

Geothermal Activity in Denmark

Agenda

Introduction

2018 Geothermal License Award

Geothermal Energy in Denmark

Comparison with Oil & Gas industry

Comparison Geothermal: NL & DK

Recommendations

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Your Speaker: Experienced Oil&Gas, Geothermal Novice



- Utrecht 1979
- Shell - 1985-1998
 - UK, Turkey, the Netherlands and Malaysia



- Clyde Petroleum – 1998
 - the Netherlands
 - Exploration & New Ventures Manager



- Wintershall Noordzee – 2002
 - Exploration Manager
 - the Netherlands, Denmark and the UK
 - set-up and ran a large (40+) department



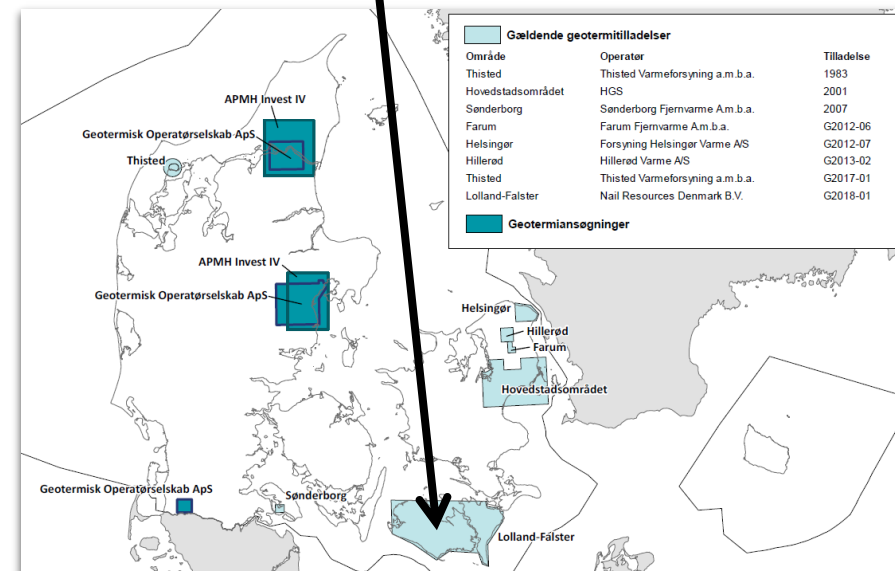
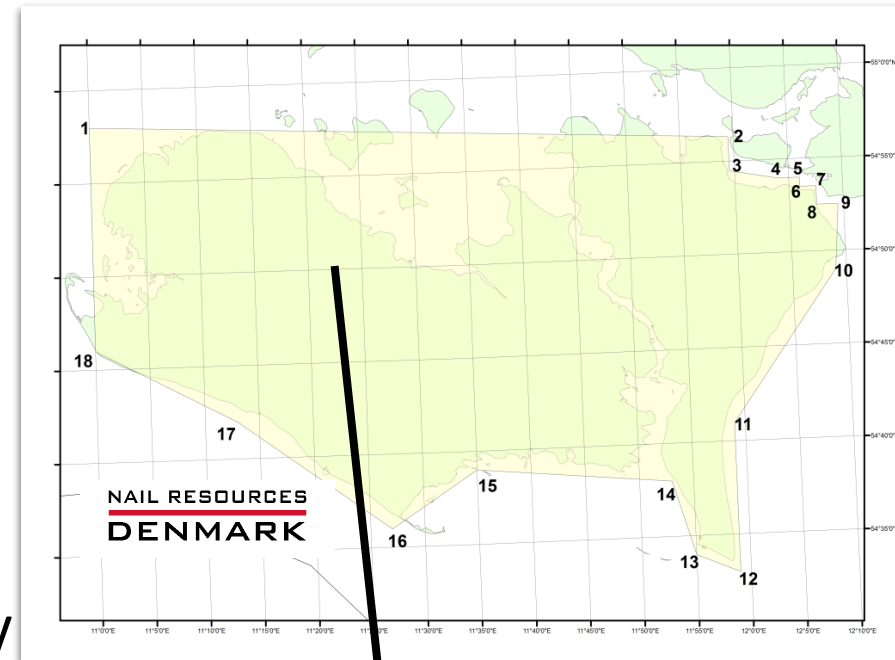
- Dyas – 2007 (Non-Operated)
 - New Ventures and Commercial Manager
 - Managing Director
 - many transactions
 - built the present organisation



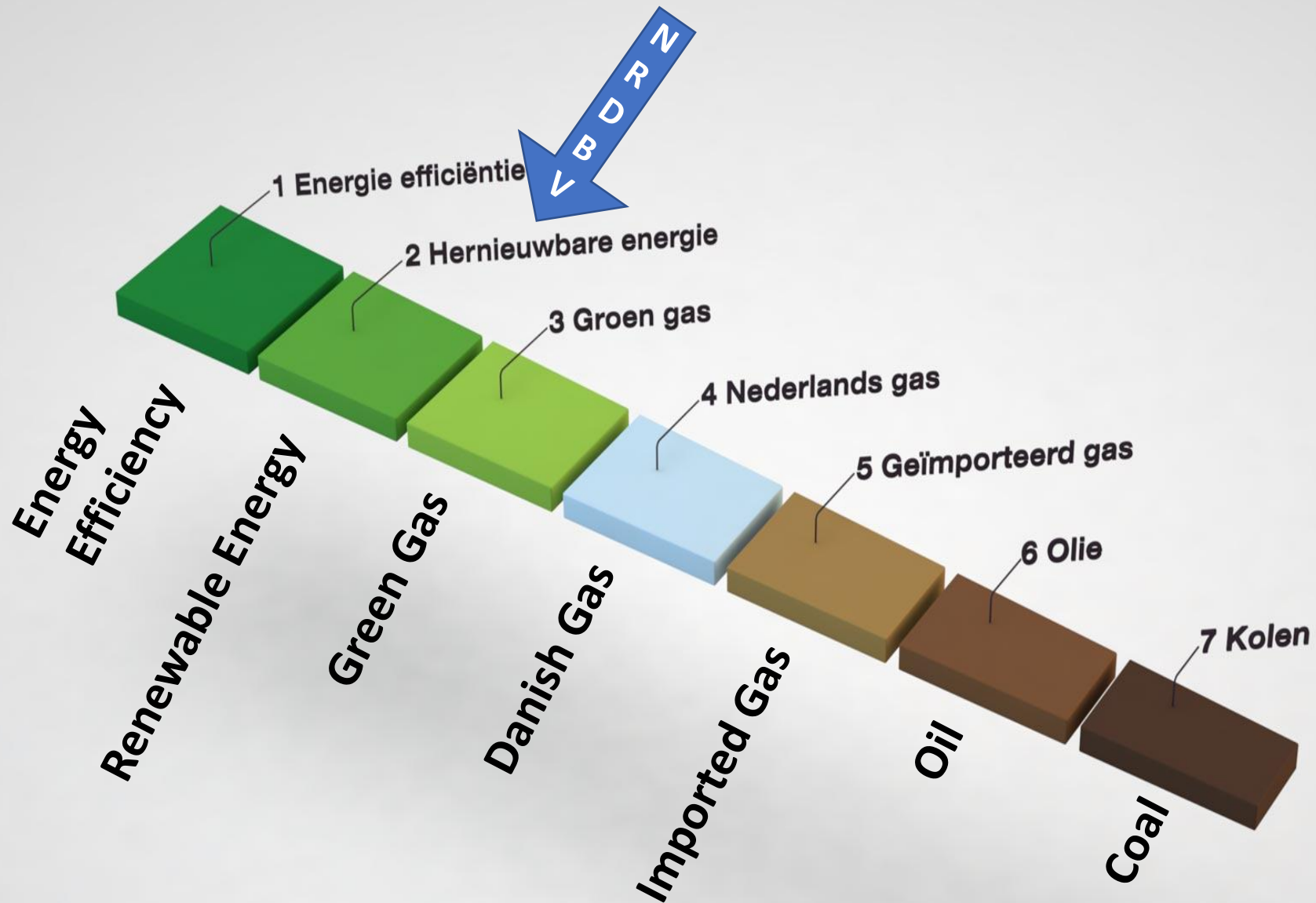
- Nail Petroleum – 2014 – consult & invest

2018 Danish Geothermal Award

- License Award
 - Lolland-Falster islands
 - From 29.03.2018, 6-year term
 - District Heating
- Award to Nail Resources Denmark BV
 - Founders
 - 50% Nail Petroleum BV
 - 50% Danica Resources ApS
 - Farminer NewCo ApS
 - \$, feasibility study, enlarged team



The “Ladder Of 7” (decreasing CO₂ footprint)



Introduction to Geothermal Energy

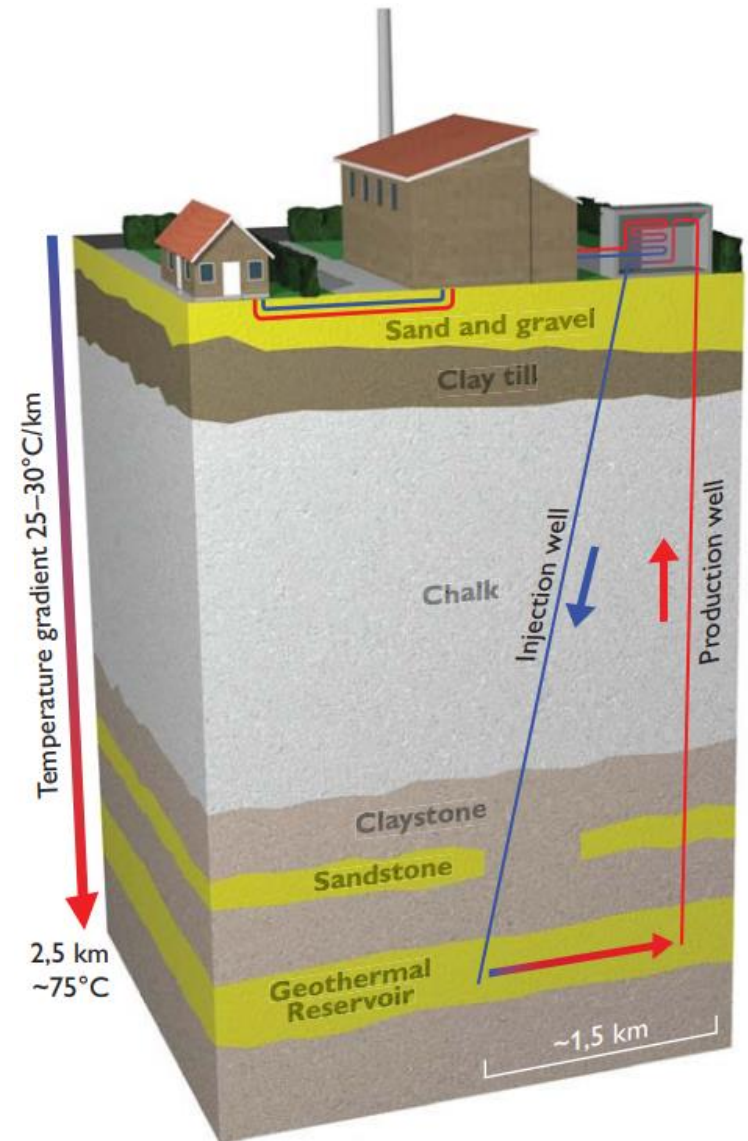
- Geothermal Plant

- Porous and permeable reservoir (typically sandstone)
 - NRDBV has complete Lolland-Falster database
- Production well
- Heat exchangers and/or absorption heat pumps
- Injection well

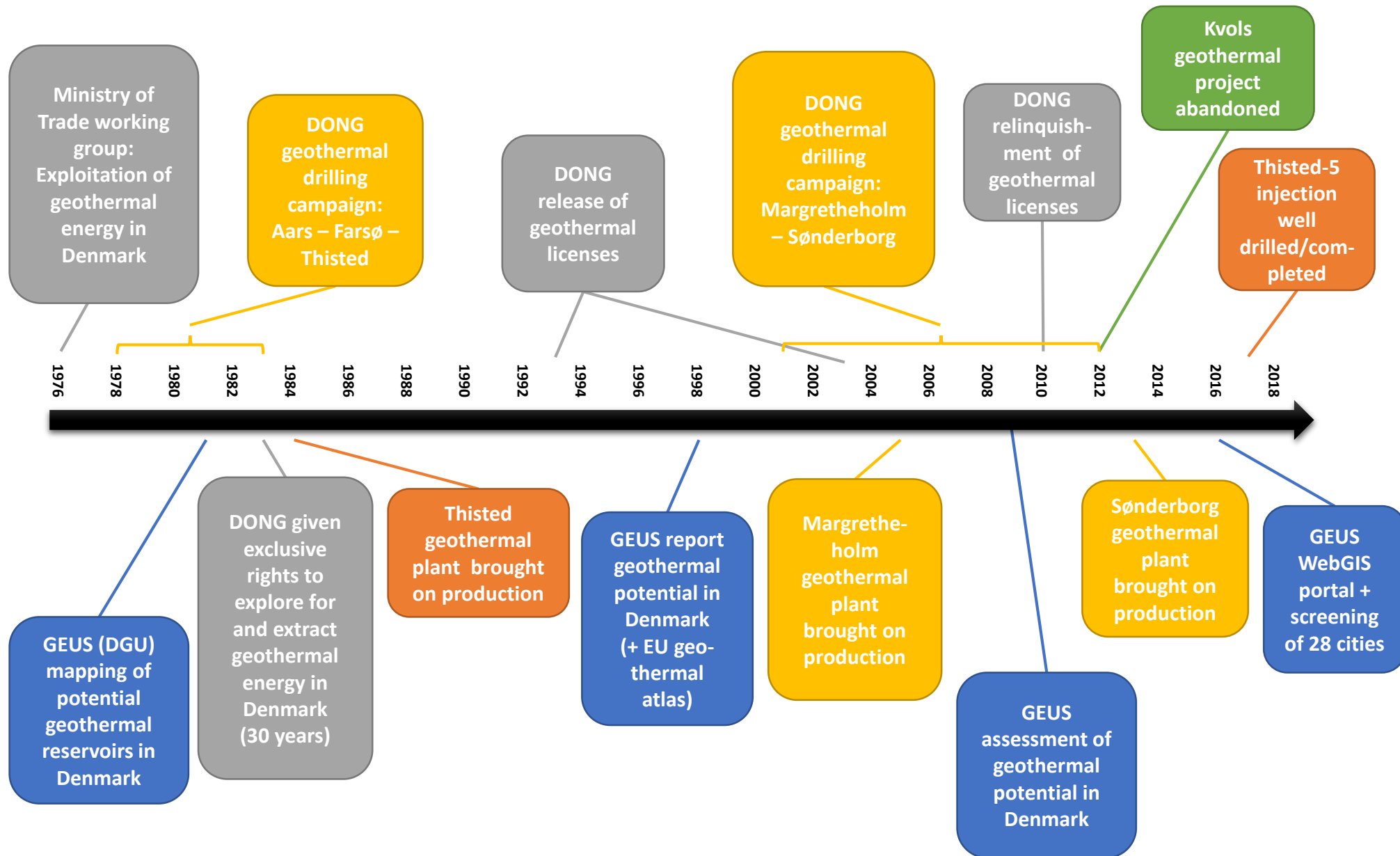
- Large geothermal plants may consist of several wells to produce and inject large volumes of water

- District Heating

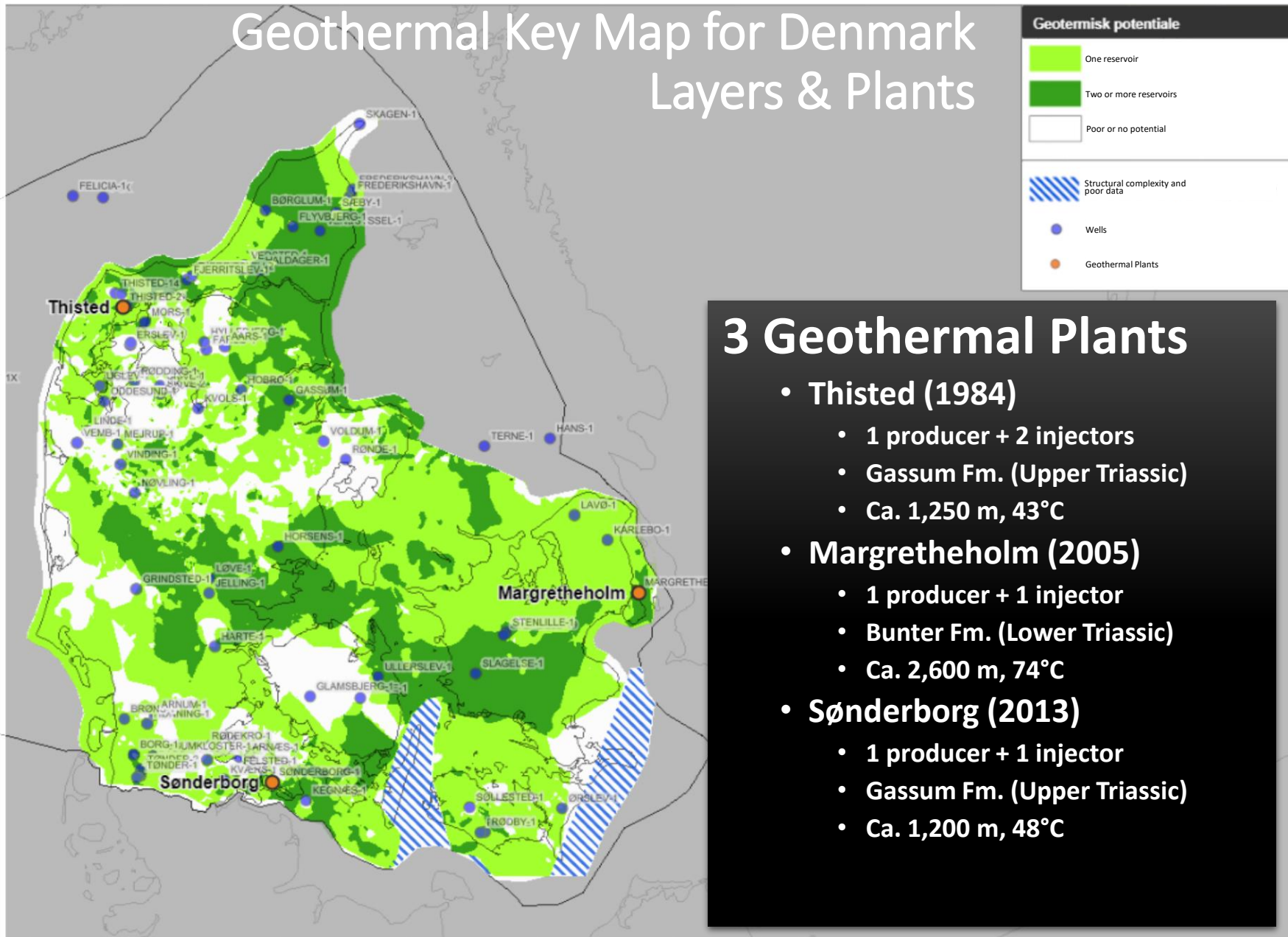
- potentially other uses – in discussion with DEA
- Geothermal gradient in Denmark not suitable for power generation
 - Geothermal gradient in Denmark: 25-30°C/km
 - "Hot Spots" to be found?



Geothermal in Denmark - timeline



Geothermal Key Map for Denmark Layers & Plants



Geothermal in Denmark - Potential

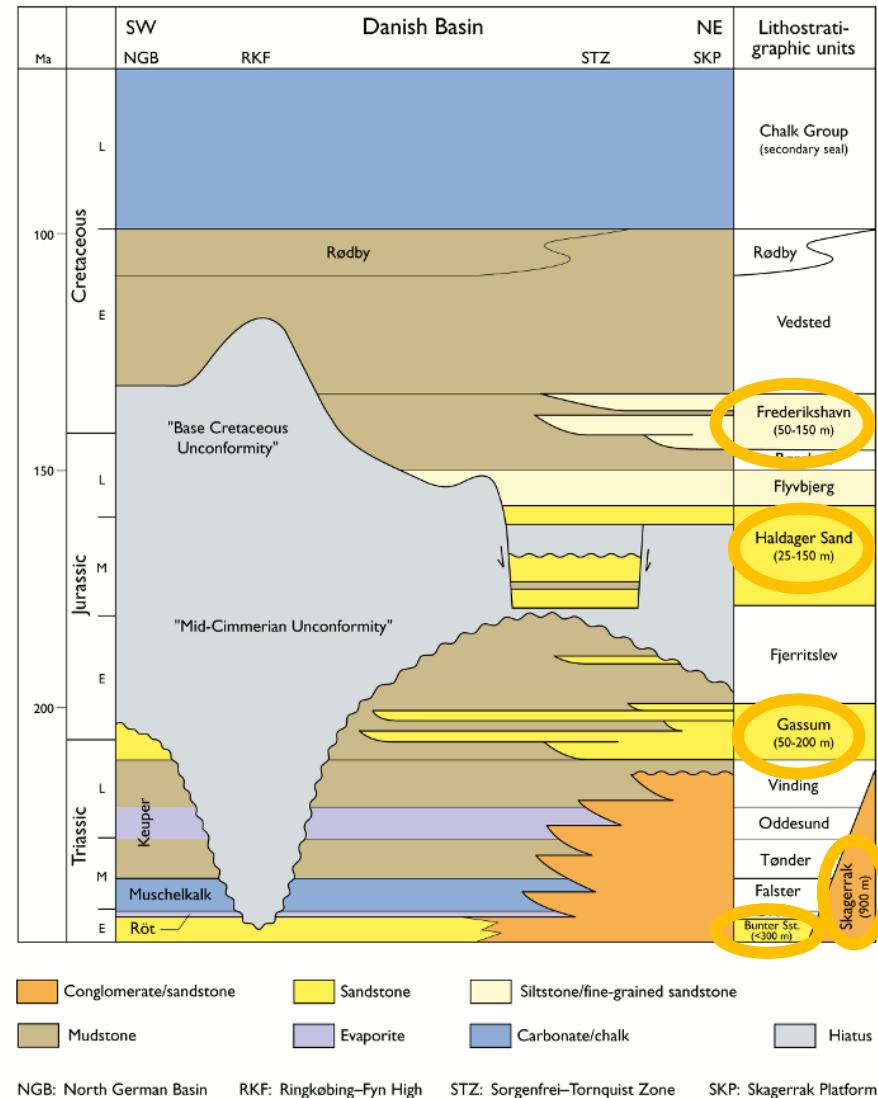
- GEUS

- 800m>GeothPotential<3000m
 - Deep = higher temp & lower poro/perm
 - Shallow = lower temp & higher poro/perm

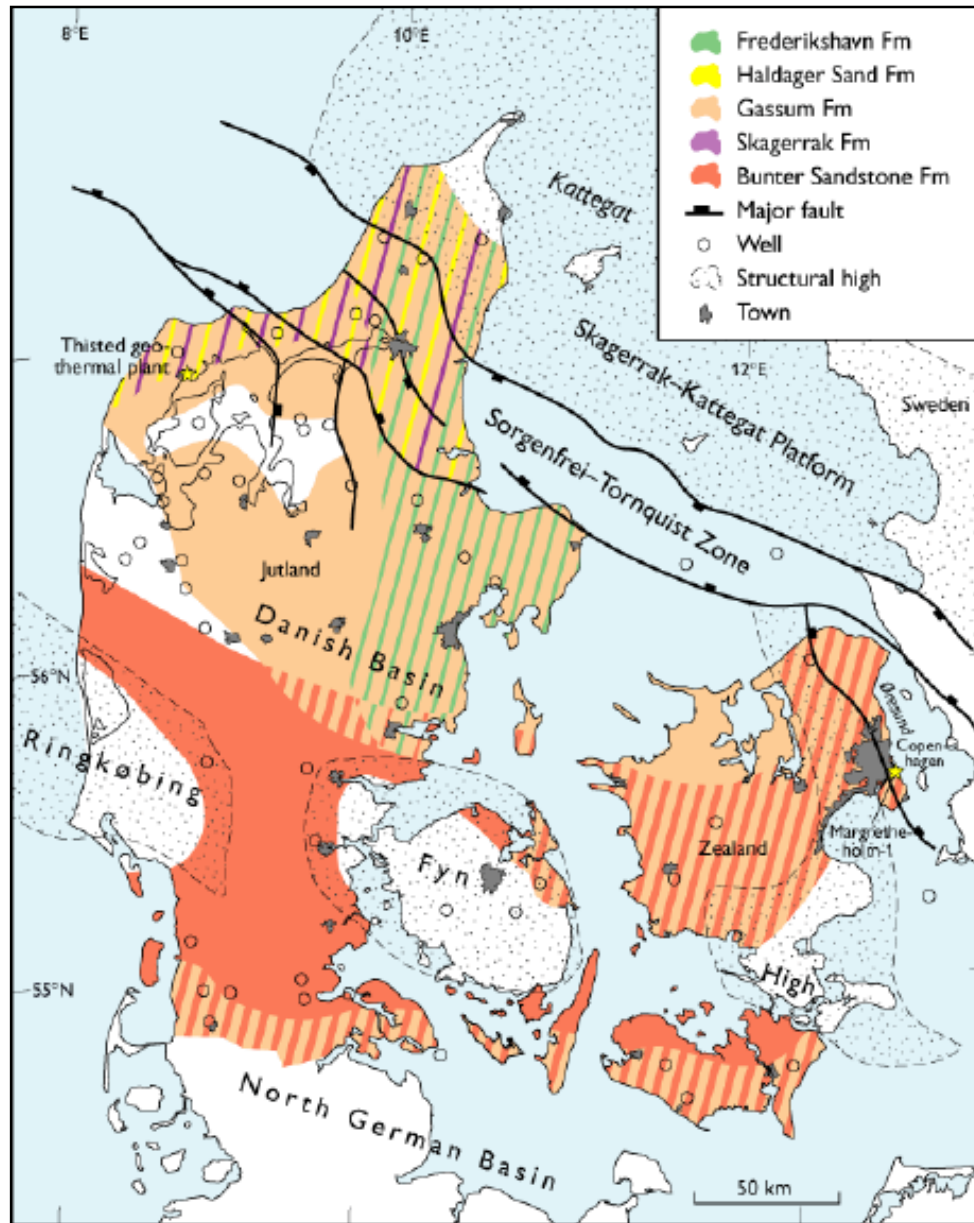
- Potential sandstone reservoirs

- Cretaceous: Frederikshavn Formation
- Jurassic: Haldager Sand Formation
- Triassic: Gassum Formation
- Triassic : Skagerrak Formation
- Triassic: Bunter Sandstone Formation

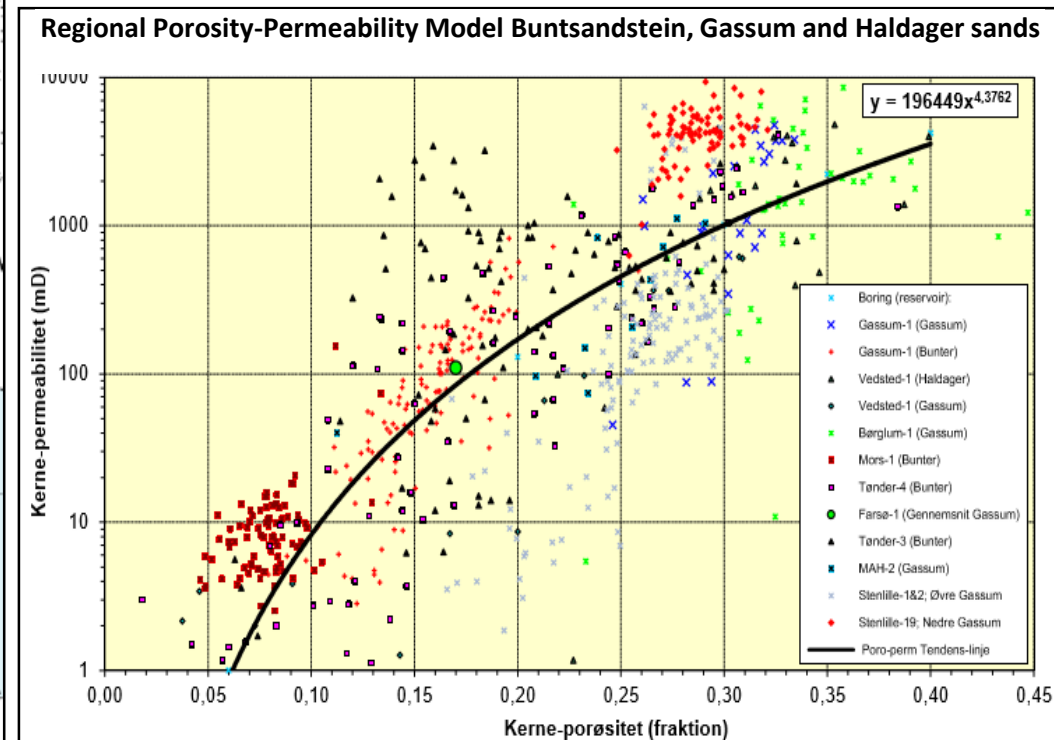
- Geothermal potential mapped by GEUS available online: "Geotermi WebGIS-portalen"



Lolland – Falster: mainly Triassic Geothermal Potential



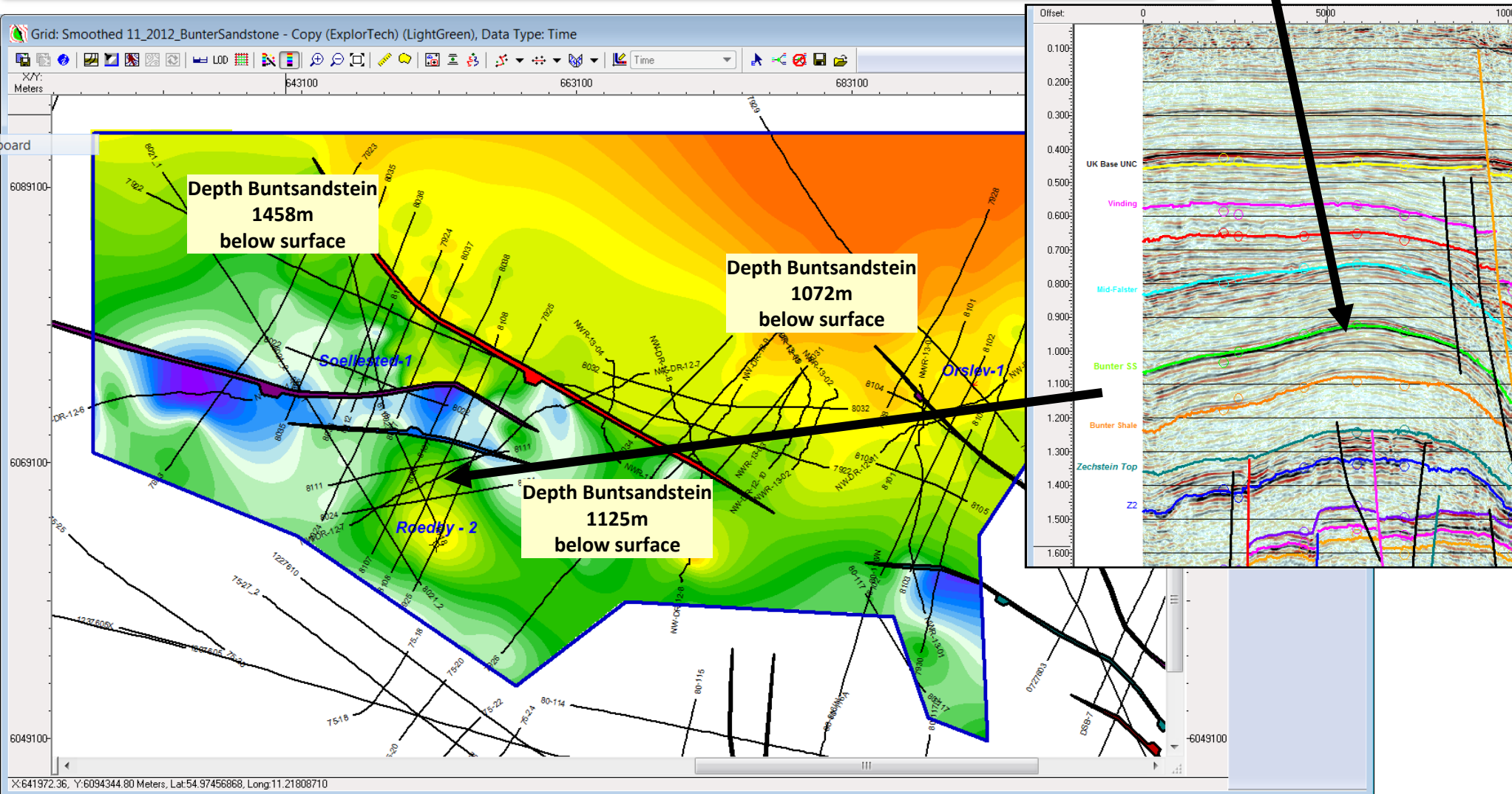
- Geus Map
 - Regional geothermal potential of possible aquifer formations, based on
 - burial depth of 1000–2500 m
 - sand thickness of more than 25 m.
- Bunter & Gassum Formations



Lolland – Falster: NRDBV Database

Buntsandstein Time Structure across Lolland – Falster. Note that the contours represent seismic Two-Way-Traveltimes. Depth of Main Triassic Reservoir indicated for the three drilled wells. Existing 2D seismic coverage and faults are also shown.

**Buntsandstein
geothermal
reservoir**



Geothermal Plans for Lolland - Falster

- Shallow Geothermal Projects

- In conjunction with Farminnee
- The GeoT-REV project attempts to revolutionise the cost and applications for Geothermal energy
 - This will focus on the currently untapped “near-shallow” geothermal resource (between 800 – 1400 m); between the deeper, existing district heating projects and the shallower, hot water storage projects
 - This will be achieved by identifying these near-shallow geothermal resources, simplifying drilling & completion techniques and developing fit-for-purpose, low cost surface equipment to exploit the low-grade heat
 - The GeoT-REV project will not only develop the methodologies to deliver low cost geothermal energy solutions, but will demonstrate this with a proof-of-concept drilling and implementation project

- Deep Geothermal Application in preparation

- West-Lolland has deep seated faults
 - Deep Geothermal Source?
- Jutland Hot Spots?

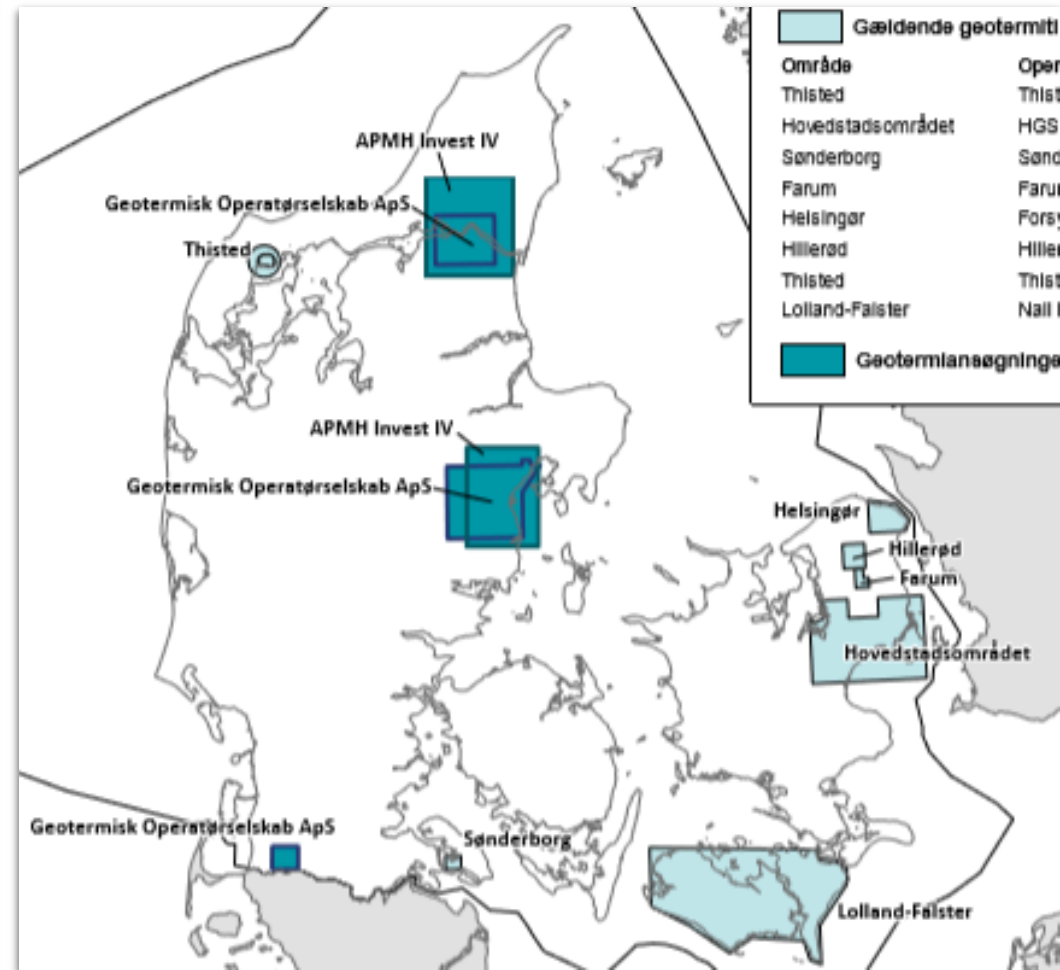
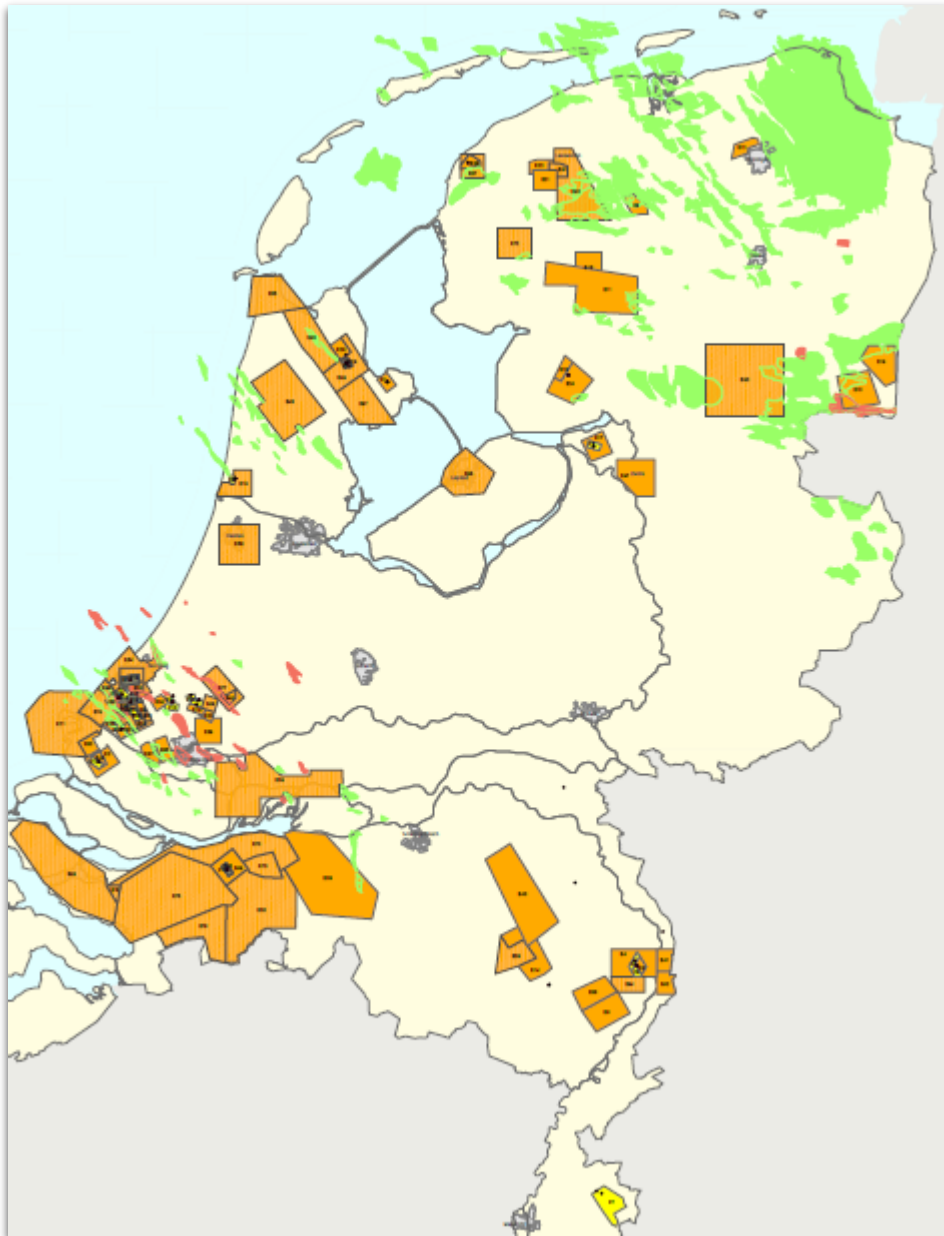
Comparison Geothermal vs. Oil&Gas

	Oil & Gas	Geothermal
Subsurface Exploration Modelling Reservoir Engineering	✓	✓
Well Planning	✓	✓ + Authorities
Well Operations	✓ (above geological target)	✓ (next to client) Authorities, Neighbours, Logistics
Cost	Small in Lifecycle	Large in Lifecycle (watch risk/reward Fo District Heating Operator)
Personnel	✓	✓

Comparison Geothermal: NL vs. DK

	Netherlands	Denmark
Operational Geothermal Plants	9 (~40 MWth)	3 (~33 MWth)
Issued Licences	See Next Slide	6
No. Of Players	20-40	5-10
Subsidy	✓ (on Revenues)	✓ (Capex Guarantee)

Geothermal Licenses – NL & DK – Existing Licenses & License Applications



Recommendations

- Denmark has great geothermal potential in large parts of the country
 - Good Geology
 - 3 operational plants
 - Legal framework in place & willing government/regulator
 - Increasing amount of licenses & players
- Recommendations
 - Simplify Danish licensing procedures
 - Procedure is demanding
 - 3 stages of approval by the DEA
 - License per client? (District Heating vs. Industrial Customers)
 - Phase out unnecessary environmental screening
 - All three GeoDH projects were thoroughly screened and it was found that there are no environmental issues in any of the plants.
 - Increase subsidy by introducing, next to the CAPEX-overrun guarantee scheme, a subsidy on revenues (like SDE+ in the Netherlands)
- Invest?