Large-Scale Thermal Energy Storage

A simulation scenario analysis

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Overview

- Site Selection Process/Potential Analysis
- Case Study I: Geothermal for low temperature grid
- Case Study II: High Temperature grid with post heating
- Case Study III: High Temperature grid with a Heat Pump
- Conclusions/Next Steps in Project

Giga TES Application Scenario Generation Process

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gigaTES

Site Selection → **Boundary Conditions** → **Role of Storage** → **Goal of Scenario**

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

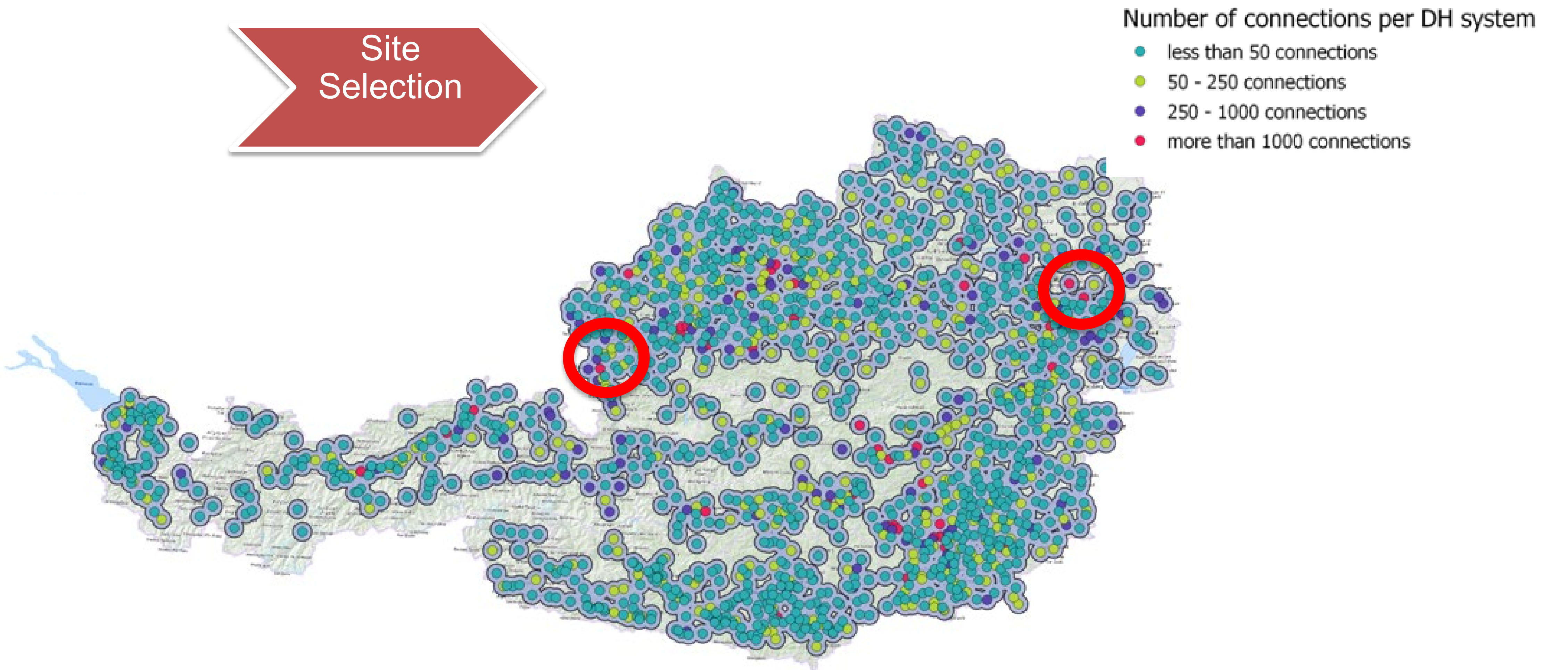
Boundary Conditions
- Heating Grid Size/density
- Network Temperatures
- Soil Conditions
- Legal Requirements
- Spatial Planning
- Environmental Conditions

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

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

Site Selection Process

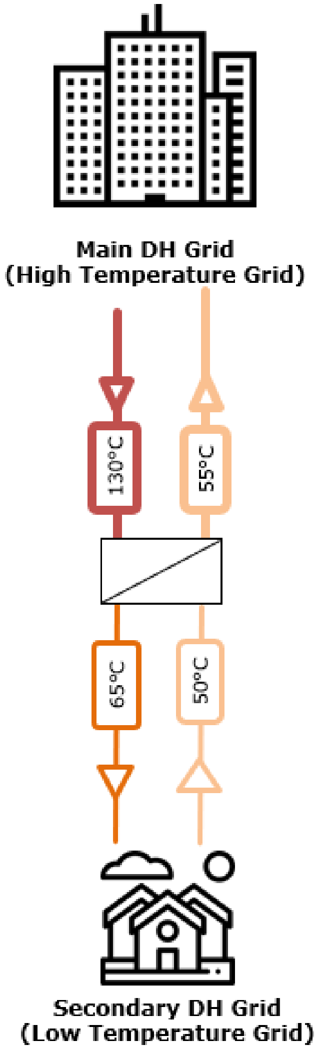
Site Selection

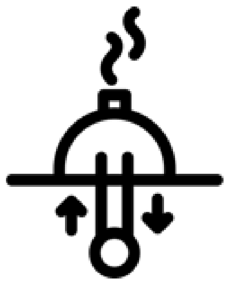


– Larger Heating Grids offer higher potential for Giga TES (>10GWh/a)

Case Study I: Low Temperature grid with Geothermal

Site Selection → Boundary Conditions





Deep Geothermal Heat

Secondary Grid Characteristic	Value
Heating Demand (Expected)	100GWh/a
Supply Temperature	65°C
Return Temperature	45-60°C

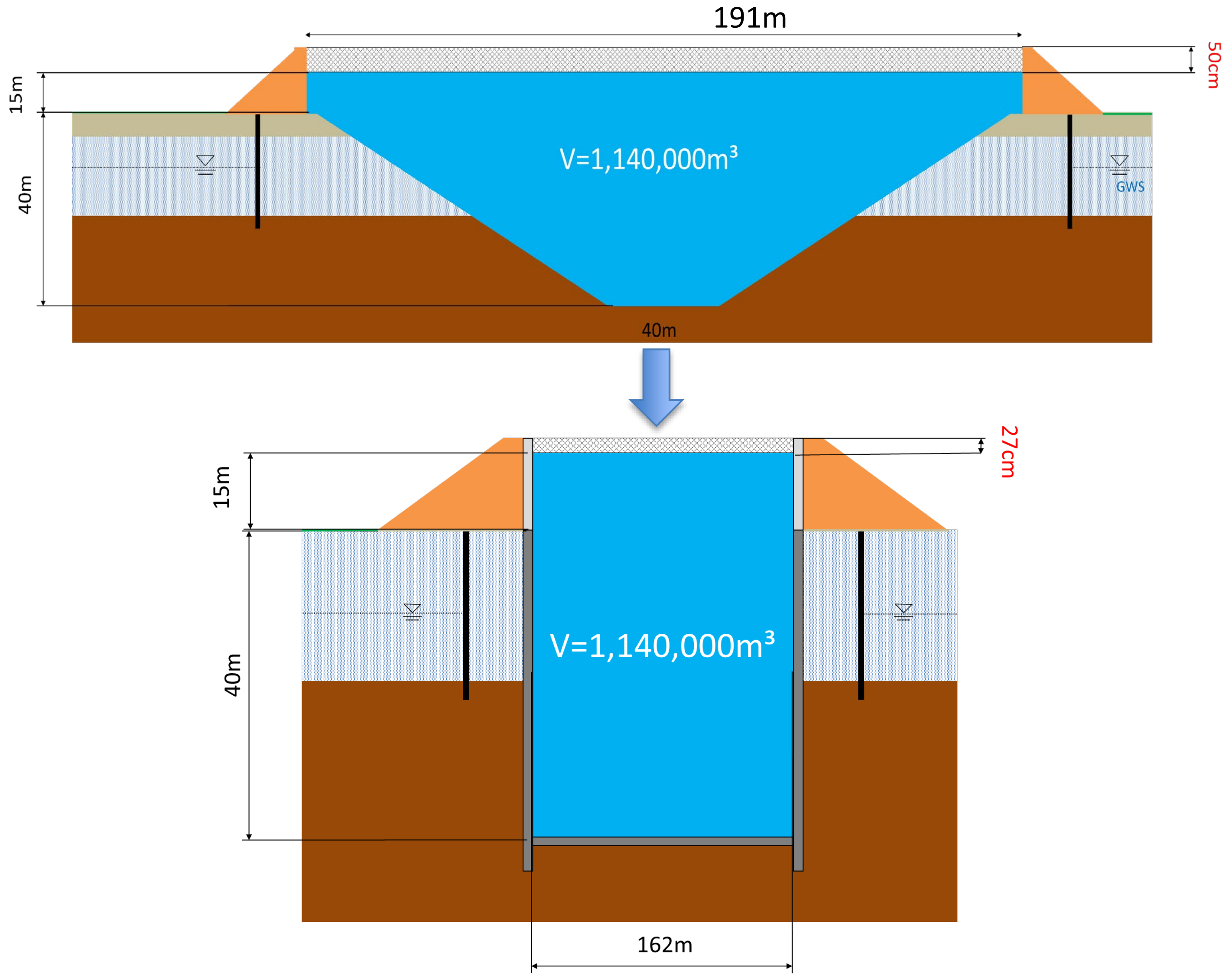
Case Study I: Goals of scenario and role of storage

Site Selection → Boundary Conditions → Role of Storage → Goal of Scenario

- **Goal of Scenario**
  – To reduce dependency on the high temperature primary grid.
  – Boost the share of renewables in the grid and subsequently reduce overall CO_2 emissions

- **Role of Storage**
  – To supply secondary grid with geothermal heat at times when it is most economically viable to do so.

Modelling Assumption – Cylindrical Equivalent of Pit Storage



Pit Storage

- Higher surface area on lid
- Smaller floor surface area

Cylindrical Equivalent

- Same Volume and Height
- Lid surface area underestimated
- Lid insulation reduced to conserve U value and heat losses

Modelling Assumption – Cylindrical Equivalent of Pit Storage

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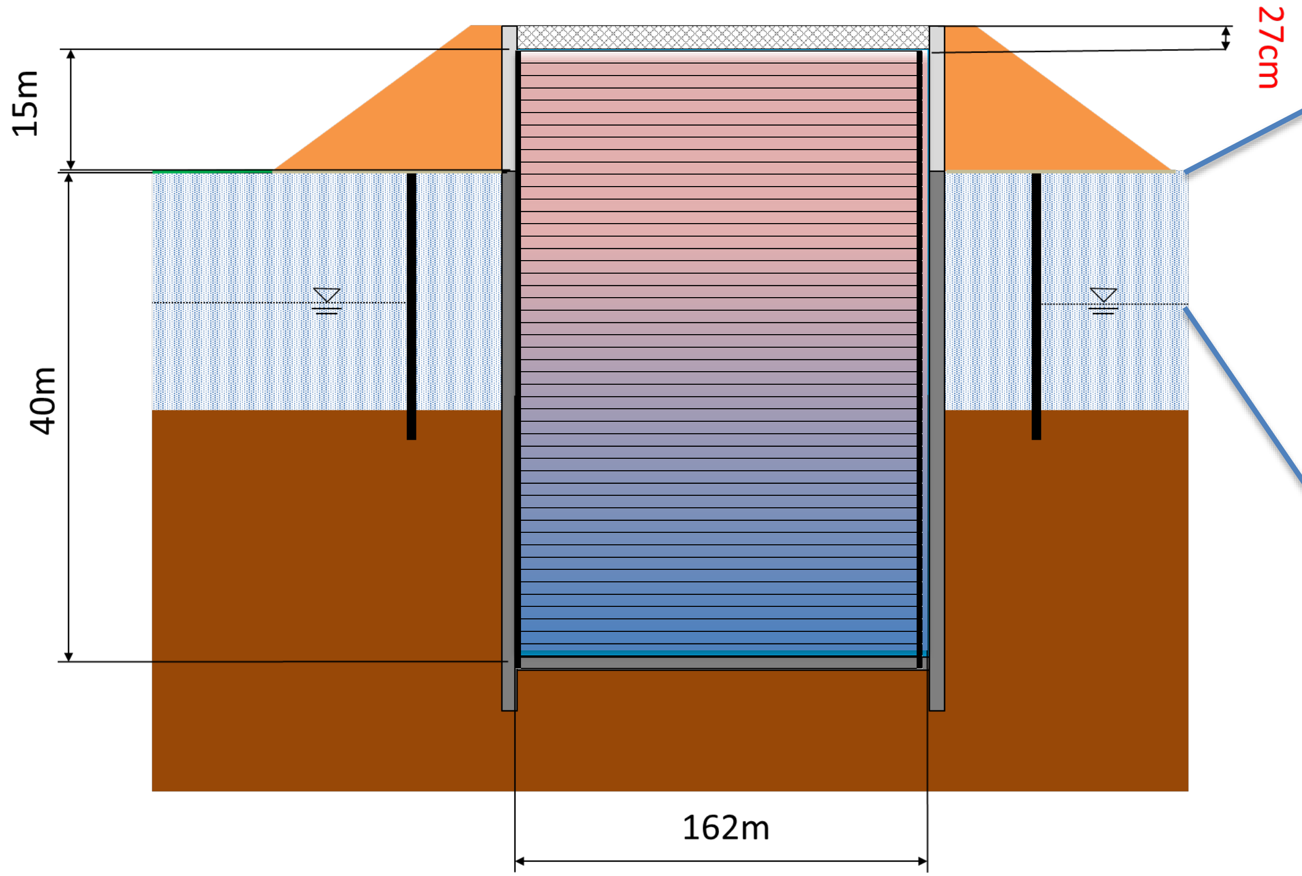
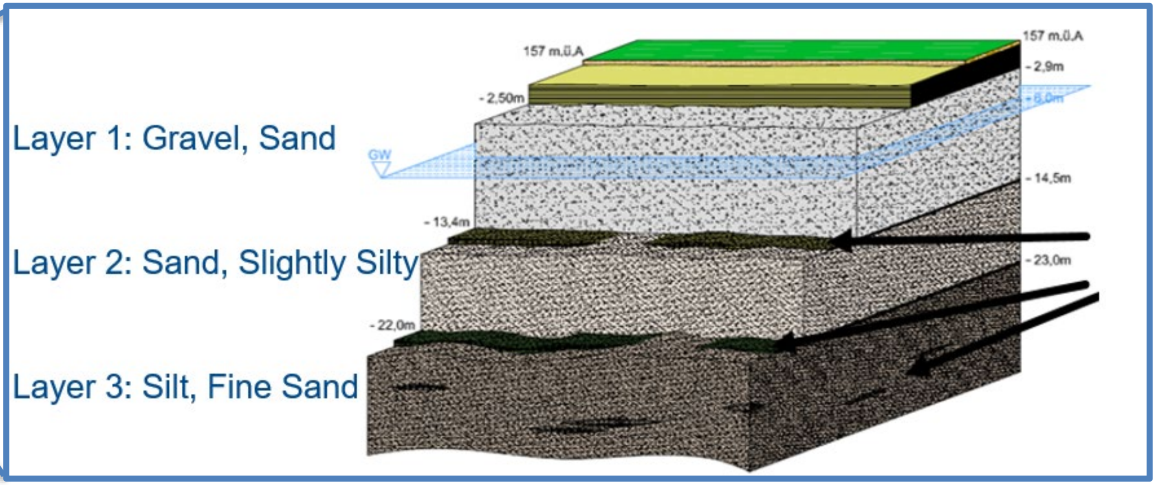


Storage Parameters

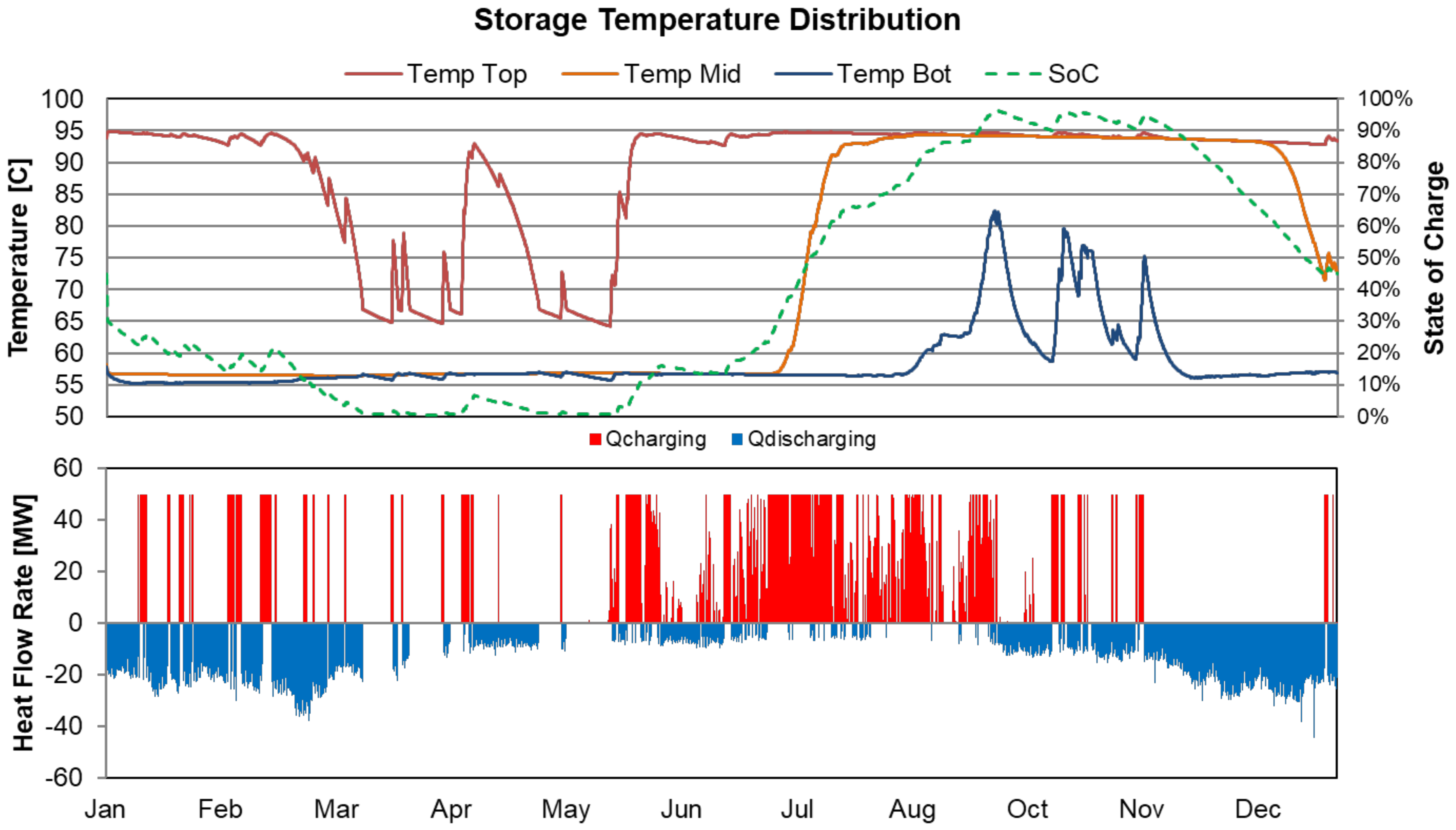
- Capacity: 50GWh (Tmax 95°C, Tmin 57°C)
- Max Charge/Discharge: 50MW
- 50 Temperature Nodes



Source: Geologie und Grundwasser GmbH

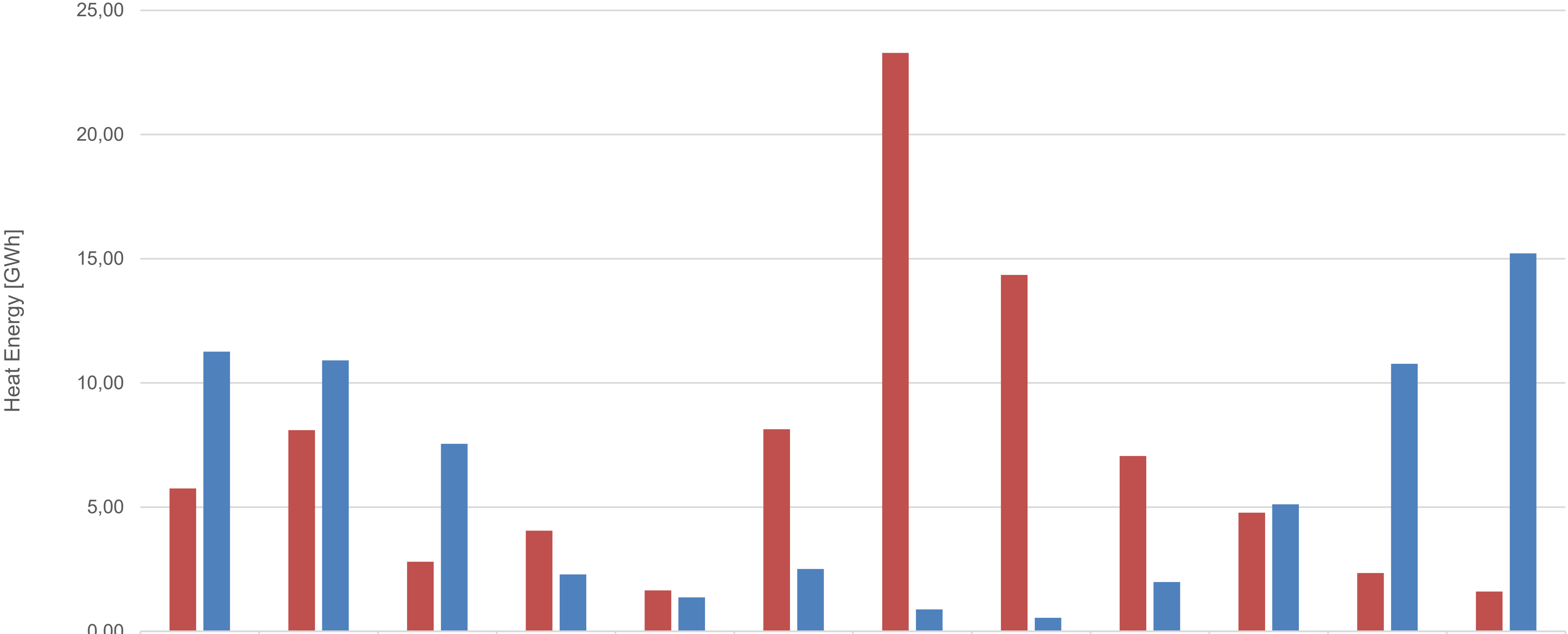
- Soil Temperature a function of depth and time

Case Study I: Low Temperature grid with Geothermal



Low Temperature grid with Geothermal: Energy Flows to/from Storage

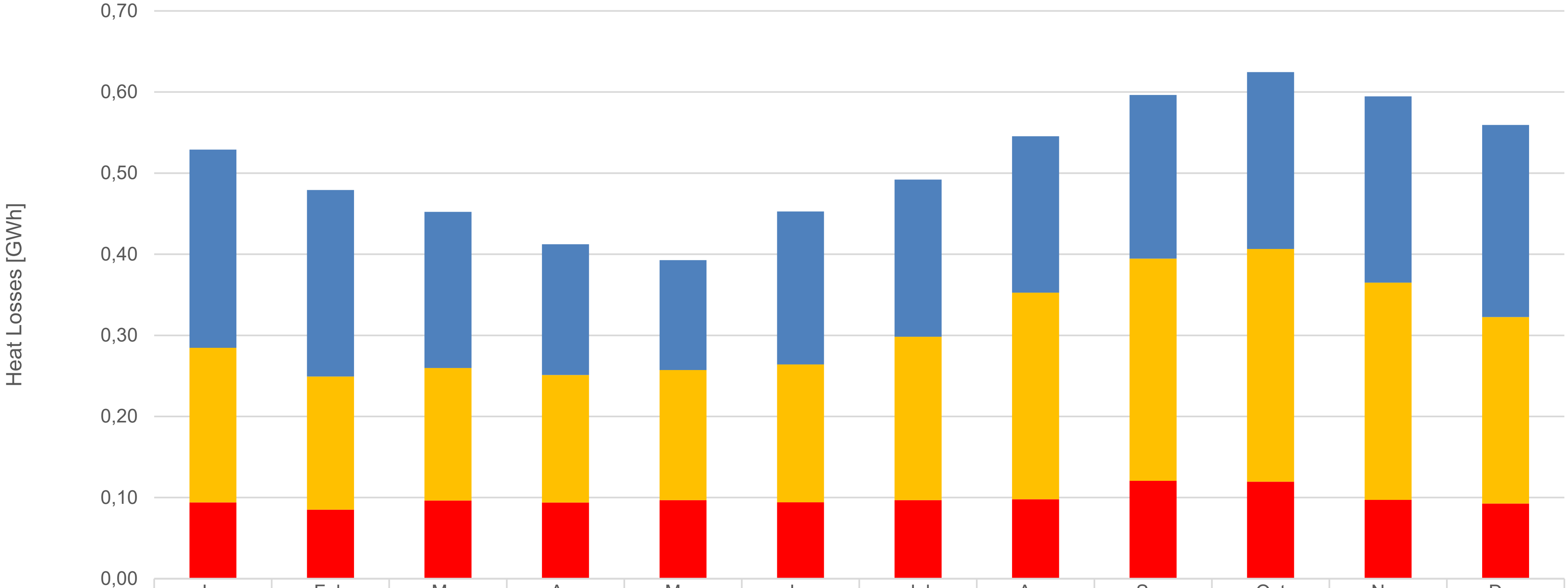
Energy to/from Storage - Monthly Breakdown



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Charging	5,75	8,10	2,80	4,05	1,65	8,14	23,29	14,35	7,06	4,78	2,35	1,60
Discharging	11,26	10,91	7,55	2,29	1,37	2,51	0,88	0,54	1,99	5,11	10,77	15,22

Low Temperature grid with Geothermal: Heat Loss Breakdown

Storage Heat Losses - Monthly Breakdown

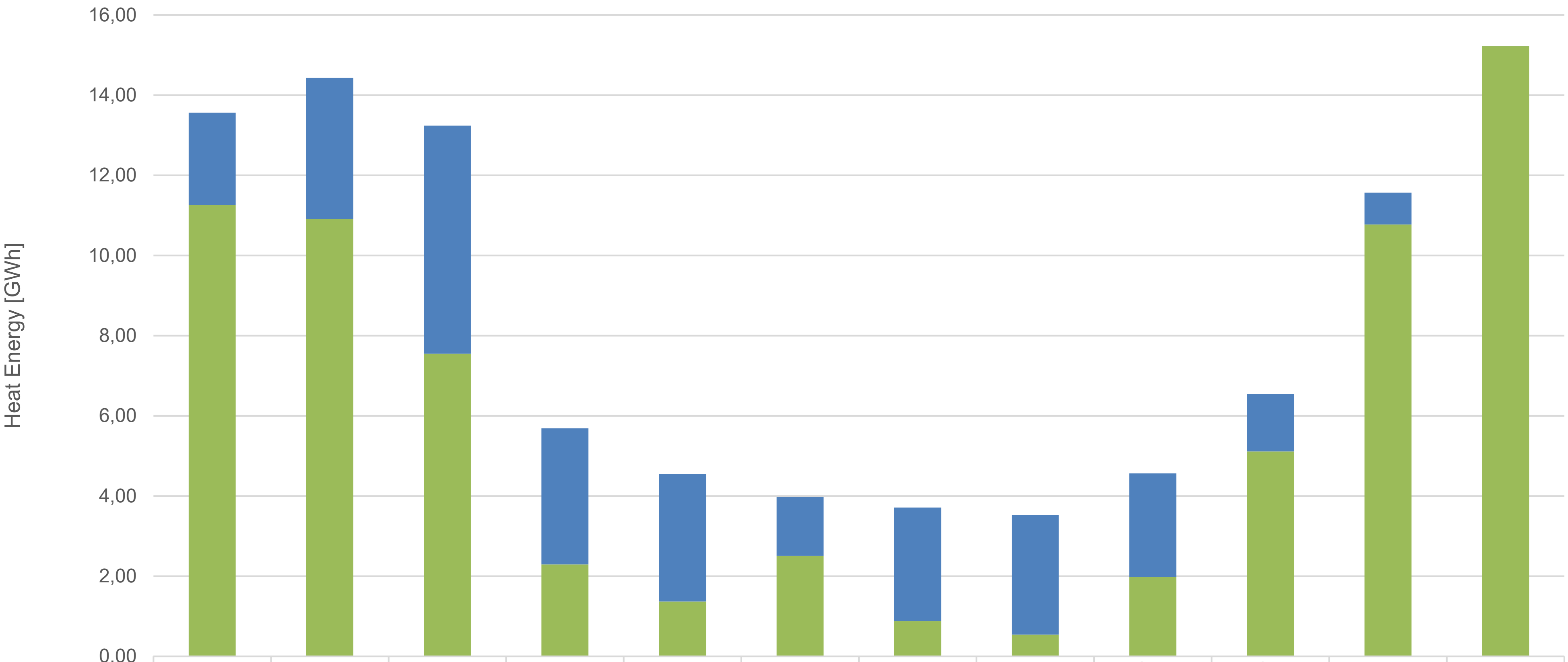


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Qloss_top	0,24	0,23	0,19	0,16	0,14	0,19	0,19	0,19	0,20	0,22	0,23	0,24
Qloss_sides	0,19	0,16	0,16	0,16	0,16	0,17	0,20	0,25	0,27	0,29	0,27	0,23
Qloss_bottom	0,09	0,09	0,10	0,09	0,10	0,09	0,10	0,10	0,12	0,12	0,10	0,09

– Total losses for reference year: 6.13GWh (2.42GWh through lid, 2.52GWh through walls, 1.19GWh through floor

Low Temperature grid with Geothermal: Energy mix with Storage

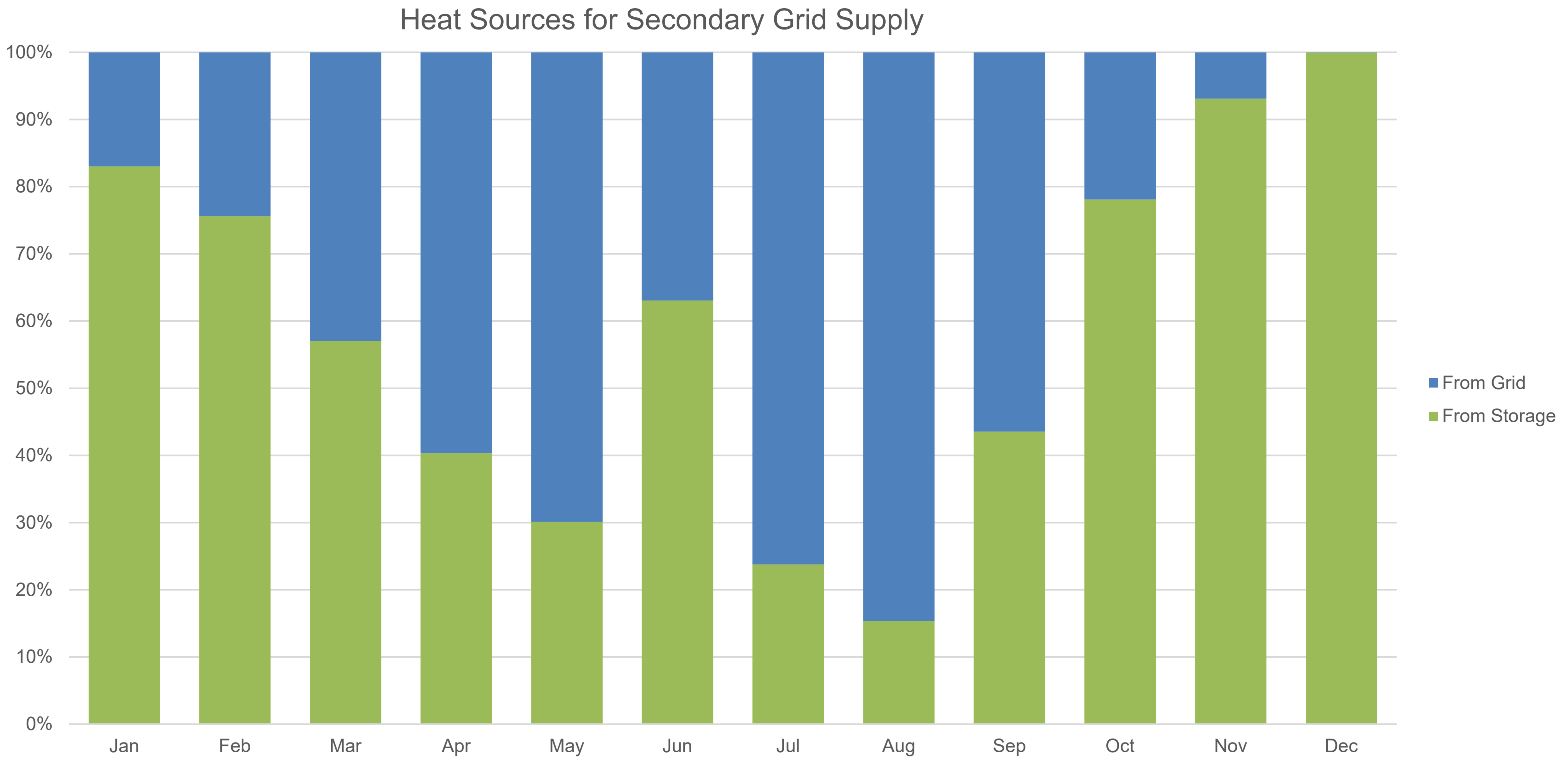
Heat Sources to meet Secondary grid Demand



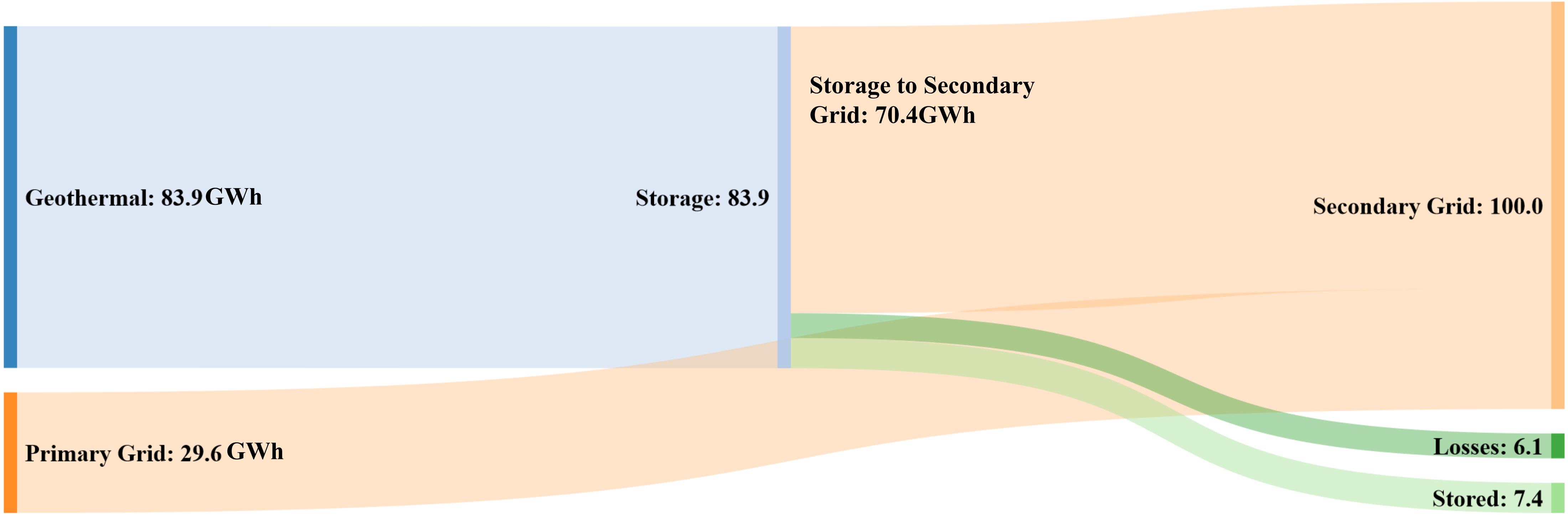
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
From Grid	2,30	3,52	5,69	3,39	3,18	1,47	2,83	2,99	2,58	1,43	0,80	0,01
From Storage	11,26	10,91	7,55	2,29	1,37	2,51	0,88	0,54	1,99	5,11	10,77	15,22

– Approx 70% of annual heating demand could be covered by the Storage alone

Low Temperature grid with Geothermal: Energy mix with Storage (percentage)

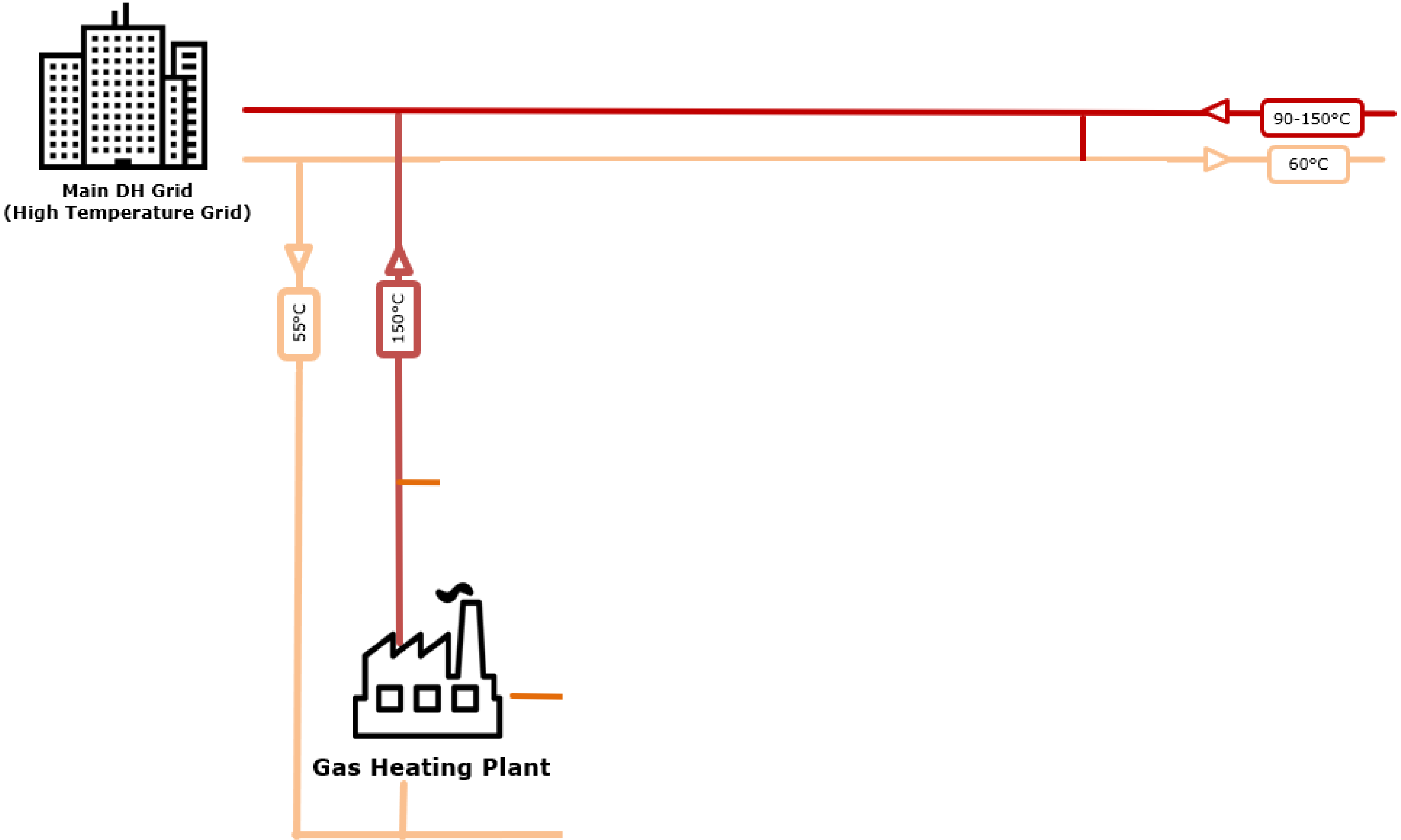


Low Temperature grid with Geothermal: Sankey Graph

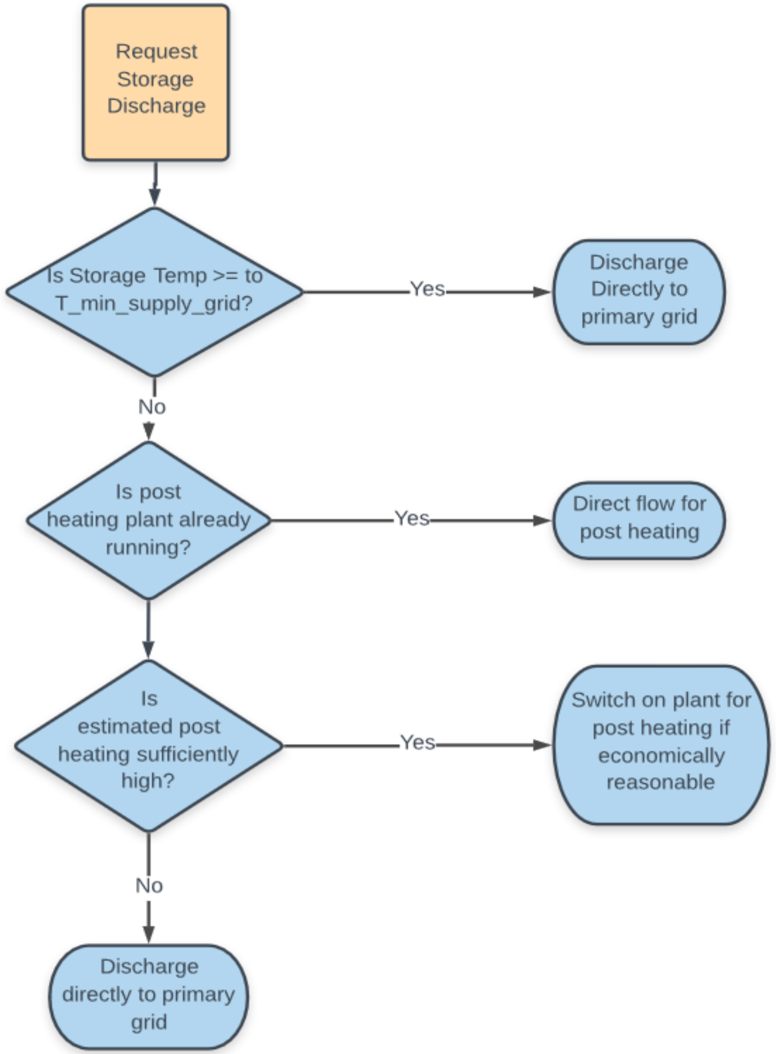


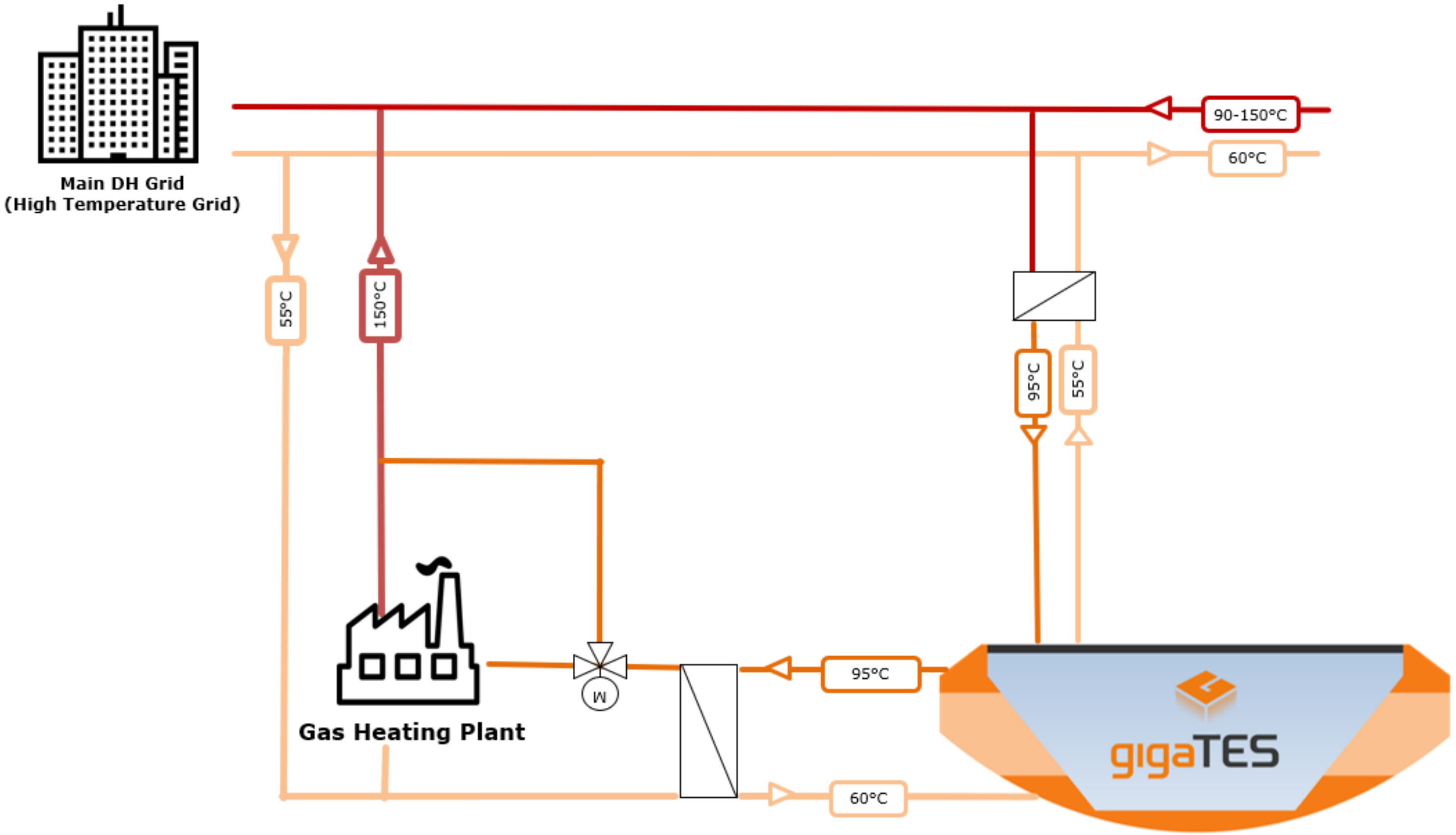
Storage Efficiency	0.93
Number of Cycles	1.4

Case Study II: High Temperature Grid with Post Heating



Primary grid case study – Discharge Control Strategy





Case Study II: High Temperature Grid with Post Heating

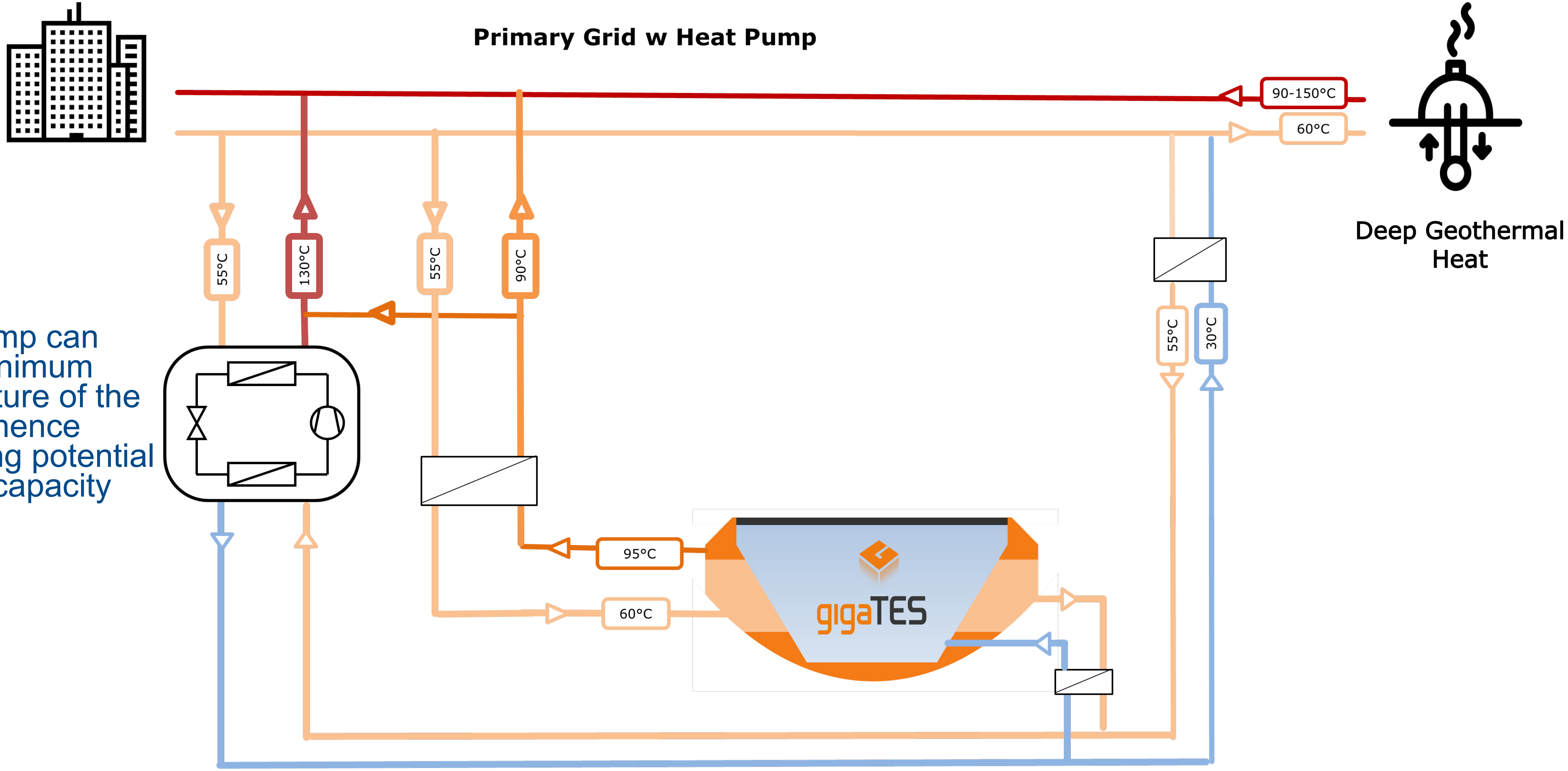
Role of Storage

- To store heat from the primary grid during times of excess heat production.
- Discharge to back to primary grid when most economically favourable.

Goal of Scenario

- To increase the share of renewables in the heating grid at the lowest possible cost

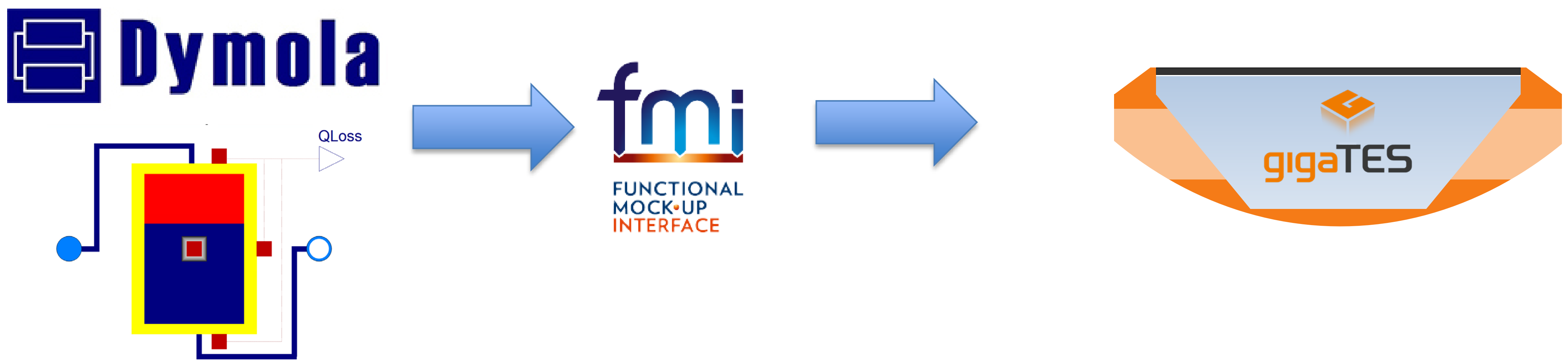
Case Study III: High Temperature Grid with Heat Pump



Heat Pump can lower minimum temperature of the storage hence increasing potential storage capacity

Next Steps in Simulations – Project Outlook

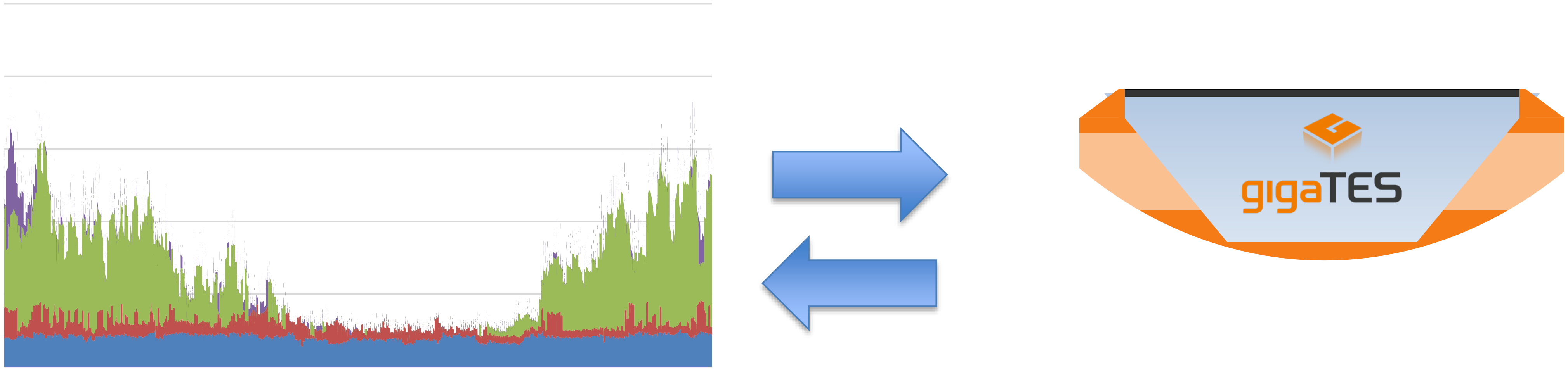
- Refinement of Scenarios/model choice:
  - Coupling with more detailed Pit Storage models
  - Complex Geometry
  - Inclusion of groundwater



Next Steps in Simulations – Project Outlook

- Scenario Evaluations – impact of variants in:
- Storage Capacity,
- Storage Construction type
- **Unit Commitment Strategy**
- Max Temperature Levels

€/MWh vs CO_2 savings per annum



Thank you for your attention!