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gigaTES

Giga-Scale Thermal Energy Storage for Renewable Districts

Fachforum Thermische Energiespeicher
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Objectives

Generate knowledge on materials and technologies, with which dedicated concepts for large scale TES for district heating can be designed, that:

- Provide cost-effective solutions for thermal storage
- Are integrated in the urban environment
- Provide more storage capacity
- Are energetically efficient
- Are well integrated in the overall district heating system
- Have long lifetime

Acknowledgements: The research leading to these results has received funding from the Austrian FFG Programme Energieforschung under project no. 860949.

Project Consortium

Industry

- PORR
- AGRU
- VAM
- SOLID
- Ste.p
- GVT
- METAWELL
- Geologie und Grundwasser
- Gabriel Chemie
- Lenzing Chemie
- Wien Energie
- Salzburg AG

Research

- AEE INTEC
- UIBK
- Johannes Kepler Universität Linz, IPMT
- Smart Minerals
- PlanEnergi (Denmark)
- SOLITES (Germany)

Total cost: 4.4 M€

Funding: 3.3 M€

Duration: 36 Months

Motivation

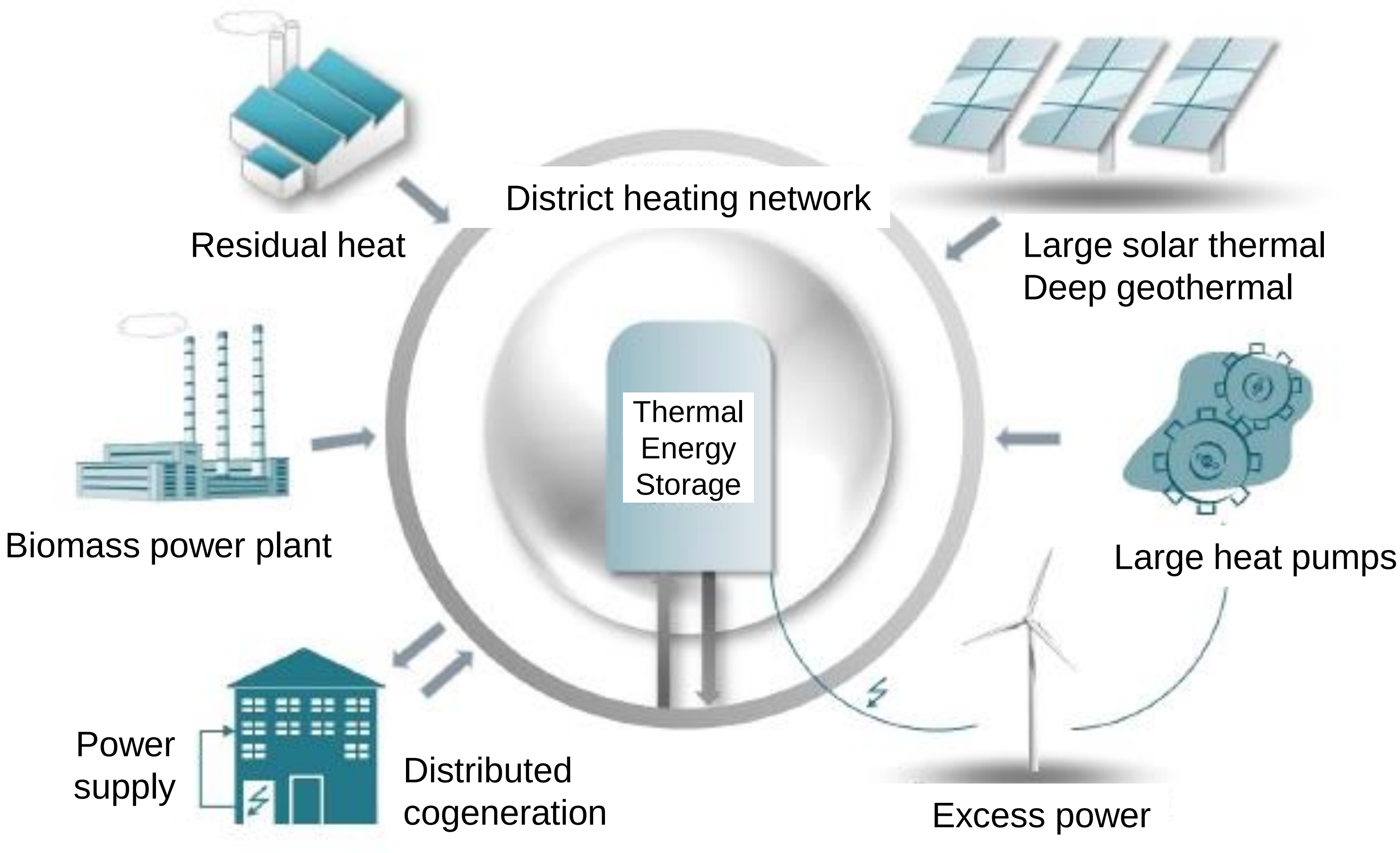
CO_2 – emissions to zero

40% of primary energy is for heating, large part through District Heating and Cooling (DHC)

Long-term international goal: switch to 100% renewables, including renewable heat

Large scale Thermal Energy Storage (TES) provides the required flexibility

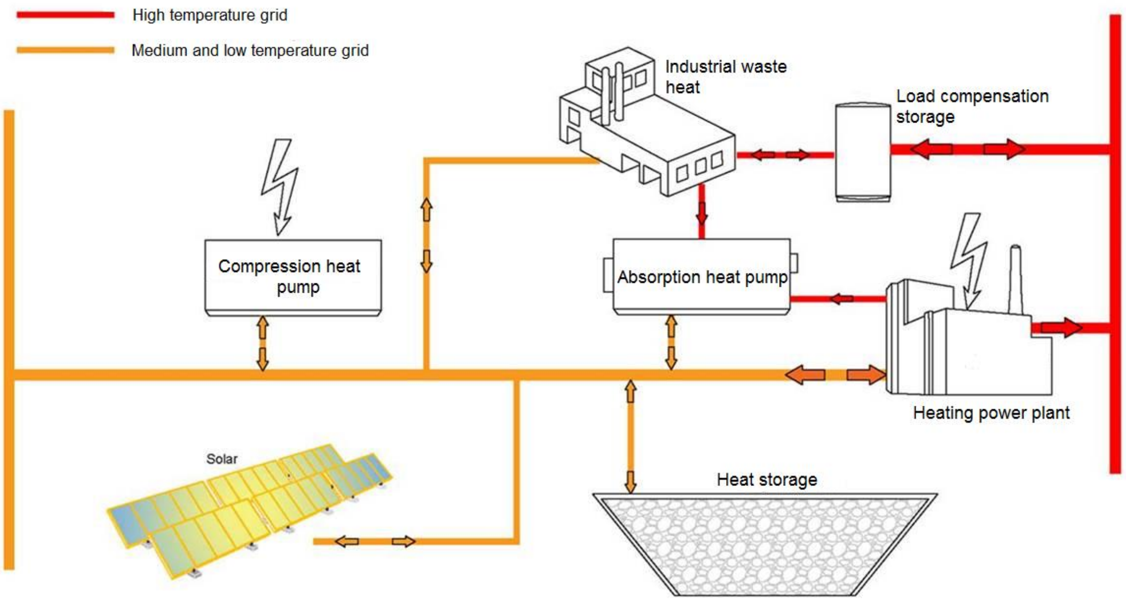
Large storages are central for system integration possibilities



Source: Studie Fernwärme 3.0 / Strategien für eine zukunftsorientierte Fernwärmepolitik

Integration of TES in District Heating Systems

- Multi-functional storage design for different combinations of:
  - Charging (base load / peak shaving)
  - Storage period (short / medium / long - term)
  - Discharging (base load / peak shaving)
  - Integration of waste heat / CHP / solar collectors
  - Integration of Power-to-Heat
- Interplay with various sources / sinks and interests
- Maximum integration of renewable energy at minimum costs



State of the art: Pit Storages

gigaTES

Volumes up to 200.000 m^3

Most experiences in Denmark

Eggenstein (D) 2007: 4.500 m³

Source Mangold, 2011

Marstal (DK) 2012: 75.000 m³ Water

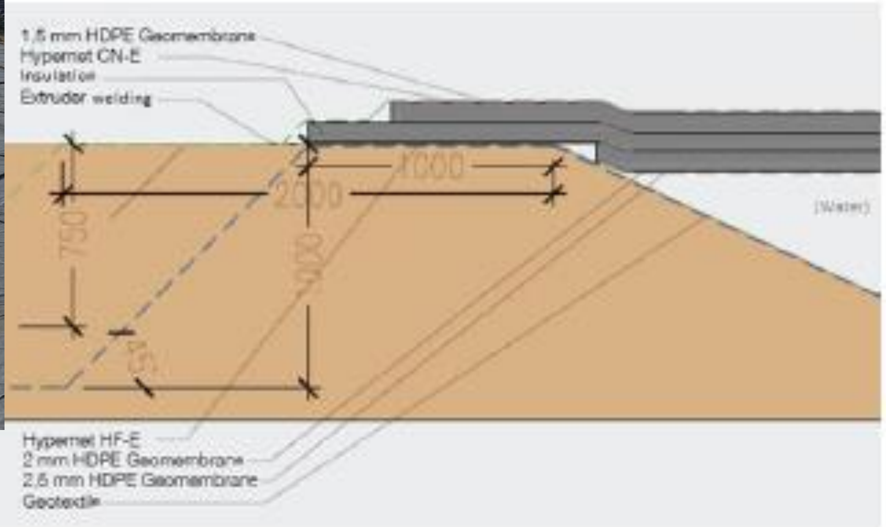
Source: http://www.sunstore.dk/

Experiences in Denmark

- 2012 Dronninglund (75000 m³)
- 2013 Marstal (69000 m³)
- 2015 Gram (122000 m³)
- 2015 Vojens (195000 m³)

  - commercially viable

Source: PlanEnergi



State of the art: Tank and Concrete storages

Tank: up to 50.000 m³
practical experiences

DH TES Theiß:
50.000 m³ Water
(former oil tank)

Source: Bilfinger VAM Anlagentechnik GmbH, 2013

Salzburg Nord:
29.000 m³

Concrete:

Segmented and solid

Above and underground

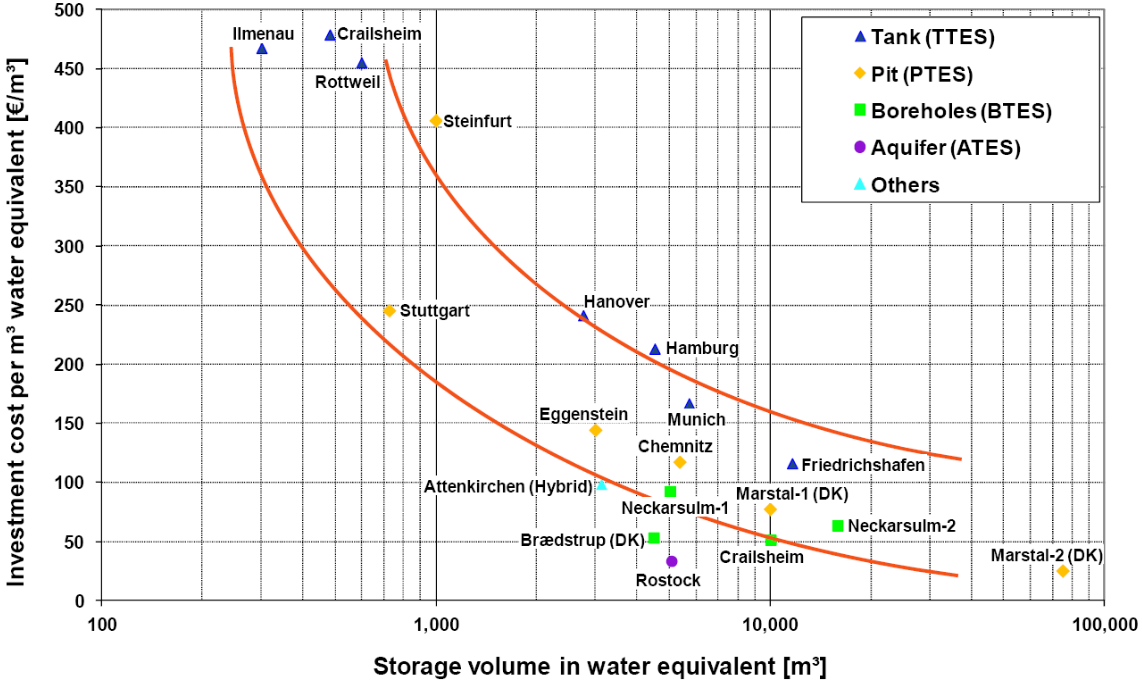
Source: Mangold, 2011

Large Thermal Storages
Impression of dimensions

Example from Linz study: TES volume of 2,0 Million m³ needed, comparable to Ernst Happel soccer stadium, Vienna.

Costs from storage system viewpoint

Learning curve for pit storages Denmark not 1-to-1 applicable to Central European situation.



DK gives lower estimate: 28 €/m³

Conventional pit construction + thermal insulation and floating lid give higher estimate: 53 €/m³

Costs from market viewpoint

Only competing future seasonal thermal storage alternative: Power to Gas to Heat

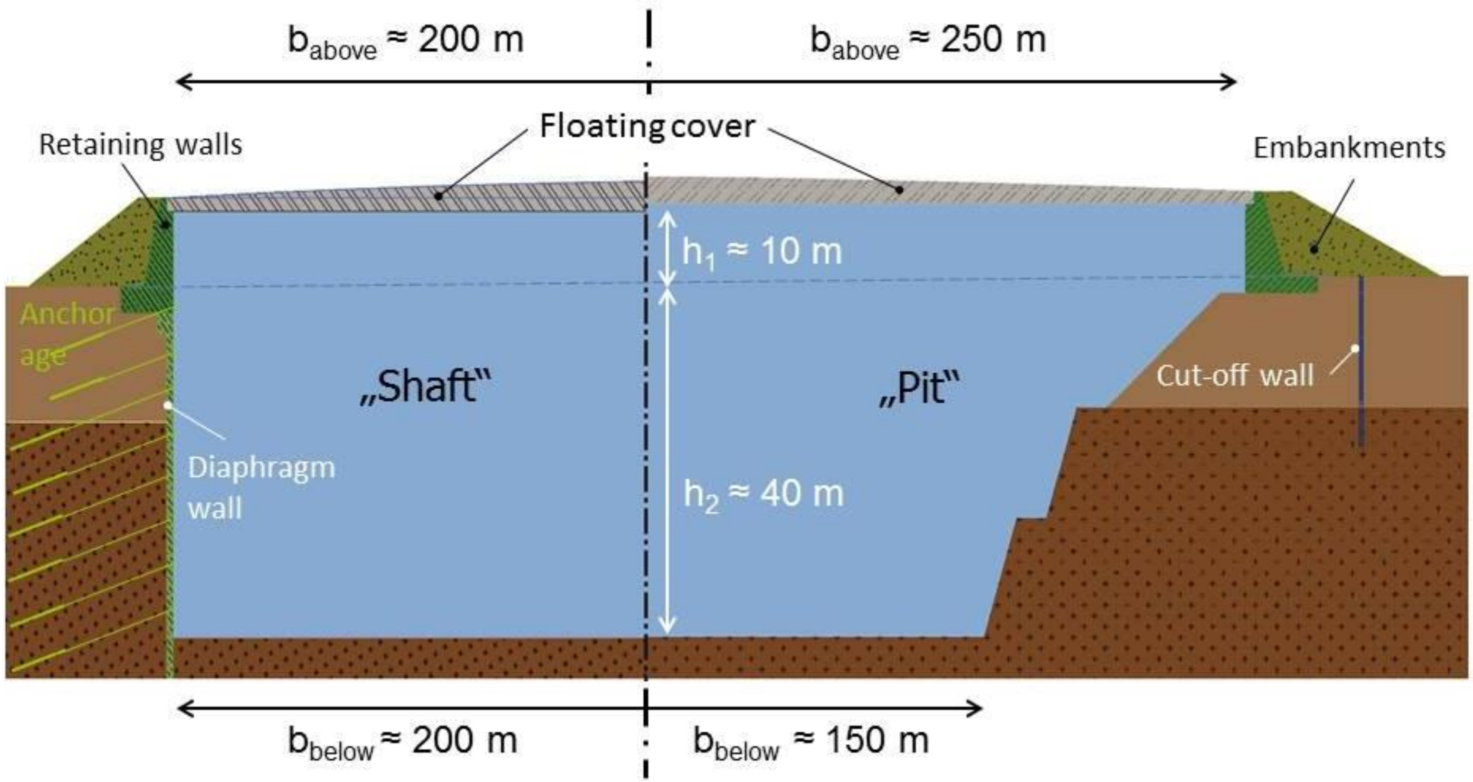
Costs hard/impossible to determine due to complicated system boundary conditions

Present steel tank TES: 7- 9.5 M€ for 60.000 m^3

(117-150 €/m^3, dependent on soil strength)

Possibilities in Giga-scale TES concepts

Two examples of different geometries and construction principles (left and right). Different sets of boundary conditions will lead to other materials and construction specifications



Work Package structure

WP2: Boundary Conditions, for Technology Development and System Integration (SOLID)

WP3: Giga-Scale Thermal Storage Technology Development (ste.p)

WP4: Materials Development and Testing (JKU)

WP5: Computer Assisted Storage Optimisation (UIBK)

WP6: System Integration and Storage Management (AEE INTEC)

WP7: Exploitation and Dissemination (AEE INTEC)

WP1: Project Management (AEE INTEC)

Research questions
Constructions and Materials

Cover for giga-TES

Large size; Elevated T; Carrying structure; Modularity; Thermal expansion

Floating covers; Modular floating covers; metal sandwich; concrete pontons

WP4, WP 3

static stability

Static pressure
T variations

diaphragm walls
bored pile walls

WP 3

Sealed against ground water

Ground water level variations

Sealed diaphragm walls
Combinations of cut-off walls and diaphragm walls

WP 3

Water and vapour tight

Elevated T
Elevated vapour pressures
Variations

Sealed diaphragm walls
Combination system of cut-off walls / diaphragm walls
Concrete formulations for sealed diaphragm walls for high T and vapour .

WP4, WP 3

Thermally insulated

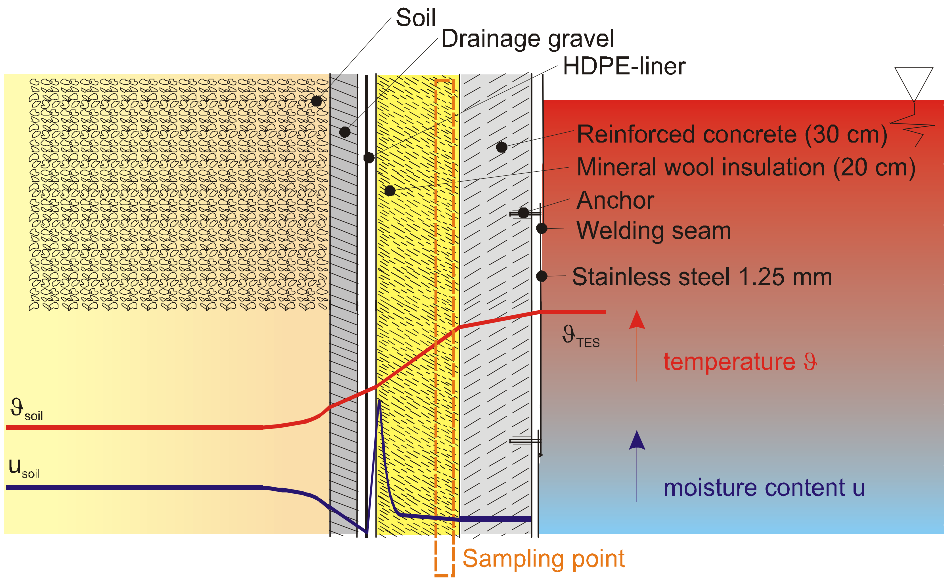
Elevated T
Static pressure
Vapour tight

Combination of cut-off walls / diaphragm walls, using enclosed soil as insulation
Investigation of usability of aerated concrete for injection works, soil grouting and cut-off walls

WP4, WP 3

Research questions

- System integration and optimisation, control optimisation
  - Heating network, heat sources, thermal storage
- Detailed and integral numerical simulation:
  - Ground water flow around storage
  - Thermal and hydraulic in storage (see example)

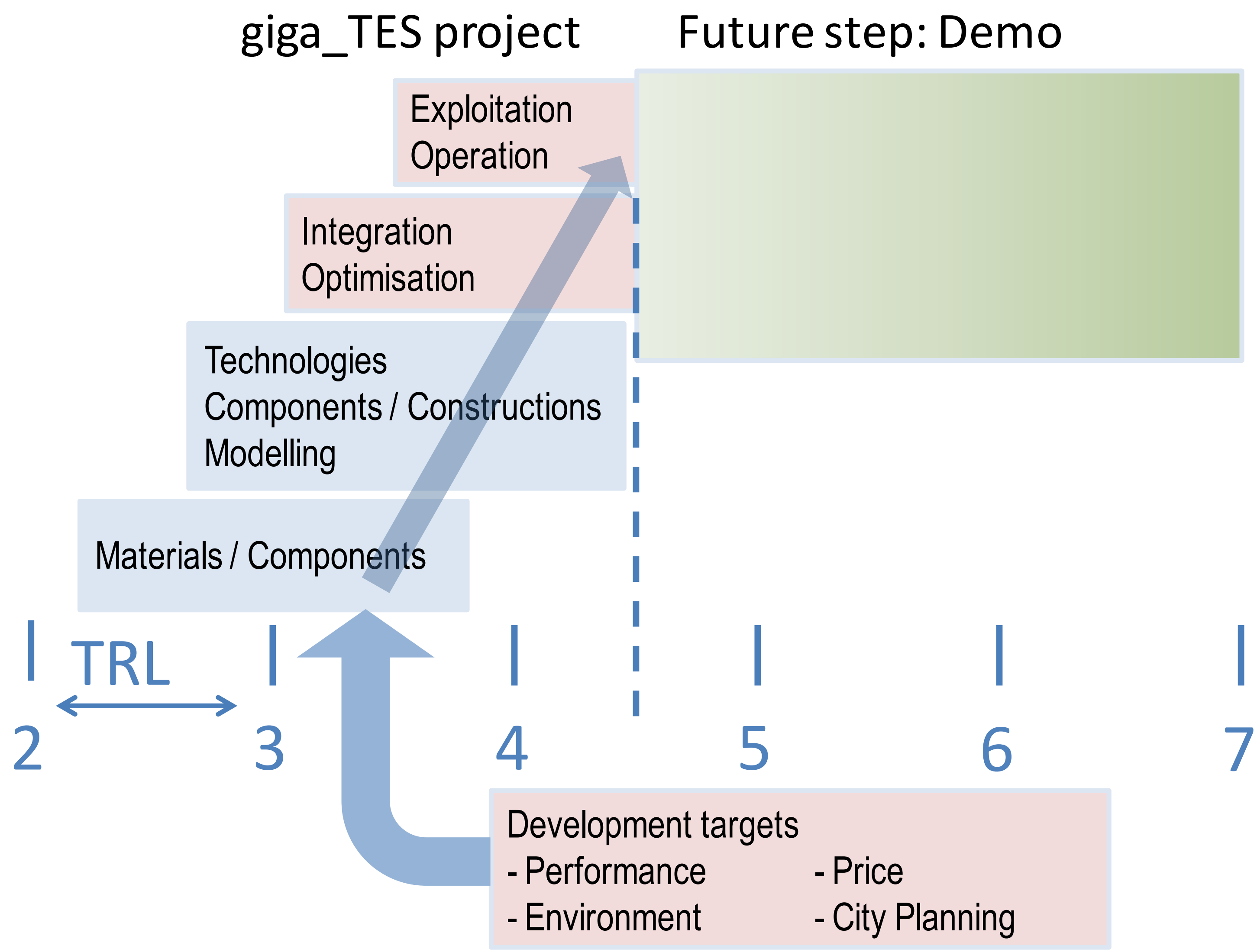


- Non-technical aspects

Project aspects

- Collaboration between Industry and Research
- International embedding; collaboration of DK and DE institutes
- Preparation for multiple introduction of technology in Austria and abroad; Industry will further develop outcomes of project for future market opportunities

Technology Readiness Levels



Key Deliverables

- Novel liner and construction materials
- Ground engineering materials and construction technologies
- Floating lid materials and construction technologies
- Numerical simulation programs
- Optimised design for a number of boundary conditions
- Exploitation Plan

Market outlook

Presently, Giga TES plans for: Aalborg, Belgrade, Graz, Linz, Salzburg

Austria:

24 % of heat demand through DHC (22,4 TWh/a)

10 biggest DHC networks have 12,5 TWh/a

Large storages + heat pumps can lead to 60% CO_2 reduction

- >10 very large storages (1.000.000 m^3)
- > 100 large storages (100.000 m^3)

Export market is a multiple of this

Project status

Scope:

- 3 volumes (100.000 – 500.000 – 2.000.000 m^3)
- 3 different soil configurations

Boundary conditions determined

First calculations of temperatures of groundwater

Charging and discharging temperatures

First samples of novel polymer liners in durability tests

Next half year: geometries and materials for the floating lid elements

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IDEA TO ACTION

Thank you
for your Attention