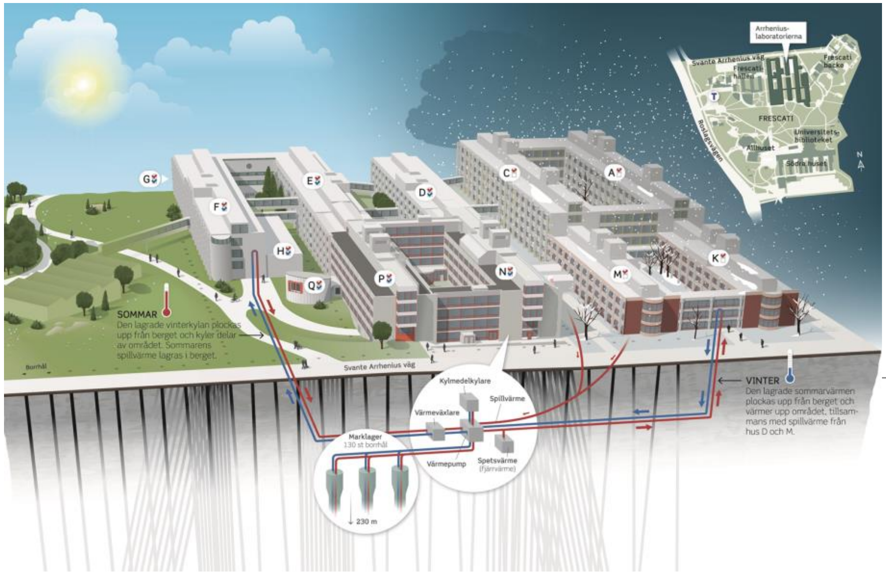
Technical Introduction to Akademiska Hus BTES at Stockholm

2016 GSHP Convention



Presenters:

Johan Tjernström – Akademiska Hus
Mikael Nygren – Tyréns
Åke Annsberg- Akademiska Hus
Jonas Jansson – Stures Brunnsborrningar
Dr. José Acuña – KTH
Dr. Alberto Lazzarotto – KTH
Patricia Monzó - KTH

AKADEMISKA HUS · Swedish Energy Agency · SKANSKA · TYRÉNS · STURES BRUNNSBORRNINGAR · KTH VETENSKAP OCH KONST

Outline

1. Akademiska hus vision and strategies with geoenergy systems
    - Expectations with the Frescati installation
2. Design and technical aspects of the Frescati GCHP system
3. Frescati GCHP system from operation perspective
4. Bore field drilling and installation of fiber cables
5. Borehole measurement project
    - First measurements

Akademiska hus vision and strategies with geoenergy Frescati installation

JOHAN TJERNSTRÖM

This is Akademiska Hus

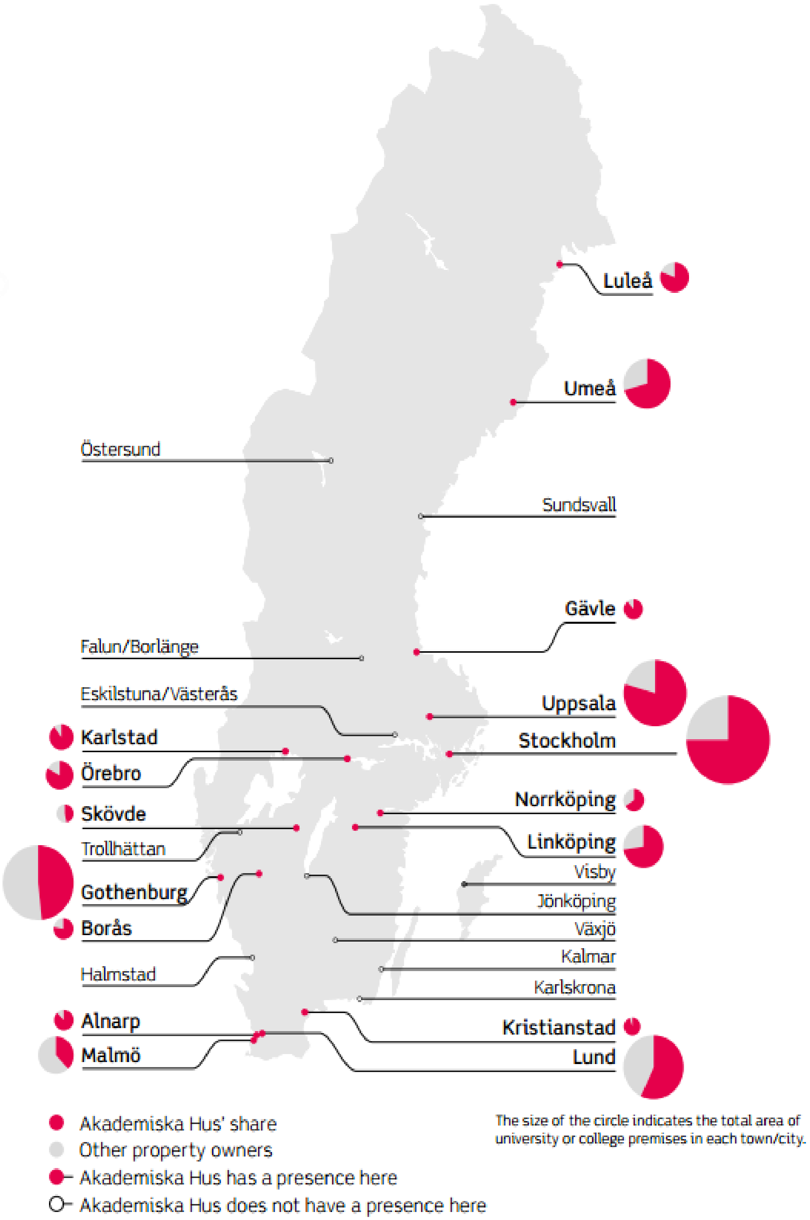
One of the largest property companies in Sweden

State-owned, with the focus on universities and colleges

Properties from north to south

A large energy consumer
- Power 400 GWh
- District heating 320 GWh
- District cooling 70 GWh

Large BTES systems in Lund, Karlstad and Stockholm



Energy-smart knowledge environments

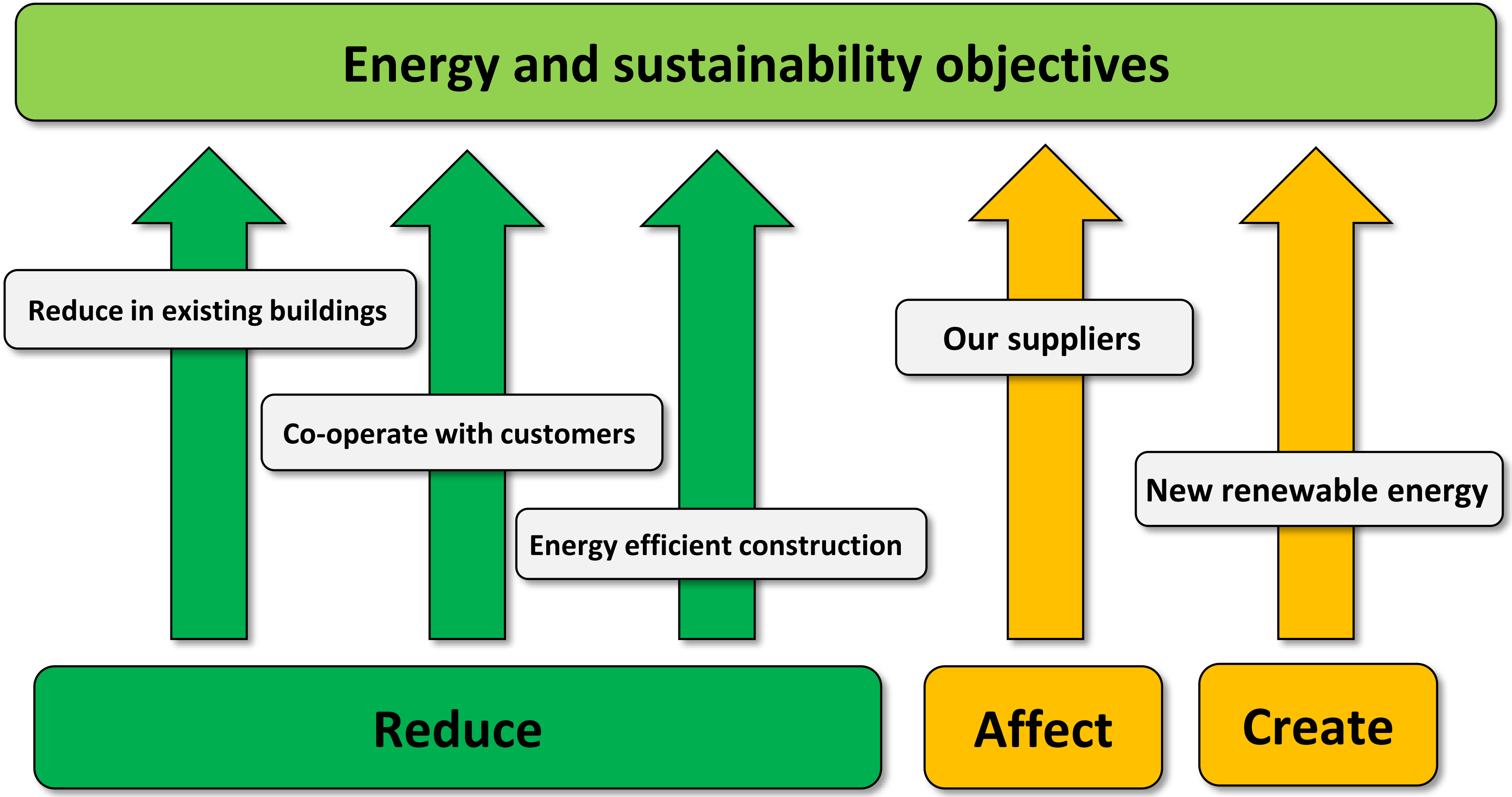
Akademiska Hus is one of the leaders in using energy more efficiently. Smart technical solutions give a growing share of our buildings very low energy consumption.

By 2025 we intend to halve the amount of delivered energy we buy compared to the year 2000.

By investing in origin-marked electricity that is generated from renewable sources, such as hydro and wind power, we also ensure that the electricity we need to buy has been produced sustainably.

We are working to eliminate the CO_2 footprint from energy use in the operation of our buildings

Energy strategy of Akademiska Hus



The geoenergy project of Campus Frescati, Stockholm

An energy study year 2012 identified a considerable potential for more efficient heating and cooling in existing Arrhenius laboratory buildings

The study suggested a comprehensive energy solution based on

- a BTES with heat pumps for heating of new and existing buildings
- upgrading of existing cooling systems including new chillers

The BTES and the heat pumps enables to utilize excess heat from the chillers. District heating supply will be reduced with 5 000 MWh/year. The electricity demand for heat pump operation will increase with 300 MWh/year

Total investments for the geoenergy system are 50 MSEK with a calculated pay-back within 15 years

Benefits with the geoenergy system

Except for economic profitability there will be other important benefits

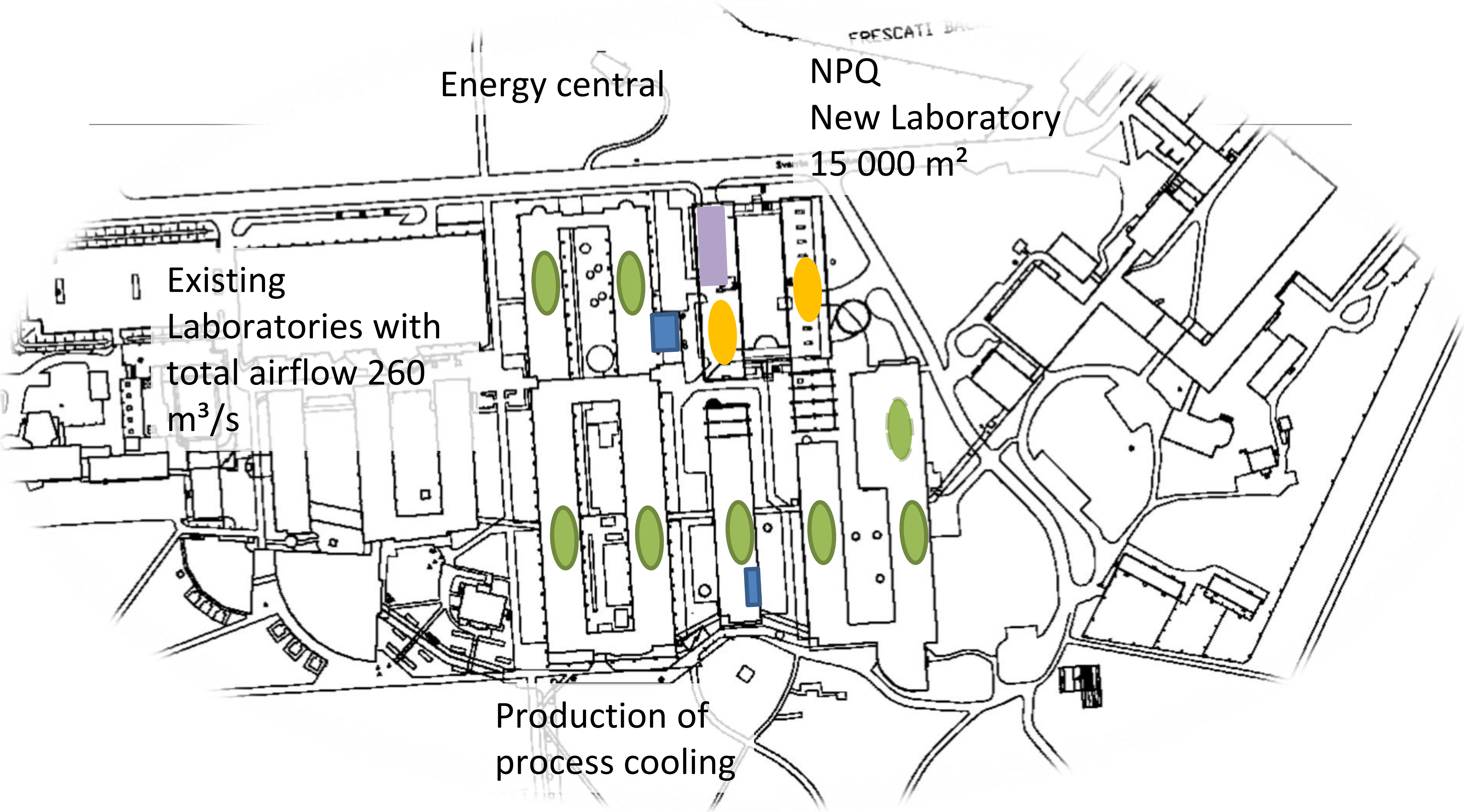
- A robust energy solution less sensitive for rises in energy prices
- The demand of district heating for Campus Frescati will be reduced with 25 %
- An upgraded, more efficient heating and cooling system with higher reliability
- CO_2 emissions will be reduced with 350 tons/year

TYRÉNS

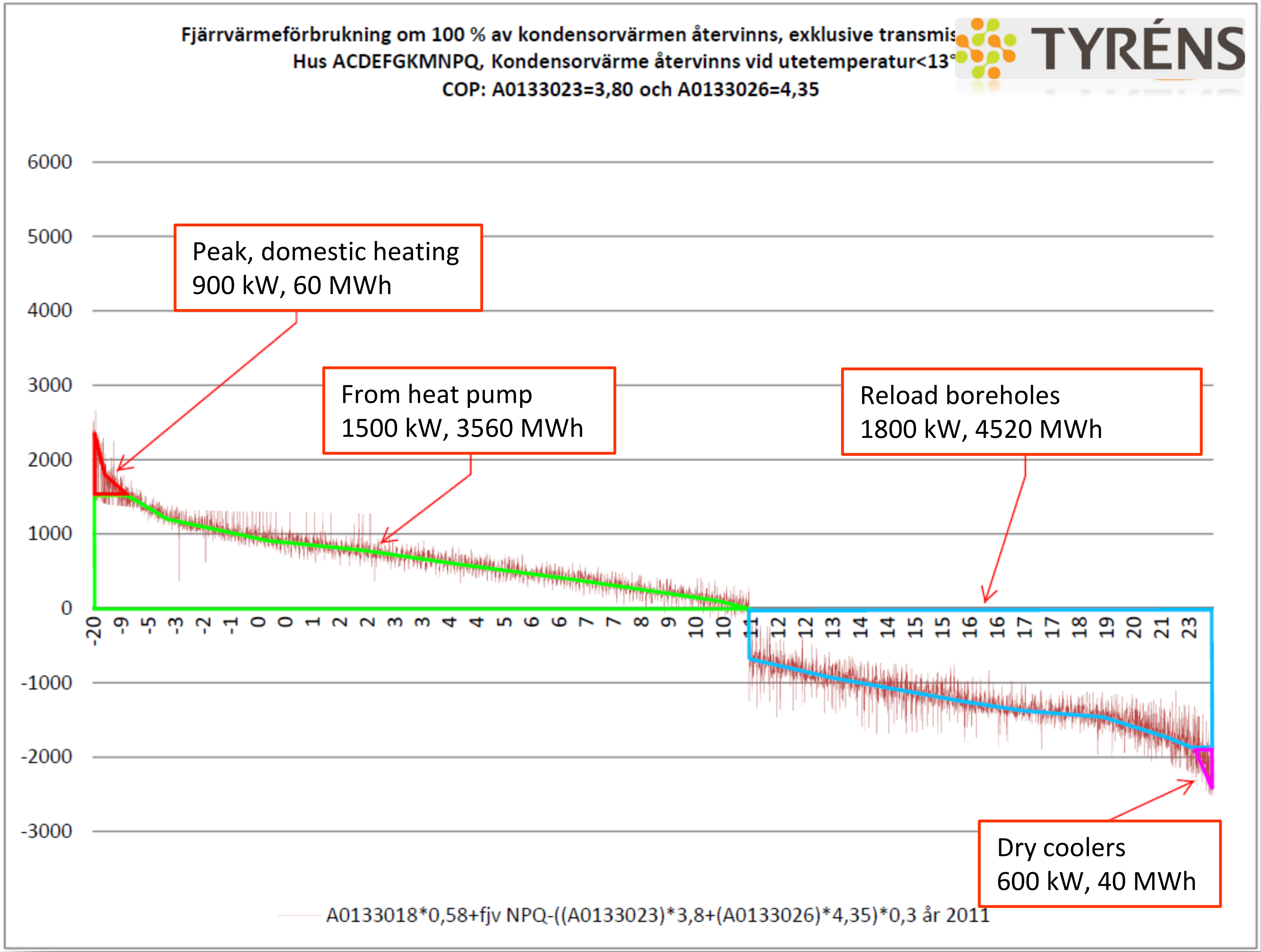
Design and technical aspects of the ground source heat pump system

MIKAEL NYGREN

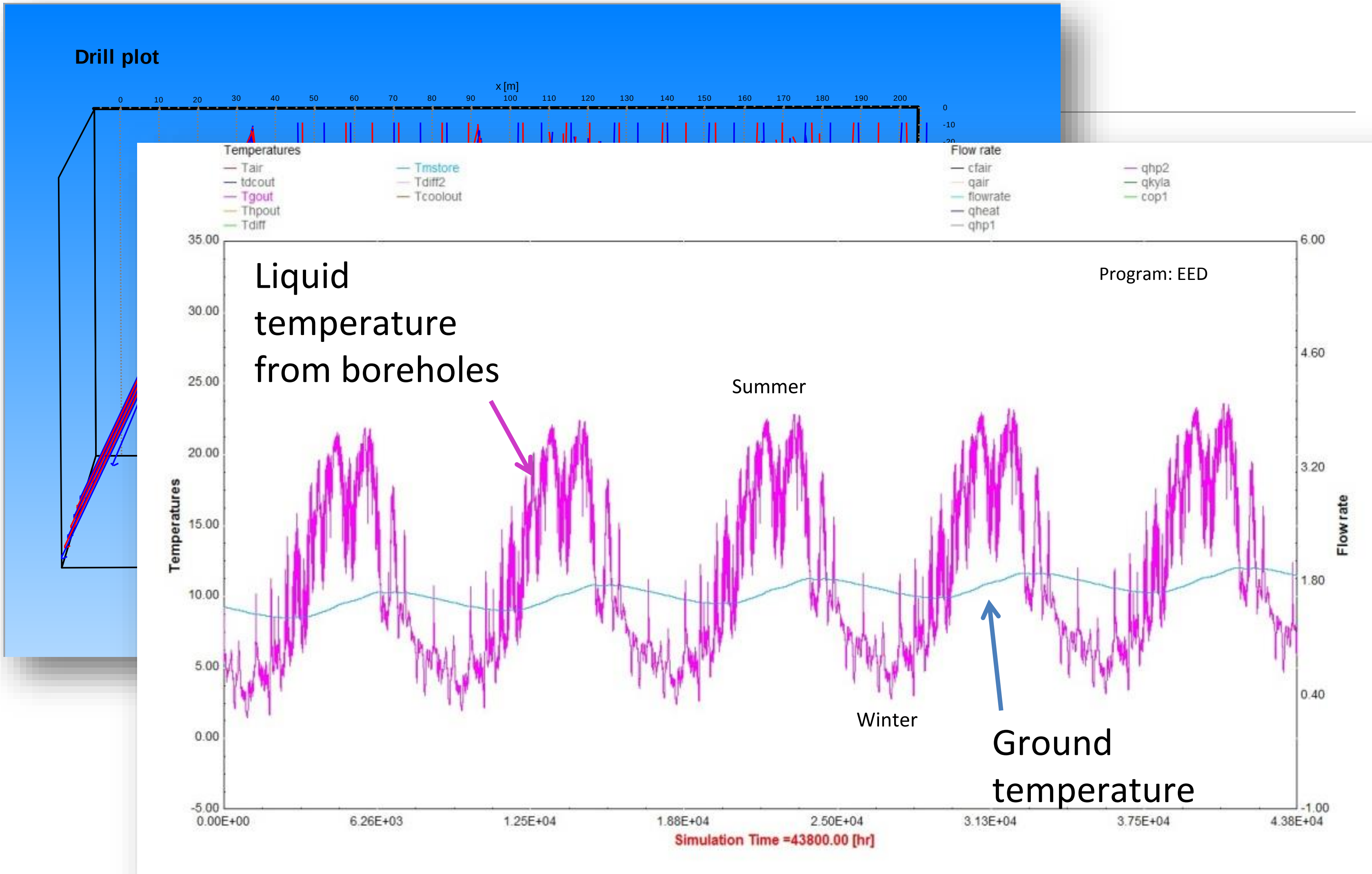
Energy cluster What's included



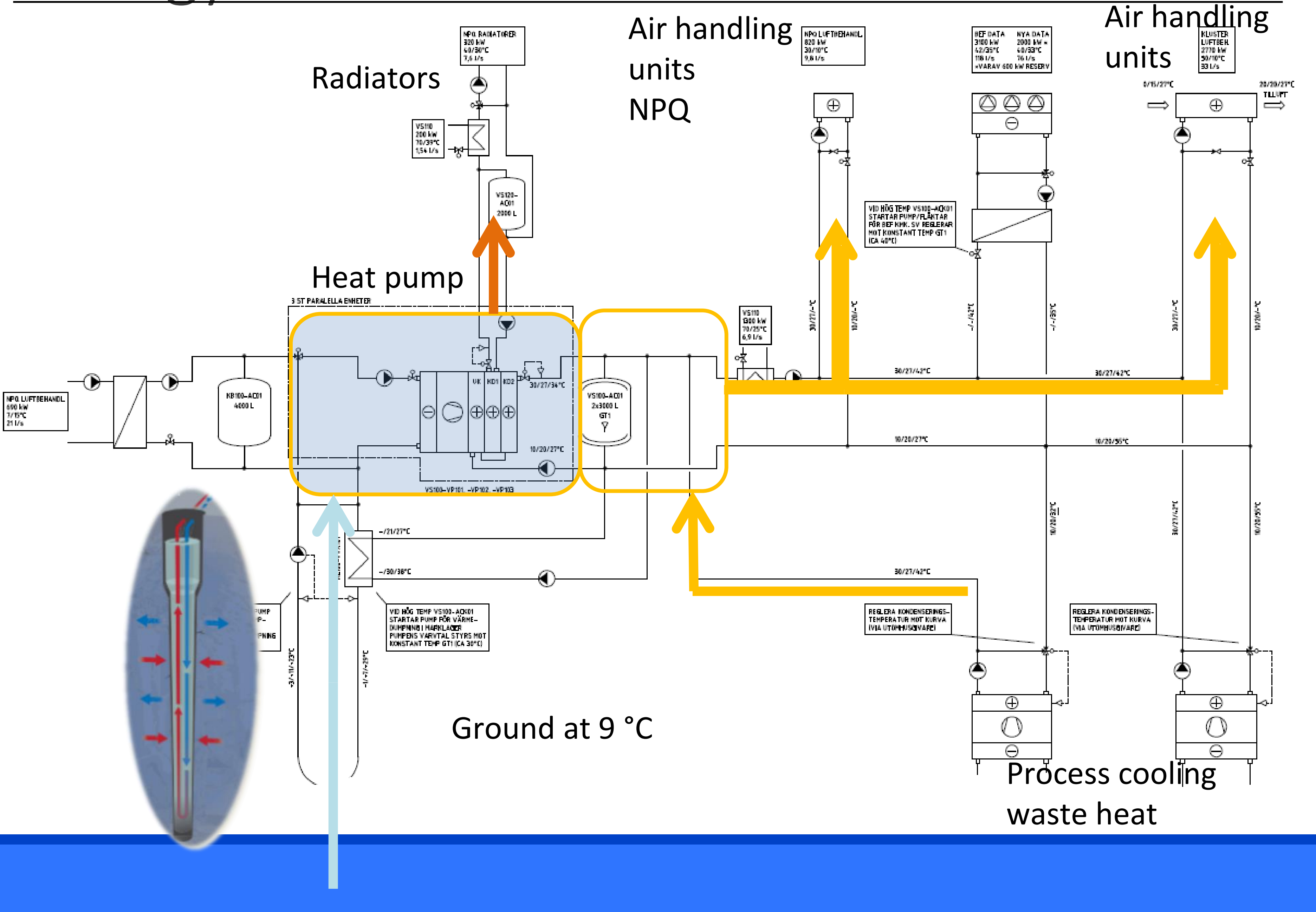
Energy cluster   Energy one year



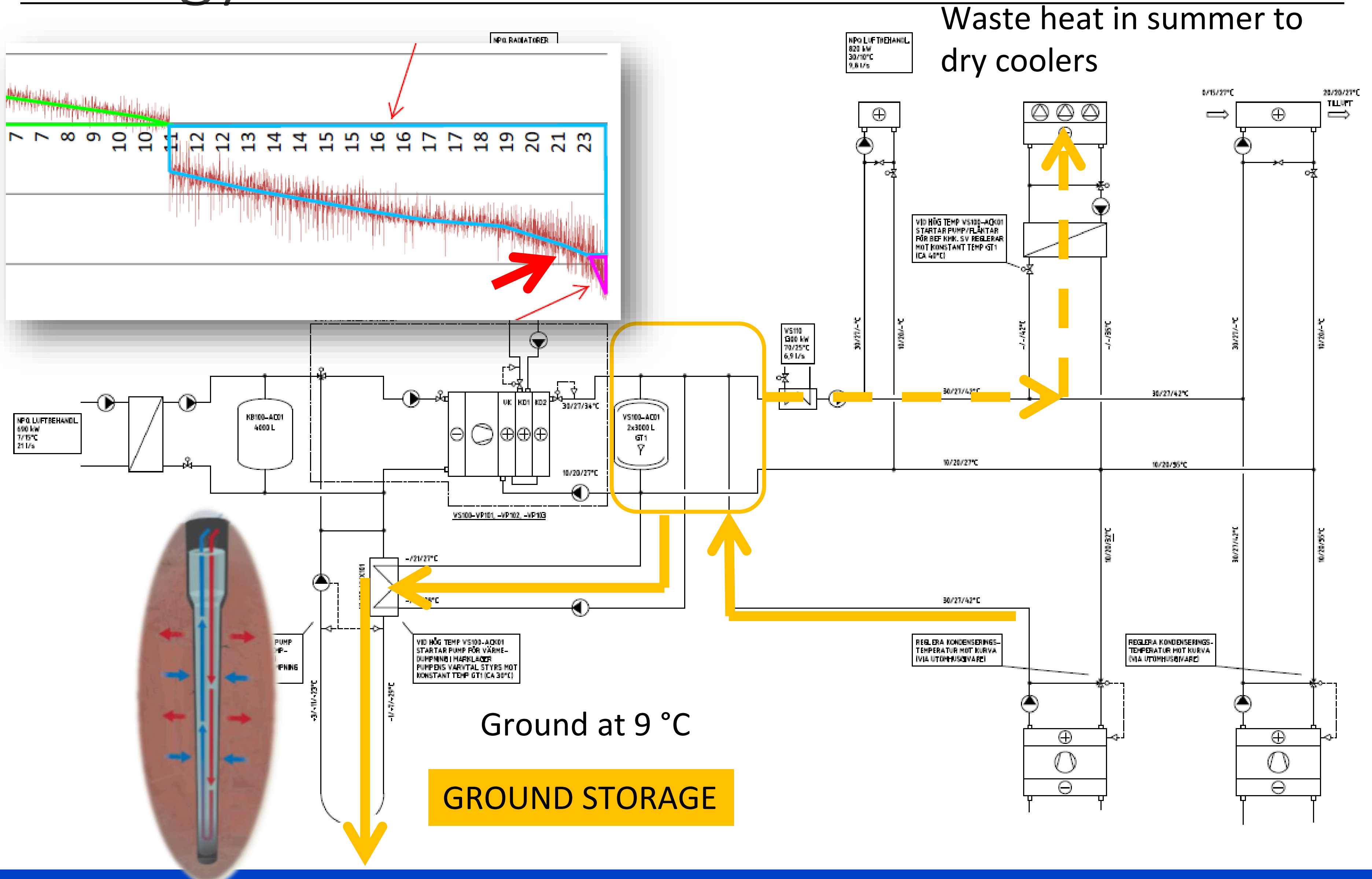
Energy cluster EED Simulation



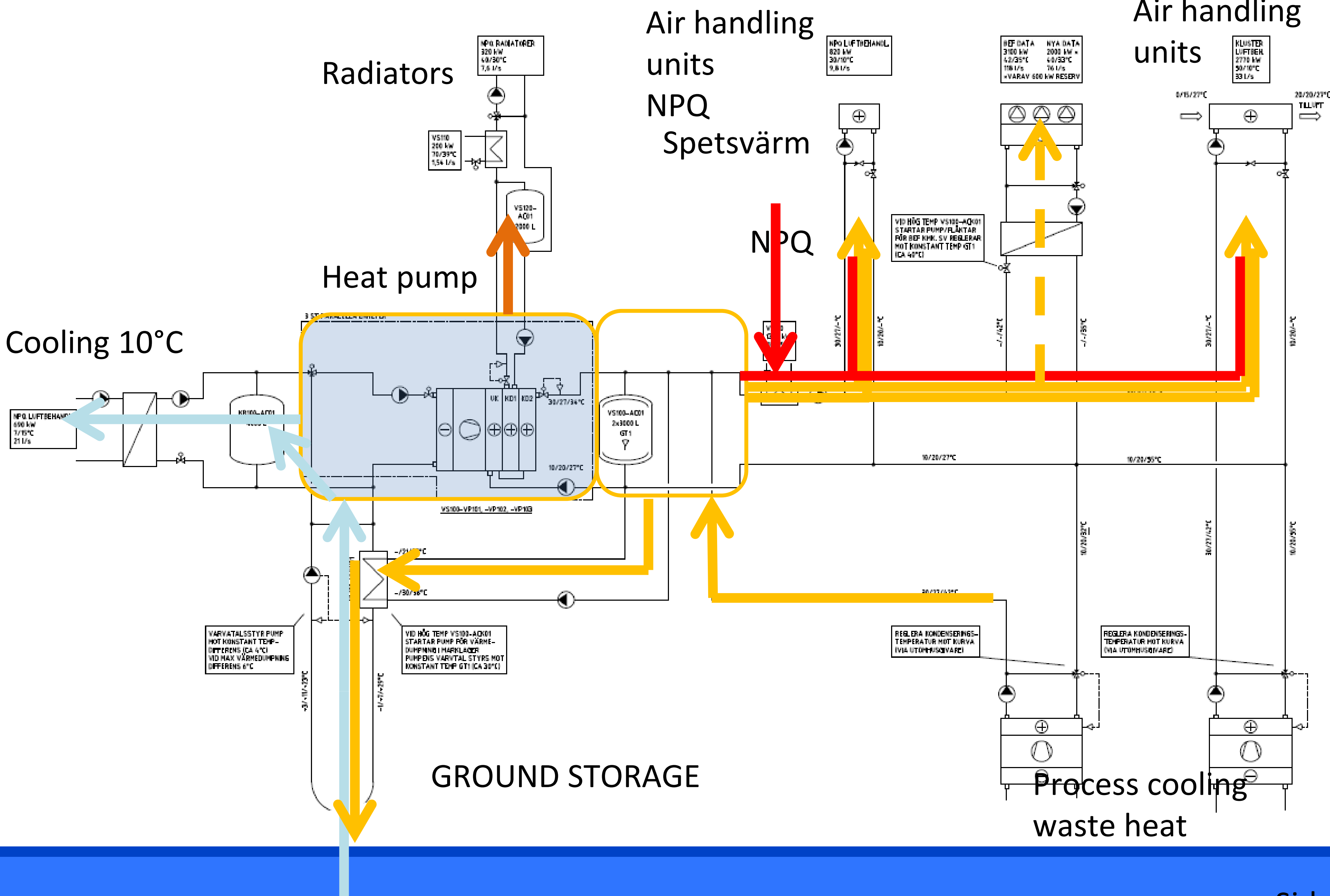
Energy cluster How



Energy cluster How



Energy cluster How

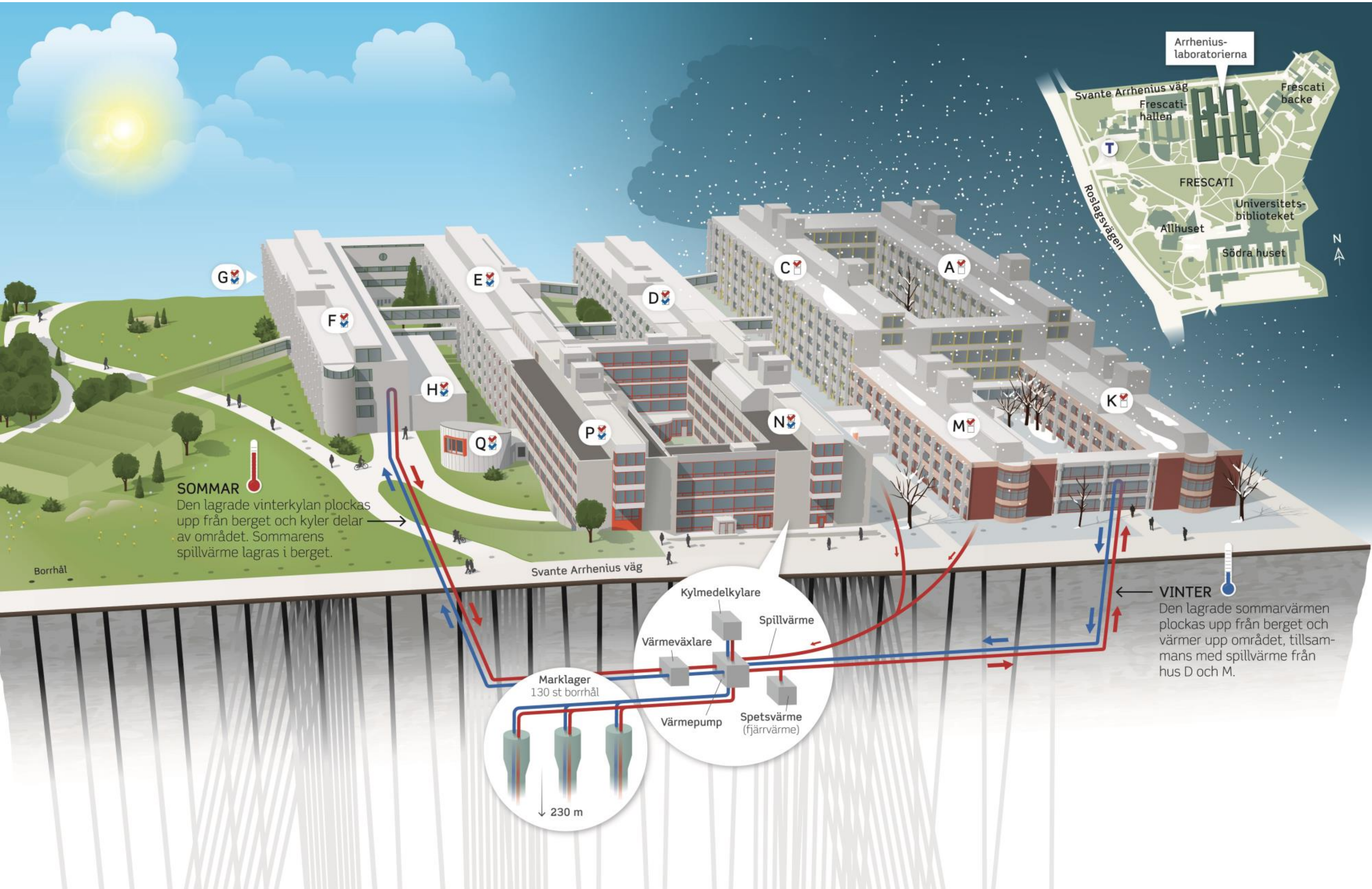


Important Design Principles

- System temperatures
  - close to temperature inside building
  - Heating system ventilation 30°C
  - Heating system radiators 40°C (new laboratory)
  - Cooling system 10°C (partly an existing system)
- Component choice
  - High efficiency pumps and heat pumps (refrigerant Ammonia COP 6,5)
- Control system
  - All pumps is speed controlled
  - Pumps adapt speed to actual demand of flow
- Reliable design parameters
  - energy measurement data (existing buildings)
  - energy calculations (new buildings)
  - test borehole (depth/capacity data)

The System from Operation Perspective

ÅKE ANNSBERG



Arrhenius-
laboratorierna
Svante Arrhenius väg
Frescati-
hallen
Frescati
backe
T
FRESCATI
Roslagsvägen
Universitets-
biblioteket
Allhuset
Södra huset
N
G
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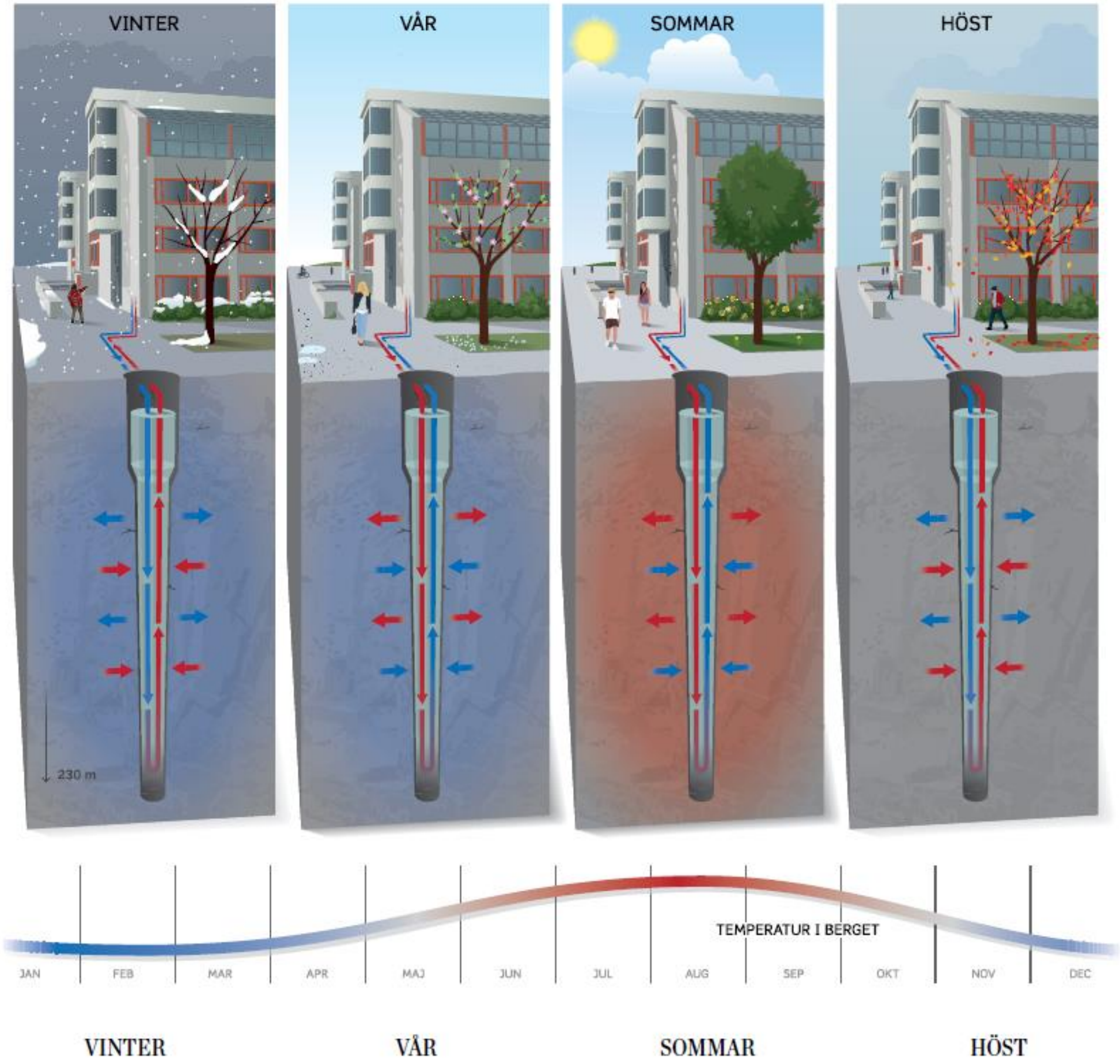
M
K
SOMMAR
Den lagrade vinterkylan plockas
upp från berget och kyler delar
av området. Sommarens
spillvärme lagras i berget.
Borrhål
Svante Arrhenius väg
Kylmedelkylare
Spillvärme
Värmeväxlare
Marklager
130 st borrhål
Värmepump
Spetsvärme
(fjärrvärme)
230 m
VINTER
Den lagrade sommarvärmen
plockas upp från berget och
värmer upp området, tillsam-
mans med spillvärme från
hus D och M.


VINTER
VÅR
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230 m
TEMPERATUR I BERGET
JAN
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OKT
NOV
DEC
VINTER
VÅR
SOMMAR
HÖST

Bore Field Drilling and Fiber Cable Installation

JONNAS JANSSON
JOSÉ ACUÑA

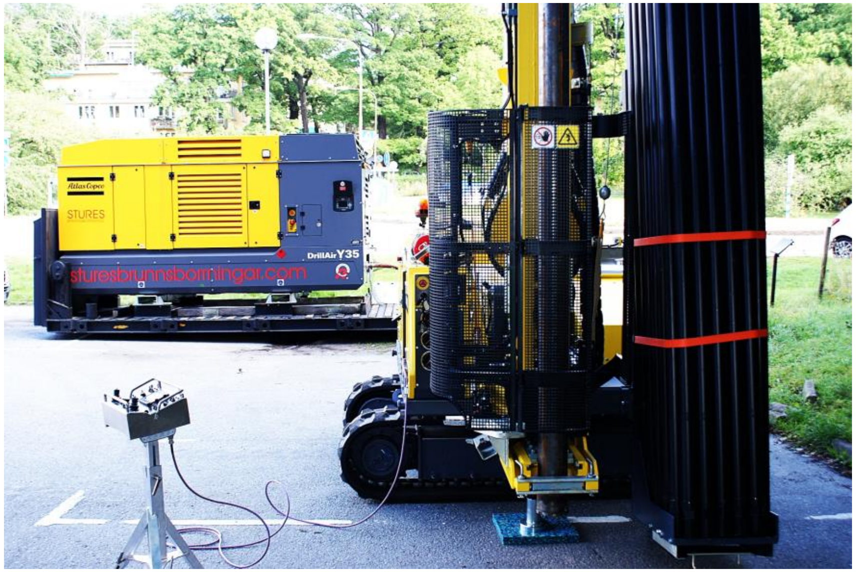
Bore Field Drilling

Some numbers:

- ✓ 130 boreholes
- ✓ 230 meter deep
- ✓ 14 manifolds
- ✓ 120 km piping

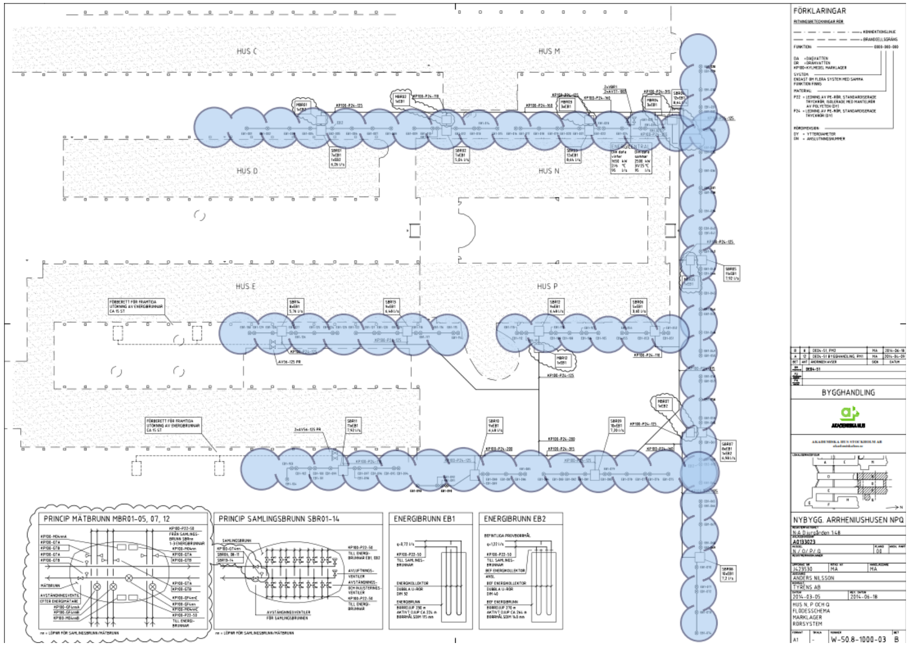
4 weeks of drilling

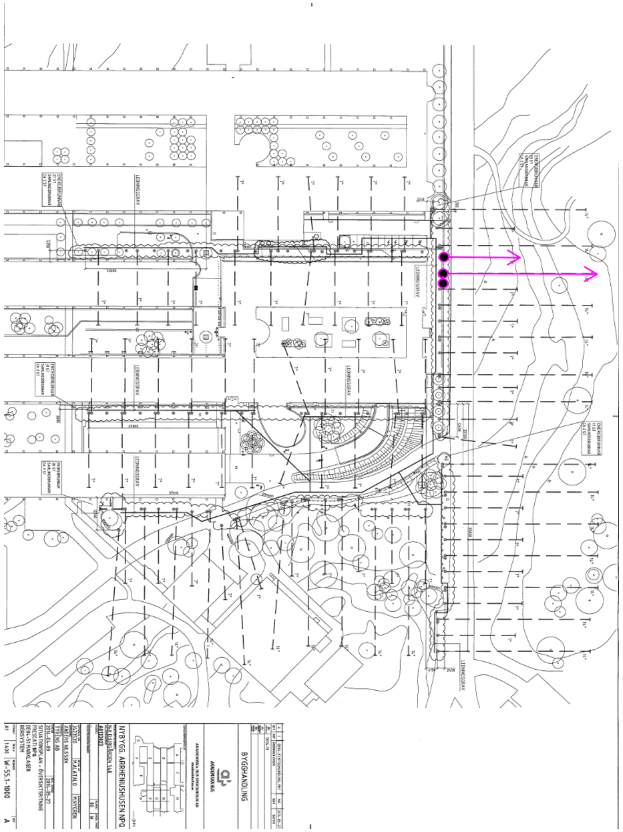
- 130 boreholes
- 230 meters deep
- Casing: 6-12m
- 5 drill riggs
- 1,5 borehole every day per unit



Drilling area

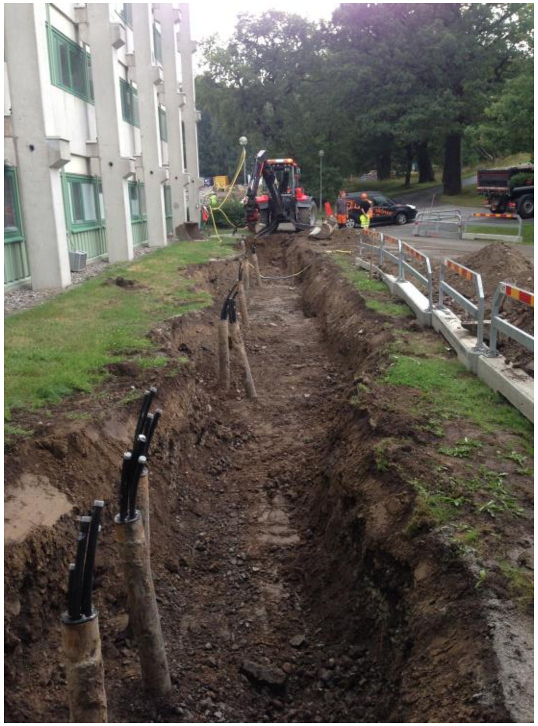
- Most of the holes are angled at 7 or 14 degrees.
- Some are even drilled straight



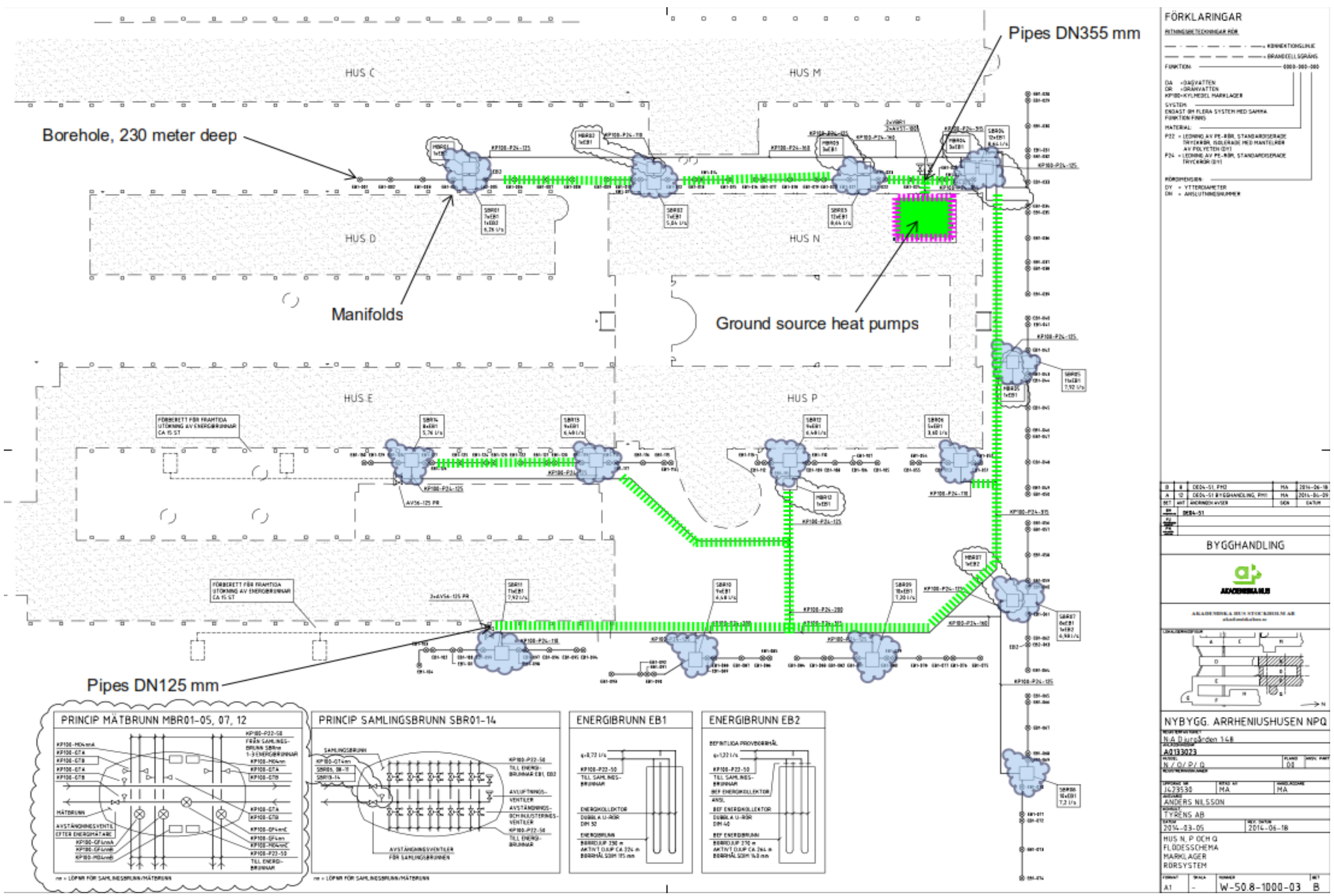


Manifolds & Borehole heat exchangers

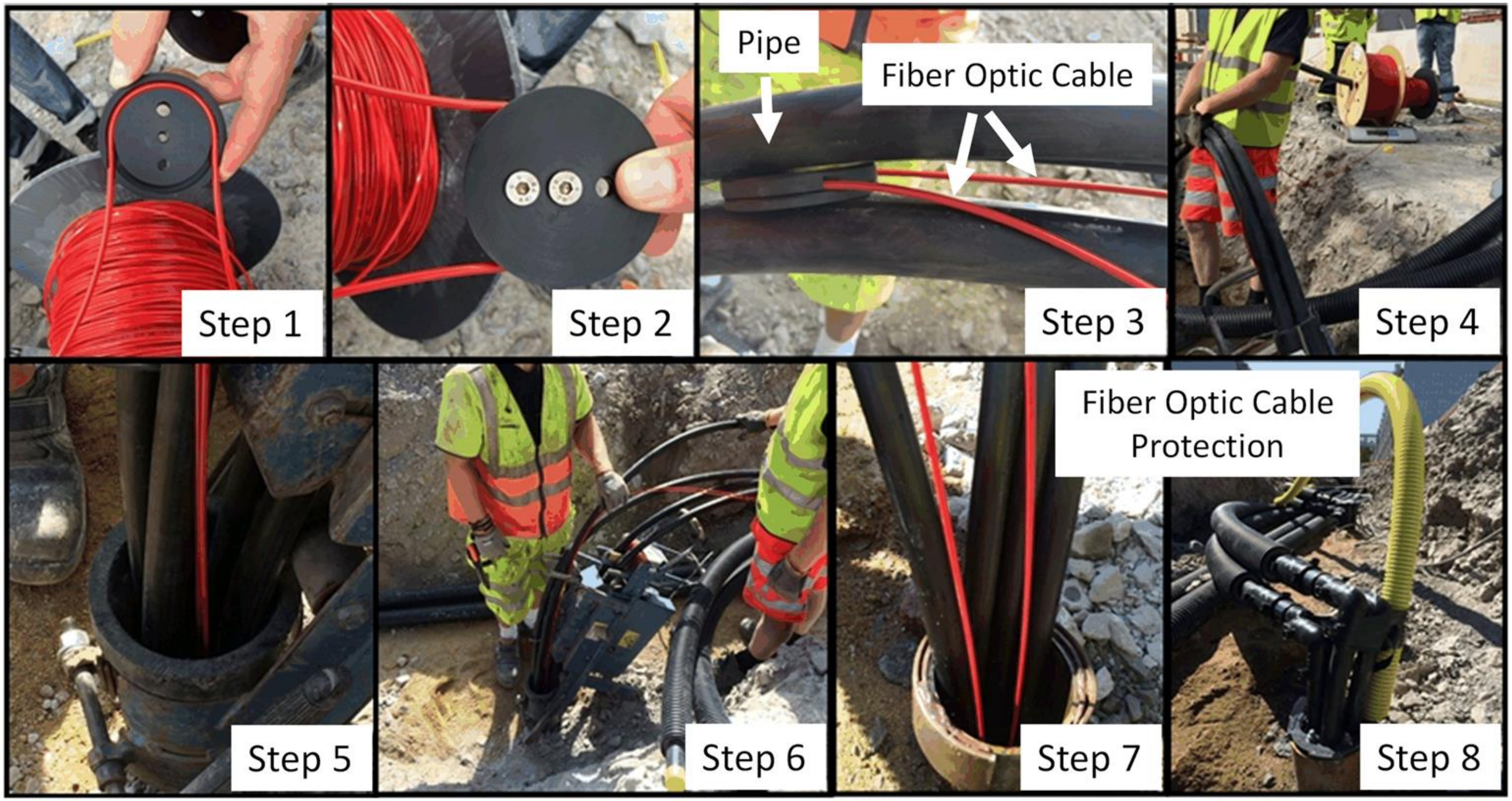
- Double U-pipe 4x32 mm
- 14 manifolds
- Headers between manifolds starts with dimension 125 mm up to dimension 355 mm connected to the ground source heat pump.



120 km pipes pipes of different dimensions



Installation of the fiber cable inside the boreholes



Bore Field Measurement Project

ALBERTO LAZZAROTTO
PATRICIA MONZÓ

Goals

Research

- Accurate **characterization of the heat transfer** in the subsurface for the Frescati Borehole Energy Storage (BTES).
- Compare the actual system operation with the expected behavior by design.

Technical

- Evaluation of the BTES operation.
- Utilize measured data to suggest possible strategies for the optimization of the overall system operation.

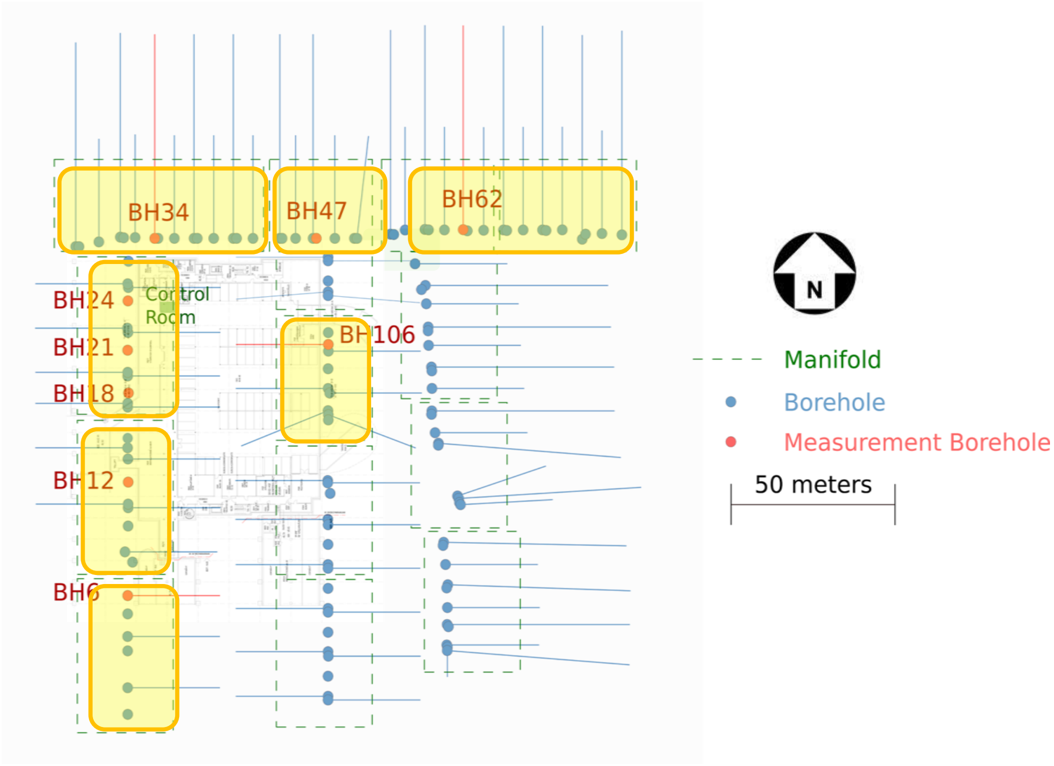
Characterize the heat transfer in the subsurface?

- What is the undisturbed ground temperature profile?
- Is the ground homogeneous?
- Are there ground water streams?
- How does the temperature of the subsurface changes in time as heat is extracted and injected into the boreholes?

Methodology

1. Measurements
2. Models & Simulations
3. Comparisons & Analysis

Measurements



- **Temperature profiles along the depth of selected boreholes.**
- **Heat flows in selected boreholes and manifolds.**
- **Inlet and outlet fluid temperature at selected boreholes and manifolds.**

Plan view of the frescati bore field system

Models & Simulations

Data

- Bore field geometry
- Ground thermal properties
- Heat load

Classic bore field model schema

Model

Output

Prediction of the *temperature evolution* of the secondary fluid circulating in the ground loop.

Comparisons & Analysis

Information

Design model

Data

- Bore field geometry
- Ground thermal properties
- **Design Heat load**

→ Model →

Ouput

Secondary fluid **temperature prediction** under **design condition**

Updated model

Data

- Bore field geometry
- Ground thermal properties
- **Measured heat loads**

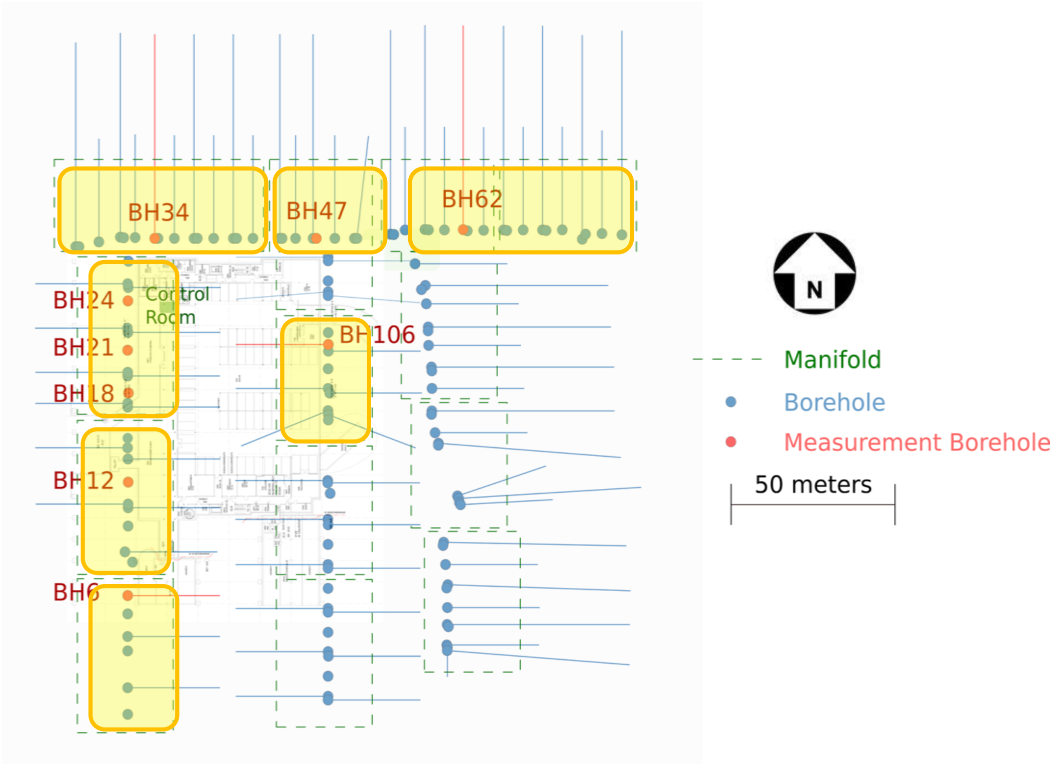
→ Model →

Ouput

Secondary fluid **temperature prediction** under actual **opertional conditions**

Actual measured temperatures and heat flows

Our Measurement Set-Up



Plan view of the frescati bore field system

Heat Flow

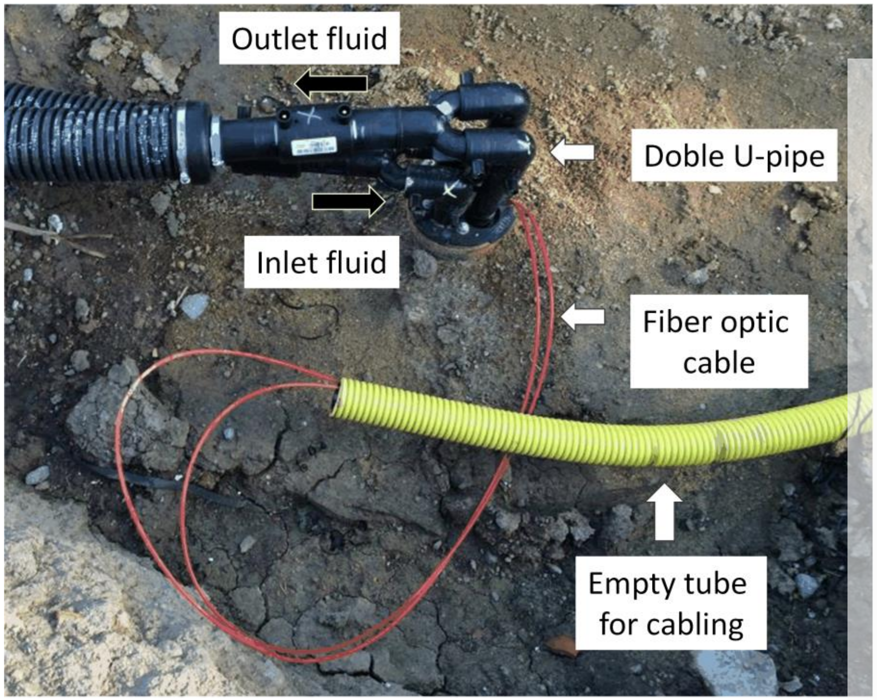
9 **boreholes**

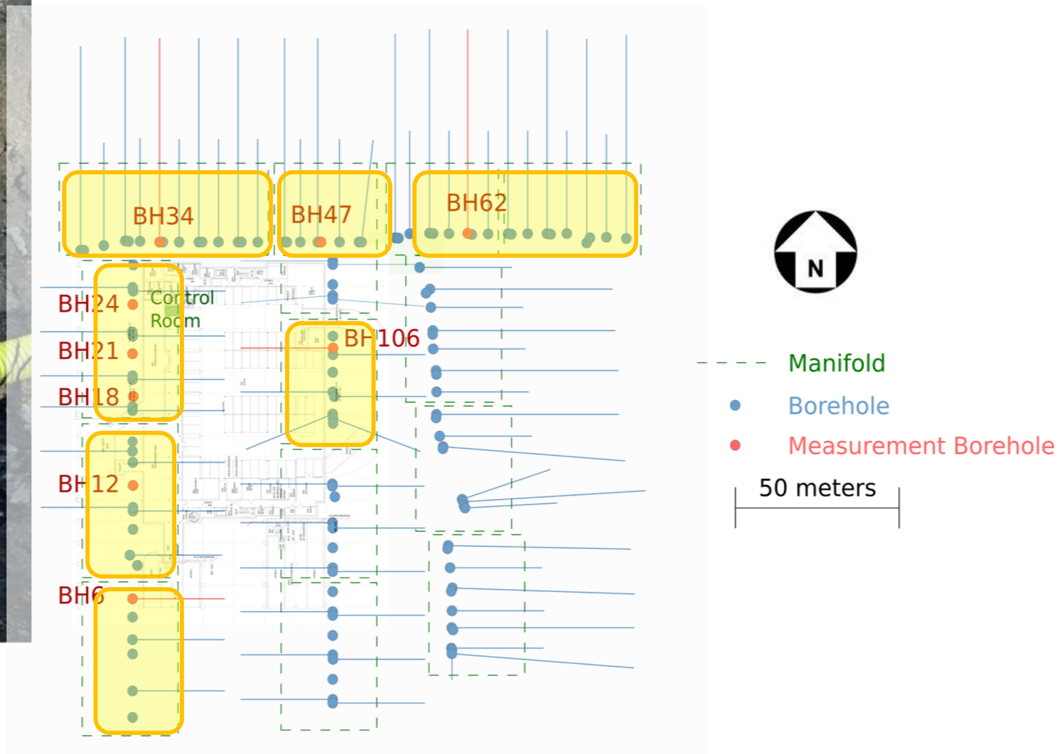
7 **manifolds**

Temperature along the depth

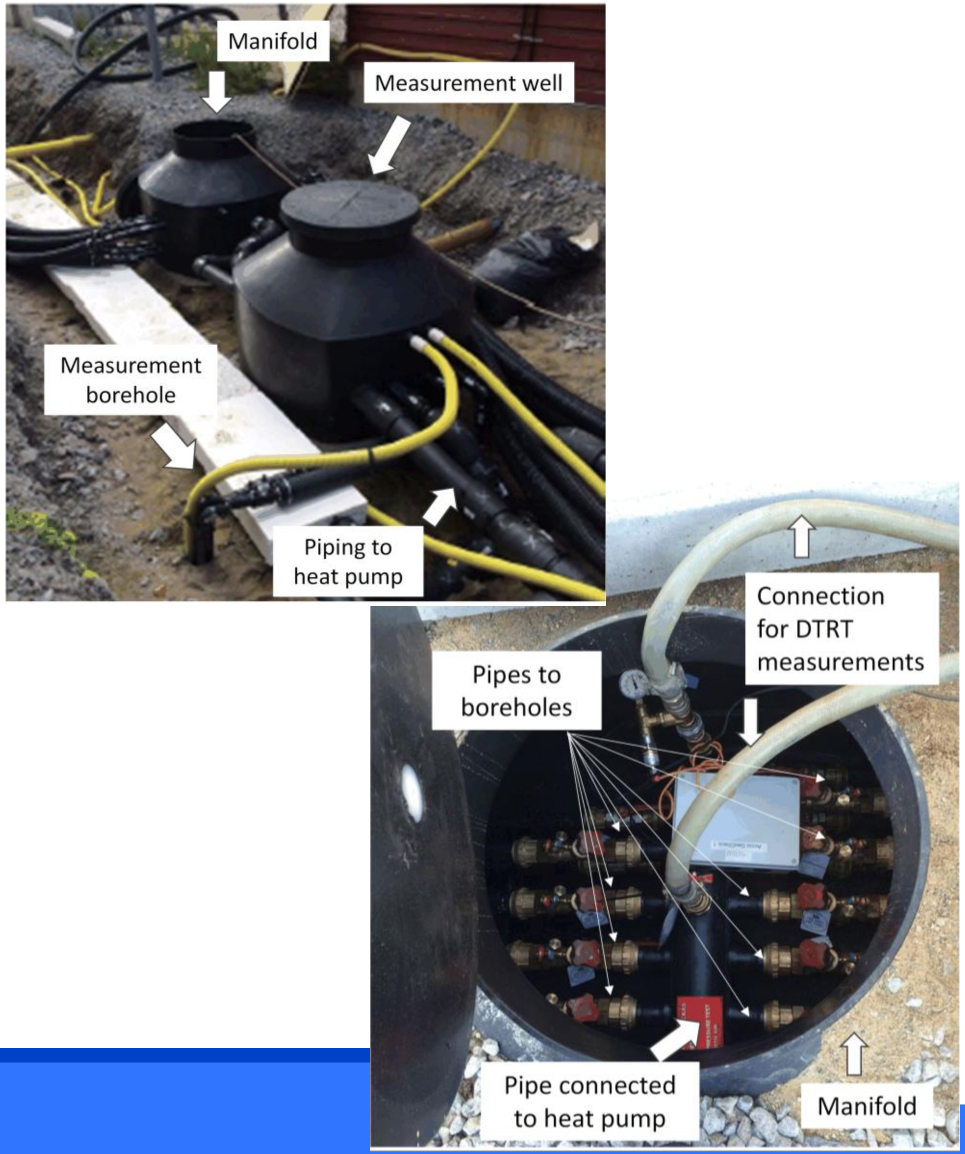
9 **boreholes**

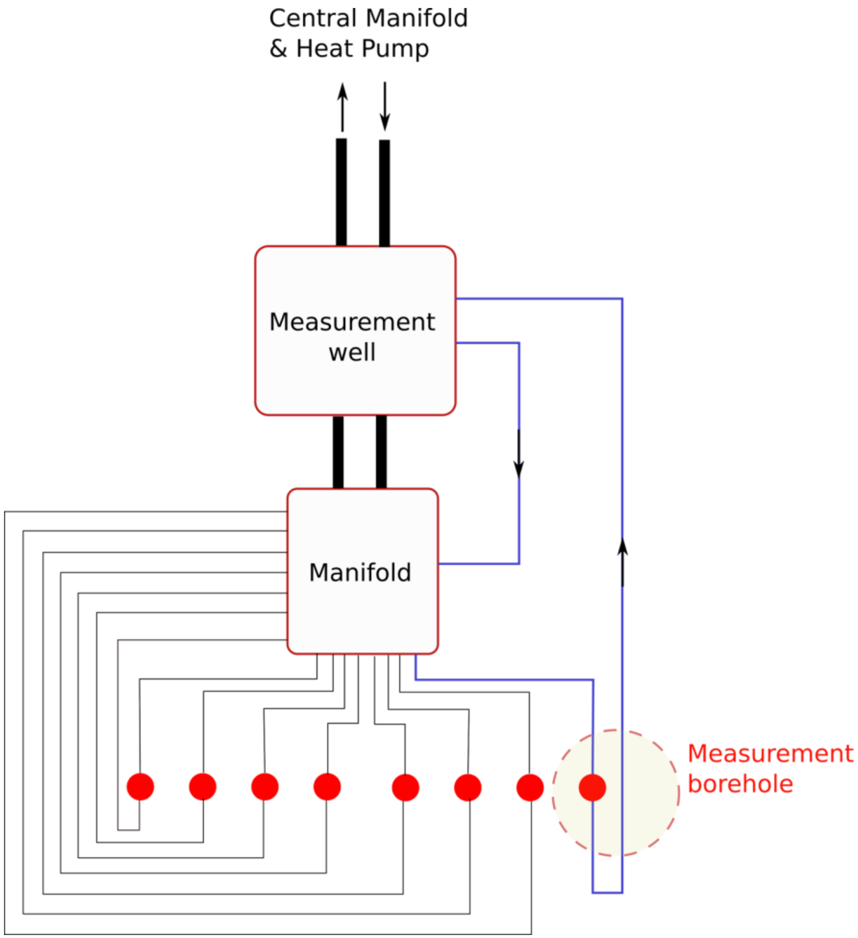
Measurement Boreholes





Measurement Wells

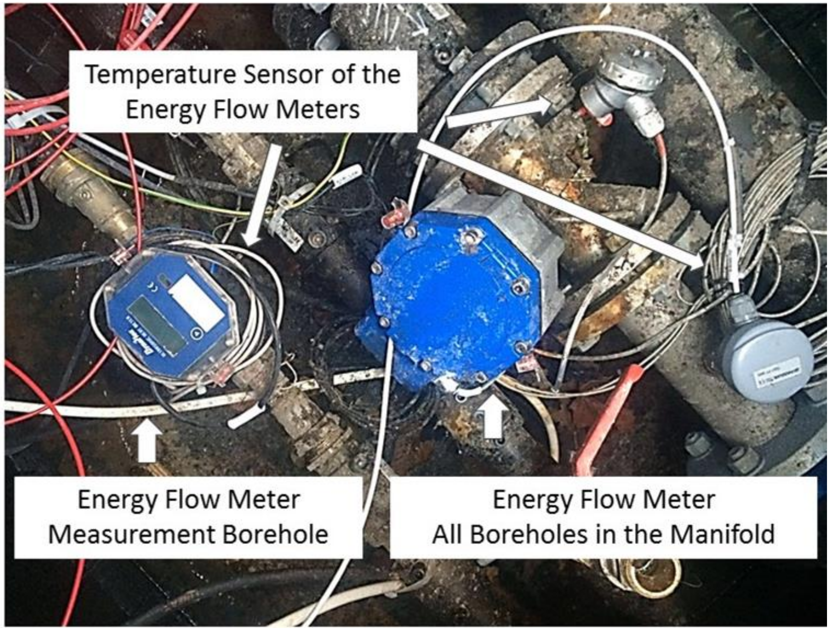




Energy Flow Measurements

Ultrasonic flow meters measures

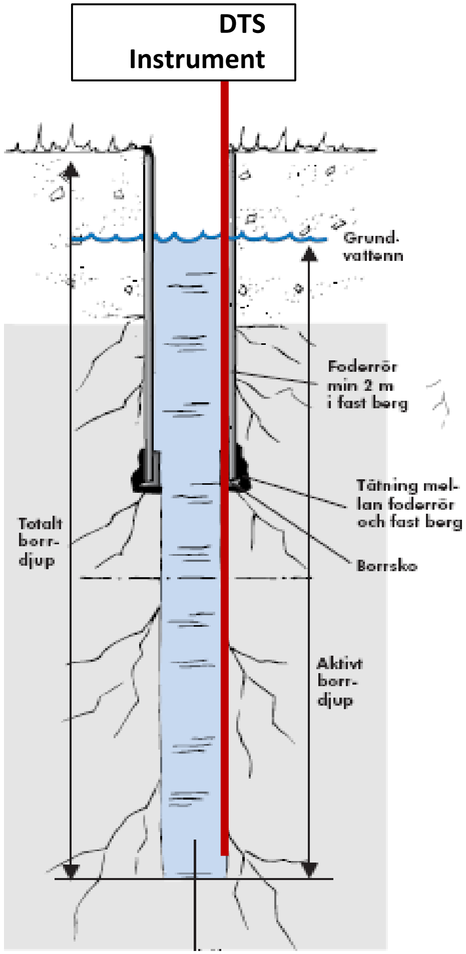
- **Mass flow**
- **Temperature difference** of the heat carrier fluid between **inlet** and **outlet** of a pipe loop.

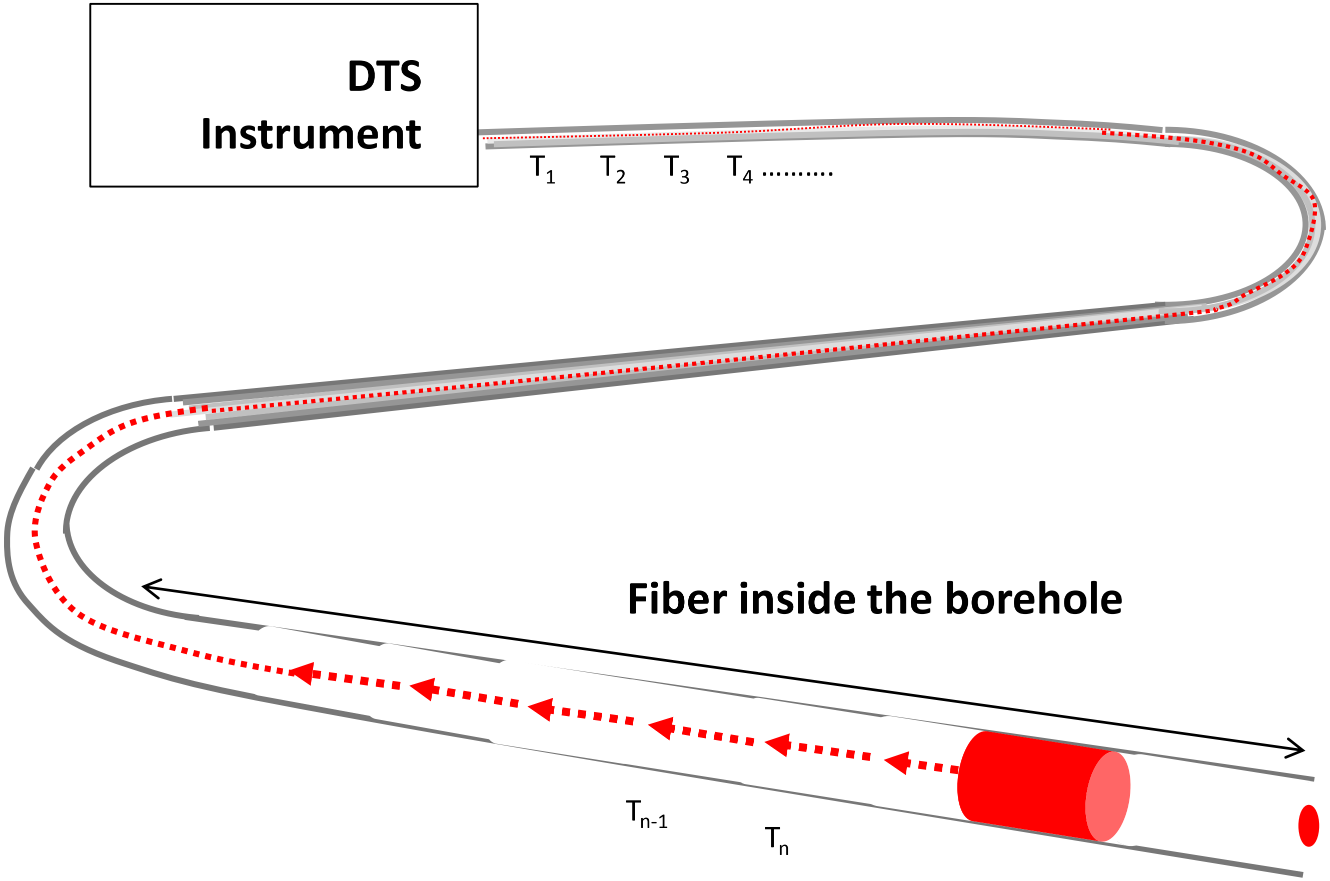


Communication

- The flow meters are digital units and they communicate via signal cable with a MBus Data Acquisition Unit.
- Data are stored to a local computer.

Distributed Temperature Sensing Technique

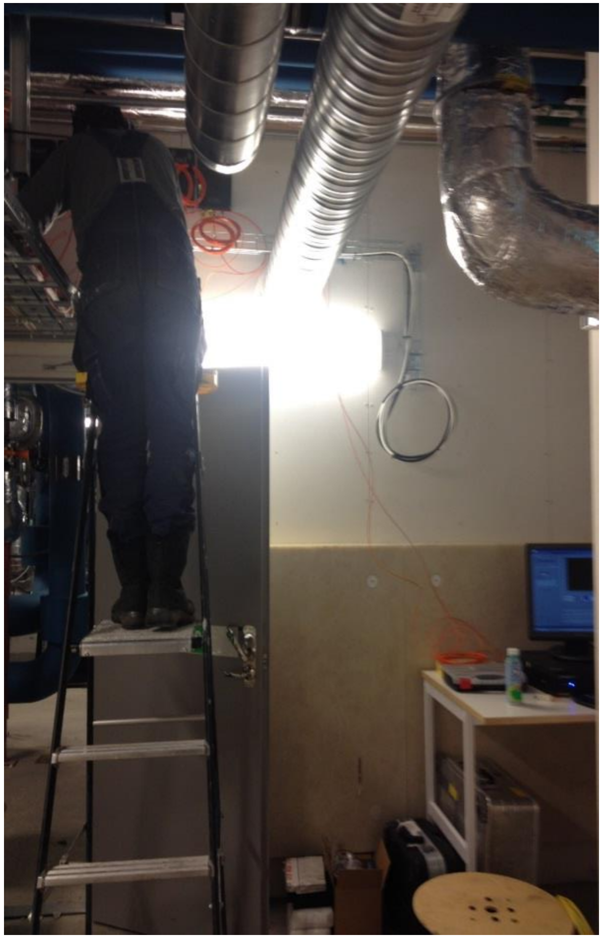


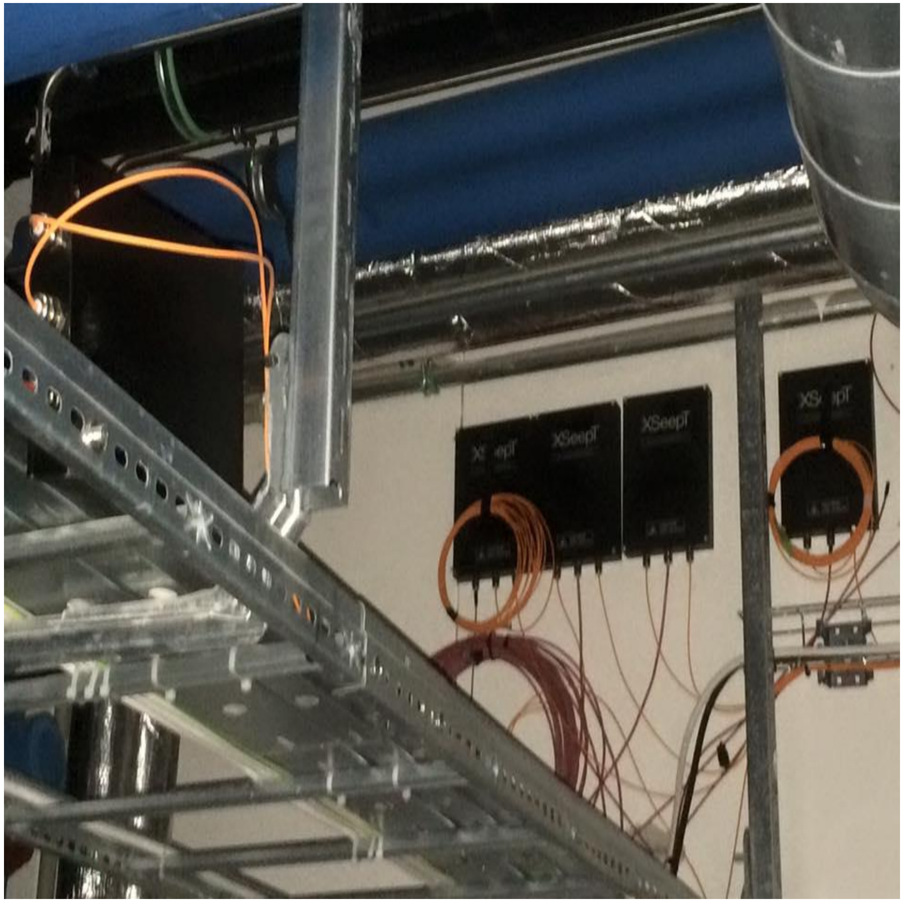


www.svepinfo.se
www.pemtec.se

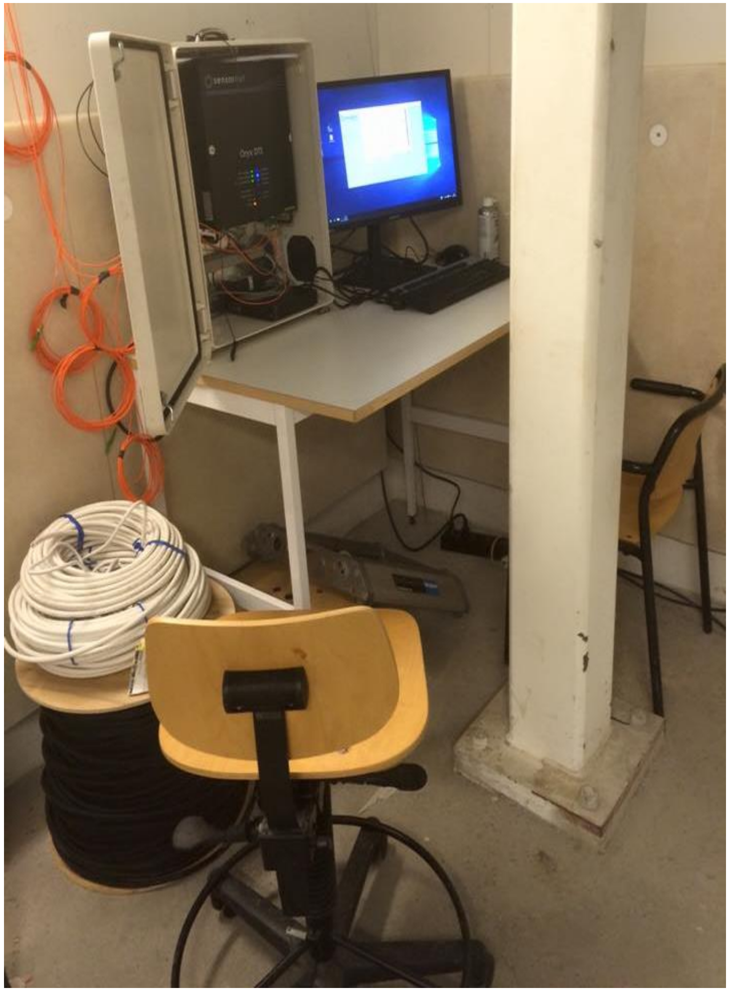
Fiber splice in the borehole

Fiber splice inside the building





DTS connections to local computer

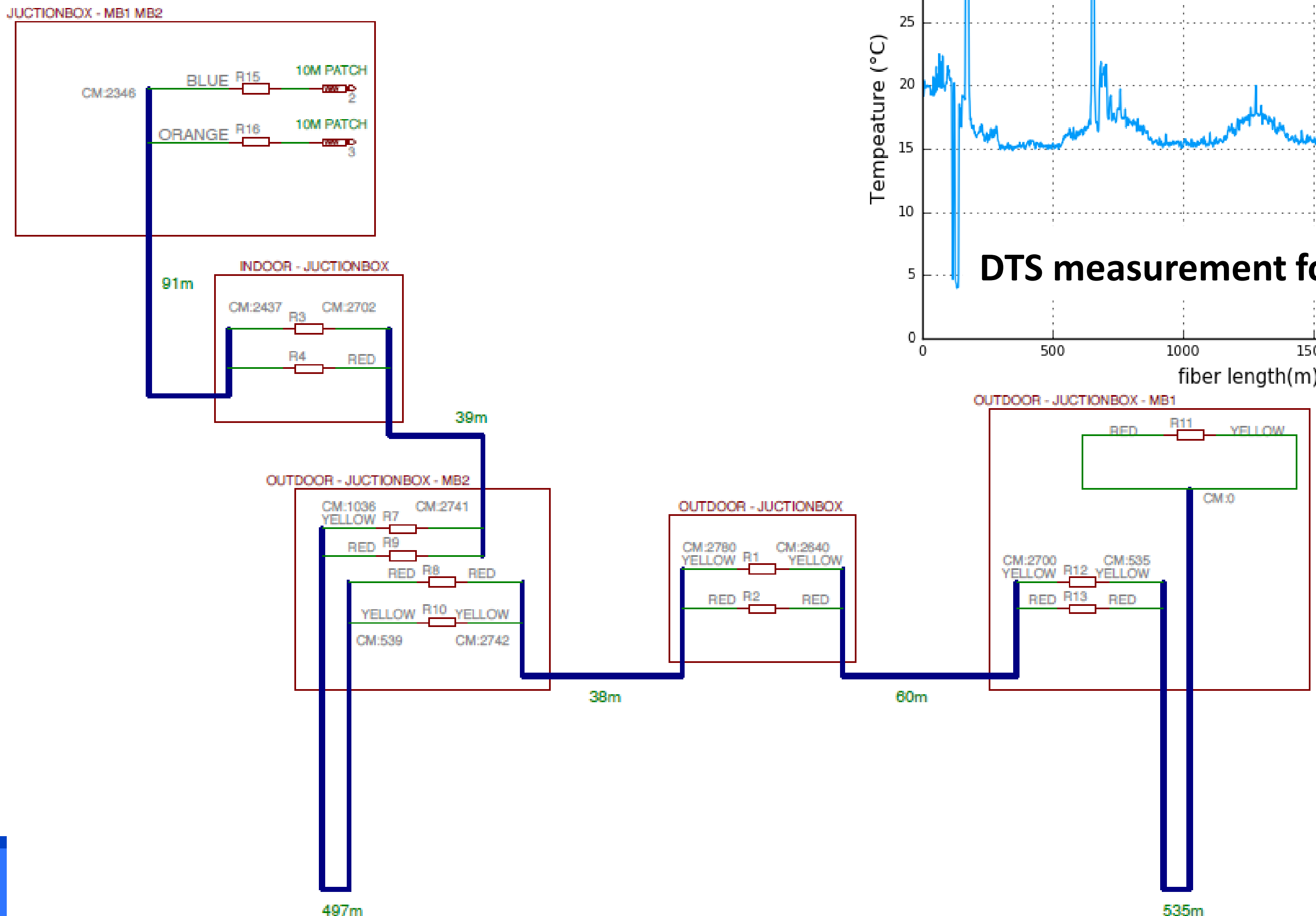


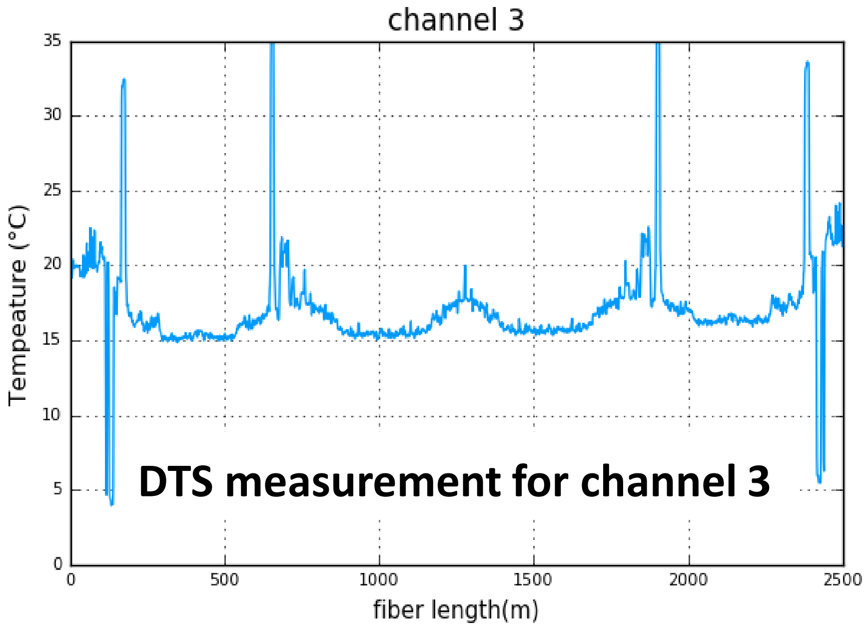
MB 1 and MB 2	2
MB 3	3
MB 3 and MB 4	2
MB 5 and MB 7 and MB 12	3

- Channel 1
- Channel 2
- Channel 3
- Channel 4

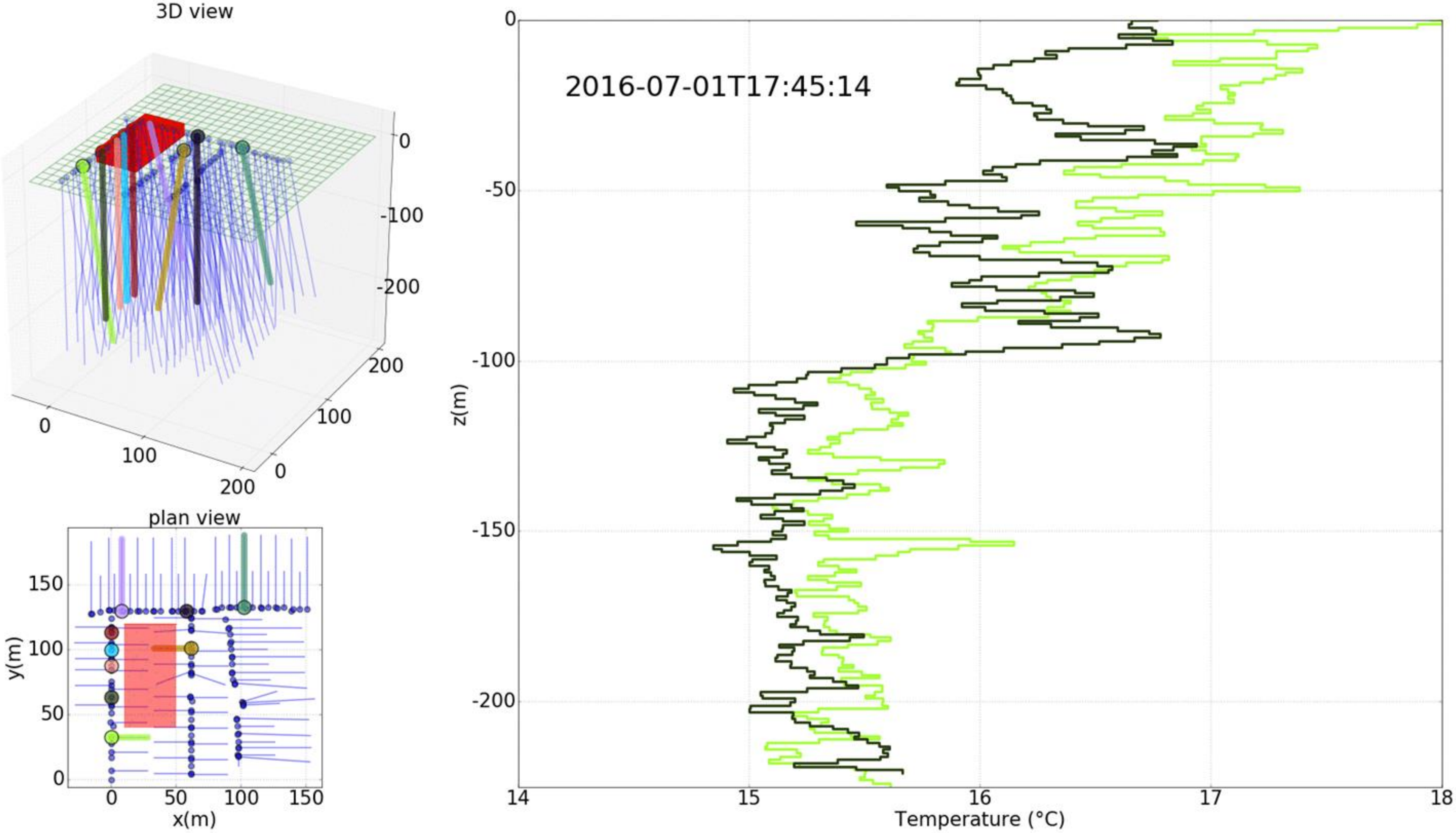
Temperature Measurements

Connection scheme for channel 3





Temperature Measurements



Temperature Measurements

video

Thank you for your attention!

2016 GSHP Convention

& to our industrial partners and sponsors!

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Questions?

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