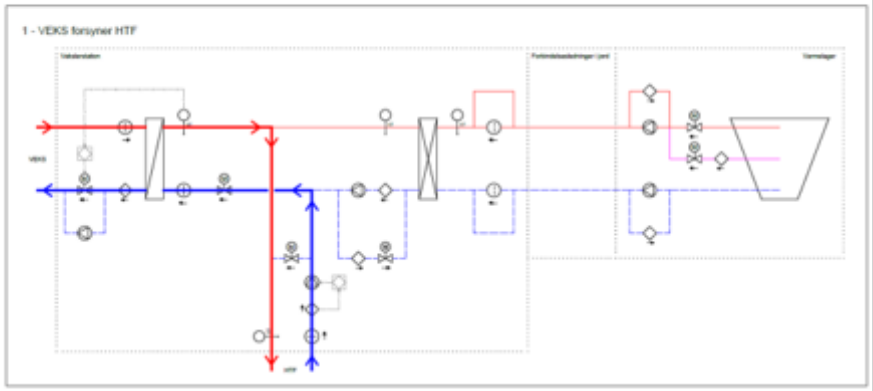
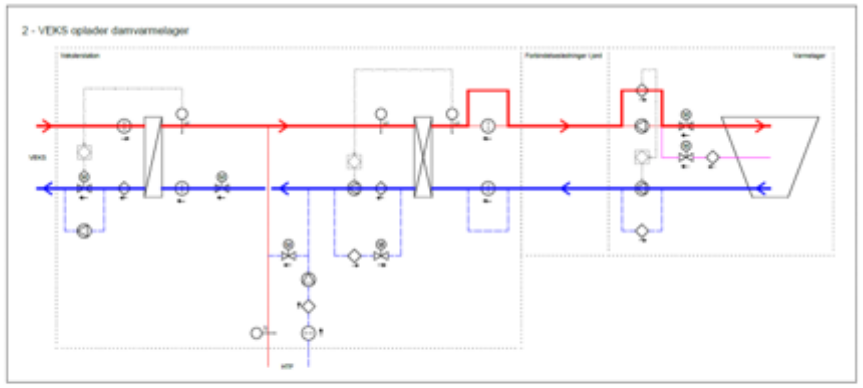
Lid Design Høje Taastrup

- Diffusion open Design
  - No accumulation of moisture
- Segmented rain water management
  - No water accumulation
- Small Heat Loss of 8% - 10% p.a.
- Life time of approx. min. 25 years
- „Lloyd's Register“ certified and to 90% recycable components





Cold test before commissioning – part of ”Pixi book”

ID		
1	**VEKS SUPPLIES HTF**	**Client**
		**Cold test of the hydraulics** **Start week 17 2022**
2	**VEKS SUPPLIES PIT HEAT STORAGE**	**Client**
		**Cold test of the hydraulics** **Start week 17 2022**

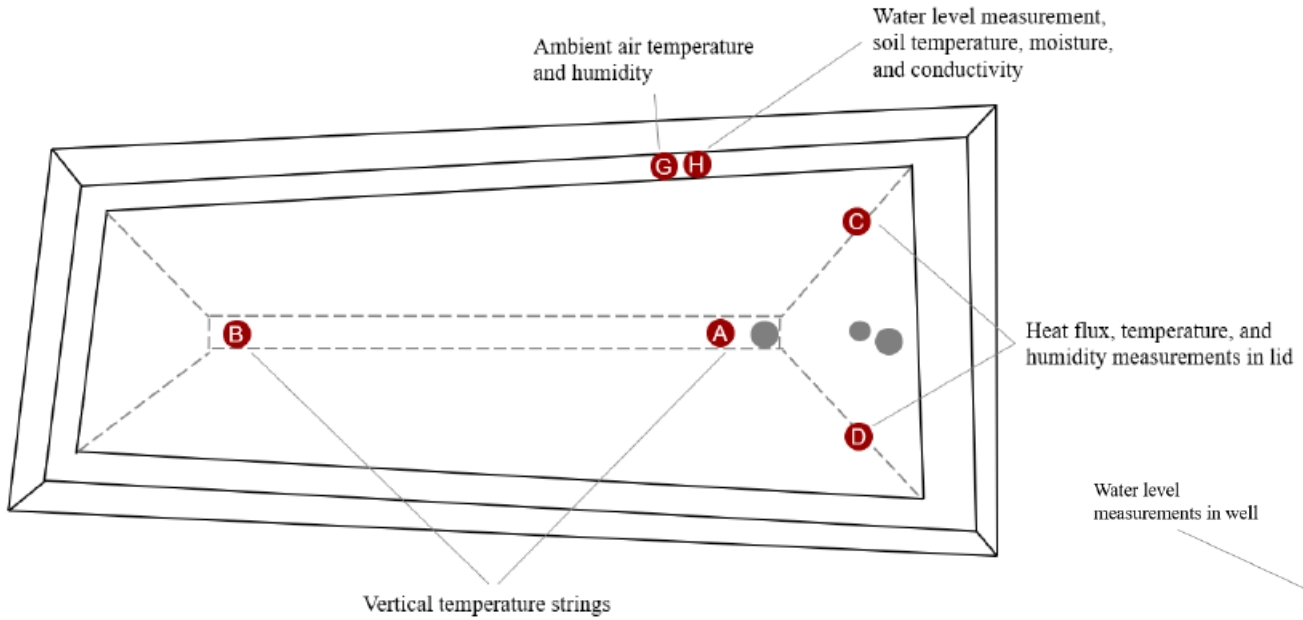
Economy

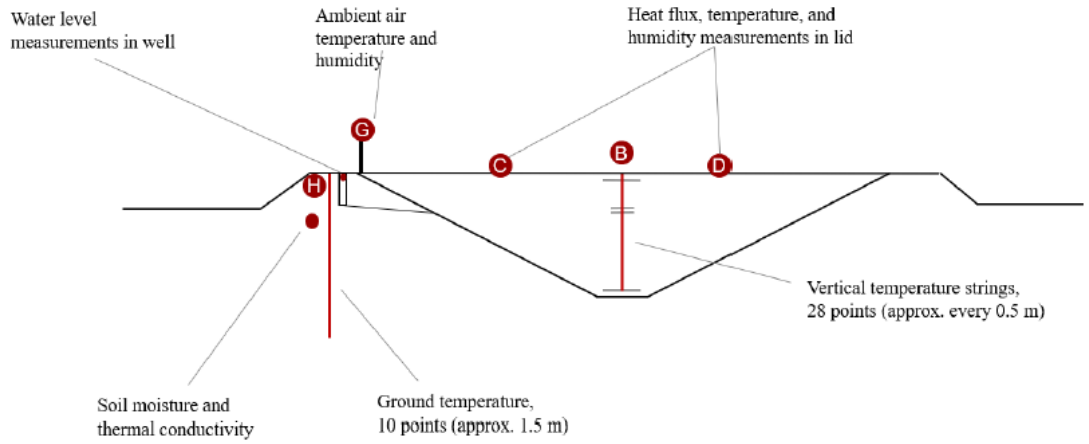
The total investment amount is 10.7 Mio. €:

Activity	Investment, Mio. €
Soil expenses	0.55
Design and supervision	1.14
Storage and pumping station	6,05
Heat exchanger building	2.42
District heating pipeline	0.94
Electricity etc.	0.44
Water	0.51
Total	12.04
EUDP subsidies	1.34
Total incl. subsidies	10.70

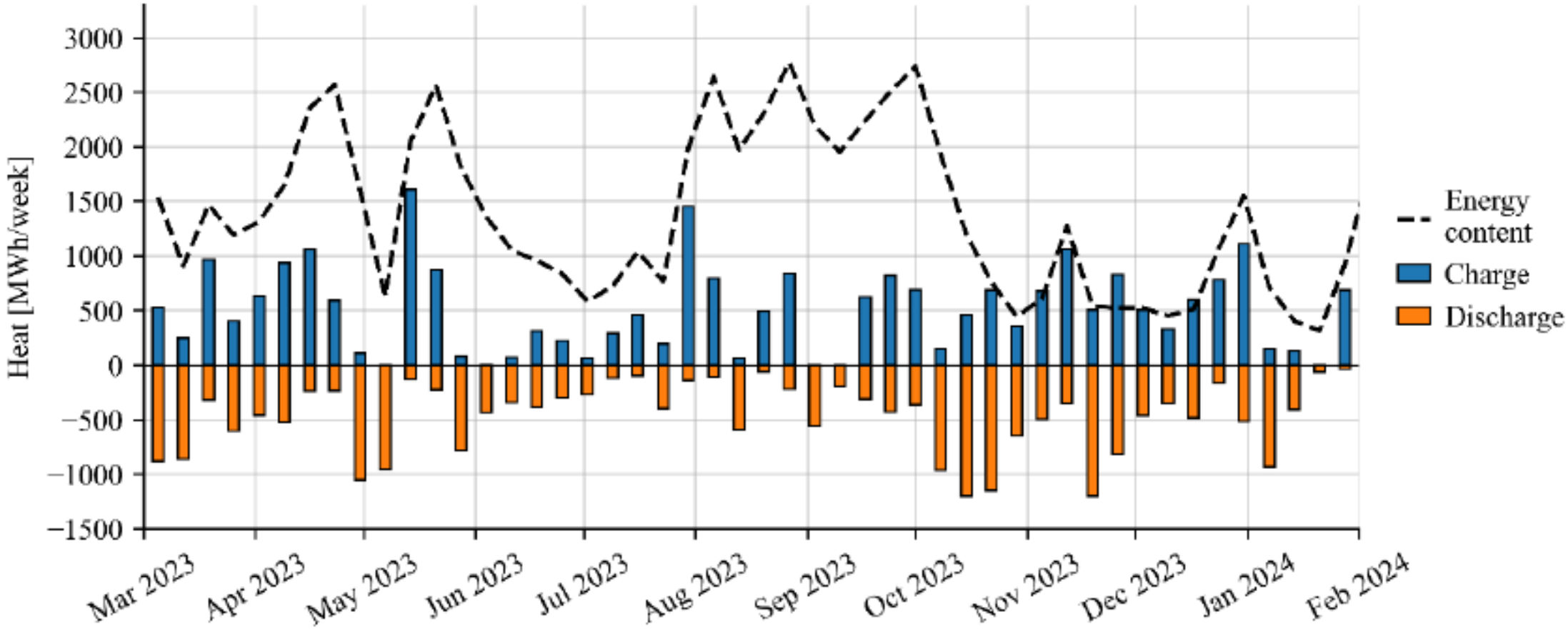
Income/year is calculated to 1.05 Mio € and operation costs are estimated to 0.16 Mio €/year. This results in a simple payback period of 12 years and an IRR of 7.5% calculated for 20 years. The lifetime for the PTES is expected to be more than 20 years.

Monitoring equipment- source DTU





Weekly charge, discharge and energy content – source DTU



Storage Efficiency of the PTES Høje Taastrup, 2nd year of operation

Table 4: Monthly charged and discharged energy, internal energy change, heat loss, and efficiency for 2024.

Period [2024]	$E_{charged}$ [MWh]	$E_{discharged}$ [MWh]	$\Delta E_{internal}$ [MWh]	$E_{loss,\ total}$ [MWh]	$E_{loss,\ lid}$ [MWh]	$E_{loss,ground}$ [MWh]	Efficiency [%]
January	1396	1629	-434	202	90	112	89
February	2961	2297	215	449	99	350	84
March	4993	4307	268	418	105	313	91
April	3793	3901	-322	214	95	119	95
May	3613	2161	994	457	88	369	83
June	1362	2112	-894	144	79	65	94
July	2660	1299	960	401	88	313	76
August	768	1534	-980	214	85	129	88
September	1388	1870	-641	159	86	73	92
October	2962	2154	595	214	98	116	91
November	4421	3766	231	424	105	319	90
December	3727	2887	537	302	106	196	90
Total	**34044**	**29917**	**529**	**3598**	**1124**	**2474**	**89**

Source: Sifnaios, I et al. Høje Taastrup Pit Thermal Energy Storage 2024 Measurement Report

In comparison: **87%** in the 1st year

Thank you for your attention

More information on

https://planenergi.eu/wp-content/uploads/2024/01/FLEX_TES-Implementationreport_final_23.12.23.pdf