PIT THERMAL ENERGY STORAGES
DENMARK, EXPERIENCE AND WORKING SYSTEMS

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March 2020

Medium-Duration Energy Storage in the Net-Zero UK

RAMBØLL Bright ideas. Sustainable change.

ABOUT ME

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Mechanical Engineer

Joined Ramboll Energy at 2016

Working as a senior consultant in decentralised energy systems

Member of the Institution of Mechanical Engineers

MSc graduate from Denmark's Technical University (DTU)

Research interest at CFD analysis of thermal stratification at PTES in Denmark

Participating in a group of Ramboll Specialist from Denmark and Europe promoting PTES technology in the UK

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AGENDA

01 **PTES basics**

Short description of technology and purpose

02 **Where and why we apply PTES**

Sectors (& technology transfer)
Economy of Scale advantage

03 **DK experience**

Project portfolio
Operational/practical experience – Vojens, DK

04 **Design improvements**

Lid
Thermal stratification

05 **Where we're heading / a market outlook**

06 **Questions**

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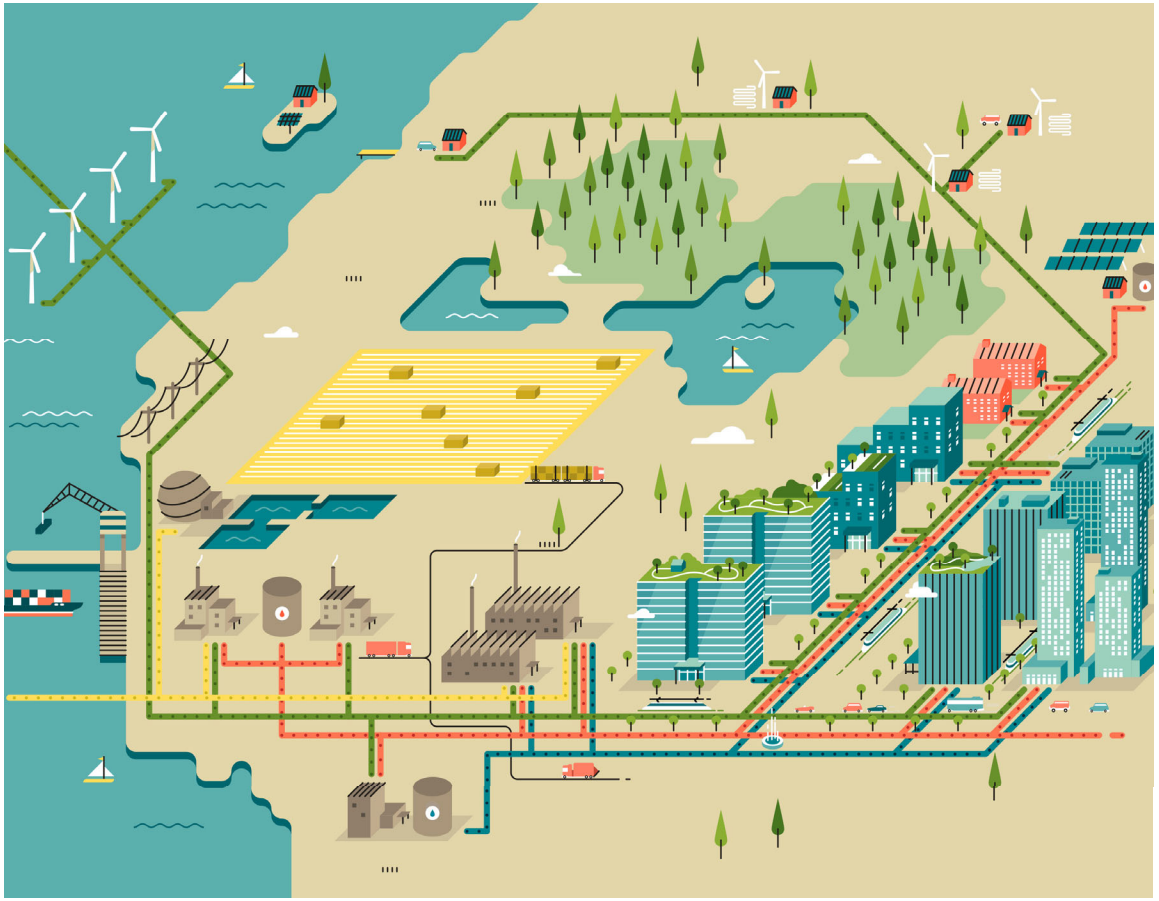
ROUTE TO A ZERO CARBON ENERGY SYSTEM

SMART CITIES

ROUTE TO ZERO CARBON

Smart technology is a key enabler in achieving sustainable and liveable societies enhancing well-being whilst reducing costs and carbon emissions

- ✓ Smart technical concepts
- ✓ Smart technologies
- ✓ Synergies
- ✓ Big data



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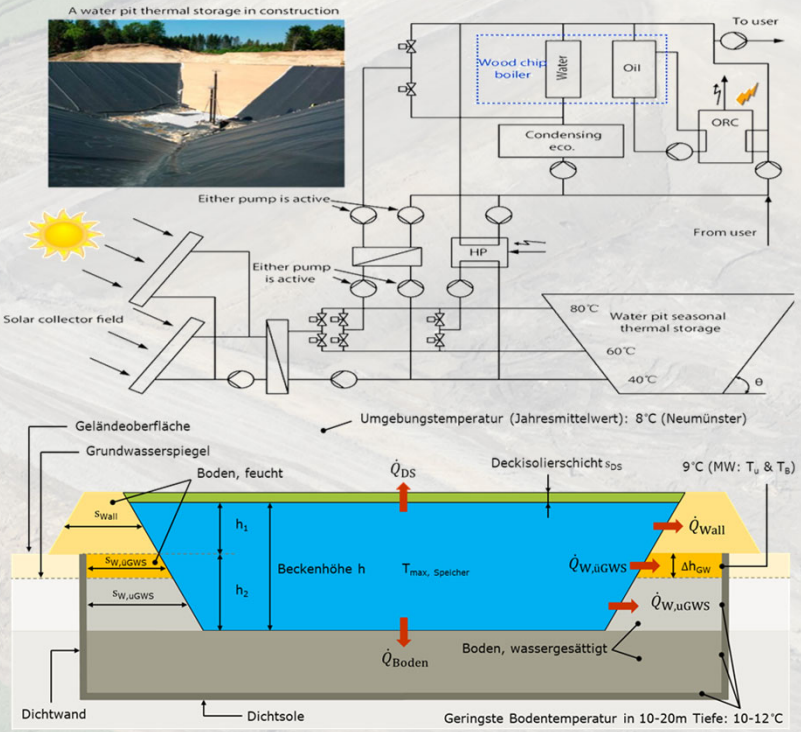
PTES basics (what is it?)

Water based thermal storage - originally utilized in DH systems with large solar thermal plants to achieve high solar fraction.

Offsetting summer/winter production/demand profiles

PTES technology synthesize a number of different engineering disciplines including design and operation of large heat storage tanks, establishing of large landfill sites (geo/civil work) and hydraulics.



http://sunstore4.eu/

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PTES BASICS

MARSTAL SOLAR FIELD AND PTES

PTES CONSTRUCTION

LID

SOLAR FIELD

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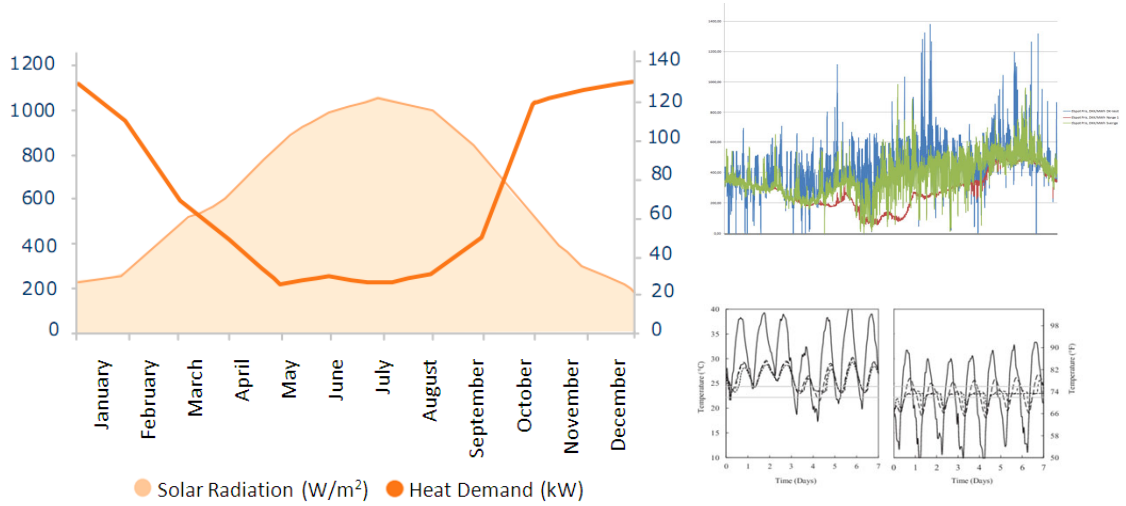
WHERE AND WHY WE APPLY PTES (SCOPE OF TECHNOLOGY)

Ensures high utilization ratio and cost effective production in energy systems where efficient production or fluctuating energy sources such as wind and solar are offset from demand on a daily, weekly or seasonal basis.



Different applications

- Large scale solar thermal in DH (seasonal)
- Off season surplus heat from CHP (seasonal/monthly/weekly)
- Cooling for process in industry (weekly/daily)
- District cooling (seasonal/monthly/weekly /daily)
- Heat Pumps (subcooling)

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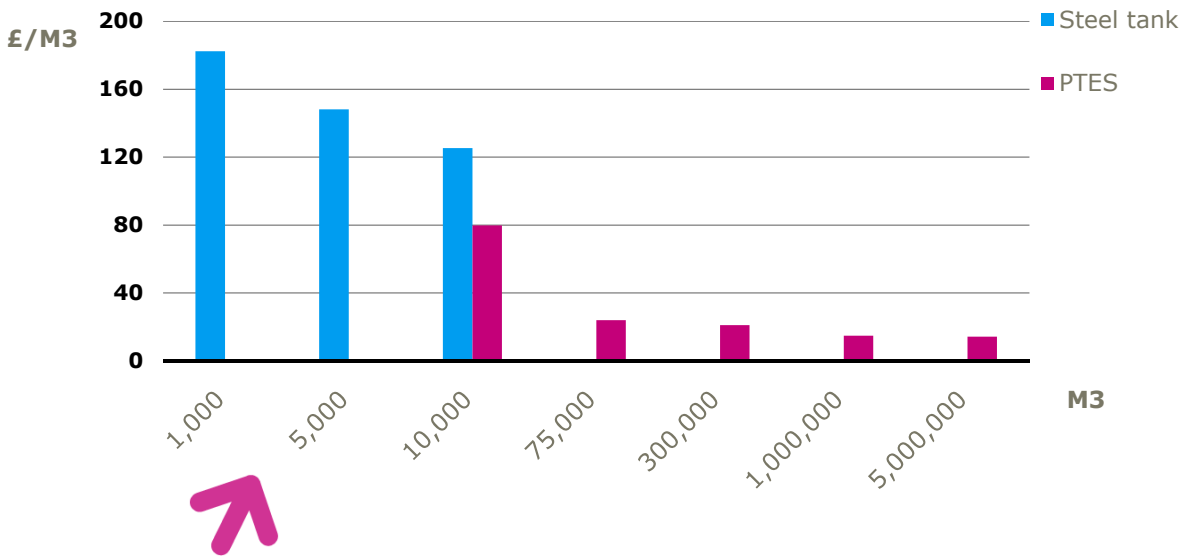
ECONOMY OF SCALE

MARGINAL COST (ABROAD/CASE SPECIFIC) £/M3 STORAGE



COST EFFICIENCY A KEY DRIVER COMAPRING TO SIMILAR STORAGE TECHNOLOGIES

UK EXPIRIENCE:

£600/m3 | £13/KWh

typical value of Steel tank solution of 1,000-2,000 m3

£24/m3 | £0.5/KWh

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EFFICIENCY

Measured seasonal efficiencies above **60%**

Number of **charge/discharge cycles is decisive** in investment planning due to direct link to energy losses – few cycles increases heat loss and decrease utilization factor

Annual efficiency increase over the first years of operation

http://solarheatdata.eu/

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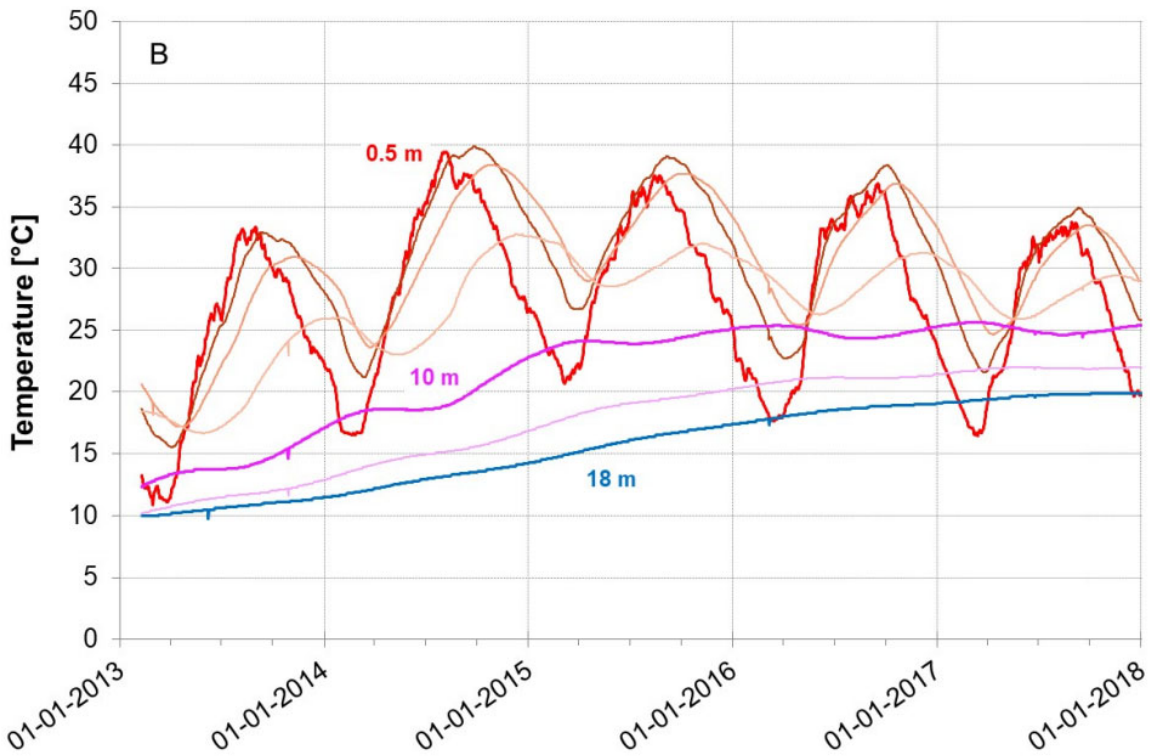
HEAT LOSS REDUCTION



Surrounding ground heats up over operation

Seasonal variations on the higher levels

Ground temperature build up at lower levels

Negative loses over winter (heat flux from ground) if lower stratification layers are subcooled by heat pump

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From Solites: https://www.solar-district-heating.eu/wp-content/uploads/2019/10/Final-report-EUDP-64014-0121_2019.05.31.pdf

WHAT WE DO (SELECTED LANDMARK PROJECTS)

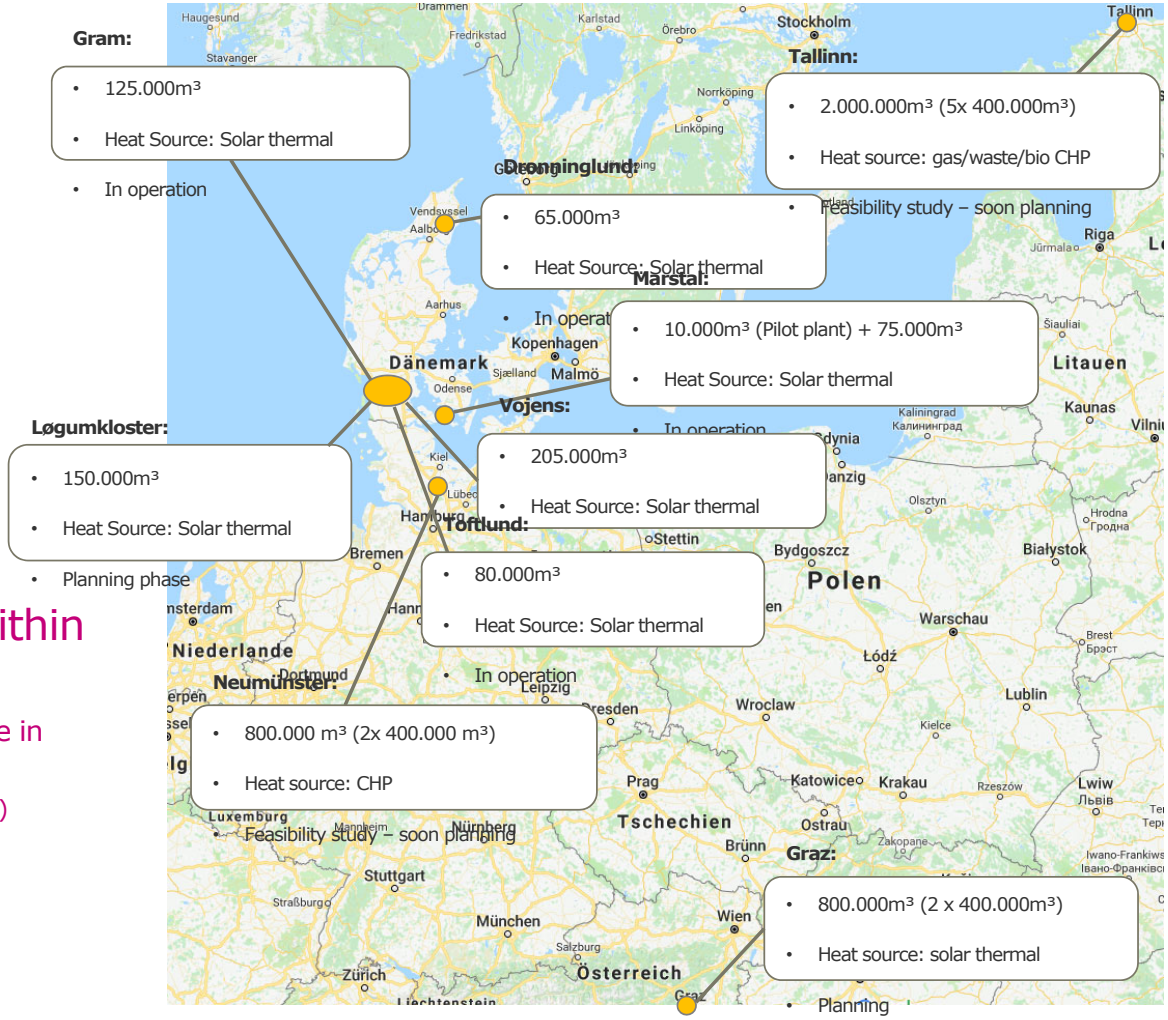
- Pit storage projects
  - 5 plants in operation
  - 6 plants being planned

- Heat Source:
  - Solar Thermal
  - CHP (gas, coal, waste-to-energy)
  - Industrial surplus heat
  - Process cooling in industry

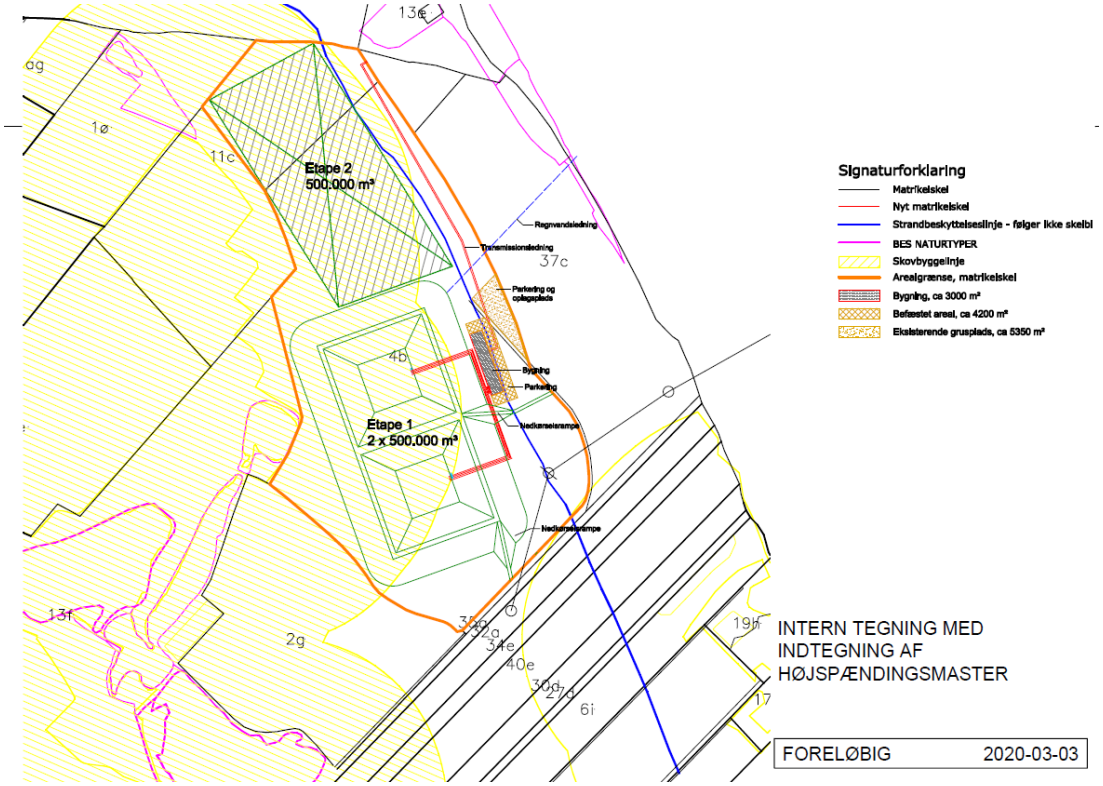
- Rambøll are global market leaders within PTES

  – We are currently or have been involved at each stage in almost every PTES plant in operation to day

  (*feasibility & planning, detail design, execution and commissioning*)



2 X 500.000 M3 PTES, DESIGN PHASE AALBORG DK



The heat storage pit will be located at a former waste disposal site, which has formerly been used to deposit slightly contaminated soil. The facility will have a magnitude of an impressive 2x500.000m3 with the possibility of extending with an additional 500.000m3 at a later stage.

The facility will equivalate to five times the size of the thermal heat storage pit that was established in Vojens, Denmark approximately four years ago. This makes it by far the world's largest heat storage facility, with an in- and outlet capacity of 250-300MW and pipelines in the size range of DN800 to DN1.000.

WORLDS LARGEST PIT HEAT STORAGE IN VOJENS, DK

- Facts and figures
  - Consumer owned DH
  - 64,000 MWh produced/year **(~50% solar)**
  - Natural gas CHP and solar
  - **71.000** m2 solar panels
  - **203.000** m3 pit heat storage

- Technology development and the most significant challenges:
  - **Thorough geotechnical surveying is a must**
  - **Weather conditions are critical during execution**
  - **High degree of water treatment required** (softening of water necessary)
  - **Extensive control/supervision** during built to ensure sealing and lid insulation
  - New designs developed for **handling drainage and drying of lid/insulation**

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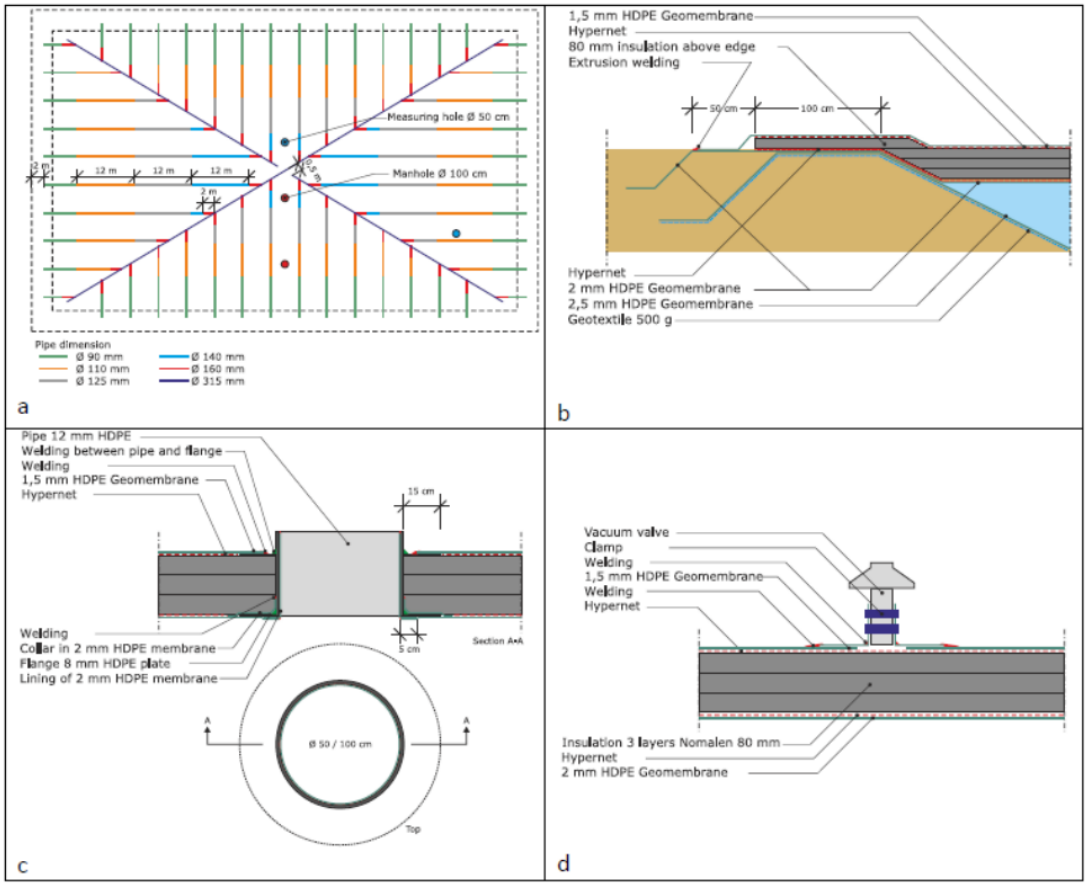
DESIGN IMPROVEMENTS



Thermally insulated Lid

Majority of heat losses associated to the lid

Weighted with steel pipes

Lid ventilation is critical

Improvements on handling drainage and drying of lid/insulation

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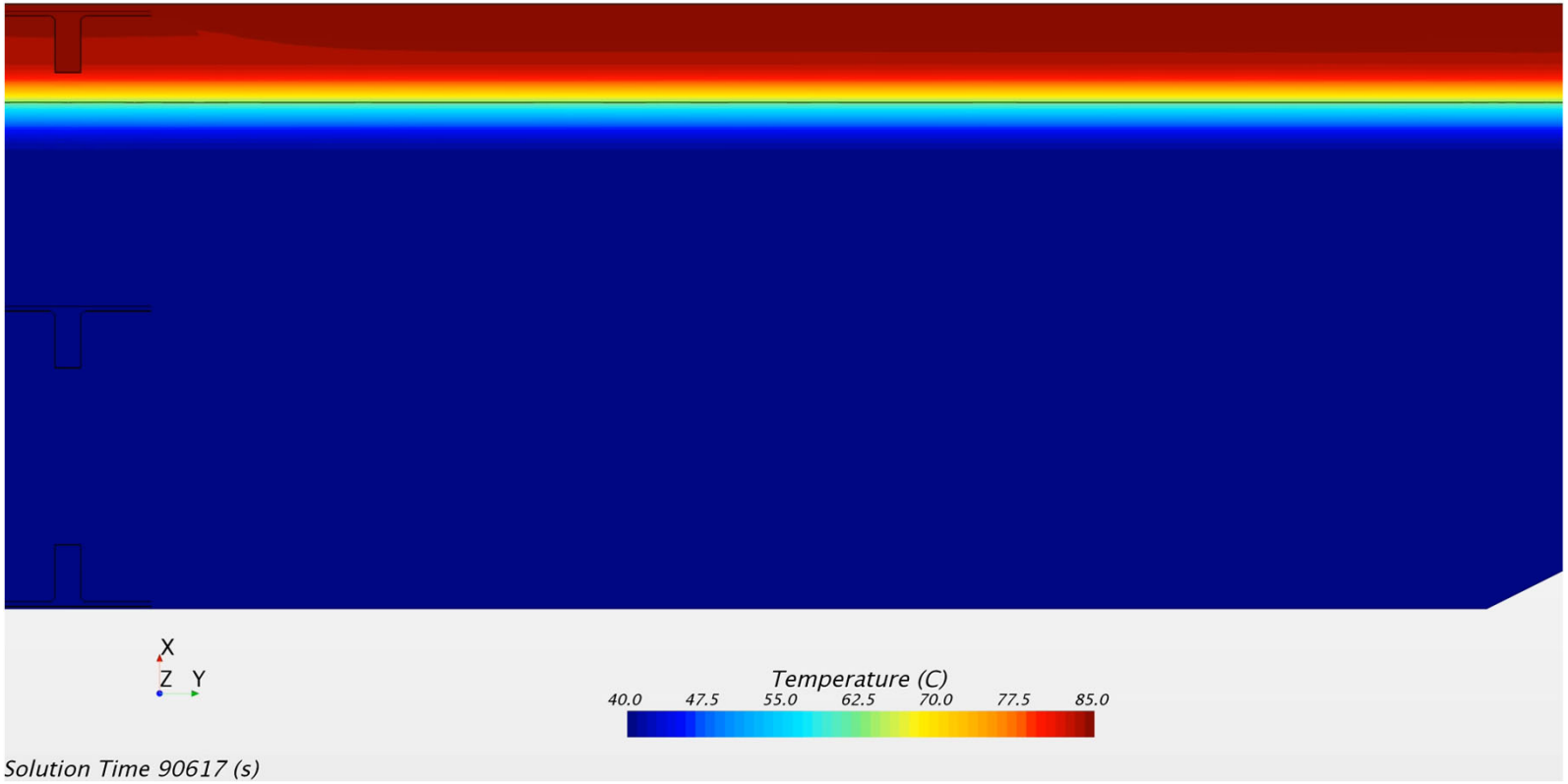
THERMAL STRATIFICATION

Charge 250 MWw, V_o = 0.4 m/s (D_o = 6600 mm)



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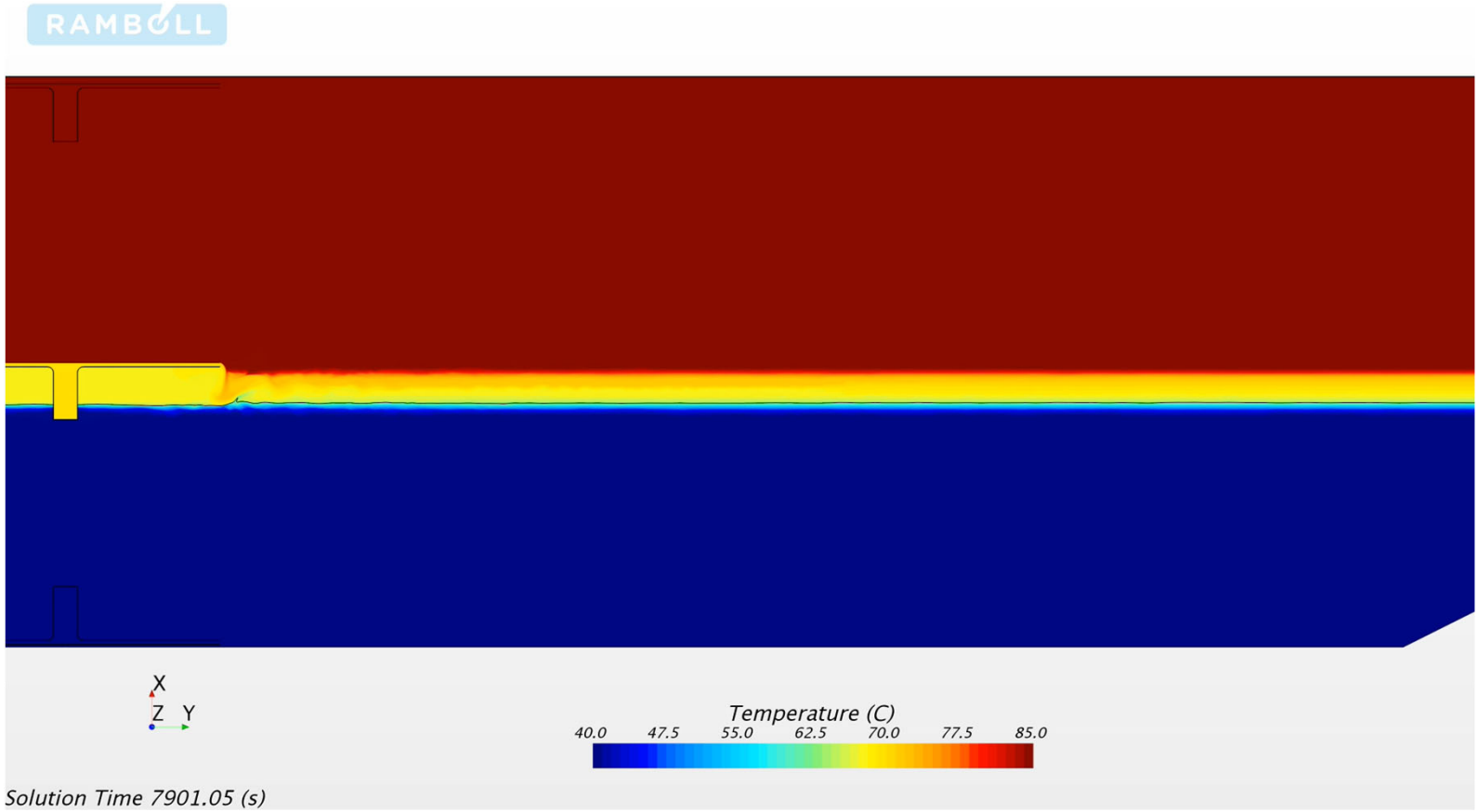

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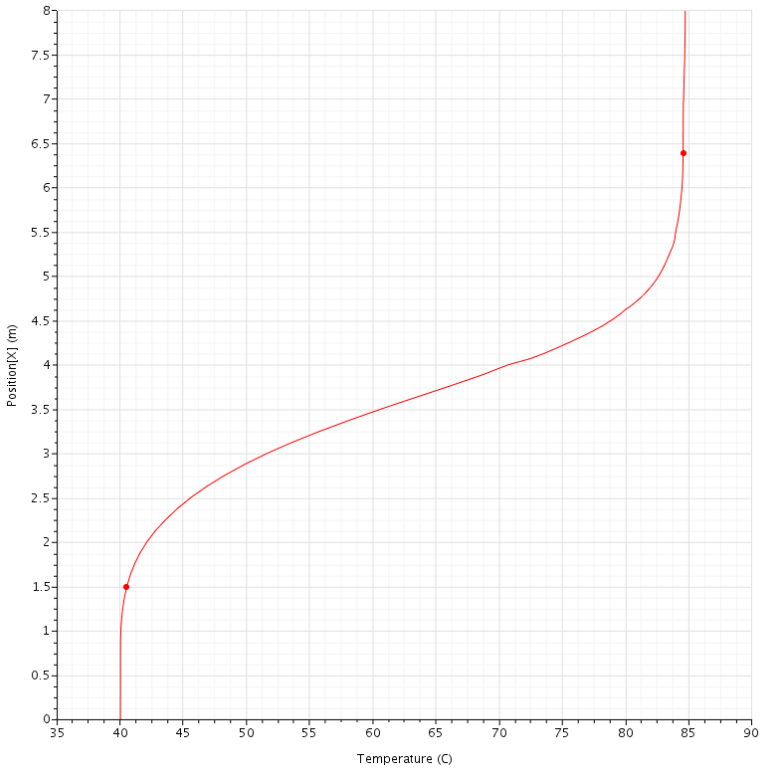
THERMAL STRATIFICATION



Charge 250 MWw, V_o = 0.4 m/s (D_o = 6600 mm)

Thermal Stratification is crucial to store heat while minimising heat losses

Velocities on the magnitude of 0.4 m/s

Aim is to avoid turbulence around diffusers

Diffusers at multiple locations to facilitate charging/discharging at different conditions

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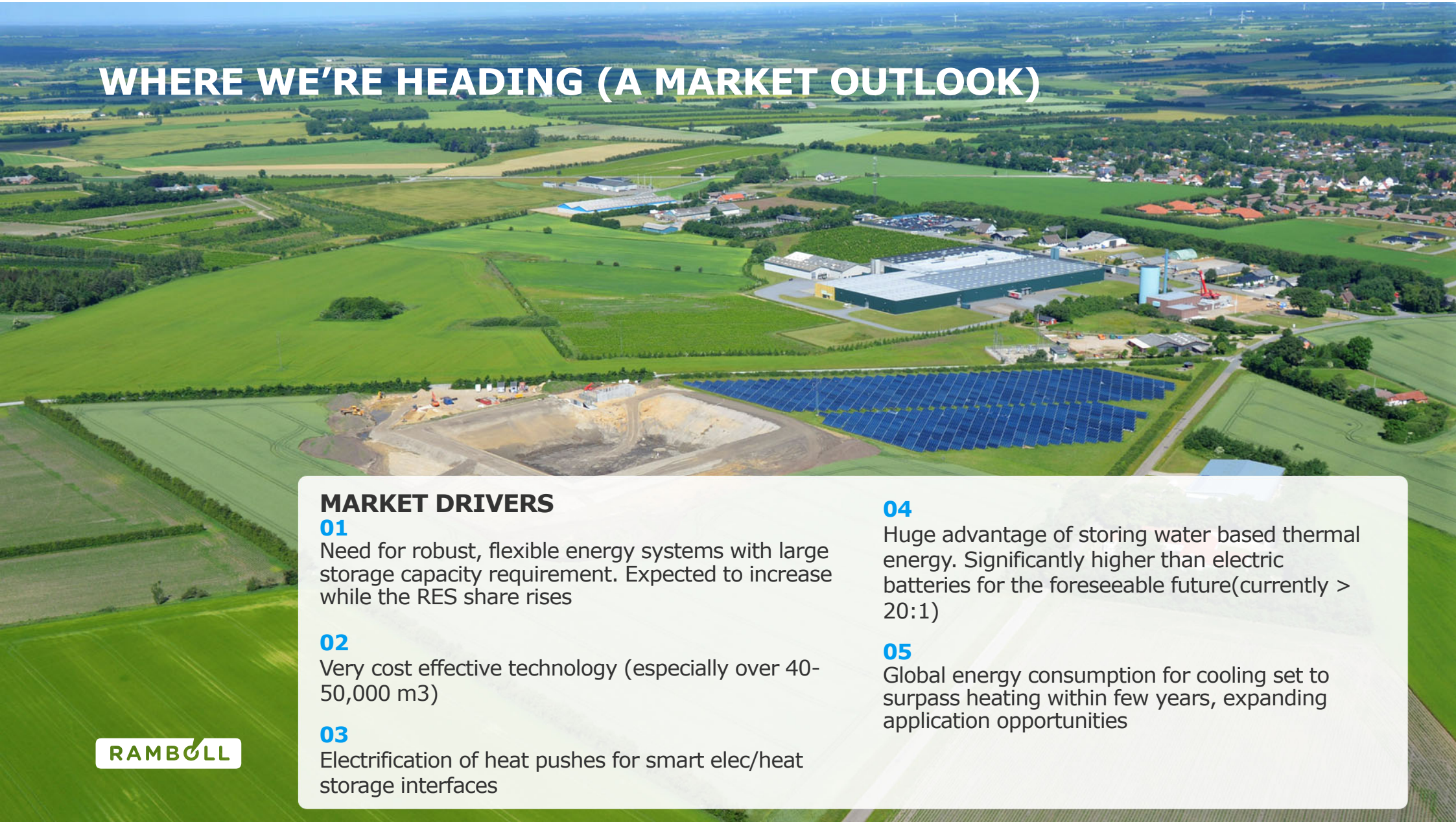
WHERE WE'RE HEADING (A MARKET OUTLOOK)



MARKET DRIVERS

01
Need for robust, flexible energy systems with large storage capacity requirement. Expected to increase while the RES share rises

02
Very cost effective technology (especially over 40-50,000 m3)

03
Electrification of heat pushes for smart elec/heat storage interfaces

04
Huge advantage of storing water based thermal energy. Significantly higher than electric batteries for the foreseeable future(currently > 20:1)

05
Global energy consumption for cooling set to surpass heating within few years, expanding application opportunities

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WHERE WE'RE HEADING (A MARKET OUTLOOK)

THE TREND:

EU trend towards low carbon energy systems.

Public & private entities deal with complex large scale energy production (electricity, cooling and heating)

Global trend towards integrating higher share of RES - this underlines the demand for cost effective storage technology

- **PTES is a proven technology within large district heating systems in DK (and perhaps soon in other parts of Europe)**

"The claim"

- More than half (@2017) of UK's primary energy demand (excluding transport) is heating or cooling, usually in the form of water.

- Why not store the actual product in demand when it is so much cheaper?

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MEET RAMBOLL'S PTES TEAM

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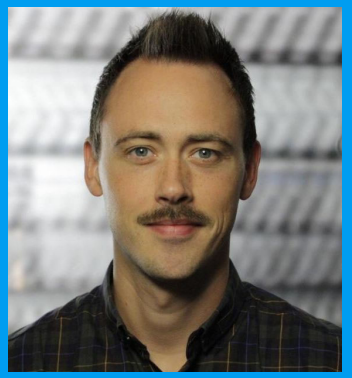

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QUESTIONS?


START
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TOP VIEW
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Polymer liners, ready for mounting
[Add text]
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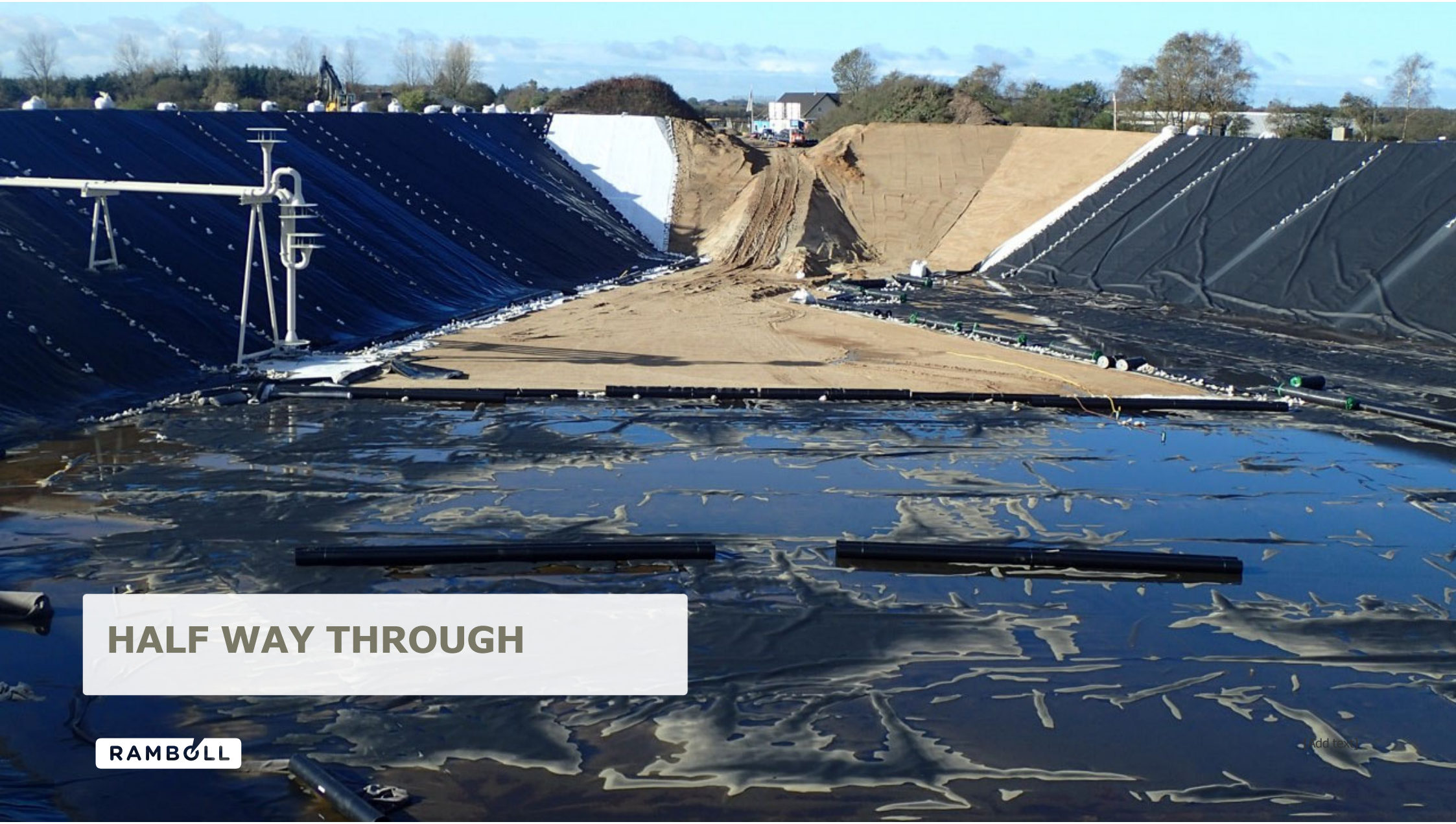

HALF WAY THROUGH

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WATER OUTLETS

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[Add text]


START FILLING
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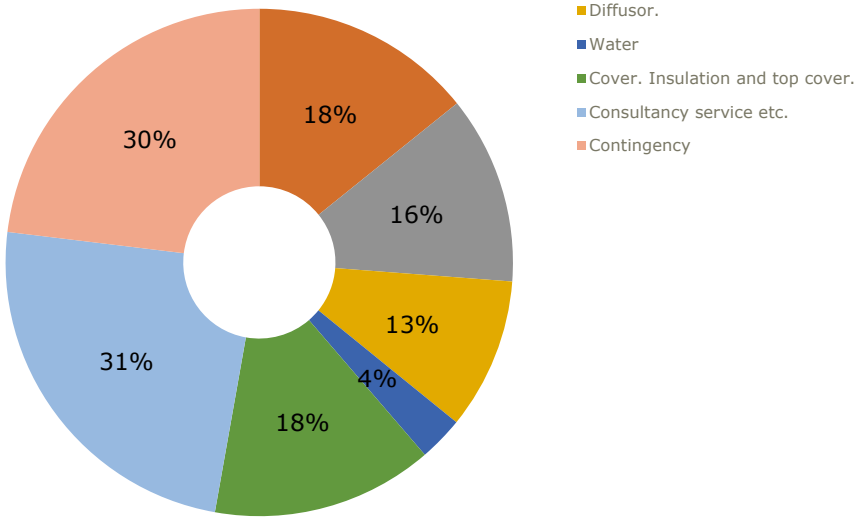
[Add text]


3 MONTH LATER
STILL FILLING
RAMBØLL
[Add text]

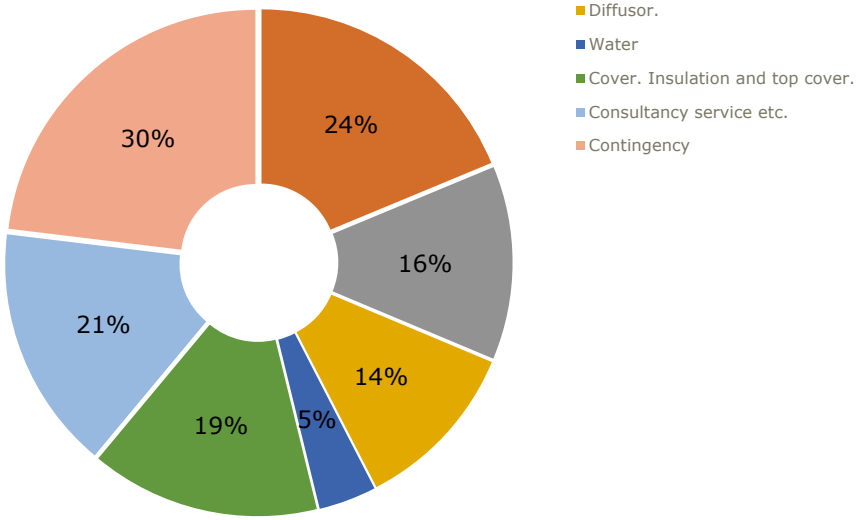

CAT
SEJER
CAT
325D

COST BREAKDOWN (CASE SPECIFIC)

50.000 M3

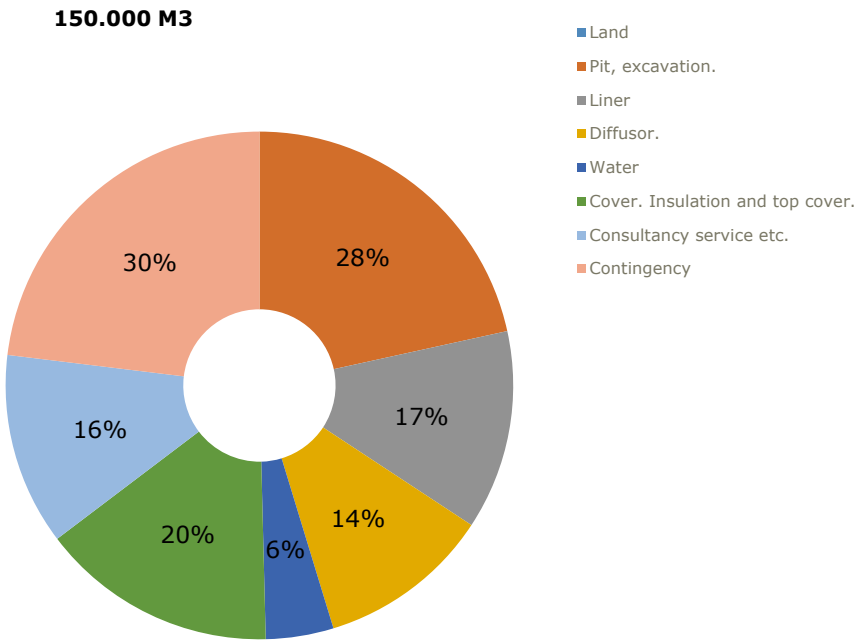


100.000 M3

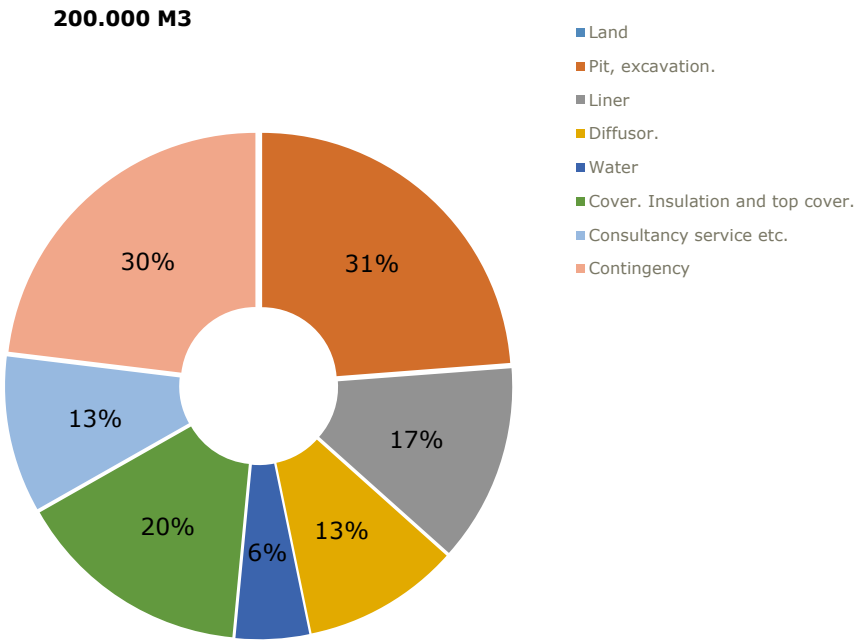


COST BREAKDOWN (CASE SPECIFIC)

150.000 M3



200.000 M3



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