Twinning - WIDESPREAD-03-2018

GeoUS

VSB TECHNICAL UNIVERSITY OF OSTRAVA

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Fraunhofer

GEOTHERMAL ENERGY 23.4.2020

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RENEWABLE ENERGY RESEARCH GROUP

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1. Types of geoenergy

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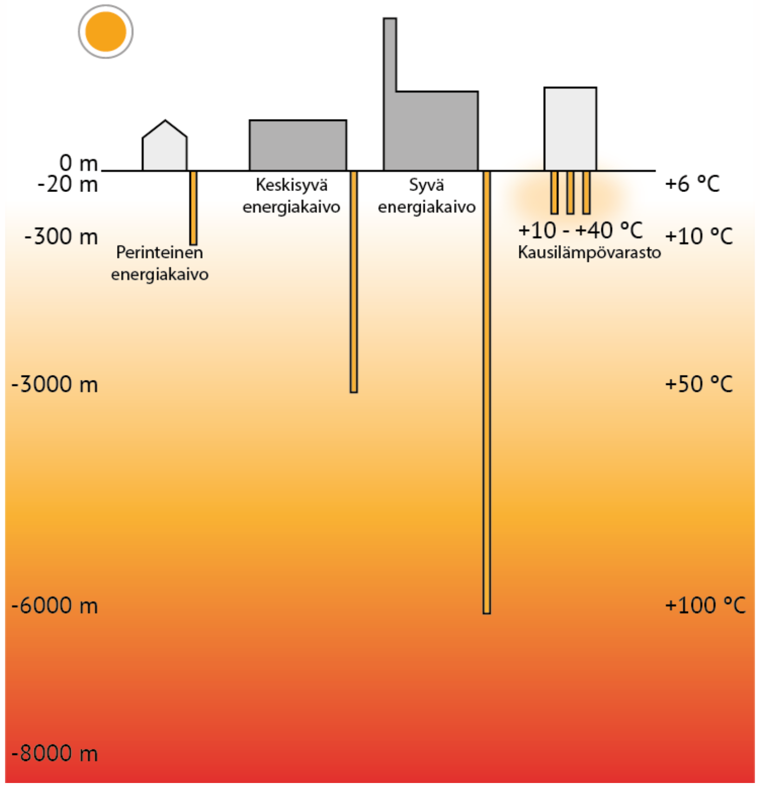
Types of geoenergy

- The types of geoenergy are:
  - Shallow
  - (Intermediate)
  - Deep
  - Seasonal heat/cool storage



Source: **RT 103137**
Lämpöenergian kausivarastointi
https://www.rakennustieto.fi
(**Building Information Group**)

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Types of geoenergy

- Different geothermal storage types
  - ATES - Aquifer Thermal Energy Storage
  - BTES - Borehole Thermal Energy Storage
  - CTES - Rock Cavern Thermal Energy Storage
  - DTES - Duct Thermal Energy Storage
  - Pit ES - Pit Energy Storage
  - PCMES - Phase Changing Material Energy Storage

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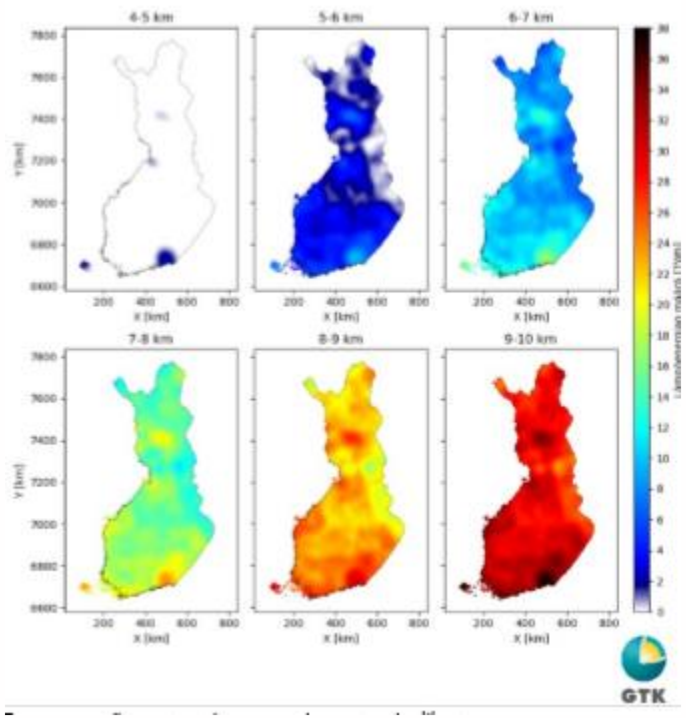
Types of geoenergy

- The selection of types depends on e.g.
  - Need
  - Regional potential
    - Geological data
    - Geochemical data
    - Geophysical data
  - Predicted production
  - Water and heat recharges
  - Economical issues



Source: GTK, *Geological Survey of Finland*,

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2. Measurement instruments

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Measurement instruments

- Distributed temperature sensing (DTS) method uses an optical fibre to function as linear sensor.
- Temperatures can be measured as a continuous profile along the whole fibre.
- DTS-measurement device emits short optical pulses (laser light), which illuminate the glass core of an optical fibre.
- One type of scattering is Raman scattering which consists of Anti-Stokes and Stokes band. Anti-Stokes band is temperature dependent, while Stokes band is not.
- The ratio of the Anti-Stokes and Stokes light intensities indicates the local temperature of optical fibre

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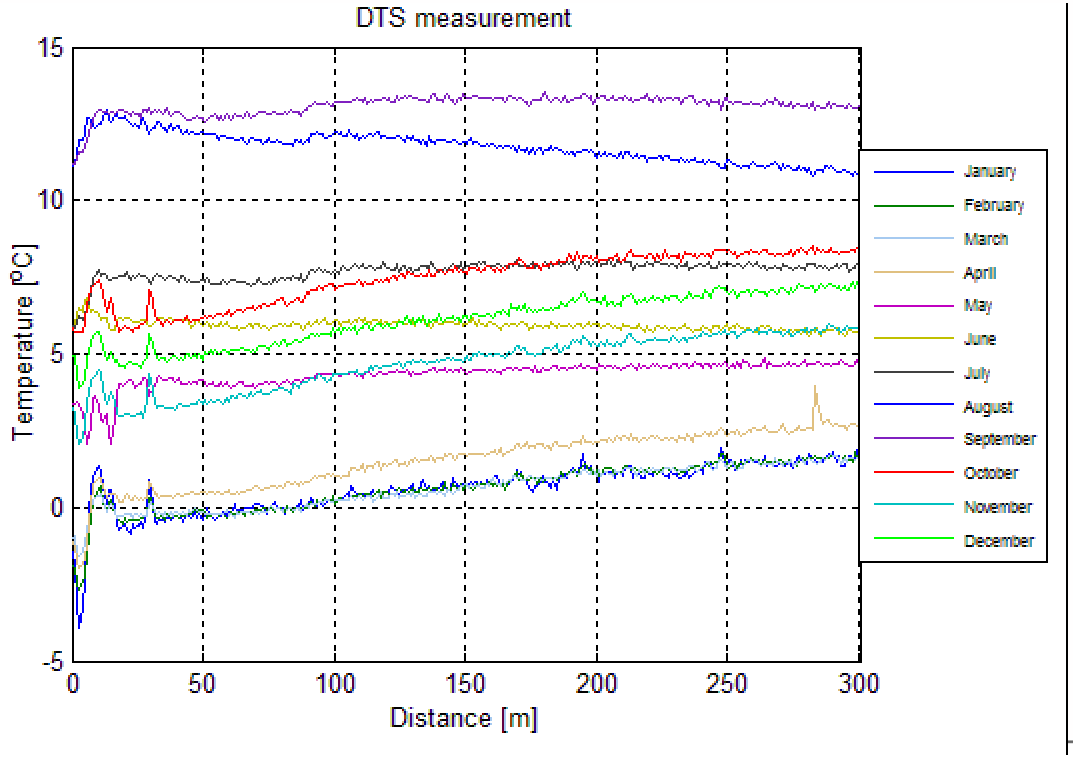
Measurement instruments

- Example of measurements



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Measurement instruments

- The thermal response test trailer consists of equipment measure heat energy flow to (or from) thermal source and a data collector with transmitter.
- The collected data can be retrieved from the trailer to the central computer for analysis.
- Heating system consists of a hot water storage tank, three electrical resistances, four switches and an electric energy meter.
- The heating power can be selected with switches from 1 to 18 kW by 1 kW increments.
- During the TR-test heat exchange fluid has been pumped to the thermal source and time, flow and temperature difference between injection and extraction are measured

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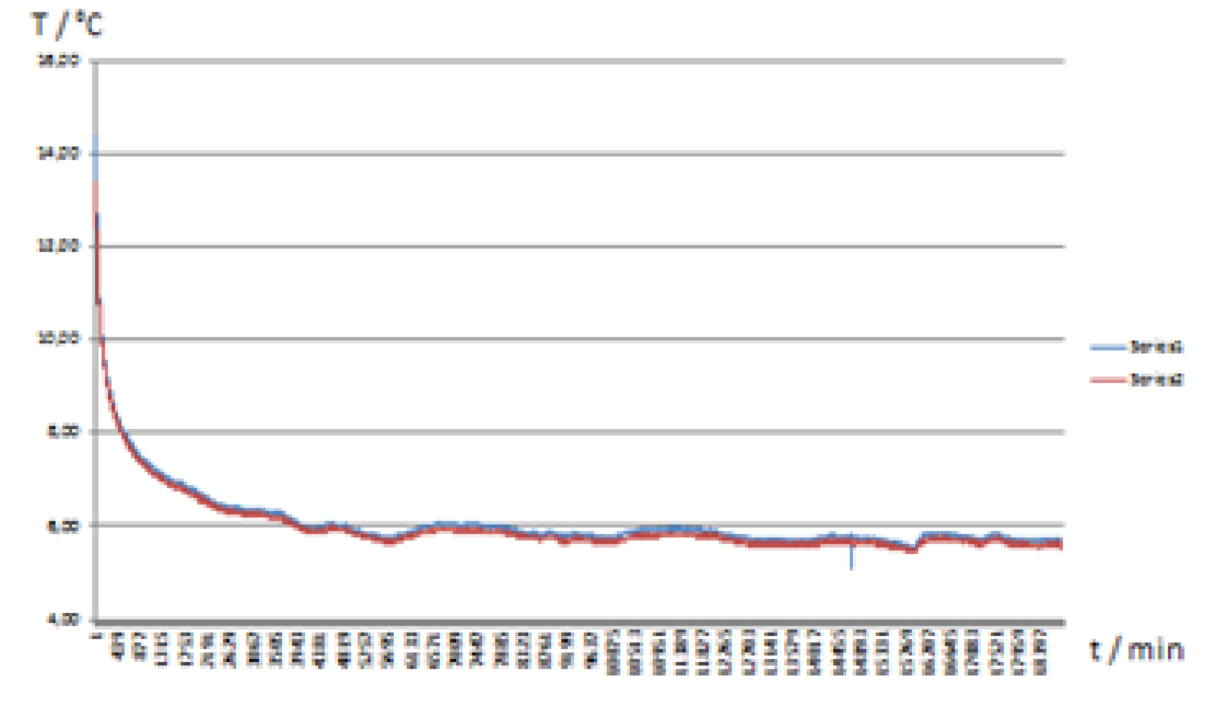
Measurement instruments

- From TRT tests:
  - basic temperature of bedrock
  - thermal conductivity
  - diffusion coefficient
  - thermal resistance



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3. Example of possible geothermal systems

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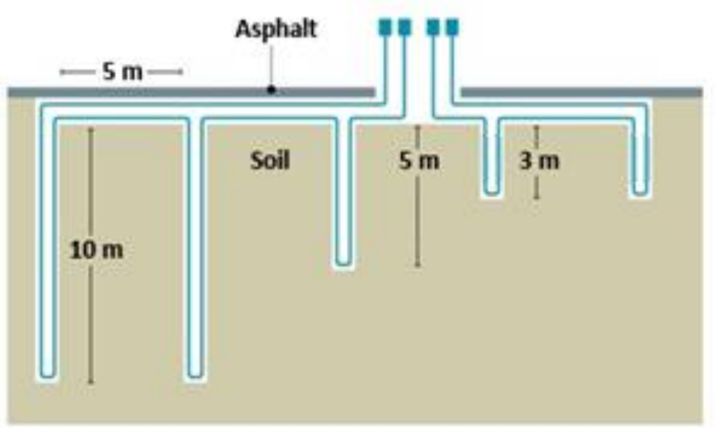
Asphalt heat

- Urban environment have often asphalted areas under which a structure with different material layers is constructed to provide stable ground.
- As asphalt has a high absorbance value, it has a good potential as a heat collector.
- It also provides a place for heat storages



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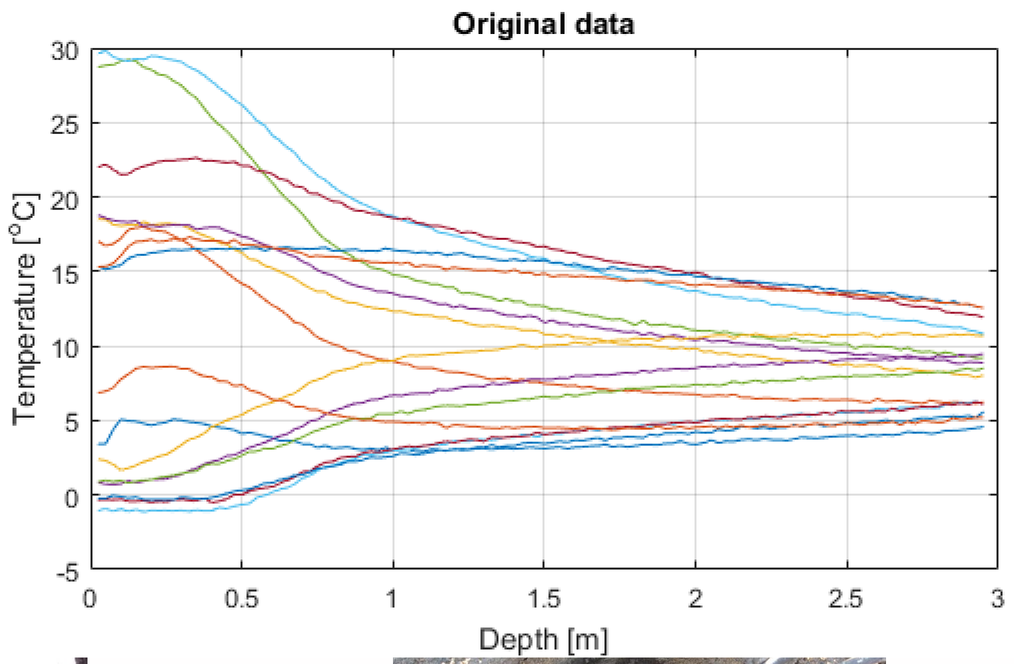
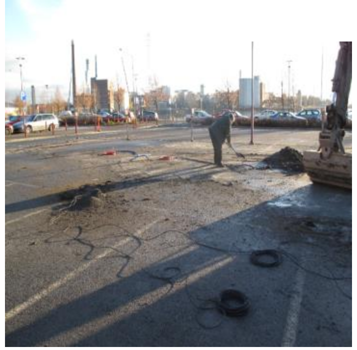
Asphalt heat

- Original temperature measurement data.
- The depth value is an approximation as the exact depth cannot be determined.





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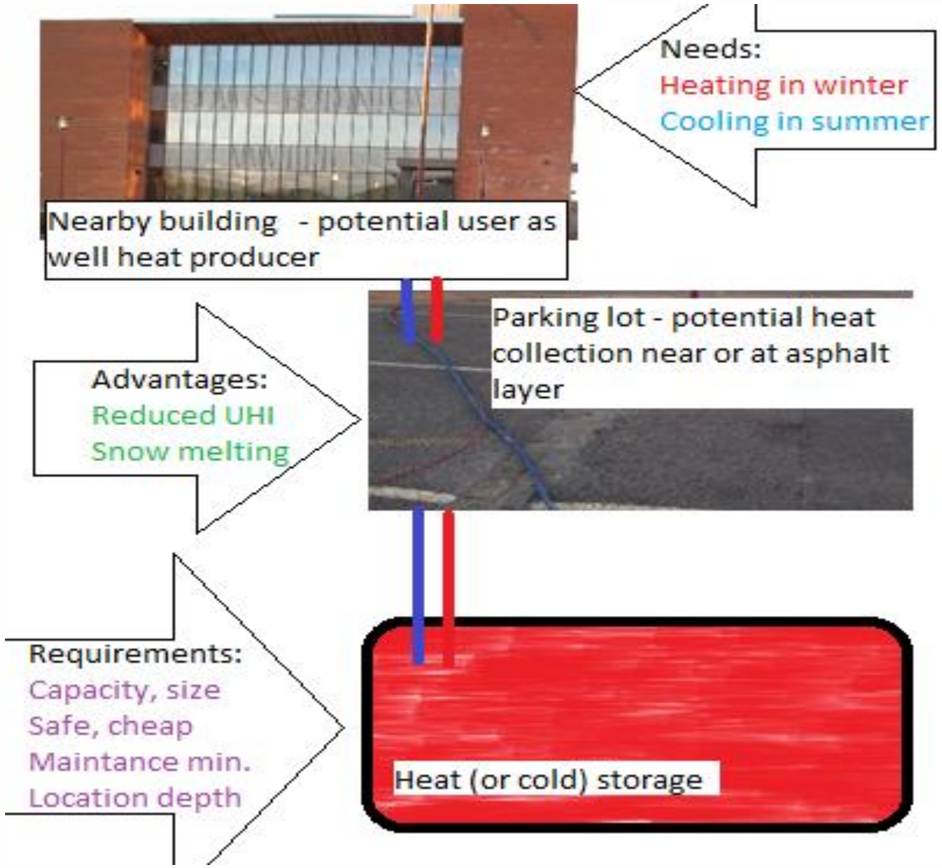
Asphalt heat



Mass for 1 m x 1 m x 1m volume unit

Name	Minimum value m³	Maximum value m³
Gravel	1201	1362
Sand (dry)	1281	1602
Sand (wet and wet packed)	1922	2082

Heat storage capacity (amount of heat) when temperature is increased by 10 ºC

Name	Minimum value kJ	Maximum value kJ
Gravel	9 488	10 760
Sand (dry)	20 496	25 632
Sand (wet and wet packed)	26 524	28 732

Heat storage capacity (amount of heat) when temperature is increased by 20 ºC

Name	Minimum value kJ	Maximum value kJ
Gravel	18 976	21 520
Sand (dry)	40 992	51 264
Sand (wet and wet packed)	53 047	57 463

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Cold/cool storages

- Cooling needs are increasing, e.g. due to:
  - Heat waves
  - Increasing temperatures
- Users
  - Residual buildings
  - Public buildings
  - Commercial buildings

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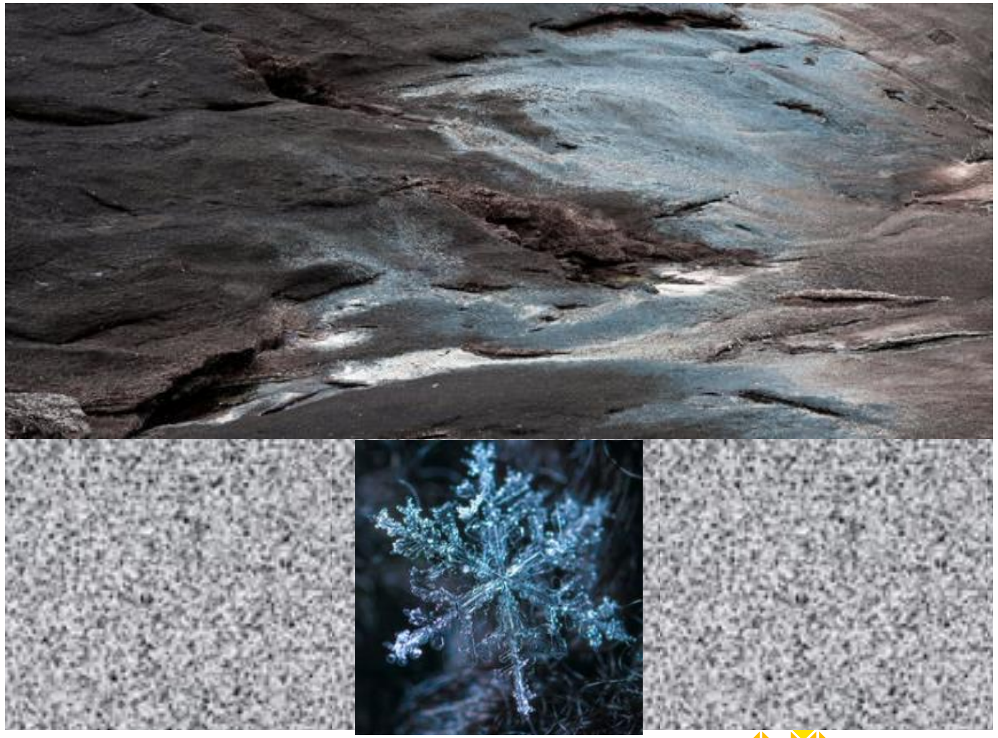
Cold/cool storages

- Cool or cold storage using bedrock or boreholes
  - Seasonal
  - Renewable cold or cool
- Source of cold / cool
  - Natural conditions (e.g. winter in Finland)
  - Produced via excess renewable electricty
  - Goal is to reduce fossil fuel usage for cooling



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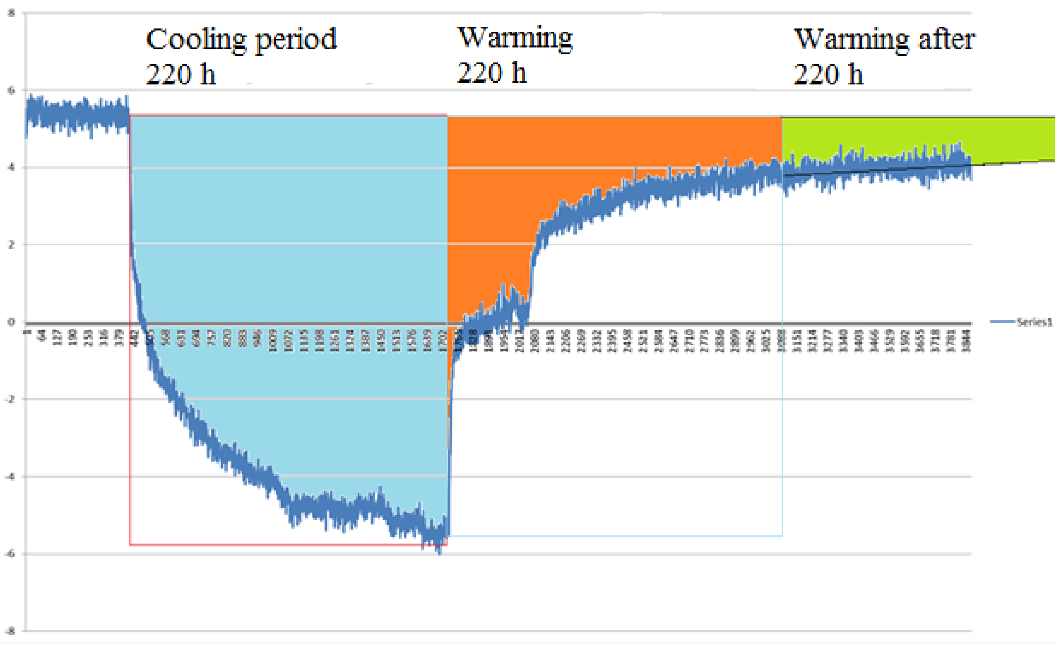
Cold/cool storages

- Dry borehole
  - Located in Laajametsä industrial area in Vaasa, Finland
  - The City of Vaasa has drilled a 200 m deep well

Results:
The blue part
    Energy transferred to the borehole (2.07 MWh).
The orange part
    Warming during the first 220 h period. The energy in this period is around 690 kWh or approximately 1/3 of the loaded.
The green part
    Some cool to be used later



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Concrete crush storage

- Demolishing of concrete buildings and crushing the demolished parts produce a lot of concrete crush
  - Need to be recycled
- Some storages uses natural storages or new materials for constructing a storage
  - Natural storages might not be available
  - Material cost of storages should be low
  - Concrete has been used in storages
  - New materials uses natural resources
    - RECYCLED AND REUSED MATERIALS PREFERABLE

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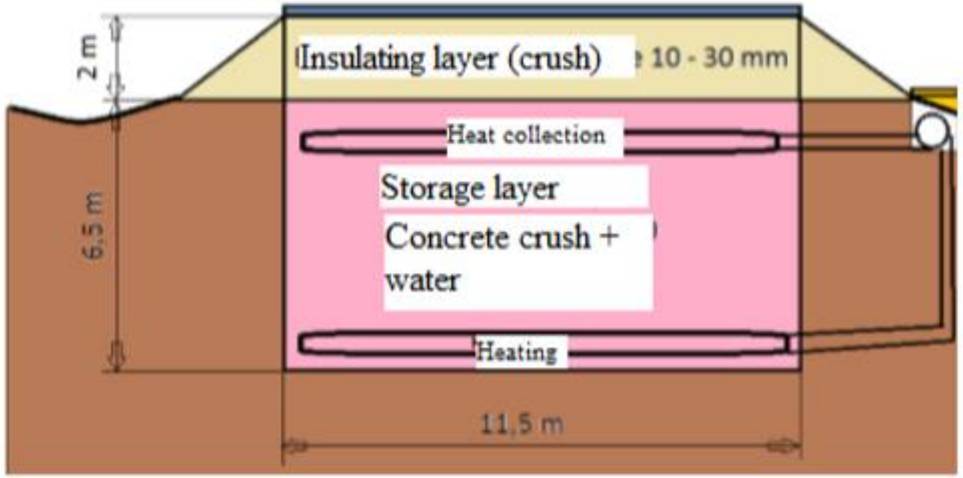
Concrete crush storage

- Heat current – an important parameter
  - It describes how material behaves as temperature changes in its environment
  - It determines capability of a material to insulate or conduct heat



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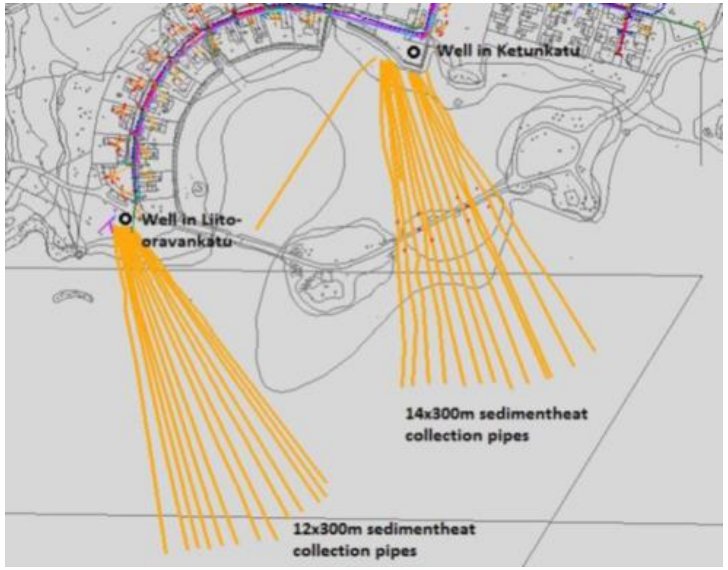
Natural heat storage/source under water body – Suvilahti case

- A renewable energy source called sediment energy
  - based on heat collection with tubes like those used in ground energy
  - installed inside a sediment layer under water body.



Source: Vaasan Eko-lämpö Oy

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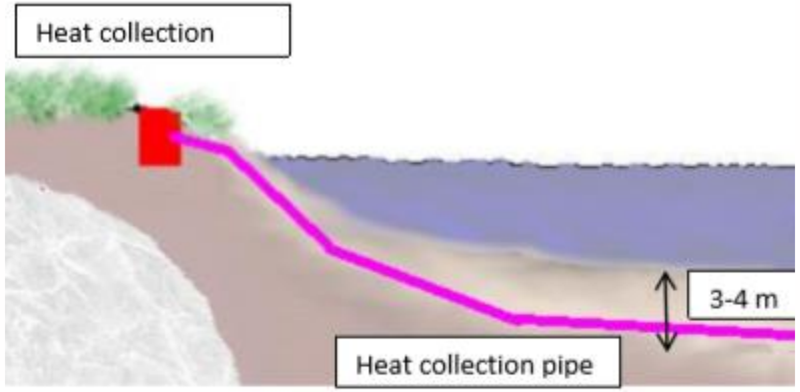
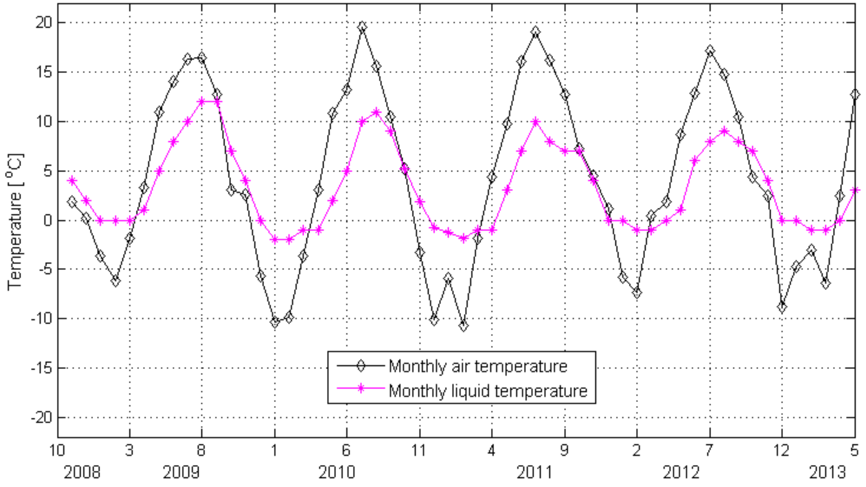
Natural heat storage/source under water body – Suvilahti case

- Renewable every year
  - It is stable
- It can be used for cooling
- This might be expentendable to certain t of sediment on the land





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Potential of old mines

- A lot of mines has been abandoned after the use
- Their geothermal potential is still available heating and cooling
- Case example: Korsnäs lead mine
  - Operating period: 1958–1972

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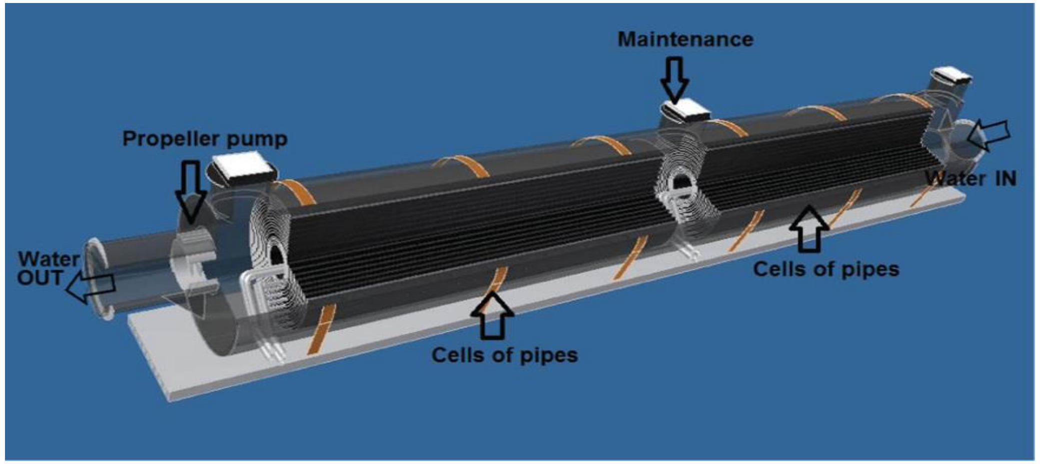
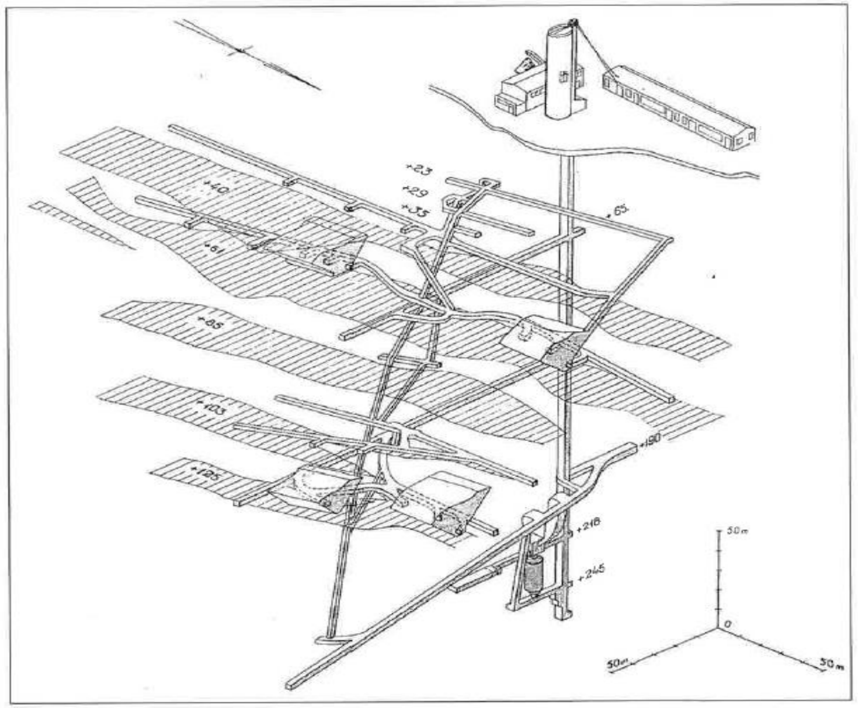
Potential of old mines

- Possible to extract e.g. with water heat exchanger



- Mega Heat Exchanger eli WHCEP - Water Heat and Cooling Energy Plant (Mr. Mauri Lieskoski, Geopipe)



- Image from book Sven Nystén m fl: Korsnäs gruvhistoria (2008, Vaasa)

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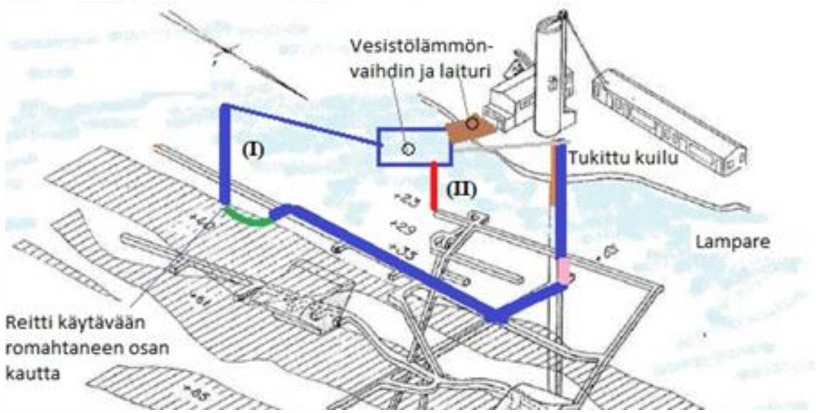
Potential of old mines

- Energy needed for heating: 310 MWh annually or 0.85 MWh daily (1.1 TJ)
- Different utilization schemes were created:
- Routes inside the main (I. 10 GJ / 2.8 MWh, II. 4,2 GJ /1.2 MWh, all galleries 0.1 TJ / 27.8 MWh).



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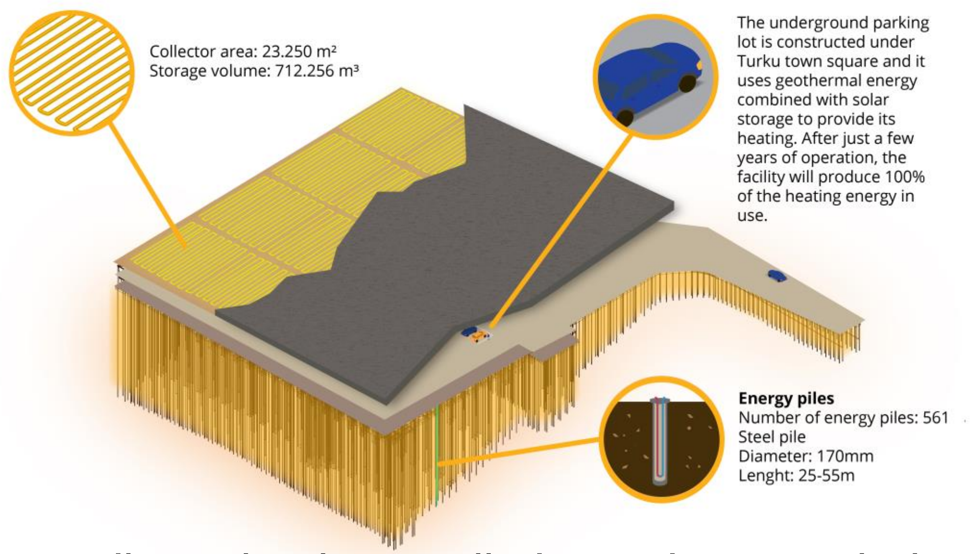
Other -Underground parking lot at Turku market square

- PhD student Rauli Lautkankare / Turku University of Applied Sciences
- Parking lot constructed in clay
- Seasonal storage of solar energy



Rauli Lautkankare, Nikolas Salomaa, Birgitta Martinkauppi and Anna Slobodenyuk, **Underground parking lot at Turku market square - Zero energy parking hall and the biggest solar energy storage in the world**

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Other – deep boreholes

- When higher temperatures are need, then deep boreholes can used
  - Not many available yet
  - Earthquakes
  - It can be combined with heat storages
  - More expensive

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4. Geothermal system evaluation

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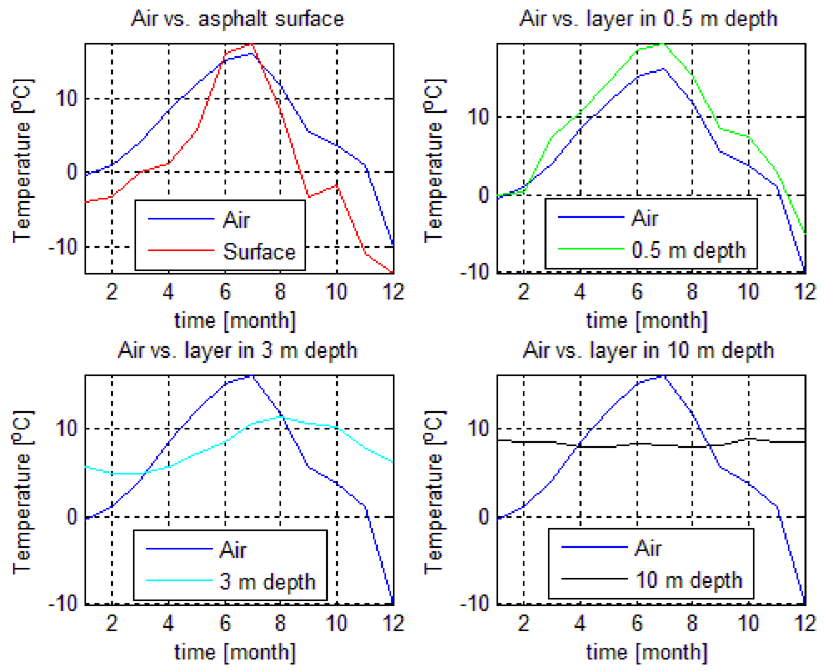
Analysis methods

- Machine learning and statistical methods are suitable
- Potential targets
  - **Behaviour of the system**
  - **Economical potential**
  - **Prediction of production**
  - **Sizing**
  - **System optimization**
  - **Thermal parameters**
  - **and so on**



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Sector coupling

- Combining electric grid and geothermal energy
- Heat exchanger / heat pump can be understand as an interface between these two
- Methods need to be developed
- **Main goals: to reduce costs and green house gases**

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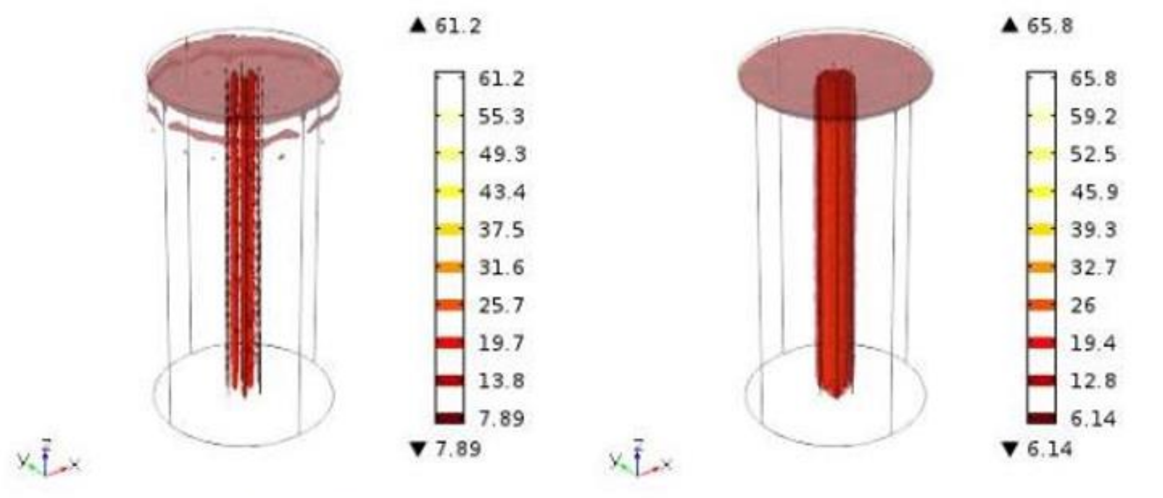
Simulations

- A borehole heat exchanger can be analyzed using Line source method and 3D modeling with Comsol.
  - to store industrial waste heat energy and later use borehole heat exchangers to provide heat for a building.
  - The planned ground heat storage consists a total of nine boreholes.



Temperature distribution in first month *Temperature distribution in twelve month*

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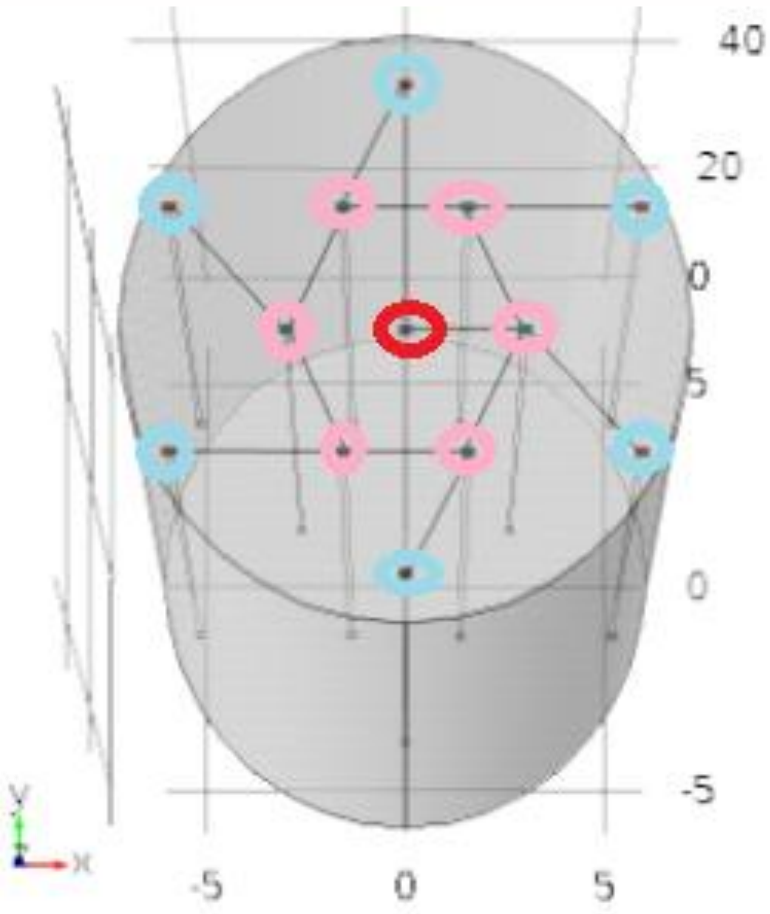
Simulations

- Borehole system in Kokkola
  - 13 boreholes
  - Centre borehole: heat injection, 5o m deep
  - The first ring: 6 boreholes, 40 m deep
  - The second ring: 6 boreholes, 40 m deep



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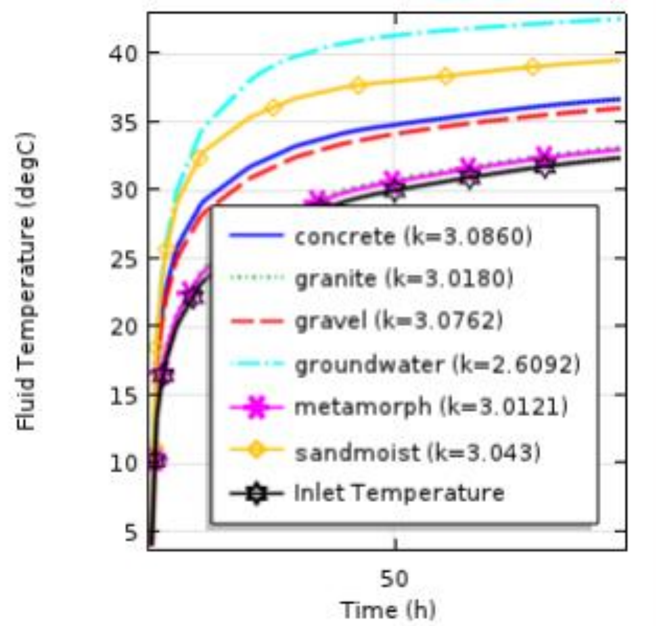
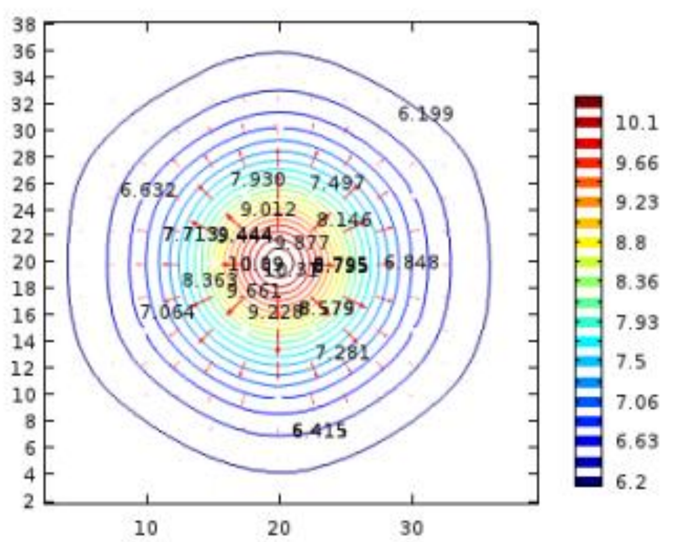
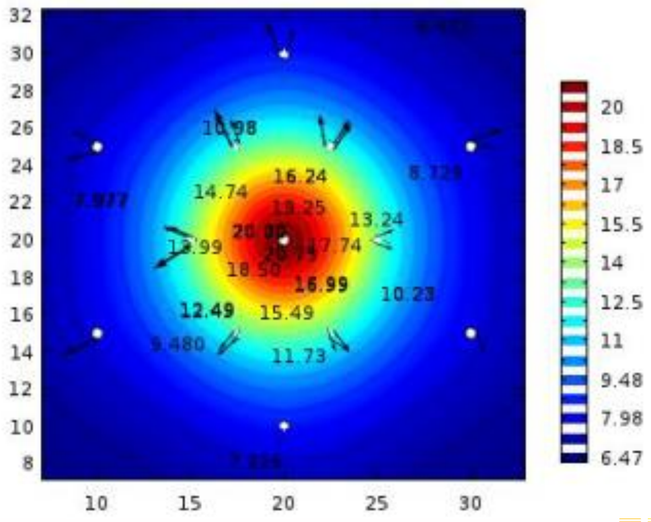
Simulations

- The grouting material has a clear effect on the performance







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5. Conclusions

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Conclusions

- Geothermal energy has a huge potential and is currently a hot topic
  - An important part can be a seasonal heat/cool storage
  - Sector coupling
- A wide variety of possible implementations is possible
- Different analysis and simulations need to be done
- Economical issues are important factors

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THANK YOU!

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