HEATSTORE
HIGH TEMPERATURE UNDERGROUND THERMAL ENERGY STORAGE (HT-UTES)

KNOWLEDGE SHARING AND MONITORING MEETING, 28. OCTOBER 2020

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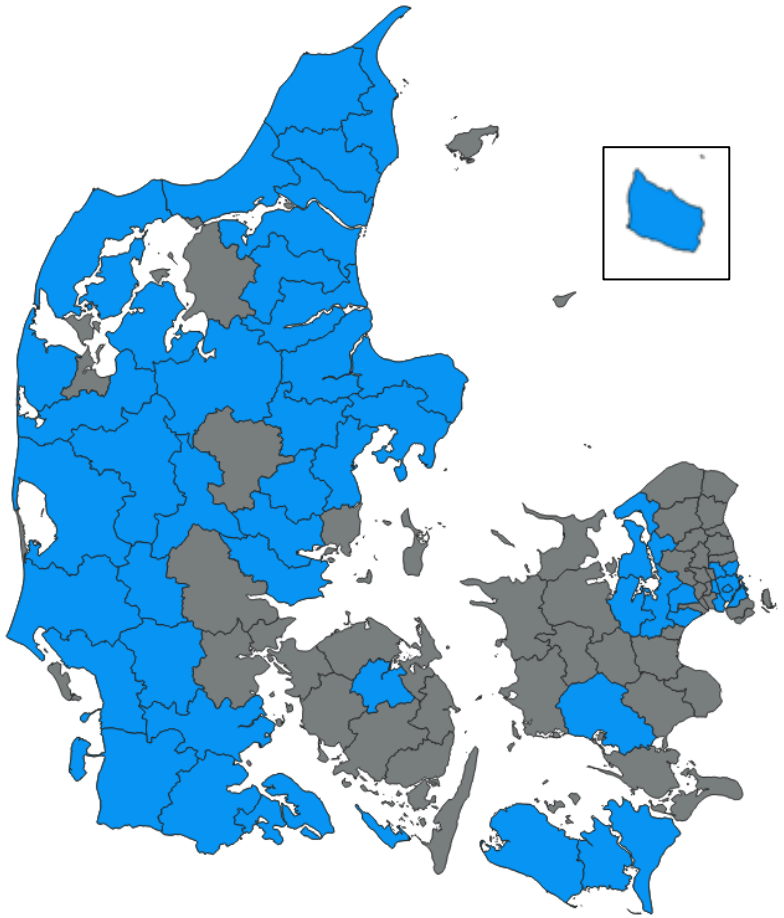
heatstore
High Temperature Underground Thermal Energy Storage

SURVEY OF INTERESTS AND REVIEW OF GEOLOGICAL CONDITIONS IN SELECTED AREAS

i. **Survey of interests (UTES tecnologies – HT-ATES, BTES and PTES)**
   i. Danish district heating (DH) and energy utilities
ii. **Review of geological conditions in selected areas**
   i. Subsurface screening and feasibilty (BTES, ATES)
   ii. Examples from Danish study cases

SURVEY OF INTERESTS AMONGST DH UTILITIES (2019)



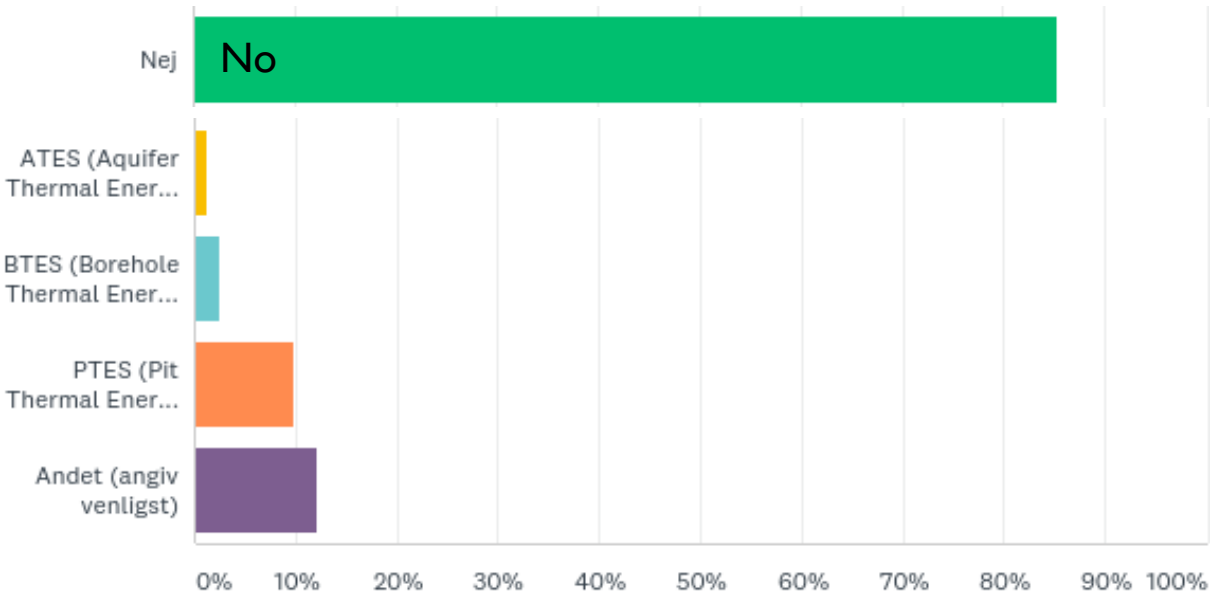
- Questionnaire send to 400 DH utilities
- Number of replies : 82 (district heating utilities)
- 10 questions

Visualisation of municipalities with DH utilities replying the questionnaire (blue colour).

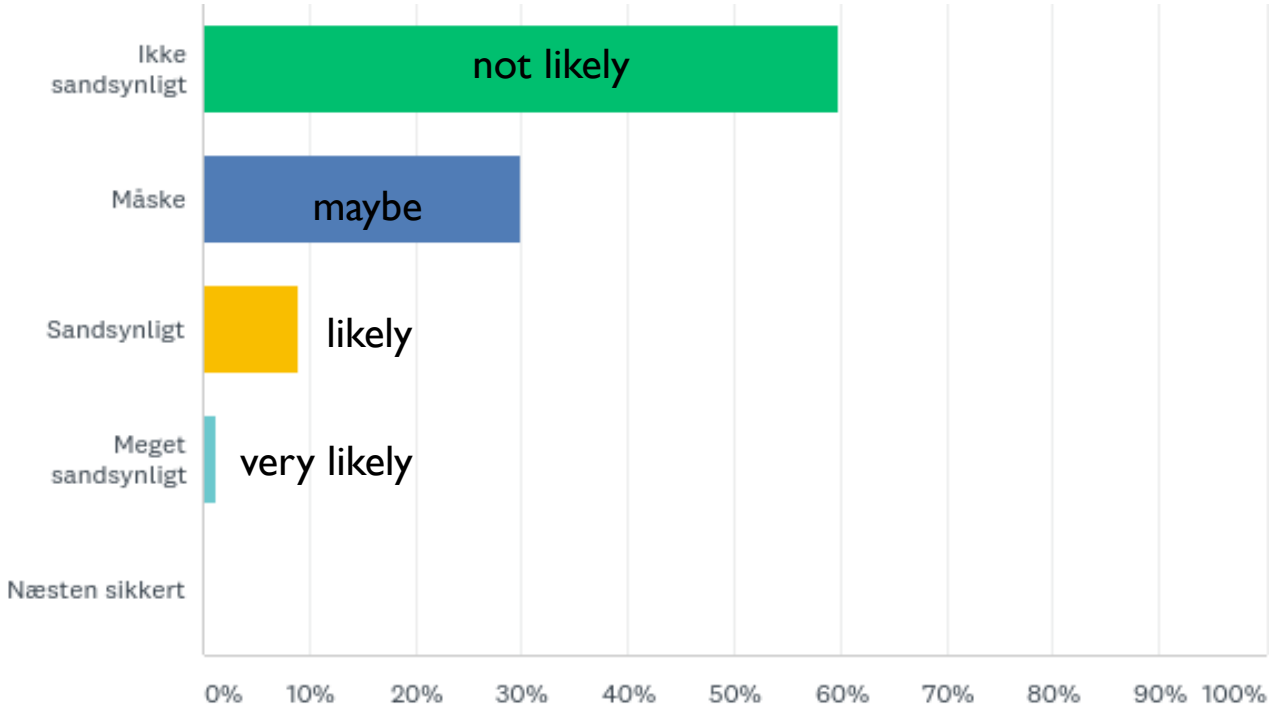
QUESTIONS ON ACTUAL OR FUTURE PLAN ON IMPLMENTING UTES TECHNOLOGIES

SURVEY OF INTERESTS

Actual plans

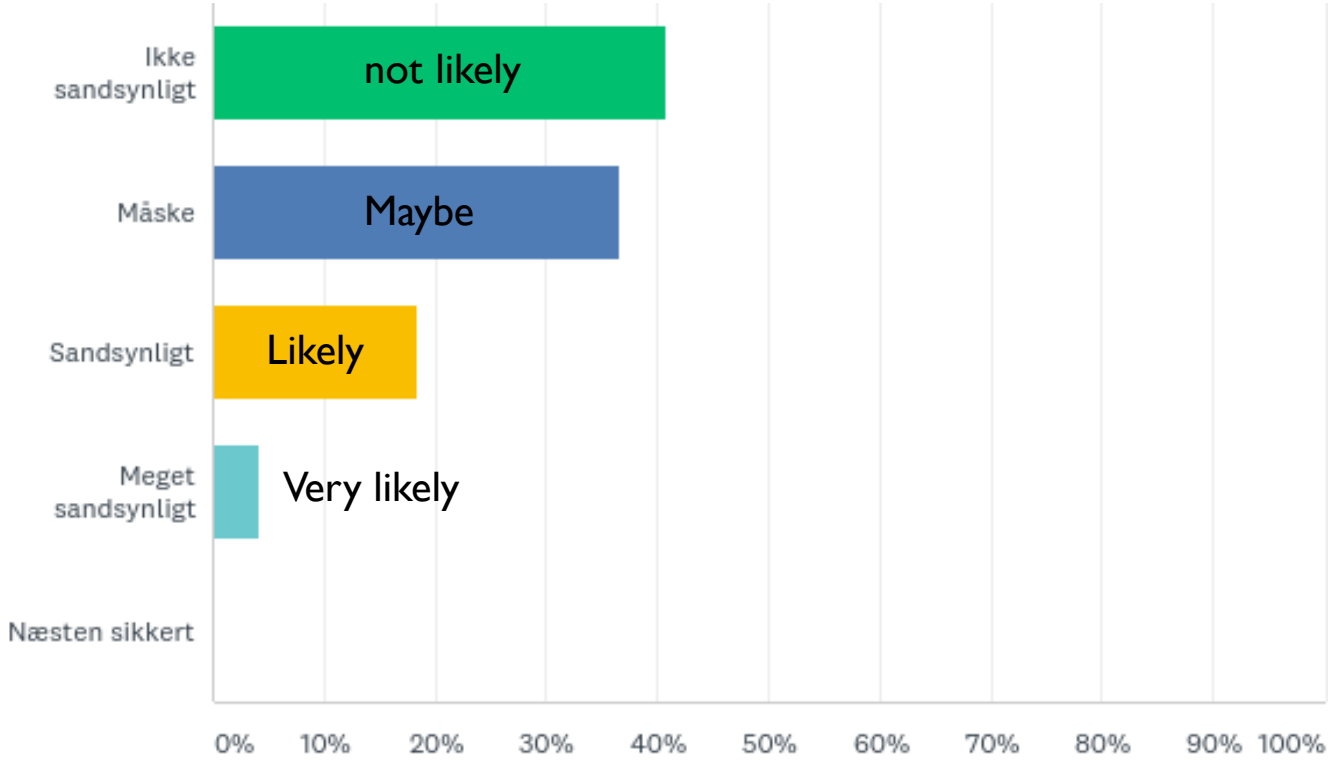


Future plans/considerations



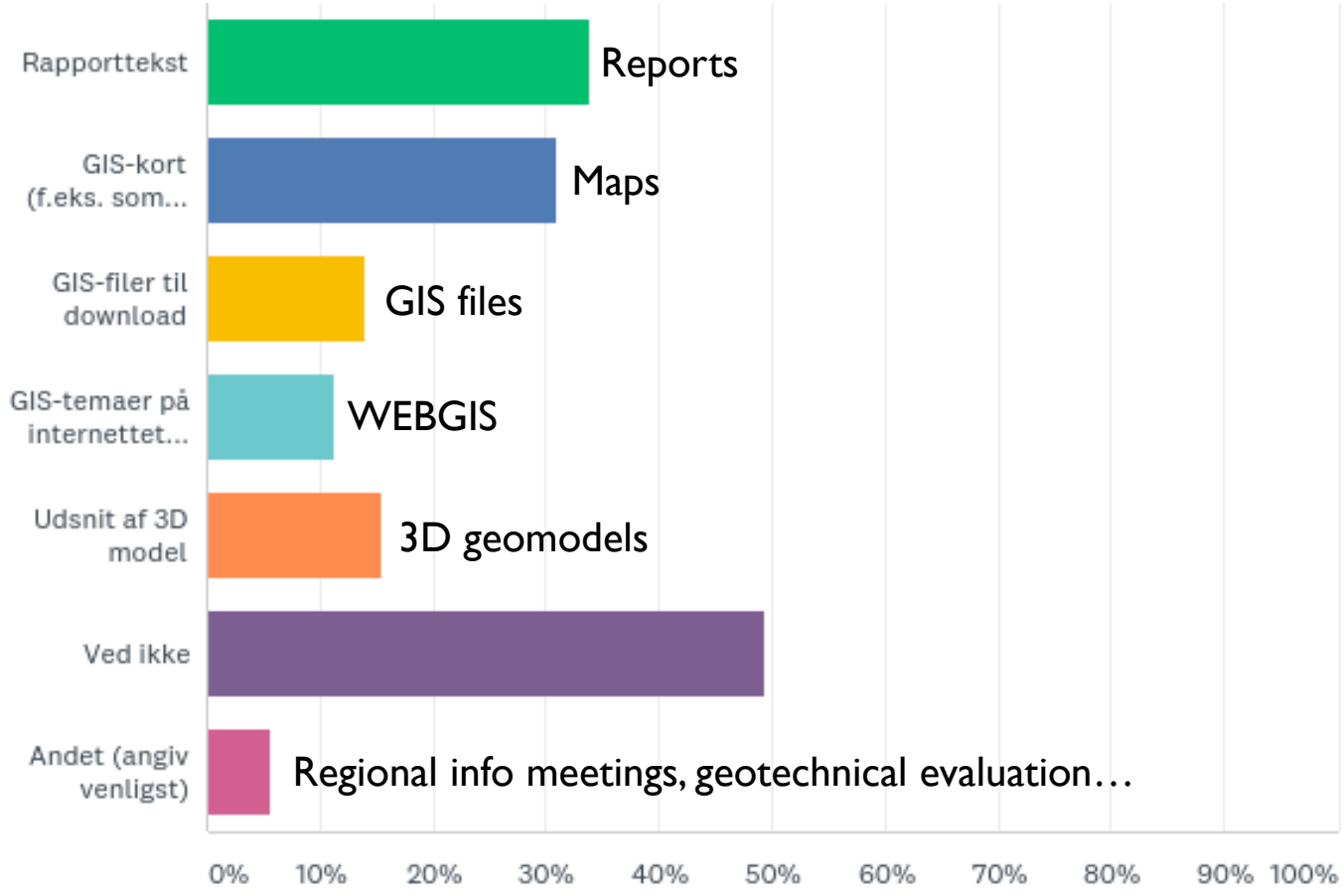
HOW CAN THE HEATSTORE PROJECT SUPPORT THE KNOWLEDGE ON UTES TECHNOLOGIES IN DENMARK?

Question:
Can easy accessable knowledge on geology and information about UTES contribute to investigate the possibilities for establishing UTES ?



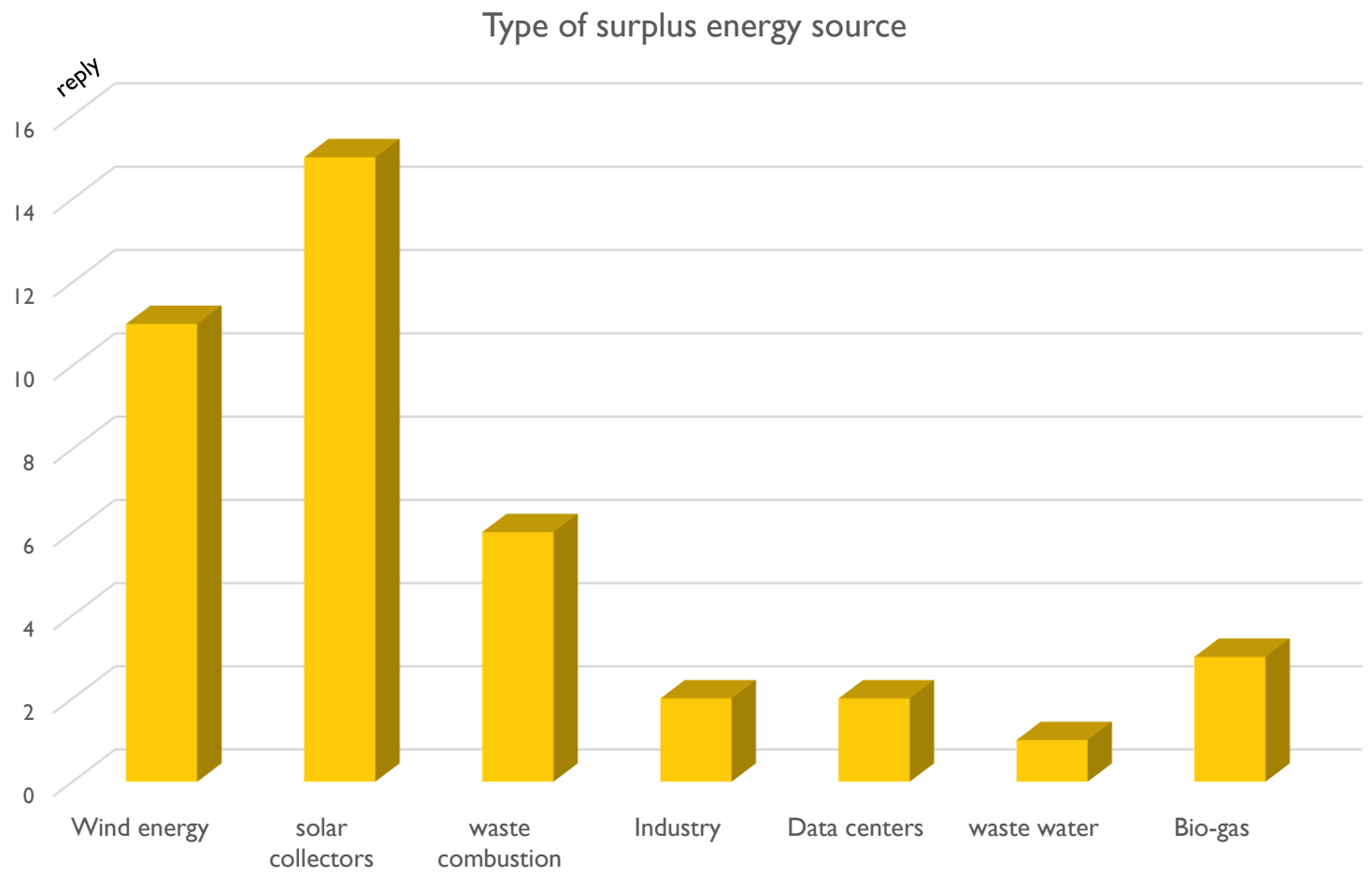
HOW CAN THE HEATSTORE PROJECT SUPPORT THE KNOWLEDGE ON UTES TECHNOLOGIES IN DENMARK?

Question:
How do we best communicate to stakeholders and descision makers on the UTES potential and knowledge sharing ?



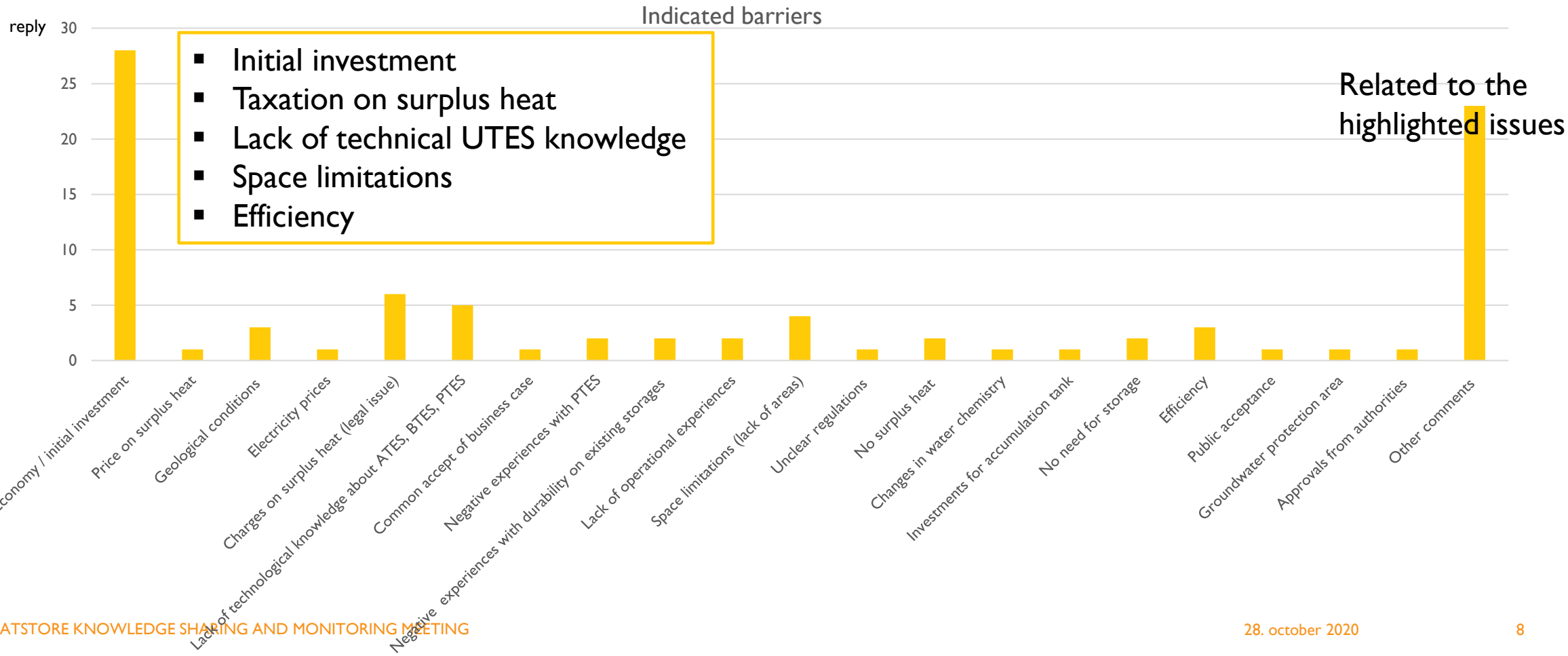
TYPES OF SURPLUS ENERGY SOURCES?

SURVEY OF INTERESTS



INDICATED BARRIERS TO OVERCOME?

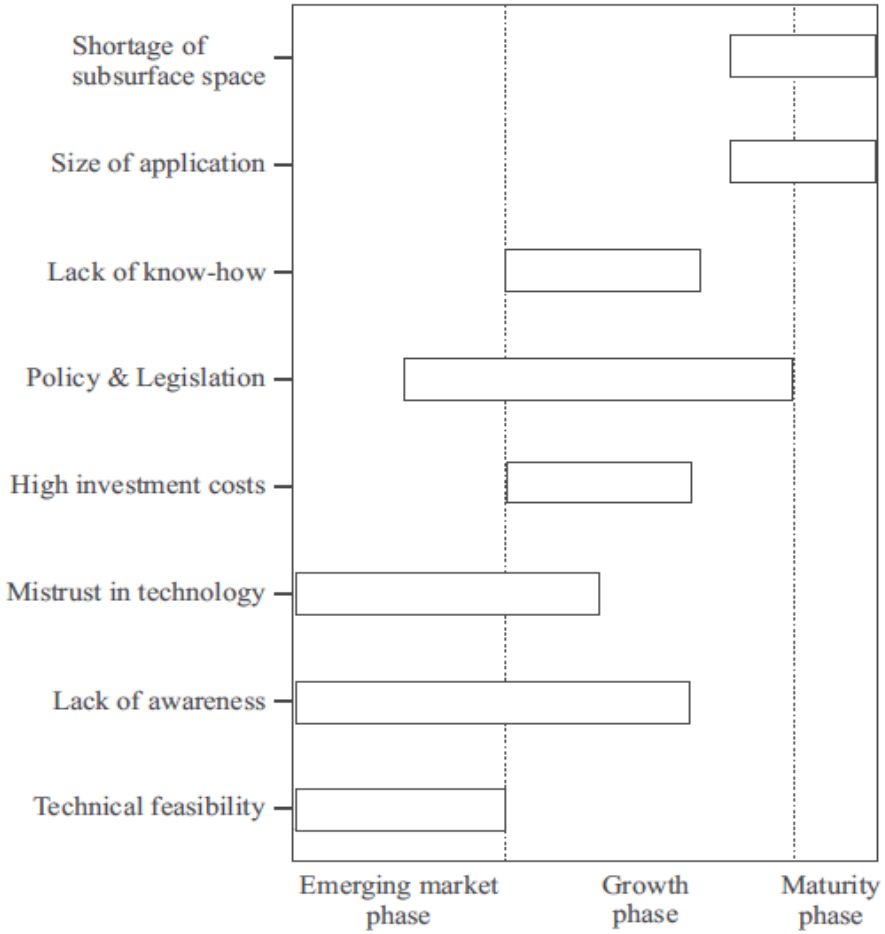
SURVEY OF INTERESTS

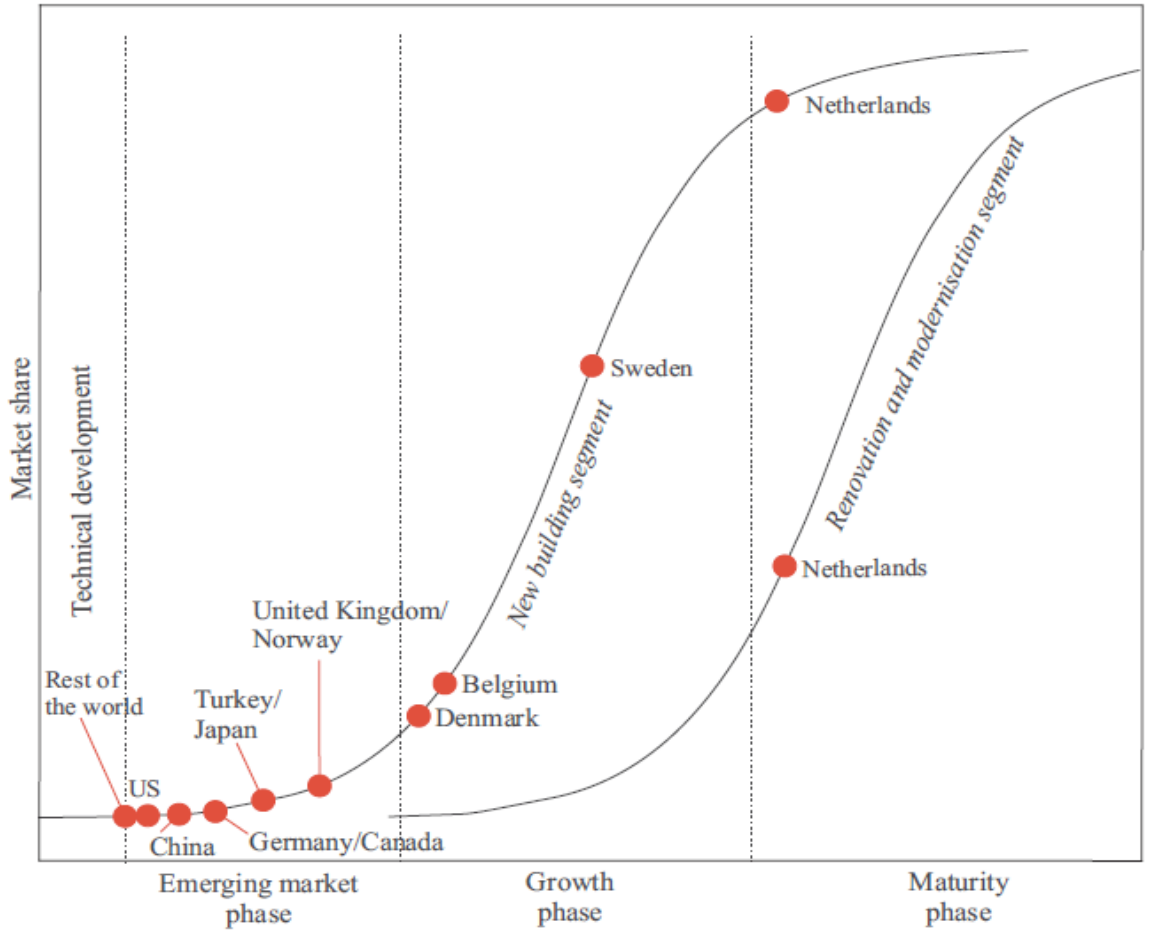


SUMMARY – SURVEY OF INTERESTS (DH UTILITIES)

- **UTES systems**
  - Most DH utilities are considering PTES (8)
  - Considerations on deep geothermal storage are mentioned
  - Actual ATES considerations is described by only 1 utility
- **Surplus energy/heat**
  - Especially surplus heat from *Solar collectors* and surplus power from *windfarms* are highlighted
  - Surplus heat from waste incineration, data centers, local industry and biogas
- **Barriers to overcome**
  - Initial investment
  - Legal issues (unclear regulation, taxation on surplus heat, permission from authorities)
  - Space demands
  - Lack of technological knowledge
- **Information**
  - Many utilities are not aware on the current access to data and knowledge on the subsurface
  - Limited knowledge/experiences on UTES systems (except PTES)

OUTLOOK - COMPARISON WITH ATES DEVELOPMENT IN GENERAL





Left: *market barriers limiting ATES development as a function of the market development leve*l (suitable subsurface and climatic conditions are assumed) and right: market development of ATES in all relevant countries considering new building and renovation segments (*reprinted from Renewable and Sustainable Energy Reviews, Vol 94, Fleuchaus, P., Godschalk, B., Stobera, I. & Blum, P. Worldwide application of aquifer thermal energy storage – A review, 861–876, Copyright (2018), with permission from Elsevier)*

SUBSURFACE SCREENING AND FEASIBILITY REVIEW OF GEOLOGICAL CONDITIONS

Theoretical storage potential

Critical information needed

- Depth of aquifers and aquitards
- Net thickness of aquifers and aquitards
- Permeability, porosity, transmissivity
- Groundwater properties (flow, salinity, viscosity, temperature, density)
- Hot well injection temperature
- Cold well injection temperature

Technical storage potential

Critical information needed

- Technological drilling restrictions
- Technological restrictions for temperature trajectory
- Technological flow restrictions (well, pumps, aquifer stability)

Economic & market potential

Critical information needed

Economics

- Time dependent (future) heat demand and supply profile (GJ/day or GJ/week)
- Specific investment costs (euro/MW)
- Fixed and variable operation & maintenance cost (eur/GJ; eur/MW)
- Economic life time (year)
- Marginal costs of heat sources (euro/GJ)
- Cost of competitive heat sources

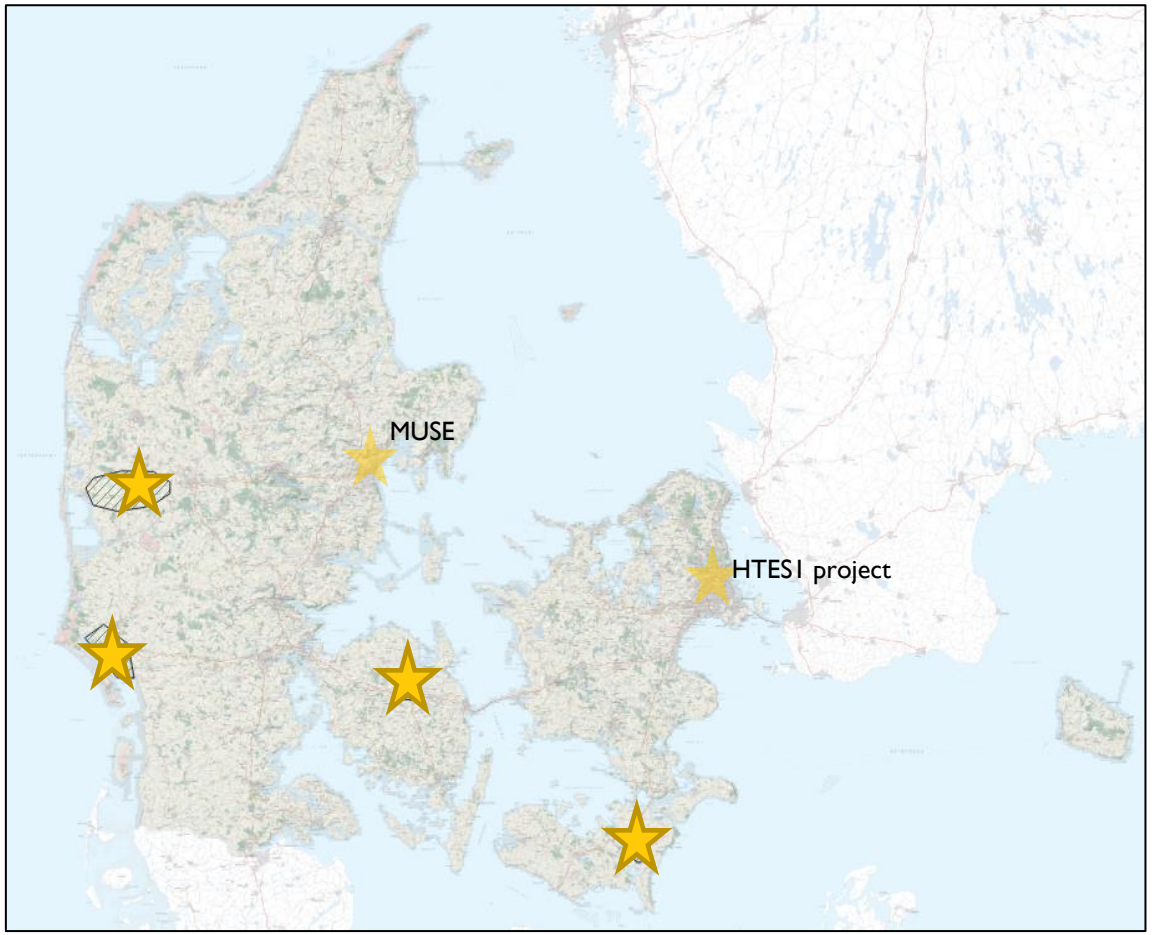
Local implementation

- Stakeholder acceptance
- Spatial planning restrictions: subsurface competition and surface restrictions (e.g. nature areas, drinking water areas)
- Regulatory framework

Methodological framework of assessing theoretical, technical and economic & market potential of **HT-ATES** (reused from https://doi.org/10.1016/j.energy.2018.01.072 with permission by Elsevier Ltd. under Creative Commons license CC-BY-NC-NDhttps://creativecommons.org/licenses/by-nc-nd/4.0/189)

GEOLOGICAL CHARACTERIZATION

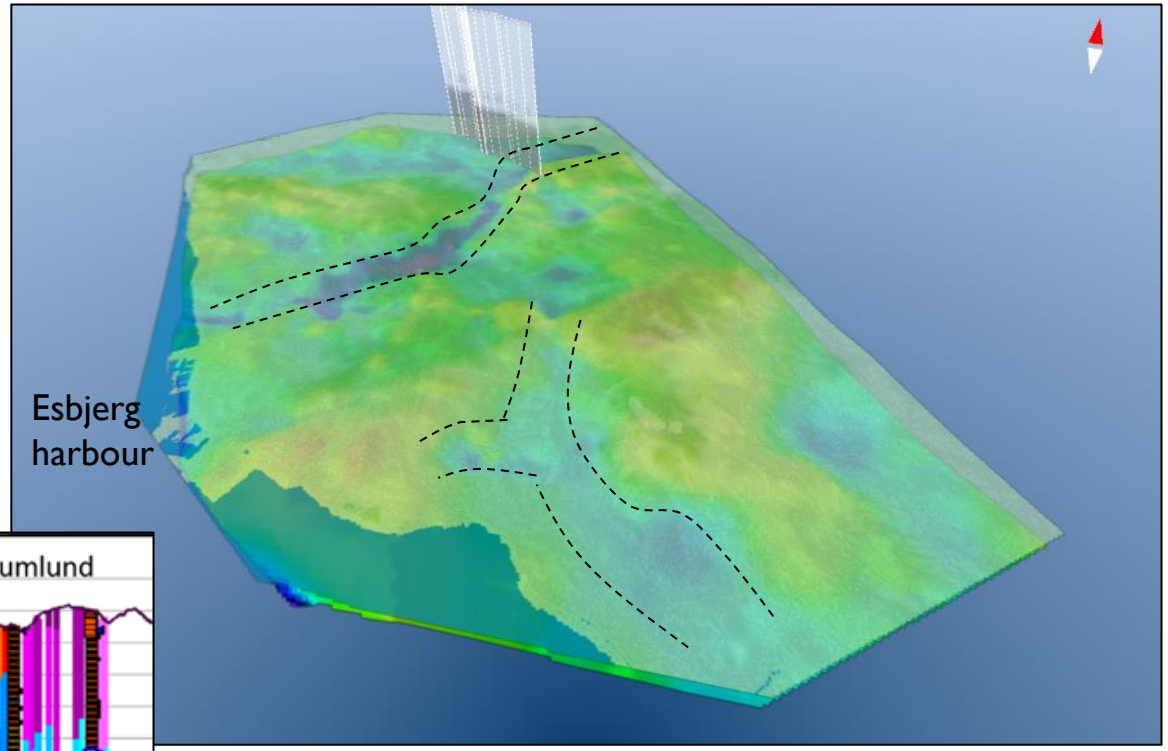
- **Selection criteria based on survey results:**
  - Indicated plans or considerations for heat storage
  - Access to surplus heat, etc.
  - Diverse geological settings in Denmark
    - *Southwest Jutland* – Miocene and Quaternary buried valleys
    - *West-central Jutland* – Semi-deep Miocene sand lobes
    - *Funen* – Quaternary, pre-Quaternary marls and limestone
    - *Southeast DK* – Quaternary and chalk
- **Synergy projects**
  - **MUSE (GeoERA)** – Aarhus a study area
  - **HTES I (EUDP)** – focus on heat storage potential beneath Copenhagen (chalk deposits)

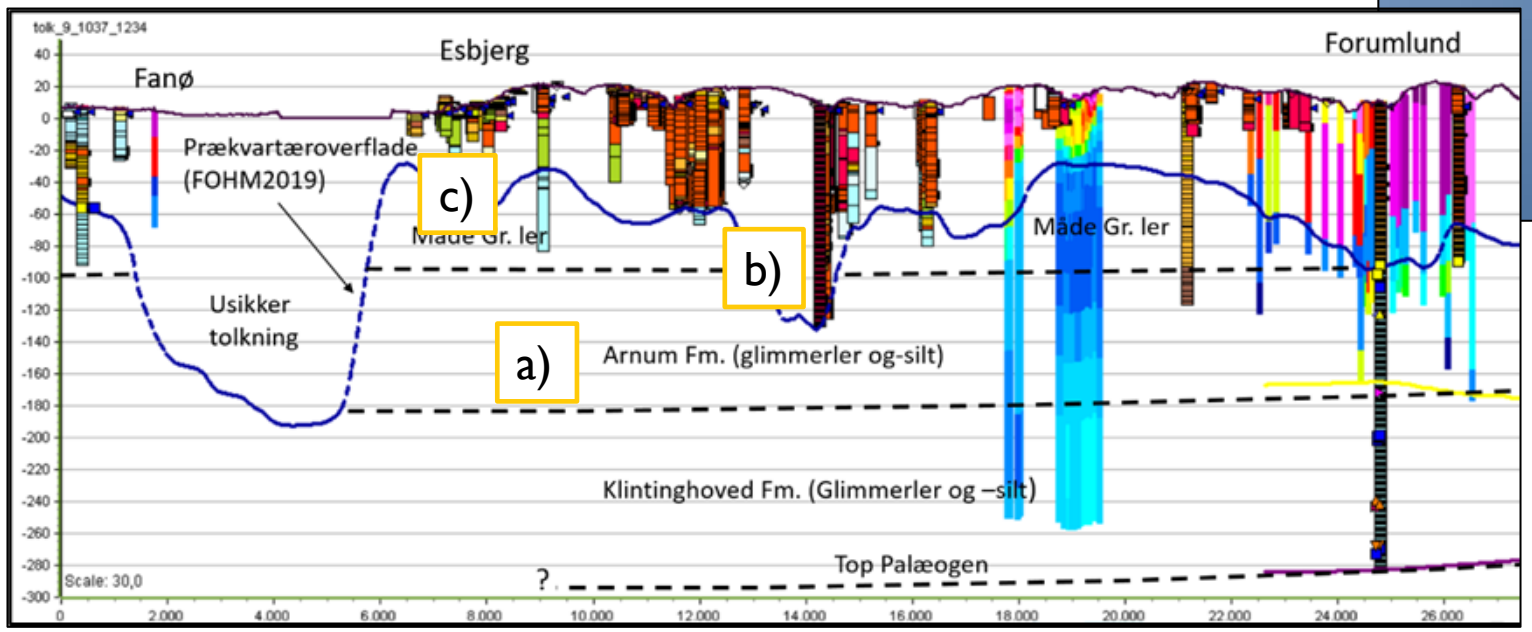


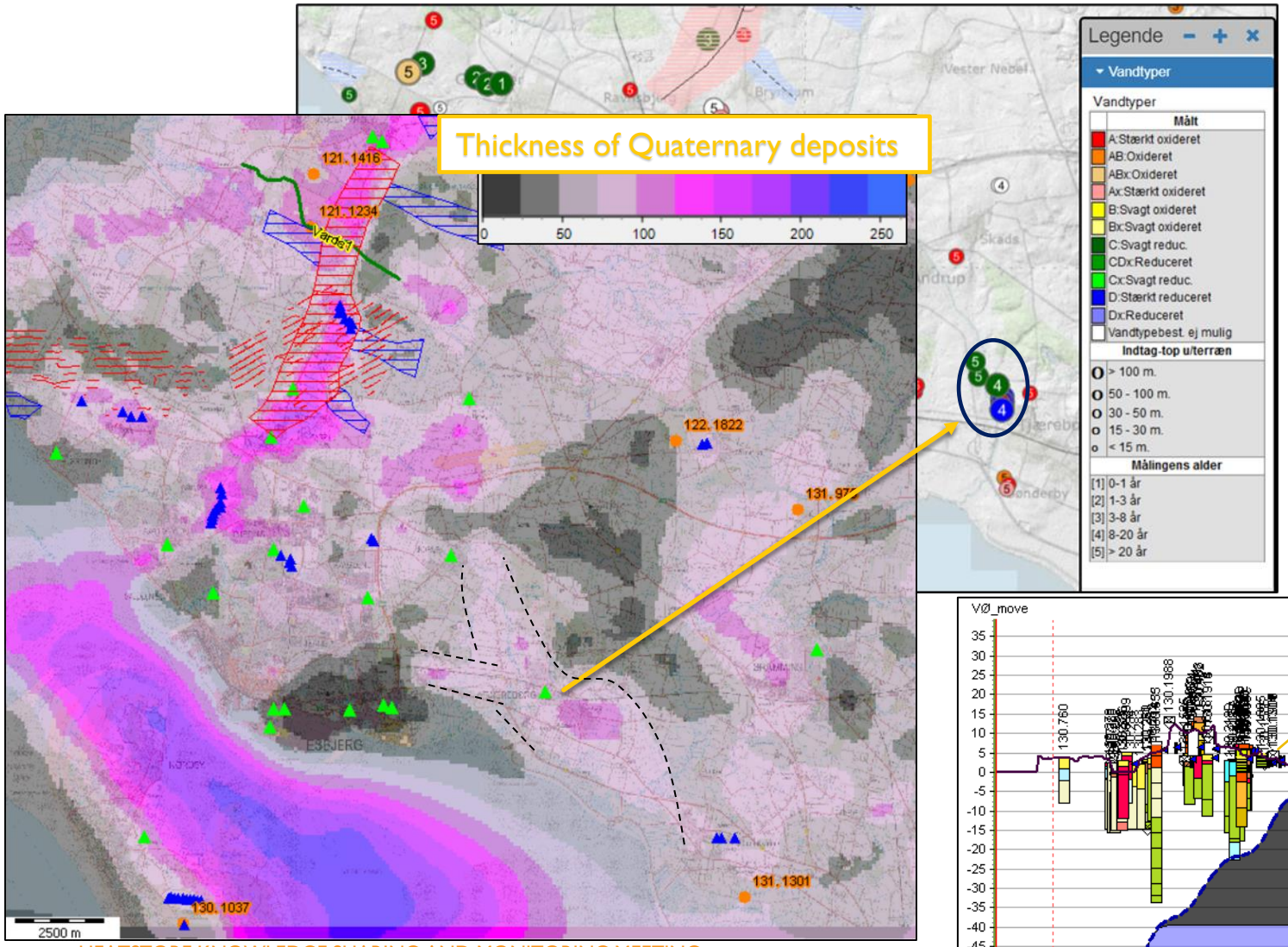
EXAMPLES FROM DIFFERENT GEOLOGICAL SETTINGS IN DENMARK

ESBJERG AREA

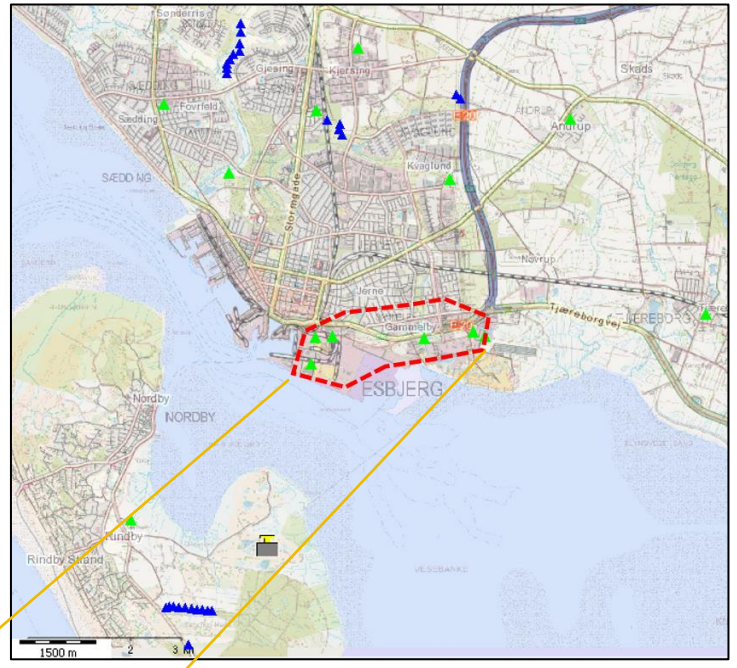
- Focus:
  - a) Sand units within Miocene layer sequence (ATES)
  - b) Buried valleys without drinking water interests (ATES)
  - c) Areas with no groundwater flow suitable for BTES

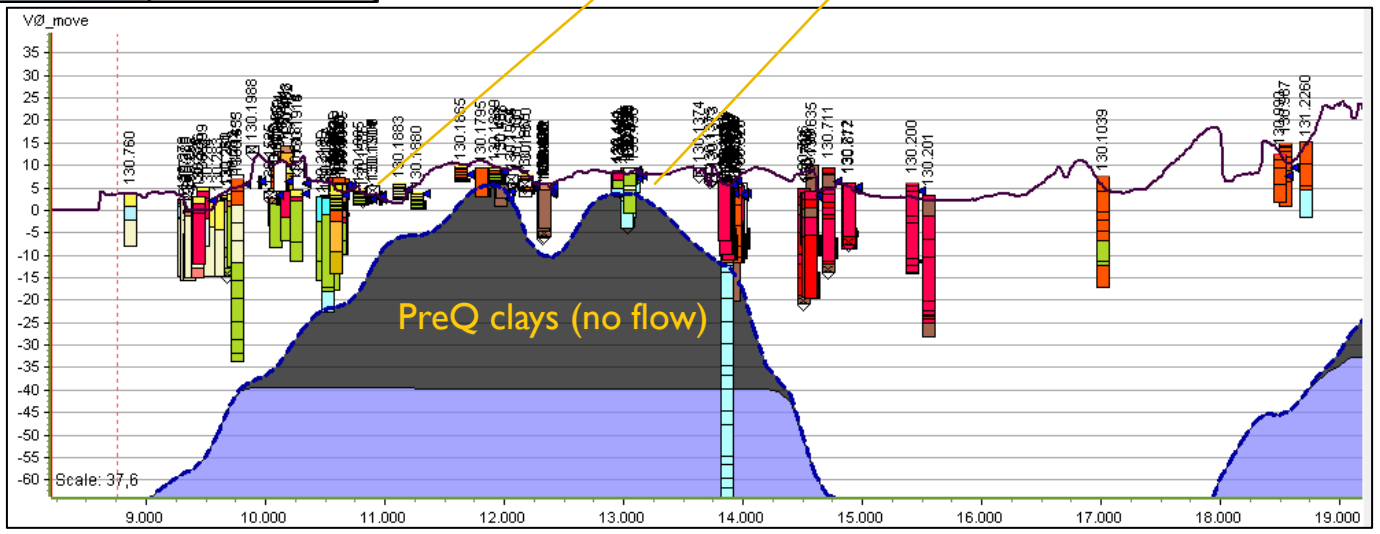





Thickness of Quaternary deposits
0
50
100
150
200
250
121.1416
121.1234
Vardet
122.1822
131.1301
130.1037
ESBJERG
2500 m

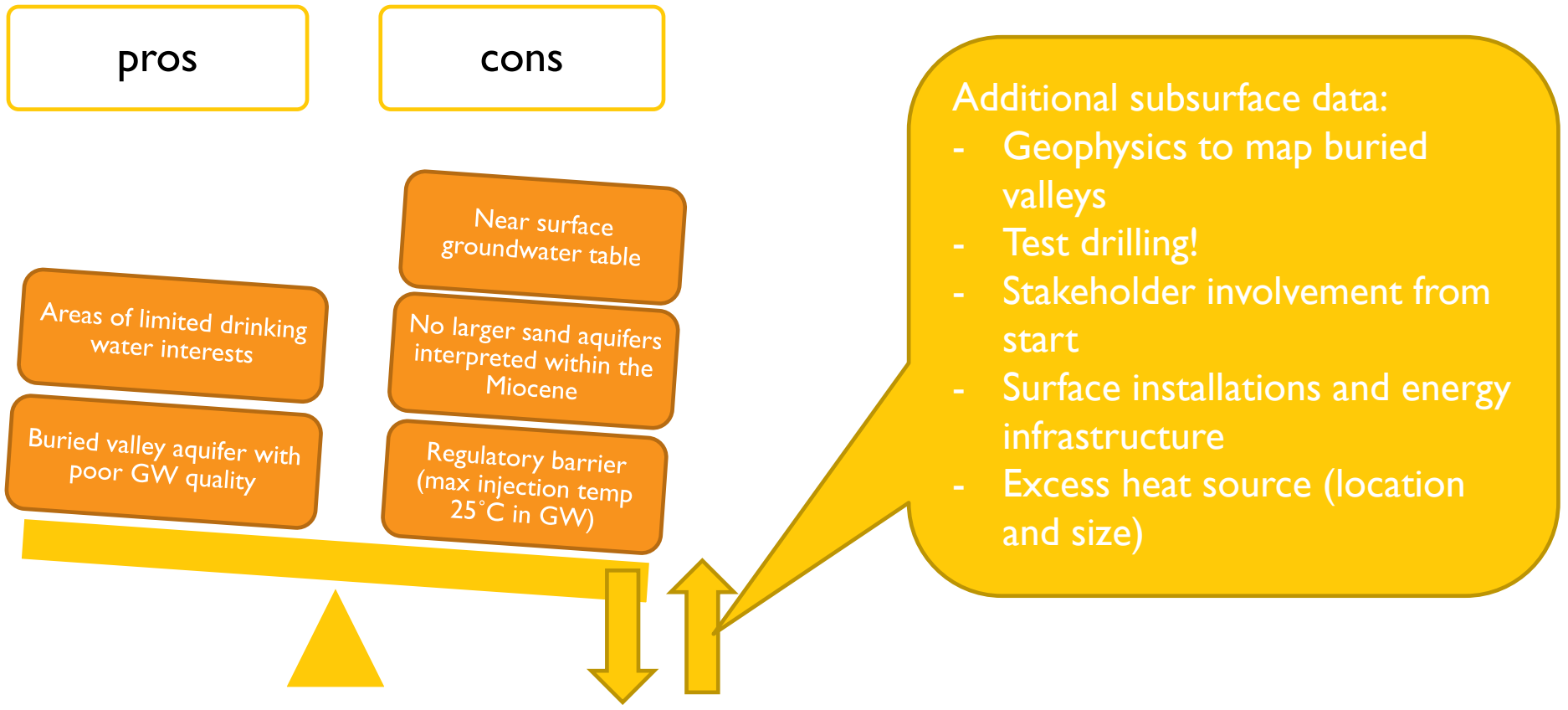
Legende
Vandtyper
Vandtyper
Målt
A:Stærkt oxideret
AB:Oxideret
ABx:Oxideret
Ax:Stærkt oxideret
B:Svagt oxideret
Bx:Svagt oxideret
C:Svagt reduc.
CDx:Reduceret
Cx:Svagt reduc.
D:Stærkt reduceret
Dx:Reduceret
Vandtypebest. ej mulig
Indtag-top u/terræn
> 100 m.
50 - 100 m.
30 - 50 m.
15 - 30 m.
< 15 m.
Målingens alder
[1] 0-1 år
[2] 1-3 år
[3] 3-8 år
[4] 8-20 år
[5] > 20 år


ESBJERG
NORDBY
1500 m


VØ_move
PreQ clays (no flow)
Scale: 37,6
9.000
10.000
11.000
12.000
13.000
14.000
15.000
16.000
17.000
18.000
19.000

EXAMPLES FROM DIFFERENT GEOLOGICAL SETTINGS IN DENMARK

ESBJERG AREA



EXAMPLES FROM DIFFERENT GEOLOGICAL SETTINGS IN DENMARK

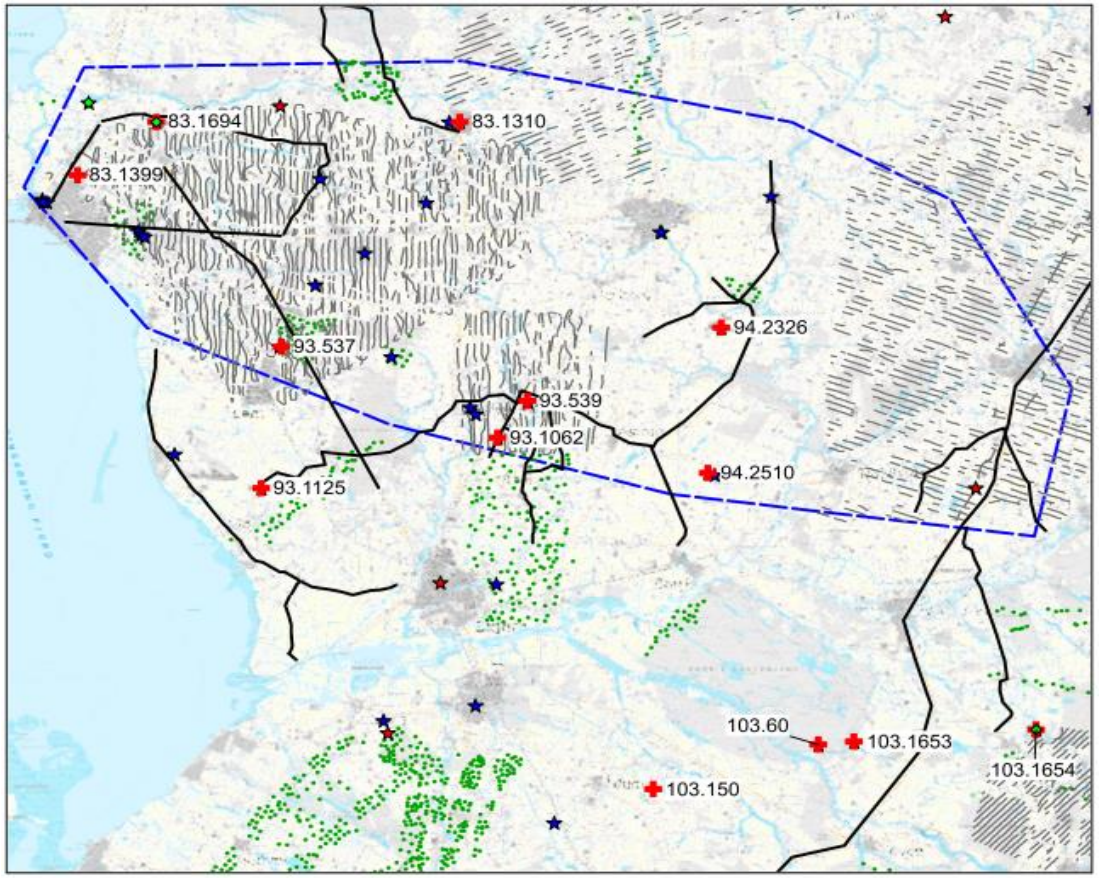
RINGKØBING-VIDEBÆK AREA

- Interested parties:
  - Ringkøbing Fjernvarme
  - Videbæk Fjernvarme
  - Arla Foods

- Sum of accessible surplus energy of approximately 50.000-60.000 MWh /yr
- Focus: Miocene sand aquifers 200-250 m b.s.l.
  → HT-ATES

EXAMPLES FROM DIFFERENT GEOLOGICAL SETTINGS IN DENMARK

RINGKØBING-VIDEBÆK AREA

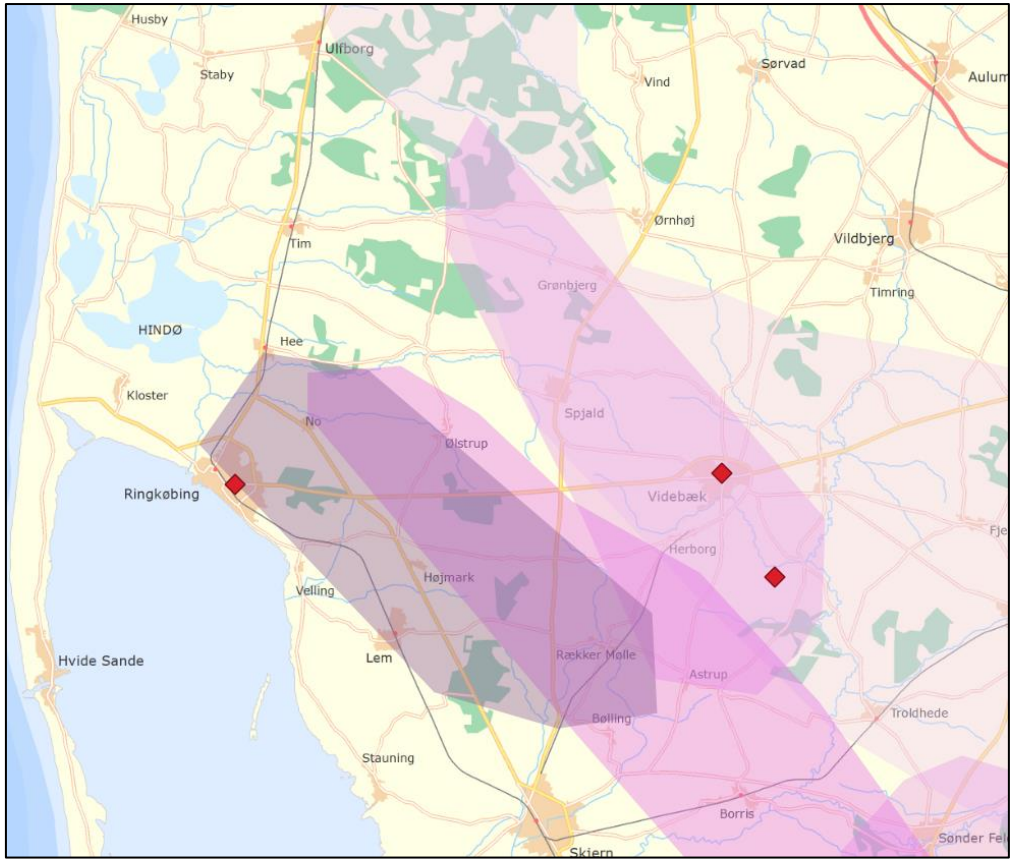


- Stratigrafiske nøgleboringer
- Boringer fra Jupiterdatabasen (>200 m)
- Boringer fra Jupiterdatabasen (>150 m)
- Boringer fra Jupiterdatabasen (Brunt vand)
- Seismik
- SkyTEM
- TEM
- Primære fokusområde

- Good data coverage of shallow subsurface
- At focus depth only seismic data and a few deeper water supply or investigation wells

EXAMPLES FROM DIFFERENT GEOLOGICAL SETTINGS IN DENMARK

RINGKØBING-VIDEBÆK AREA



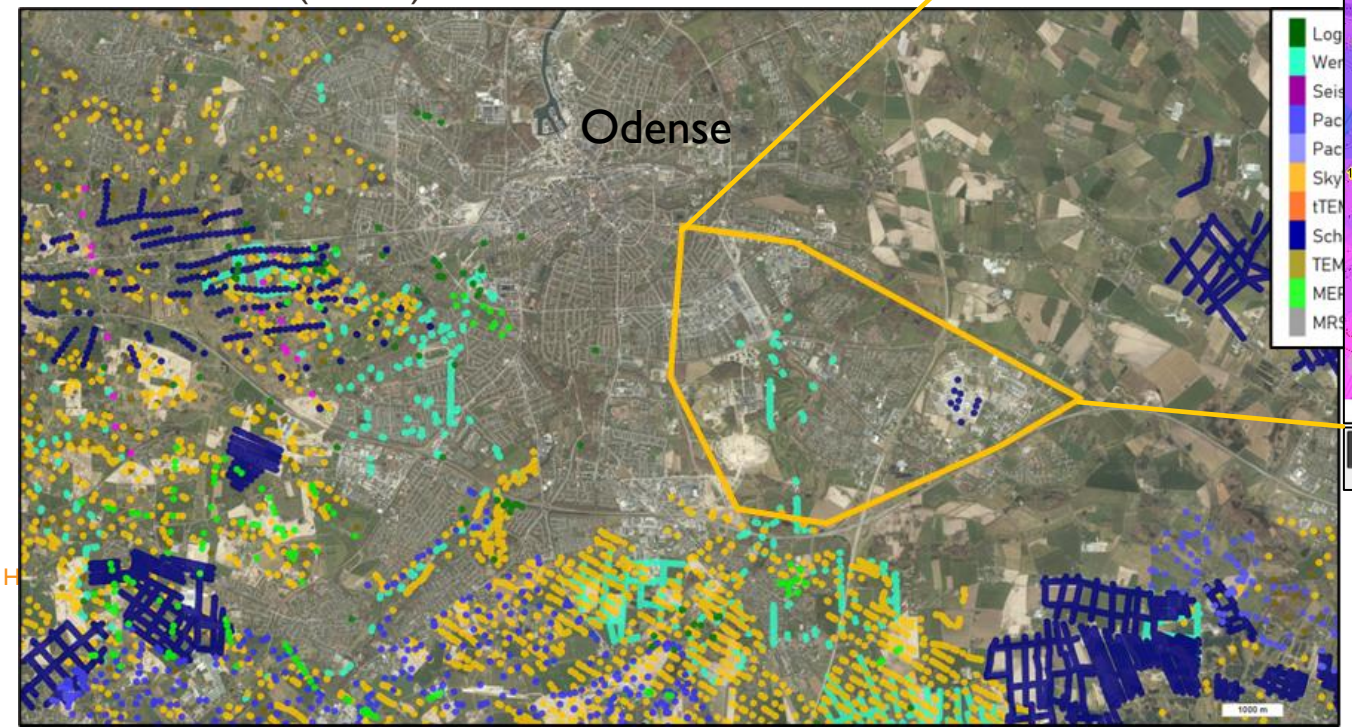
Estimated sand lobes (aquifers) at focus depth

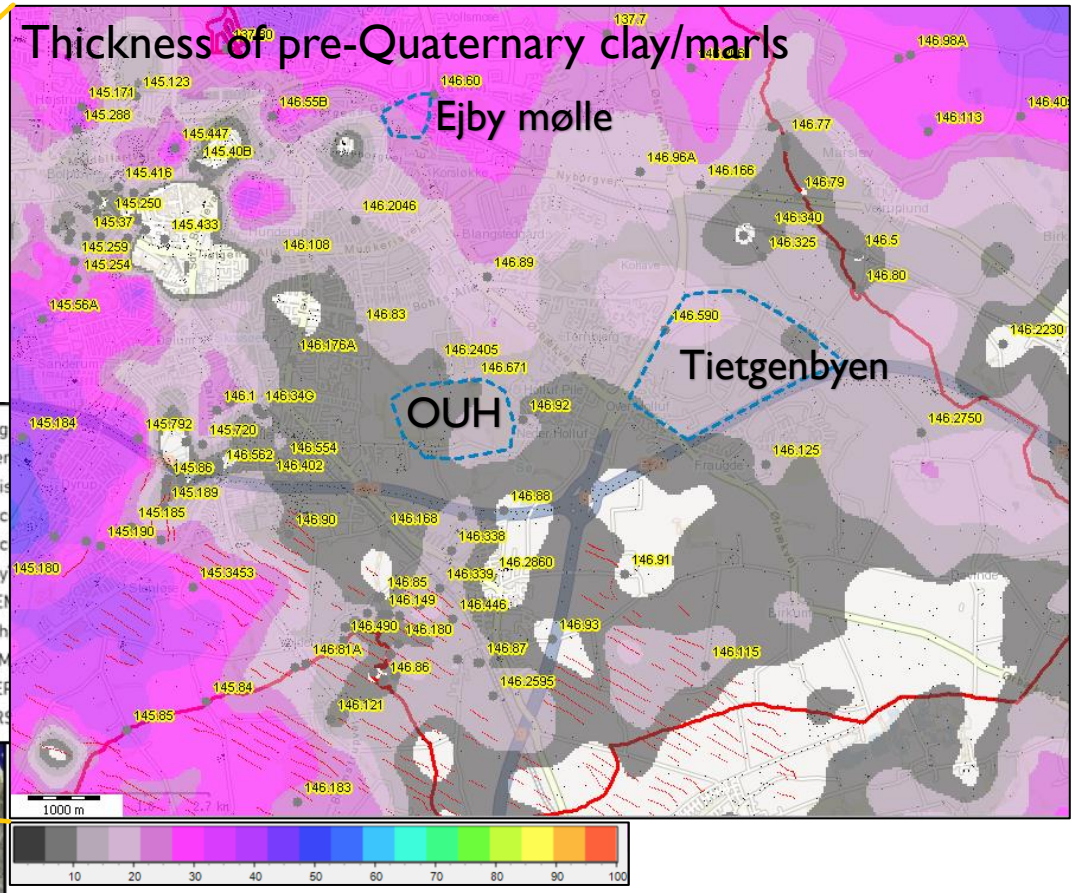
- Present investigation shows:
  - Aquifers inhomogeneous, both in extent and lithology
  - Expected variations in hydraulic conductivity
  - Varying groundwater quality (possible aquifer bodies with low groundwater flow – limited hydraulic contact to larger aquifer systems)
  - Potential conflict with drinking water supply
  - Need for detailed mapping for specific location - test drilling essential

EXAMPLES FROM DIFFERENT SETTINGS IN DENMARK

ODENSE AREA

- Focus in three areas of specific interest:
  - a) Quaternary succession → areas of limited groundwater flow and no drinking water interests (BTES)
  - b) Potential zone of fractures – pre-Quaternary marls and limestone (ATES)

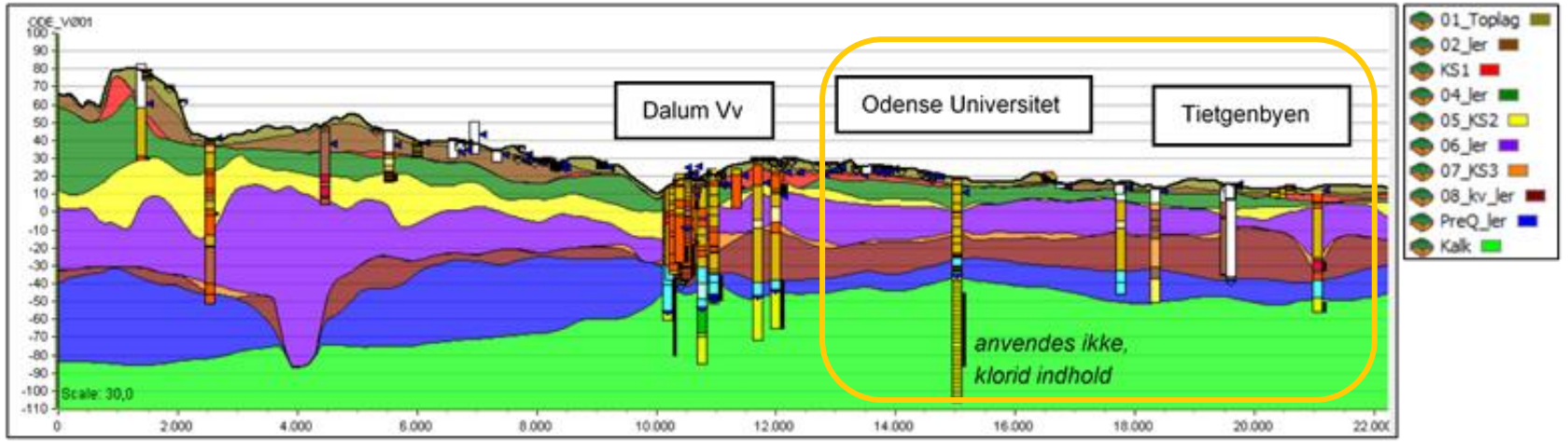


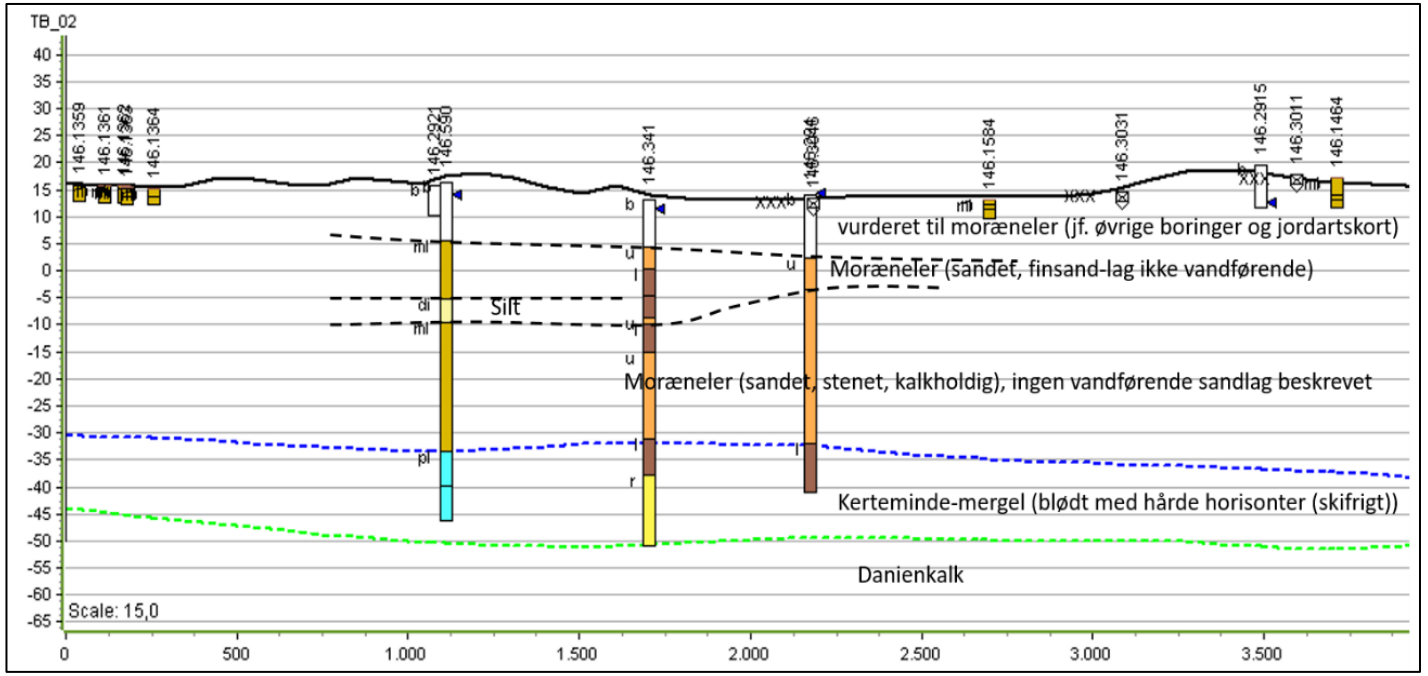


EXAMPLES FROM DIFFERENT SETTINGS IN DENMARK

ODENSE AREA

- Up to 50 m thick predominantly moraine clays
- 10-30 m thick marls/clays – partly fractured, but limited groundwater flow
- Limited data coverage, existing investigation drilling at SDU (university)
- Groundwater chemistry show residual content of salt in depth → indicating low groundwater flow and limited hydraulic contact to surface





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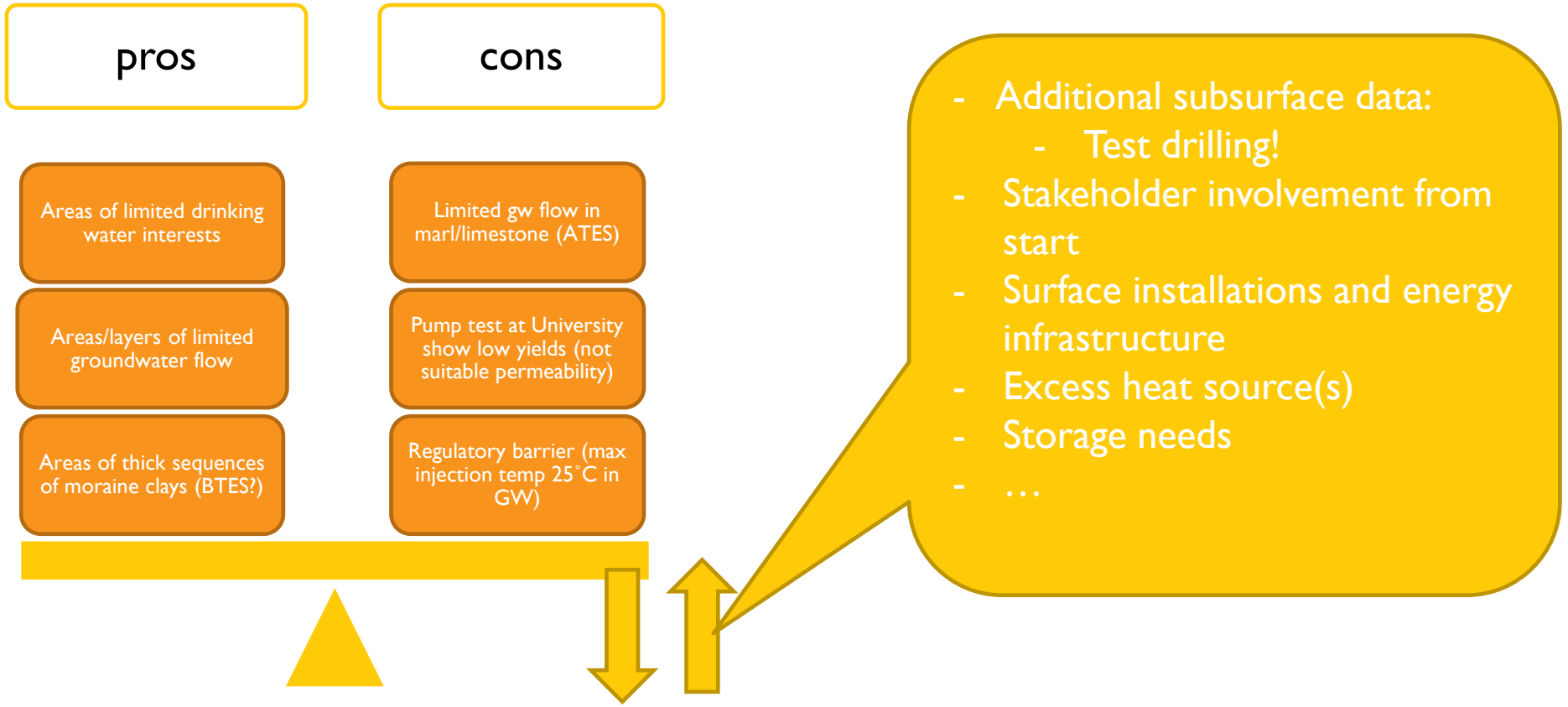
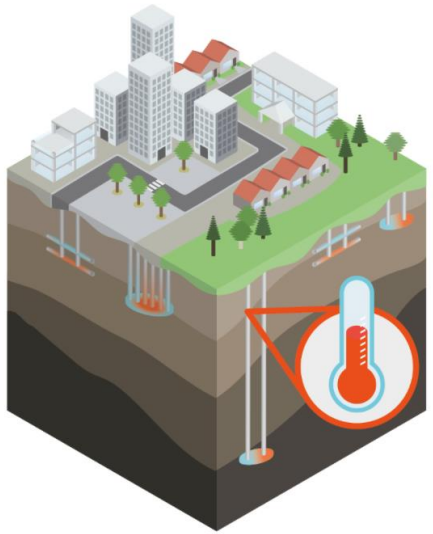
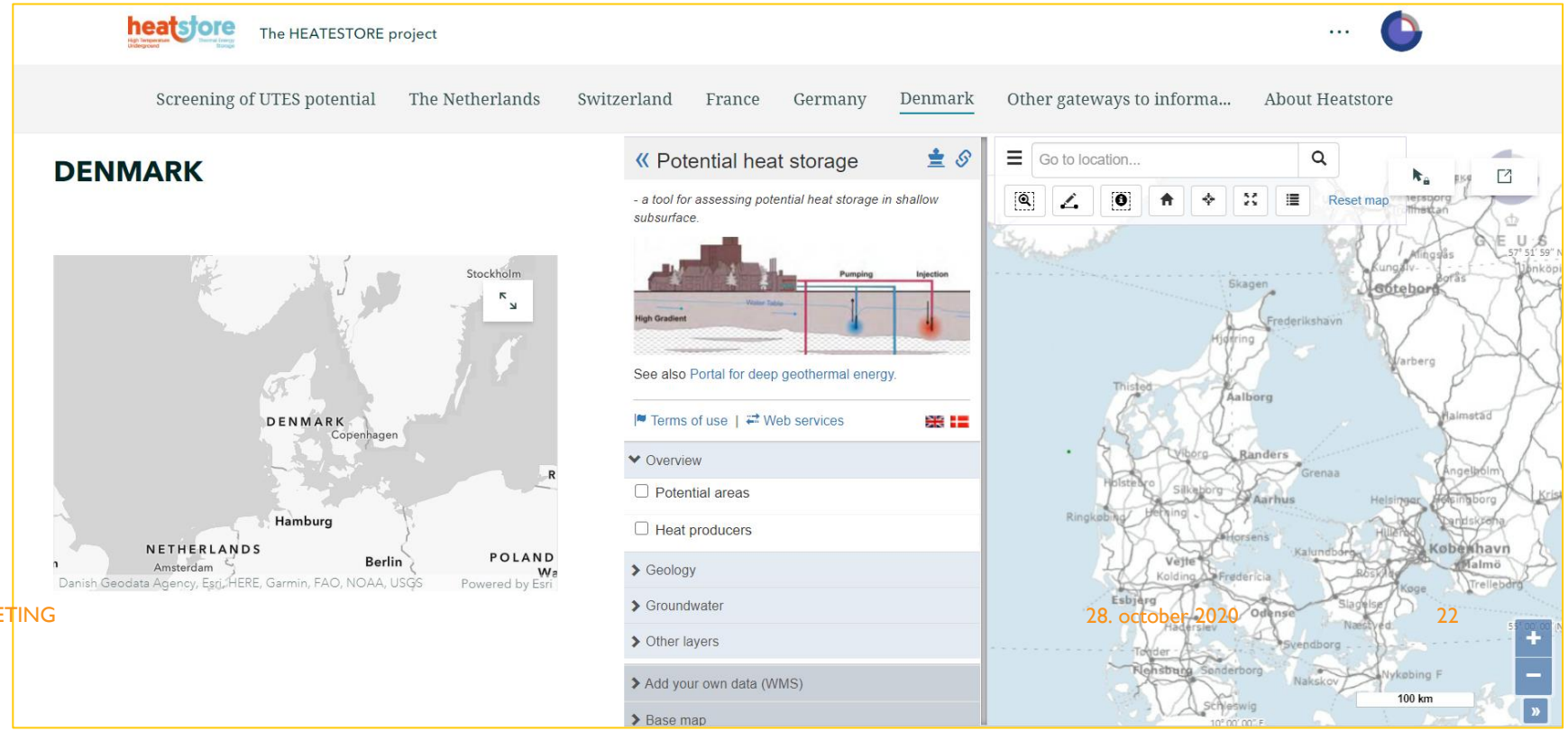
ODENSE AREA



PUBLIC WEB PLATFORM – PLANS FOR IMPROVEMENT

- Implementation of geological models (3D) from the national groundwater mapping), source: EPA (Miljøstyrelsen)
- Geo-referred links to public site-specific reports/notes on shallow geothermal/UTES potential
- HEATSTORE story map (website) → screening results, focus and process from partner countries





THANK YOU FOR YOUR ATTENTION

HEATSTORE (170153-4401) is one of nine projects under the GEOTHERMICA – ERA NET Cofund aimed at accelerating the uptake of geothermal energy by 1) advancing and integrating different types of underground thermal energy storage (UTES) in the energy system, 2) providing a means to maximise geothermal heat production and optimise the business case of geothermal heat production doublets, 3) addressing technical, economic, environmental, regulatory and policy aspects that are necessary to support efficient and cost-effective deployment of UTES technologies in Europe. The three-year project will stimulate a fast-track market uptake in Europe, promoting development from demonstration phase to commercial deployment within two to five years, and provide an outlook for utilisation potential towards 2030 and 2050.

This project has been subsidized through the ERANET cofund GEOTHERMICA (Project n. 731117), from the European Commission, RVO (the Netherlands), DETEC (Switzerland), FZJ-PtJ (Germany), ADEME (France), EUDP (Denmark), Rannis (Iceland), VEA (Belgium), FRCT (Portugal), and MINECO (Spain).