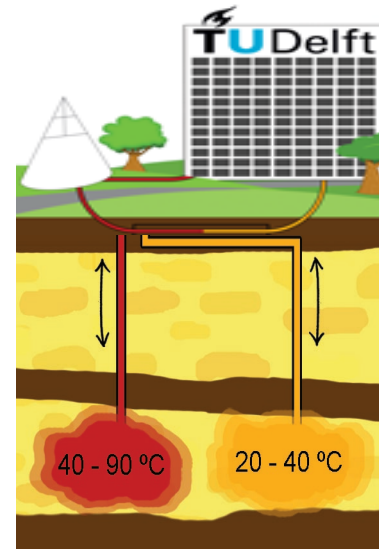


# HT-ATES, A hot topic for deep research

Dr.ir. M. Bloemendal  
2020-11-04



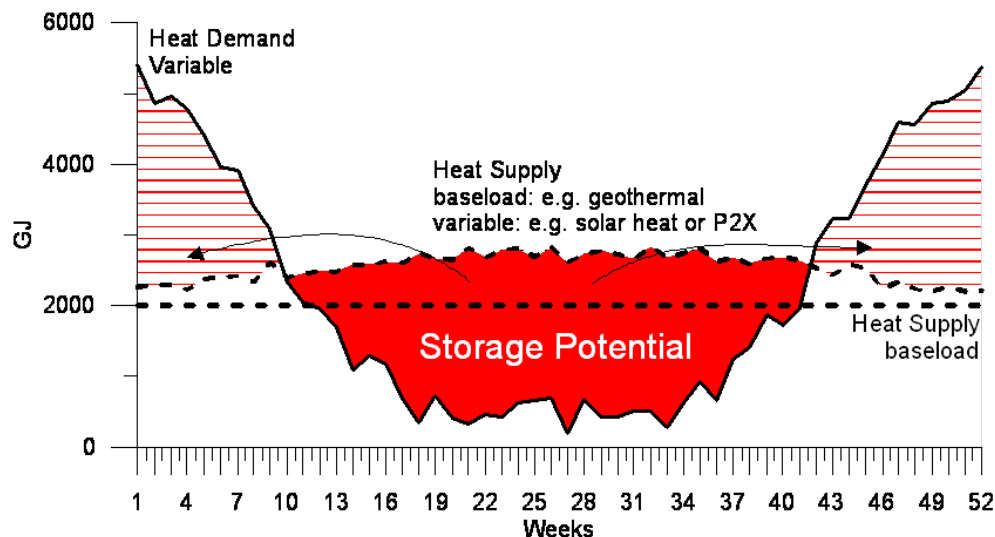
KWR

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# A hot topic for deep research

## Energy agreement (Paris/NL)

→ Heat is important

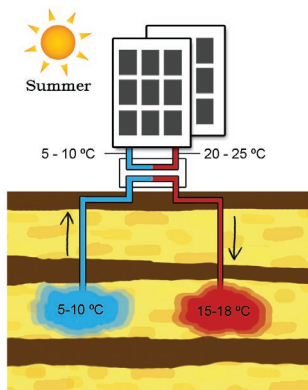


Hartog, N., M. Bloemendal, E. Slingerland and W. A. van (2017). "Duurzame warmte gaat ondergronds." VV+ sept-okt 17.

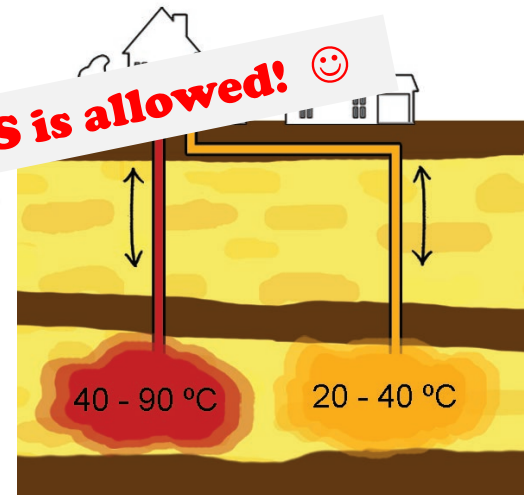
# HT-ATES

- $<25^{\circ}\text{C}$  standard regulatory framework
- $>25^{\circ}\text{C}$  Permitted as pilot / research projects

High Temperature ATES  
Houses, greenhouses & utility



**HT-ATES is allowed!** 😊

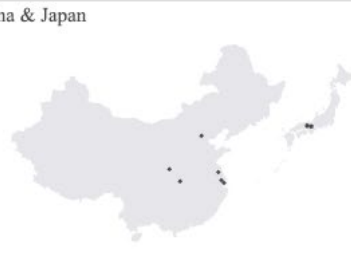




Netherlands & Belgium



China & Japan



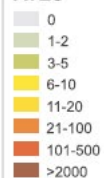
Denmark



Great Britain



ATES



● Implemented ATES

**In NL we are good at ATES**



Sweden & Norway



North America



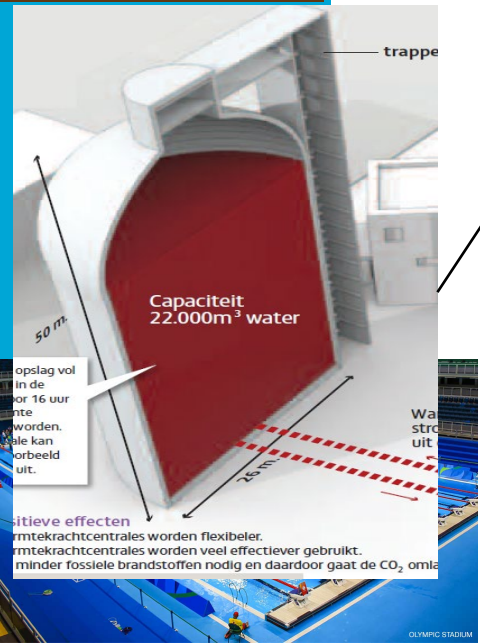
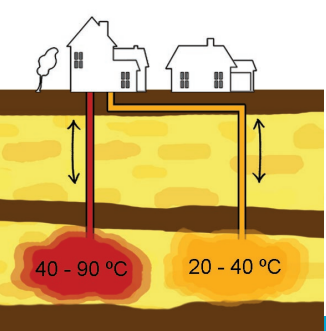
Germany



Turkey



# High Temperature ATEs Houses, greenhouses & utility



number of ATEs systems [-]



Permit capacity x1000 [m³/y]

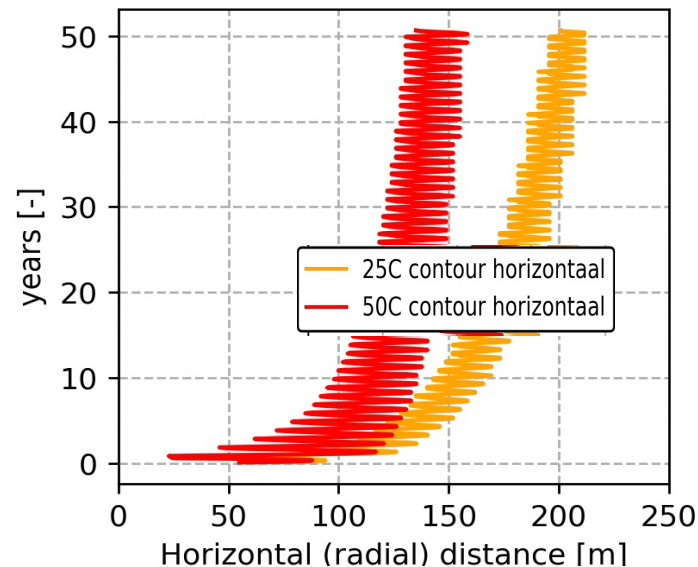
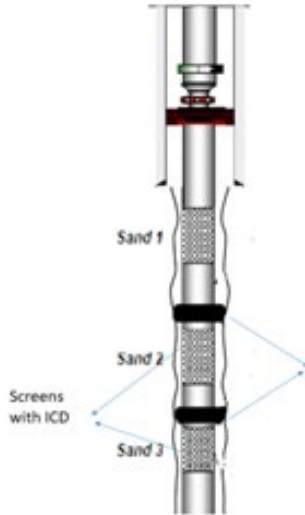
Bloemendal, M. and N. Hartog (2018). "Analysis of the impact of storage conditions on the thermal recovery efficiency of low-temperature ATEs systems." Geothermics 17(C): 306-319.

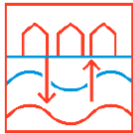


# A hot topic for deep research

Stable & robust operation

1. Infrastructure / Materials
2. Control / integration
3. Losses & impact
4. Policy





# WINDOW

Learning by doing

22 sites  
quick-scan



7 sites  
feasibility study



2-4 sites  
Full design,  
pilot drilling



2-4 sites  
demo projects

General research

- Technical potential
- Characteristics
- Optimisation and control, System integration
- Well design, materials
- Impact, Monitoring



Stijn Beernink

Rules and regulation



Deltares

TNO innovation  
for life

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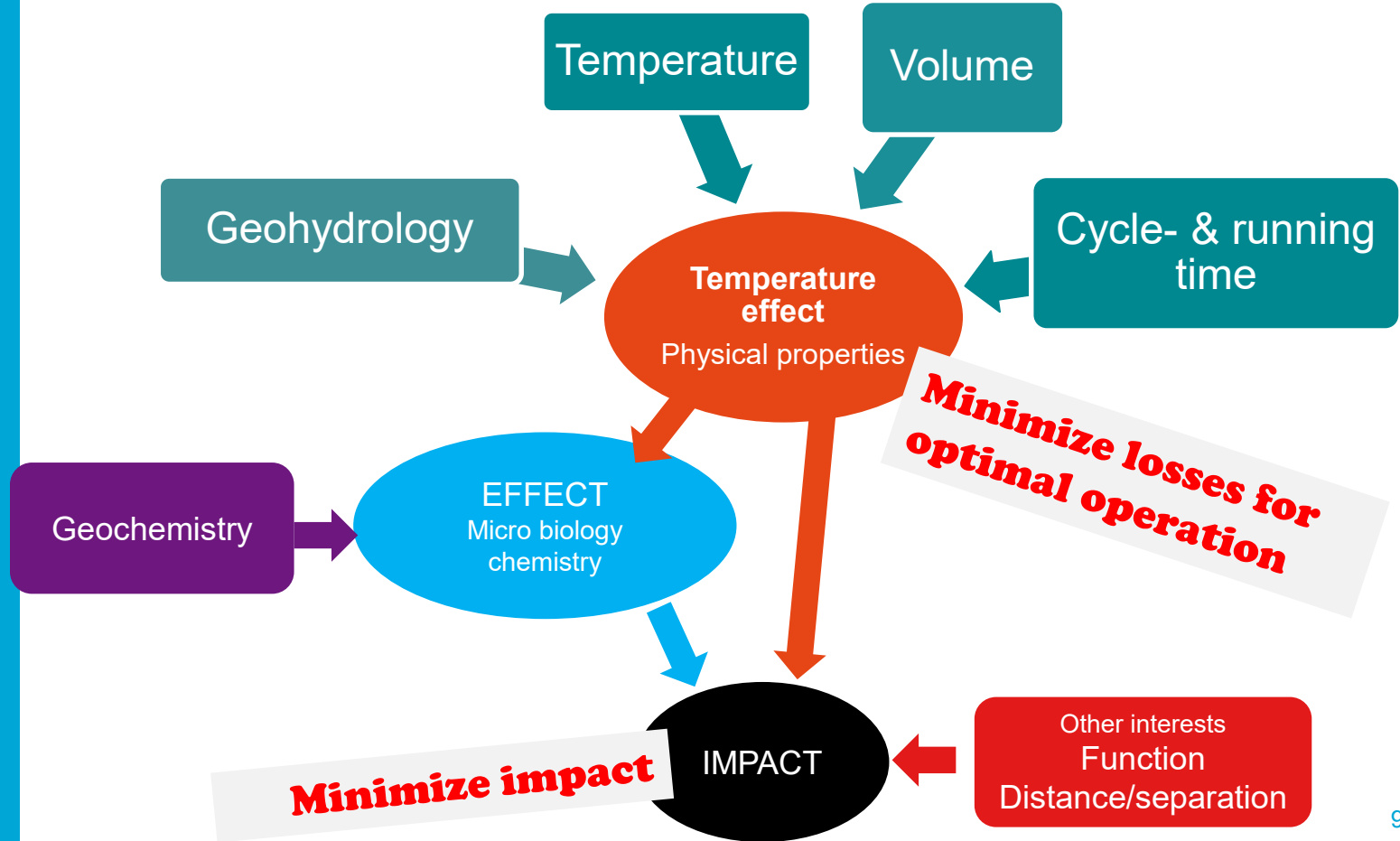
# A hot topic for deep research

Stable & robust operation

1. Infrastructure, Materials
2. Control / integration
3. **Losses & impact**
4. Policy



# Losses → Impact ?

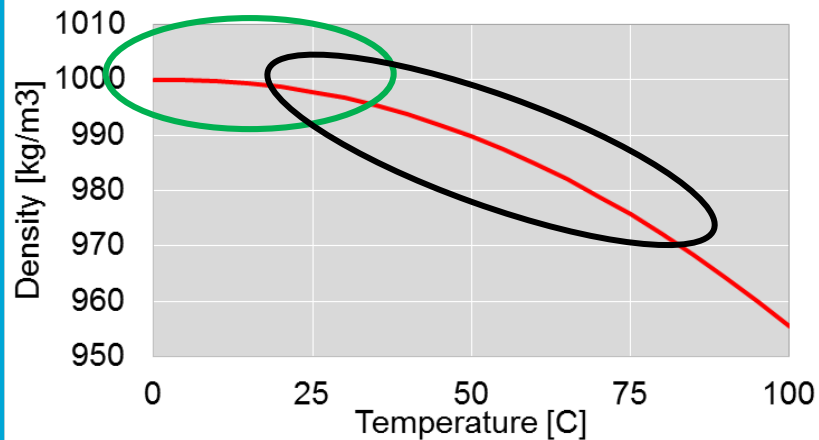


# Losses

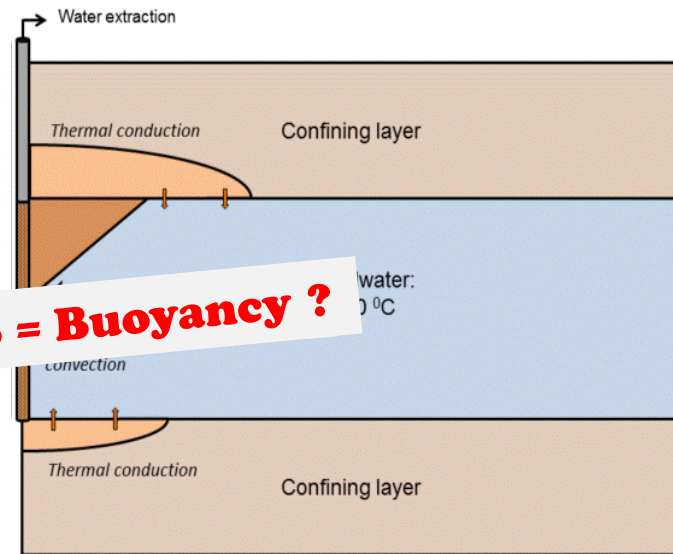
- Dispersion
- Conduction ←
- Buoyancy ←
- Advection

# Buoyancy

Density of fresh water vs temperature



**HT-ATES = Buoyancy ?**



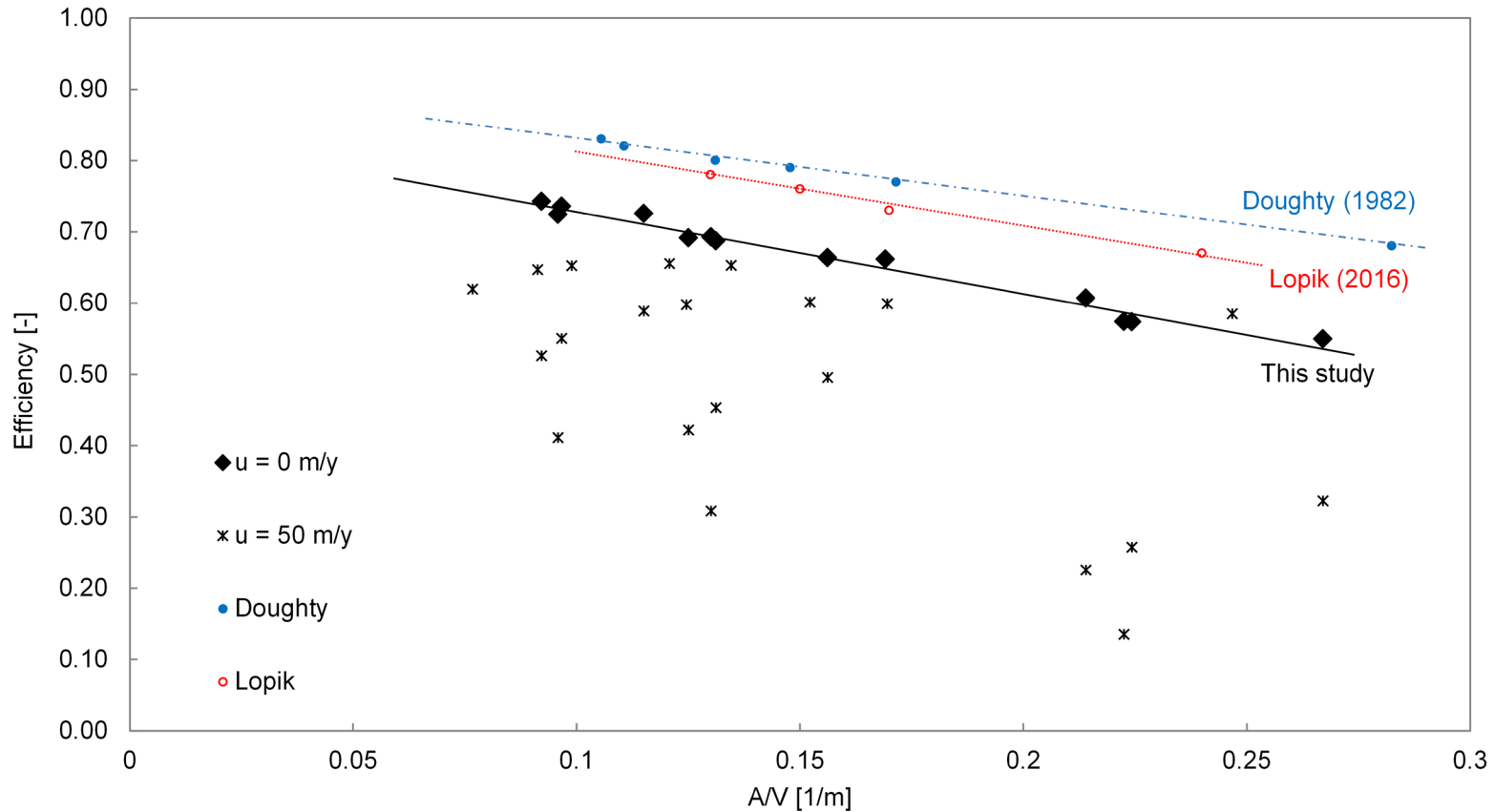
Lopik, J. H. v., N. Hartog and W. J. Zaadnoordijk (2016). "The use of salinity contrast for density difference compensation to improve the thermal recovery efficiency in high-temperature aquifer thermal energy storage systems." Hydrogeology Journal.

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# Heat losses by conduction

Bloemendal, M. and N. Hartog (2018). "Analysis of the impact of storage conditions on the thermal recovery efficiency of low-temperature ATES systems." *Geothermics* 17(C): 306-319.



12°C

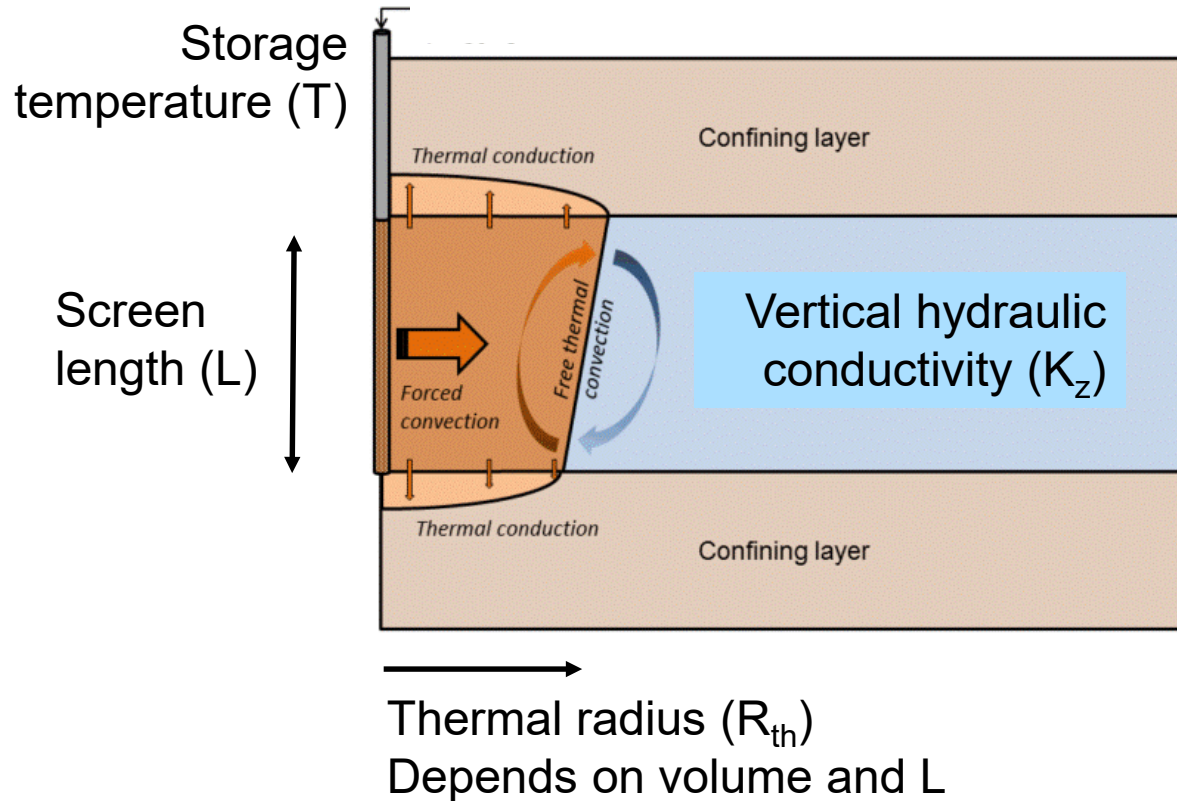


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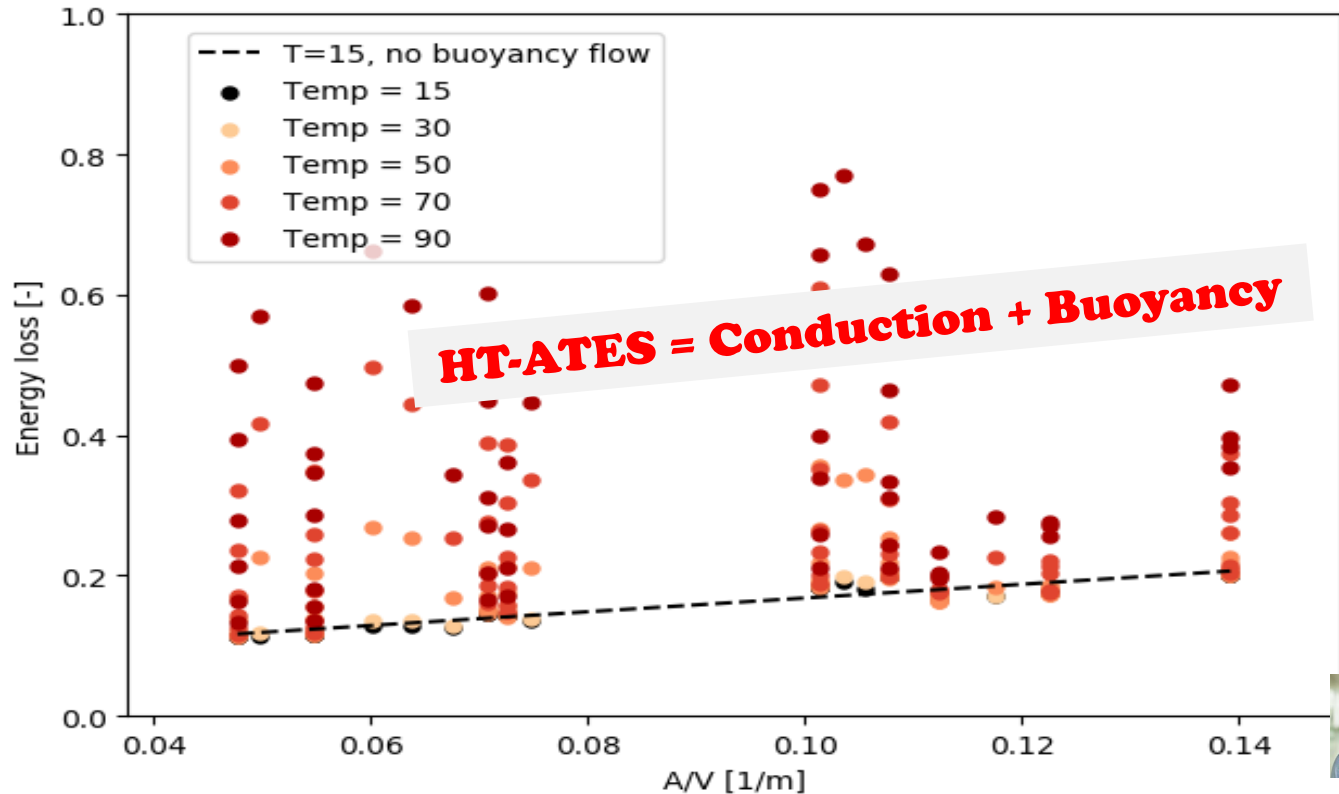
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# Exploratory simulations

Identify optimal storage conditions

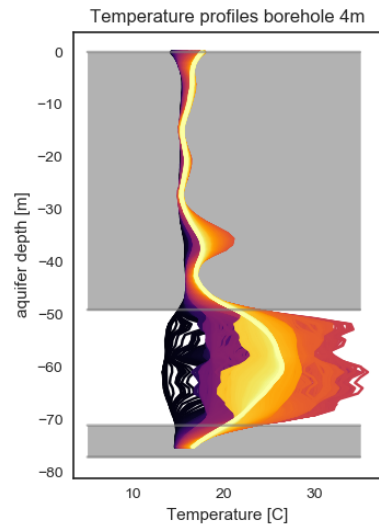
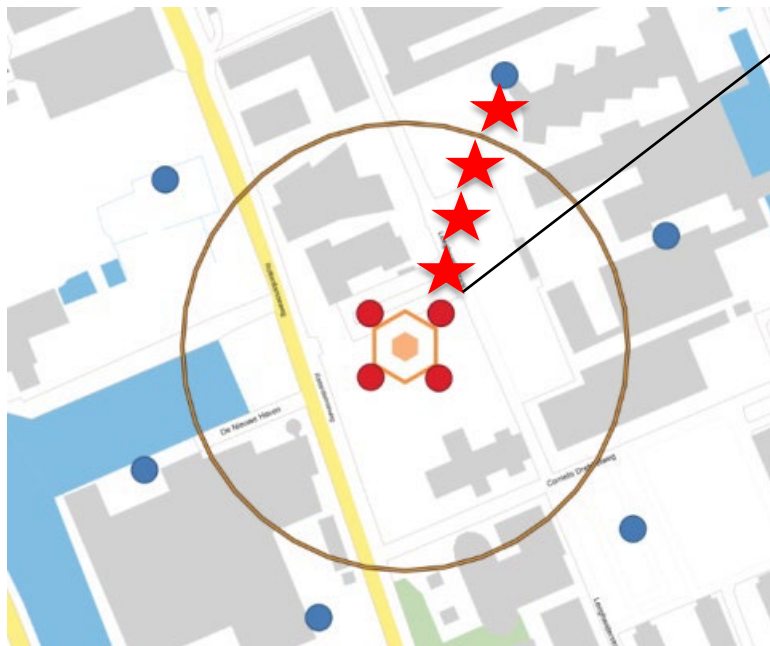


# Buoyancy and conduction losses



# A hot topic for deep research

## DTS monitoring



Underground heat transport

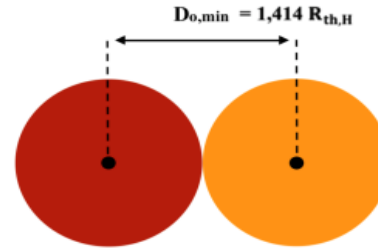
- Buoyancy / conduction
- Heterogeneities, uncertainties
- Chemistry / microbiology

# Well placement

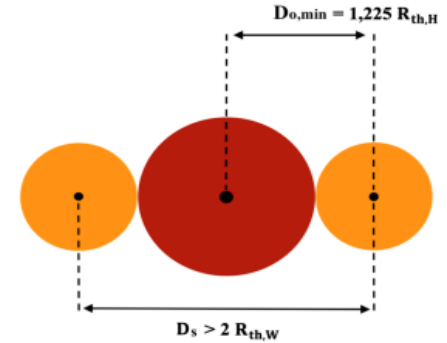
## HT-ATES:

- Heat losses from both wells

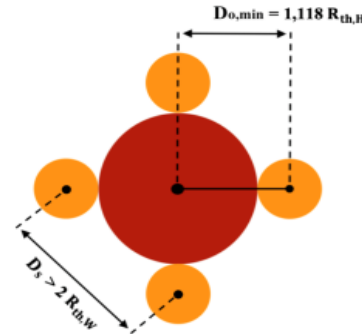
1 Warm well



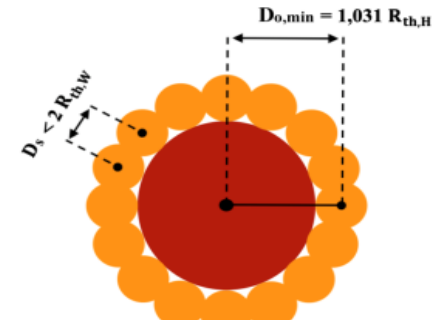
2 Warm wells



4 Warm wells



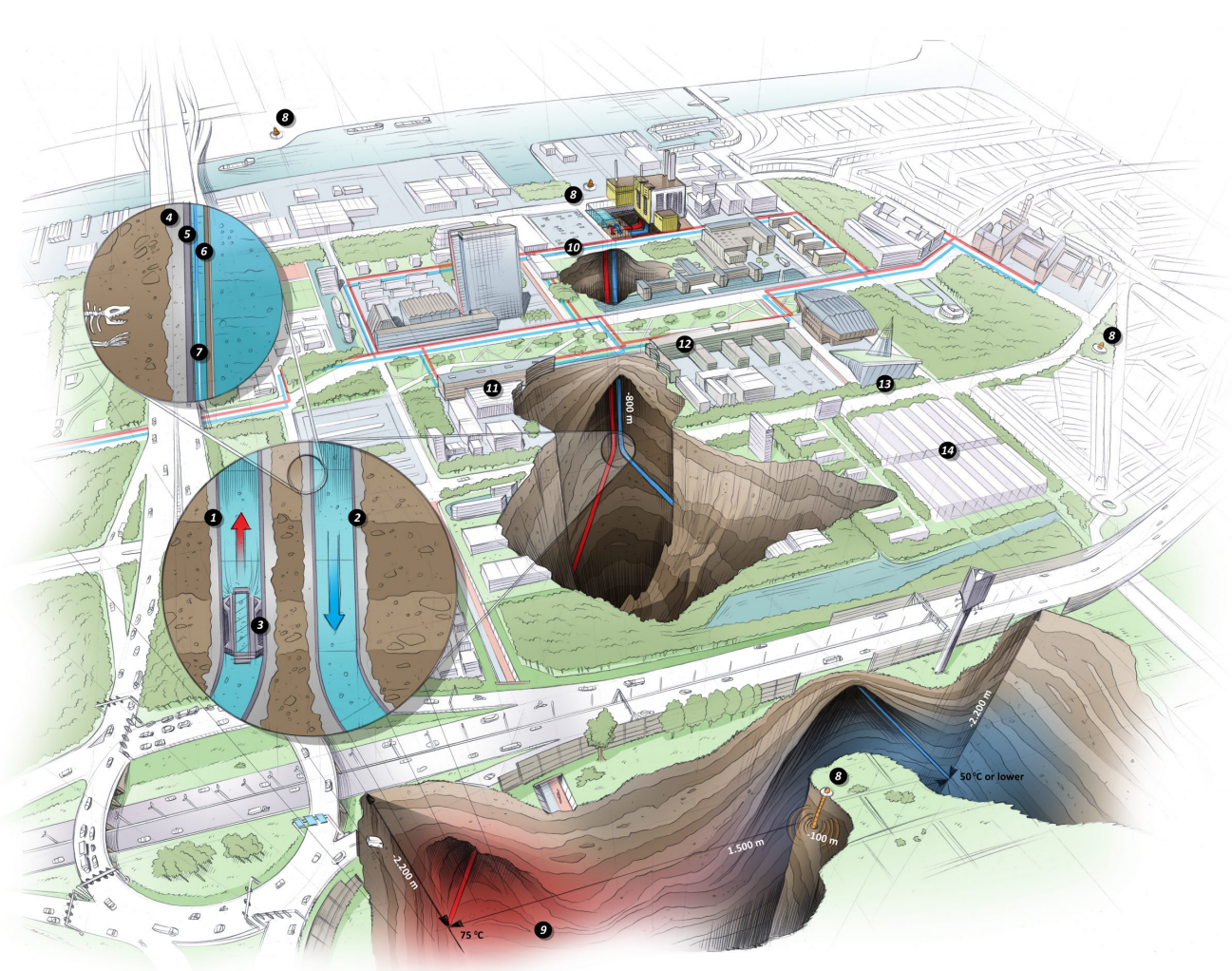
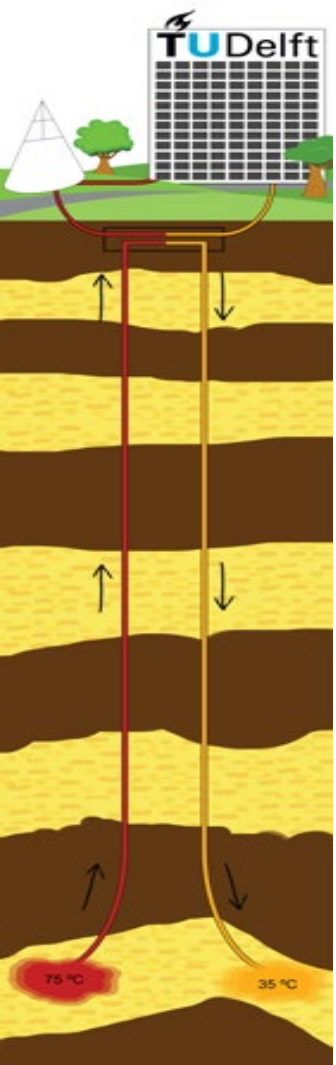
16 Warm wells

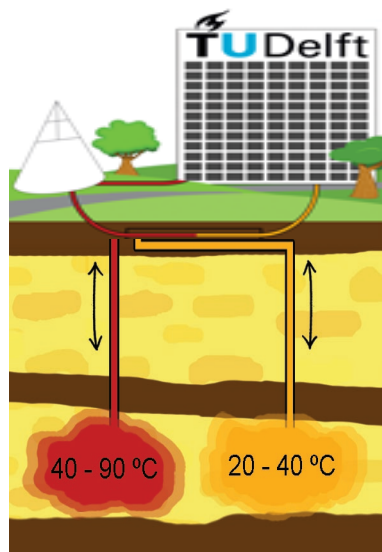
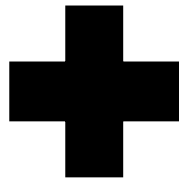
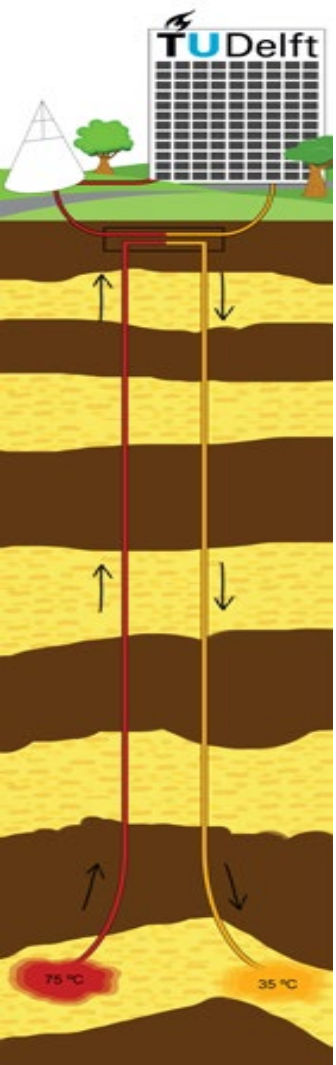




# A hot topic for deep research

- Well design and completion
- Monitoring & Control
- Model optimisation
- Integration in DHN with DAPwell





Novel combination of  
geothermal energy and HT-ATES  
&  
World-wide unique research infrastructure

# HT-ATES, A hot topic for deep research

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2019-11-07

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