

State of the art of Low and High Temperature ATEs in the Netherlands

IF Technology - Hoorn - 20 April 2023



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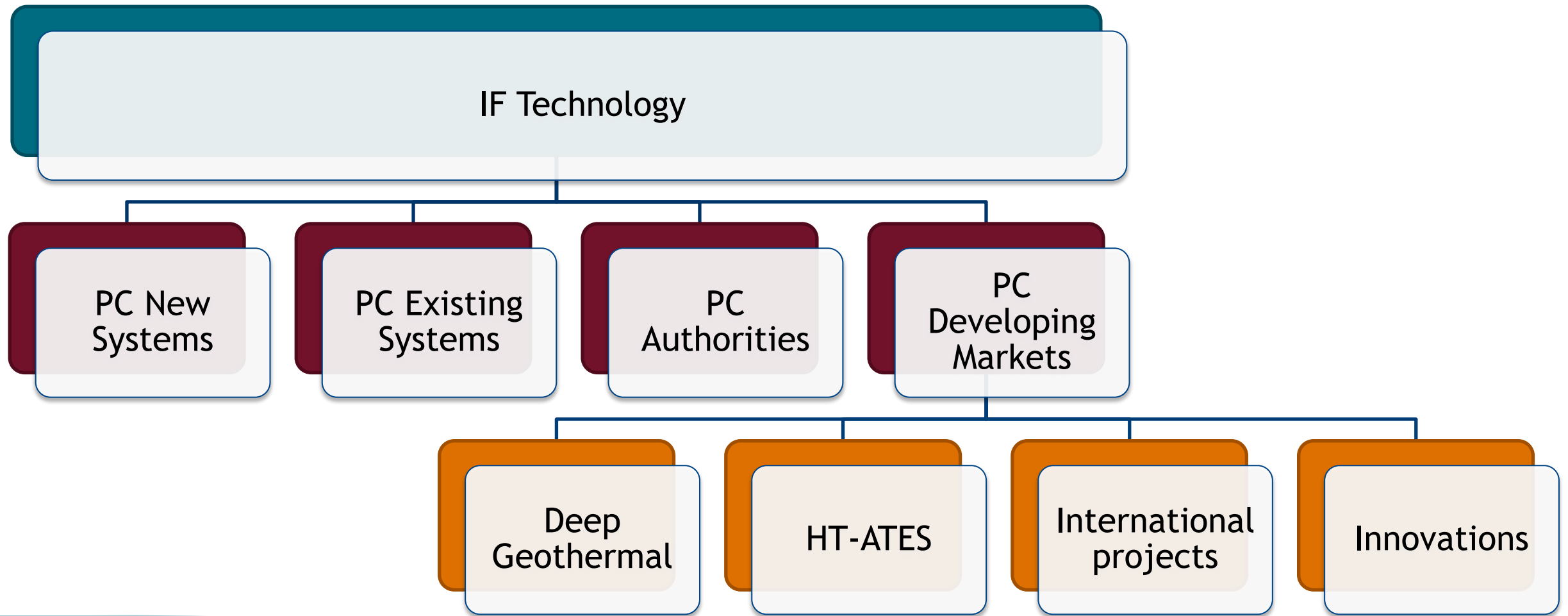


IF Technology - Creating Energy

- Consultant and engineering company in shallow and deep geothermal energy systems
 - Market leader in underground energy storage systems (UTES) and involved in most deep geothermal projects in the Netherlands
 - Employing approx. 80 geologists, hydro-geologists, civil-, mechanical- and well engineers and energy consultants
 - Founded in 1989 and based in Arnhem in the Netherlands
 - Involved in more than 3,000 projects in the Netherlands and abroad
 - Projects in: NL, BE, UK, USA, JP, CN, IND, RU, DK, SP, ROM, SK, etc.
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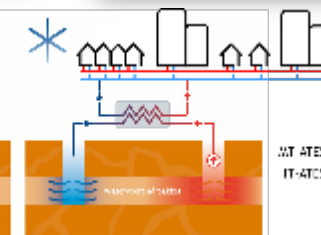
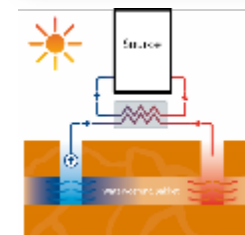
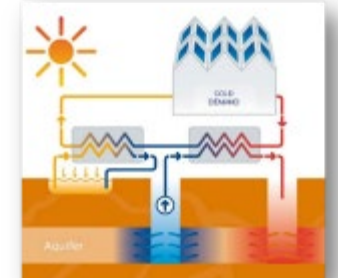
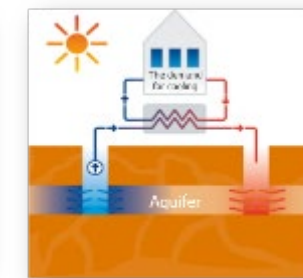
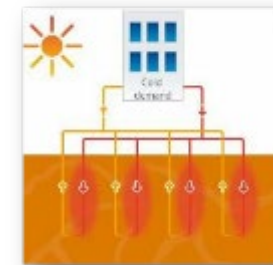
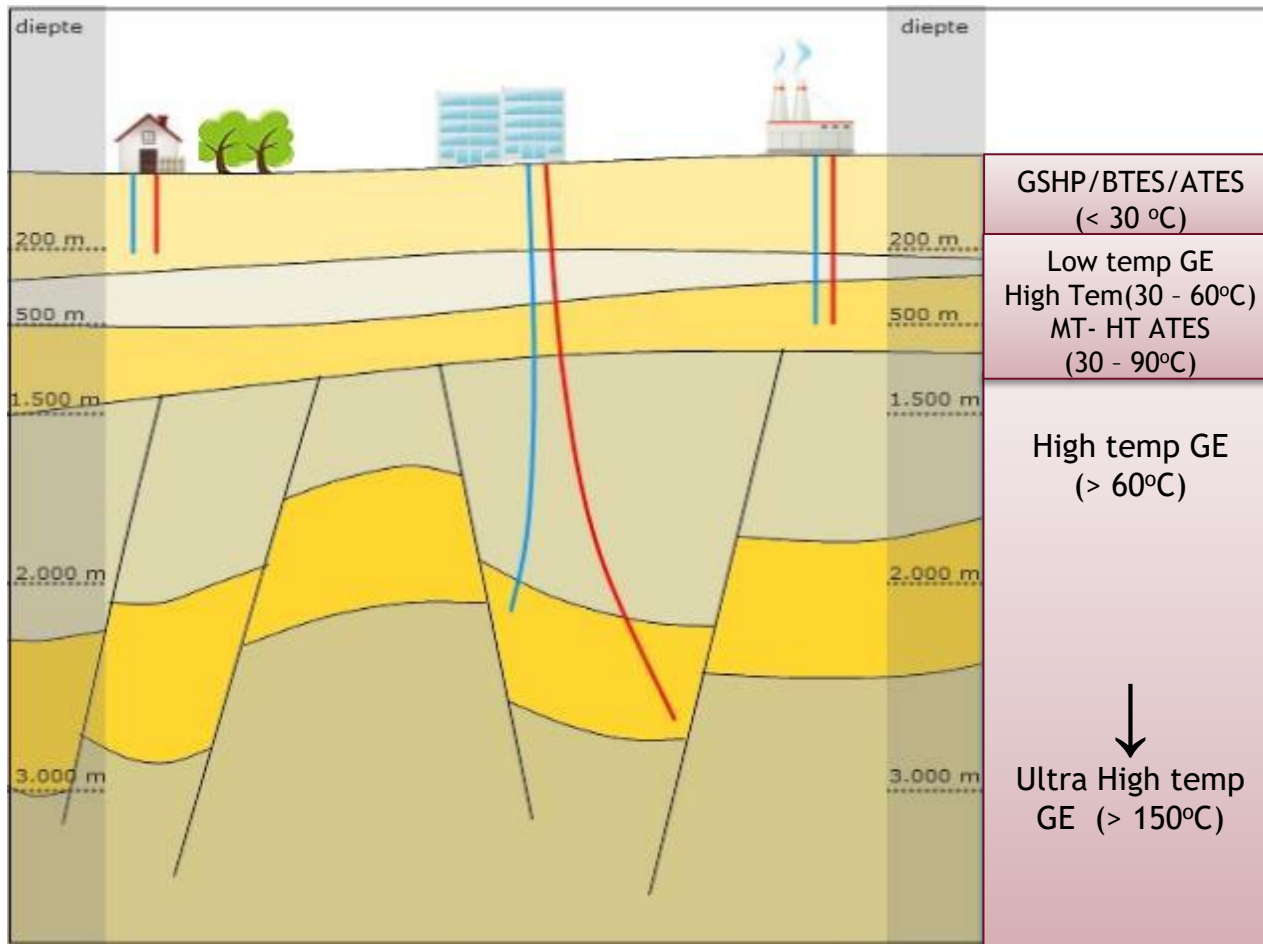


Our services from a to z for all your geothermal systems

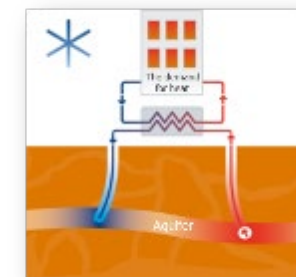


Geothermal solutions

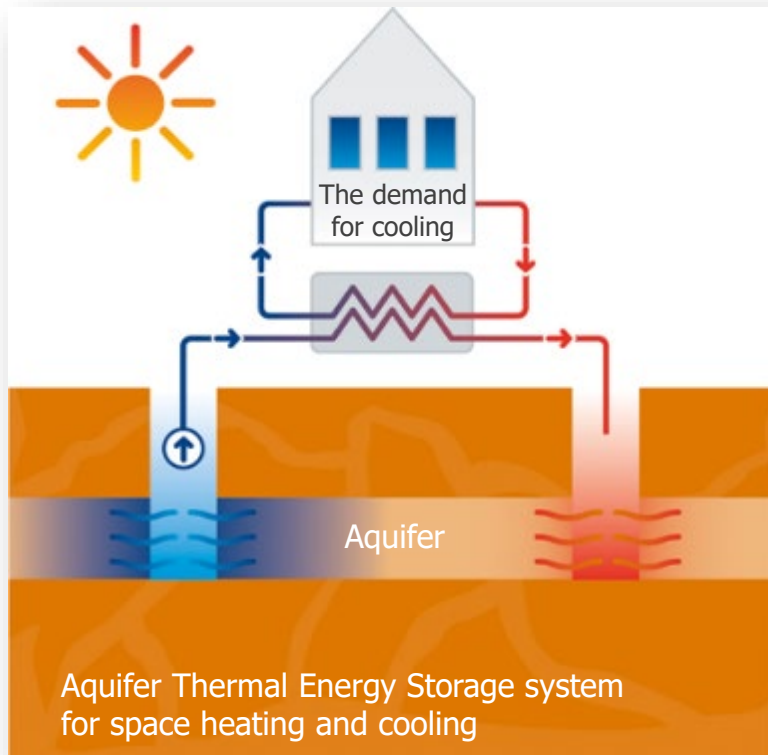
Overview geothermal energy



MT ATEs: storage temp 25-50°C
HT-ATEs: storage temp $> 50\text{ }^{\circ}\text{C}$

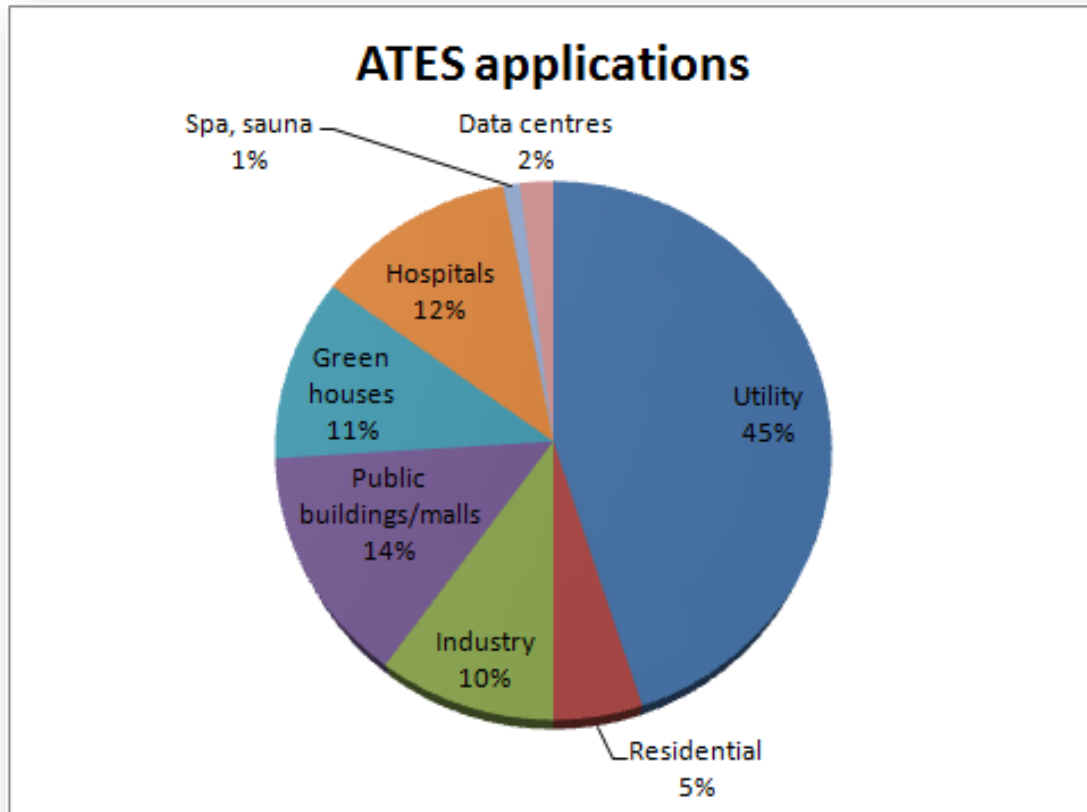


Aquifer Thermal Energy Storage Systems



- Storage of seasonal energy = battery
- Cold well (range 5-10 °C)
- Warm well (range 13-17 °C)
- Depth 40 to 250 m
- Flow rates 25 - 250 m³/h per doublet
- Energy and CO₂ savings up to 80%
- No smell, no noise, no visual impact

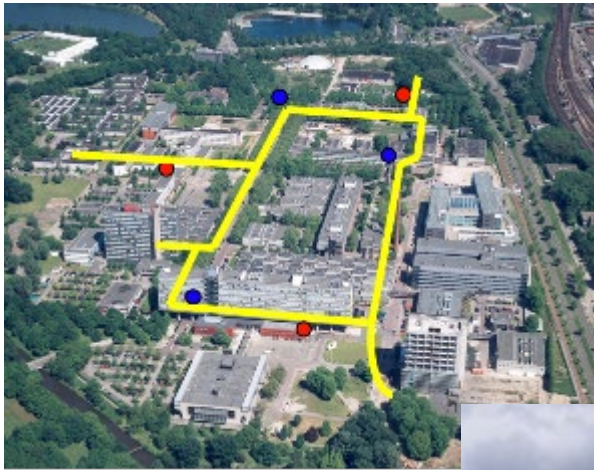
Current (major) Dutch market



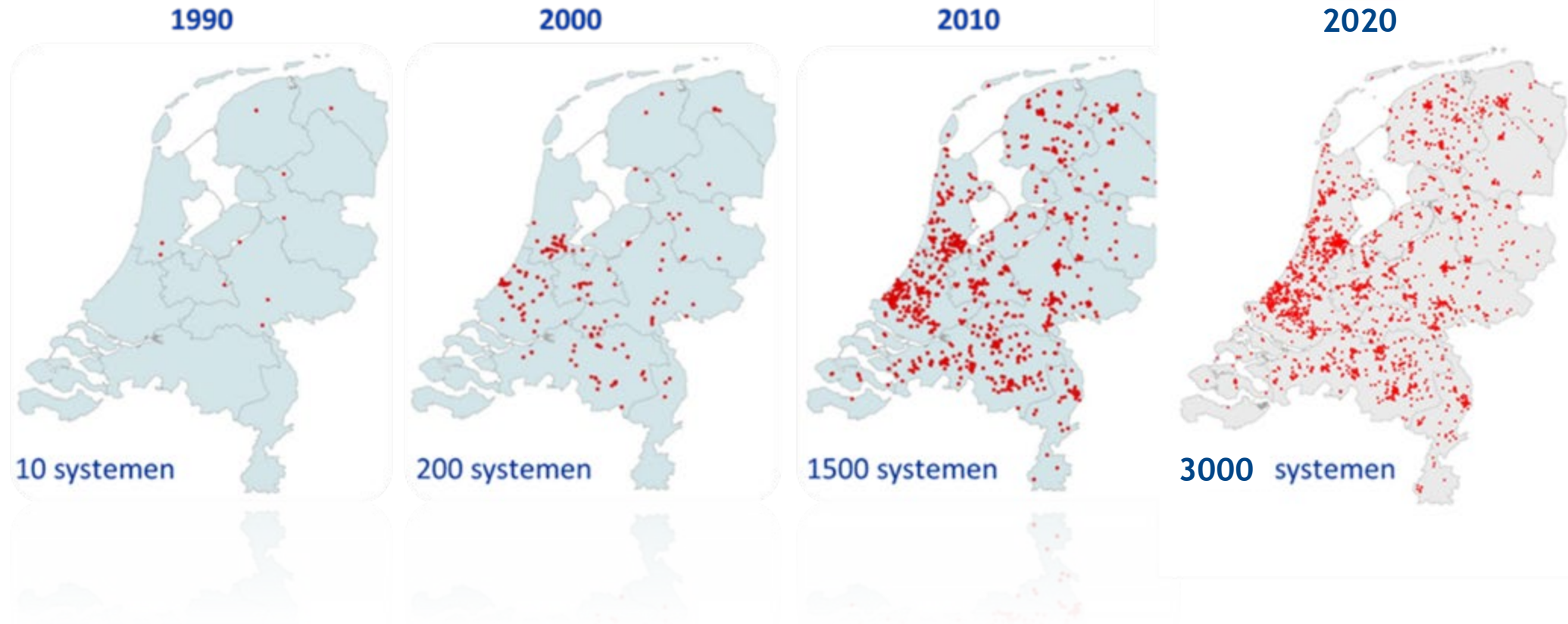
ATES applications

- Utility (office buildings)
- Hospitals
- University campuses
- Greenhouses
- Airports
- Data centers
- Shopping malls
- Residential areas

A few of our 3,000 reference projects



From early adaptors in 1990 to mainstream today



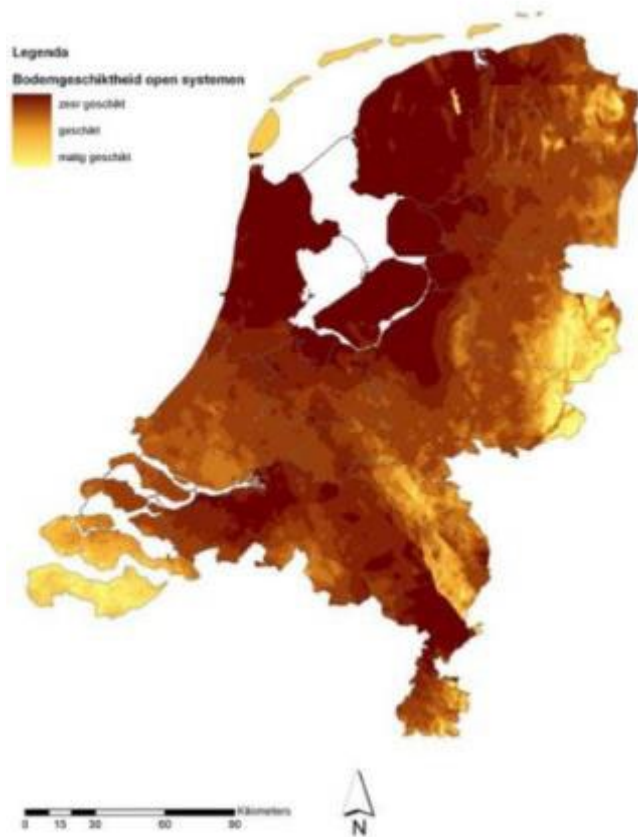
ATES market worldwide

Country	Estimated amount of larger ATES systems
The Netherlands	> 3,000
Sweden	> 220
Belgium	> 30
UK	> 30
Germany	> 10
Denmark	5-10
Norway	> 5
China	50
USA	10

So, why is it a success in NL?



We have aquifers



- ATES needs proper aquifers.
- The Netherlands does have many good aquifers.
- Most requests for ATES can be accepted and realised.
- This resulted in a broad acceptance of the technology.
- Also due to good aquifers, the upfront research costs were limited.
- Due to the scale, a lot of research has been done to clogging problems and solutions have been found.

Good climate for ATES



- Cooling is often the business
- ATES and BTES is a storage technology. Heat of the summer and cold of the winter will be stored and re-used in the next season.
- A warm and a cold period are required to store energy, but also to have a demand of energy.
- The Netherlands does have a C climate (Köppen system), so moderate winters and summers.
- ATES is not subsidized.

We adapt the legal framework together

Interests of stakeholders

- Sustainable energy, CO₂ reduction
- Soil and groundwater protection
- Drinking water companies
- Commercial companies - authorities
- Other groundwater users

Together: development and improvement of the legal framework and this will be update each 10 year.



Next step: from ATES to MT-ATES

MT-ATES

- Middle Temperature ATES (> 25 °C to 50 °C)
- Idea 1: remove Heat Pump from the system
- Idea 2: keep the concept the same as ATES, similar materials and no water treatment
- Energy source heat: solar collectors, refrigerators

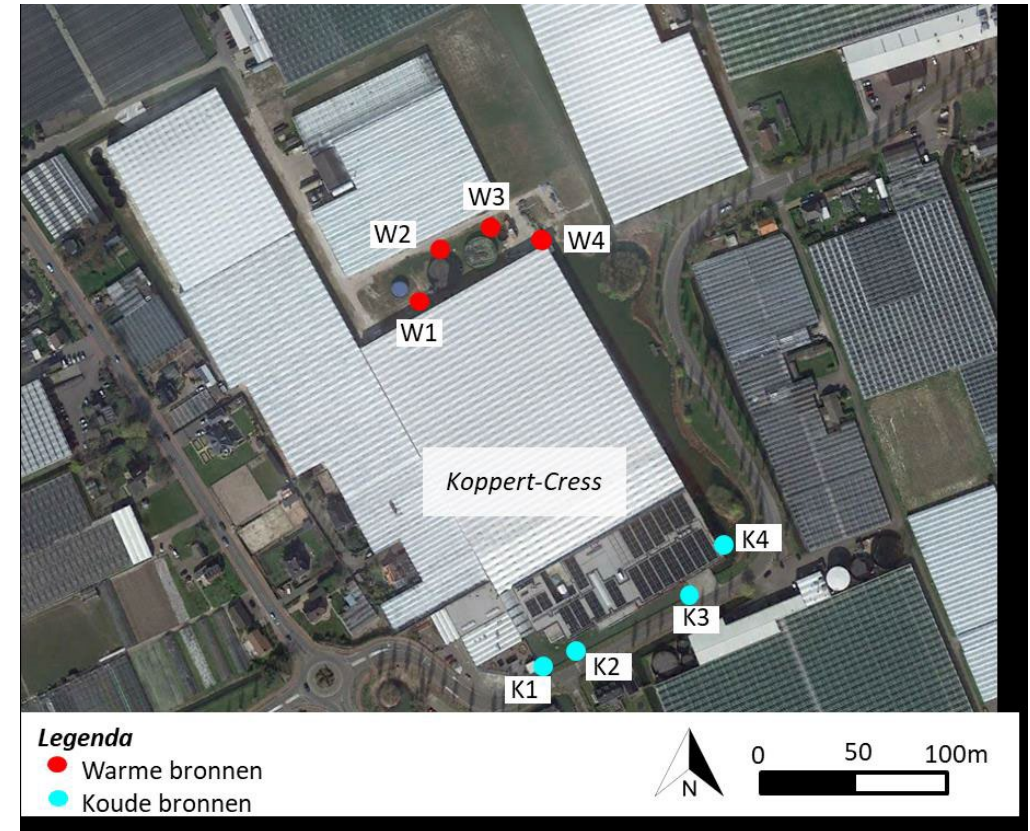
Advantages

- Direct cooling with cold well
- Direct heating with hot well
- Result: high COP, lower primary energy consumption



MT-ATES at Koppert Cress

- Since 2012, ATES system with 4 cold and 4 warm wells
- Depth filters: 55 - 75 & 135 - 160 mbsl
- Since 2015, allowed to store heat at max. 45 °C
- ATES system is used for heating and cooling of the greenhouse and the production halls
- Heat is derived from the HP's and the cooling of the LED lights



MT&HT-ATES projects

project	realization	Average storage temp. [°C]	Heat storage [MWh _t]	Heat delivery [MWh _t]
Office complex, Bunnik	1985	25-30	370 (?)	172 (?)
University of Utrecht	1991-1997	90	6.000	3.520
Heuvelgalerie Eindhoven	1992	32	3.300	1.600
Dolfinarium Harderwijk	1997	40	7.650	4.600
Hooge Burch Zwammerdam	1998-2003	88	2.250	1.100
2 MW, Haarlem	2002	43 (2008)	1.650	1.155
NIOO, Wageningen	2011	45	1.280	580
Koppert Cress	2015	45		
ECW Energy, Middenmeer	2021	85	28.000	20.000

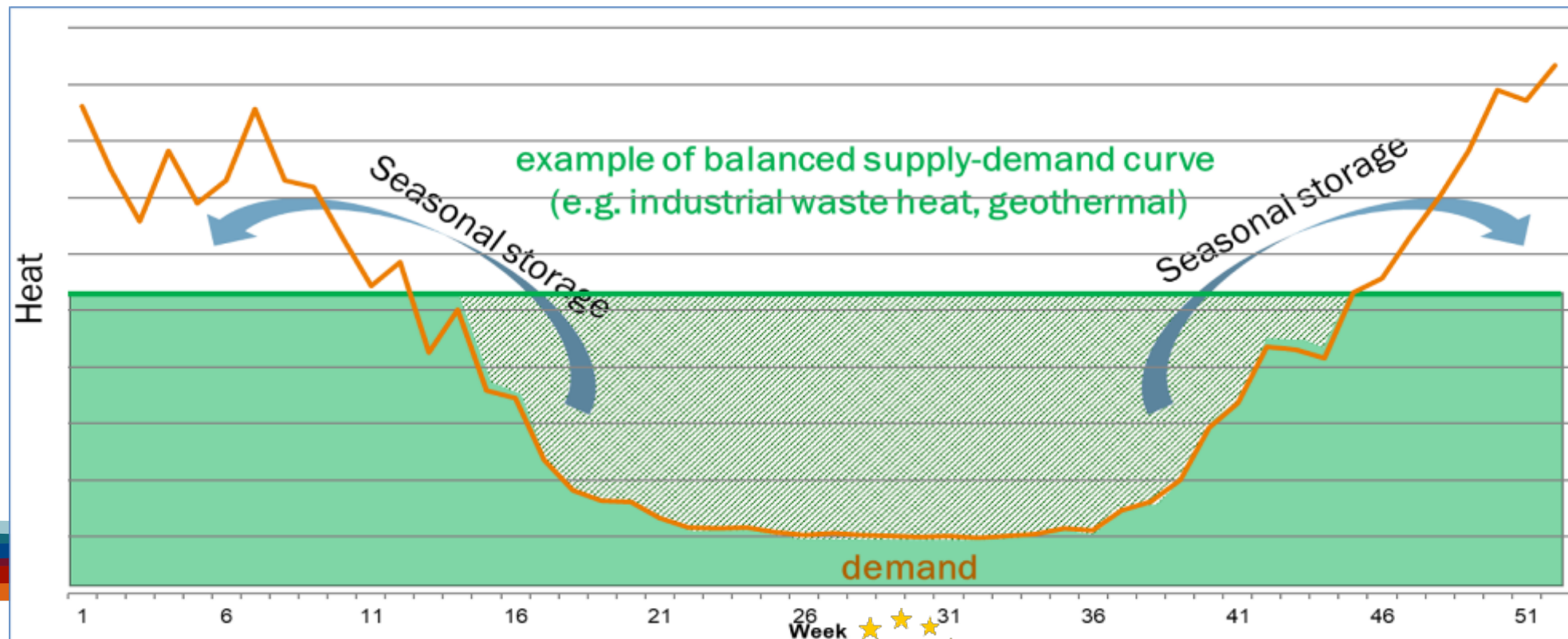


From MT-ATES to HT-ATES

Why should we use an HT-ATES: bathtub

Summer: Heat Excess
Winter: Heat Demand

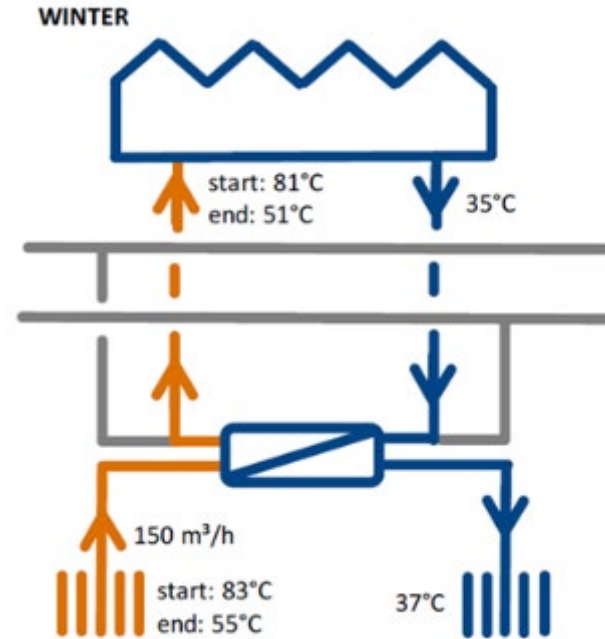
} Solution = Heat Storage



High temperature storage - sources and users

Sources

- Geothermal wells
- Solar collectors
- Waste heat
- Industrial heat
- Power to heat (H₂ production or electricity)
- CHP: electricity + heat



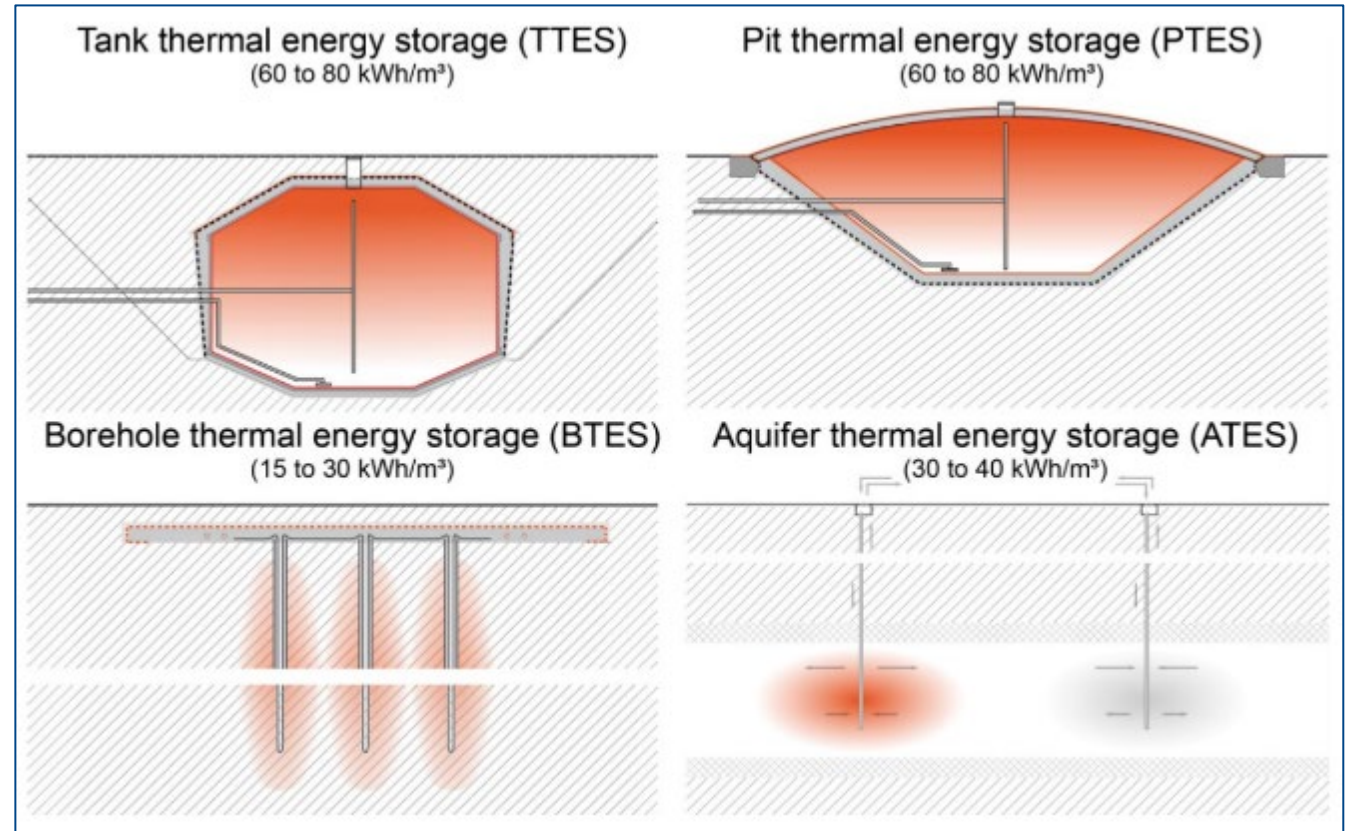
Users

- District heating networks
- Greenhouses
- Residential areas

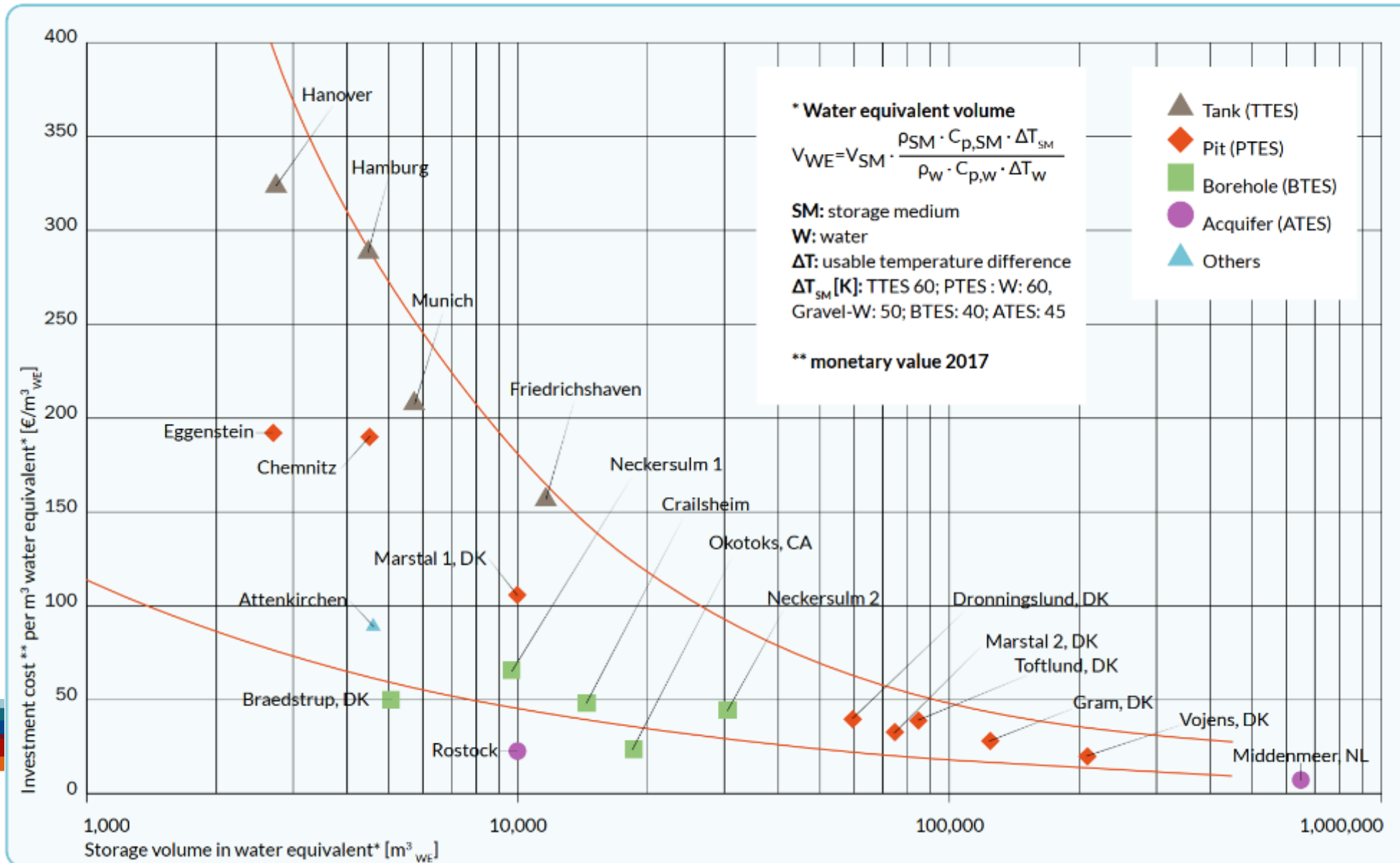
Options for large scale heat storage

HT-TES

- TTES (tank)
- PTES (pit)
- HT-BTES (boreholes)
- HT-ATES (aquifers)

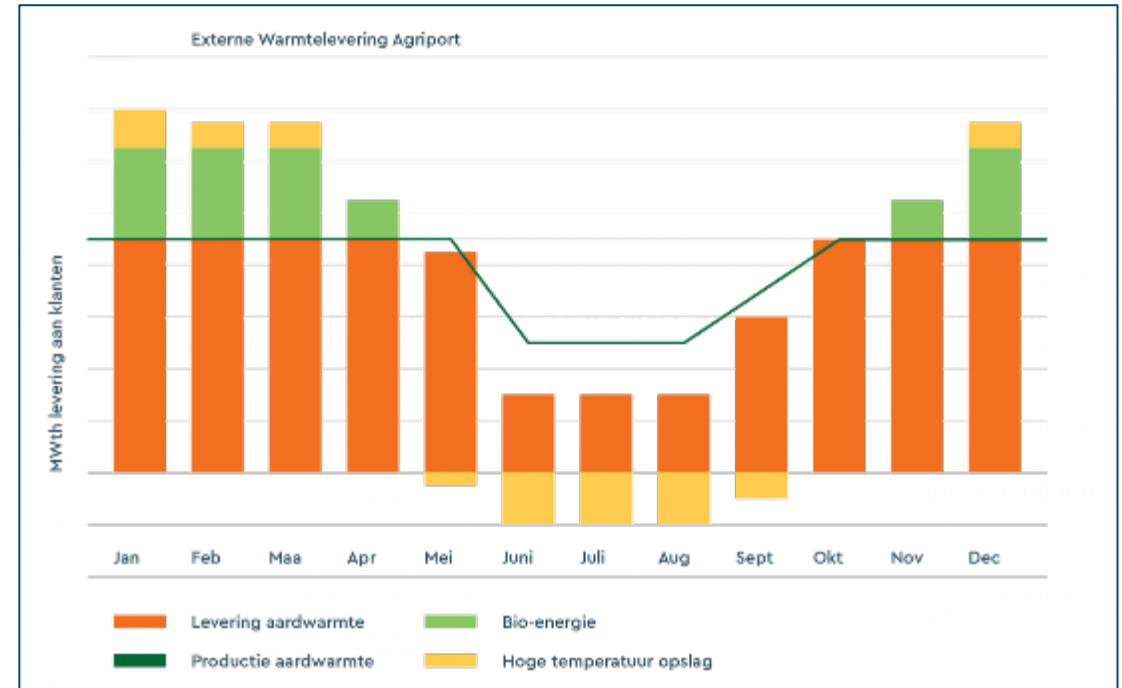


Costs of large scale heat storage



Other advantages of HT-ATES

- Increased geothermal annual yield (bathtub)
 - In some cases, more subsidy on the produced heat
- Stable geothermal operation - lower costs and smaller risks failures pumps (ESP's)
- Smaller CAPEX for Deep Geothermal
 - 1x 20 MW Deep Geothermal or
 - 1x 10 MW DG + 1x 10 MW HT-ATES
- Increases flexibility of the operator in heat production, storage and supply
- Options for balancing electricity net congestions



Reference project: Deep Geothermal + HT-ATES ECW Energy, Middenmeer, the Netherlands



2017

First
screening



2019

Test drilling



2020

Realisation
doublet



2021

First
loading
cycle

ECW Energy: DG + HT-ATES

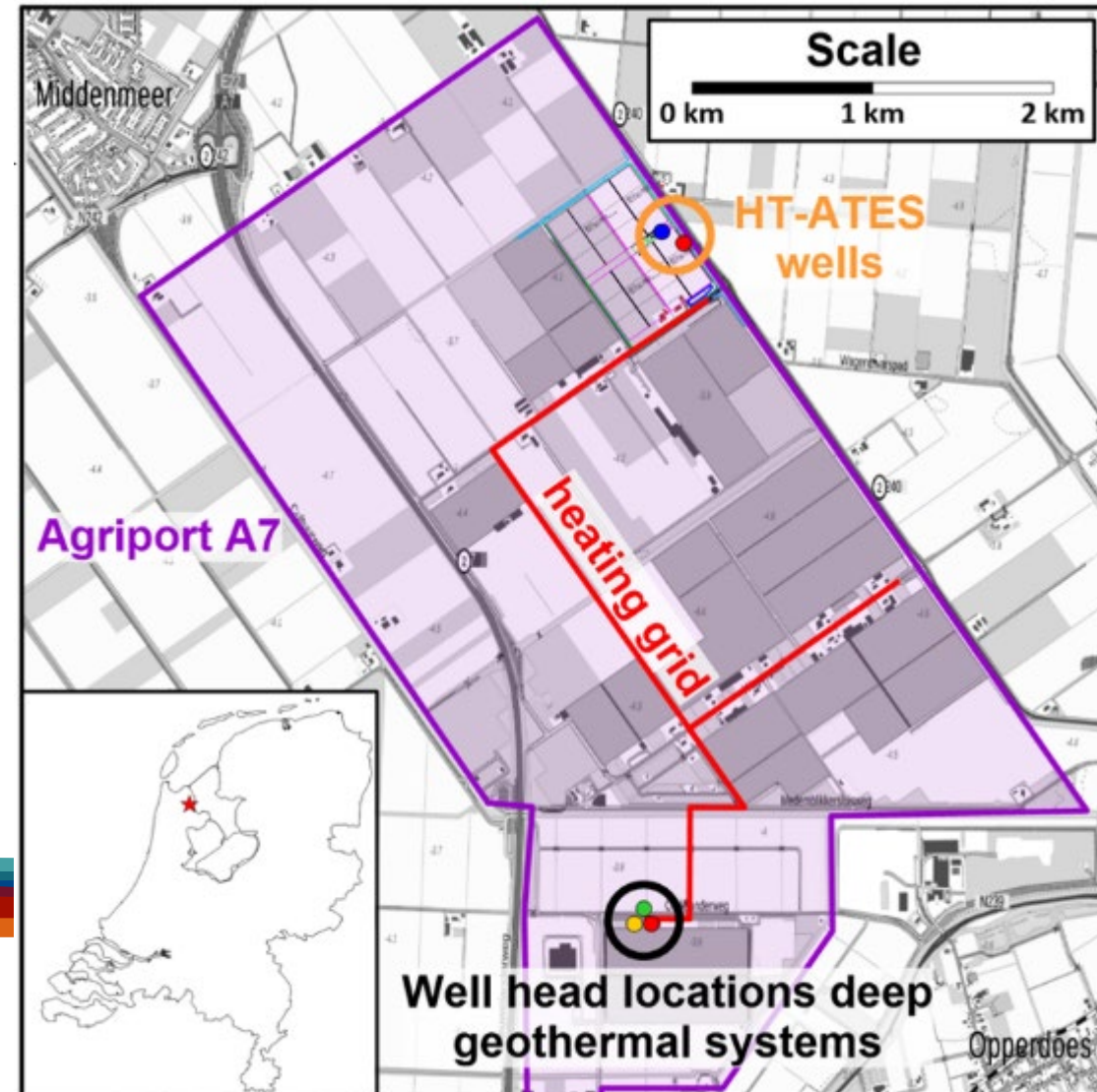


ECW Energy

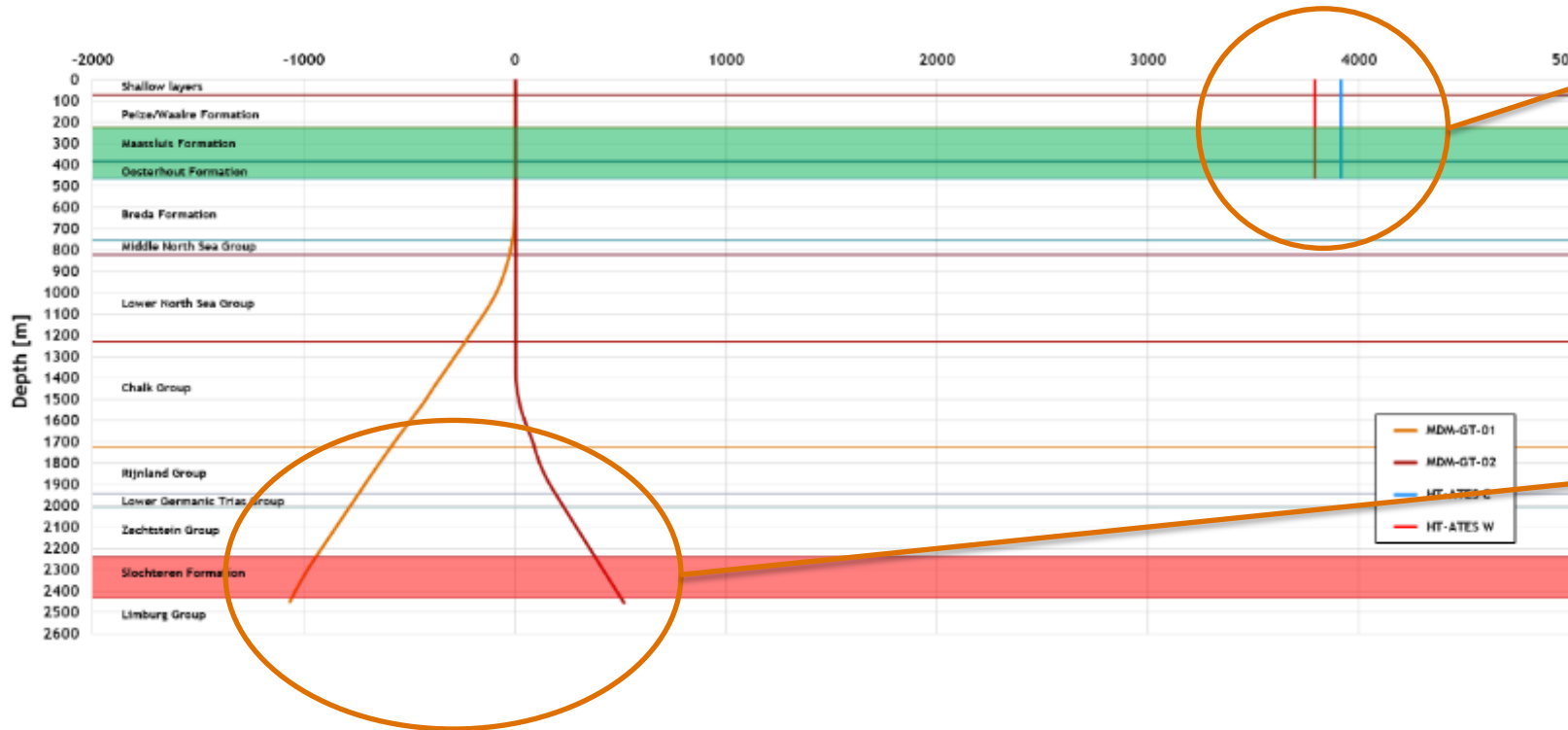
- Large geothermal operator in the Netherlands
- 5 doublets, 56 MWt; 300 GWh/a

Geothermal system Middenmeer

- 3 Geothermal doublets in Middenmeer (80 - 85 °C)
- Heating grid to supply greenhouses



ECW Energy: DG + HT-ATES



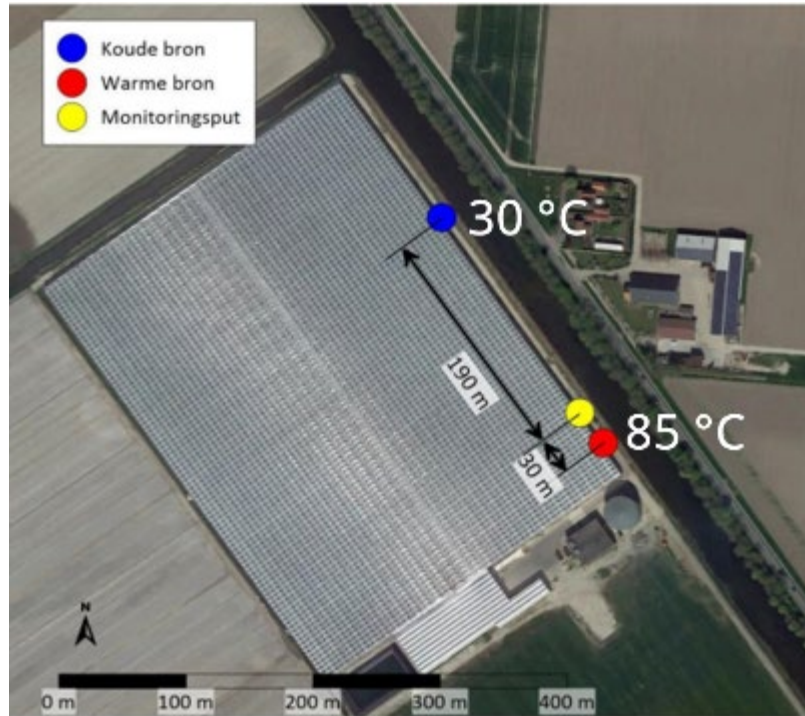
HT-ATES Aquifer (~400 m depth)

- ~ 25 m thick Aquifer
- Unconsolidated sand
- Between thick clay layers

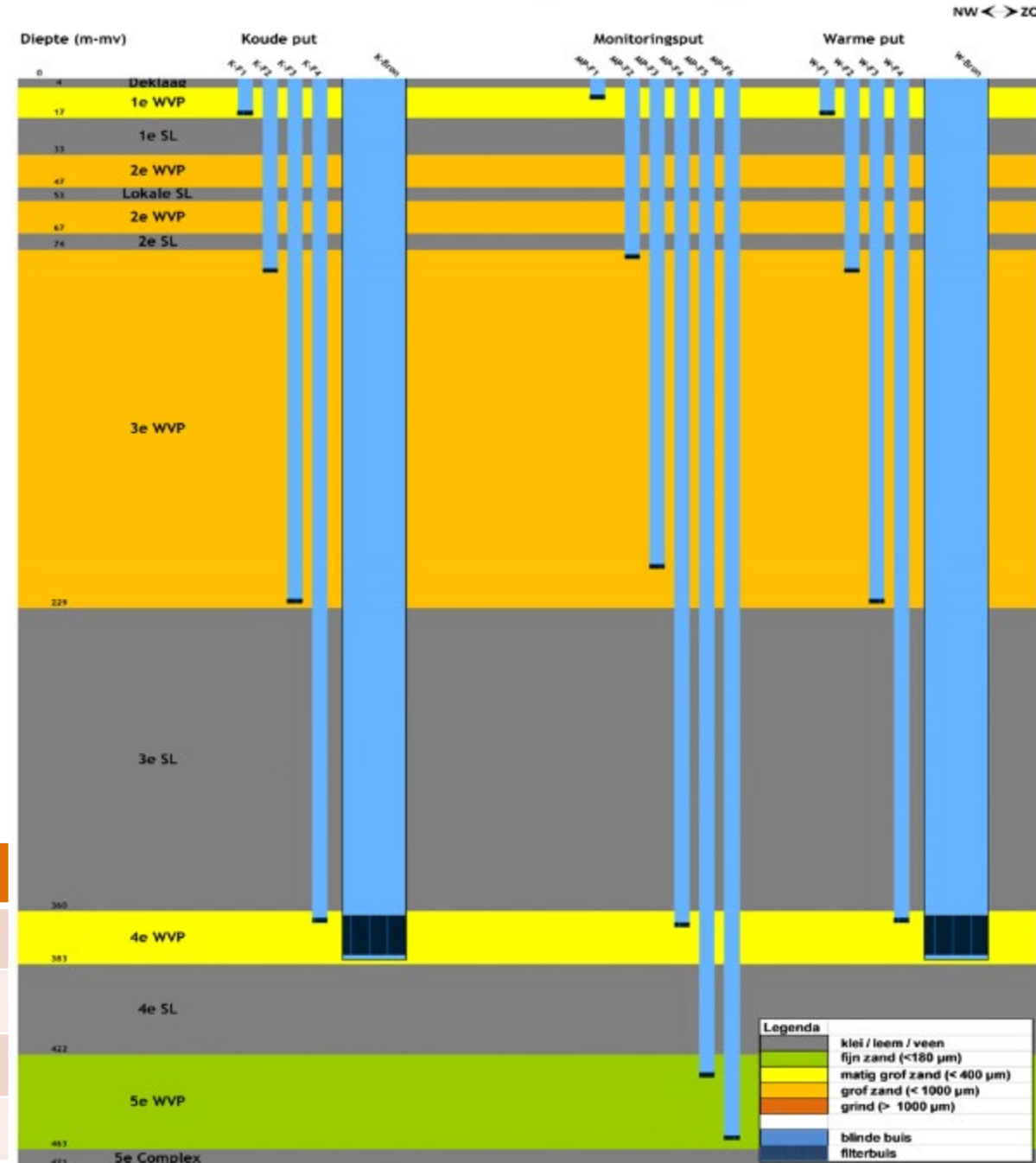
Geothermal Reservoir (> 2km)

- Sandstone
- Slochteren Formation

ECW Energy: HT-ATES

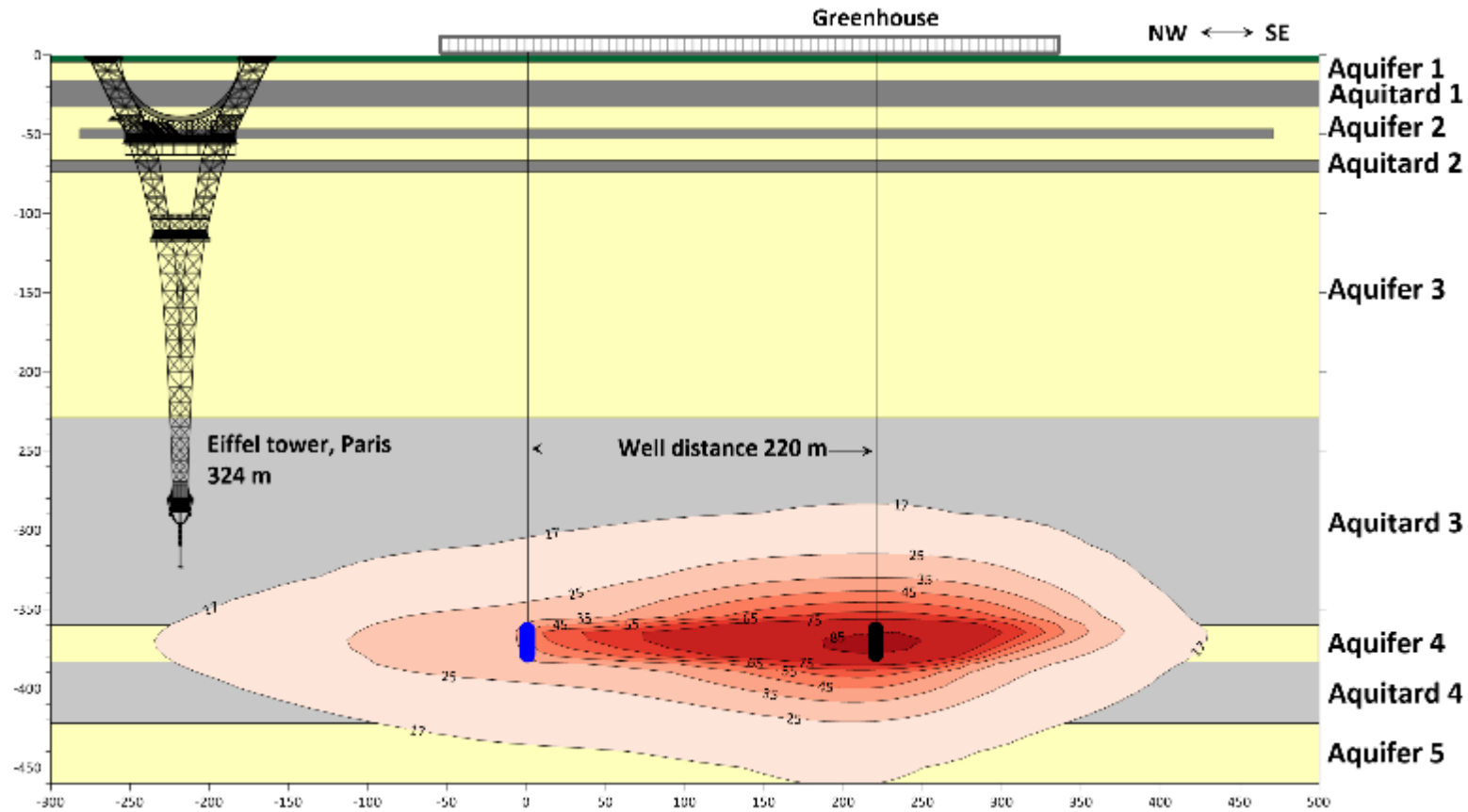


HTO ECW - Filterstelling bronnen en peilbuizen



Parameters permit application	10 MW	Winter	Summer
maximum water displacement	[m ³ /season]	350,000	350,000
Target flow	[m ³ /hour]	150	150
Average injection T	[°C]	35	85
Energy supply and charge	[MWh/yr]	20,000	27,000

HT-ATES: modelling temperature development



A few pictures of the realization

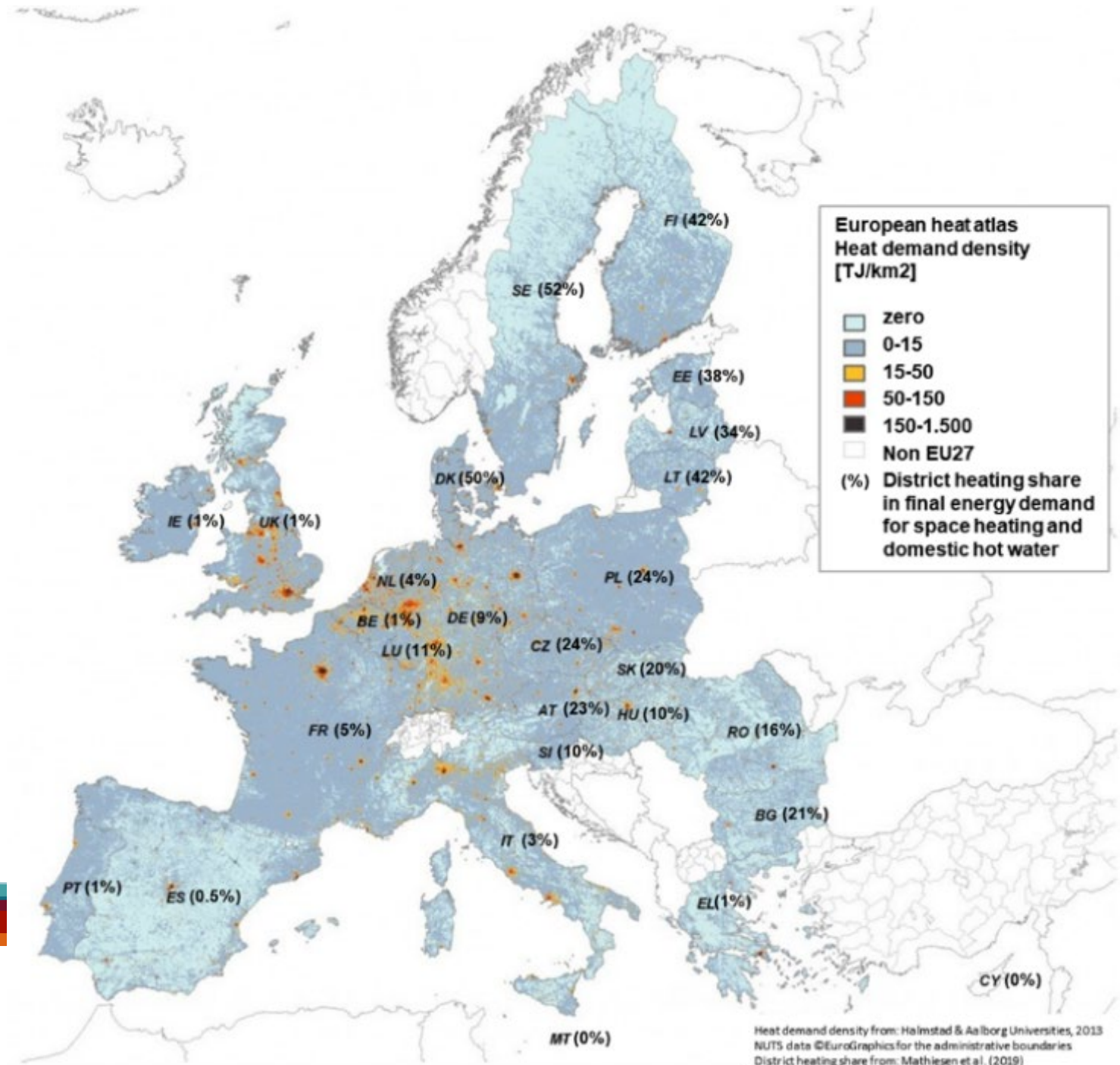


A few pictures of the installation



European Heat Demand

- HT-ATES great solution as heat buffer
- Fits well with District Heating Networks
- Heat demand is high in Europe
- In the Netherlands 100 - 200 HT-ATES systems expected
- In Europe up to thousands



Conclusions

We believe that geothermal technologies are more and more essential for our energy transition!



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