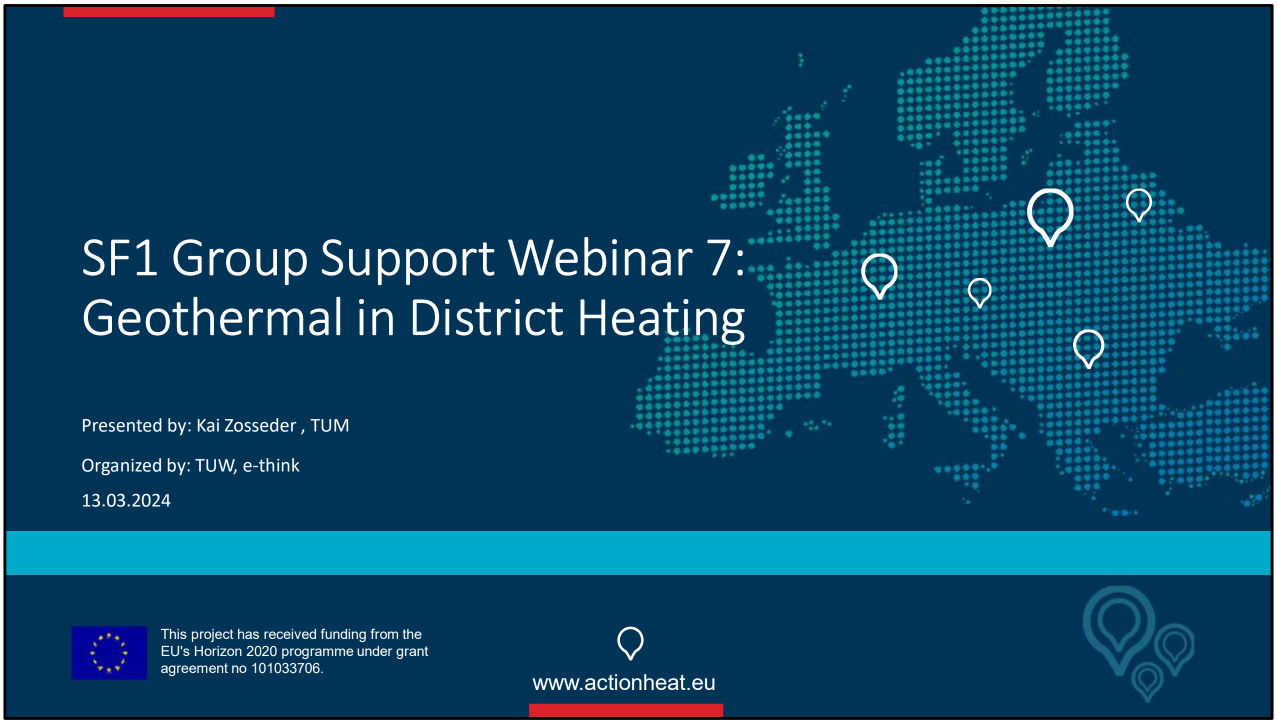
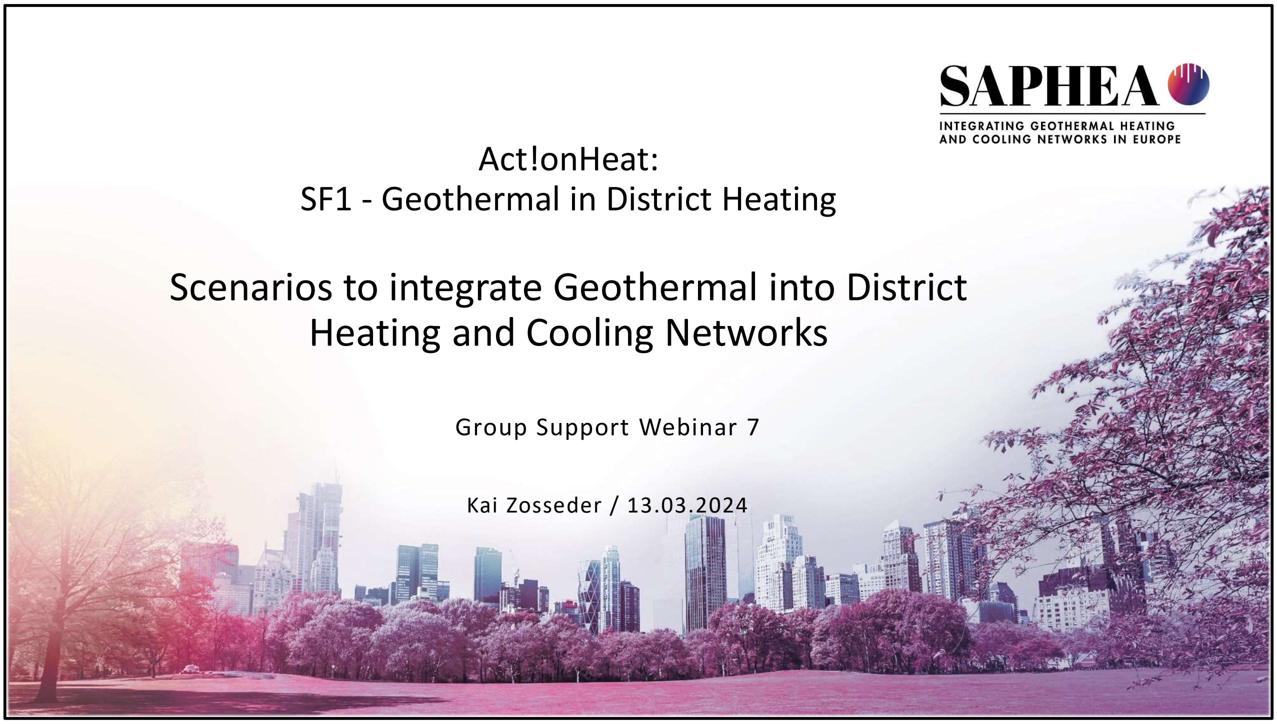


Webinar 7:
Geothermal in District Heating

Act!onHeat SF1

- Serial 3:
    - Webinar 7
        - Strategical Heating & Cooling planning
        - Group support for municipalities and stakeholders
- Organized by:
    - e-think / Austria
    - TU-Wien / Austria



- The presentation provides an overview of the Scenarios to integrate Geothermal into District Heating and Cooling Networks.
- The work was carried out within the SAPHEA project and presented by Dr. Kai Zosseder.

Motivation:

- Decarbonisation to reach climate goals
- Security of energy supply

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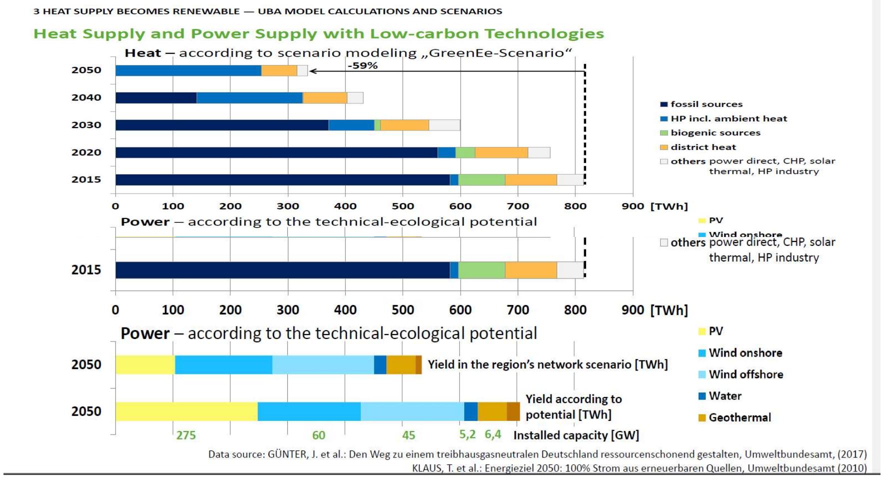
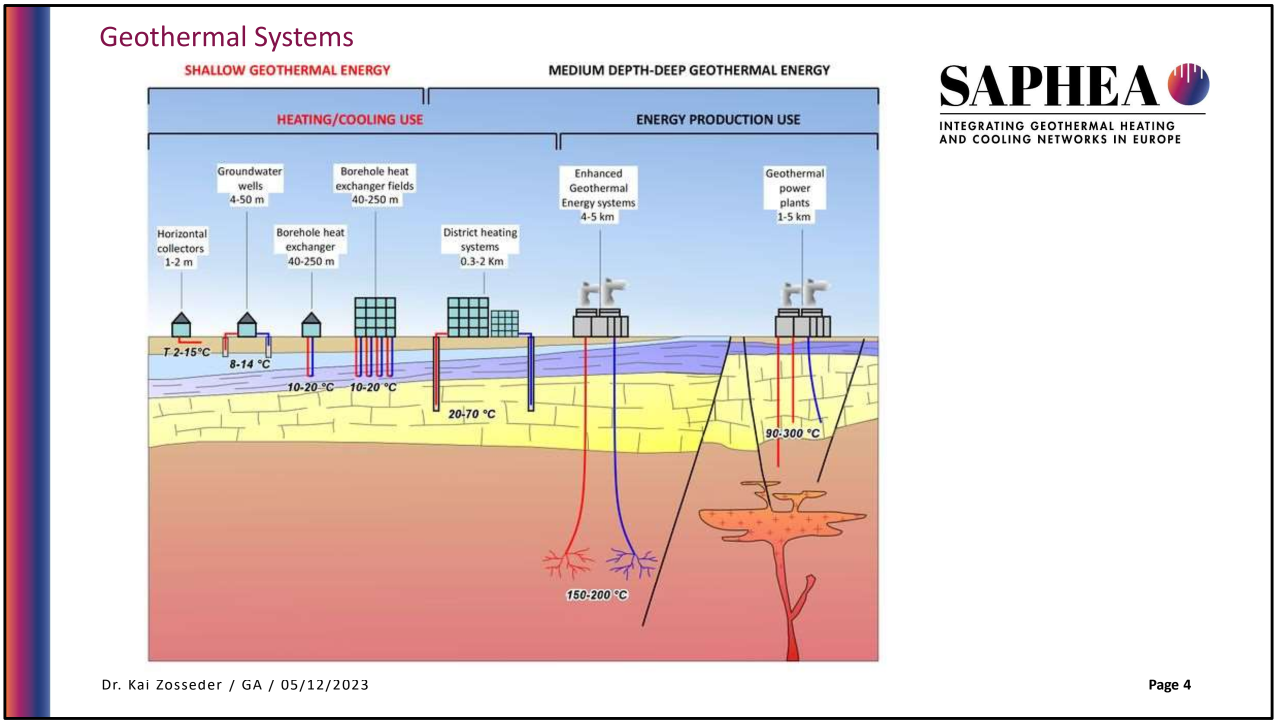
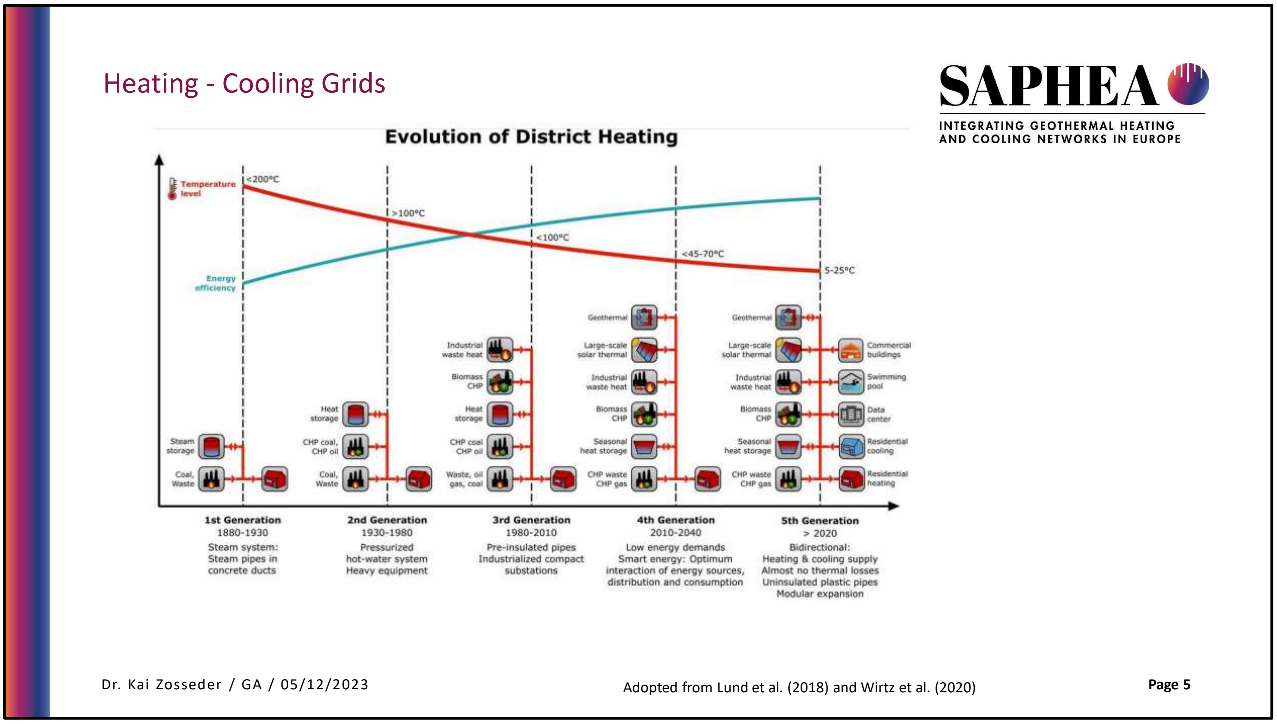


The motivations for using geothermal in district heating are:

- Achieving decarbonization targets
- Security of supply
- Ambient heat could contribute to a major portion of the supply shares in the future



- Overview of geothermal systems, including shallow and deep geothermal sources.
- Emphasis on geothermal energy as a stable, low-emission heat source.
- Details on technical aspects such as:
    - Depth of wells.
    - Heat extraction methods.
    - Suitable temperature ranges for different applications in district heating and cooling.



- Focus on heating and cooling grids and their integration with geothermal systems.
- Highlights the role of geothermal energy in creating efficient and flexible heating and cooling grids, facilitating energy transfer between sources and users.
- Emphasizes how newer generations, including 4th and 5th, enhance energy efficiency and integrate renewable sources like geothermal energy more effectively.

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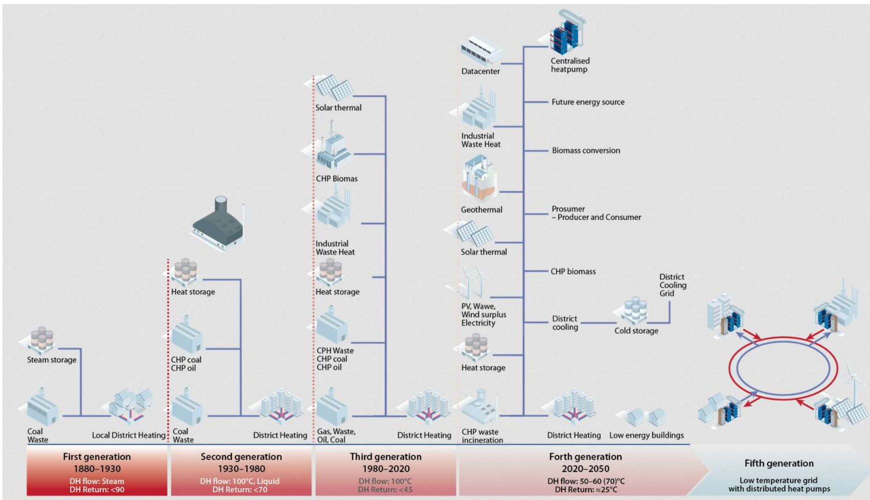

- This slide contains visual content without specific text or detailed information.
- Likely serves as a transition or visual representation of geothermal systems or district heating concepts.
- Could be used to emphasize the shift towards geothermal energy in heating and cooling networks.

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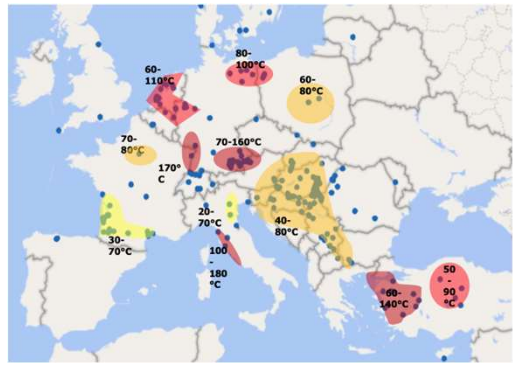
„Geothermal“ Networks distributed in Europe

Table 1: Statistical KPIs of direct geothermal energy used in heating networks in Europe as for 2019 based on the EGEC Geothermal Market report 2020 (data source: European Geothermal Energy Council).

KPI	Sample Size	P50	P75
Installed capacity (MW)	341	7	14
Temperature of production well (°C)	179	72	80
Capacity factor (gross heat / installed capacity (kh/yr)	234	2,59	3,98

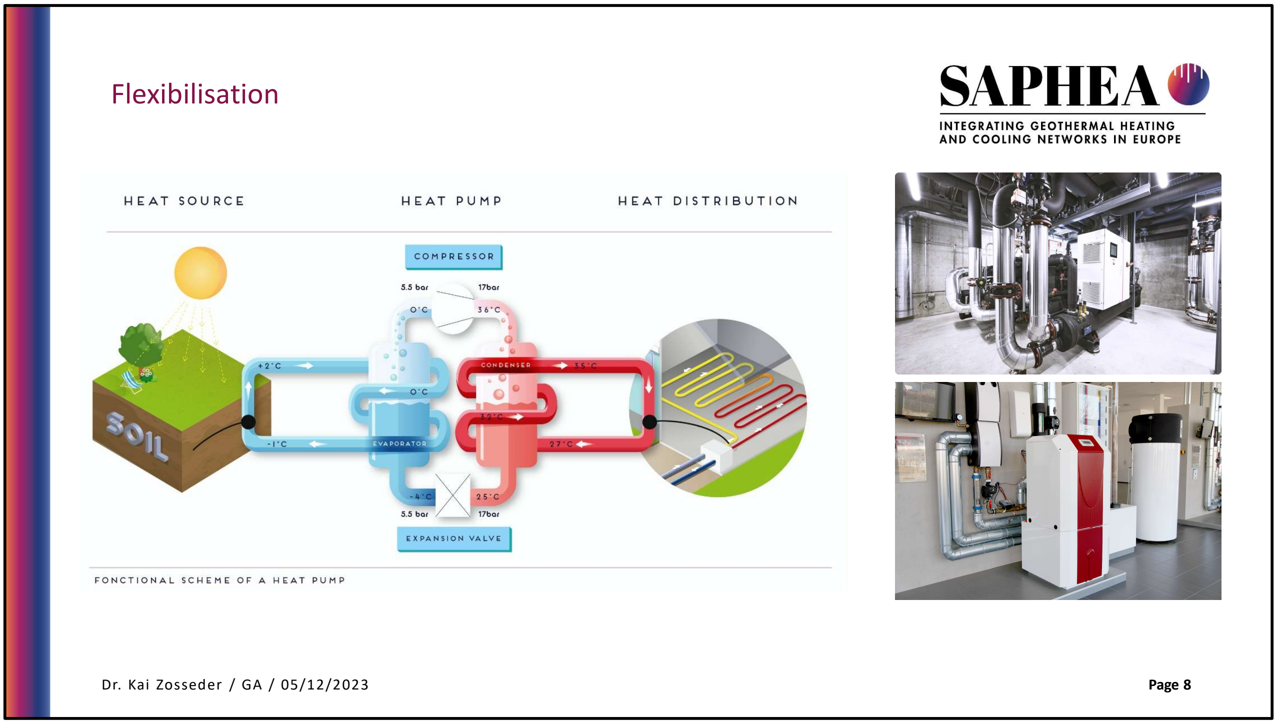
Source: Goetzl et al., 2022

- **364 direct use geothermal DH networks** in Europe ~ **5.6 GW capacity**
- **Approx. >100 5G networks** in Europe linked to geothermal technologies



Source: EGEC Geothermal Market Report 2021

- Overview of 364 geothermal district heating networks in Europe, providing around 5.6 GW capacity, with over 100 emerging 5th generation (5G) networks.
- 5G networks support flexible energy systems and better integration with renewables like solar and wind.
- Expanding geothermal can reduce fossil fuel dependency, support EU climate goals, and improve energy resilience year-round.



- Focus on the concept of “flexibilization" in district heating, emphasizing the role of geothermal energy in balancing supply and demand.
- Highlights how geothermal can be used alongside other energy sources to manage peak loads and optimize system efficiency.
- Flexibilization is crucial for adapting to varying energy demands and integrating renewable sources, ensuring a stable energy supply throughout the year.

Flexibilisation

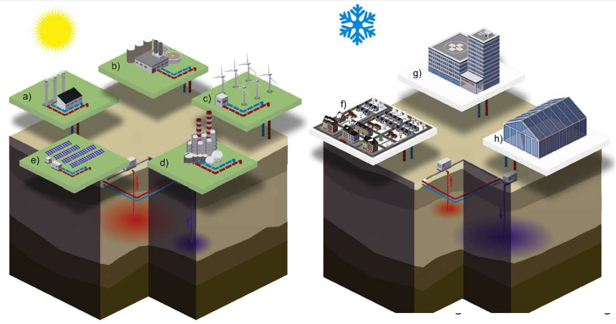
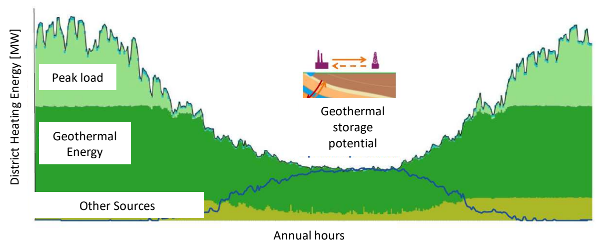


Fig. 1. Basic principle of HT-ATES. In summer, the aquifer is charged with surplus heat frc power-to-heat (c), industrial heat waste (d) or solar (e). The stored heat is recovered in winte or industrial applications such as greenhouses (h).



- Discusses the potential of geothermal energy storage to enhance system flexibility in district heating.
- Illustrates how geothermal can handle peak loads by storing excess heat and using it when demand is high.
- Emphasizes the integration of geothermal with other renewable sources to maintain a consistent energy supply, optimizing district heating efficiency throughout different seasons.

Combination with Geothermal Sources

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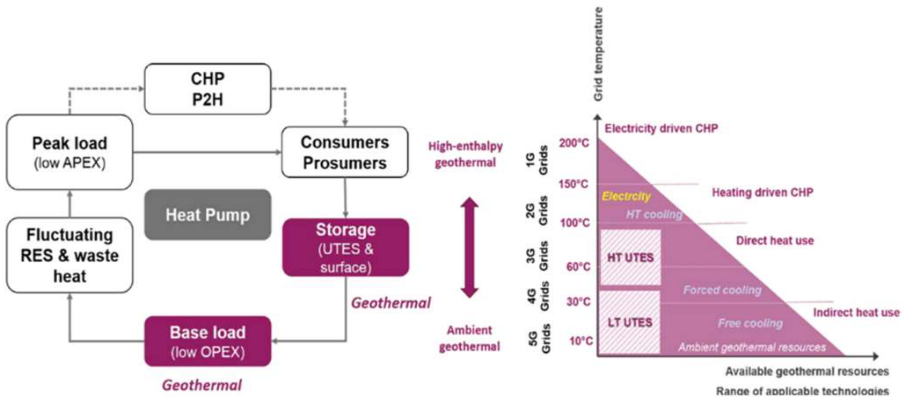
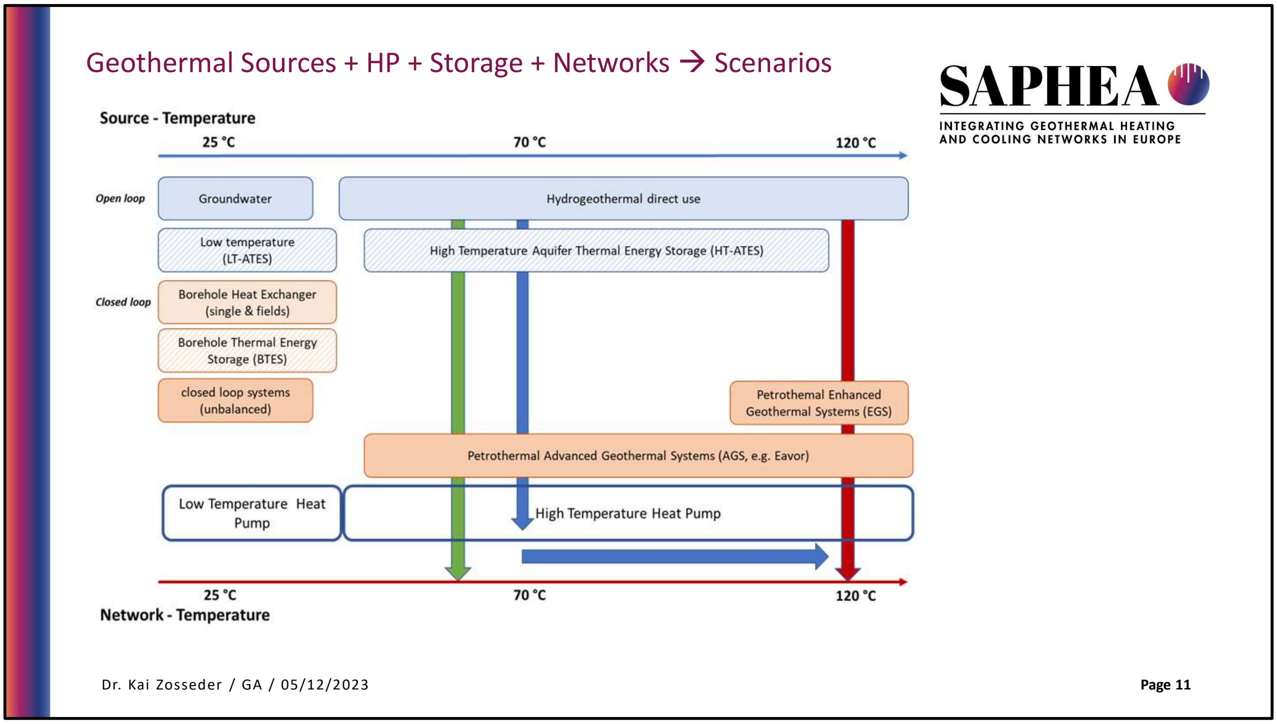
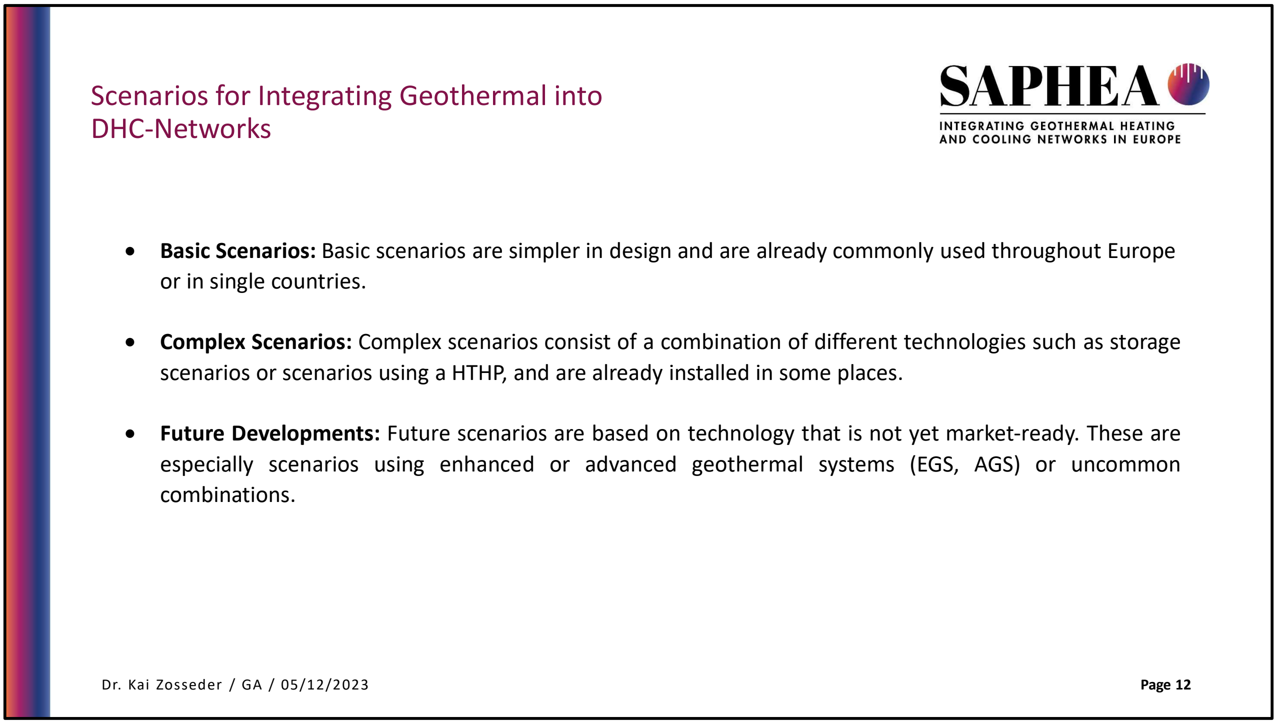


Goetzl et al. (2020)

- Explores the combination of geothermal energy with other heat sources to enhance district heating systems.
- Highlights the potential benefits of hybrid systems that integrate geothermal with technologies like heat pumps and thermal storage.
- Such combinations allow for greater adaptability and improved efficiency in meeting varying heating demands.



- Presents scenarios combining geothermal energy with heat pumps, storage solutions, and district heating networks.
- Emphasizes the need for strategic planning to optimize the mix of technologies for different regional contexts.
- Highlights the potential of these combinations to enhance the flexibility and sustainability of district heating systems.



- **Basic Scenarios**: These are simpler, commonly used configurations across Europe, involving standard geothermal integration.
- **Complex Scenarios**: These involve a combination of technologies such as heat pumps, storage systems, and high-temperature heat pumps (HTHP), already in use in some areas.
- **Future Scenarios**: Based on advanced geothermal systems (EGS/AGS) and emerging technologies that are not yet market-ready but hold potential for broader adoption in the future.

Basic Scenarios

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Number	Scenario name	Type	SourceT [°C]	Aquifer/ ground	GridT [°C]
Basic scenarios					
B 01	Shallow geothermal & Free cooling - DC Network	basic	5-25	aquifer/ground	0-15
B 02	Groundwater + decentral LTHP - LT Network	basic	10	aquifer	10-25
B 03	Hydrothermal Direct Use - HT Network	basic	90 <<	aquifer	80 - 120
B 04	Hydrothermal Direct Use - MT Network	basic	40 - 90	aquifer	40 - 60
B 05	Groundwater + central HP - MT/HT Network	basic	10 - 30	aquifer	25- 90
B 06	BHE + central HTHP/BTES - MT/HT Network	basic	-4 - 30	ground	25 - 90
B 07	BHE + decentralized LTHP - LT Network	basic	-4 - 25	ground	10

- **Basic Scenarios**: These are straightforward, simpler designs already implemented across Europe, focusing primarily on integrating shallow or direct-use geothermal technologies into existing district heating and cooling (DHC) networks.
- **Examples of Basic Scenarios**:
  - Shallow geothermal systems combined with district cooling networks.
  - Direct-use hydrothermal wells extracting groundwater for medium- to high-temperature district heating applications.

Basic scenarios typically involve mature technologies, such as low-temperature heat pumps or direct geothermal use, which offer more accessible entry points for integrating geothermal energy into local networks. These systems often have lower investment costs and can serve as a foundation for future expansion or hybridization with more complex technologies.

Complex Scenarios

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Number	Scenario name	Type	SourceT [°C]	Aquifer/ ground	GridT [°C]
Complex scenarios					
C 01	Basic + LT ATES + LT/MTHP - LT/MT Network	complex	30 >	Aquifer	40 - 60
C 02	Hydrothermal + HTHP - MT/HT Network	complex	30-90	aquifer	60 - 120
C 03	Hydrothermal + Sorption Chiller - DC Network	complex	60 - 100	aquifer	6 - 15

- **Overview**: Combines geothermal with technologies like high-temperature heat pumps (HTHPs) and storage systems.
- **Key Points**:
    - Uses geothermal alongside other energy sources for greater efficiency.
    - Already installed in some European regions, improving heat supply flexibility.

Future Scenarios

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Number	Scenario name	Type	SourceT [°C]	Aquifer/ ground	GridT [°C]
Future scenarios					
F 01	Basic + HT-ATES – MT/HT Network	future	90 >>	aquifer	90
F 02	Advanced Geothermal Systems (AGS)	future	90 >>	ground	90
F 03	Enhanced geothermal system (EGS)	future	90 - 120	ground	90
F04	Deep BHE + HTHP – MT/HT Network	future	20 – 50	ground	90

- Focuses on future developments in geothermal integration, especially advanced and enhanced geothermal systems (AGS and EGS).
- **AGS and EGS**: These technologies involve closed-loop systems or enhanced geothermal wells, which are still in development and not widely commercialized.
- Potential for these systems to provide more flexible and scalable geothermal energy, making them applicable in a wider range of geographic and economic contexts.

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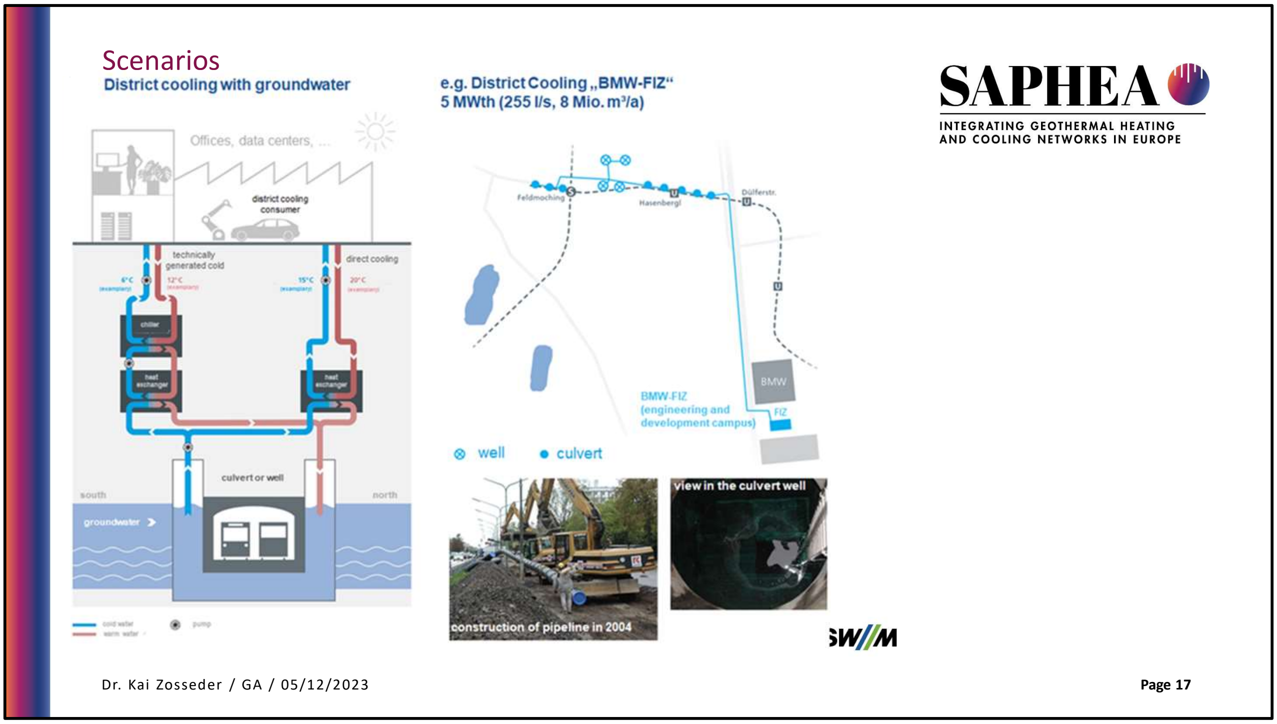
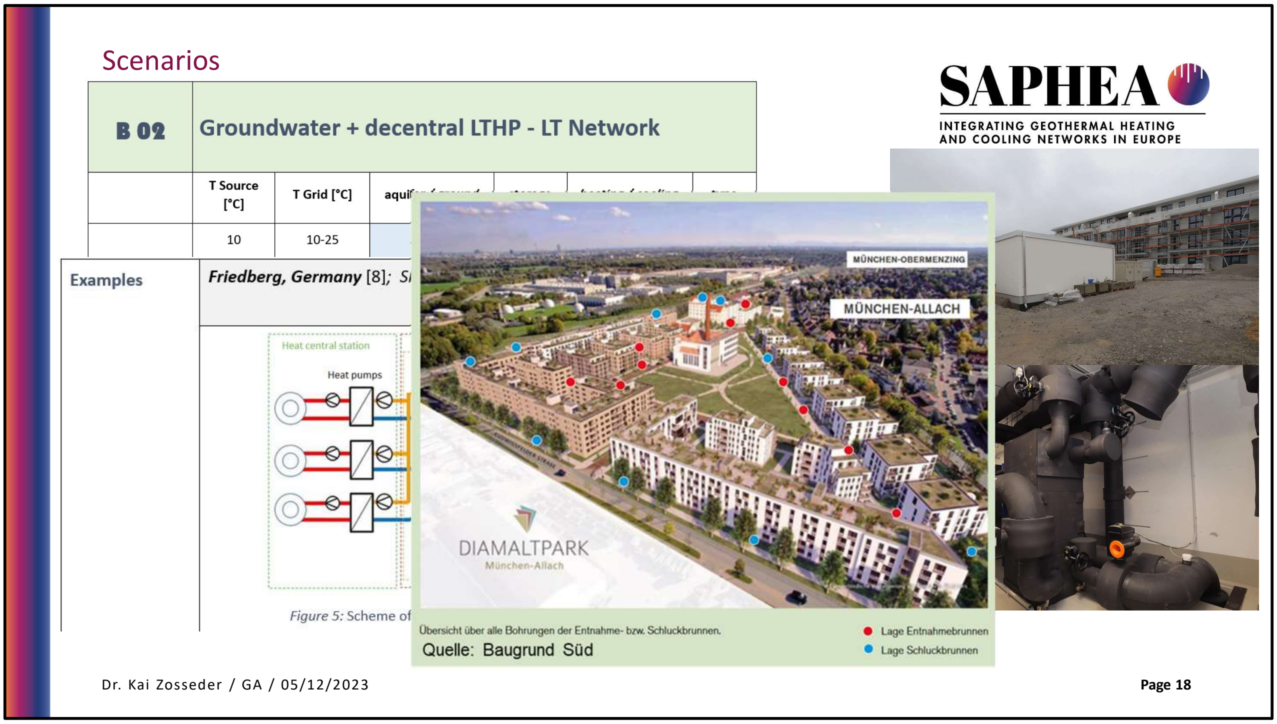
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

Basic Scenarios

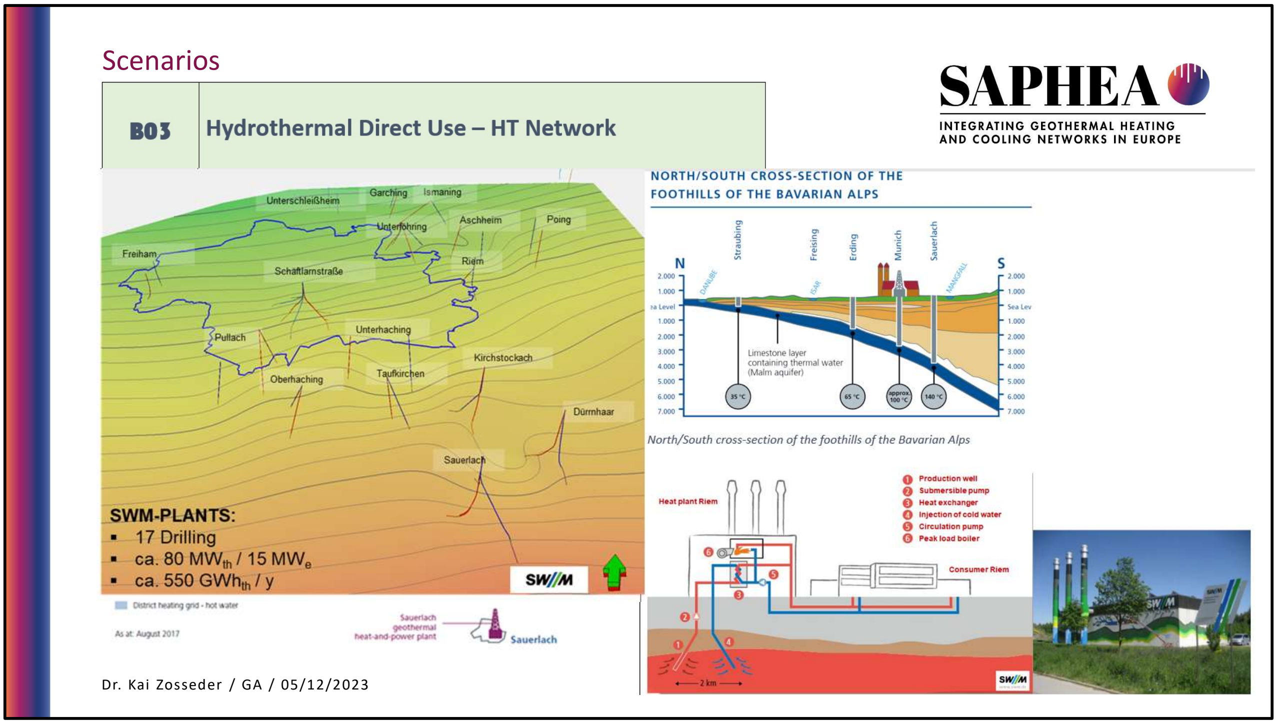


- Utilizes shallow geothermal energy with groundwater wells to supply cold water for district cooling (DC) networks.
- Cooling is delivered directly via a closed circuit, with supply temperatures typically around 4-8°C and return temperatures of 13-16°C.
- Suitable for systems where free cooling can be used, minimizing energy consumption and eliminating the need for mechanical chillers in many cases.

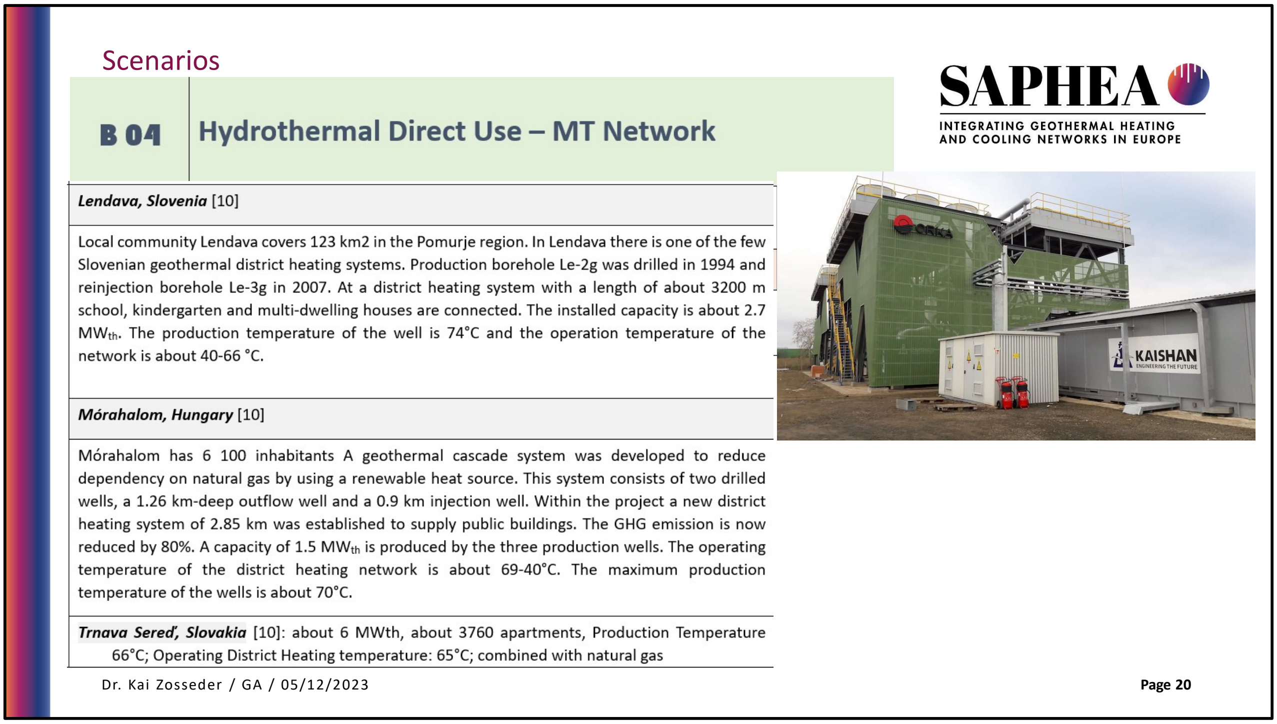
This setup is cost-effective with low maintenance and running costs, offering a highly efficient solution for district cooling



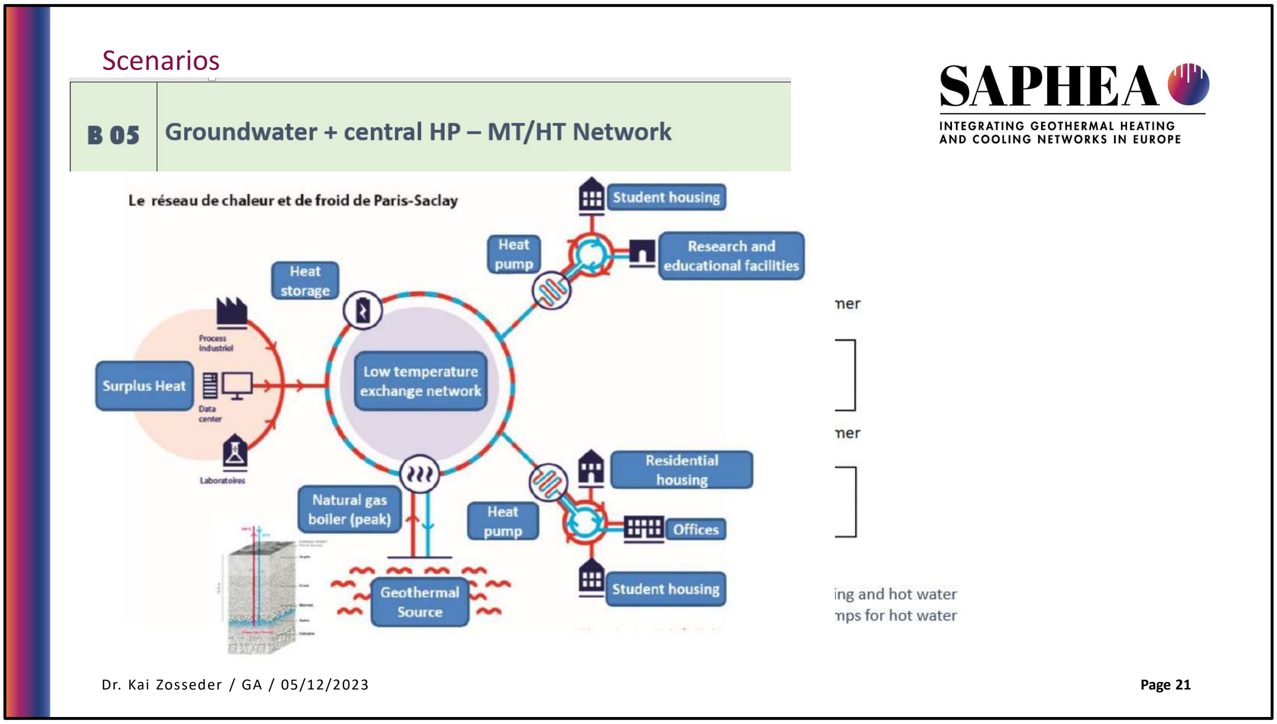
- In this scenario, groundwater wells are used to extract water at a low temperature (around 10°C) for a low-temperature district heating network (10-25°C).
- Each building has a decentralized low-temperature heat pump (LTHP) that raises the temperature to meet the required heating level for the building.
- This system, often referred to as a 5th Generation District Heating and Cooling (5GDHC) network, primarily serves as a provider of low-temperature ambient heat.
- It is particularly efficient for areas where low-temperature heating or cooling is needed, with minimal heat loss and flexible network operation.



- Involves hydro geothermal well doublets extracting groundwater at 90-120°C from deep geothermal reservoirs.
- Heat is transferred directly to high-temperature district heating networks (90-120°C).
- Suitable for high-temperature district heating systems (2nd and 3rd generation).
- Example of implementation: Munich, Germany, where this system is used to supply district heating.

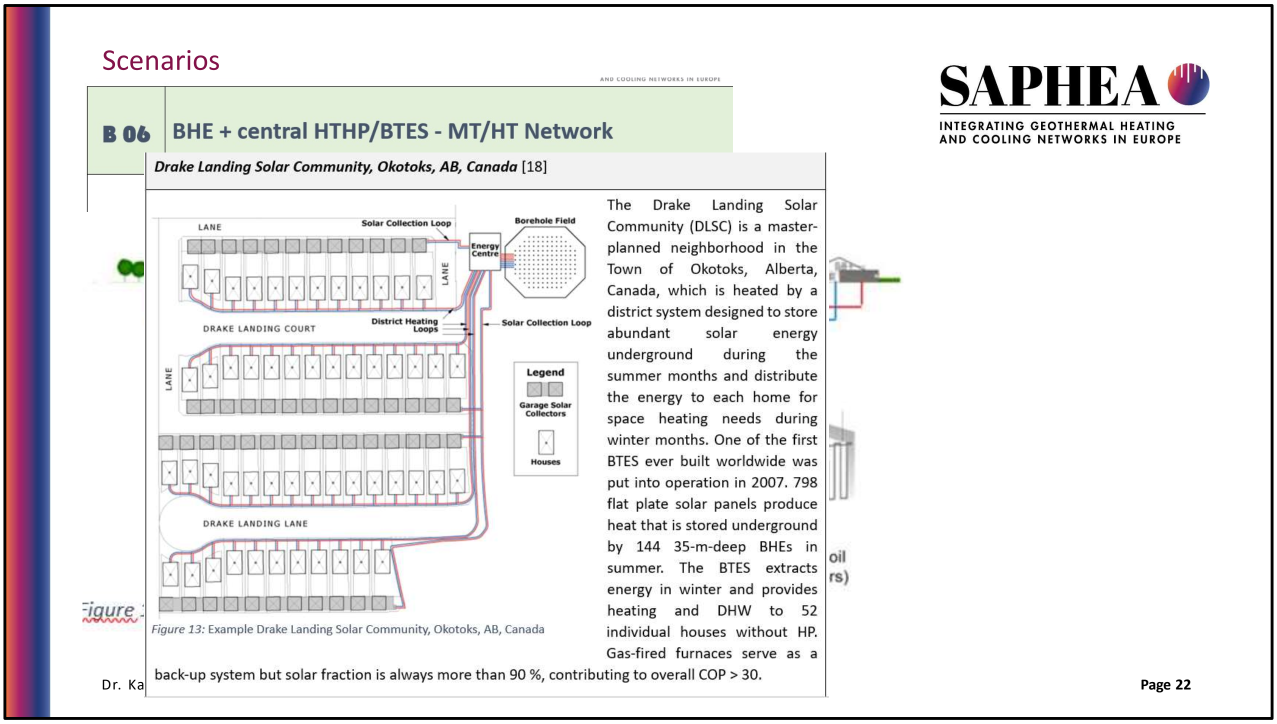


- Hydrothermal well doublets extract groundwater at 40-90°C from geothermal reservoirs at depths of approximately 1,500 meters and below.
- Heat is transferred via heat exchangers to district heating networks, supplying hot water at 40-60°C to end users.
- This scenario is suitable for medium-temperature networks (2nd and 3rd generation DHC systems).
- Examples include the Lendava system in Slovenia and Mórahalom in Hungary, where geothermal heating systems operate with moderate temperatures to meet local demand.



- Groundwater wells at shallow depths (10-30°C) combined with central large heat pumps to increase the temperature for district heating.
- The scenario typically serves medium- and high-temperature networks (25-90°C), covering the base load of the heat demand.
- Often integrated with other sources like combined heat and power (CHP) for added flexibility and efficiency in district heating networks.

This scenario is suitable for 4th generation district heating (4G DH) systems, offering flexibility in temperature adjustment to meet diverse energy demands across different regions.



- Borehole heat exchangers (BHE) are used in combination with high-temperature heat pumps (HTHP) and borehole thermal energy storage (BTES) systems.
- BHEs are installed at depths of 50-200 meters to deliver energy year-round, providing either heating or cooling depending on the season.
- During summer, heat is collected via solar panels or waste heat and stored in shallow BHEs (<50 m), while in winter, heat is extracted from deeper BHEs and delivered to the grid for heating.
- Short-term storage tanks (50-100 m³) improve system efficiency by acting as an intermediary between the BTES and the heating grid.

Scenarios

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B 07	BHE + decentralized LTHP - LT Network

Silkeborg. Denmark

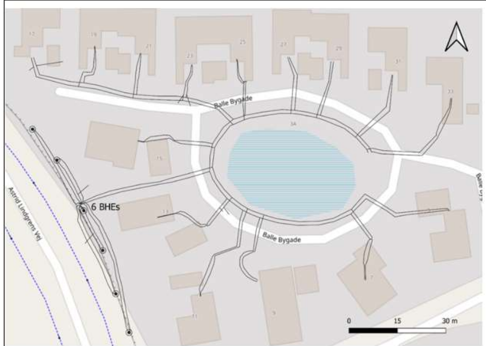
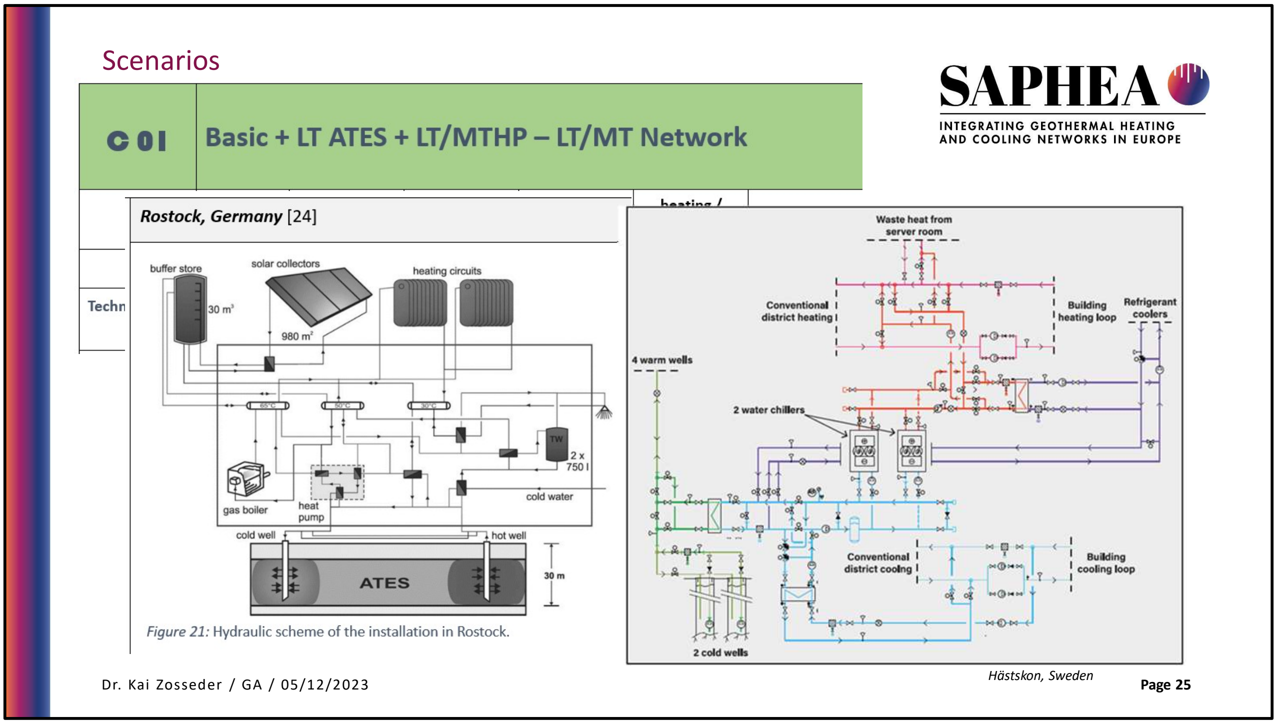


Figure 18: The thermonet at Balle Bygade in Silkeborg with 15 connected consumers. Balle Bygade no. 9 is the existing house built in 1979 (lower center of figure).

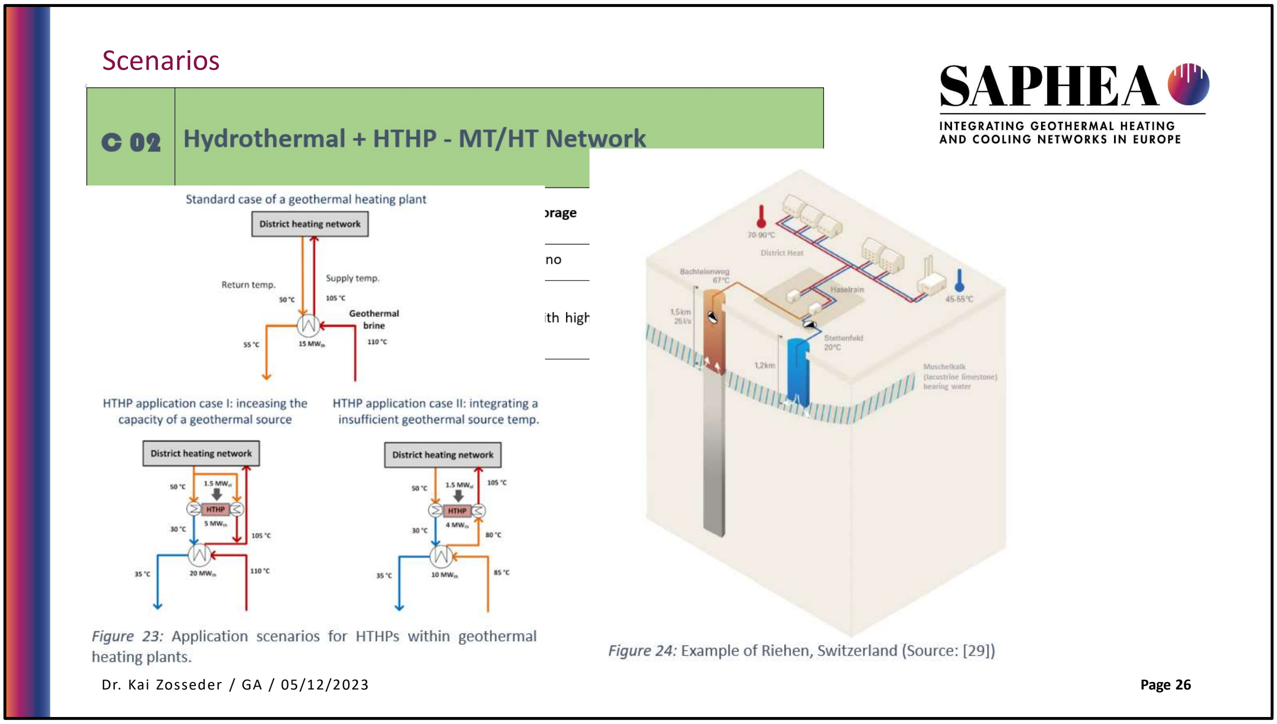
The 5GDH grid/thermonet consists of ca. 1340 m uninsulated PE forward and return pipes including the consumer connections with dimensions Ø40, Ø50, Ø63 and Ø90 mm. The thermonet connects six 120 m long borehole heat exchangers (BHE) with single-U Ø40 mm SDR probes, and a drilled diameter of 15.2 cm, to individual brine-to-water heat pumps in 15 (14 6kW and 1 10 kW) family houses. The annual heating consumption amounts to approximately 167 MWh and SCOP is 3.3 at the system level.

- Borehole heat exchangers (BHEs) are used to exchange thermal energy with a low-temperature district heating network.
- Each user is equipped with a decentralized low-temperature heat pump (LTHP) that adjusts the temperature of the heat from the BHE for space heating or cooling.
- The system can operate in both heating and cooling modes, depending on seasonal demand, with energy being extracted or injected into the ground.
- Suitable for 5th generation district heating and cooling (5GDHC) networks, this setup optimizes energy efficiency with minimal heat losses.

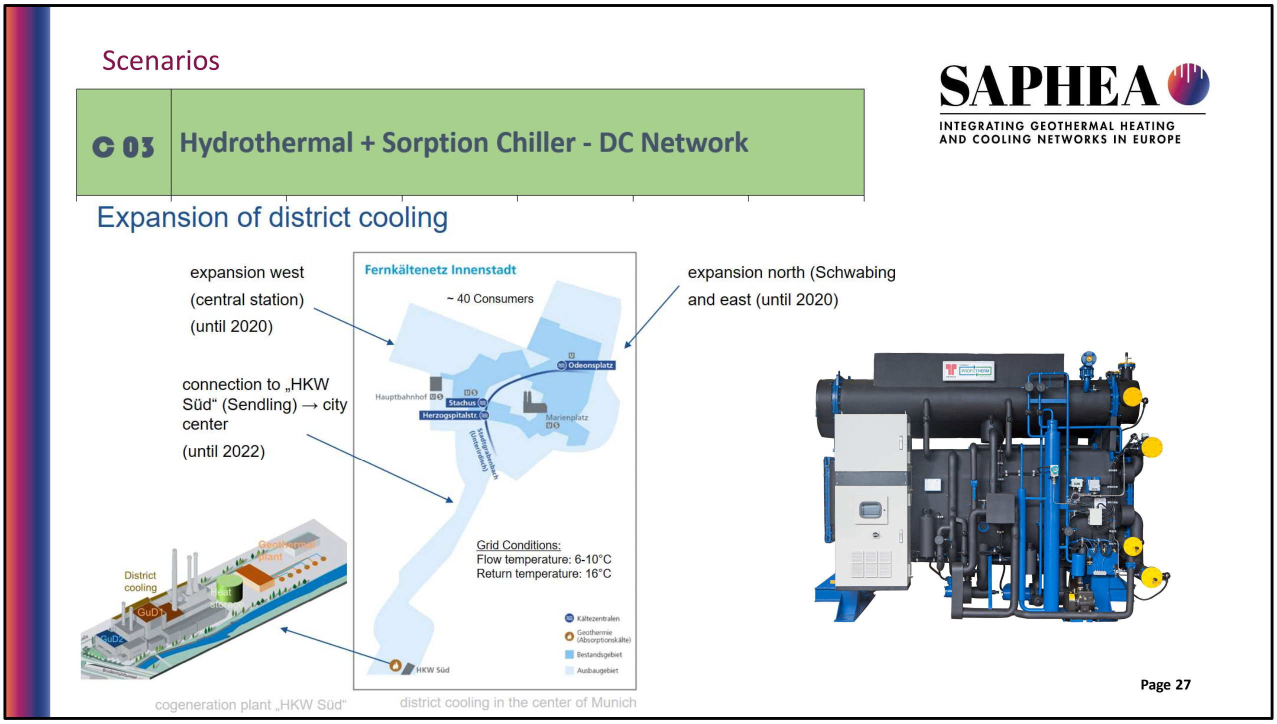
Complex Scenarios



- The scenario uses Aquifer Thermal Energy Storage (ATES) systems to provide low-temperature (LT) and medium-temperature (MT) heating for district heating networks.
- Groundwater is extracted from aquifers and stored for later use, supporting efficient heating in buildings, with temperatures ranging from 30°C in the aquifer to 40-60°C in the grid.
- The system enables cooling during summer by utilizing cold groundwater stored in the previous winter season and reinjecting excess heat from cooling processes into the warm well for winter heating.



- Demonstrates the use of hydrothermal well doublets combined with high-temperature heat pumps (HTHP) to supply medium- to high-temperature district heating networks.
- The scenario shows how lower-temperature geothermal sources (30-90°C) are lifted by HTHPs to match the heating grid requirements of 60-120°C.
- This setup increases the efficiency and flexibility of district heating systems, enabling better use of lower temperature geothermal resources in regions that require higher network temperatures.



- Hydrothermal well doublets extract geothermal heat (60-100°C), which is used to drive sorption chillers for district cooling networks.
- The cooling network operates with supply temperatures around 6-10°C and return temperatures of 15-17°C.
- This scenario is suitable for larger commercial and industrial buildings, where sorption chillers offer a lower electricity demand compared to traditional vapor compression cycles.

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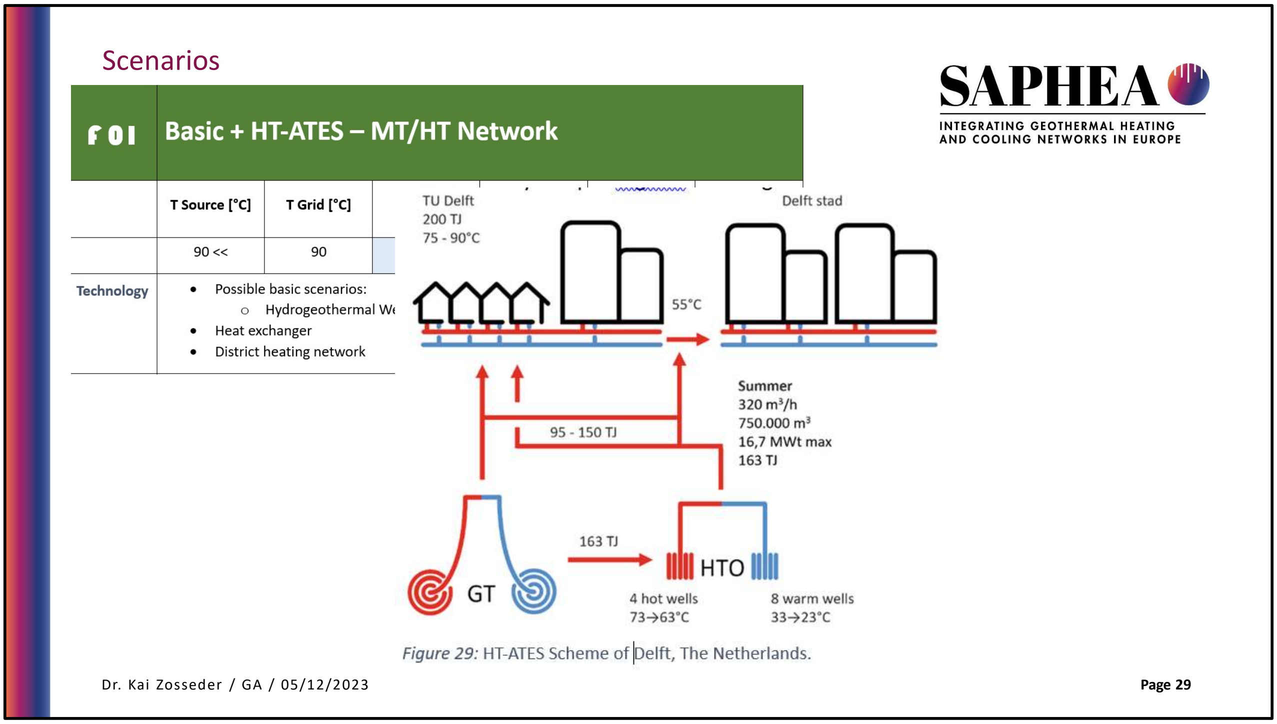
Future Scenarios



- The scenario demonstrates the use of high-temperature Aquifer Thermal Energy Storage (HT-ATES) systems to provide heat to medium- and high-temperature district heating networks.
- Aquifers serve as storage mediums, with stored temperatures reaching up to 90°C at depths between 300 and 3,000 meters.
- Heat is extracted from the aquifer using well doublets and transferred via heat exchangers to district heating networks, ensuring consistent heat supply.

Scenarios

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F 02 Advanced Geothermal Systems

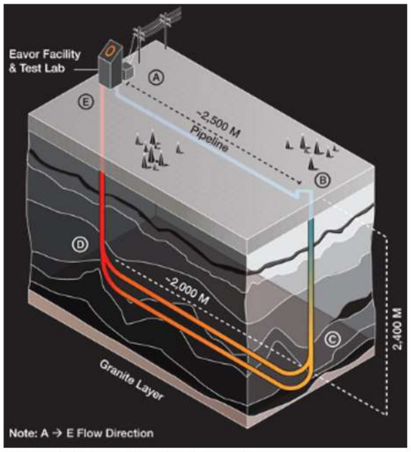


Figure 30 Eavor-Lite (Prototype)

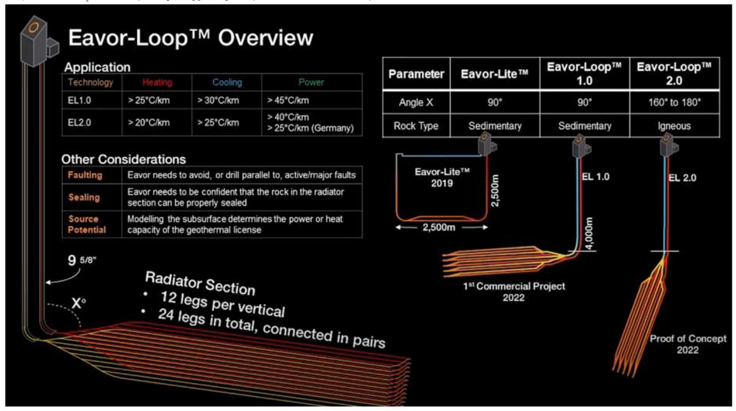
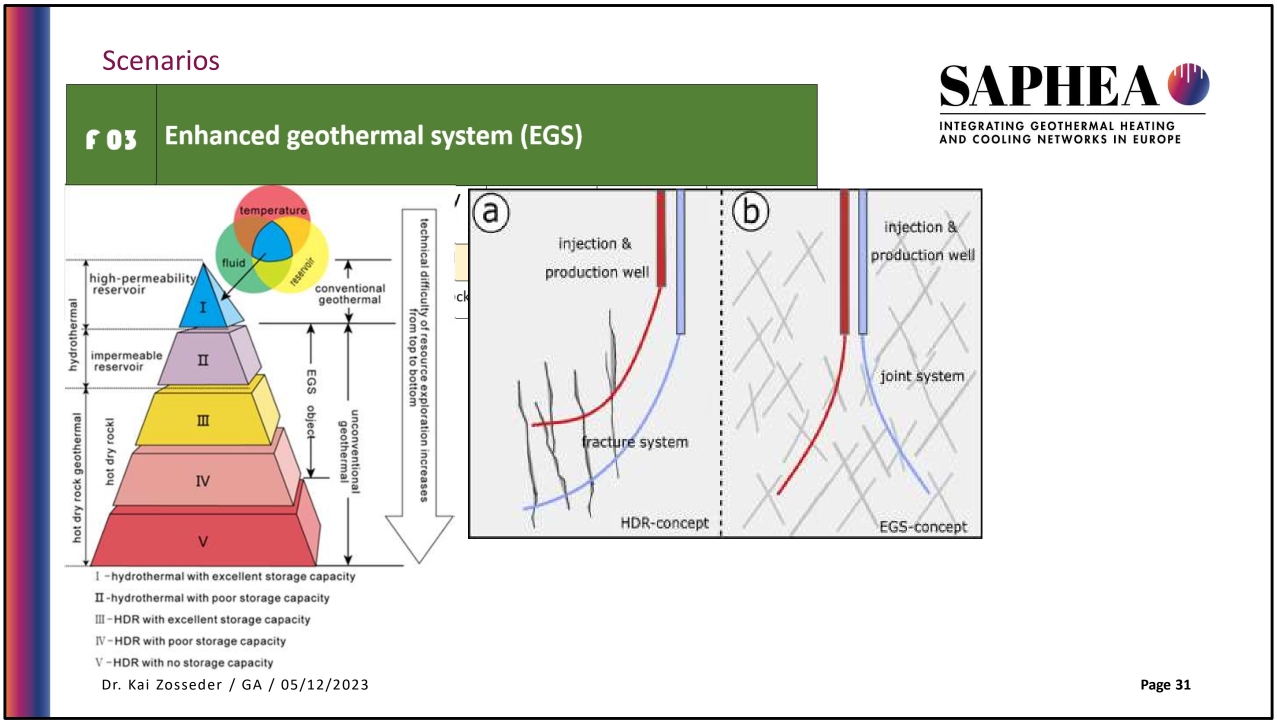
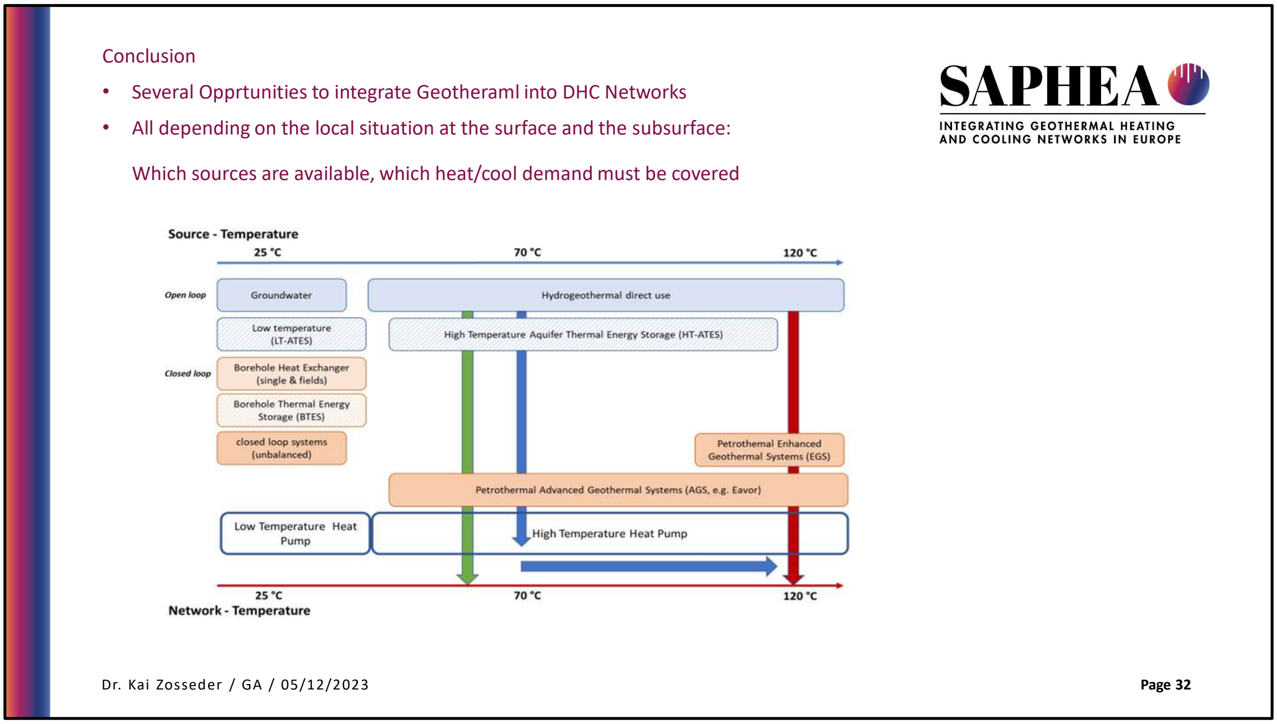


Figure 31: Eavor-Loop™

- This scenario focuses on **closed-loop geothermal systems** like **Eavor-Loop™** and **GreenLoop**, where no fluids are extracted from the Earth.
- Fluids circulate in sealed pipes deep underground, picking up heat by conduction, and carry it to the surface for heating or electricity generation.
- These systems reduce risks such as seismic activity and water consumption and can be implemented in a variety of locations due to their scalability.
- Suitable for future developments in both heating and power generation applications.



- The Enhanced Geothermal System (EGS) harnesses geothermal heat from deep underground (3-6 km), utilizing low-permeability rocks.
- EGS involves creating a large subterranean heat exchanger by injecting pressurized water into the rock to widen existing cracks, enhancing the flow of heat.
- EGS systems can provide heat for district heating networks and are capable of operating at temperatures between 90-120°C, offering potential for high-efficiency, high-temperature heating solutions in the future.



- Several opportunities exist to integrate geothermal energy into district heating and cooling (DHC) networks, contingent upon local surface and subsurface conditions.
- The availability of geothermal sources and the specific heating and cooling demands that need to be met will dictate the most effective integration approach.
- Strategic planning and assessments are essential for optimizing the mix of technologies tailored to local circumstances.

Thank you!

Get in contact with us:
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INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

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