Large-scale heat storage – technological developments in Austria and internationally

Highlights of Energy Research 2021

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Why Large Thermal Energy Storages for District Heating?

Target for 100% renewable energy generation;

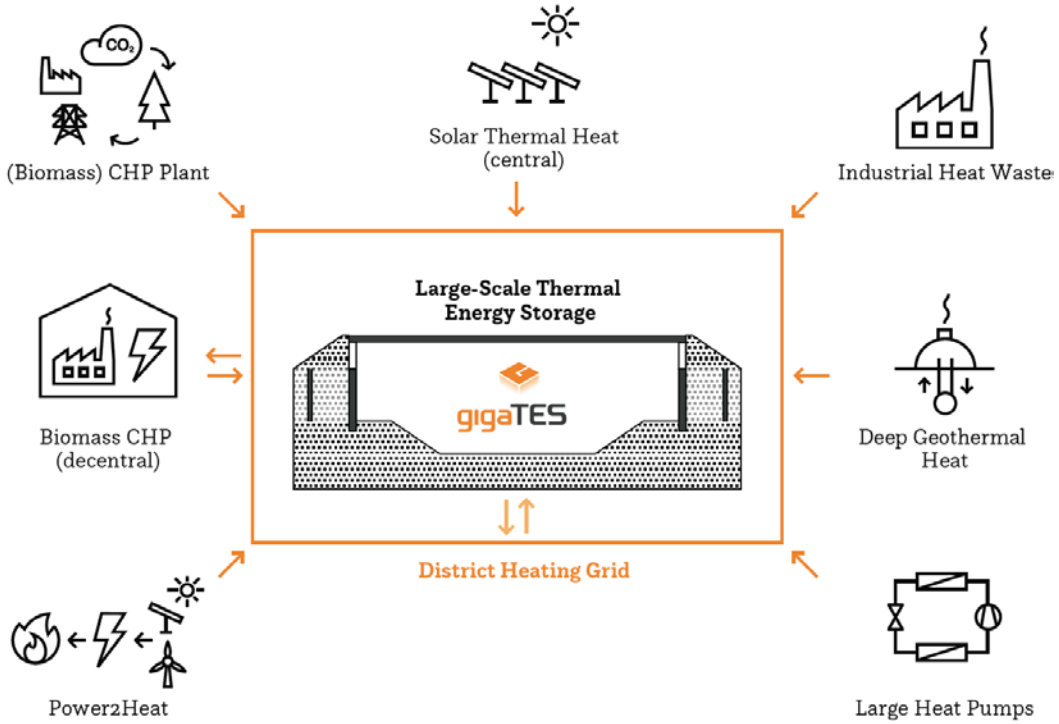
<u>LTES provide:</u>

- More flexibility in DH Systems
- Higher share of renewables and waste heat
- Peak shaving, P2H (sector coupling)
- Large variation of operational conditions:
  short term ⇔ long term
  middle size ⇔ very large DH system

<u>Larger storages are needed:</u>

To serve DH systems and other large applications

To further reduce specific costs



giga_TES: development of materials and concepts for giga-scale thermal energy storages

- Large thermal energy storages (LTES) for district heating (also enabling seasonal storage)
- At present LTES mainly realised in Denmark:

Source: Arcon-Sumark

Until now: ~200.000 m³ (Vojens, DK)

x10

gigaTES

Concepts up to 2.000.000 m³

– Transforming the technology from Denmark for application in Austria and Central Europe

powered by klima+ energie fonds

This project is funded by the Austrian Climate and Energy Fund in the framework of the Energy Research Program e!MISSION.at - Energy Mission Austria.

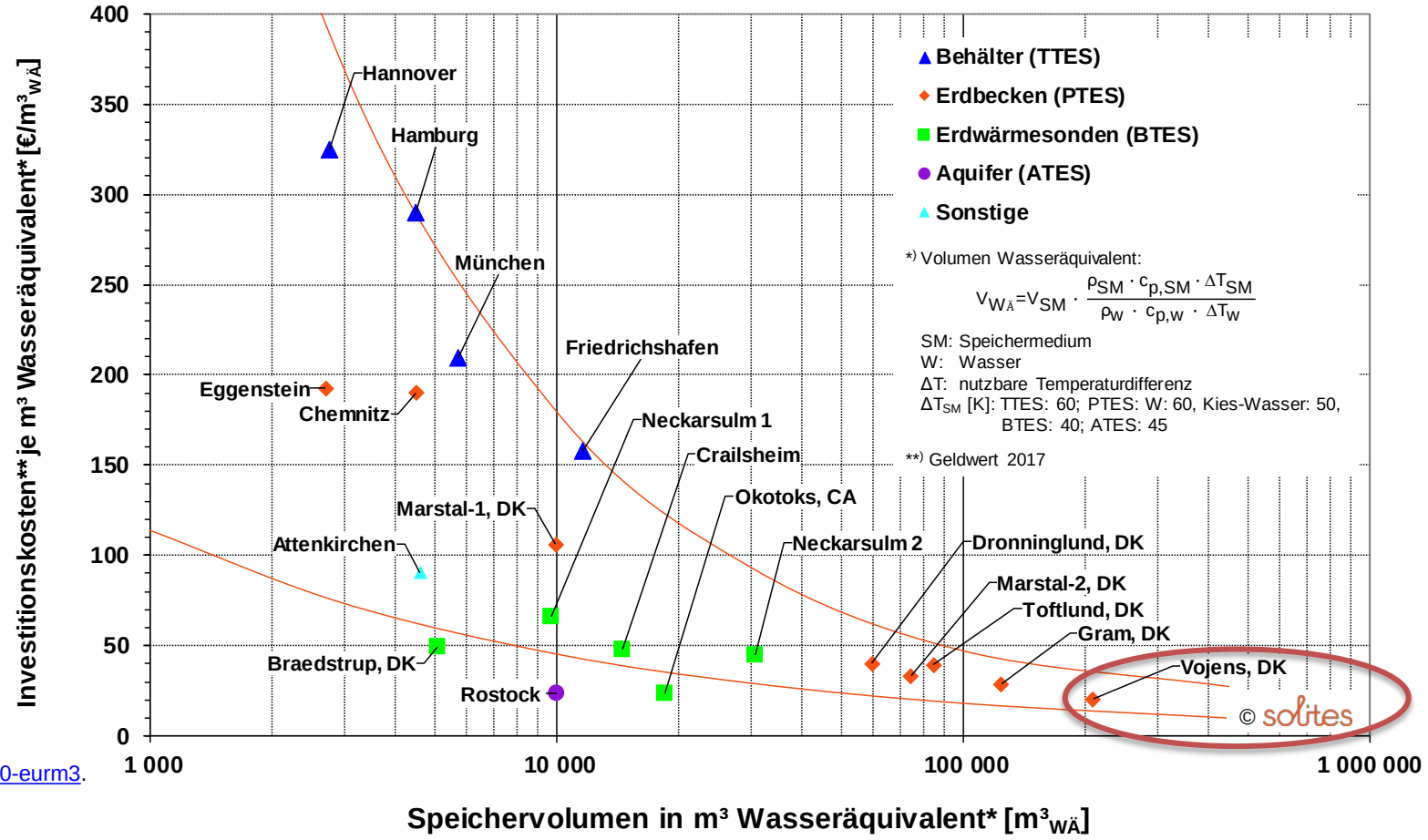
Large – Larger - Giga

- Seasonal storage requires low heat losses:
  with increasing volume, the specific heat losses decrease due to shrinking surface to volume ratio

- Storage has to be economically viable:

  Specific costs decrease with increasing volume

- Vojens, DK:
  ~24 €/m³ ≙ ~0,70 €/kWh
  (ΔT=30K)



Source: Epp, Baerbel. „Seasonal pit heat storage: Cost benchmark of 30 EUR/m³ | Solarthermalworld.org". *www.solarthermalworld.org/*, 17. Mai 2019. https://www.solarthermalworld.org/news/seasonal-pit-heat-storage-cost-benchmark-30-eurm3.

Project consortium

- Austrian flagship-project (01/2018 – 06/2021):

Industry

Geologie & Grundwasser GmbH
TB für Technische Geologie
WIEN ENERGIE
GVT Verfahrenstechnik GmbH
Salzburg AG
BILFINGER
ste.p
GABRIEL-CHEMIE GROUP
Metawell
metal sandwich technology
SOLID
solarinstallation+design
Solar energy systems
agru
Lenzing Plastics
PORR

Research

TU WIEN
smartminerals
science to design the future
AEE INTEC
JKU
JOHANNES KEPLER UNIVERSITÄT LINZ
universität innsbruck

Foreign expertise

PlanEnergi
solites

Development Challenges

- Build below groundwater level
- Build deeper (expensive cover can be smaller)
- Store at higher temperatures

  - Materials and constructions
    - To cope with higher temperatures (90-95 DegrC)
    - To provide water and water vapour tightness
    - To withstand mechanical stresses (through temperature change or geophysically)

  - Development areas:
    - Polymer materials
    - Concrete
    - Wall building constructions (materials – geometry – construction techniques)
    - Cover constructions (self-carrying, floating, submerged)

Large-scale heat storage

Technological developments in Austria

Josef-Dieter Deix
23.11.2021

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PORR is
Home of Construction

Focus on Building

We are and remain a construction company and build as much as possible ourselves.

One-stop-shop

From the idea, over planning, construction & execution to operation as a general or total contractor.

Building is a People Business

We build with and for people.

Pioneering Spirit

On the cutting edge for more than 150 years.

Technology Leader

We set new standards in the construction industry.

Sustainability

We take Sustainability Seriously

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giga-TES
research project 2017-2021

> 1.000.000m³ storage size

heat resistance up to 95°C water

innovative design ideas

interdisciplinary research consortium

investigation of several construction types

renewable energy, protection of storage environment

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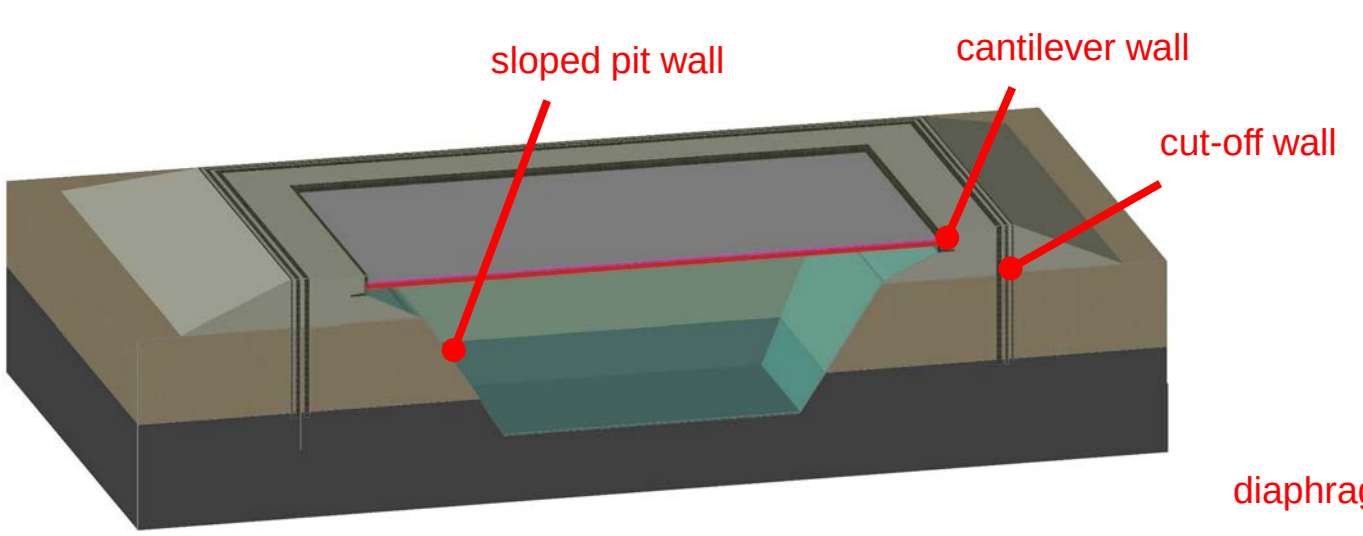
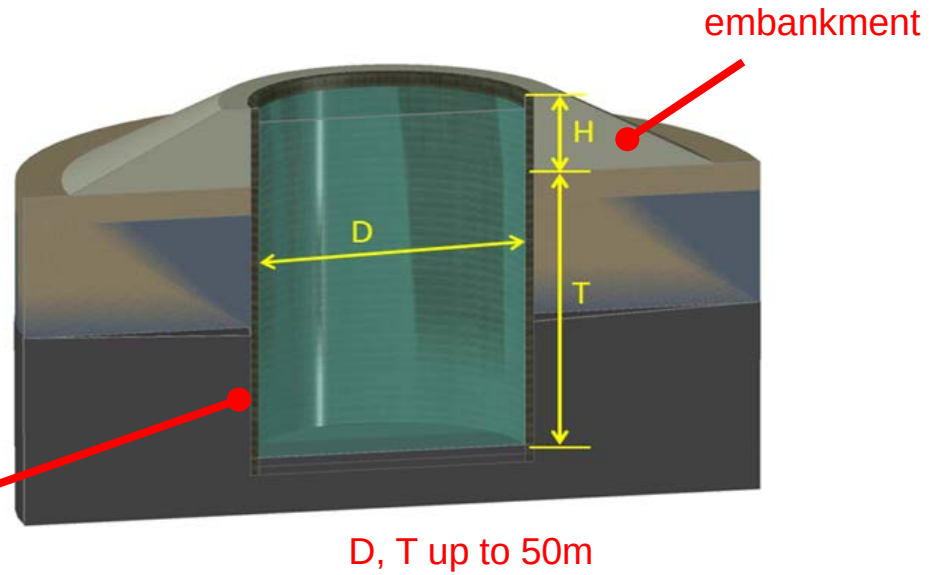
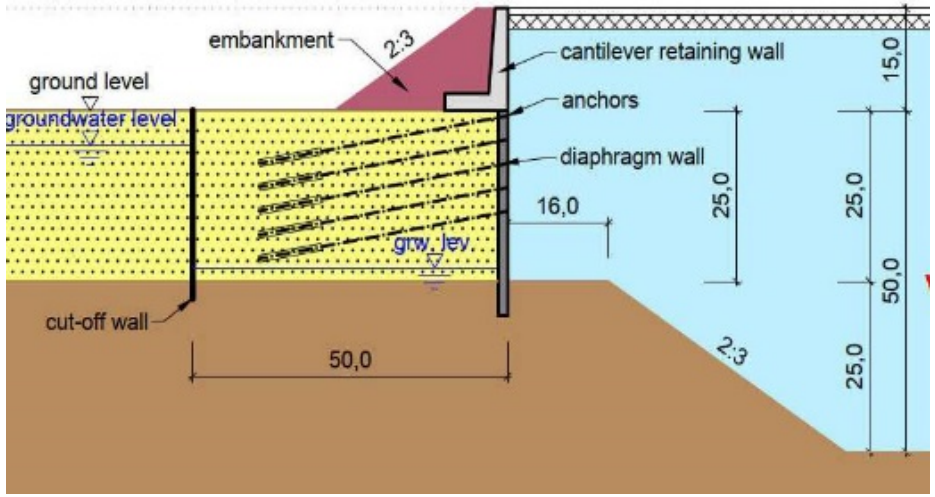
study of various construction types



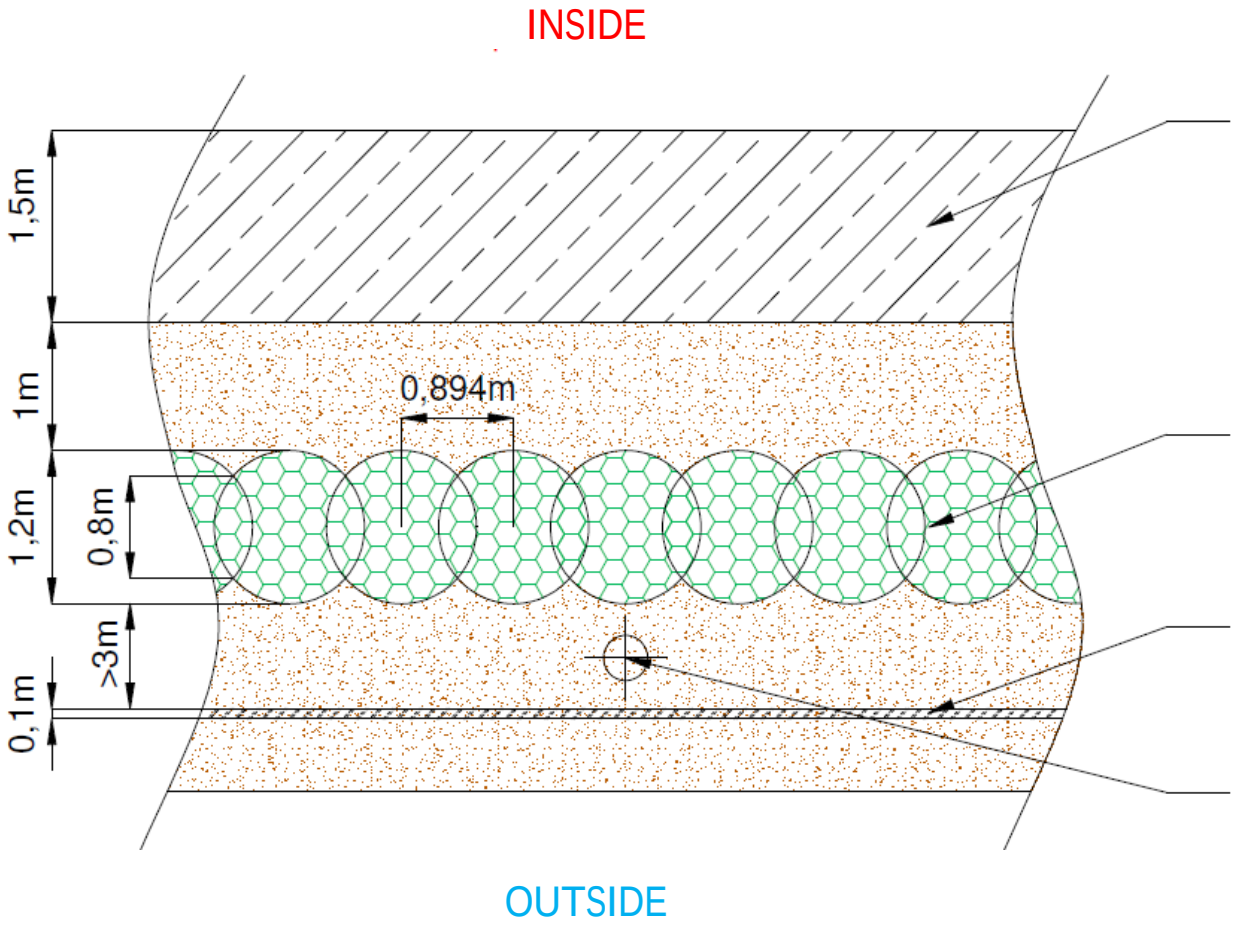


D, T up to 50m

- technical solutions
- static design
- cost estimation



insulating pile wall - patent



circular diaphragm wall (shaft)

Schlitzwandschacht

insulating pile wall (foam glass)

Dämmbohrpfahlwand

cut-off wall

Dichtwand

well

Brunnen

absolved on-site tests

- Insulating pile wall
  - *cement bonded insulating material*
  - *compacted insulating material*
- Heat resistant design of joints in diaphragm wall construction

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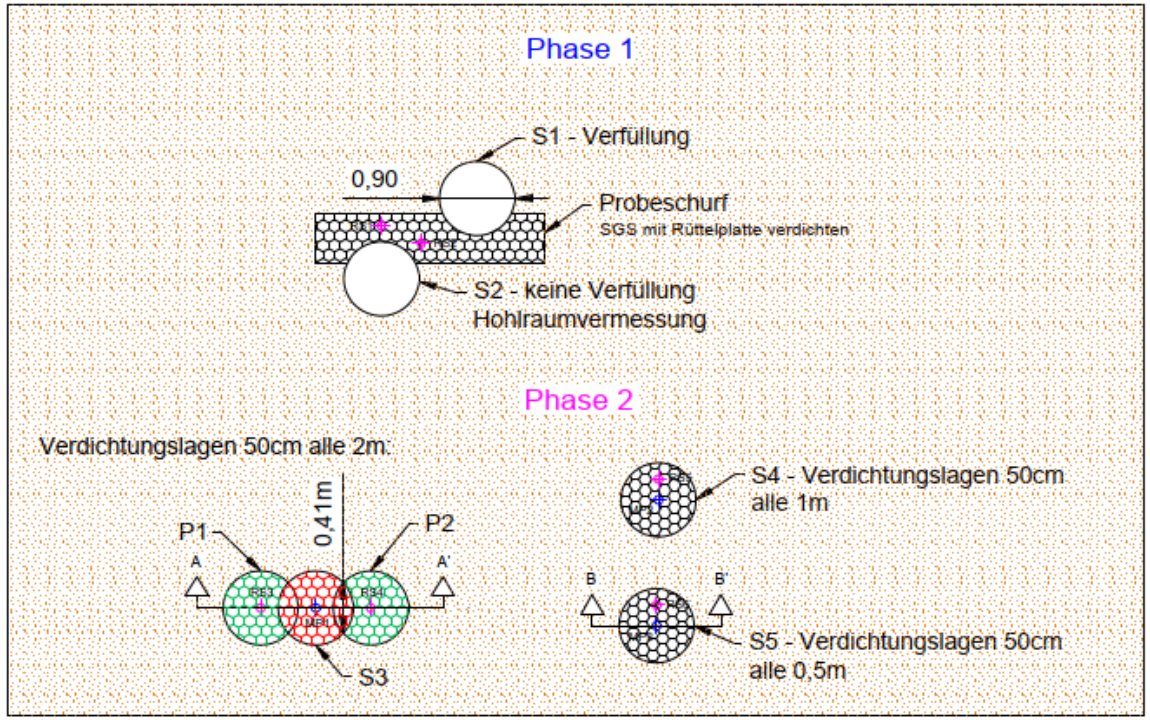
mock-up 1 and mock up 2: insulating pile wall



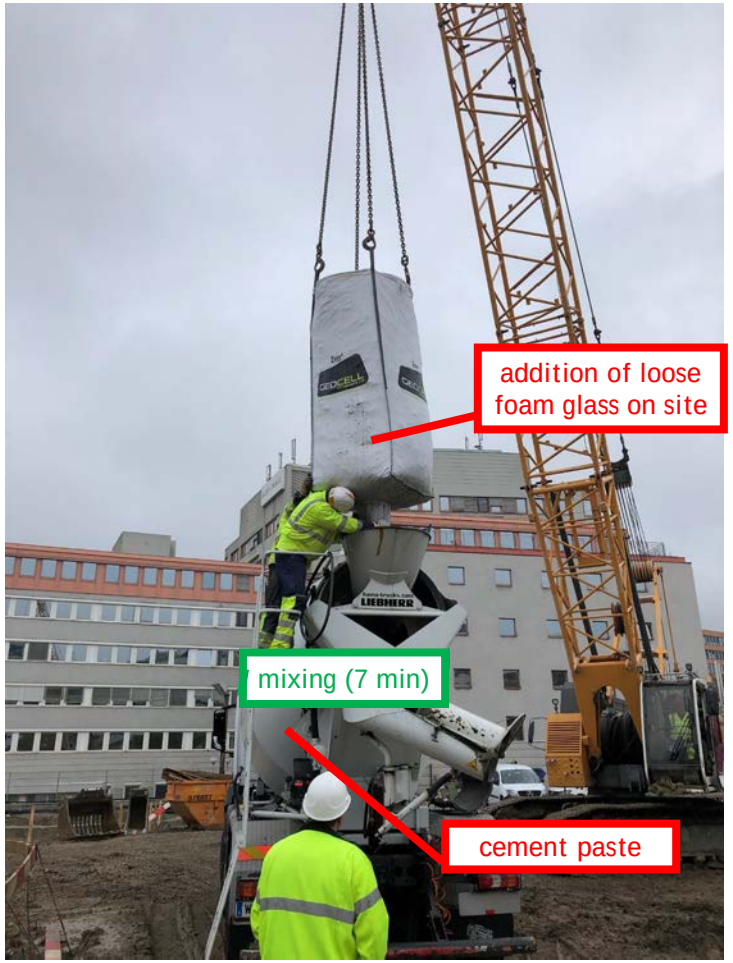
expected information about

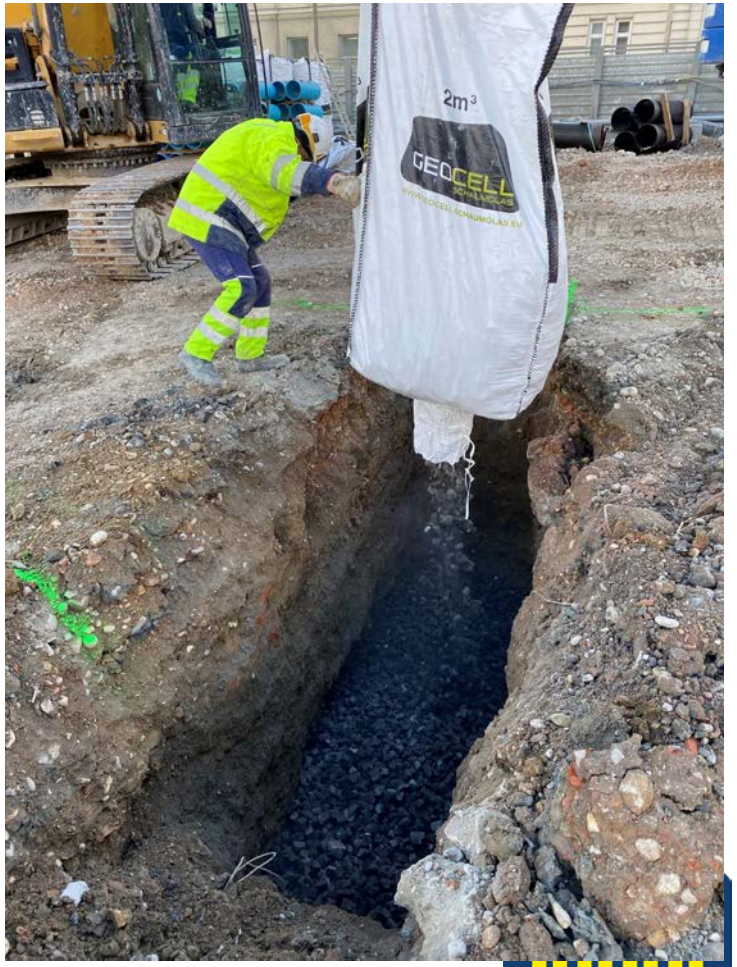
- handling with cement bonded and loose foamglass
- drilling properties
- stability of concrete bonded foamglass in the field
- no cement bonded material and compaction of foam glass to reach stability
- chemical analysis of excavation material -> dump category

mock-up 1 + 2: execution

casting

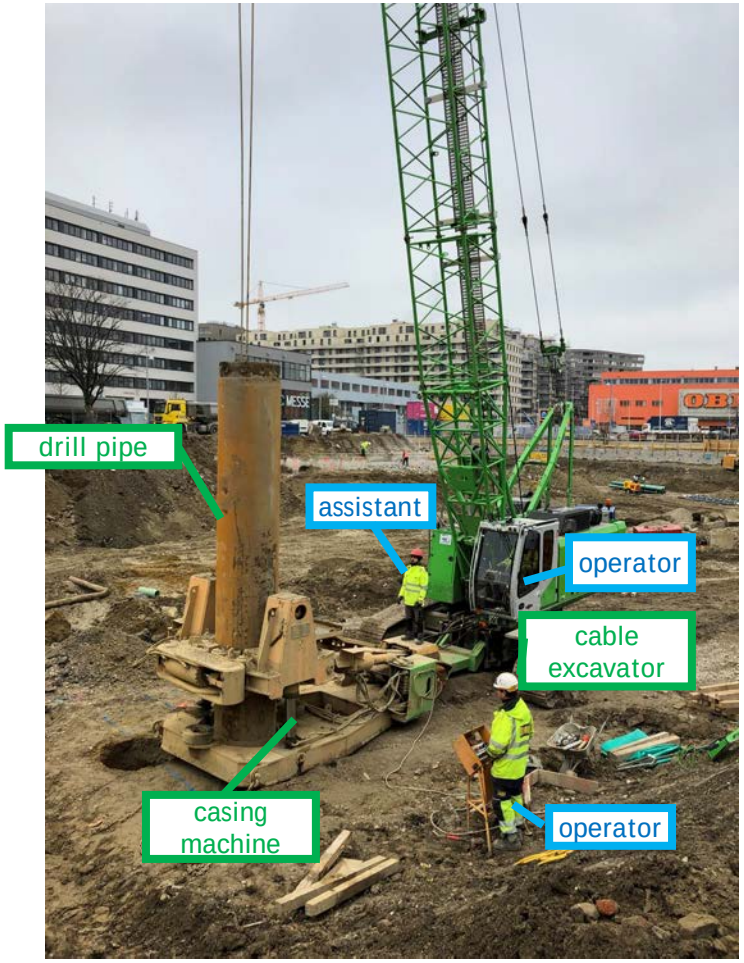
Betonage

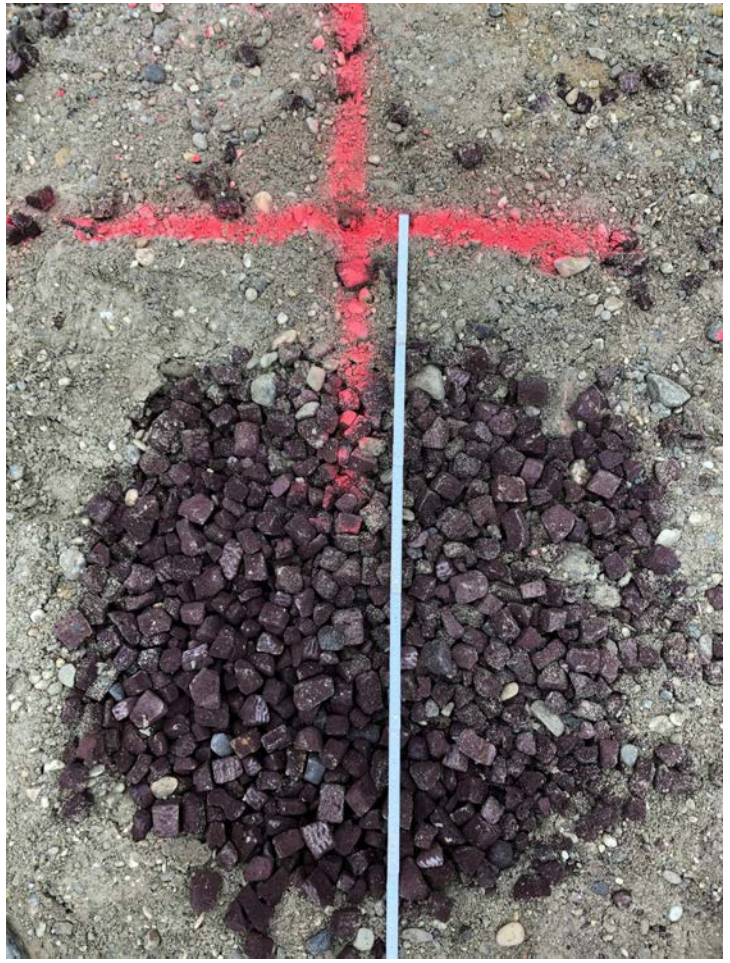


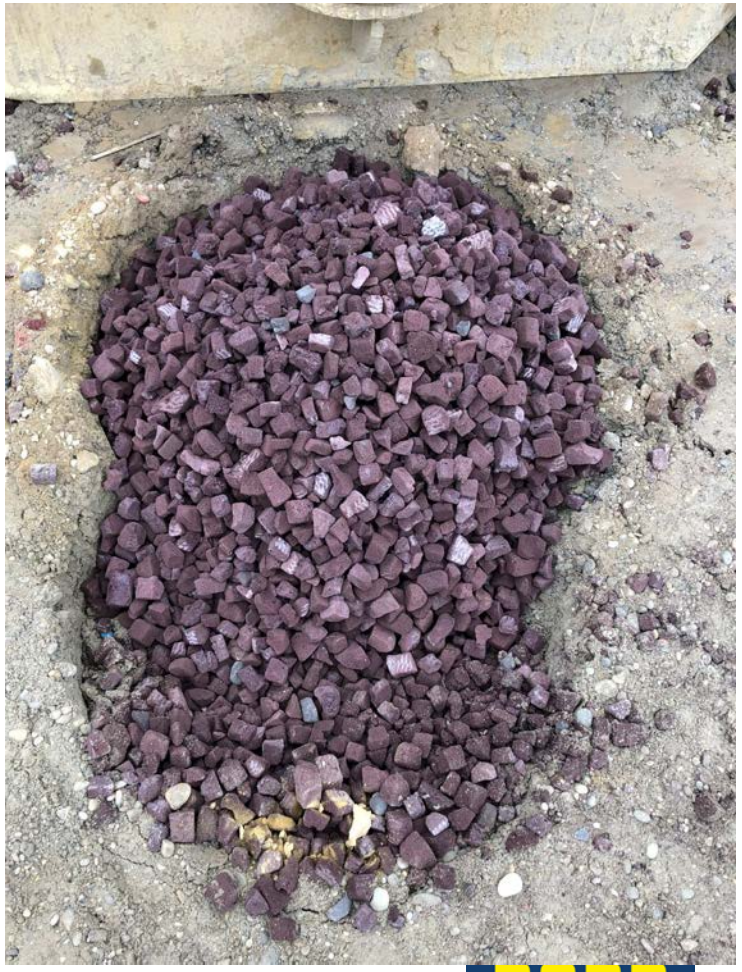


mock-up 1 + 2: execution

drilling tests

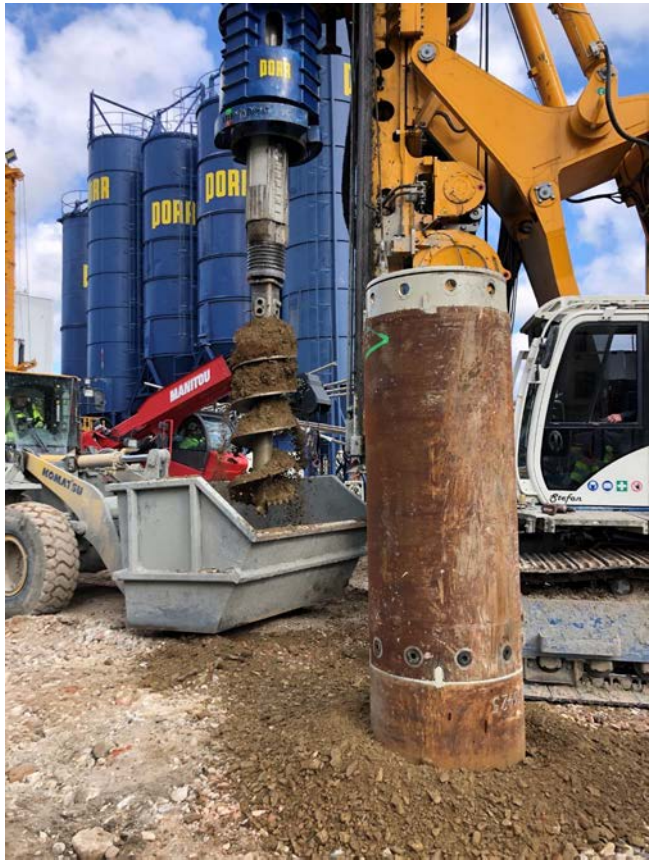




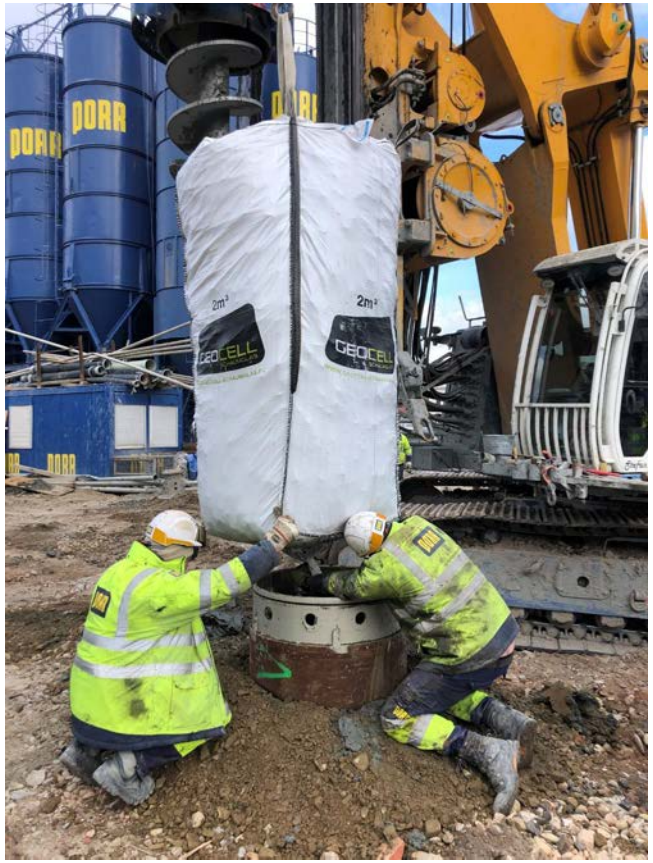


mock-up 2: pile construction

- **compaction layers**



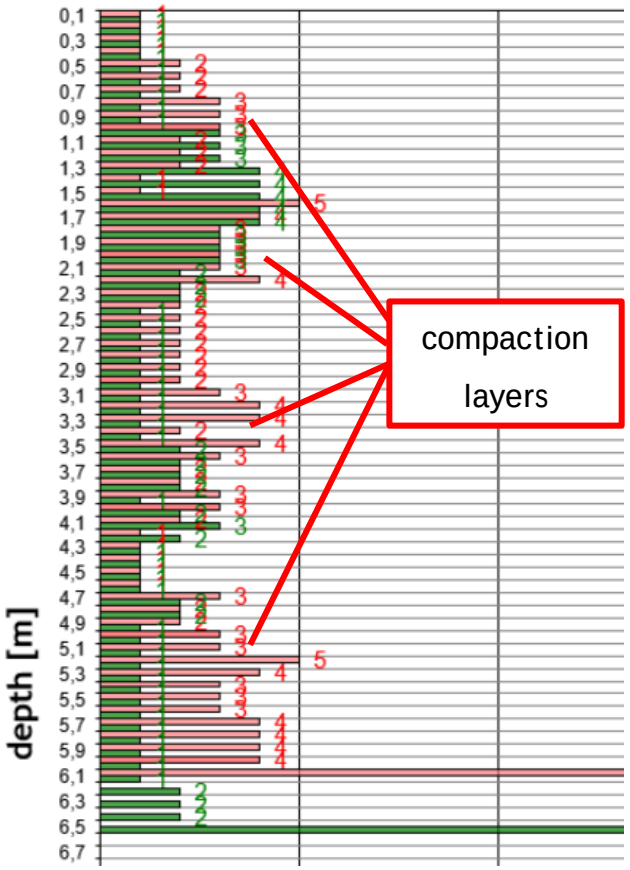
1. drilling



2. filling

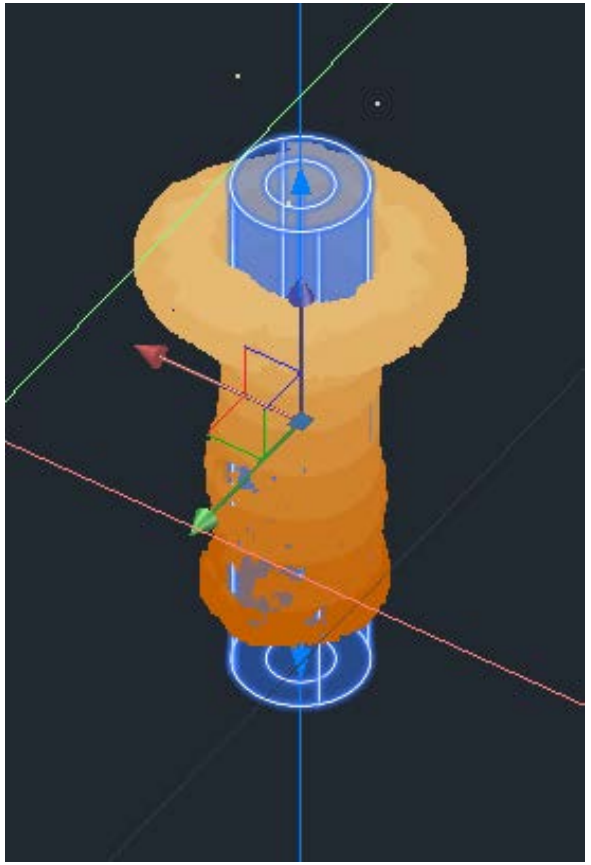
3. compacting

mock-up 2: in situ tests



ram penetrometer tests

borehole laser scanning



borehole laser scanning

thank you for your attention

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International developments for LTES

International Energy Agency

Technology Collaboration Programme on Energy Storage (ES TCP)

Task39 Large Thermal Energy Storages for District Heating

Started October 2020 – duration of 3 years

International experts to work on common goals

45 experts from 11 countries participate in the Task

IEA ES Task39 Goal:

Determine aspects important in

Planning – Design – Decision Making – Realising

of

Large Thermal Energy Storage for integration into District Heating (or industrial processes)

given

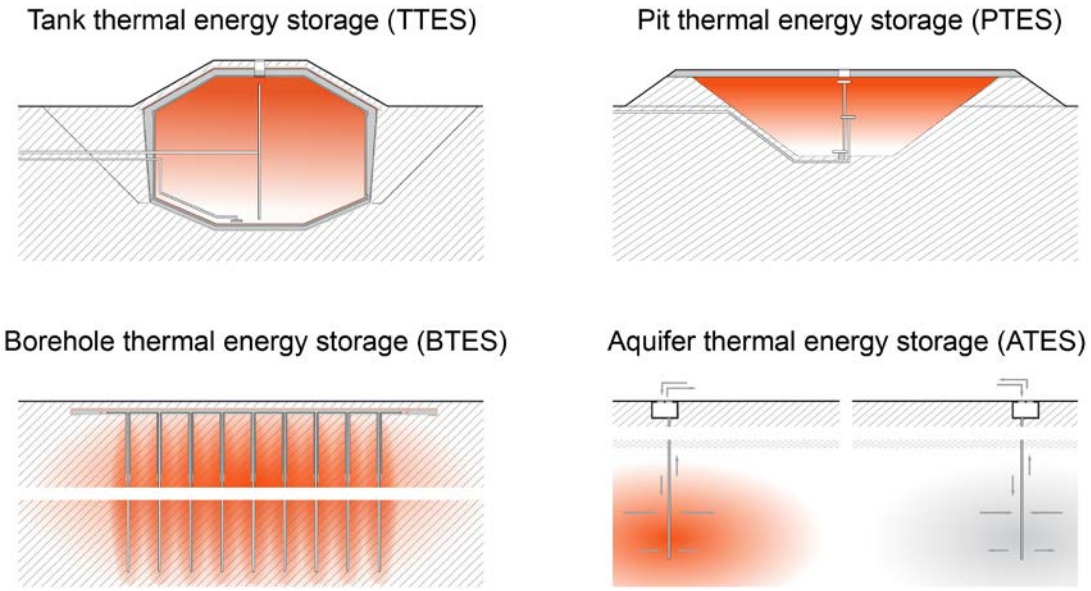
Boundary Conditions for different locations and different system configurations

Task39 Objectives

- Definition of a number of representative application scenarios, the connected boundary conditions and Key Performance Indicators
- Improve LTES materials and materials performance measurement methods
- Prepare guidelines for obtaining proper water quality
- Compare the performance and accuracy of simulation models for LTES
- Derive validation tests for LTES simulation models
- Generate and disseminate decision makers information packages

Scope

- 4 types of storages are considered:
  - Pit Thermal Energy Storages (PTES)
  - Tank Thermal Energy Storage (TTES)
  - Aquifer Thermal Energy Storages (ATES)
  - Borehole Thermal Energy Storages (BTES)
- Water or soil is the storage medium



- The (water equivalent) volume typically larger than 50,000 m^3, (for tanks and slightly over-pressurised storages possibly much smaller)
- The storages are applied in district heating systems or in industries
- Seasonal storage, daily storage and multifunctional storage will be included
- Dissemination is targeted to decision makers in policy, municipalities, utilities and DH heating companies

Some example developments

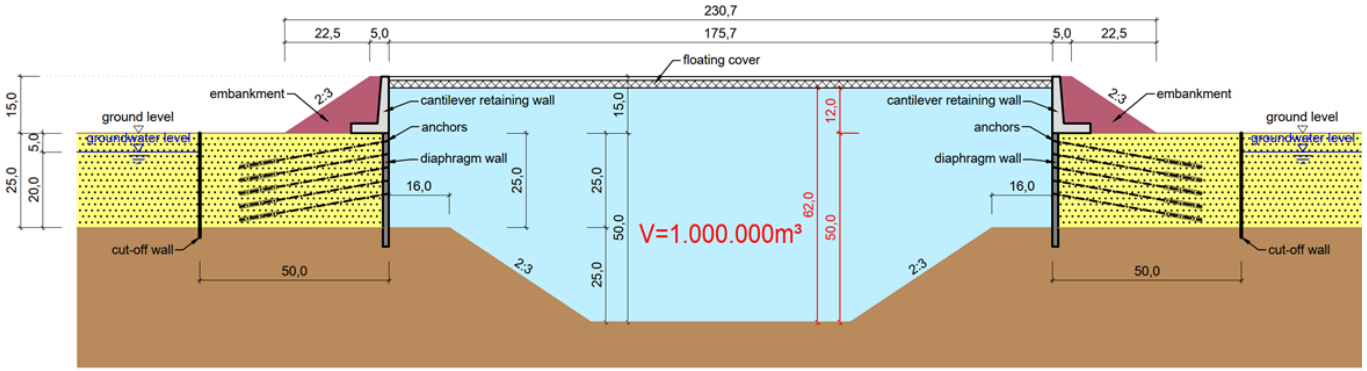
giga_TES

Austrian Flagship project

Different concepts

Materials development

Integration, costs



Source: Step

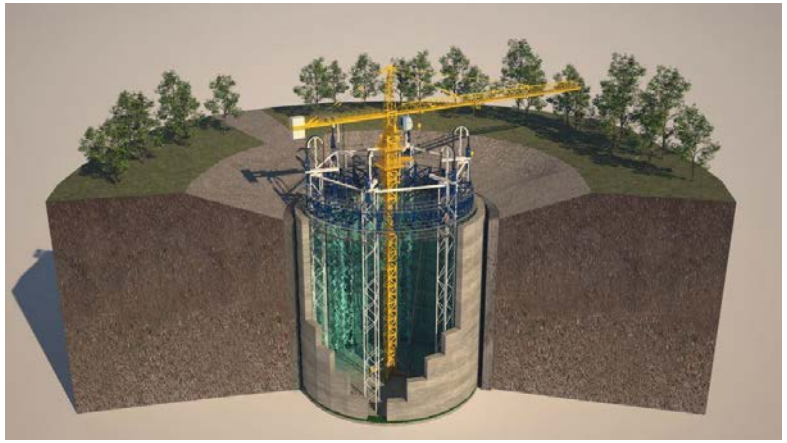
Ecovat

Dutch manufacturer

Underground concrete cylindrical storage

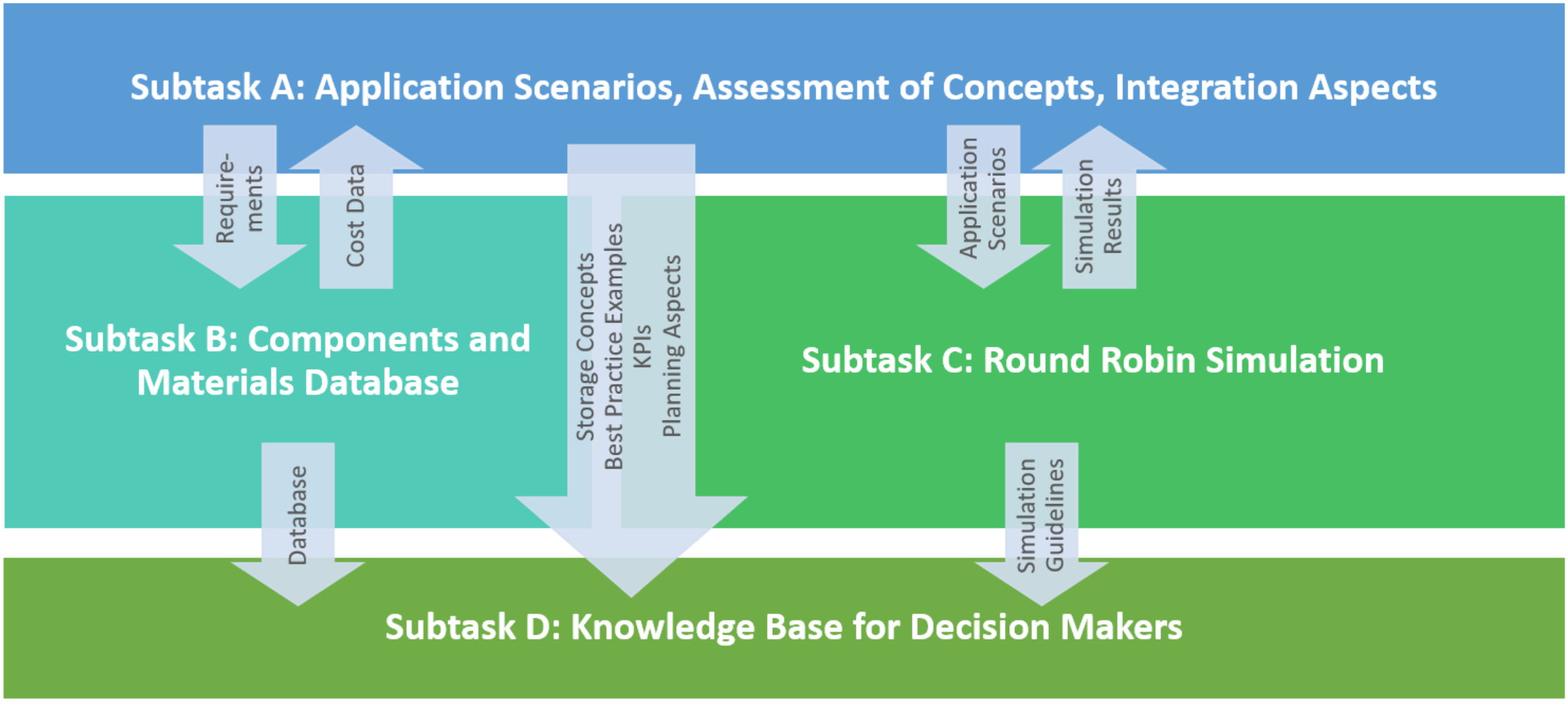
Series production

Up to 90,000 m^3



Source: Ecovat

Subtasks and their interdependencies



Next steps in Task39

- Numerical simulations round robin starts this winter (21 institutes will collaborate in this
- Questionaire to stakeholders on stakeholders information needs
- Concept for material database

- Next experts meeting 8 April 2022 in Graz, Austria.
- https://iea-es.org/annex-39/

Giga_TES Webinar

For more detailed information on the achievements of the giga_TES project:

- Final webinar in German
- Tuesday, 30 November
- 9:30 – 12:30 CET
- https://www.aee-intec-events.at/webinargigates.html

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IDEA TO ACTION

Your reaction is welcome

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