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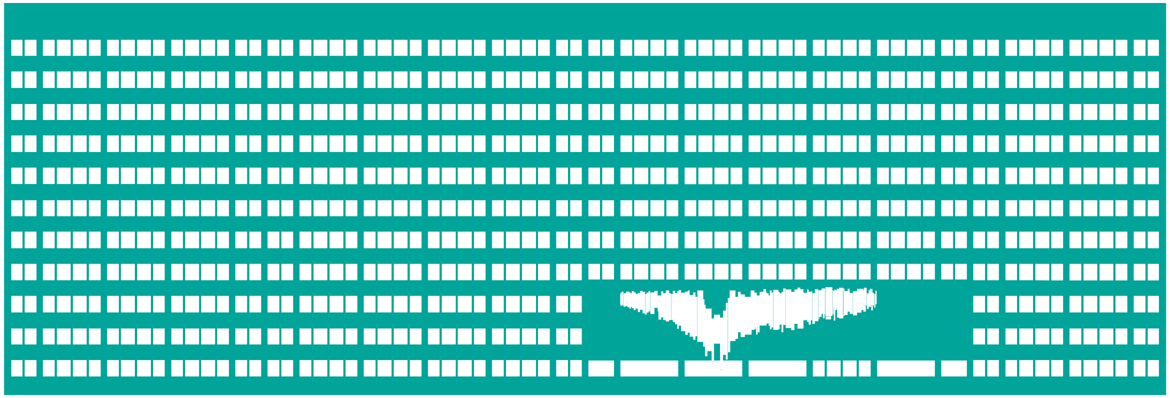

www.vsb.cz

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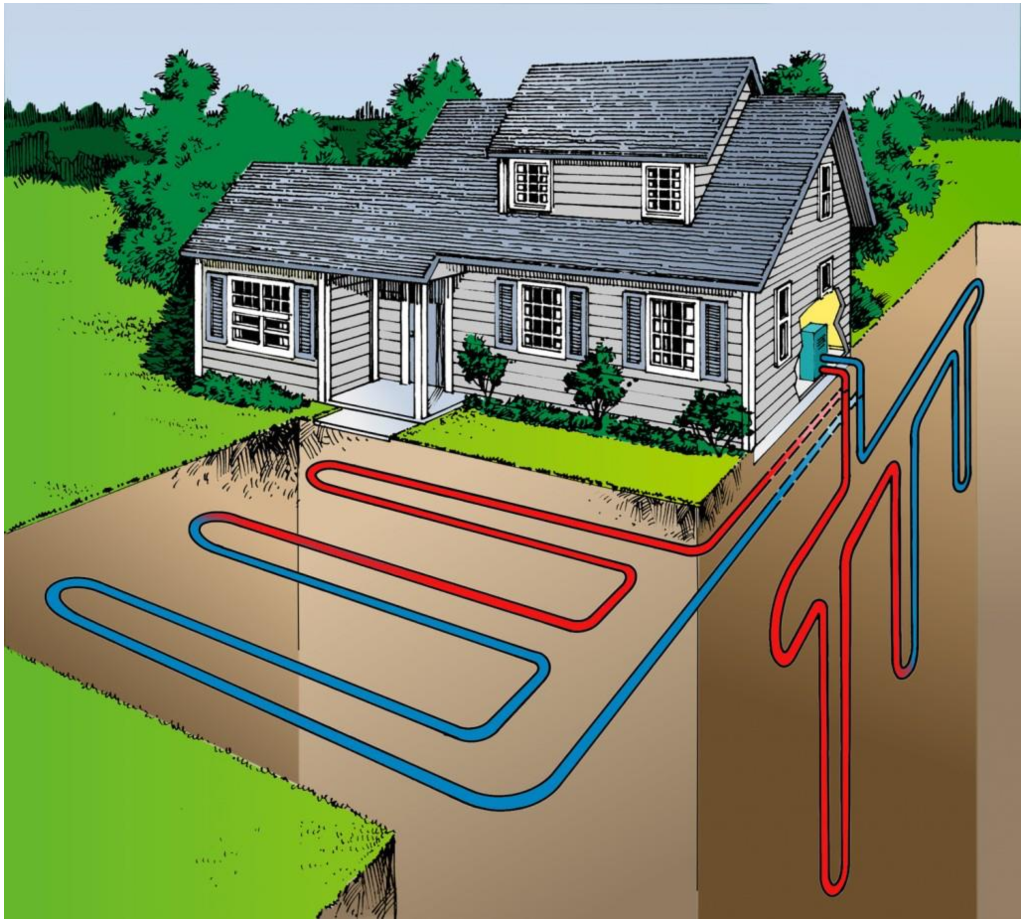
Geothermal Energy



Geothermalinnovation.org

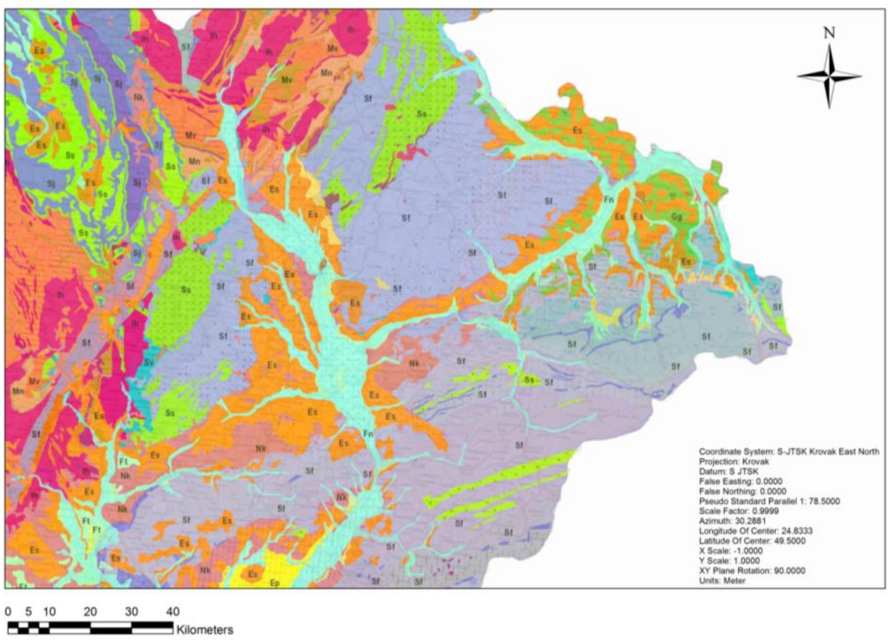
Research in geothermal energy exploitation

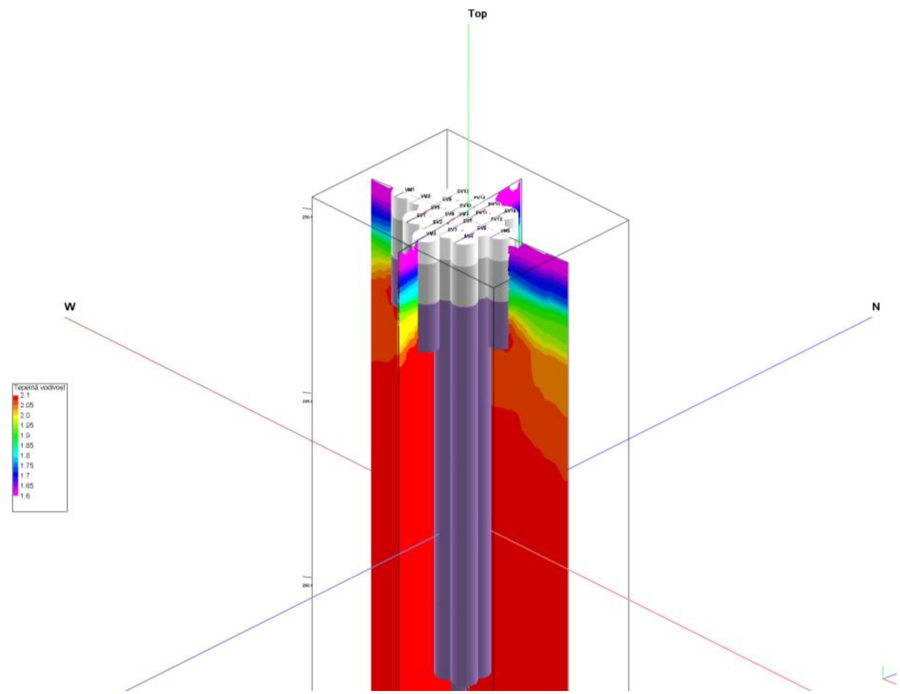
1. **Classification of rock environment for exploitation and storage of heat energy by Borehole Heat Energy Exchangers (BHE) and another geostructures**

2. **Improvement of technology of BHE installation in specific rock environment described by reliable characteristics necessary for design and construction**
   a) **in situ measurement and testing**
   b) **laboratory testing**
   c) **numerical simulation of heat transfer**

3. **Preparation of comprehensive methodology for decision-support making process of investors**

Classification of rock environment





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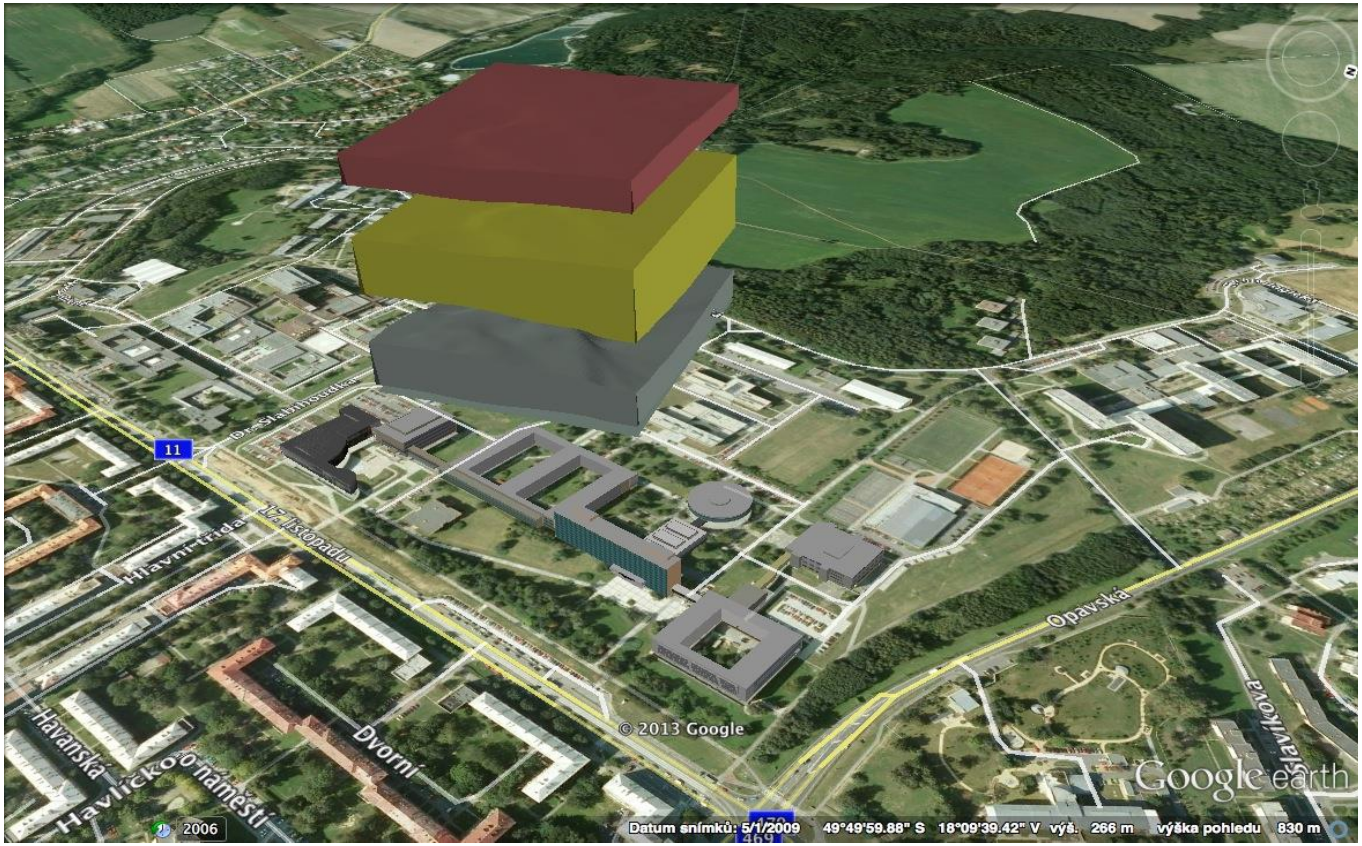
Creation of comprehensive rock environment model



3D model of the rock environment of VSB - TUO

a) Quaternary
b) Tertiary
c) Lower Carboniferous

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In situ measurement and testing

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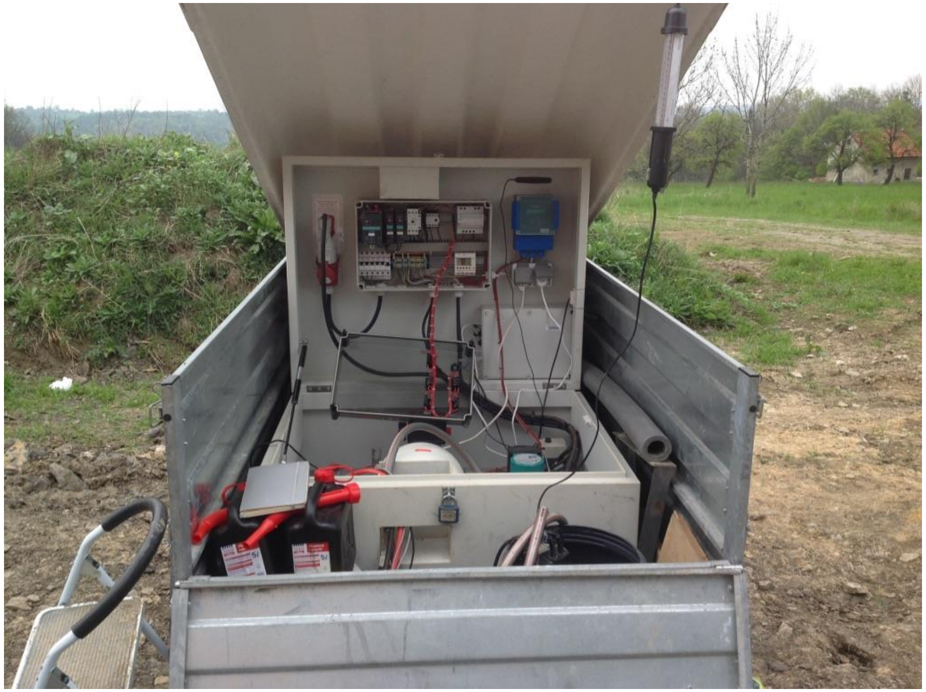
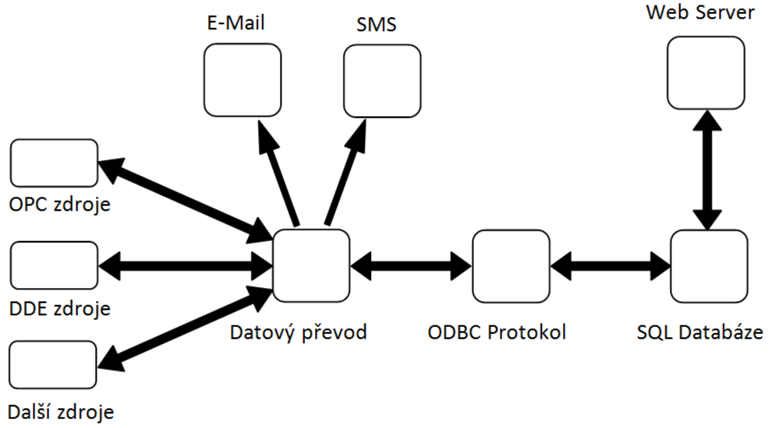
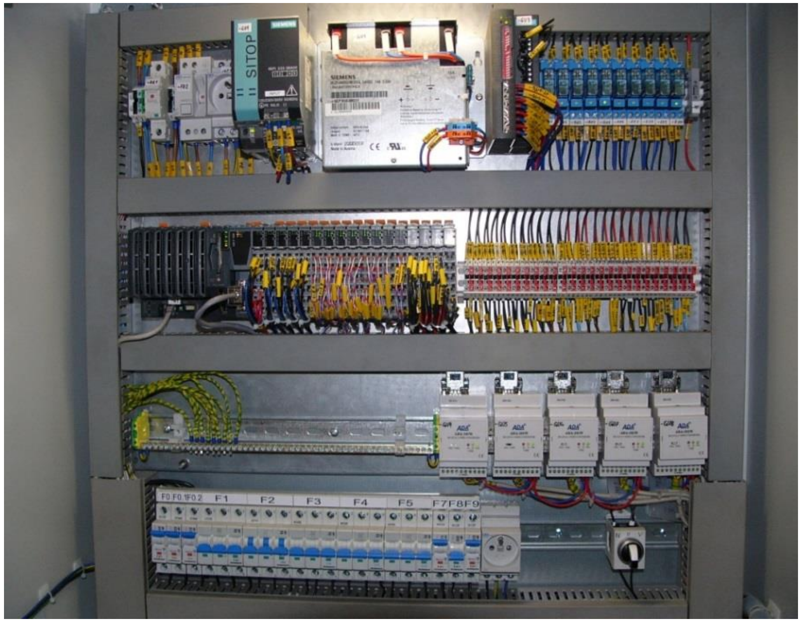
Thermal response test



Measurement and quantitative analysis of rock environment heat parameters „in situ“



Scheme of data transfer from BHE to database, web server)



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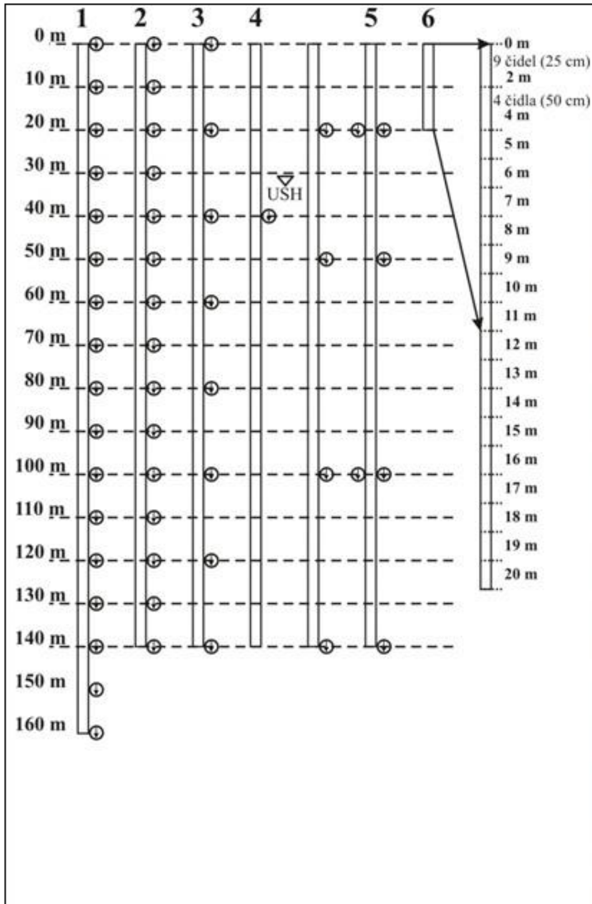
Monitoring of boreholes - temperature

Shallow monitoring borehole (No.: 6)



Geological profile of a shallow monitoring borehole MMMV1

0.0 to 0.3 – clay
0.3 – 1.0 – dark grey sandy clay
1.0 – 2.0 – dark brown, slightly sandy dry clay
2.0 – 3.0 –dark brown, slightly sandy dry clay
3.0 – 4.0 –dark brown, slightly sandy dry clay
4.0 – 5.0 –dark brown, slightly sandy plastic clay
5.0 – 6.0 – dark brown, slightly sandy clay, inserts of light grey dry clay
6.0 – 7.0 – red-brows, slightly clayey dry sand
7.0 – 8.0 – light grey clayey sand
8.0 – 9.0 - light grey clayey plastic sand
9.0 – 10.0 – light grey clayey plastic sand
10.0 – 11.0 – dark grey plastic clay
11.0 – 12.0 – dark grey plastic clay
12.0 – 13.0 – dark grey plastic clay
13.0 – 14.0 – dark grey plastic clay
14,0 - 15.0 – dark grey plastic clay
15.0 - 16.0 – dark brown clayey sand
16.0 – 17.0 – dark brown slightly clayey sand
17.0 – 18.0 – dark brown sand
18.0 – 19.0 – dark brown sand
19.0 – 20.0 – dark brown sand
20.0 – 21.0 – dark brown sand

1 – monitoring borehole with 17 temperature sensors
2 – monitoring borehole with 15 temperature sensors
3 – monitoring borehole with 8 temperature sensors
4 – hydrogeological borehole
5 – boreholes with heat pumps
6 – shallow monitoring boreholes with 30 temperature sensors

SPW – static groundwater level

Location of temperature sensors in monitoring boreholes (Pt 1000)

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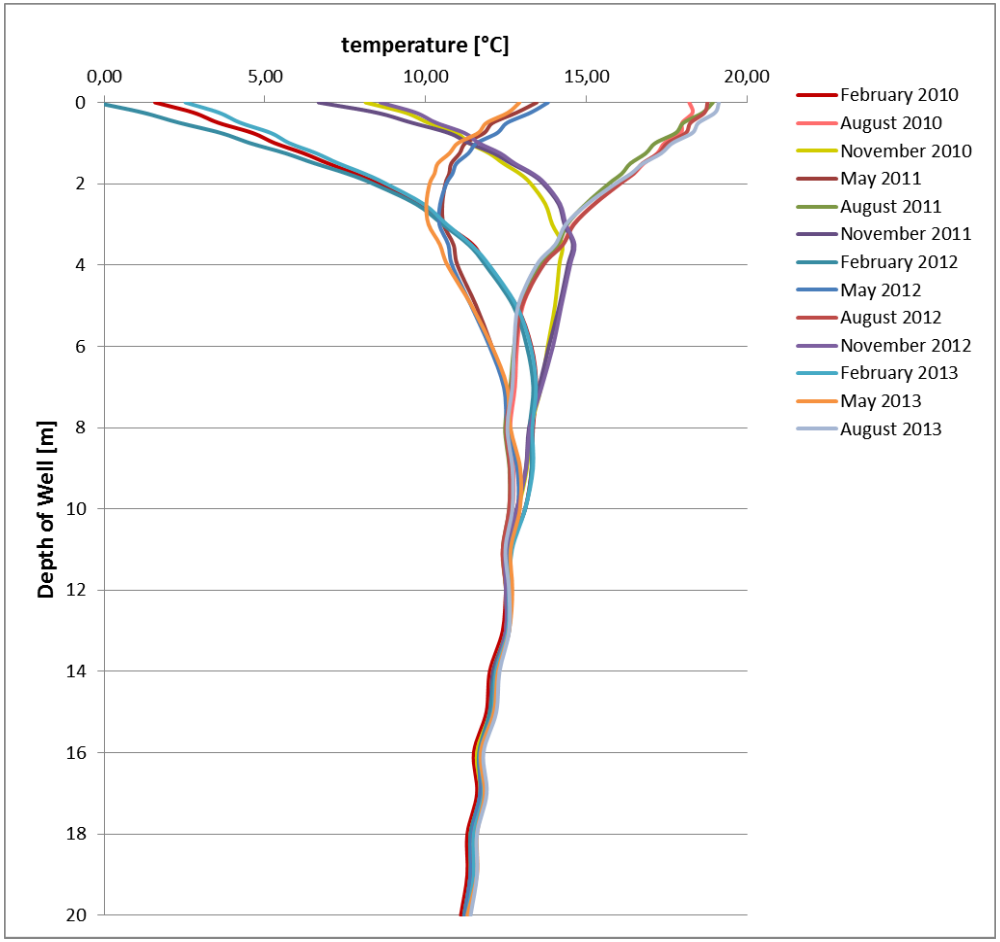
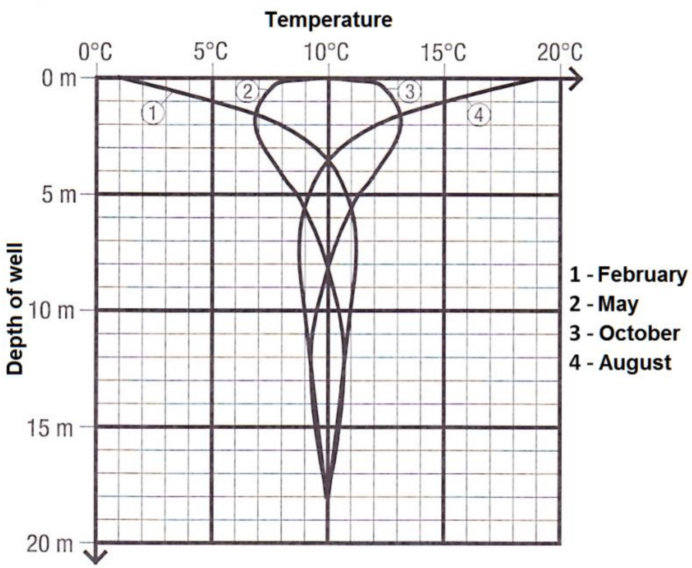
Determination of seasonal temperature variation



Literature data



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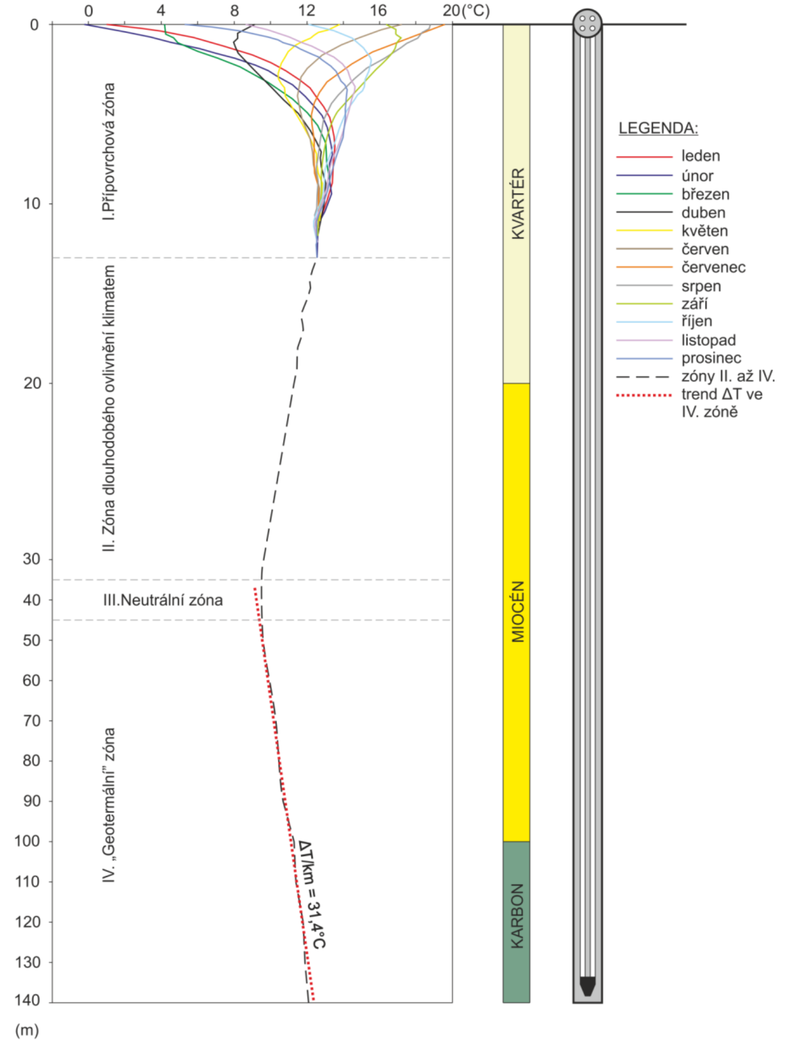
Determination of neutral temperature zone



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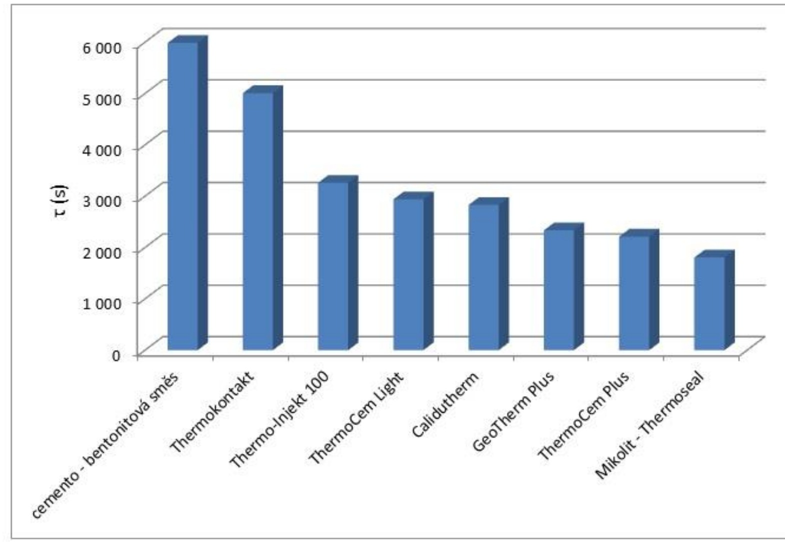
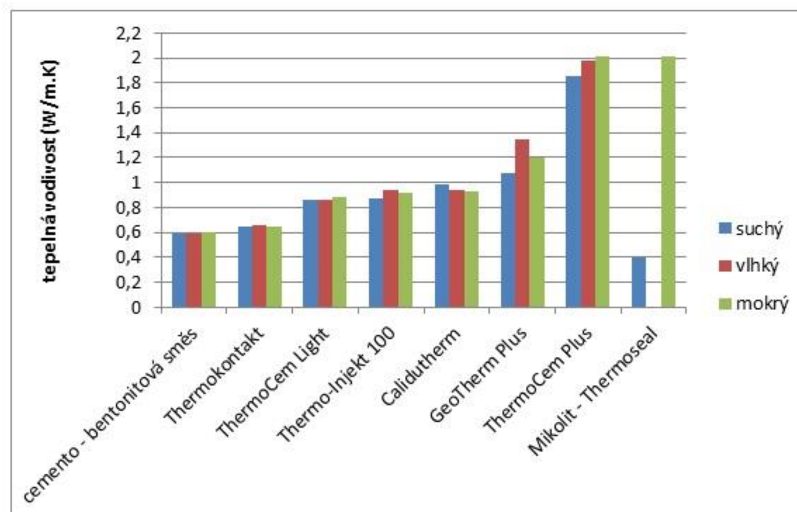
Laboratory testing of thermal conductivity of grouting mixtures

Thermo STEND S





Heat transfer simulation in rock environment for Borehole Heat Exchanger – BHE

Objectives and activities:

1. Analytical heat transport modelling – line source.
2. Methodology of heat transport modelling.
3. Calibration of mathematical model of heat transfer in the rock environment i.e. application on high temperature heat storage – BTES - GreenGas DPB, a. s.
4. Implementation of optimisation module OPTIM (Simplex method) into FEFLOW.

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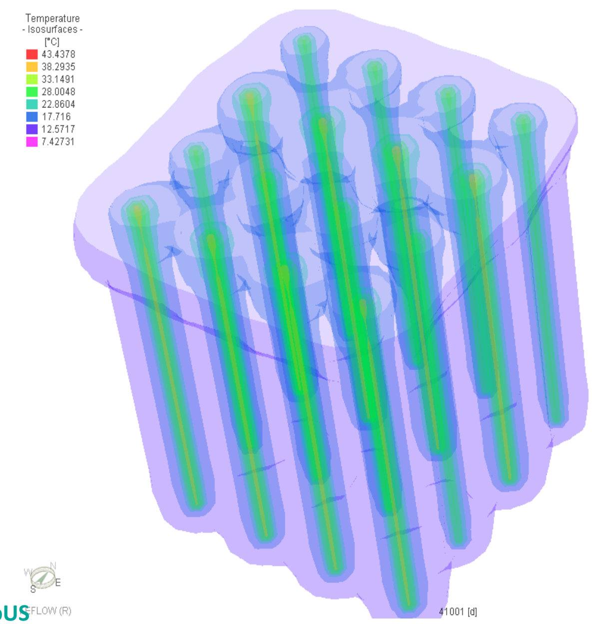
Heat transfer simulation in rock environment for Borehole Heat Exchanger – BHE

Numerical modelling of heat transfer in the rock environment:

1. Software FEFLOW – DHI WASY, Berlin (Germany).
2. FEM method – simulation of conductive and convective heat transfer.
3. Full range of boundary conditions (BCs), including BHE.



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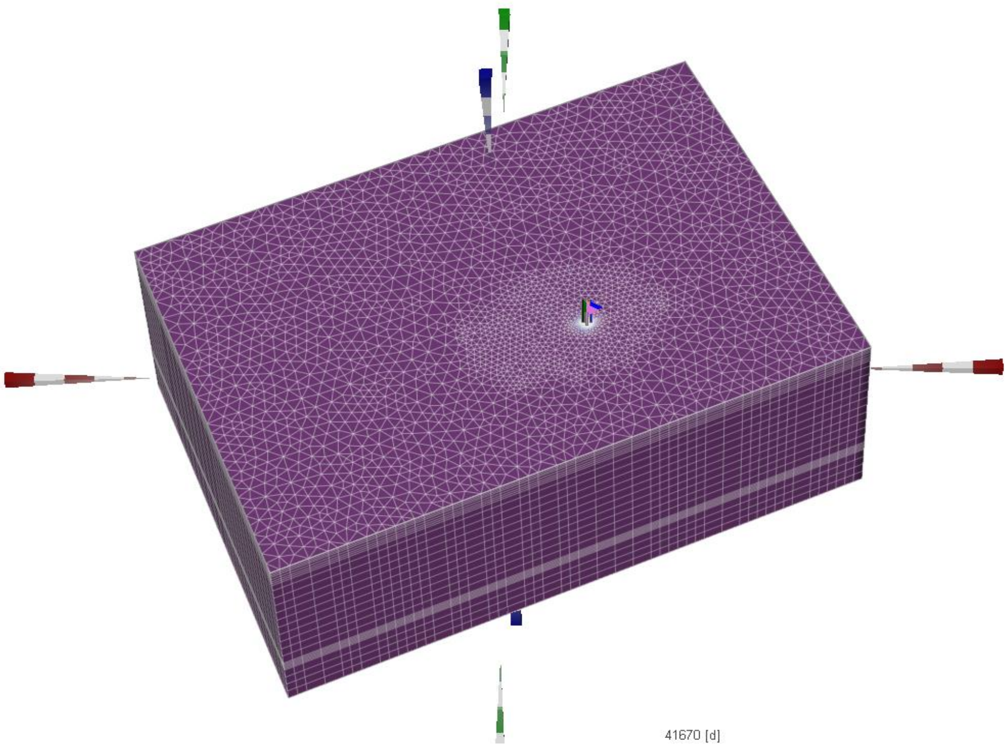
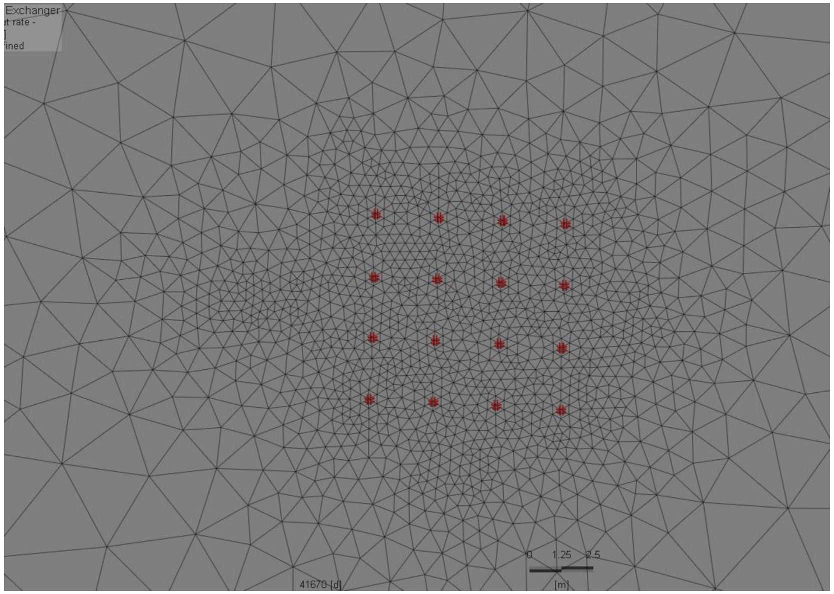
Heat transfer simulation in rock environment for Borehole Heat Exchanger – BHE

Discretization of area – 3D layered model





Discretization of area – detail topview

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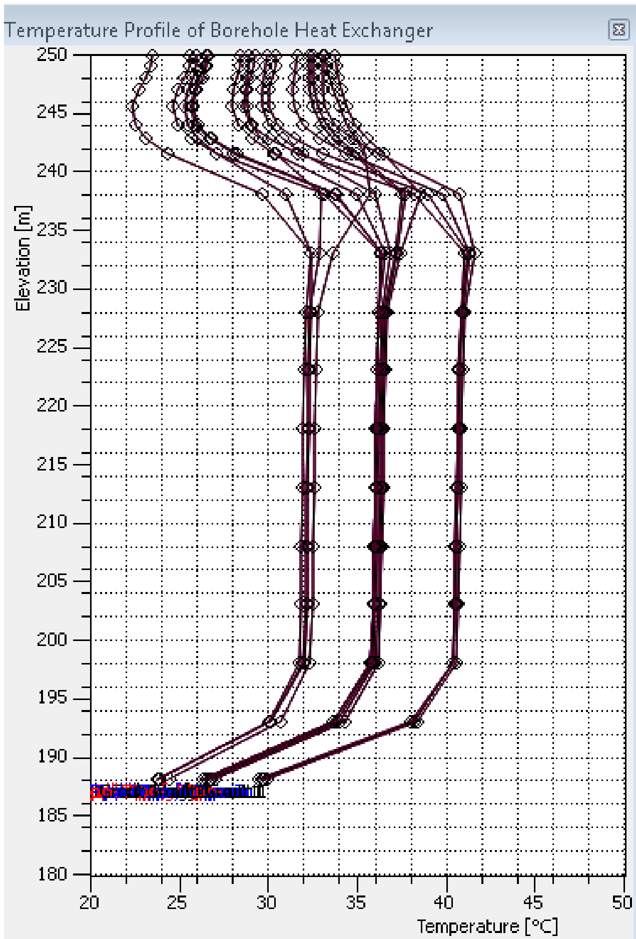
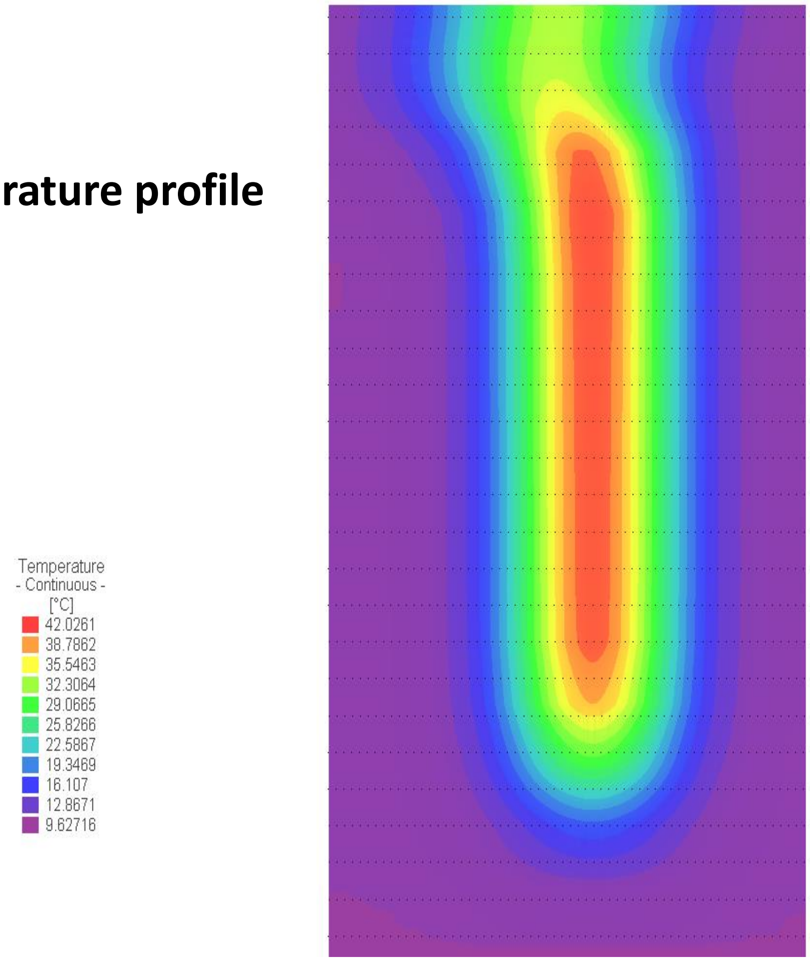
Heat transfer simulation in rock environment for Borehole Heat Exchanger – BHE



Temperature profile



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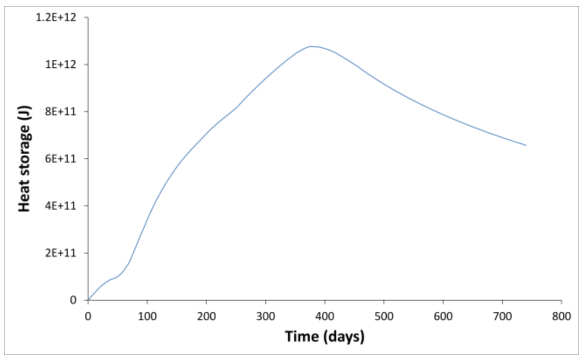
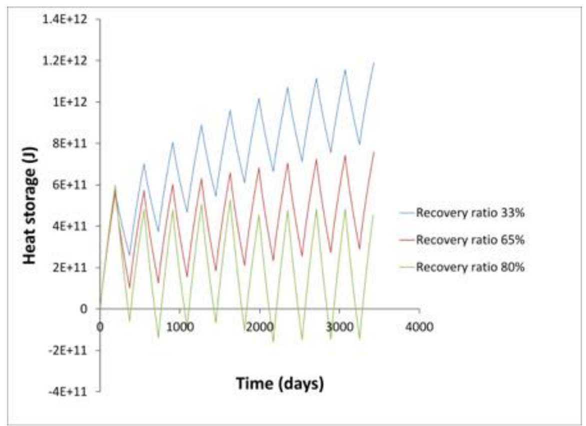
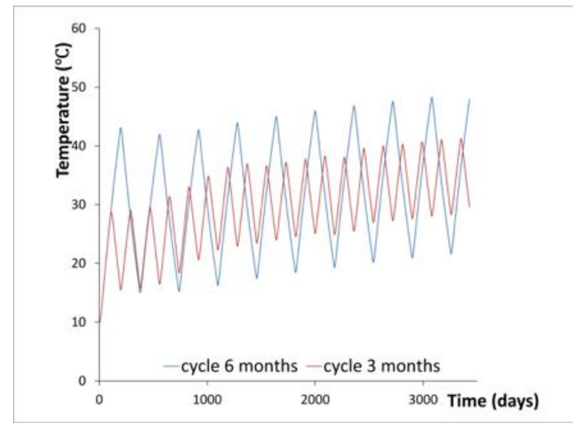
Results of optimisation

- Optimisation of length of recharging and discharging cycles,
- Estimate of heat budget stored in the rock environment which can be utilised later (calculation of lost – dissipation in the rock environment).







Heat budget stored in the rock

Recovery ratio – 33, 65 a 80%

Simulation of recharging cycles

Recovery ratio 65%
80% overexploitation
33% long-term temperature rise

„Seasonal Underground Storage – BTES“

Pilot installation - Green Gas DPB, a.s.

High temperature

- 95 °C

Total borehole depth 1.100 m

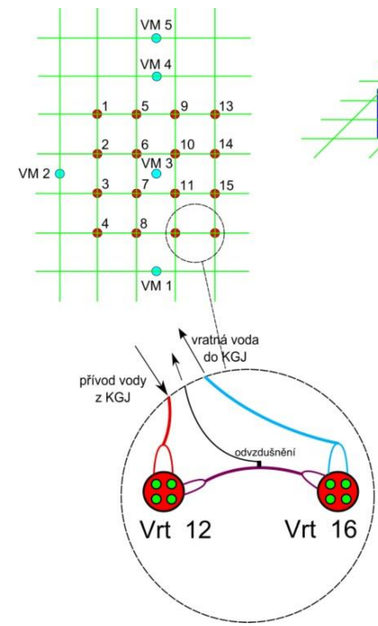
- Energy boreholes 16 x 60 m
- Monitoring boreholes 80 m, 15 m

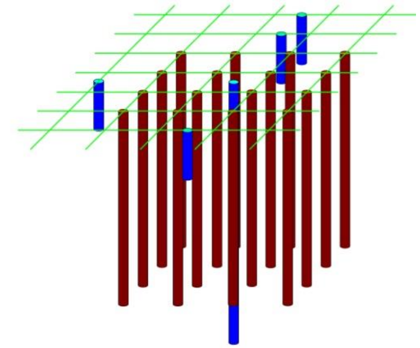
Temperature monitoring

- Fluid
- Rock massif

Monitoring of charging and re-charging heat

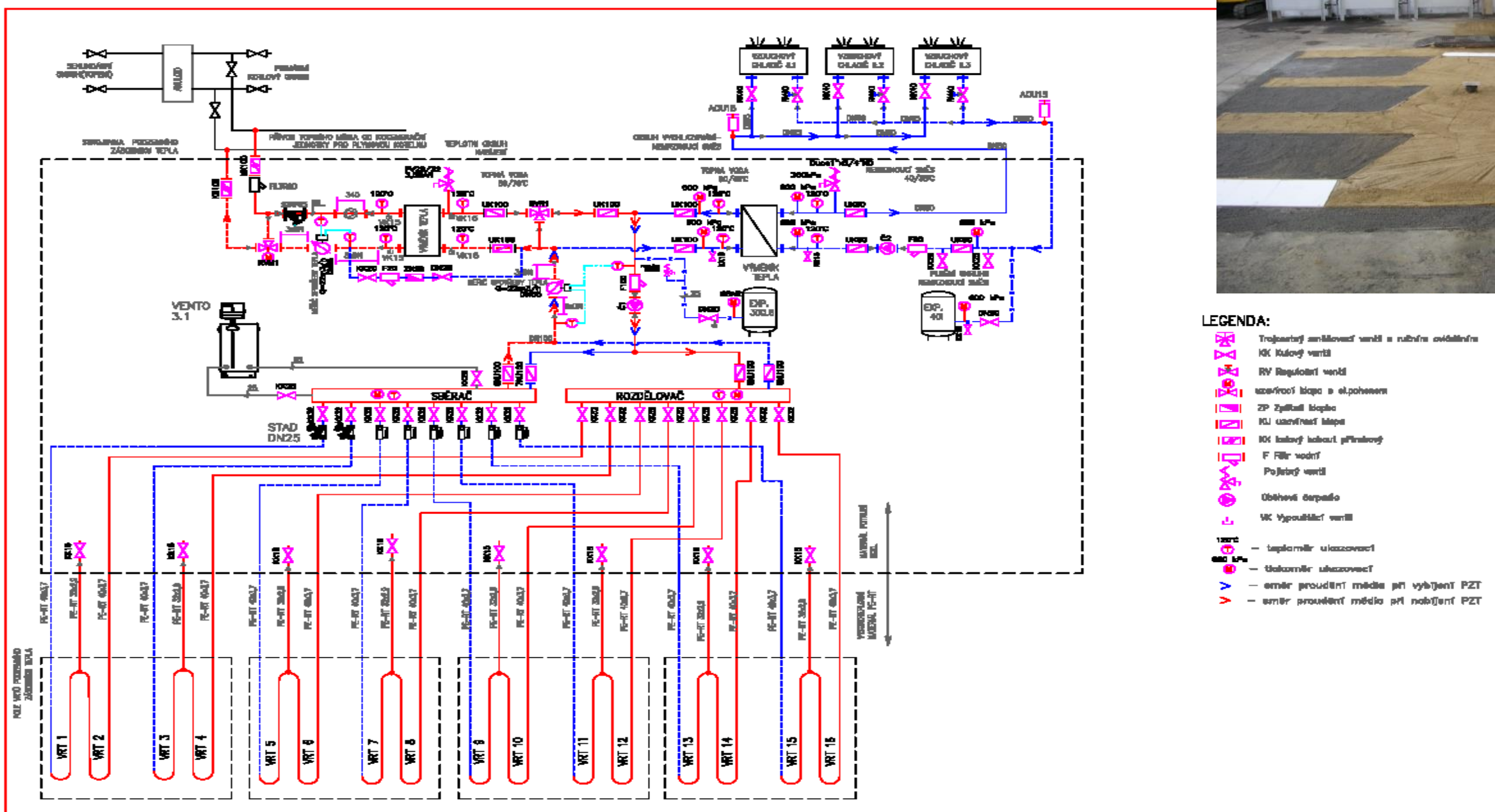
Compatibility with installation at VSB





„Seasonal Underground Storage – BTES“

Scheme of installation Green Gas DPB, a.s.



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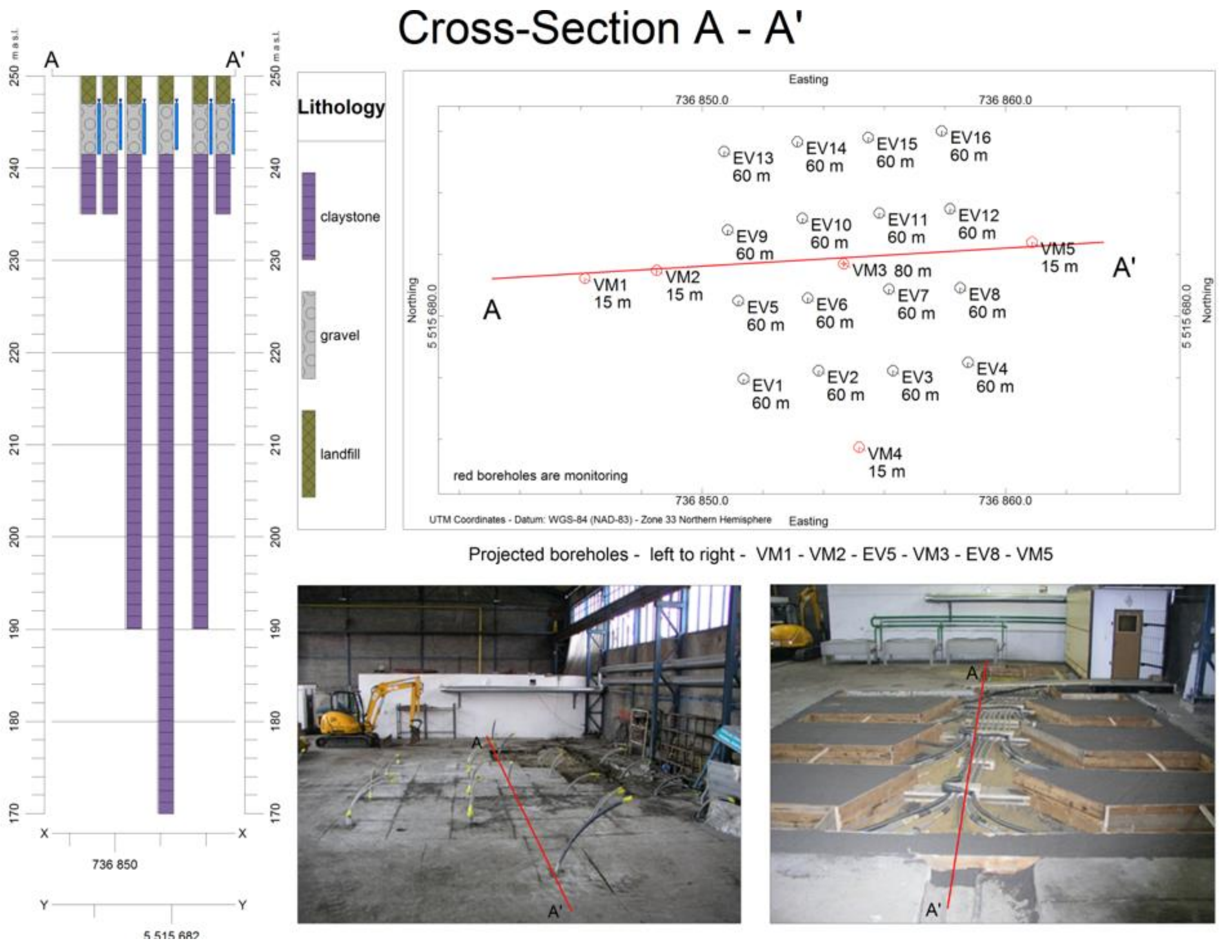
Drilling of BHE for seasonal BTES

BHE installation



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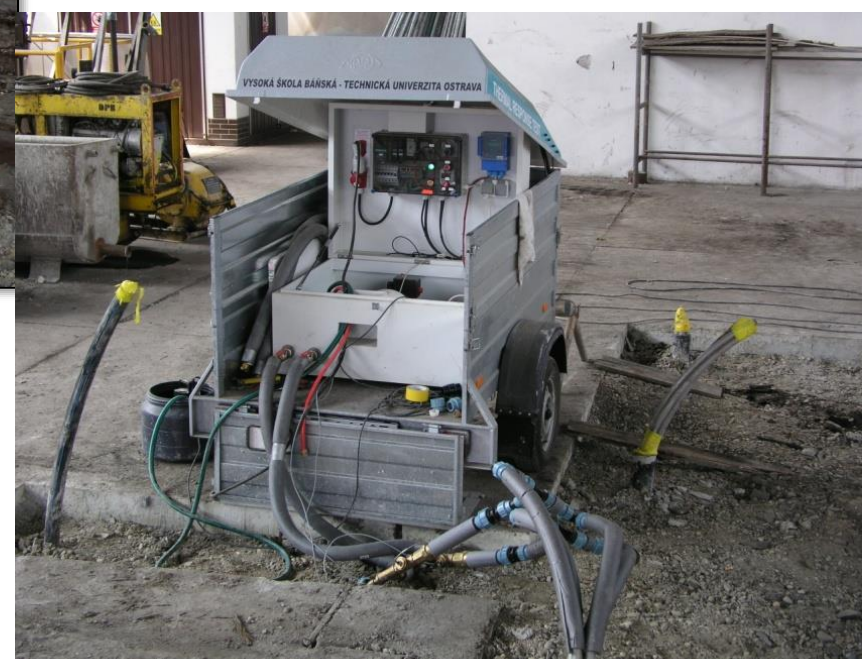
Testing of rock environment – Thermal Response Tests at GreenGas, a.s.



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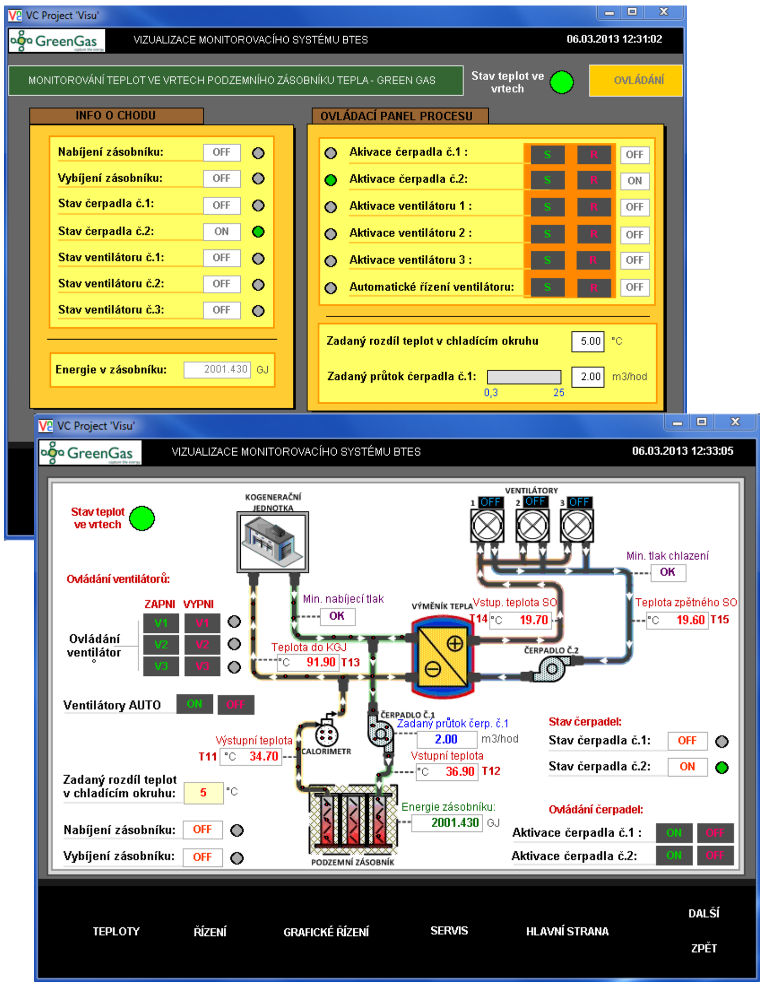
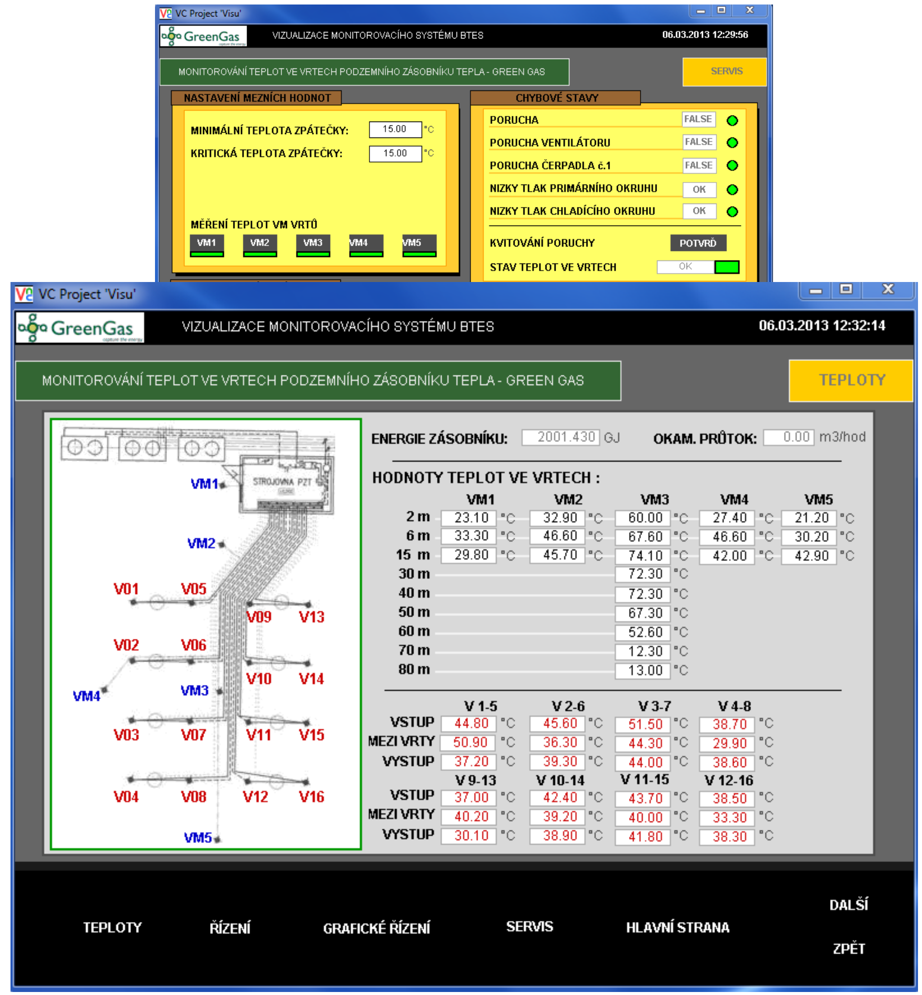
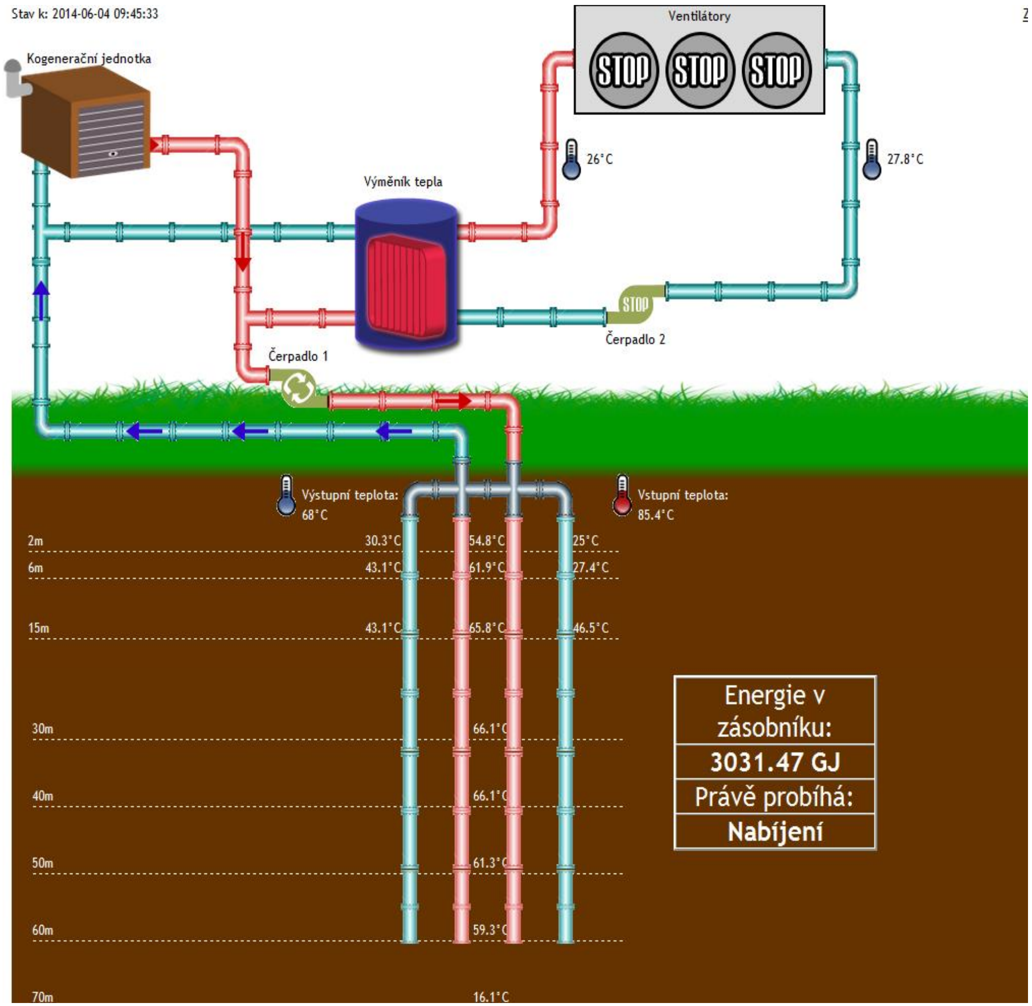
„Seasonal Underground Storage – BTES“ – Control system





„Seasonal Underground Storage – BTES“

Vizualization of heat flow



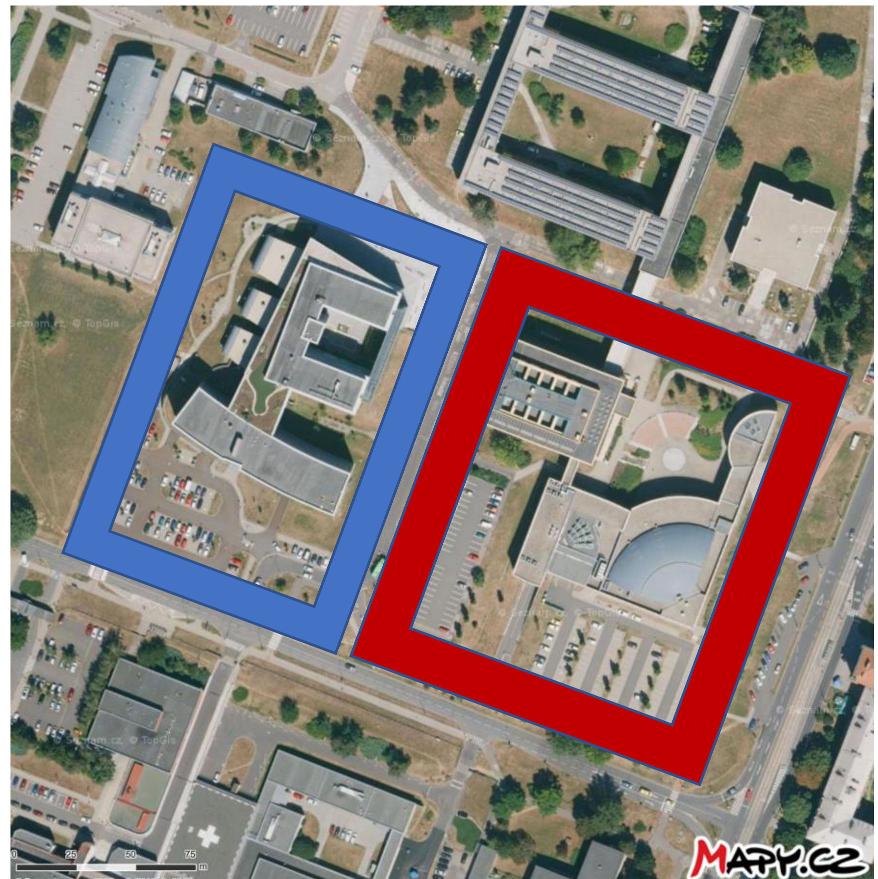
Geothermal heating system at VSB-TUO

Conference hall

Faculty of Electrical Engineering and Informatics

2x 700 kW
2x 110 boreholes 140 m deep

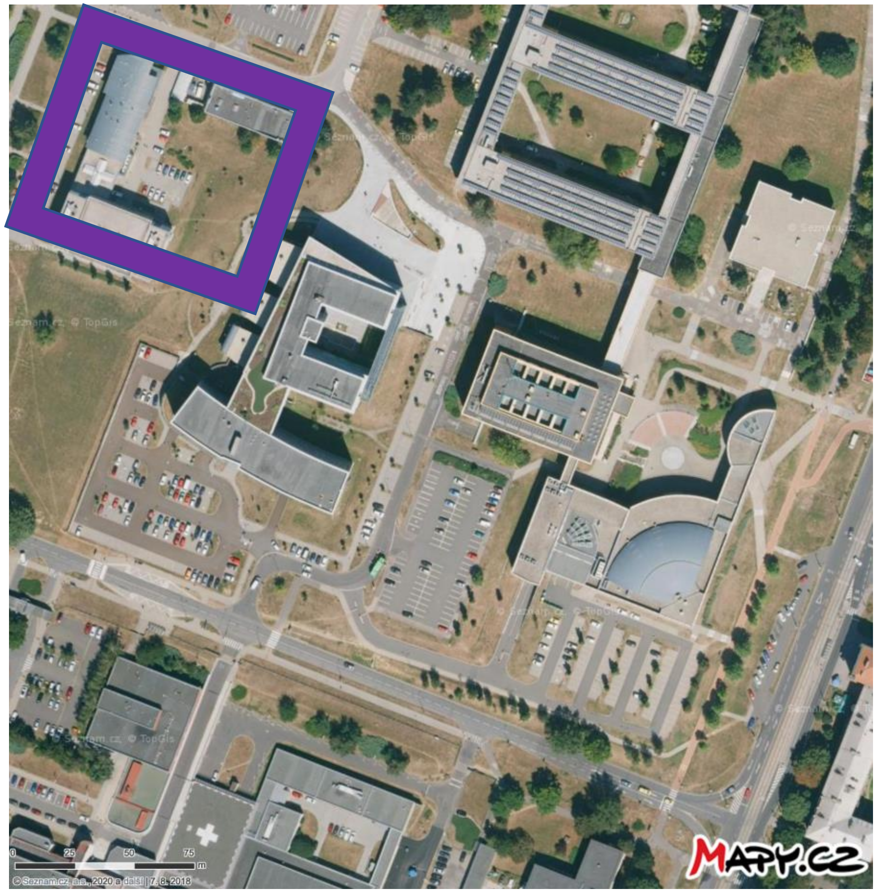
over 30 km of geothermal boreholes



Geothermal research system at VSB-TUO

Research polygon

Testing and monitoring boreholes with the depth to 160 m



Experimental passive family house with geothermal heating

Passive house with geothermal borehole (in front)

Heat pump

Passive house

Control center

Geothermal borehole detail

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Project TAČR: Utilization of the Earth’s Crust Heat Energy as Renewable Energy Source Including Verification of Possibility of Heat Energy Accumulation

Project No.:

TA01020932

01/2011 - 12/2014

VSB – Technical University of Ostrava

17. listopadu 15, 708 33 Ostrava - Poruba

Partners:

Green Gas DPB, a.s.

DHI a.s.

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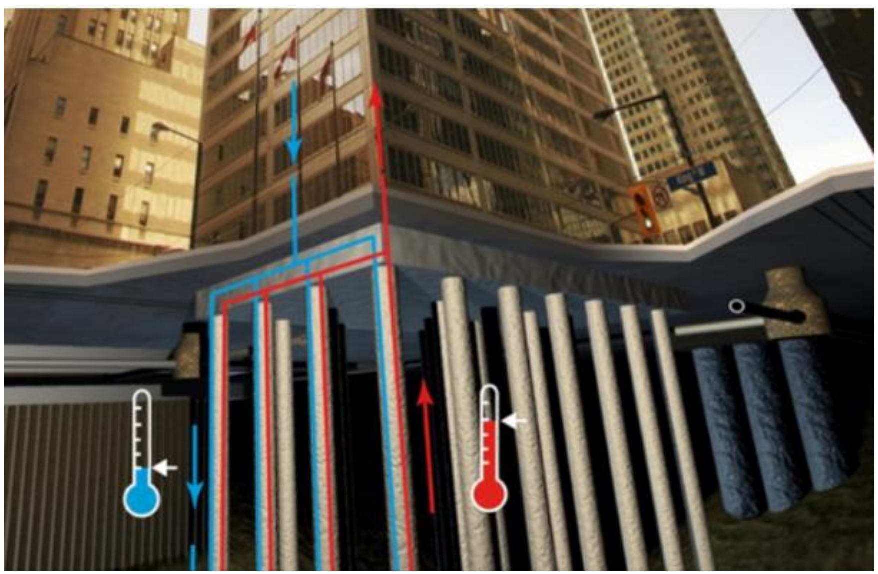
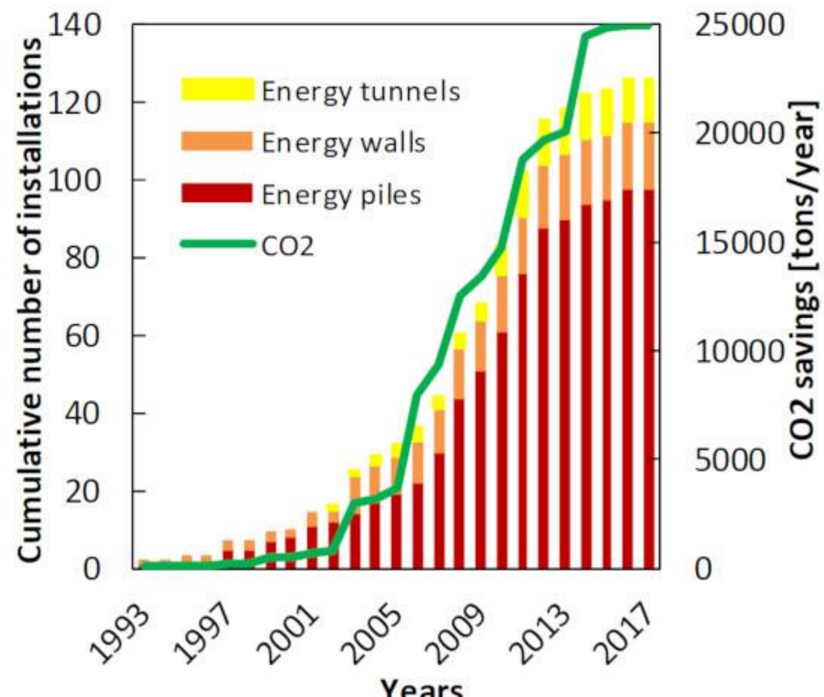
Energy geostructures

Foundation slab , piles for deep foundations, retaining walls, tunnel lining segments, paved areas (parking etc.)





Laloui, L., and Di Donna, A. 2013. Energy geostructures: innovation in underground engineering. ISTE Ltd and John Wiley & sons Inc. [Source: © EPFL-LMS /M. NUTH 2010]

Energy geostructures

Crucial challenges:

- increasing knowledge of the coupled thermal- mechanical behaviour of the soil
- increasing knowledge of the coupled thermal- mechanical behaviour of the building material (concrete, concrete mixture) under cyclic load, reliability of material
- increasing knowledge of „rock environment- energy geostructure“ interaction under cyclic load
- optimization of coupled thermo-mechanical and hydro-thermal performance of structures regarding the material and geometrical characteristics of structures and pipe loop system inside them
- the interaction of energy structure group

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Thank you for your attention

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