

# TESSE<sup>2</sup>B

the smart energy storage

## Thermal Energy Storage Systems

for energy efficient building an integrated solution for residential building  
energy storage by solar and geothermal resources

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# Geothermal Heat Pumps with PCM in Boreholes

## B2B Meeting Bochum

Univ.-Prof. Dr. Johann Goldbrunner (Geoteam/Austria)



European  
Commission

Bochum, Germany, 22<sup>nd</sup> June 2017

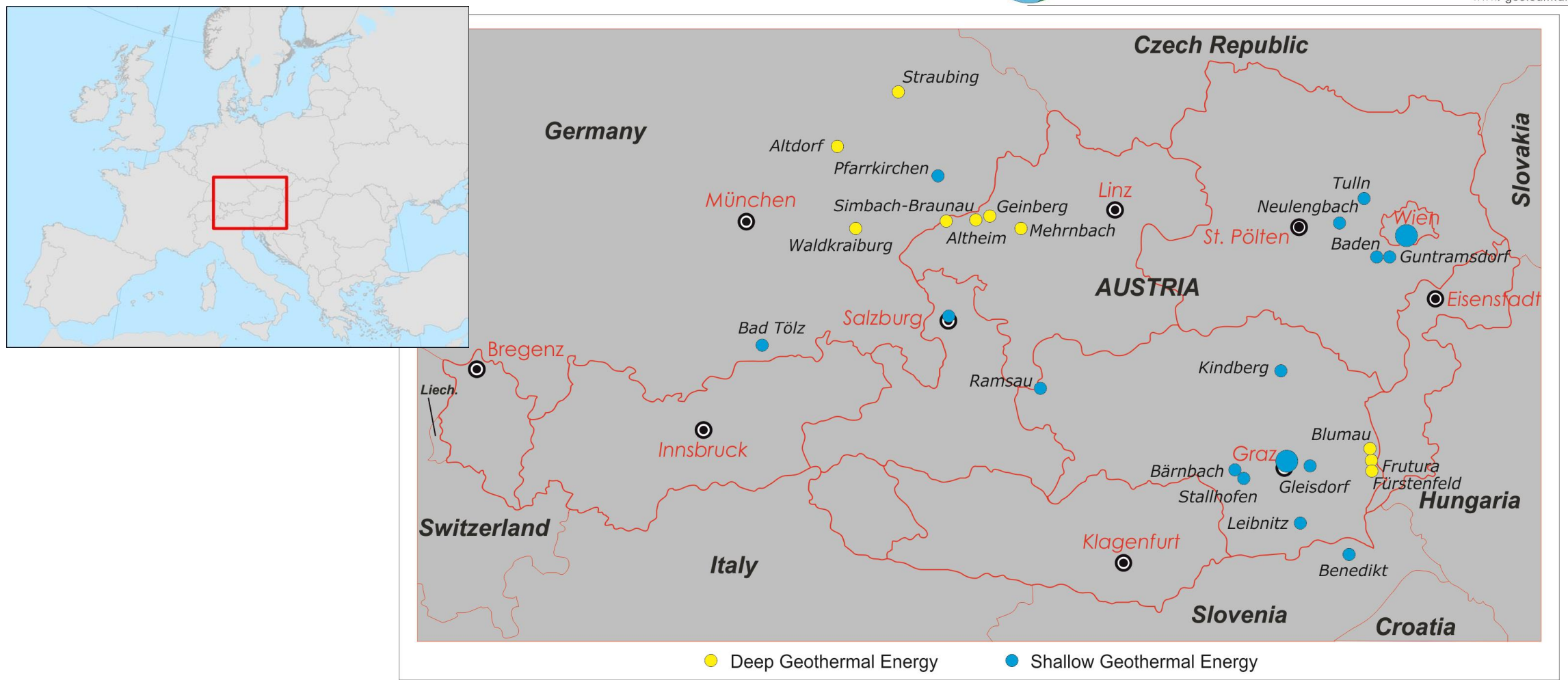


## INTRODUCTION *GEOTEAM*

- ▷ *Geoteam* was founded in 1993.
- ▷ The company is specialized in consultancy for hydrogeology, geothermal energy (deep and shallow) and environmental services.
- ▷ Since 2009: the head office is located in Graz.
- ▷ The company currently employs seven geologists.
- ▷ The main focus lies in consulting, planning and directing test programs concerning the exploration, development, monitoring and redevelopment of groundwater and deep groundwater resources.
- ▷ *Geoteam* is one of the leading consulting agencies in the sectors of hydrogeology, geothermics and environmental services in Austria and Southern Germany.



### GEOTEAM GEOTHERMAL PROJECTS (SHALLOW AND DEEP)





## GEOTEAM IN TESSE2B

- ▷ The idea is to develop enhanced borehole heat exchangers (BHEs) with integrated PCM that will take advantage of the increased underground thermal storage and maximize the efficiency of the ground coupled heat pumps (GCHP).
- ▷ The weakest link in BHEs is the heat transfer in the ground that is mainly conductive and its thermal diffusivity is low. This leads to a much slower ground thermal response than the heat pump requirements, resulting in thermal waves being transmitted into the ground through the BHEs causing lower coefficient of performance (COP) of ground source heat pumps (GSHP).
- ▷ To improve the effectiveness of BHEs, integrating PCMs into the BHEs will be adopted. Employing PCMs will be an effective way to store thermal energy in the BHEs and smooth the generated thermal wave.



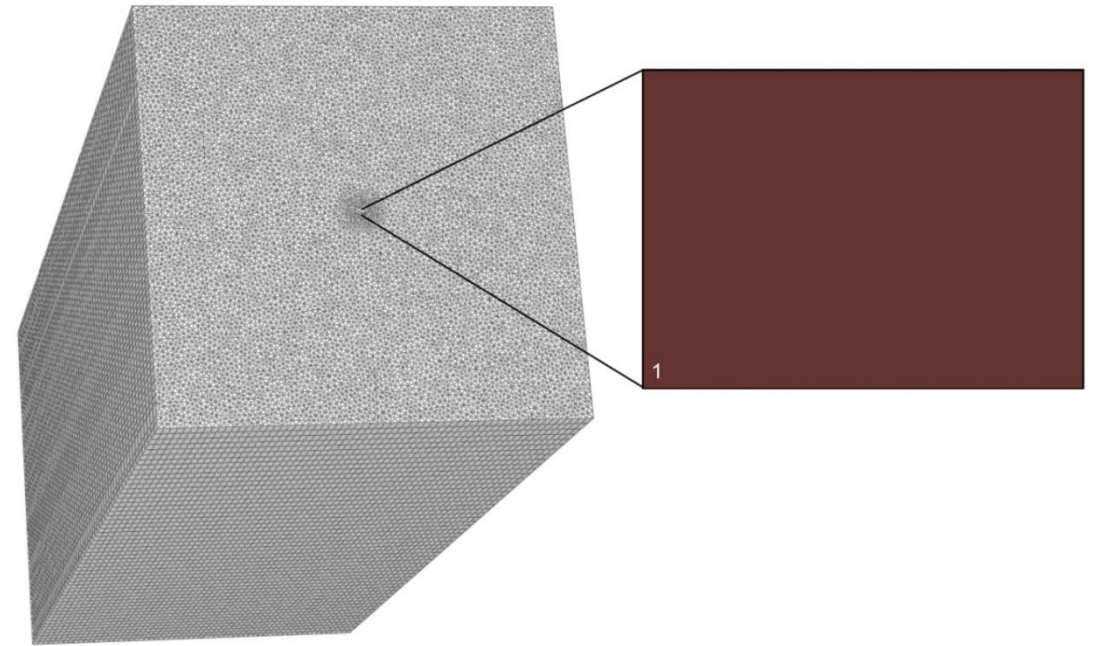
## GEOTEAM'S ROLE IN THE PROJECT

- ▷ covering the geological/hydrogeological aspects for the selection of the PCMs for the three pilot sites (Cyprus, Spain, Austria).
- ▷ Work Package Leader: the analysis and design of the enhanced PCM BHEs.
- ▷ designing the layout of the BHEs of the three pilot sites.
- ▷ hosting and supervising the pilot site in Austria.

## COMPONENTS OF A BHE/MODEL

### ▷ subsurface

- thermal conductivity
- heat capacity
- non saturated/saturated zone
- groundwater bearing zones



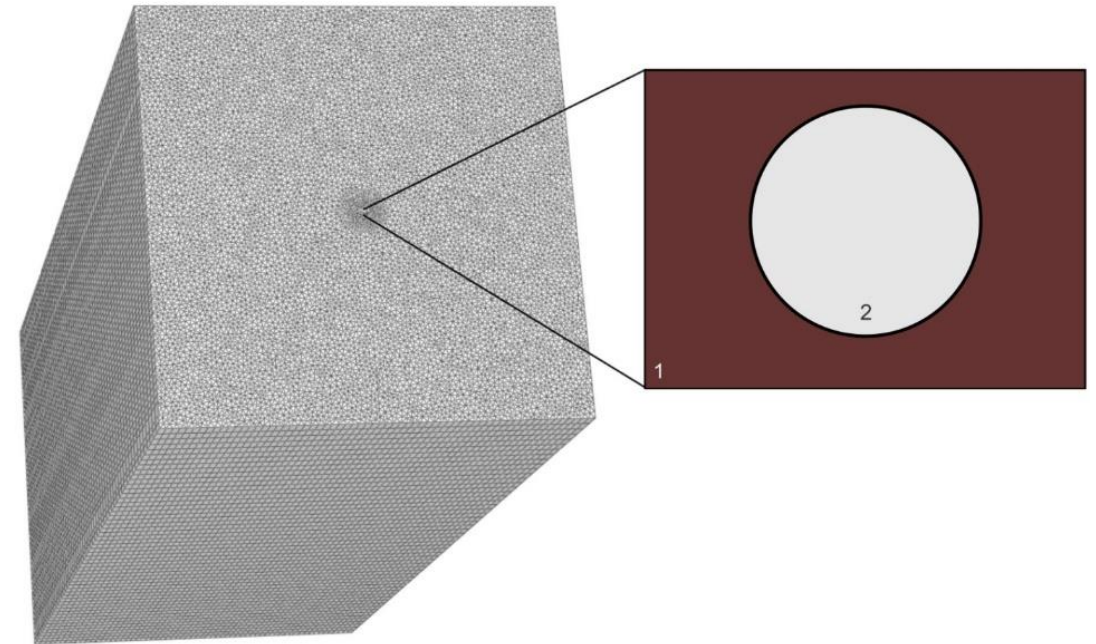


## COMPONENTS OF A BHE/MODEL

▷ subsurface

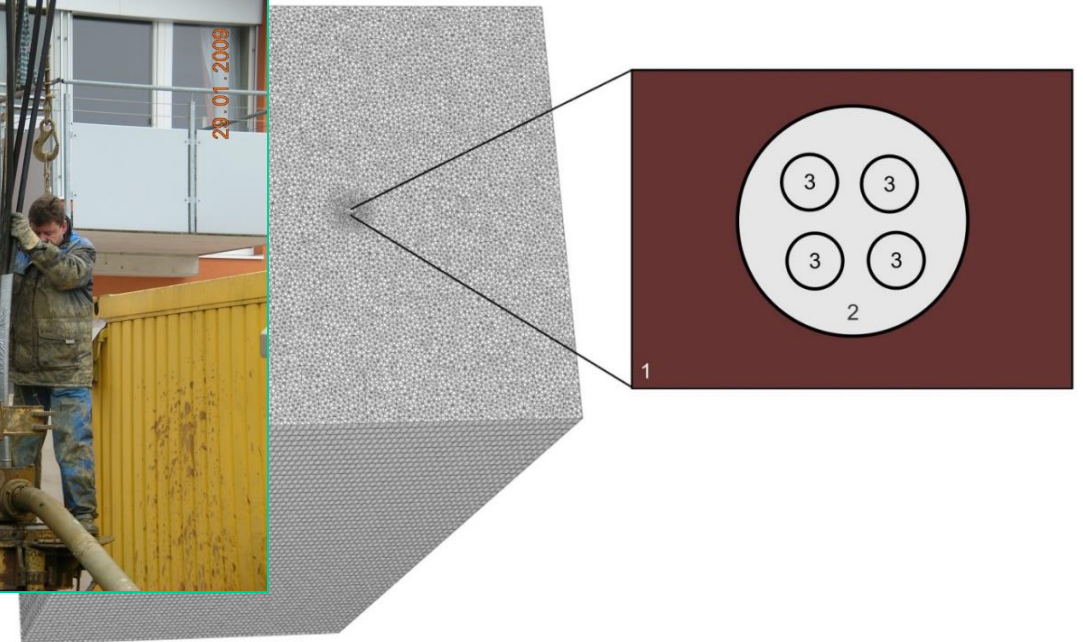
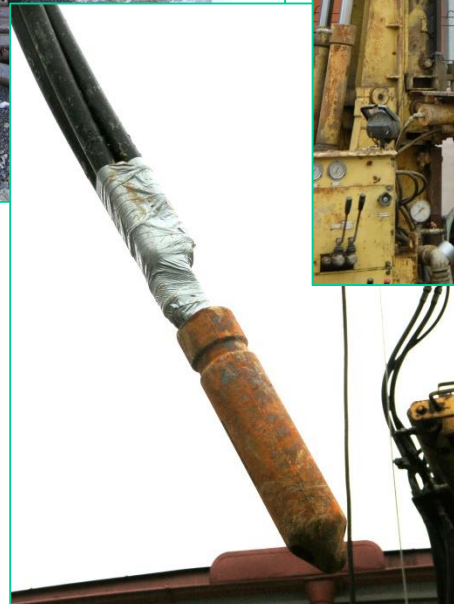
▷ borehole

- borehole diameter
- borehole geometry
- deviation



## COMPONENTS OF A BHE/MODEL

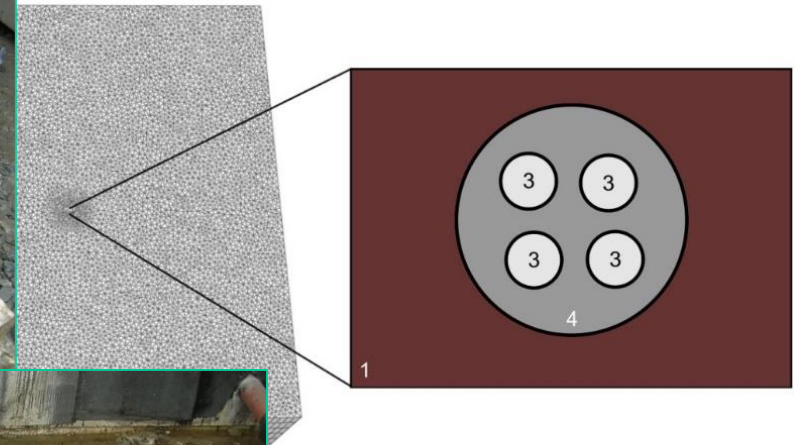
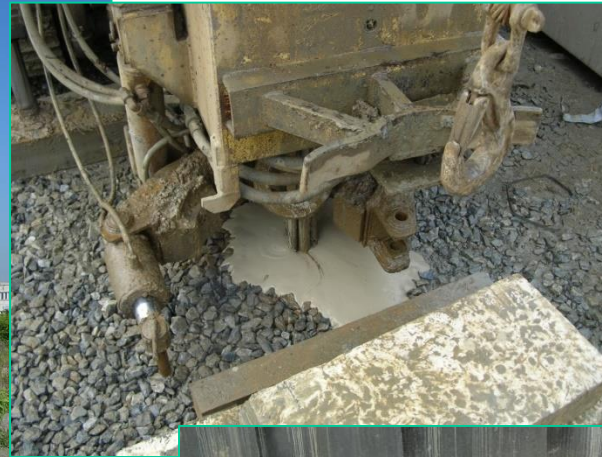
- ▷ subsurface
- ▷ borehole
- ▷ BHE-tubes





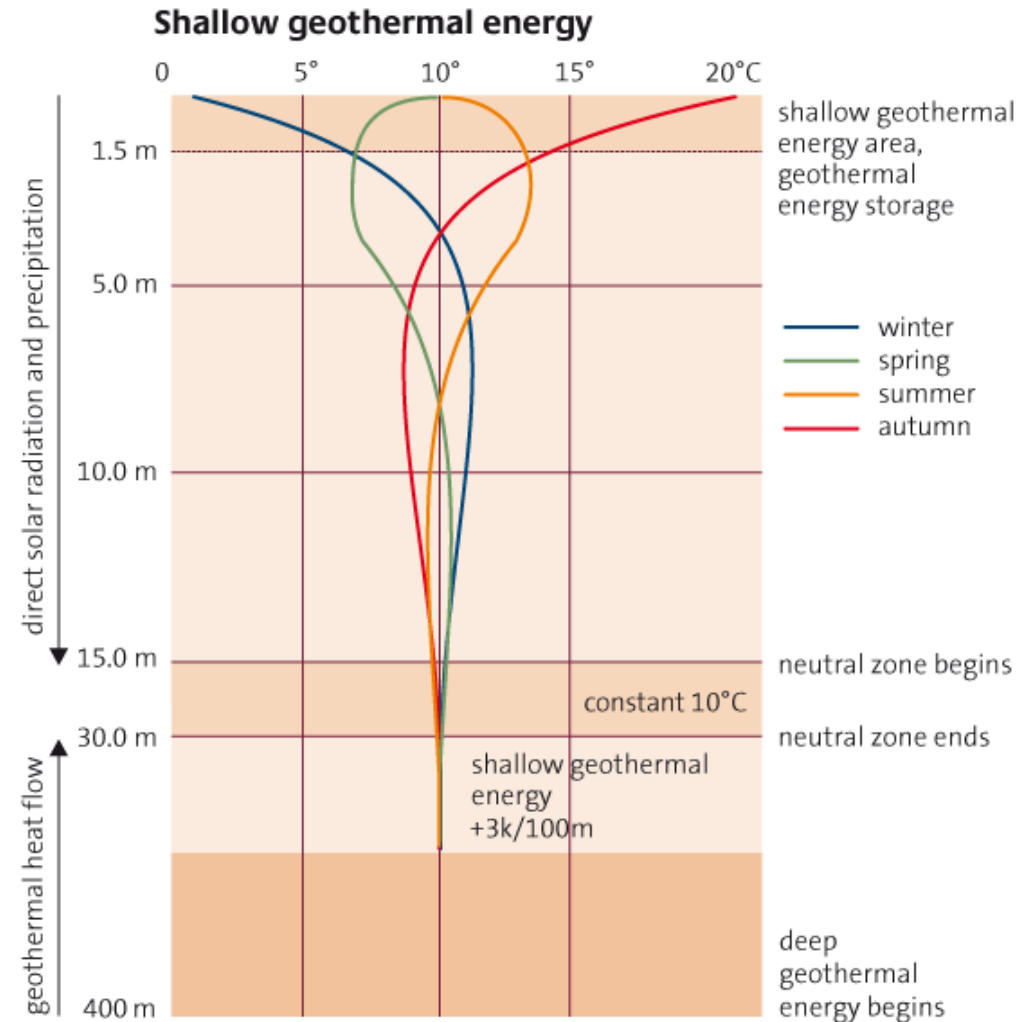
## COMPONENTS OF A BHE/MODEL

- ▷ subsurface
- ▷ borehole
- ▷ BHE-tubes
- ▷ grout
  - thermal conductivity
  - longterm stability



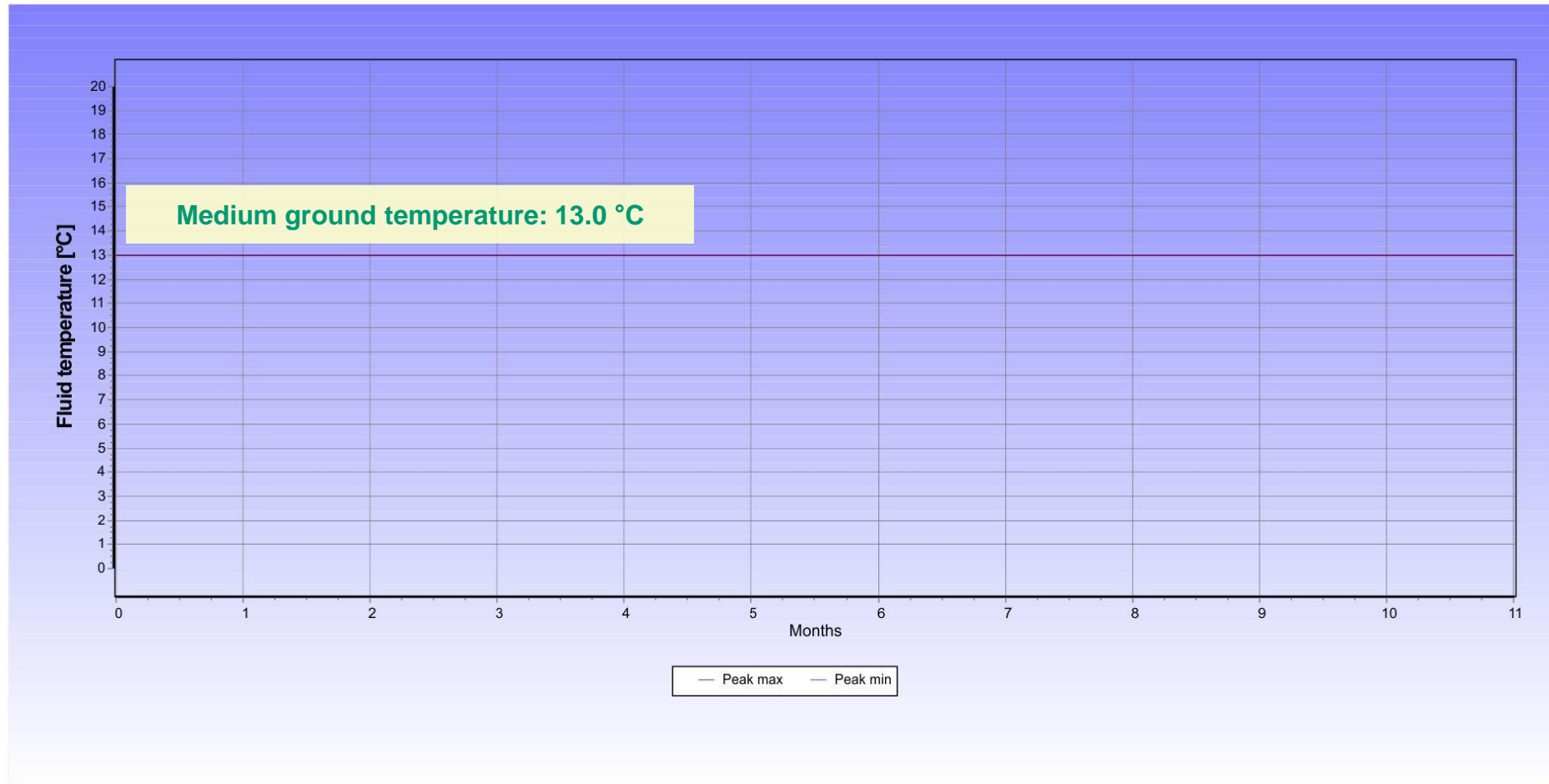
## EXPECTED BENEFITS OF ADDING PCM

- ▷ Ground temperature influenced from the surface up to 15 m
- ▷ Temperature of the neutral zone in non Alpine Regions in Austria: 9 – 10 °C



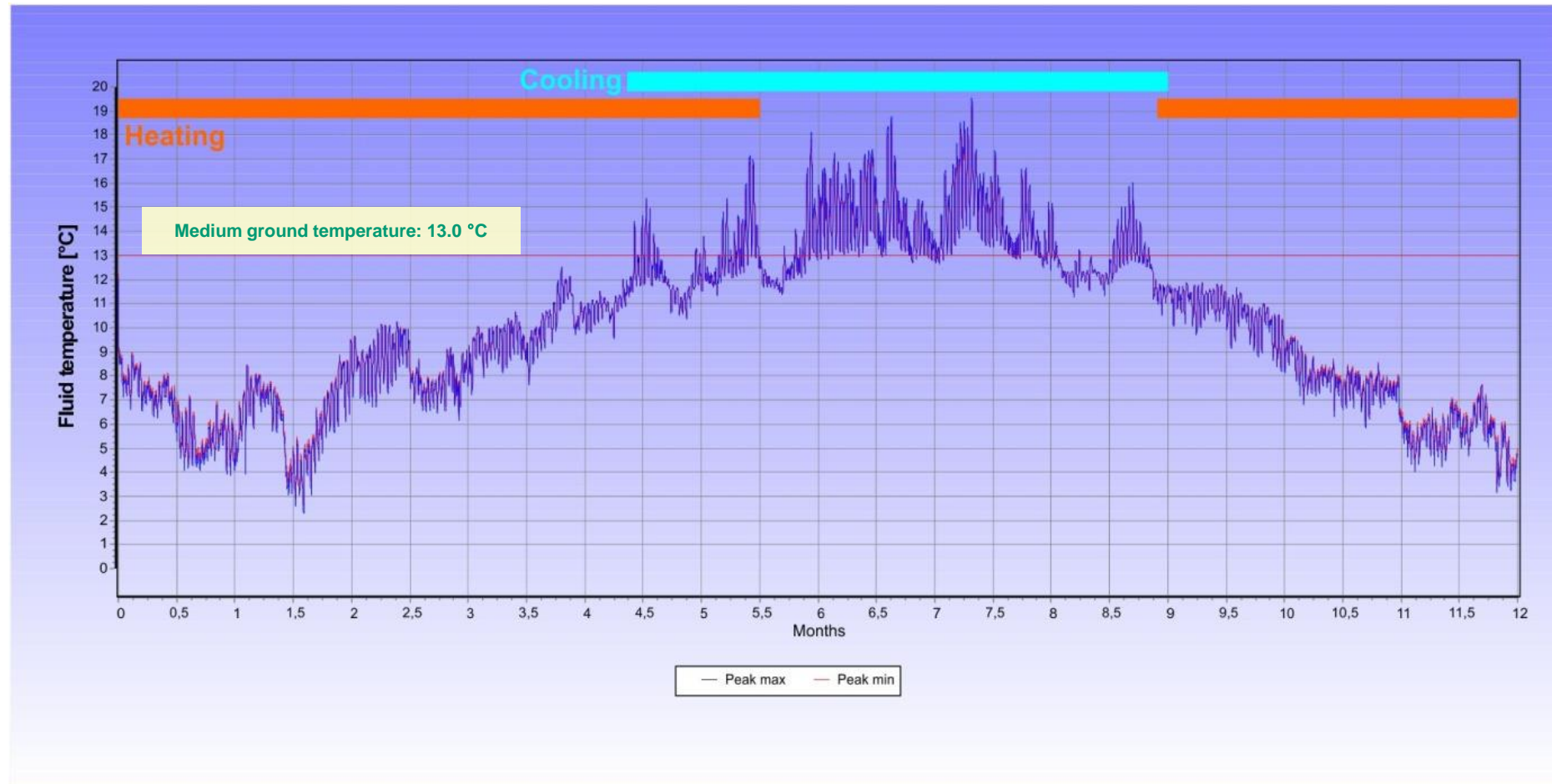
## EXPECTED BENEFITS OF ADDING PCM

▷ Medium fluid temperature (BHE 100 m deep) without load:



## EXPECTED BENEFITS OF ADDING PCM

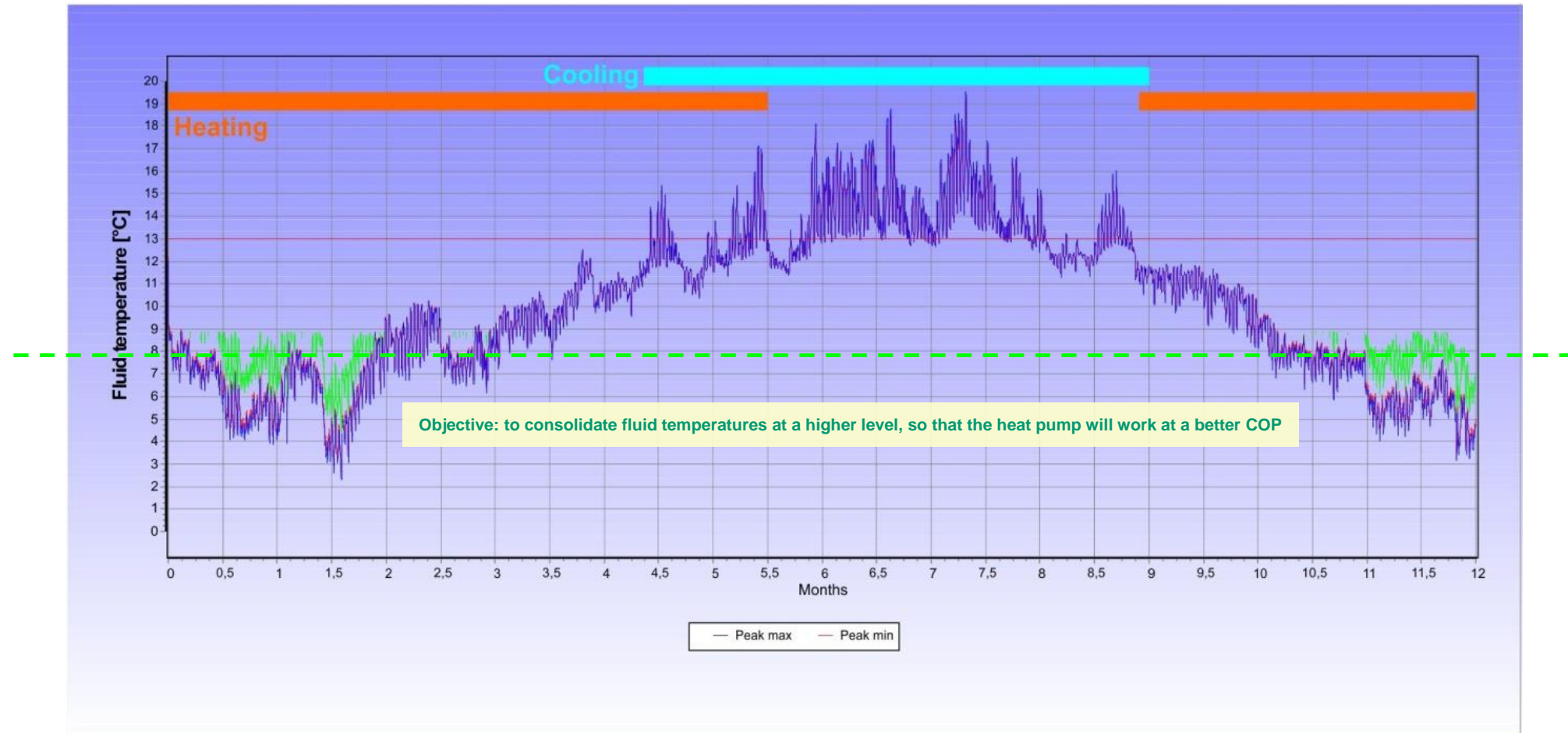
▷ Medium fluid temperatures for a typical year, heating and cooling load:





## EXPECTED BENEFITS OF ADDING PCM

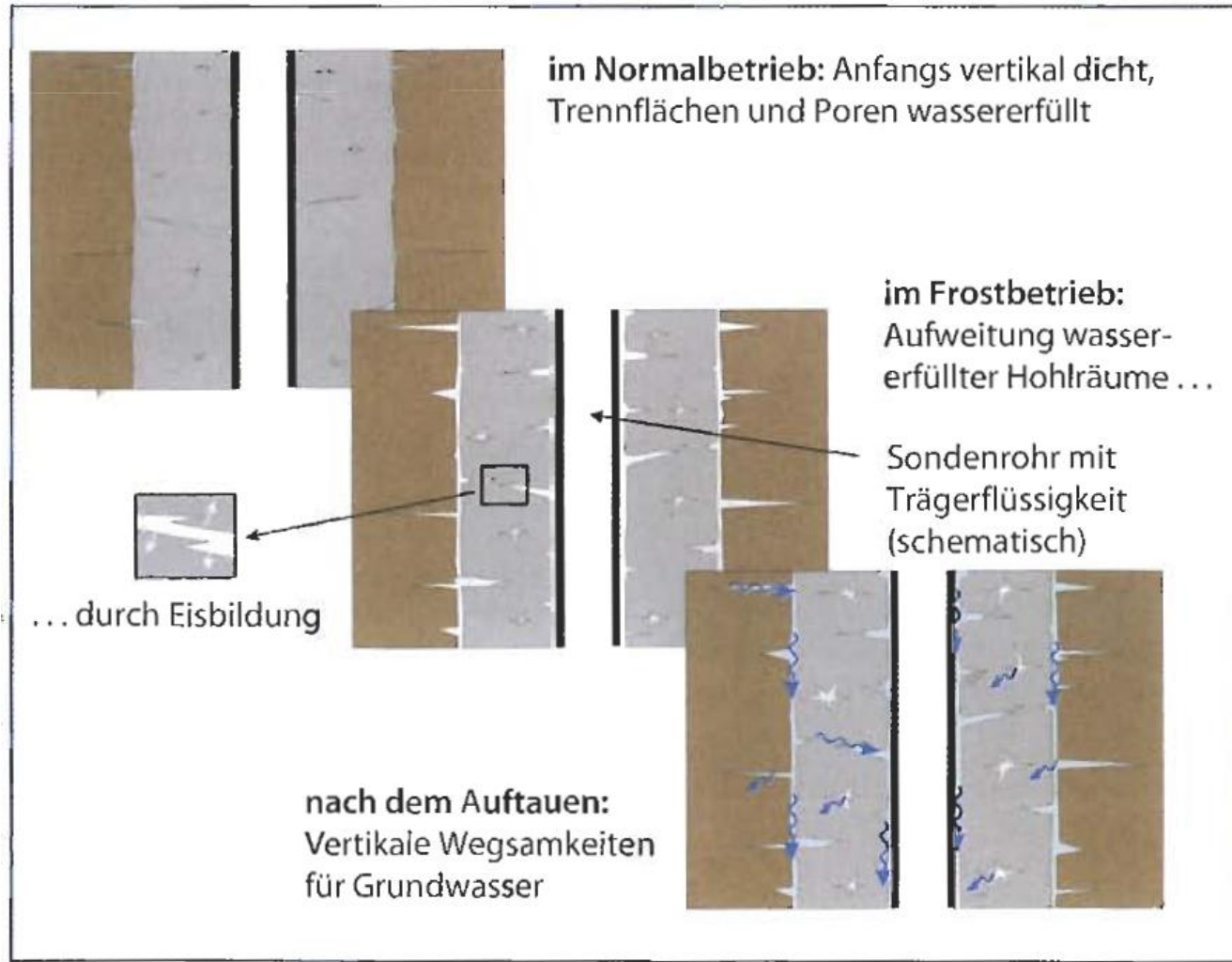
- ▷ Medium fluid temperatures within a year, with heating and cooling and PCM:



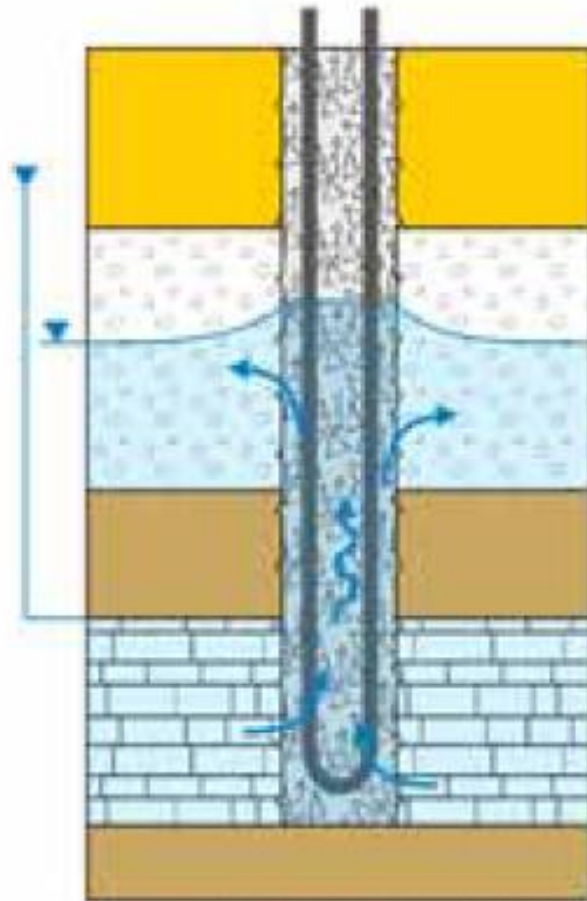
## LEGAL AND TECHNICAL ASPECTS

▷ PCMs must not affect:

- Grout (stability/permeability)
- Ground or Groundwater



Effect of frost-dew changes on the permeability of a BHE



Ascending fluids in the annulus  
of a BHE with inadequate grouting:  
The Staufen example  
Taken from I. SASS, 2009



## LEGAL ASPECTS

- ▷ The Austrian Water Law emphasizes the absolute priority of the use of groundwater for drinking water purposes above all other types of use: § 30: “In particular, ground water and spring water must be kept in a condition that allows the use as drinking water”.
- ▷ By the amendment to the water law of 2011 there is generally no requirement of an official approval of BHEs up to a borehole length of 299 m. However, in certain areas of particular importance to water management, the federal governments may prescribe a permit requirement, limit the drilling depth or even prohibit BHEs.
- ▷ The district, where the Austrian TESS<sup>E2</sup>B demonstration project is situated, is definitely free of any requirement for a water right licence. The obligation to comply with environmental regulations rests therefore with the plant designer.

## INVESTIGATED METHODS OF ADDING PCM

- ▷ Microencapsulated powder added to the grout

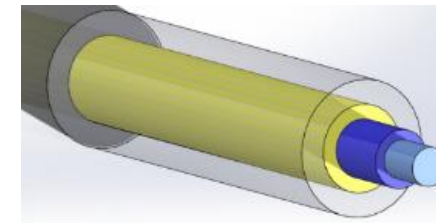
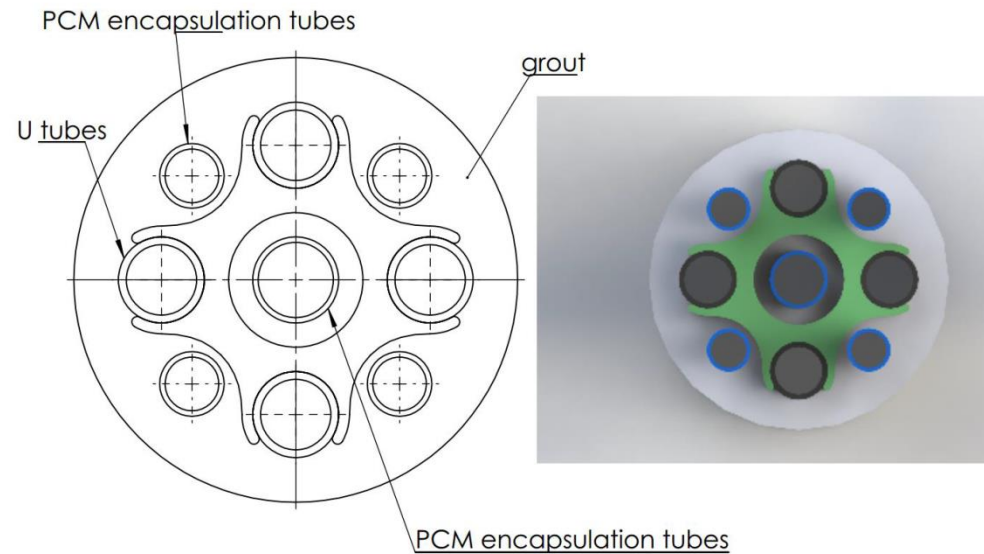


- ▷ First results:
  - 35 % PCM have to be added to the grout to be effective
  - BUT stability of the grout is affected

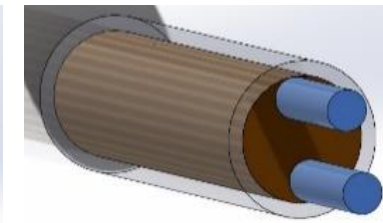


## INVESTIGATED METHODS OF ADDING PCM

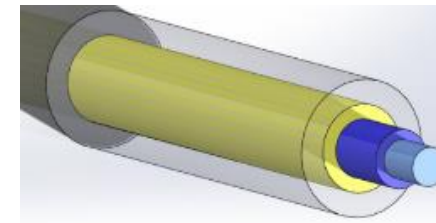
### ▷ Macroencapsulated PCM in tubes



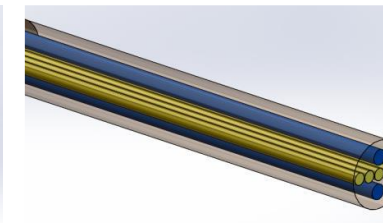
Coaxial - Interior Ring



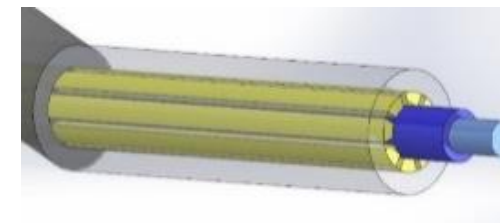
U-Tube with surrounding tube



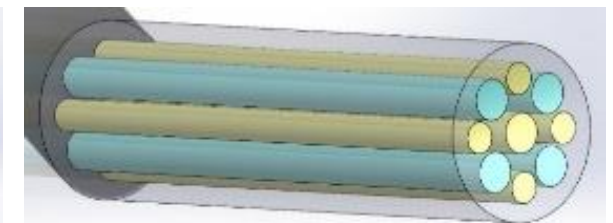
Coaxial - Exterior Ring



U-Tube with extra tubes



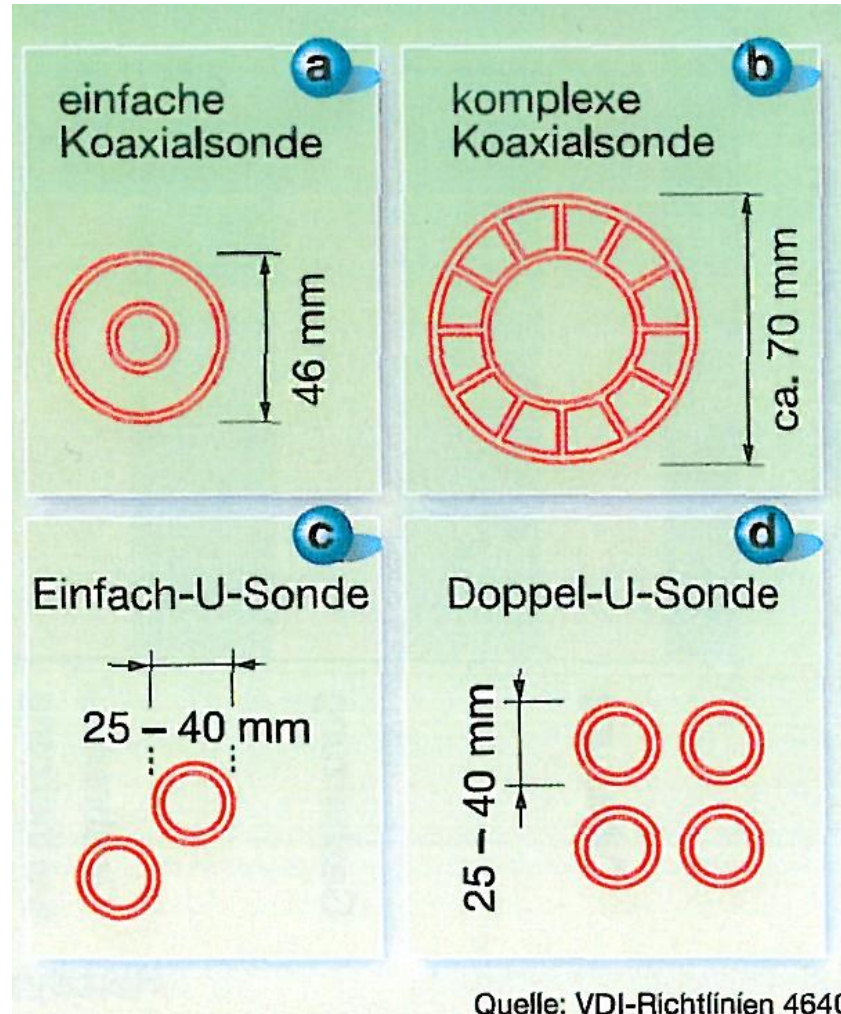
Coaxial - Exterior Ring with Fins



Double U-Tube with extra tubes

### ▷ Next steps:

- Computational Fluid Dynamics (CFD) simulation to determine the best solution
- 3D numerical simulation for optimisation, comparison with common BHE



Types of commercial BHEs  
Possibilities for encapsulating  
the PCMs





**TESS<sub>E</sub><sup>2</sup>B**  
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**Thank you  
for your attention**

**Thermal Energy  
Storage Systems**

for energy efficient building an integrated solution for residential building  
energy storage by solar and geothermal resources

