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INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

Act!onHeat:
SF1 - Geothermal in District Heating

Scenarios to integrate Geothermal into District Heating and Cooling Networks

Group Support Webinar 7

Kai Zosseder / 13.03.2024

Motivation:

- Decarbonisation to reach climate goals
- Security of energy supply

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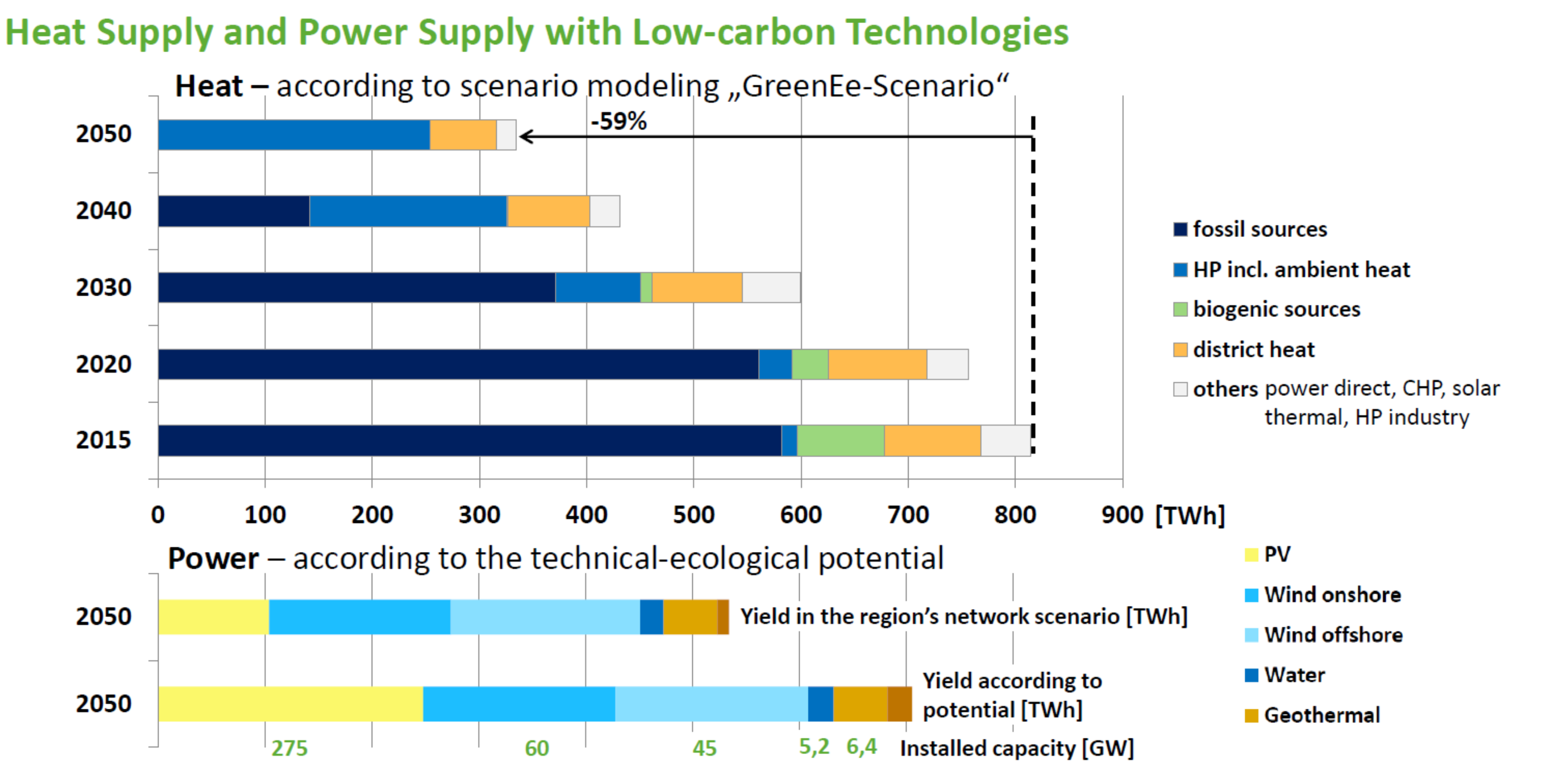
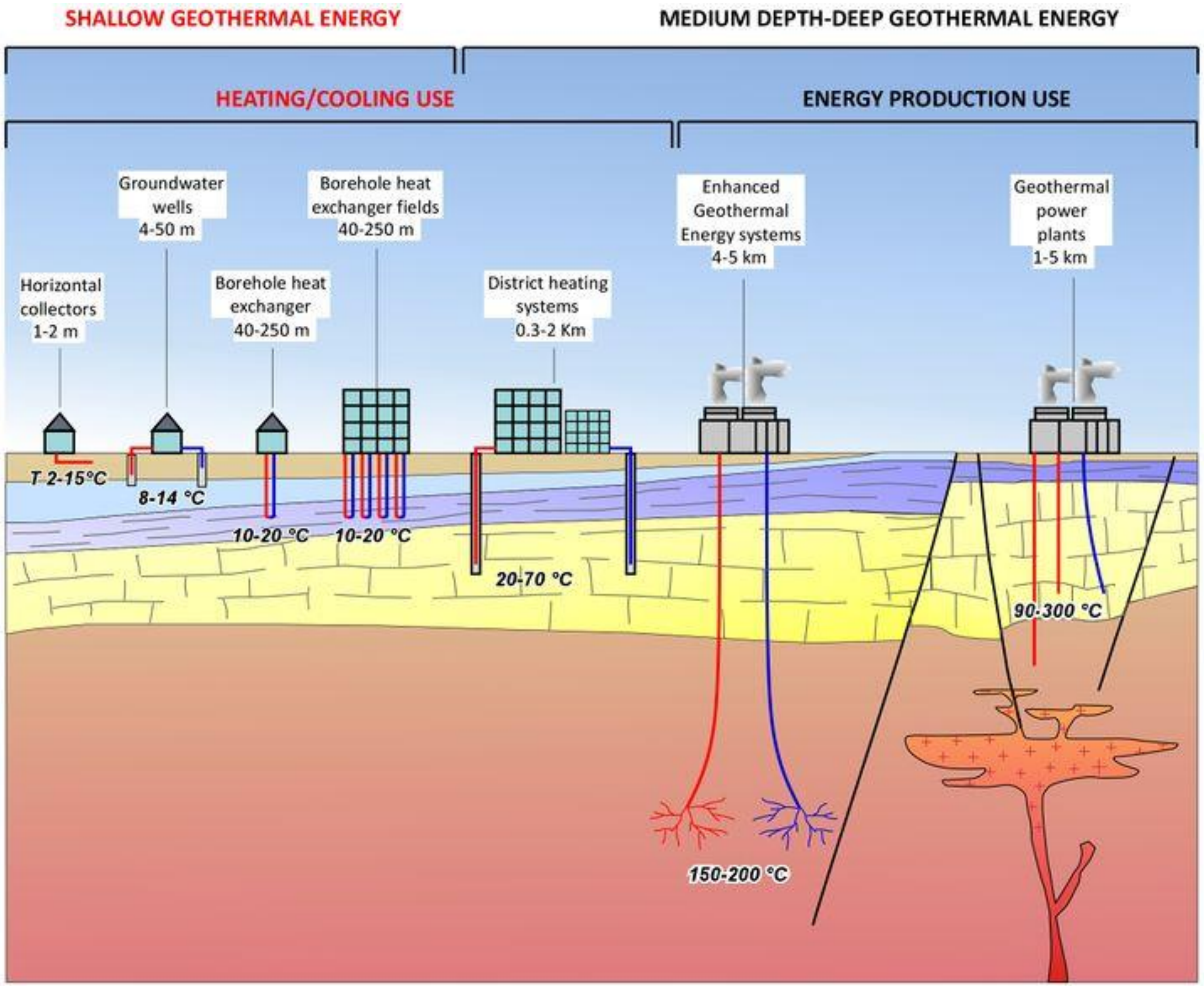
3 HEAT SUPPLY BECOMES RENEWABLE — UBA MODEL CALCULATIONS AND SCENARIOS



Data source: GÜNTER, J. et al.: Den Weg zu einem treibhausgasneutralen Deutschland ressourcenschonend gestalten, Umweltbundesamt, (2017)
KLAUS, T. et al.: Energieziel 2050: 100% Strom aus erneuerbaren Quellen, Umweltbundesamt (2010)

Geothermal Systems



Heating - Cooling Grids

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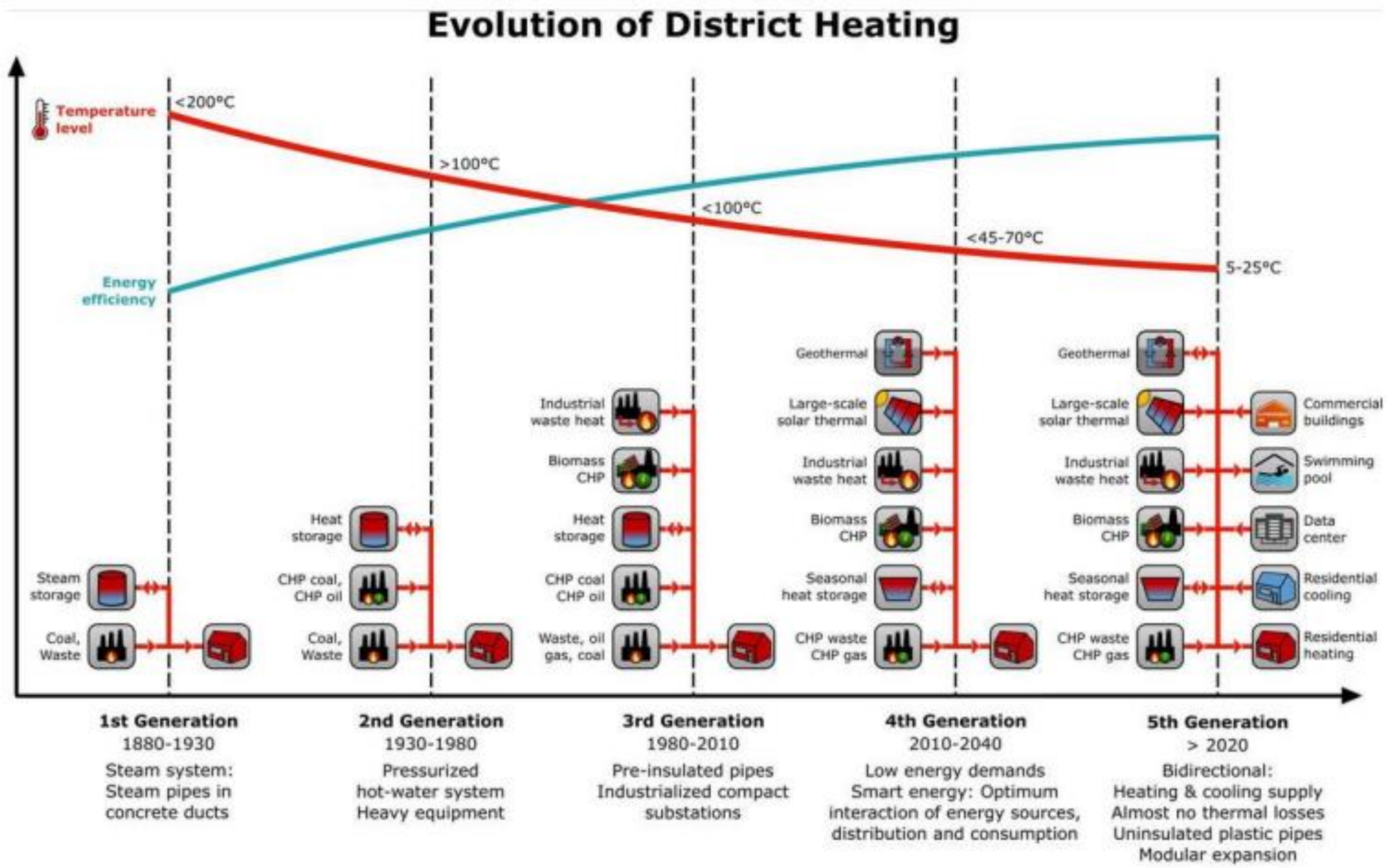
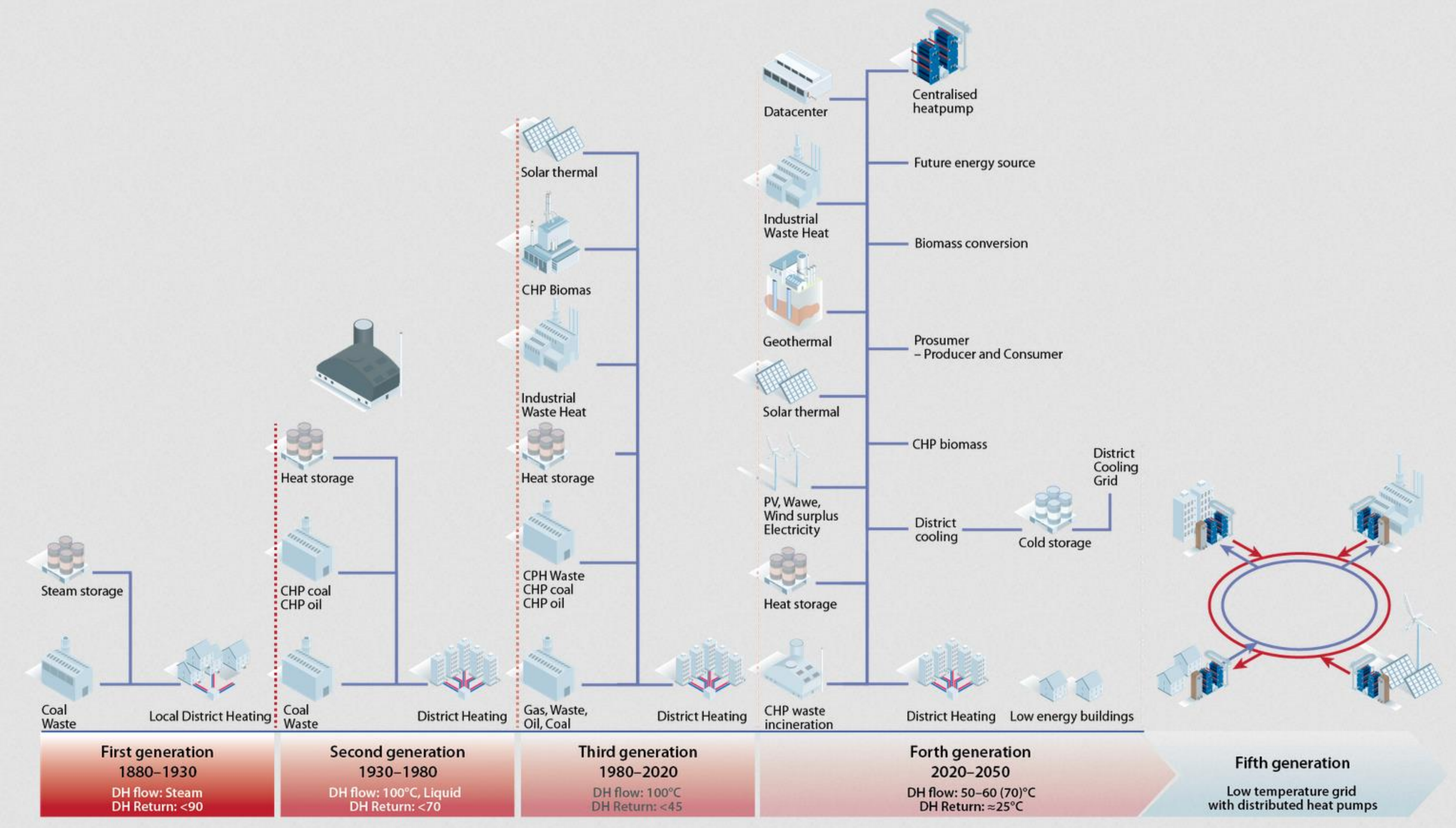


Adopted from Lund et al. (2018) and Wirtz et al. (2020)


Steam storage
Coal
Waste
Local District Heating
Heat storage
CHP coal
CHP oil
Coal
Waste
District Heating
Solar thermal
CHP Biomas
Industrial
Waste Heat
Heat storage
CPH Waste
CHP coal
CHP oil
Gas, Waste,
Oil, Coal
District Heating
Datacenter
Centralised
heatpump
Future energy source
Industrial
Waste Heat
Biomass conversion
Geothermal
Prosumer
– Producer and Consumer
Solar thermal
CHP biomass
PV, Wawe,
Wind surplus
Electricity
District
cooling
Cold storage
District
Cooling
Grid
Heat storage
CHP waste
incineration
District Heating
Low energy buildings
First generation
1880–1930
DH flow: Steam
DH Return: <90
Second generation
1930–1980
DH flow: 100°C, Liquid
DH Return: <70
Third generation
1980–2020
DH flow: 100°C
DH Return: <45
Forth generation
2020–2050
DH flow: 50–60 (70)°C
DH Return: ≈25°C
Fifth generation
Low temperature grid
with distributed heat pumps

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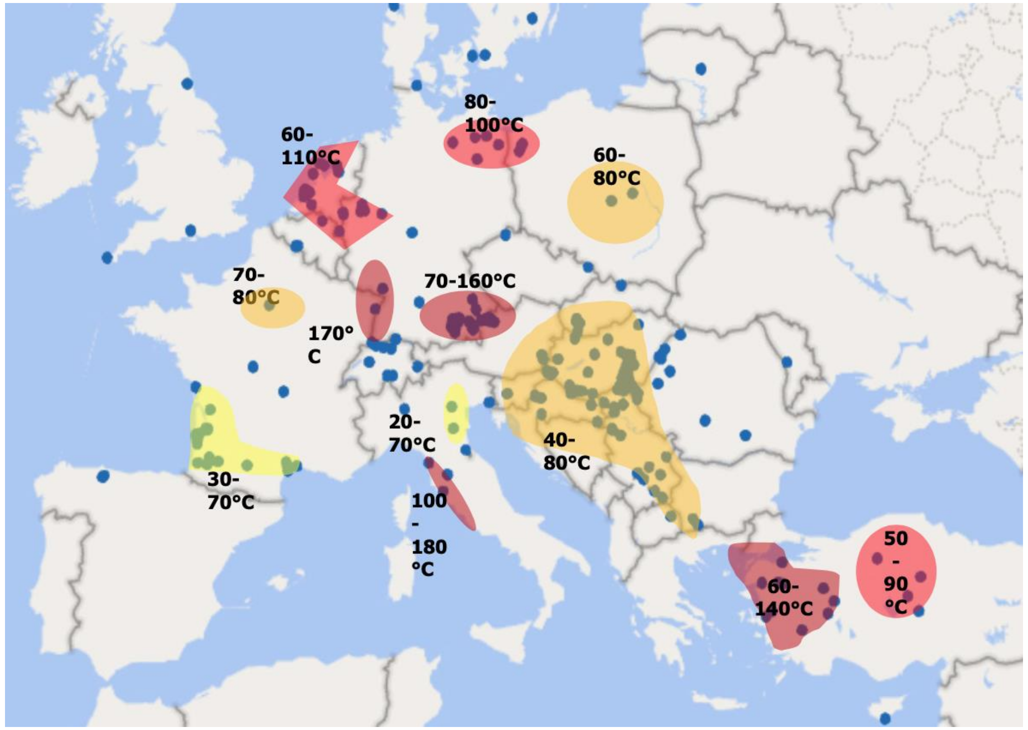
„Geothermal“ Networks distributed in Europe

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



Source: EGEC Geothermal Market Report 2021

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

Flexibilisation

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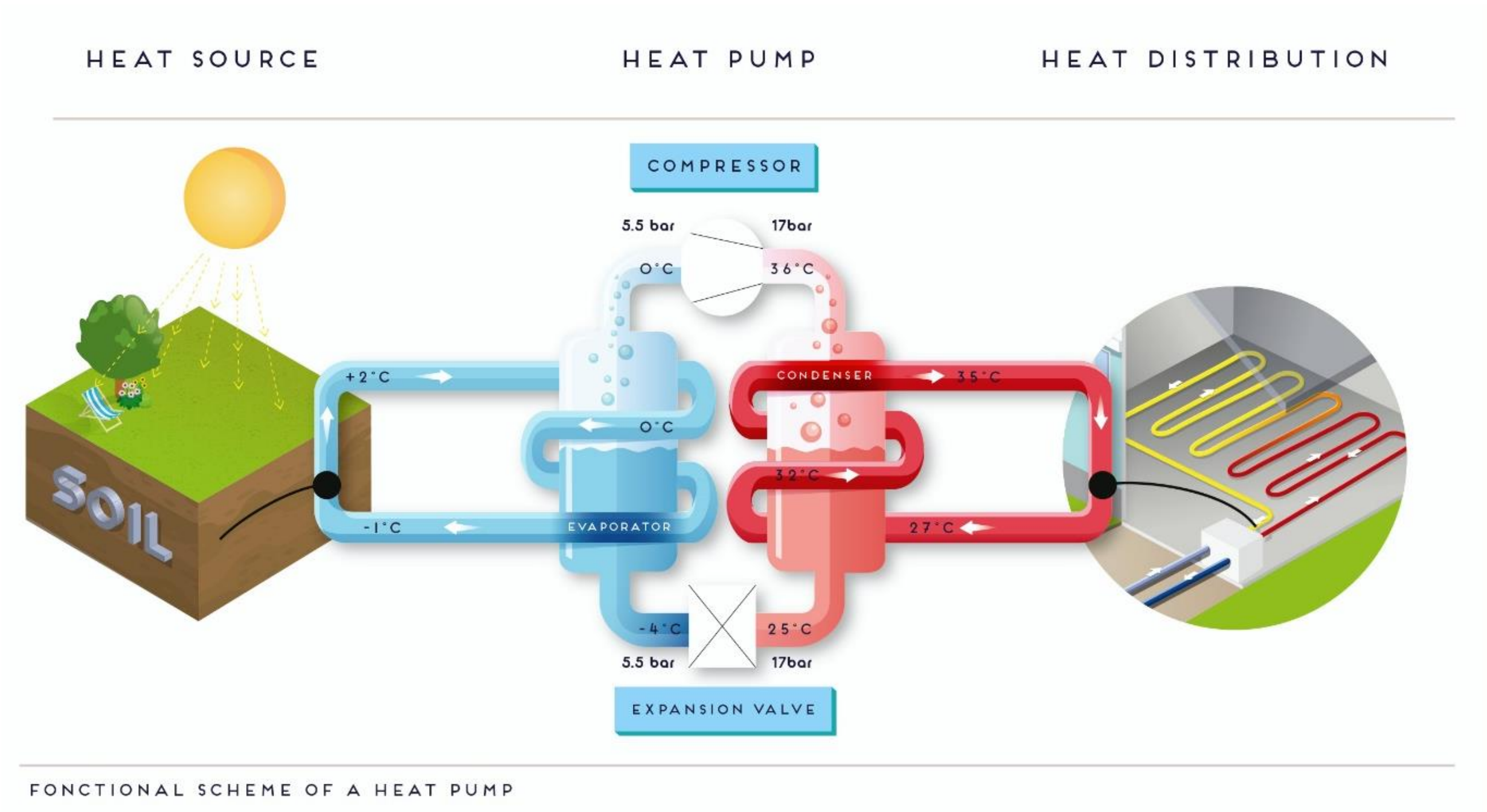


Flexibilisation

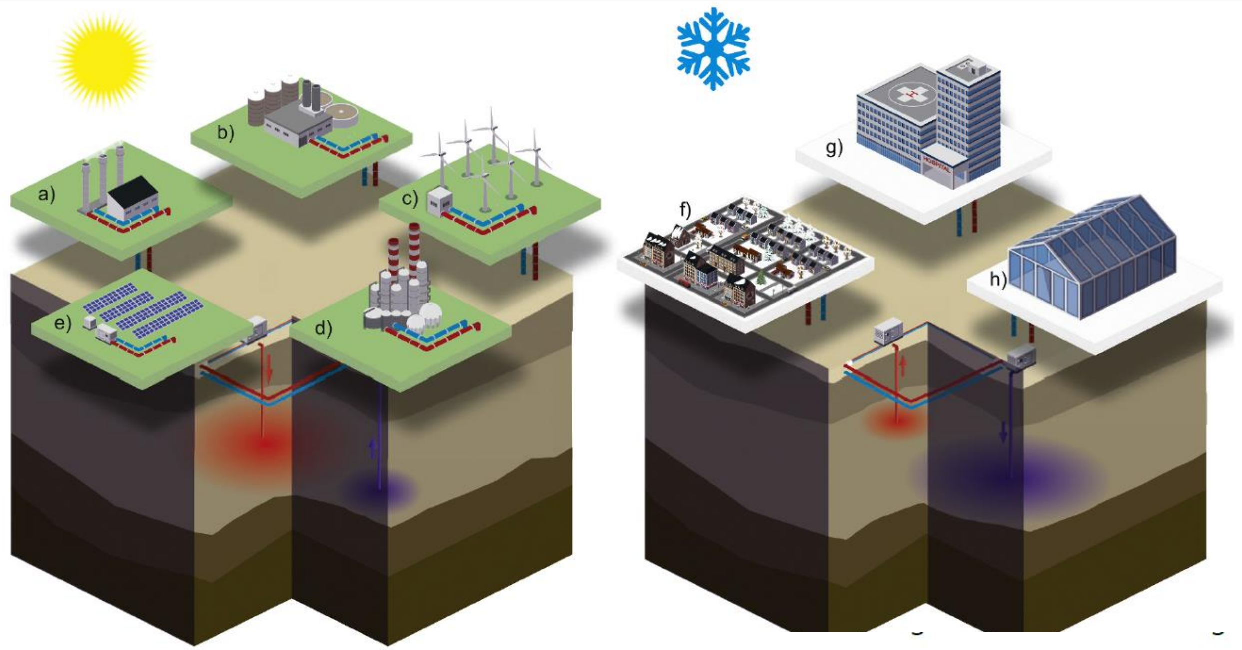
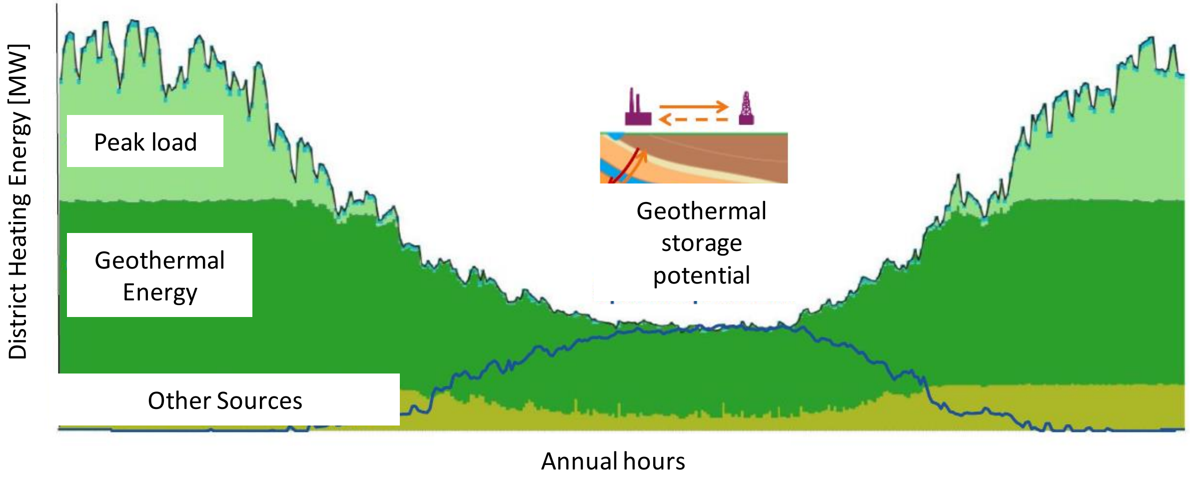
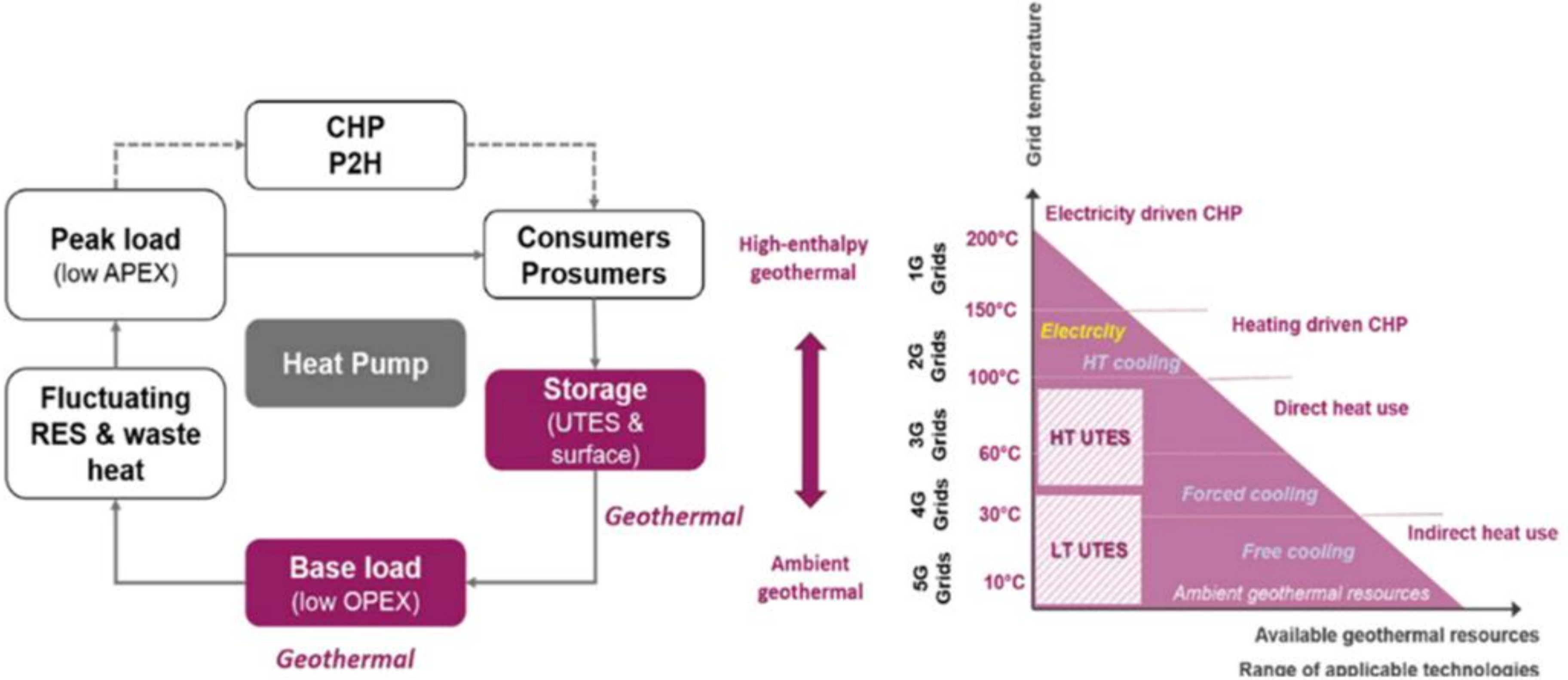


Fig. 1. Basic principle of HT-ATES. In summer, the aquifer is charged with surplus heat fro
power-to-heat (c), industrial heat waste (d) or solar (e). The stored heat is recovered in winte
or industrial applications such as greenhouses (h).

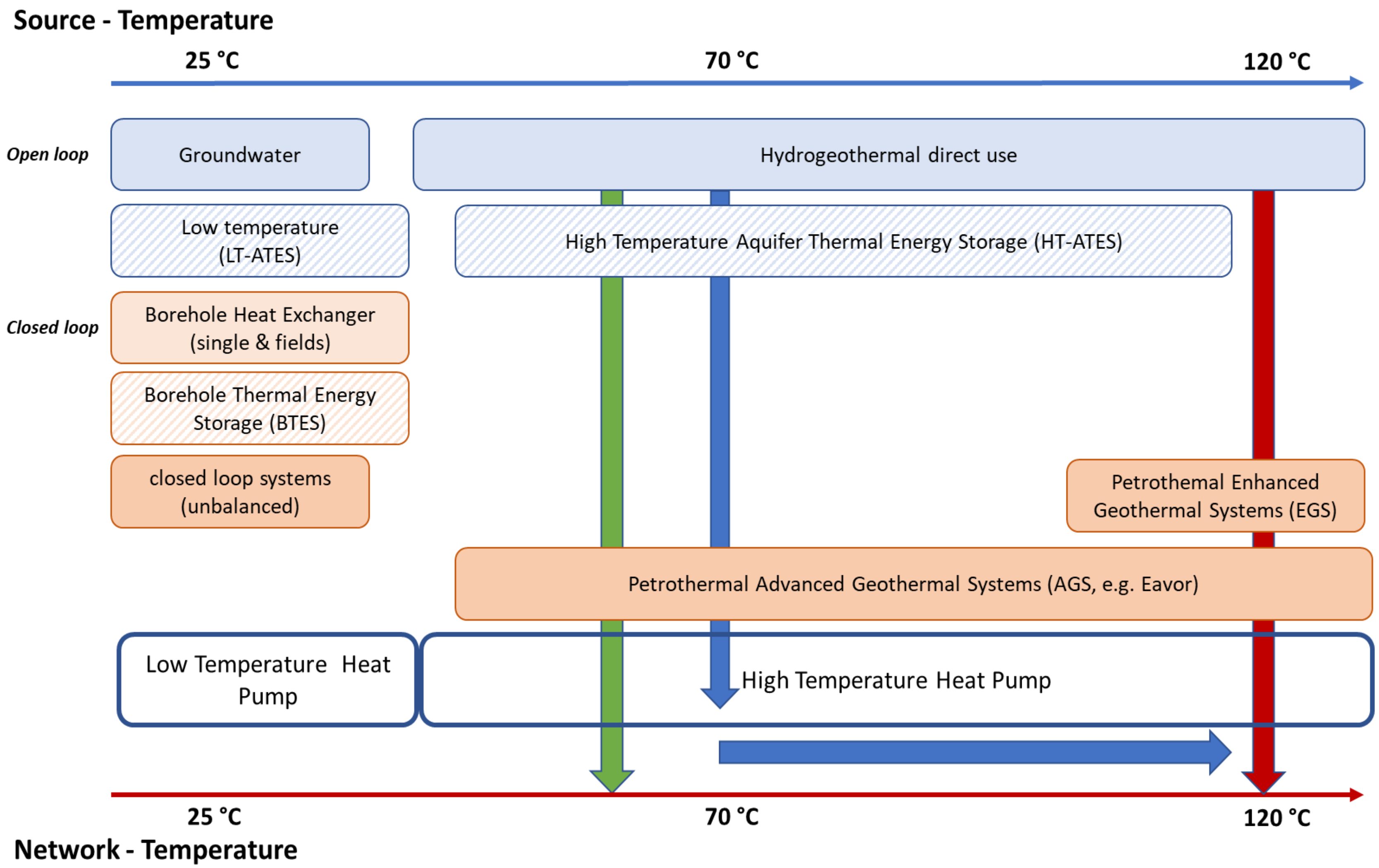


Combination with Geothermal Sources



Goetzl et al. (2020)

Geothermal Sources + HP + Storage + Networks → Scenarios



Scenarios for Integrating Geothermal into DHC-Networks

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- **Basic Scenarios:** Basic scenarios are simpler in design and are already commonly used throughout Europe or in single countries.

- **Complex Scenarios:** Complex scenarios consist of a combination of different technologies such as storage scenarios or scenarios using a HTHP, and are already installed in some places.

- **Future Developments:** Future scenarios are based on technology that is not yet market-ready. These are especially scenarios using enhanced or advanced geothermal systems (EGS, AGS) or uncommon combinations.

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

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

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

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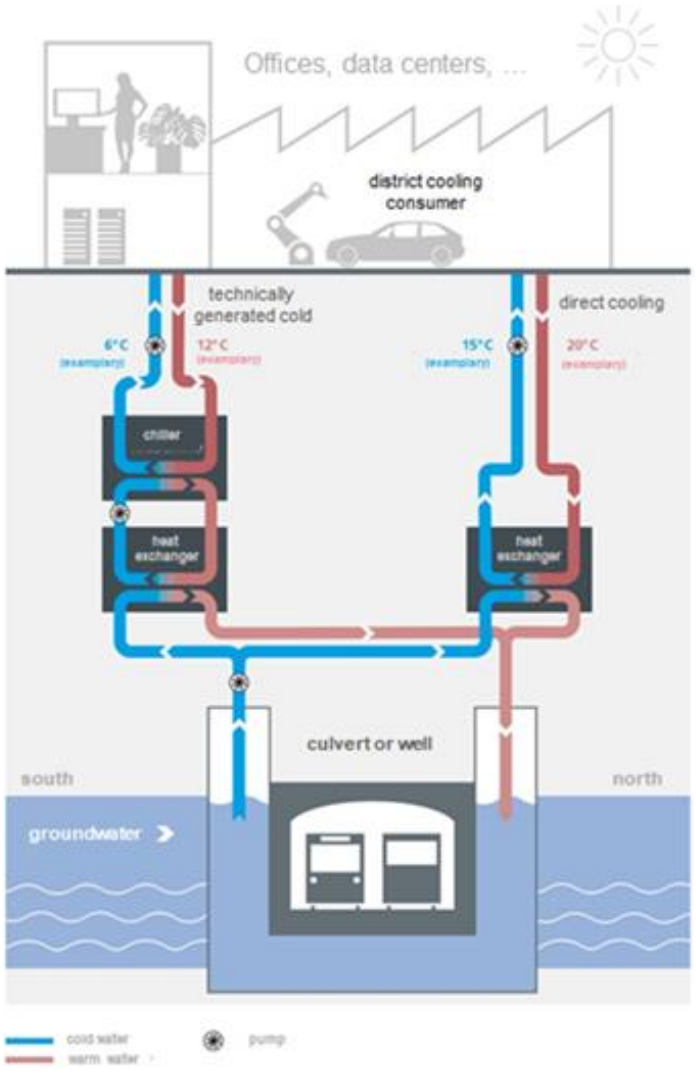
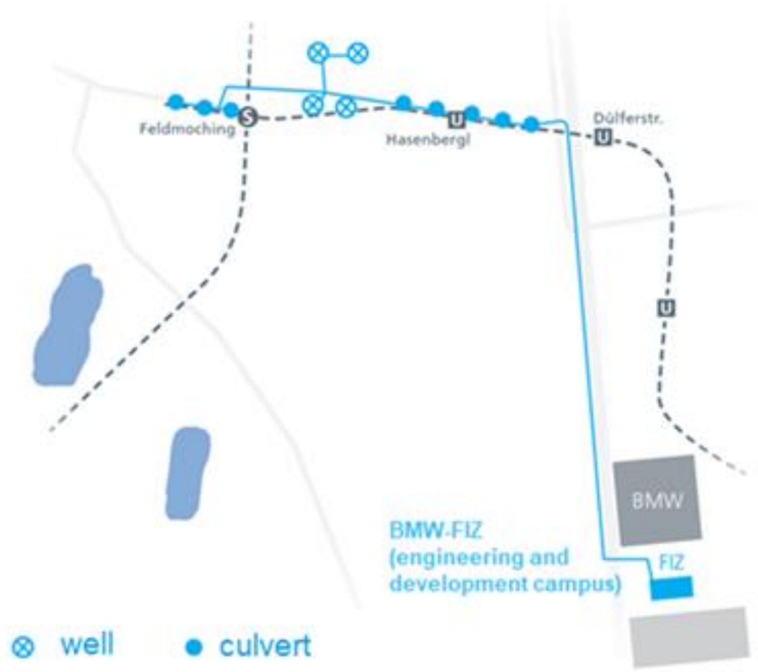
Basic Scenarios

Scenarios

District cooling with groundwater



e.g. District Cooling „BMW-FIZ“
5 MWth (255 l/s, 8 Mio. m³/a)



SW//M

Scenarios

B 02	Groundwater + decentral LTHP - LT Network
	T Source [°C]
	10

Examples	*Friedbe*

Übersicht über alle Bohrungen der Entnahme- bzw. Schluckbrunnen.

Quelle: Baugrund Süd

- Lage Entnahmebrunnen
- Lage Schluckbrunnen

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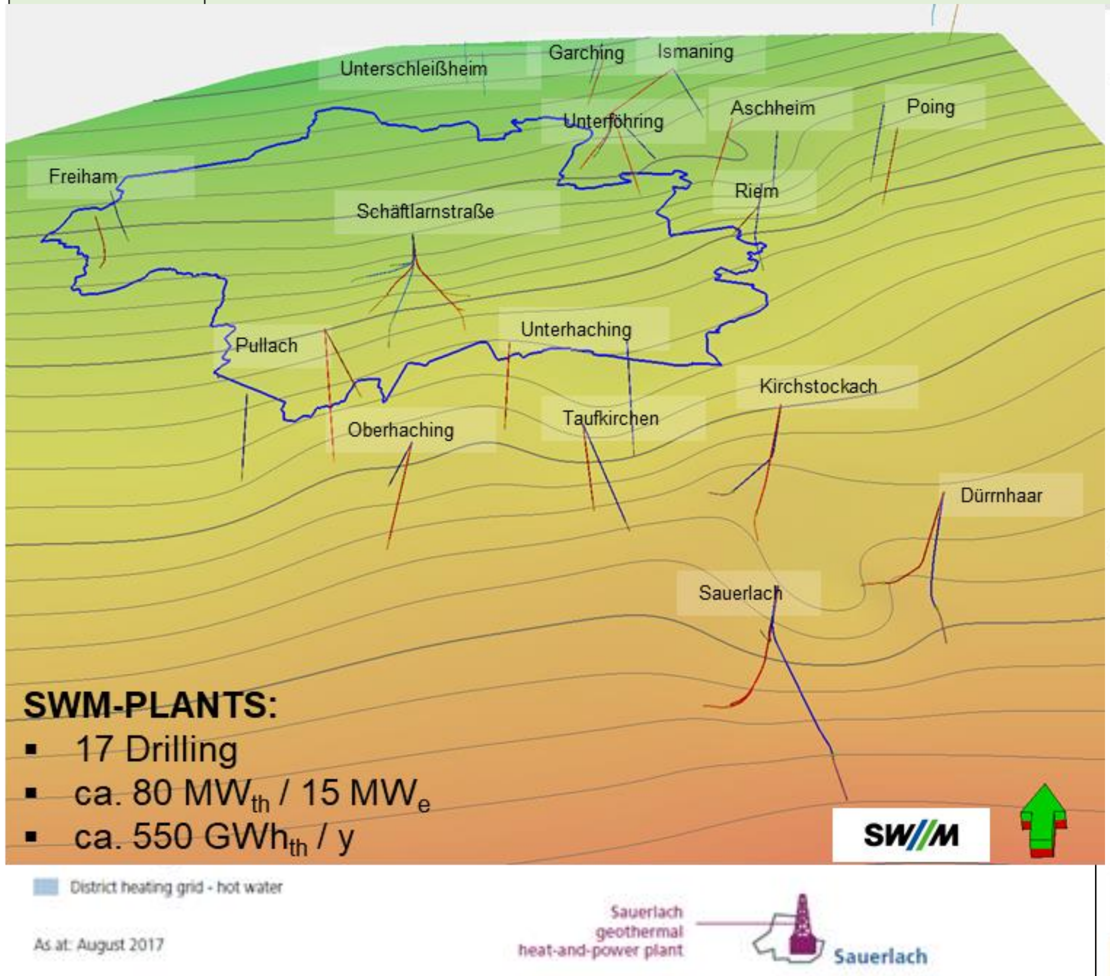
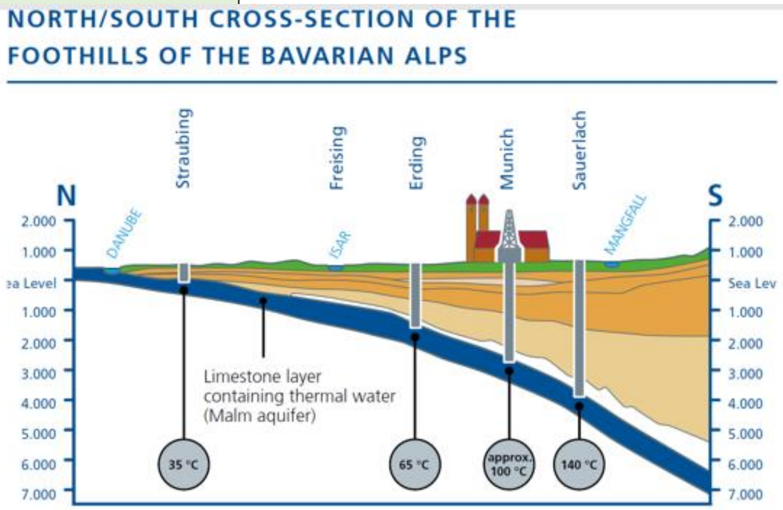
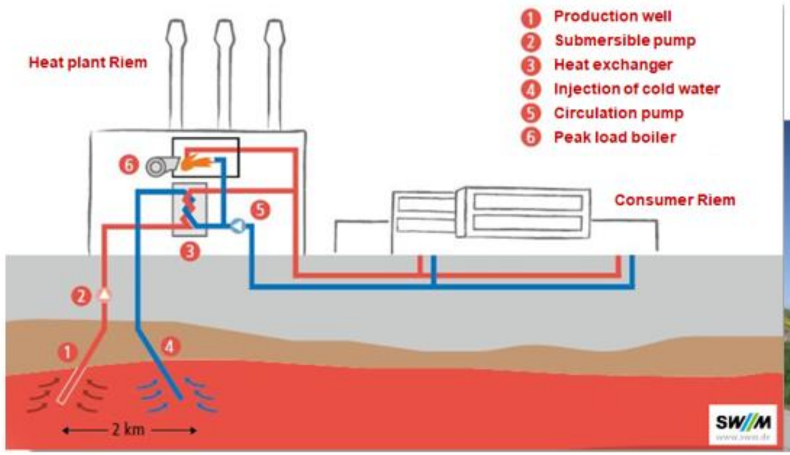
Scenarios

B03	Hydrothermal Direct Use – HT Network





North/South cross-section of the foothills of the Bavarian Alps



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B 04 Hydrothermal Direct Use – MT Network

Lendava, Slovenia [10]

Local community Lendava covers 123 km2 in the Pomurje region. In Lendava there is one of the few Slovenian geothermal district heating systems. Production borehole Le-2g was drilled in 1994 and reinjection borehole Le-3g in 2007. At a district heating system with a length of about 3200 m school, kindergarten and multi-dwelling houses are connected. The installed capacity is about 2.7 MW_{th}. The production temperature of the well is 74°C and the operation temperature of the network is about 40-66 °C.

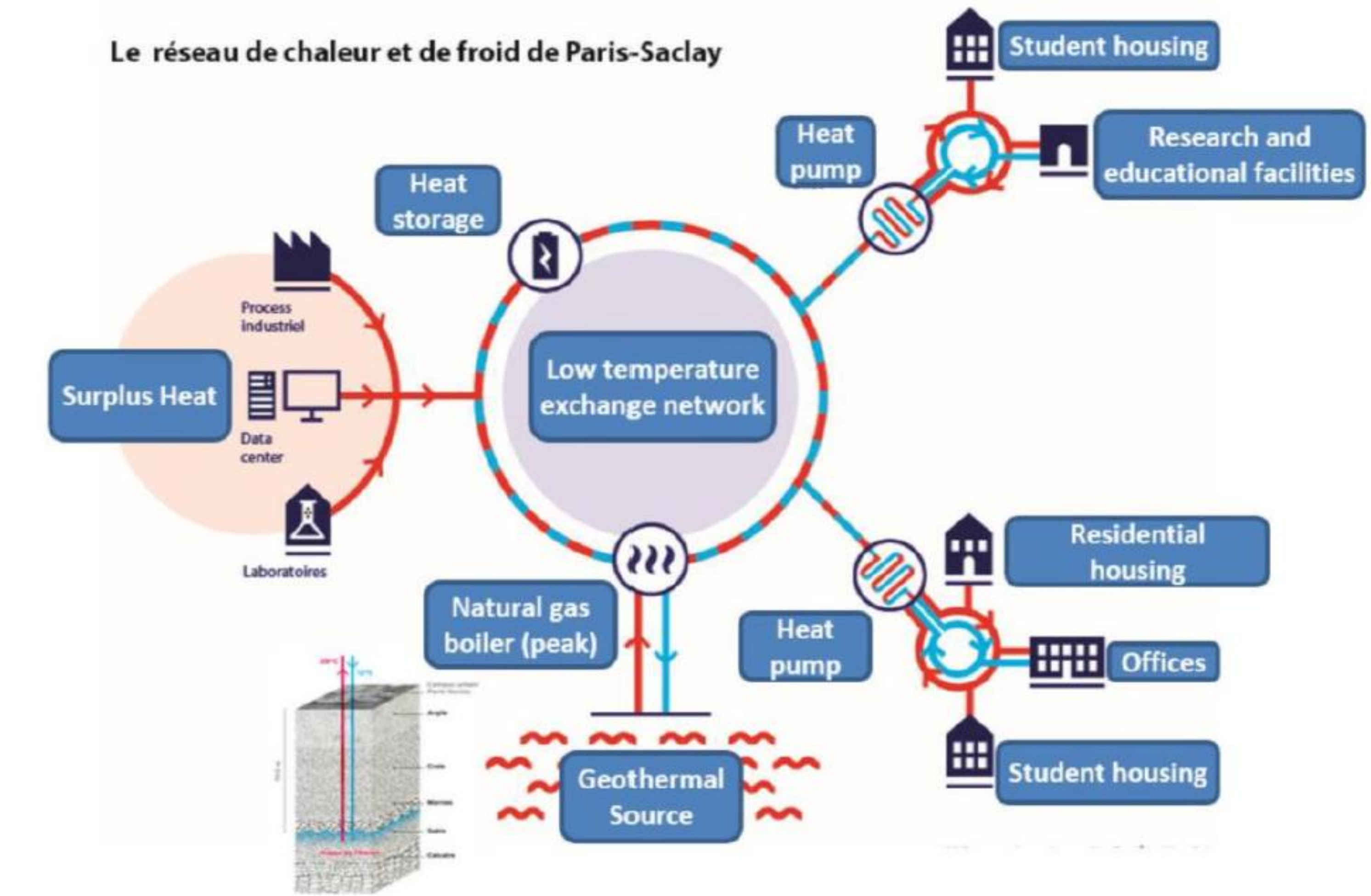
Mórahalom, Hungary [10]

Mórahalom has 6 100 inhabitants A geothermal cascade system was developed to reduce dependency on natural gas by using a renewable heat source. This system consists of two drilled wells, a 1.26 km-deep outflow well and a 0.9 km injection well. Within the project a new district heating system of 2.85 km was established to supply public buildings. The GHG emission is now reduced by 80%. A capacity of 1.5 MW_{th} is produced by the three production wells. The operating temperature of the district heating network is about 69-40°C. The maximum production temperature of the wells is about 70°C.

Trnava Sereď, Slovakia [10]: about 6 MWth, about 3760 apartments, Production Temperature 66°C; Operating District Heating temperature: 65°C; combined with natural gas

Scenarios

B 05	Groundwater + central HP – MT/HT Network



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nps for hot water

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B 06 BHE + central HTHP/BTES - MT/HT Network

Drake Landing Solar Community, Okotoks, AB, Canada [18]

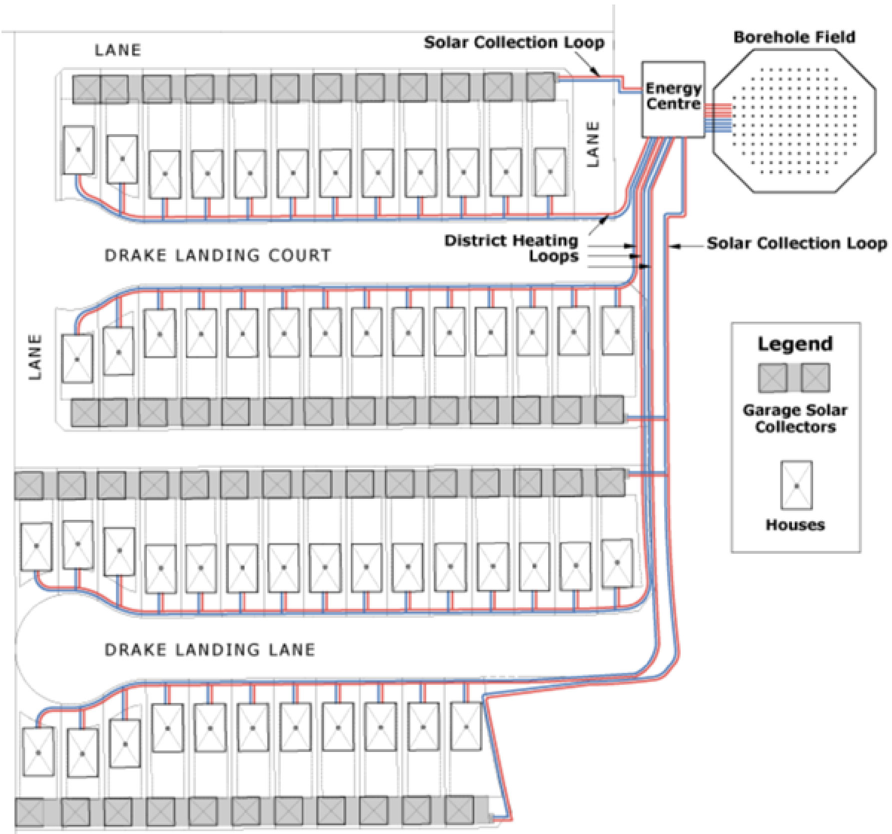

Figure 13: Example Drake Landing Solar Community, Okotoks, AB, Canada

The Drake Landing Solar Community (DLSC) is a master-planned neighborhood in the Town of Okotoks, Alberta, Canada, which is heated by a district system designed to store abundant solar energy underground during the summer months and distribute the energy to each home for space heating needs during winter months. One of the first BTES ever built worldwide was put into operation in 2007. 798 flat plate solar panels produce heat that is stored underground by 144 35-m-deep BHEs in summer. The BTES extracts energy in winter and provides heating and DHW to 52 individual houses without HP. Gas-fired furnaces serve as a back-up system but solar fraction is always more than 90 %, contributing to overall COP > 30.

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Figure :

Scenarios

B 07	BHE + decentralized LTHP - LT Network

Silkeborg. Denmark

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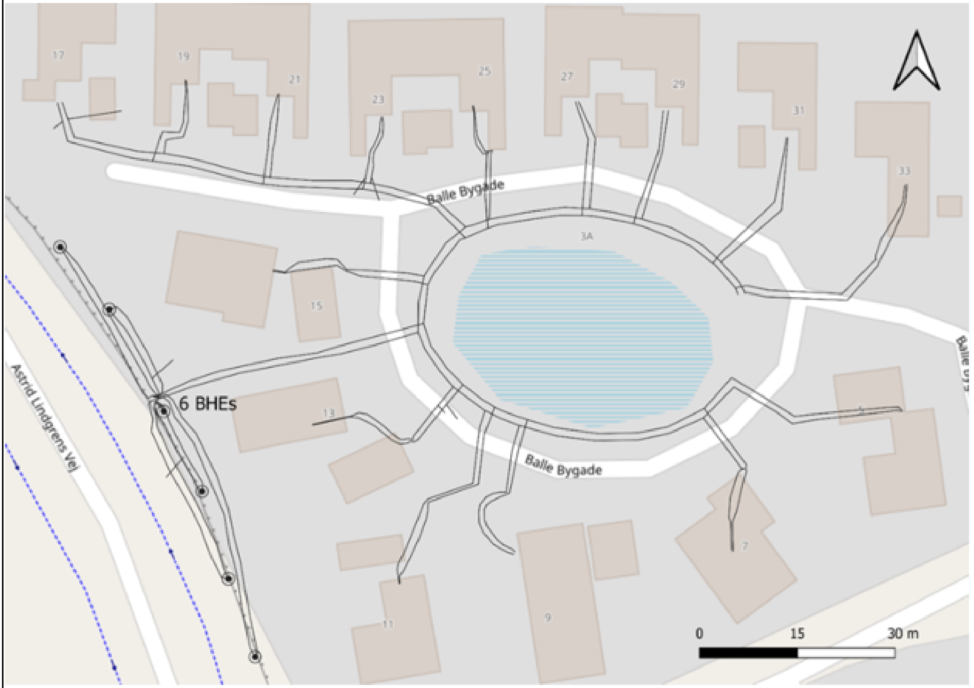
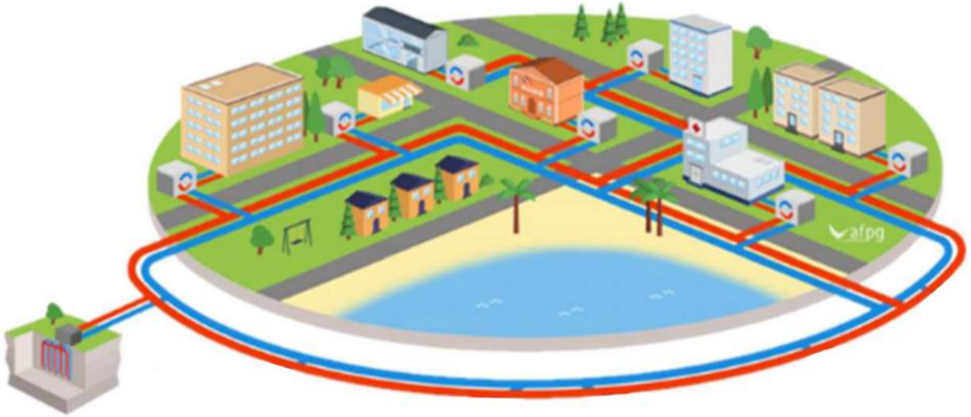


Figure 18: The thermonet at Balle Bygade in Silkeborg with 15 connected consumers. Balle Bygade no. 9 is the existing house built in 1979 (lower center of figure).

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.



Complex Scenarios

Scenarios

C 01	Basic + LT ATES + LT/MTHP – LT/MT Network

heating /

Techn

Rostock, Germany [24]

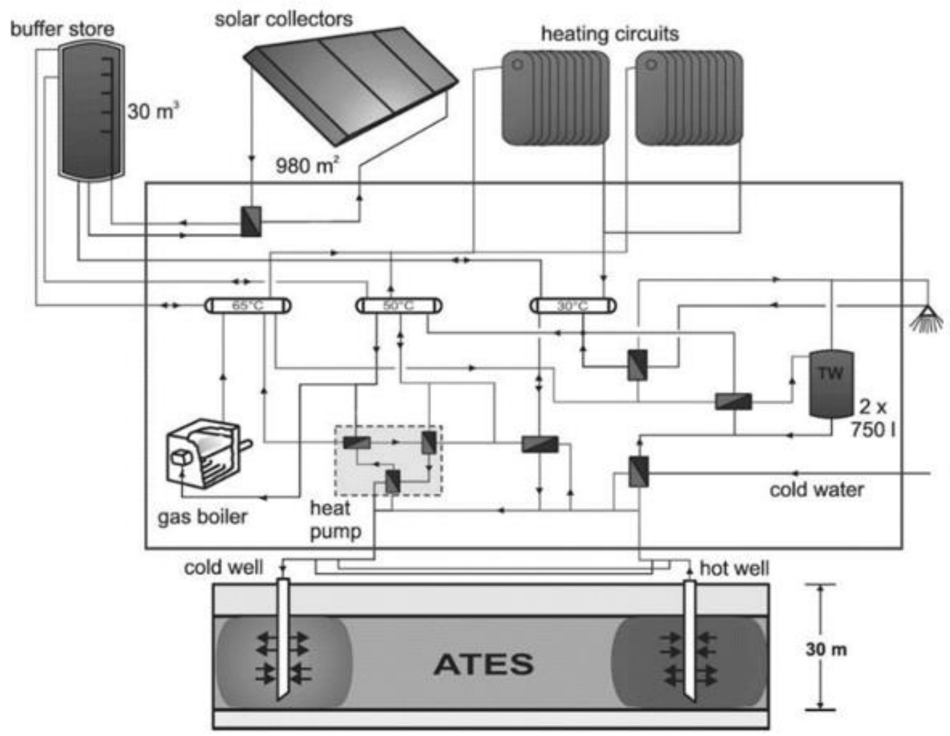
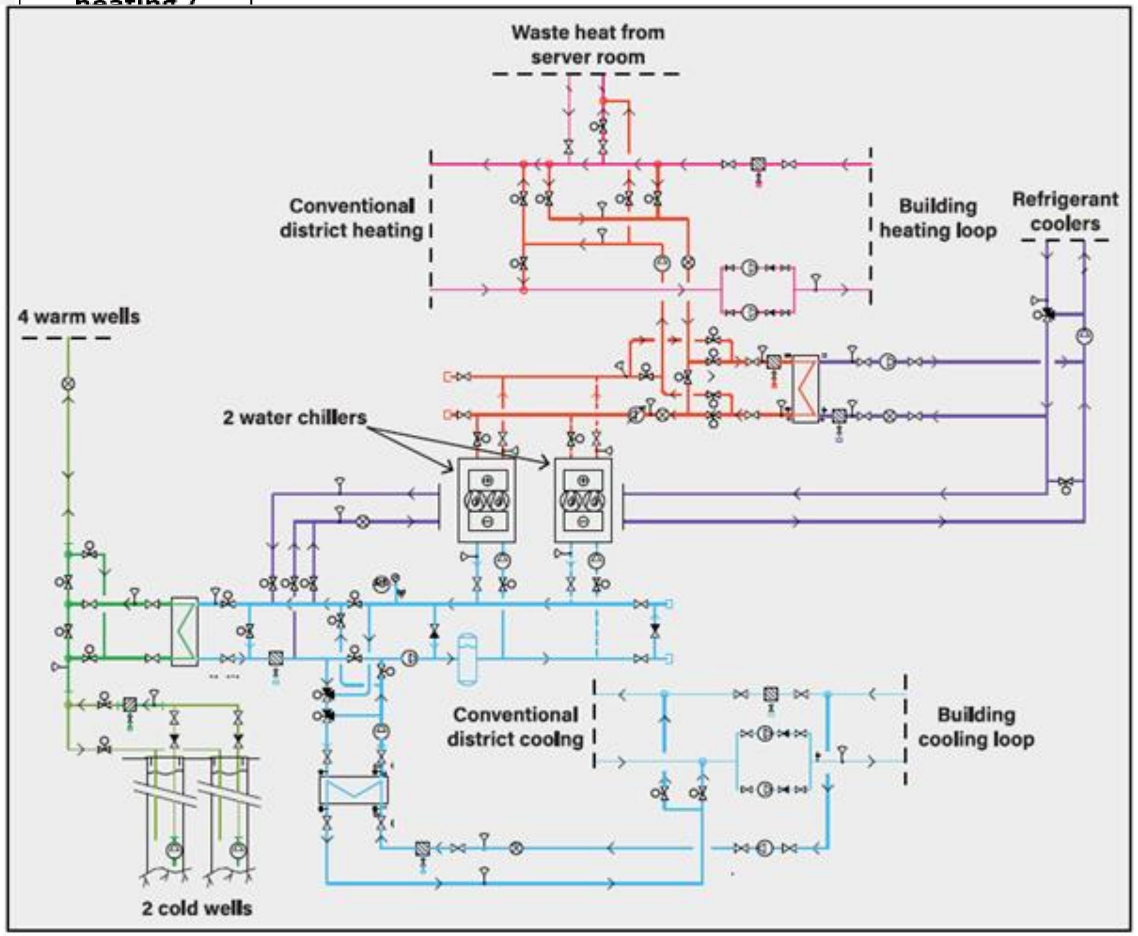


Figure 21: Hydraulic scheme of the installation in Rostock.



Hästskon, Sweden

Scenarios

C 02	Hydrothermal + HTHP - MT/HT Network

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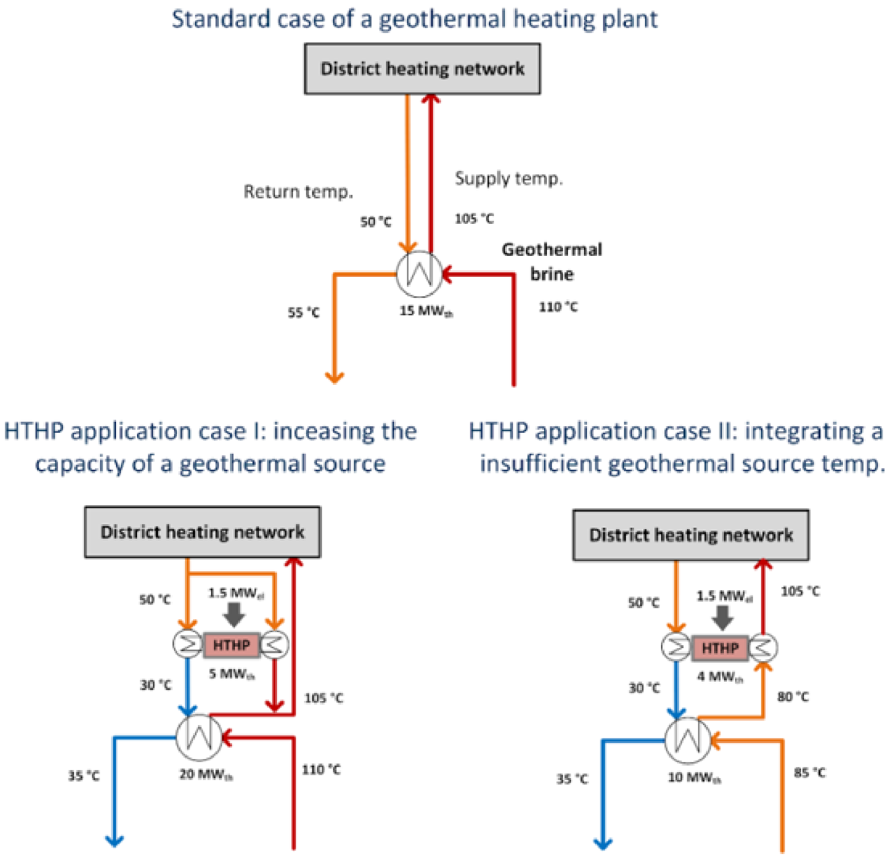


Figure 23: Application scenarios for HTHPs within geothermal heating plants.

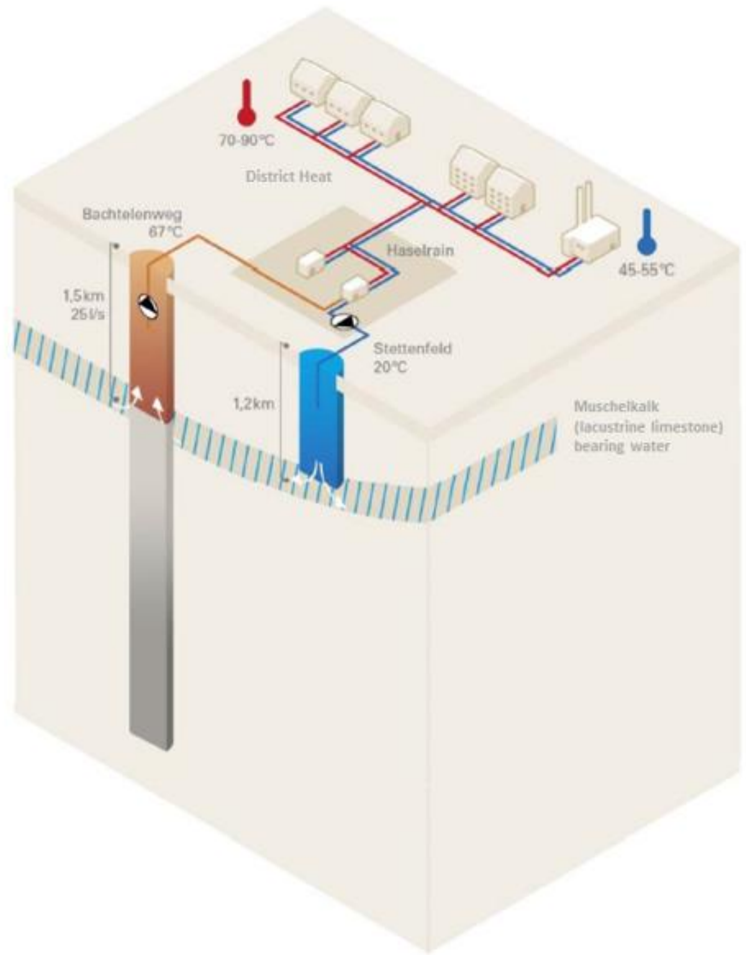


Figure 24: Example of Riehen, Switzerland (Source: [29])

Scenarios

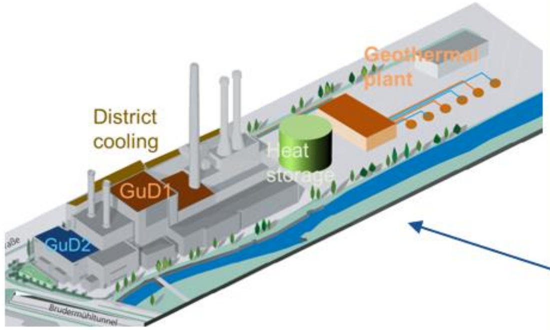
C 03	Hydrothermal + Sorption Chiller - DC Network

Expansion of district cooling

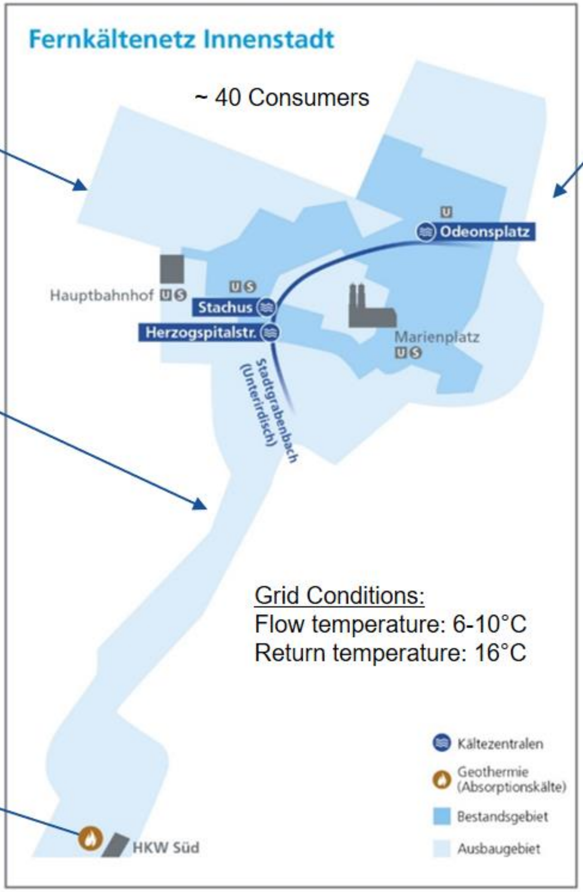
expansion west (central station) (until 2020)

expansion north (Schwabing and east (until 2020)

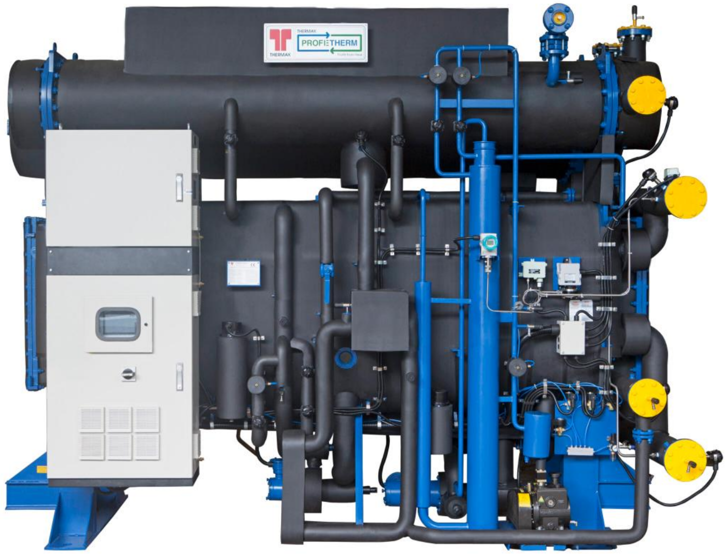
connection to „HKW Süd“ (Sendling) → city center (until 2022)



cogeneration plant „HKW Süd“



district cooling in the center of Munich



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Future Scenarios

Scenarios

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F01	Basic + HT-ATES – MT/HT Network	
	T Source [°C]	**T Grid [°C]**
	90 <<	90
Technology	• Possible basic scenarios: ○ Hydrogeothermal We • Heat exchanger • District heating network	

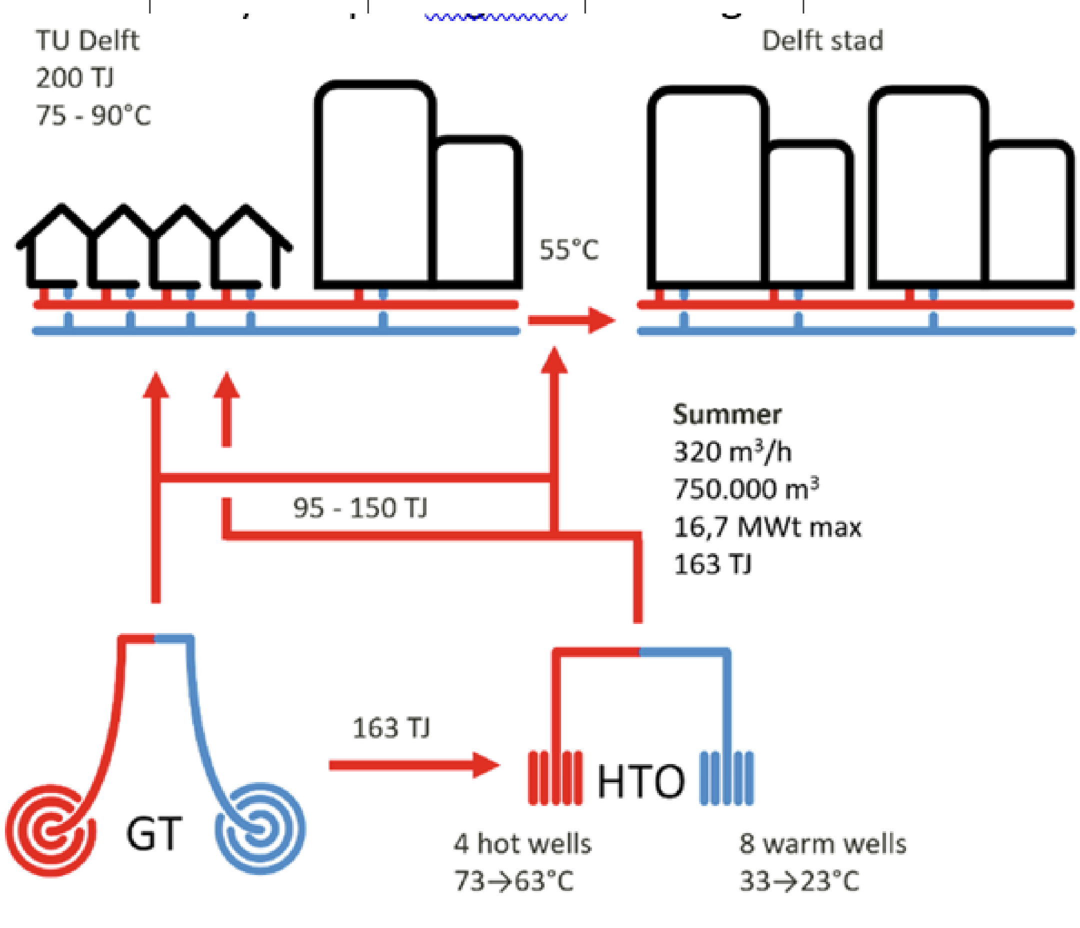

Figure 29: HT-ATES Scheme of Delft, The Netherlands.

Scenarios

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F 02 Advanced Geothermal Systems

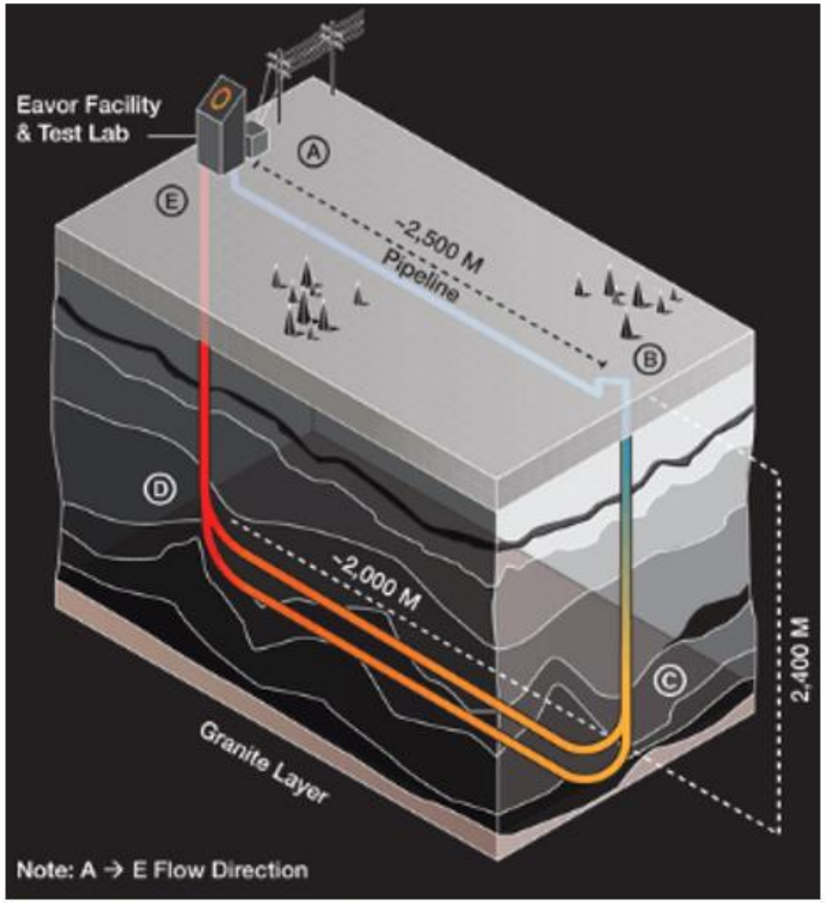


Figure 30 Eavor-Lite (Prototype)

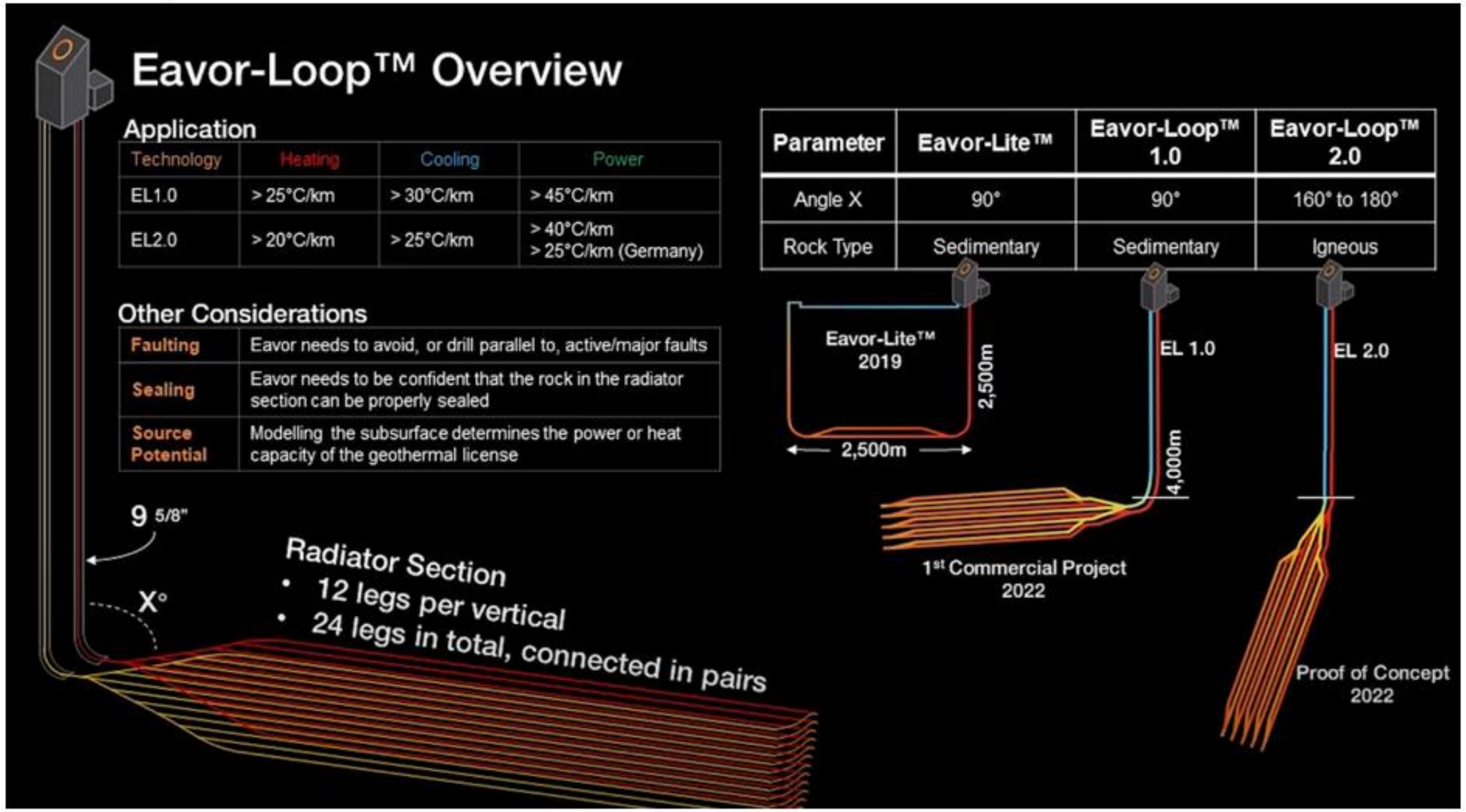
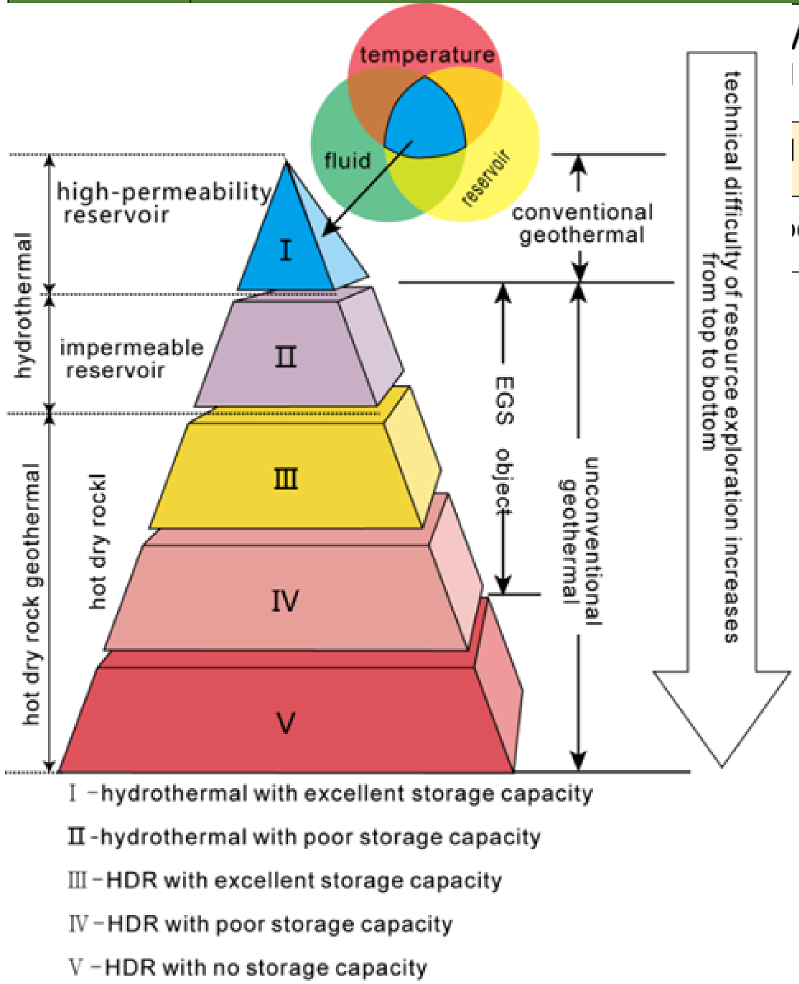
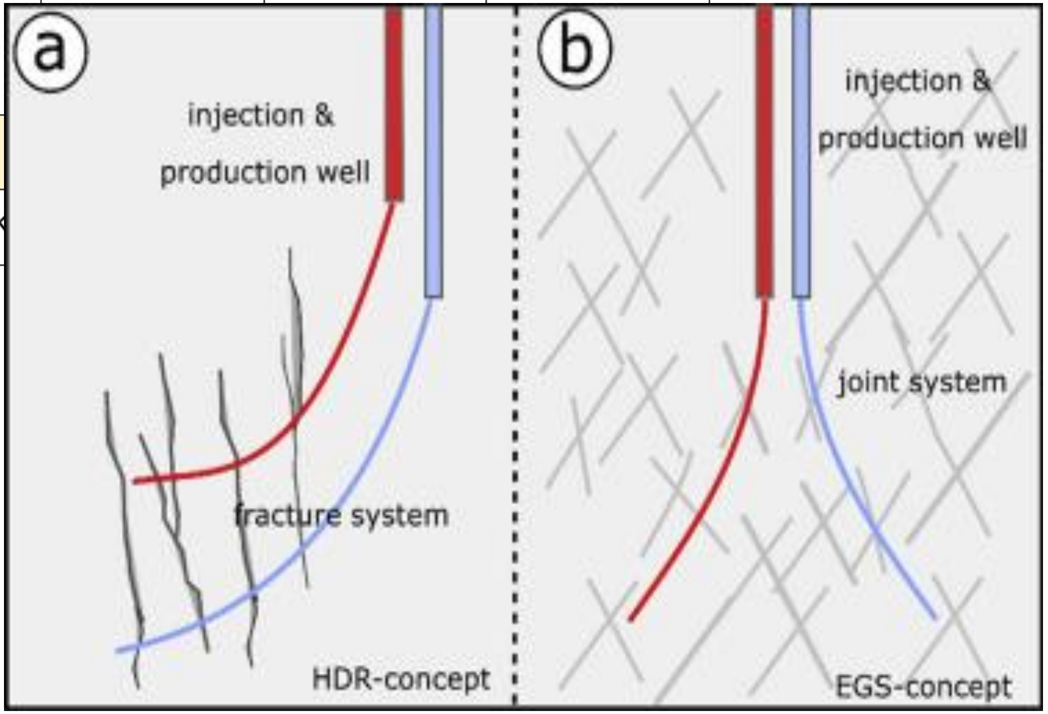


Figure 31: Eavor-Loop™

Scenarios

F 03	Enhanced geothermal system (EGS)

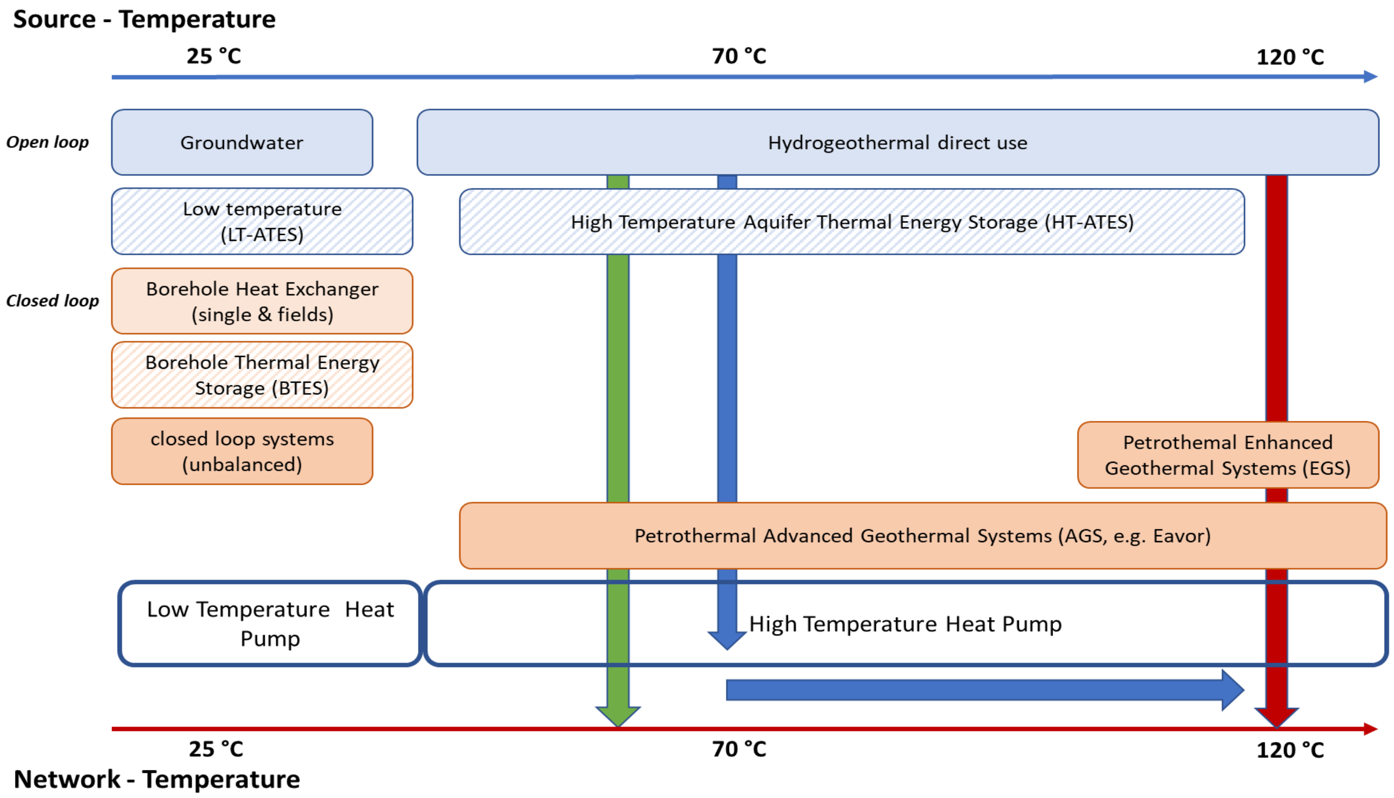




Conclusion

- Several Opprtunities to integrate Geotheraml into DHC Networks
- All depending on the local situation at the surface and the subsurface:

  Which sources are available, which heat/cool demand must be covered



Thank you!

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