Giga-Scale Pit Storage as an Essential Part of District Heating Systems

A Simulation based case study

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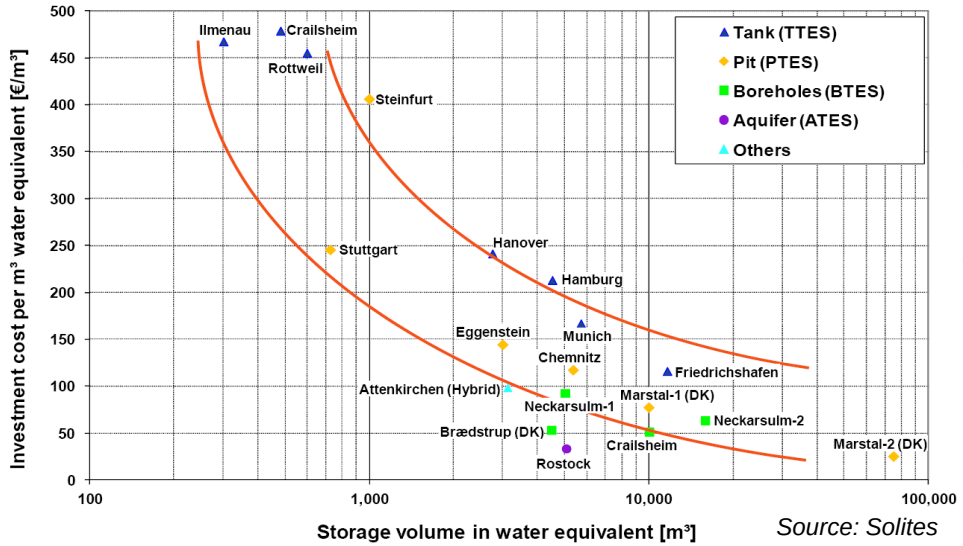
General

- Development of sophisticated concepts for giga-scale seasonal Thermal Energy Storages (TES) applicable in Austria and Central Europe

Source: Arcon-Sumark

Until now: ~200,000 m³ (Vojens, DK)

x10



Source: Solites

Concepts up to 2,000,000 m³

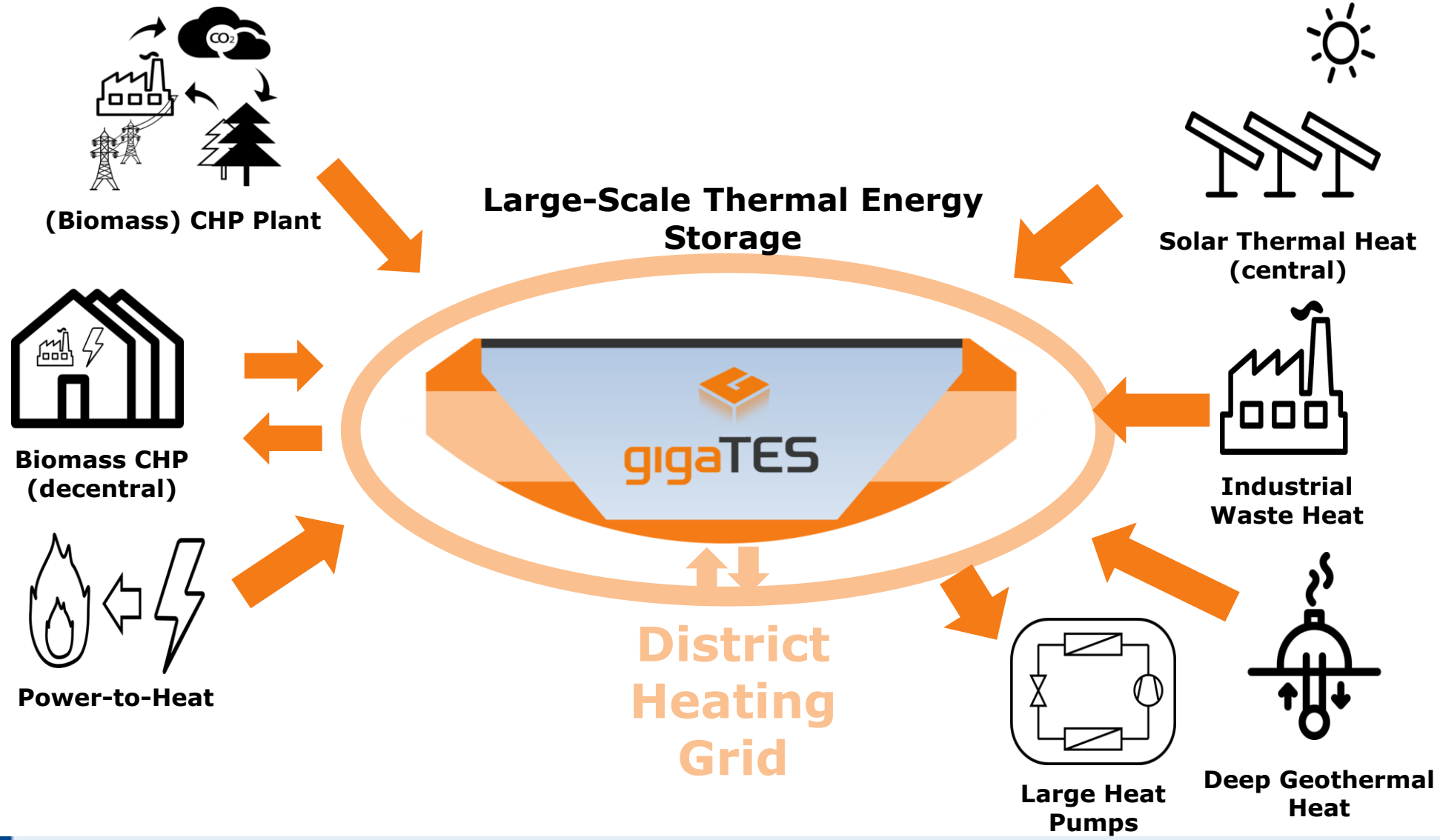
- Objective: Transformation of the technology from Denmark to Austria and Central Europe
- Austrian Flagship Project (01/2018 – 12/2020):

Industry

Research

Foreign expertise

Role of a Giga TES Storage



Giga TES Application Scenario Generation Process

- Proximity to Heating Grids
- High Heat Density
- Excess Waste/Renewable heat sources
- Favourable Geological + Hydrogeological conditions for pit excavation

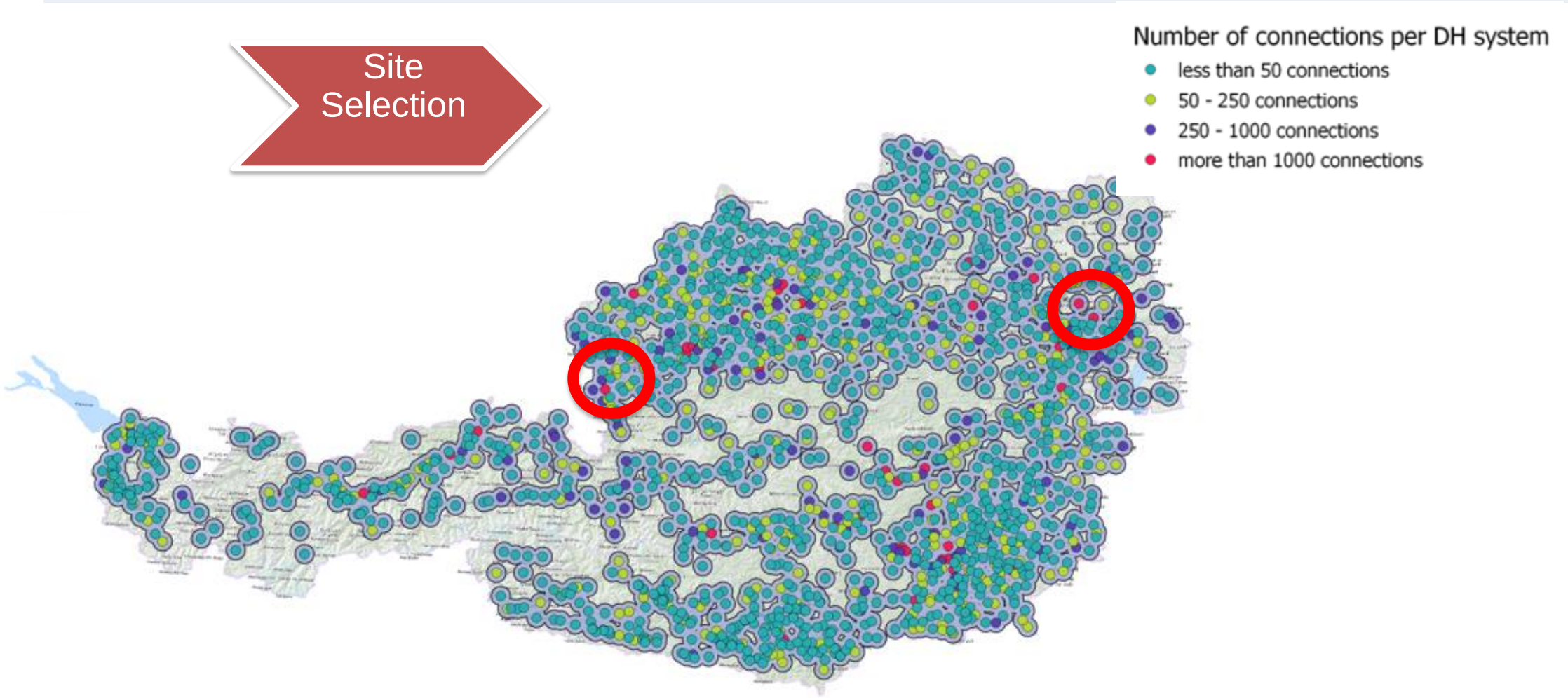
- Heating Grid Size/density
- Network Temperatures
- Soil Conditions
- Legal Requirements
- Spatial Planning
- Environmental Conditions

- Seasonal Storage
- Peak load shaving/shifting
- Multi-functional

- Optimise share of renewables in grid
- Optimise network costs/unit commitment strategy

Site Selection Process

Site Selection

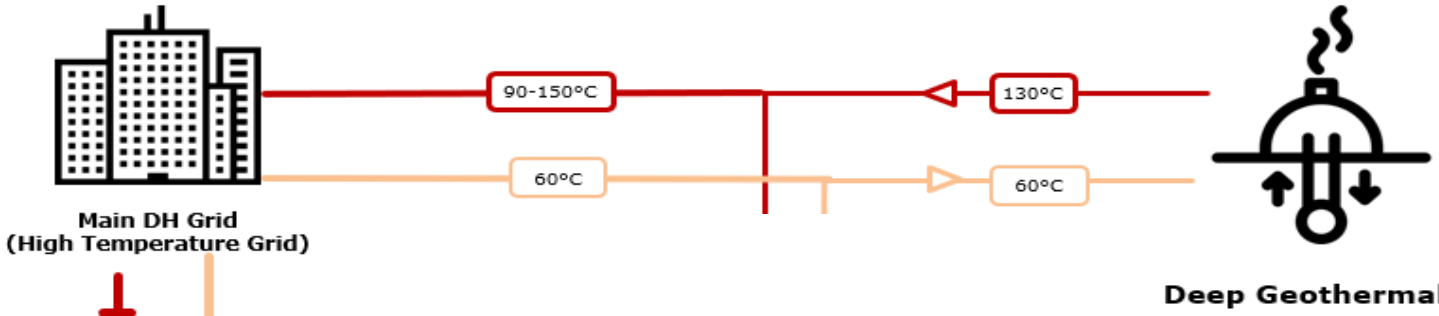


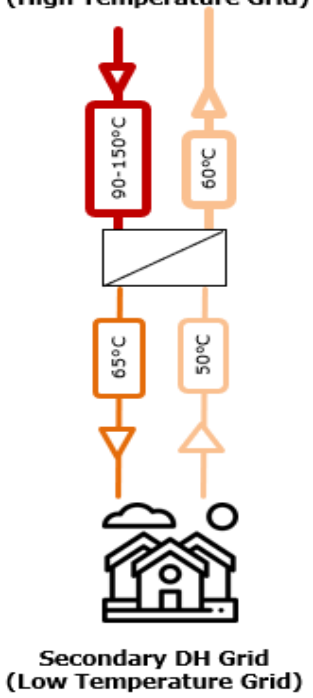
– Larger Heating Grids offer higher potential for Giga TES (>10GWh/a)

Vienna Heating Grid

- **Motivation:**
  - Nearby Geothermal heat source expected to supply 60MW$_{th}$ at 130°C to heating grid all year round.
  - Estimated surplus of approximately 40GWh of geothermal heat over the Summer months due to must-run heat sources.
  - Large scale pit storage could utilise of the surplus geothermal heat for use in the winter months.
  - Storage can offer additional source of flexibility for optimising the CHP plants in the grid depending on electricity generation prices.
- **Challenges:**
  - Primary grid temperatures up to 150°C -> storage temperatures limited to 95°C
  - Limitations in space, budget, novel liner material, water sourcing….

Case Study I: Low Temperature grid with Geothermal





Secondary Grid Characteristic	Value
Storage Temperature Range	95°C/50°C
Excess Geothermal Heat	38GWh/a
Heating Demand of Secondary Grid (Expected)	100GWh/a
Supply Temperature	65°C
Return Temperature	45-60°C

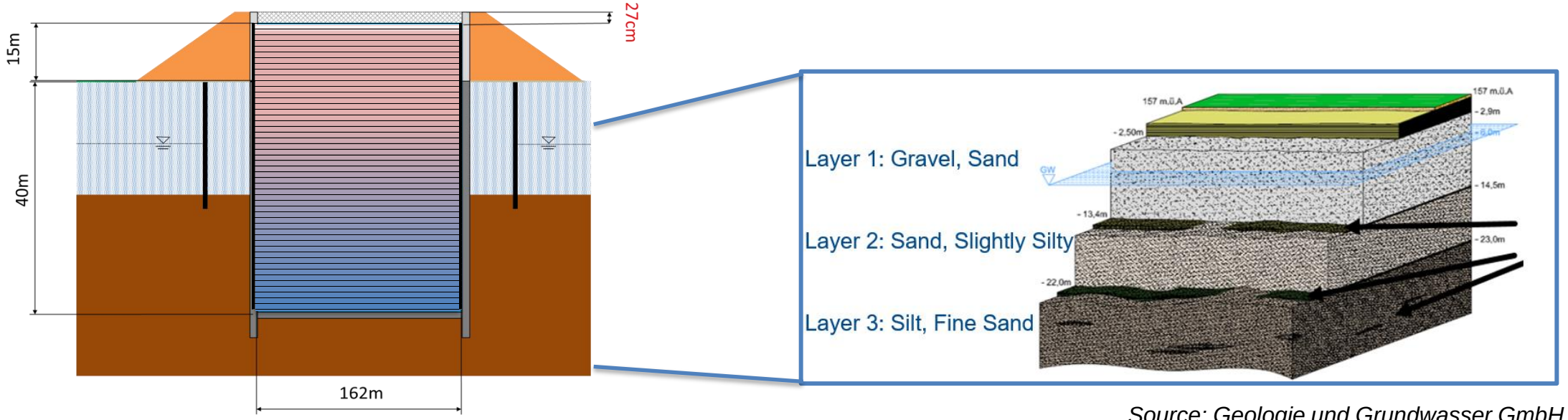
Case Study I: Storage Parameter Study.

Storage Design Parameters

- Capacity -> (500,000-1,200,000m^3)
- Storage height (30-65m)
- Lid insulation thickness (30-50cm)
- Wall insulation thickness (0-50cm)

KPI‘s

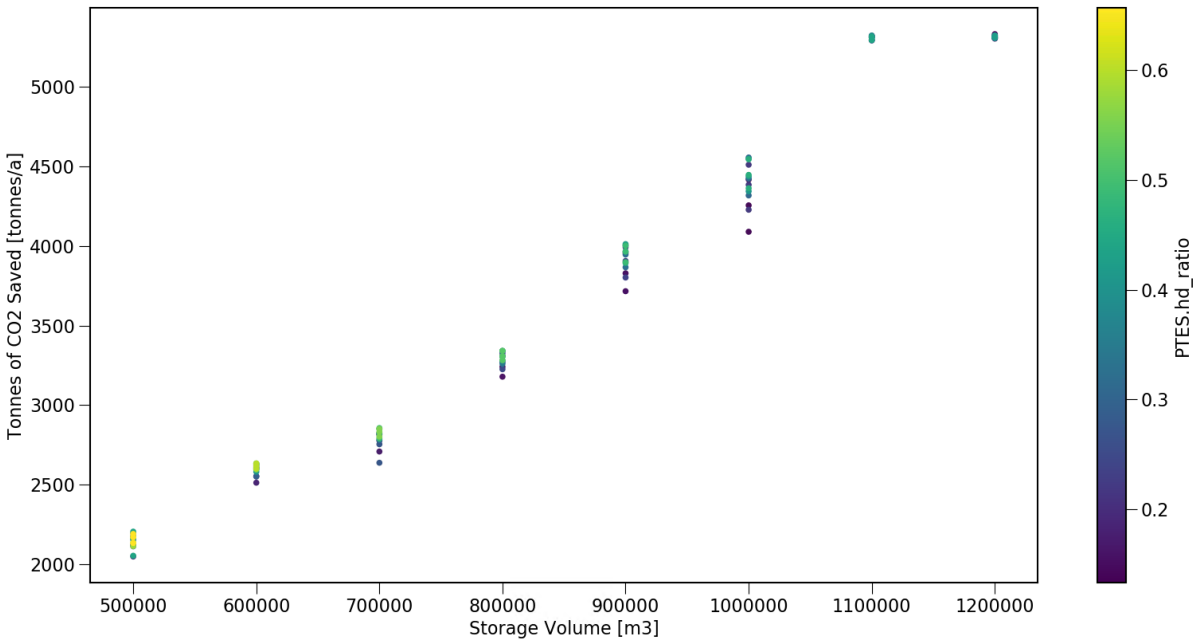
- Levelised Cost of Heat (€/MWh)
- CO_2 savings (tonnes per annumn)
- Thermal losses from storage
- …

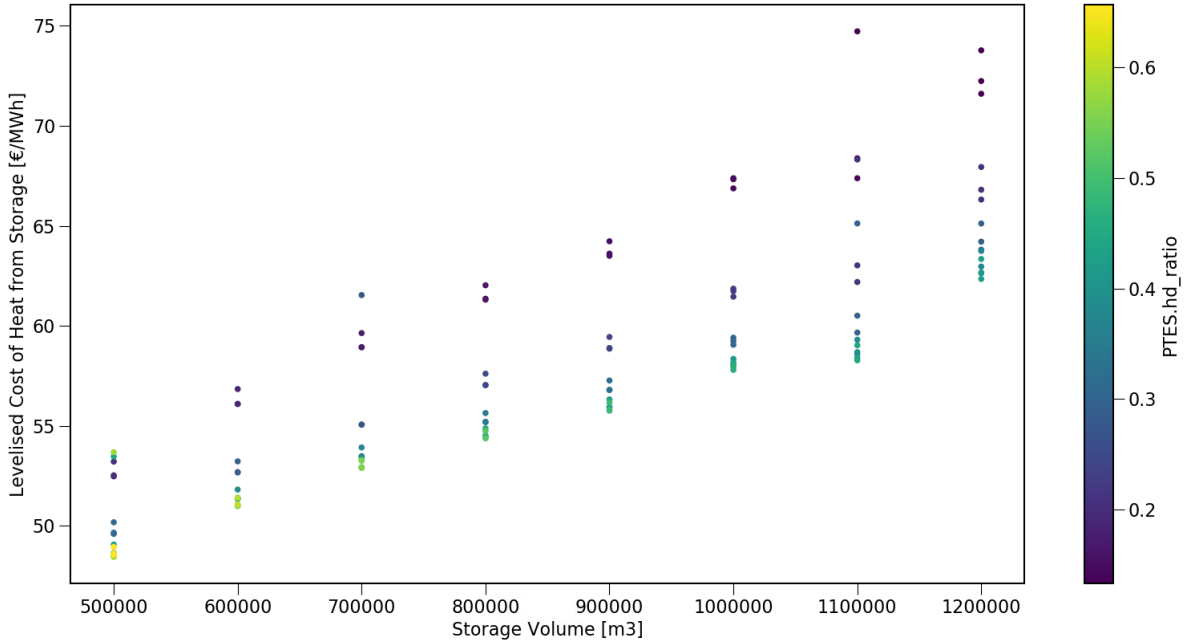


Source: Geologie und Grundwasser GmbH

Case Study I: Parameter Study

- Objectives to maximise CO2 savings at the lowest possible €/MWh:





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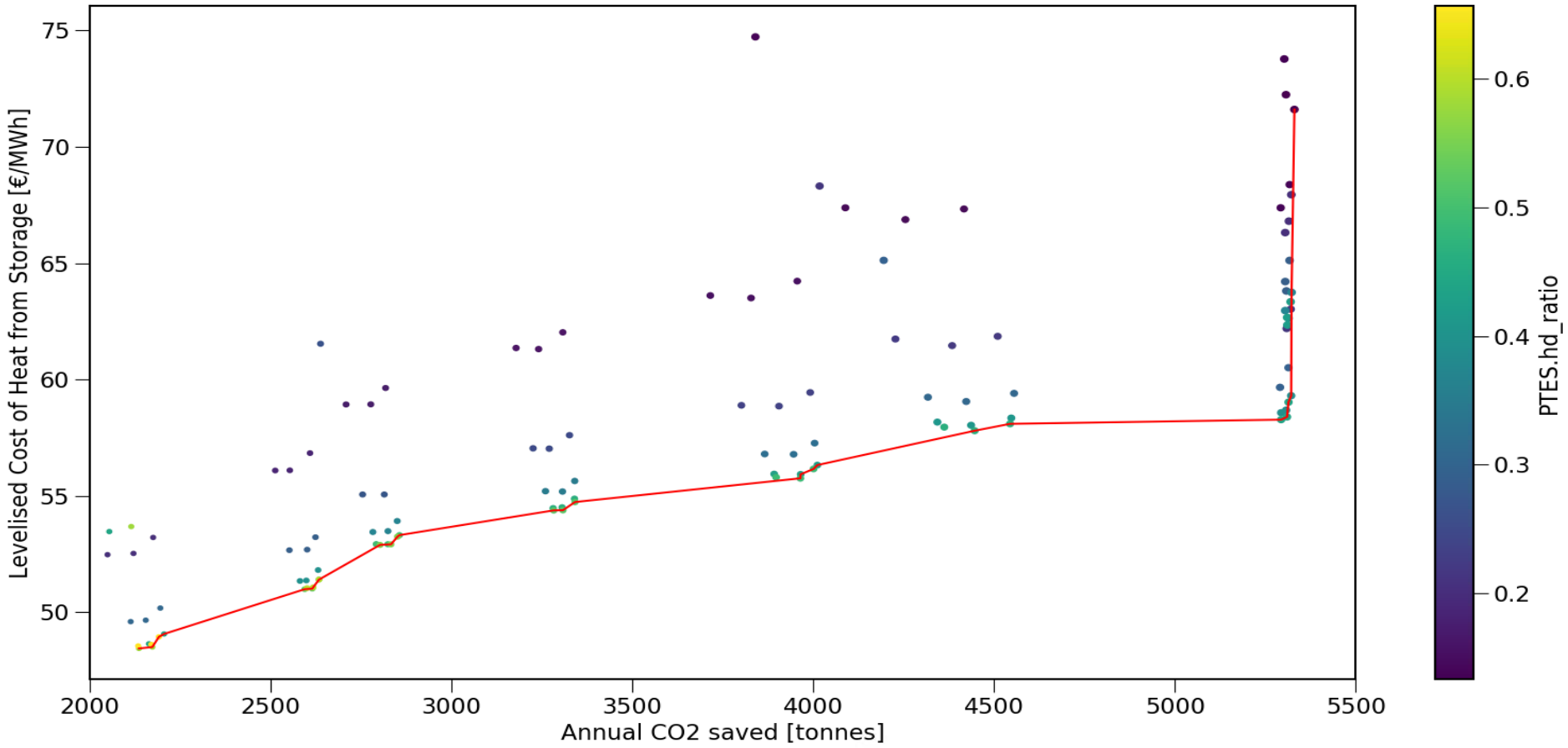
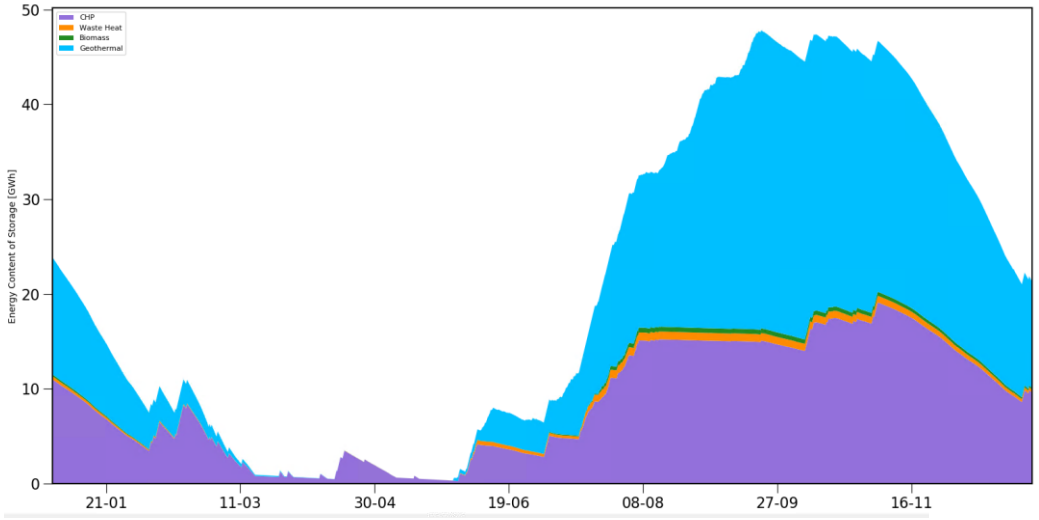
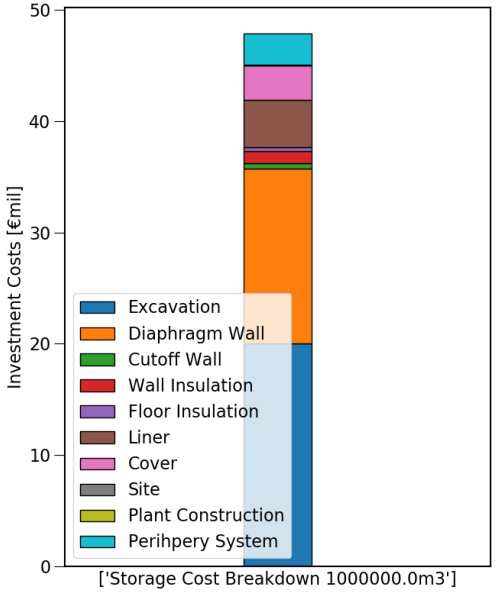
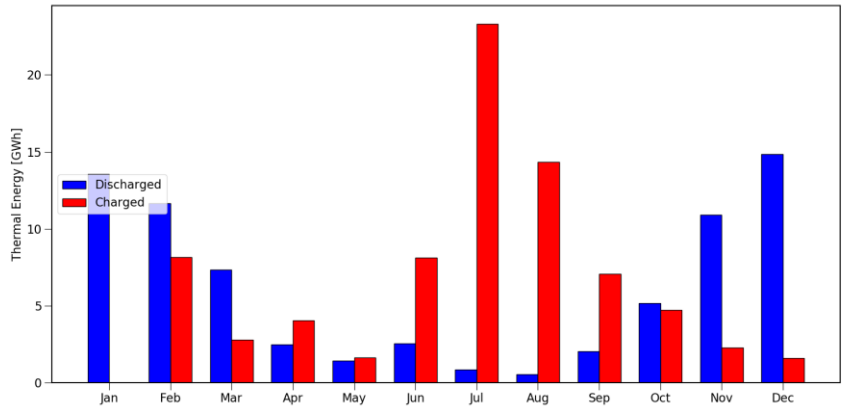


Case Study I: Low Temperature grid with Geothermal

- 1,000,000m3 configuration, 50m deep, all surfaces insulated.

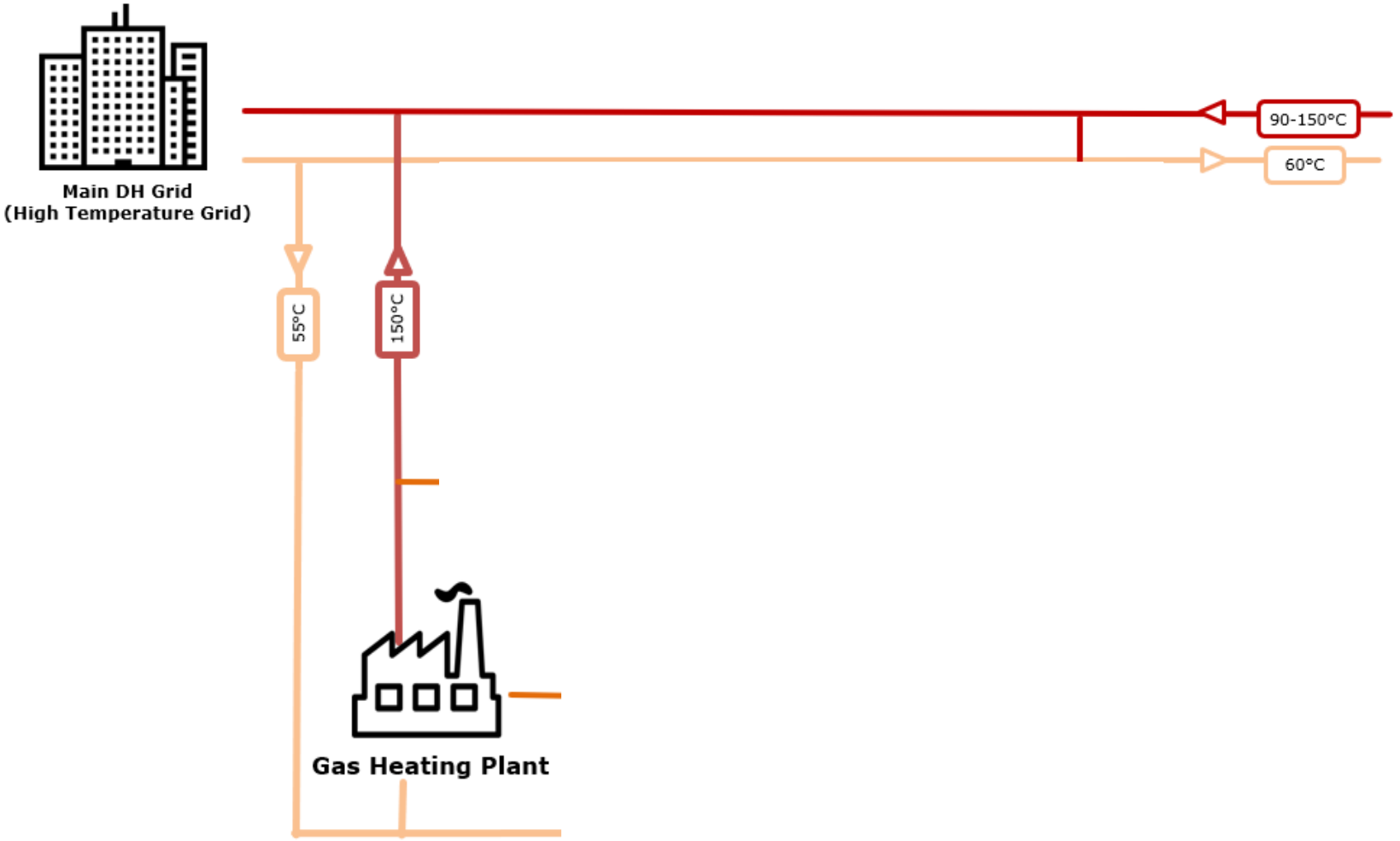






KPI	Value
Energy Charged	77.4GWh/a
Energy Discharged	73GWh/a
Losses	6.9GWh/a
Number of Storage Cycles	1.4
Tonnes of CO2 saved	4,500t/a
Levelised cost of heat	€59.5/MWh

Case Study II: High Temperature Grid with Post Heating



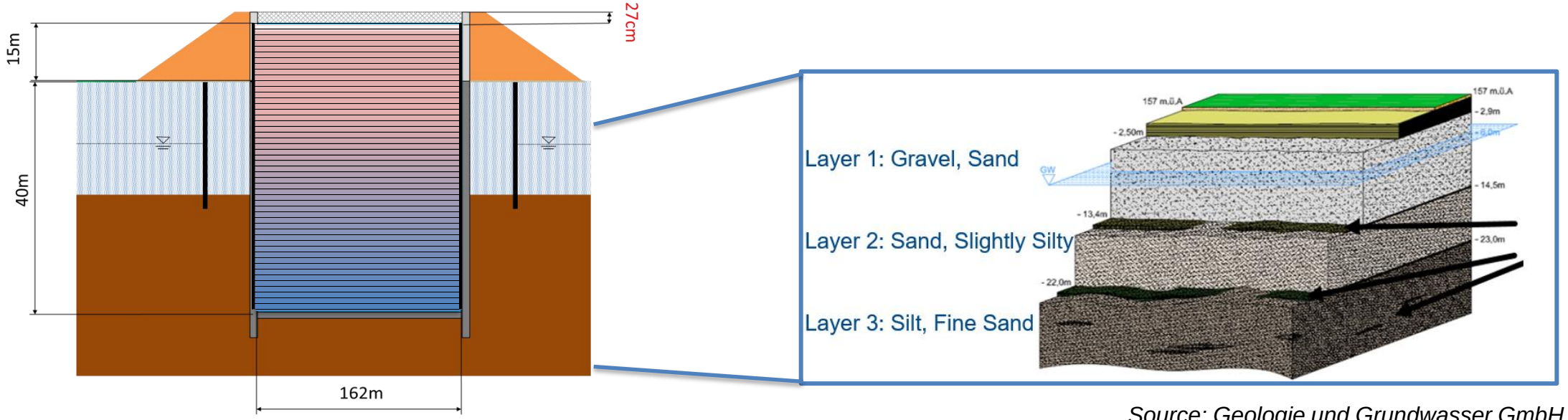
Case Study II: Storage Parameter Study.

Storage Design Parameters

- Capacity -> (1,000,000-2,000,000m³)
- Storage height (30-65m)
- Lid insulation thickness (30-50cm)
- Wall insulation thickness (0-50cm)

KPI‘s

- Levelised Cost of Heat (€/MWh)
- Thermal losses from storage



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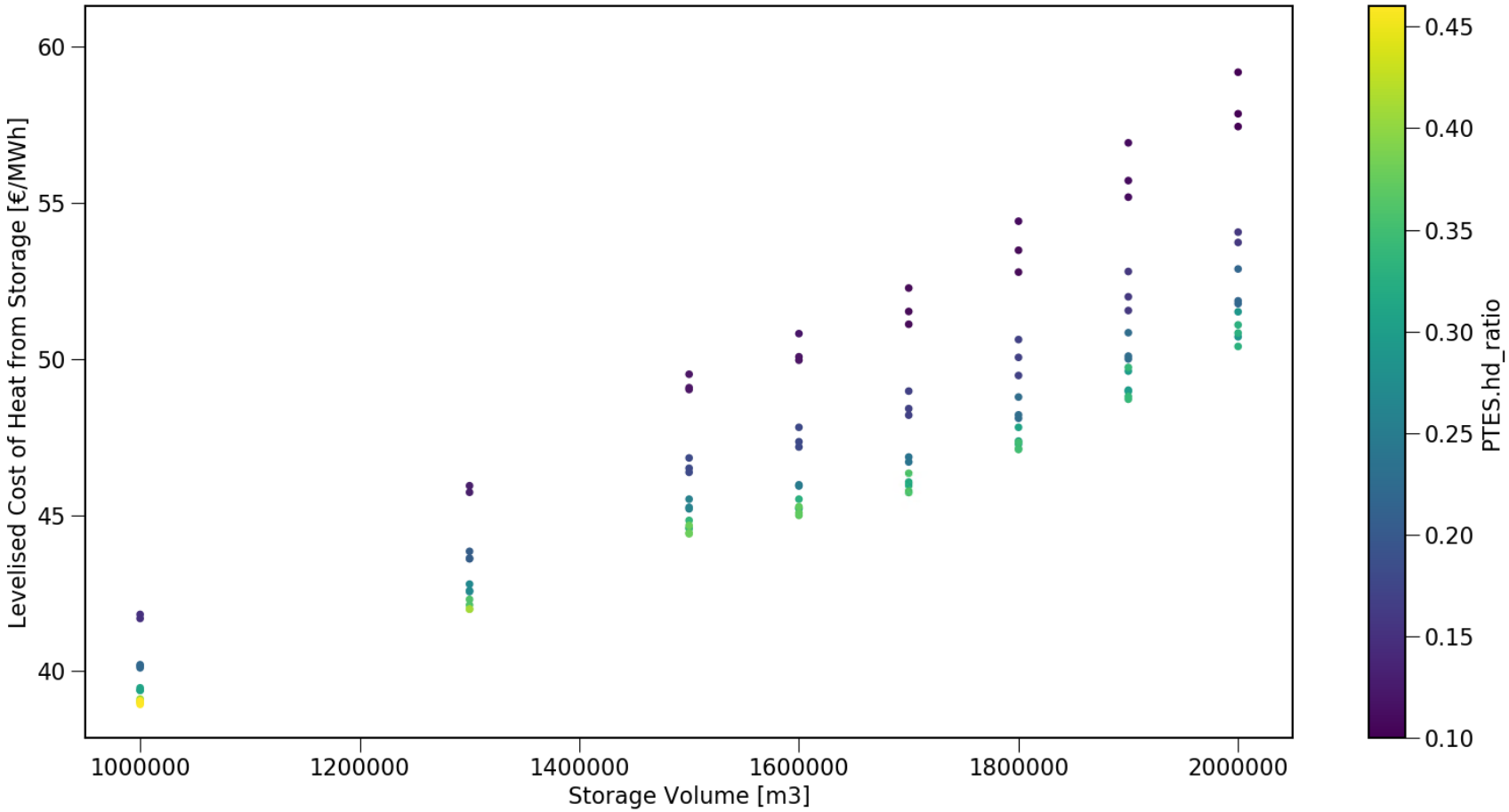

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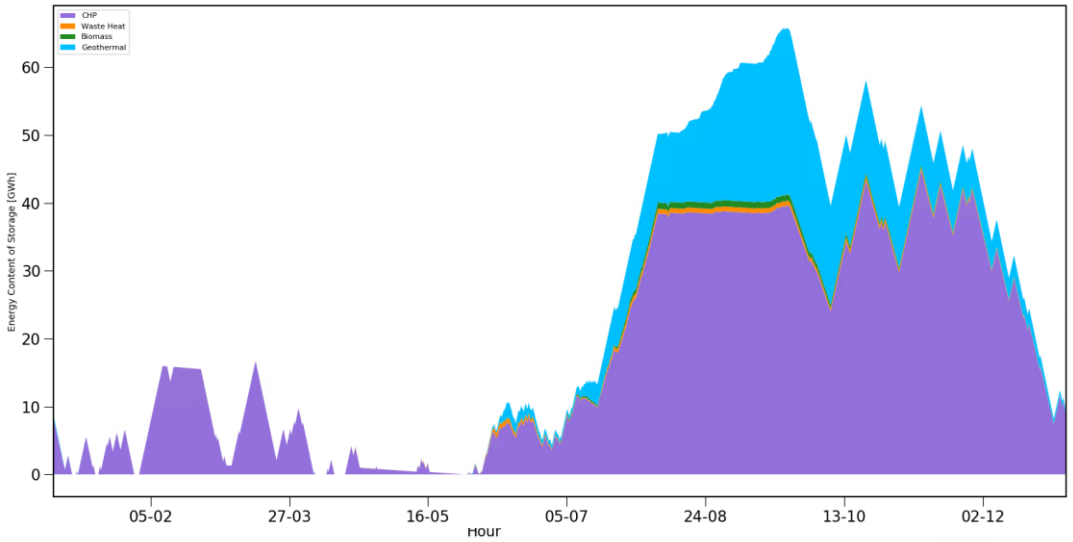
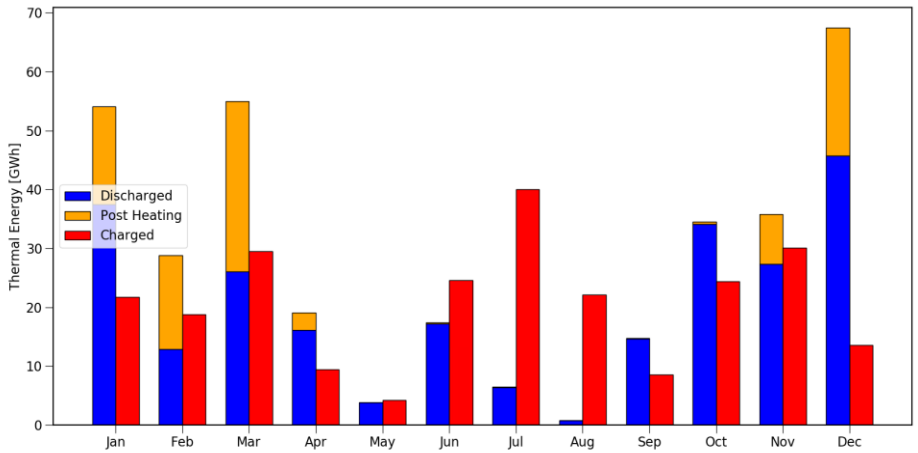
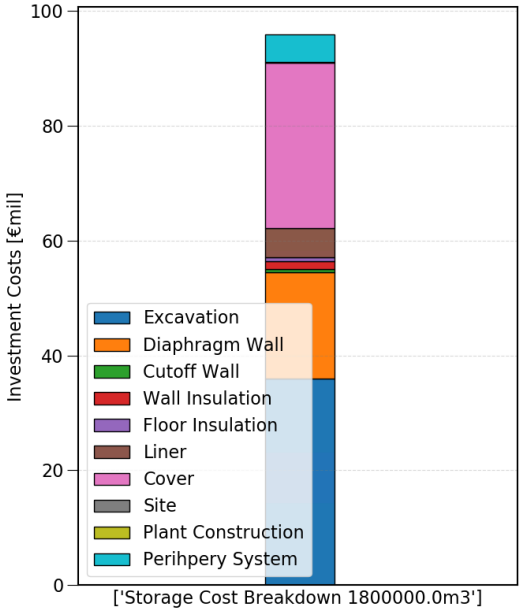






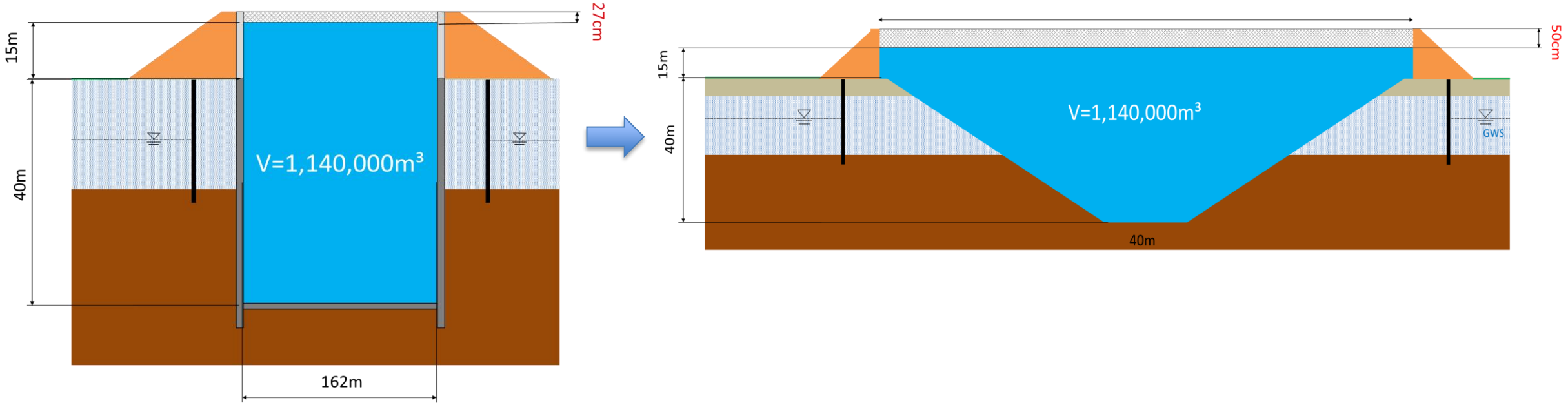
KPI	Value
Energy Charged	244.8GWh/a
Energy Discharged	237.42GWh/a
Post Heating Required	94GWh
Thermal Losses	11.36GWh/a
Number of Storage Cycles	3.26
Tonnes of CO2 saved	4,500t/a
Levelised cost of heat	€48.5/MWh

Summary

- Low temperature secondary grid scenario is ecologically feasible with a net reduction in CO_2 emissions -> no additional CO_2 due to post heating expected.
- High temperature primary grid scenario is more economically viable -> higher degree of storage cycles possible.
- Post heating from gas boiler makes it unattractive from an ecological perspective.
- The height-diameter ratio has the highest impact on performance after capacity with thermal losses and efficiency being significantly improved for deeper storages
- Deeper storages mean smaller surface area and investment costs for the lid, though limitations on depth depend on hydrogeological conditions.

Next Steps in Simulations – Project Outlook

- Improvement of Modelica models:
  - Impact on thermal losses, stratification and costs for other geometries.



- Scenario Variants -> coupling with Heat Pump, higher renewable surplus

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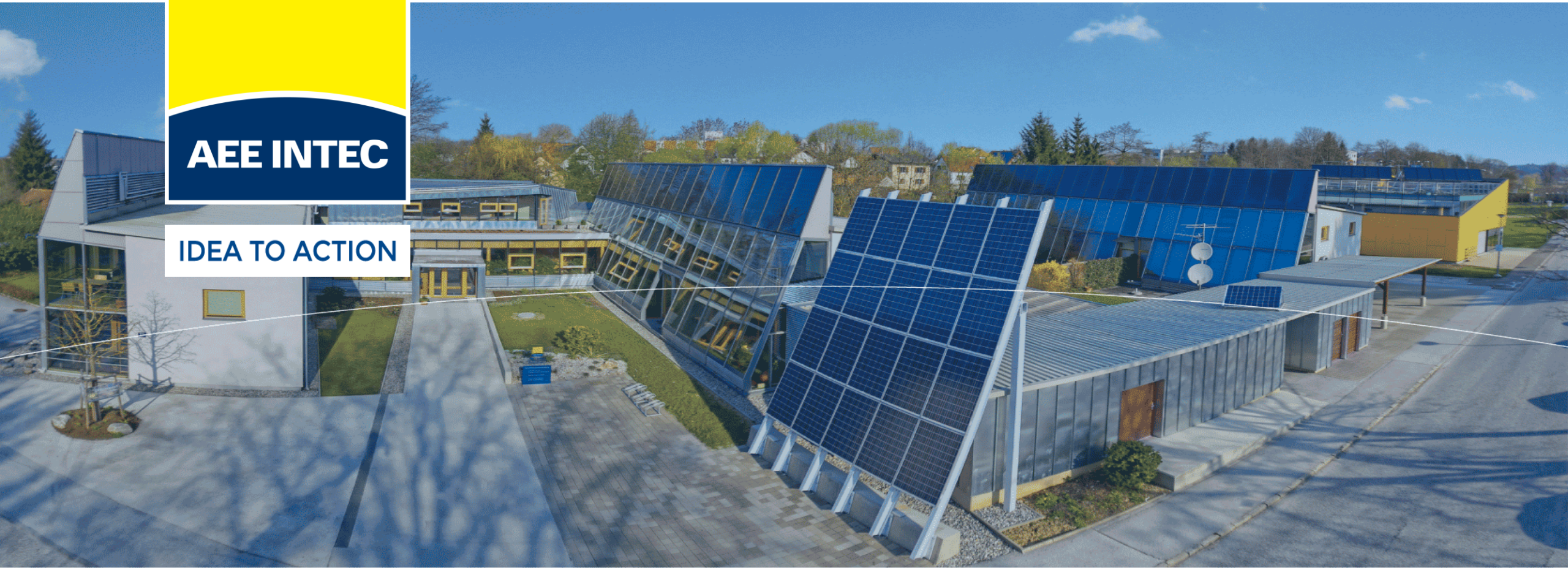
IDEA TO ACTION



Thank you for your attention!

Follow our latest project updates here: https://www.gigates.at/index.php/de/

Costs Reference

Contribution	(Specific) Costs	Remark
Excavation	20 €/m³	Partly wet excavation
Diaphragm wall	550 €/m²	50 m deep
Cut-off wall	50 €/m²	In case of ground water in 5 m distance
Insulation	100 €/m³	Bottom (pressure resistant)
	200 €/m³	Wall (including installation)
Liner	150 €/m²	VA, Stainless steel (HT)
	50 €/m²	Polymer liner (LT)
Cover	200 €/m²	Floating cover (50 cm ins.)
	800 €/m²	Trafficable floating cover
Plant construction	40,000 €	Independent TES construction
Site facilities	50,000 €	Fixed