



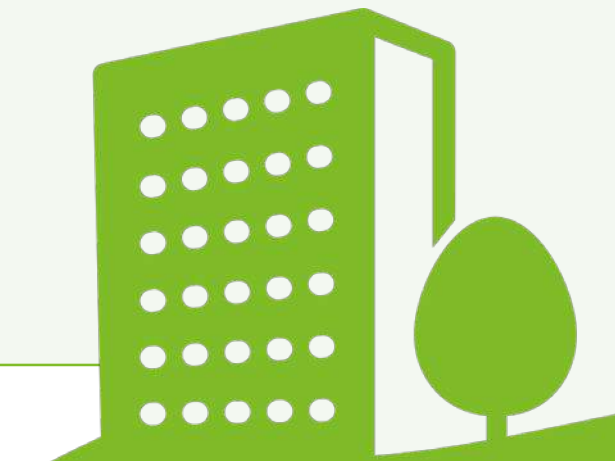
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Perspetivas de aplicação em contexto urbano

Opportunities, challenges and proposed measures to better integrate shallow geothermal systems in urban areas based on lessons learned in Vienna, Austria

Gregor Goetzl, Geological Survey of Austria



6 DEZEMBRO 2022

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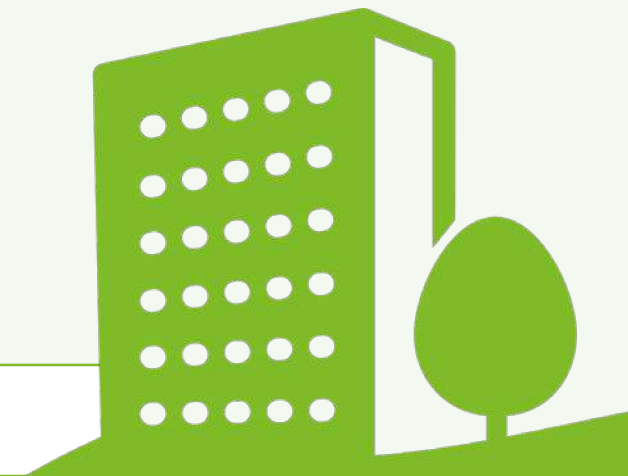
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Cities are important hubs for reaching our environmental and climate goals – on the other side they offer key challenges for the transformation of the heating and cooling sector



Content

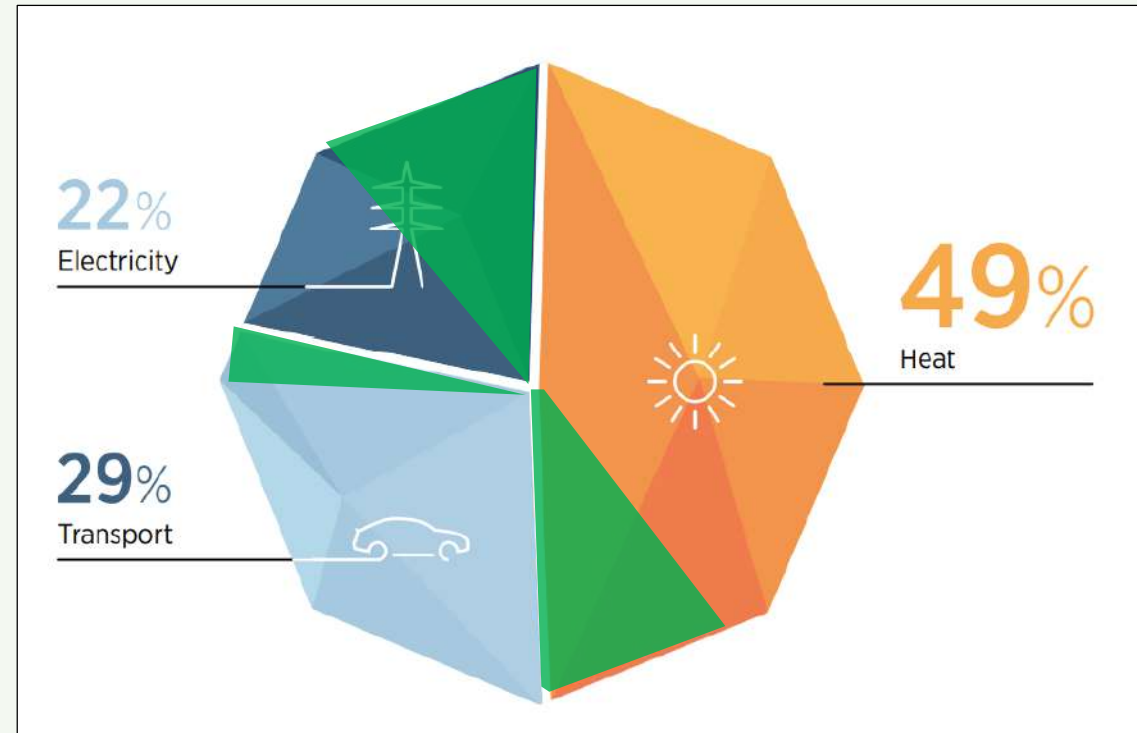
- 1) The opportunities and challenges we need to face to enable the clean transformation of urban heating and cooling
- 2) Short outline of urban geothermal energy
- 3) Findings from research and pilot activities on the integration of shallow geothermal energy in Vienna, Austria
- 4) Conclusions and recommendations to foster urban shallow geothermal energy use



Opportunities and challenges in urban areas

RES in the energy sector

- Renewable share in heating and cooling 22.1% in 2020 (source Eurostat)
- Space heating underestimated sector (~30% of final energy consumption @ RES share of 23%)
- Less flexibility given in the HC sector towards transformation than in other energy sectors
- Use of fossil fuels – climate & geopolitical dimension since 2022



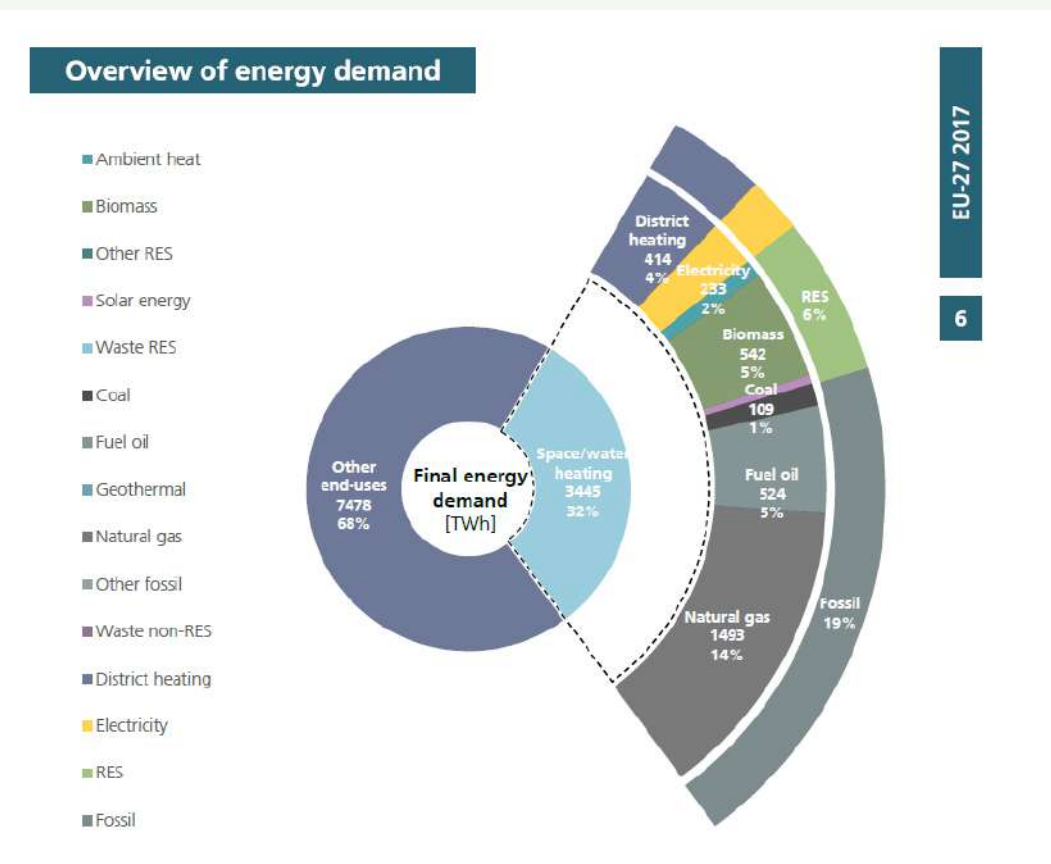
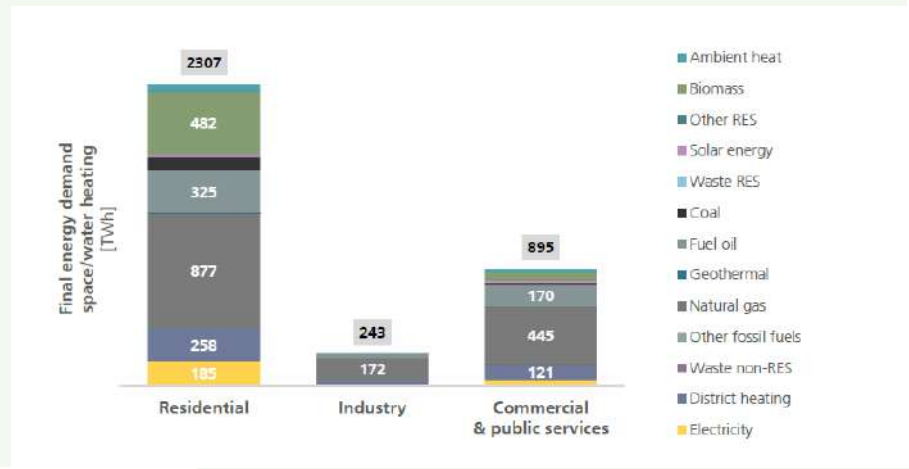
source: IEA, 2020a; IEA, 2020b.

Share of non-fossil energy sources as for 2018 (source: DGE ENER/C1/2018-494)



Opportunities and challenges in urban areas

- **Residential buildings** cover 67% of the final energy demand for space/water heating
- **Heating sector:** share of fossil 59%, share of natural gas 74% inside fossils
- **Renewables in HS:** share of 18.8%, dominated by biomass
- **District heating:** share of 12.5%

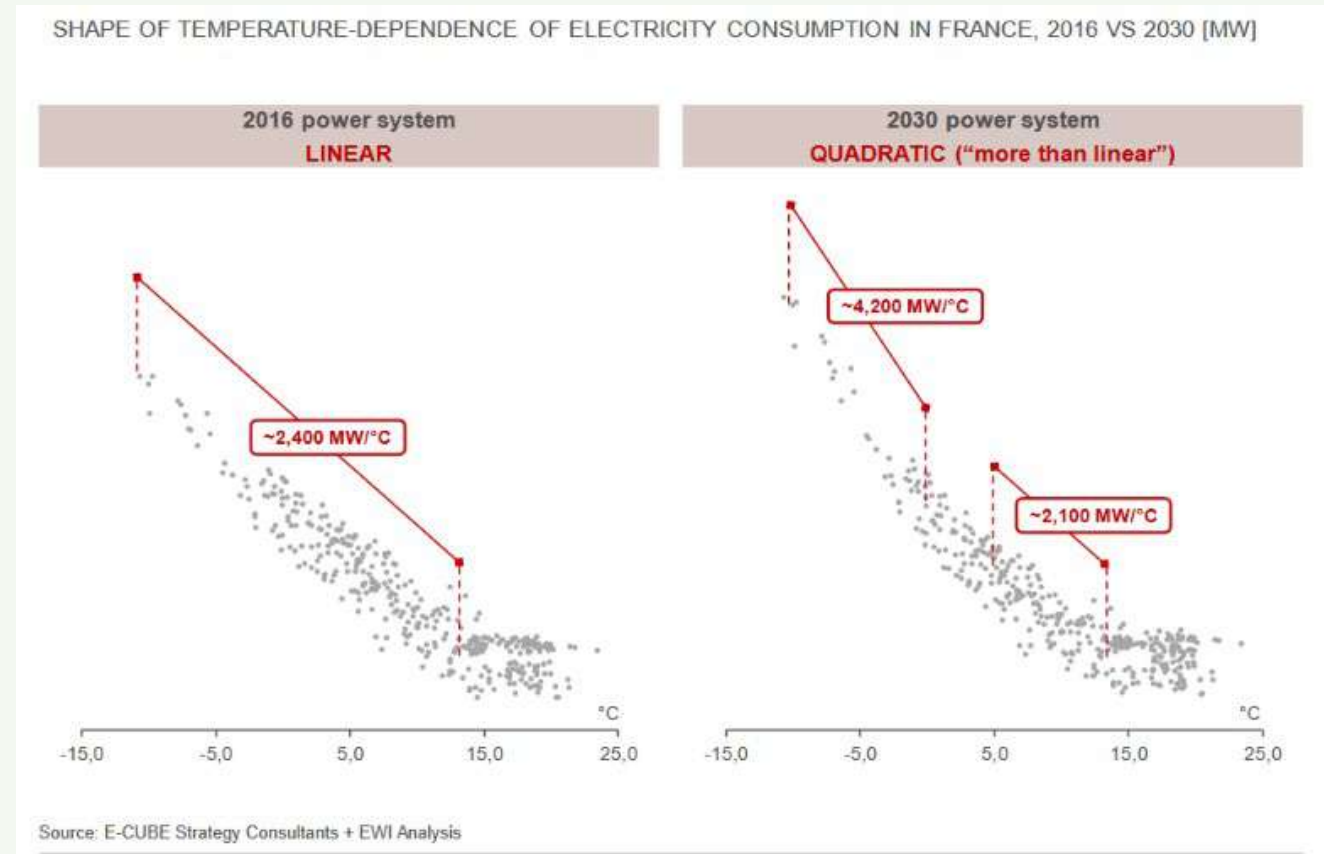


source: DGE ENER/C1/2018-494)

Opportunities and challenges in urban areas

Electrifying the HC sector bears risks and leads to high costs

- Peak load supply is not a linear function – implications on production and distribution of electricity
- Increase of cooling demand through climate change increases the pressure on efficient cooling → Heat Roadmap Europe project estimates + 700% cooling load until 2050



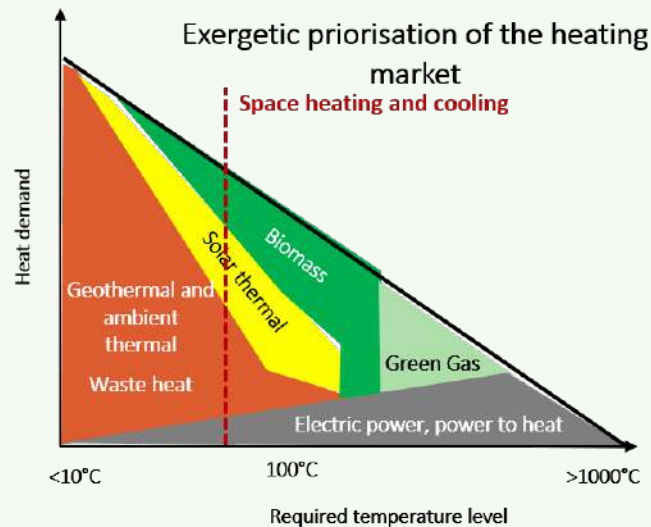
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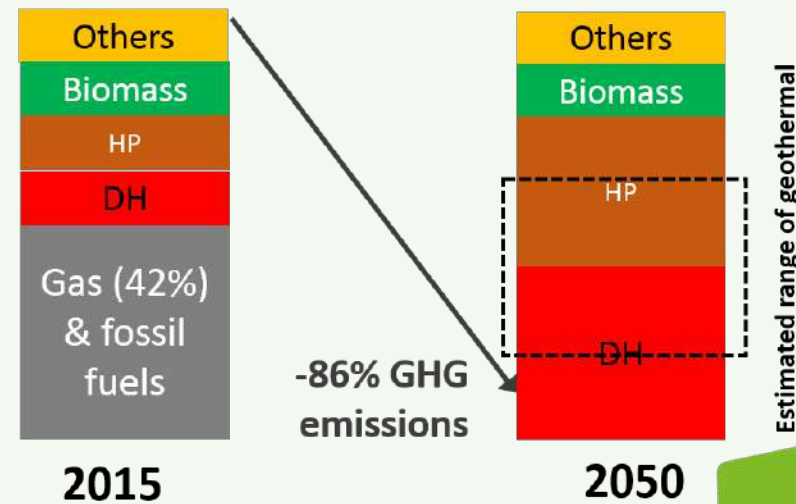
Opportunities and challenges in urban areas

Meeting the challenges by rethinking the use of exergy

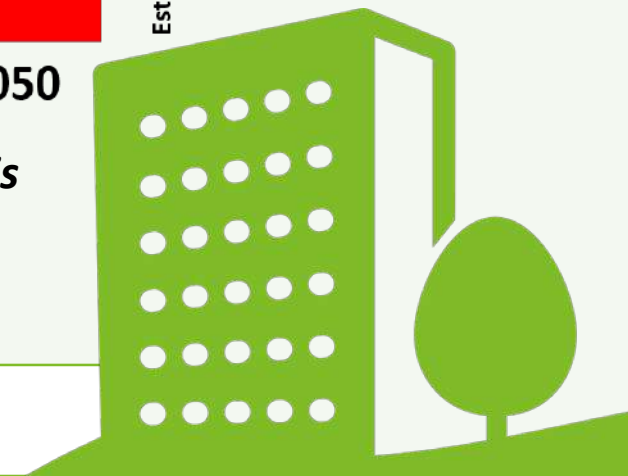
Exergy = Useful energy (mechanical work), which can be extracted from a system representing high quality energy (taken from <https://exergyconomics>)



Findings from the Heat Road Map Europe projects



Heat Roadmap Europe (<https://heatroadmap.eu/project/>): „decarbonisation of the HC sector is possible without a massive expansion of bioenergy and inventing new technologies“



75% of the European population lives in urban areas

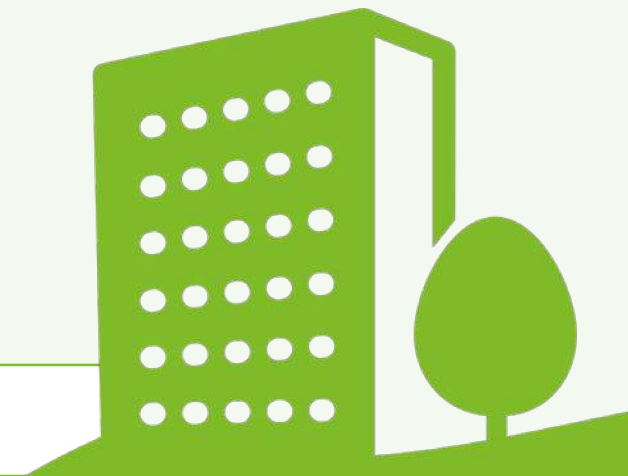
Opportunities and challenges for decarbonizing the heating & cooling sector



- High energy density and steady heating and cooling demand
- Higher income level
- Facilitated access to innovation and services



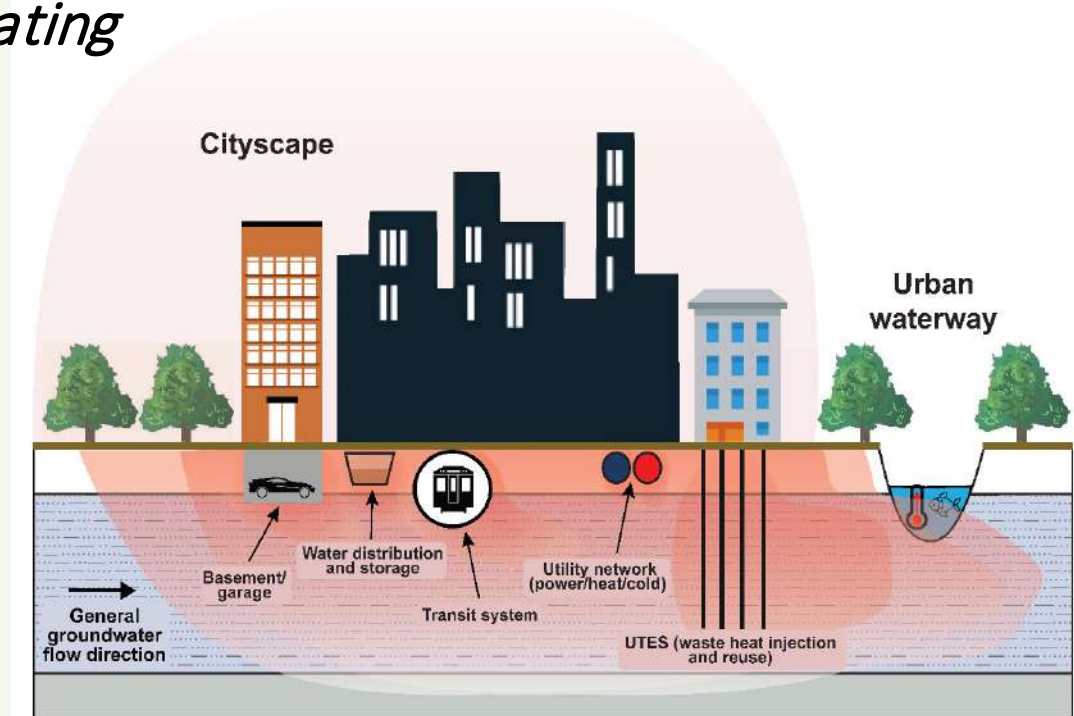
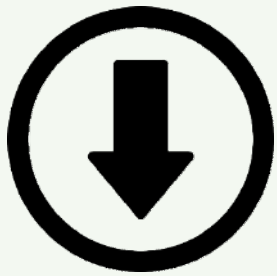
Source: <https://climate.copernicus.eu/demonstrating-heat-stress-european-cities>



75% of the European population lives in urban areas

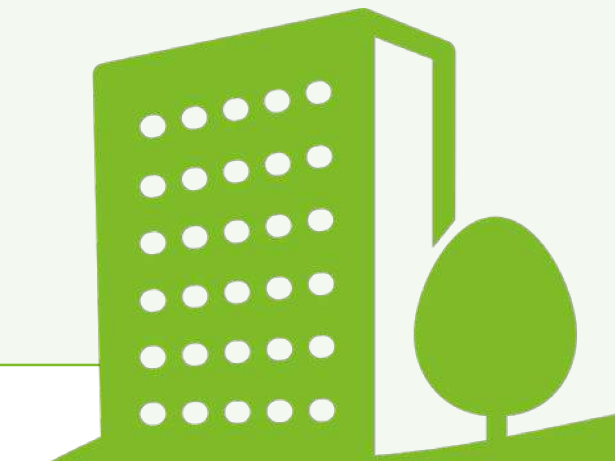
Opportunities and challenges for decarbonizing the heating & cooling sector

- Lack of surface space
- High dependency on imports
- Vulnerability towards impact of climate change and environmental pollution



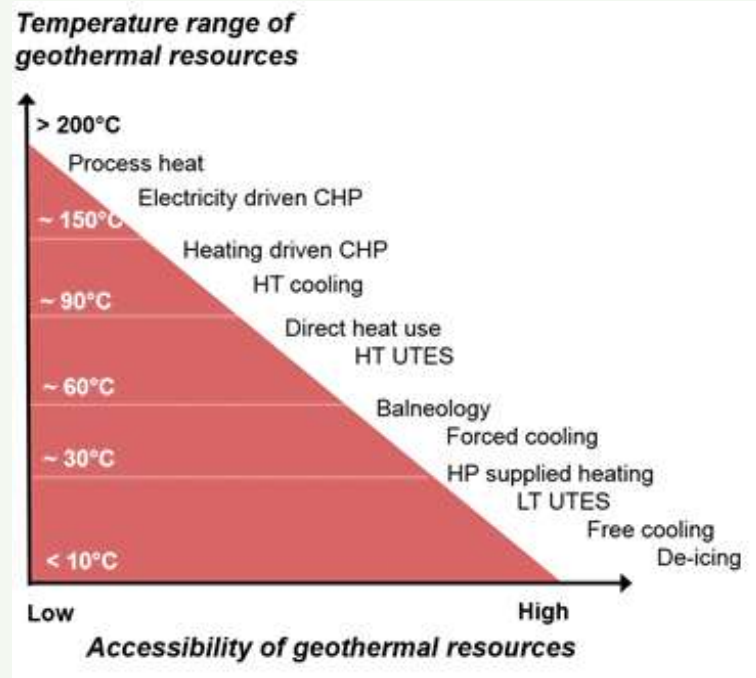
Source: Goetzl et al, 2022

Why not transforming threats into opportunities?

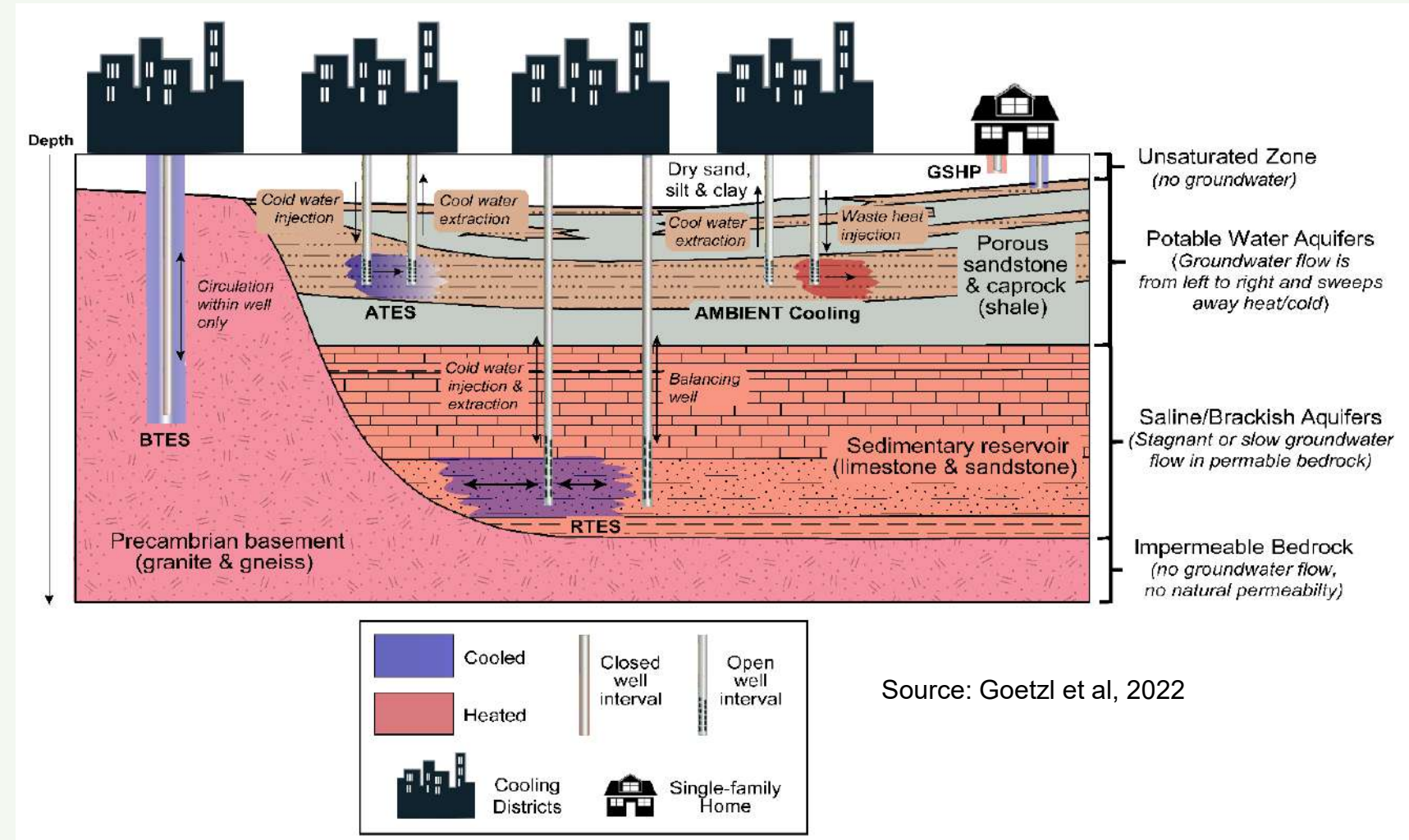


Urban geothermal energy use – the way out of the crisis?

The geothermal resource triangle



Source: CA18219 Geothermal-DHC

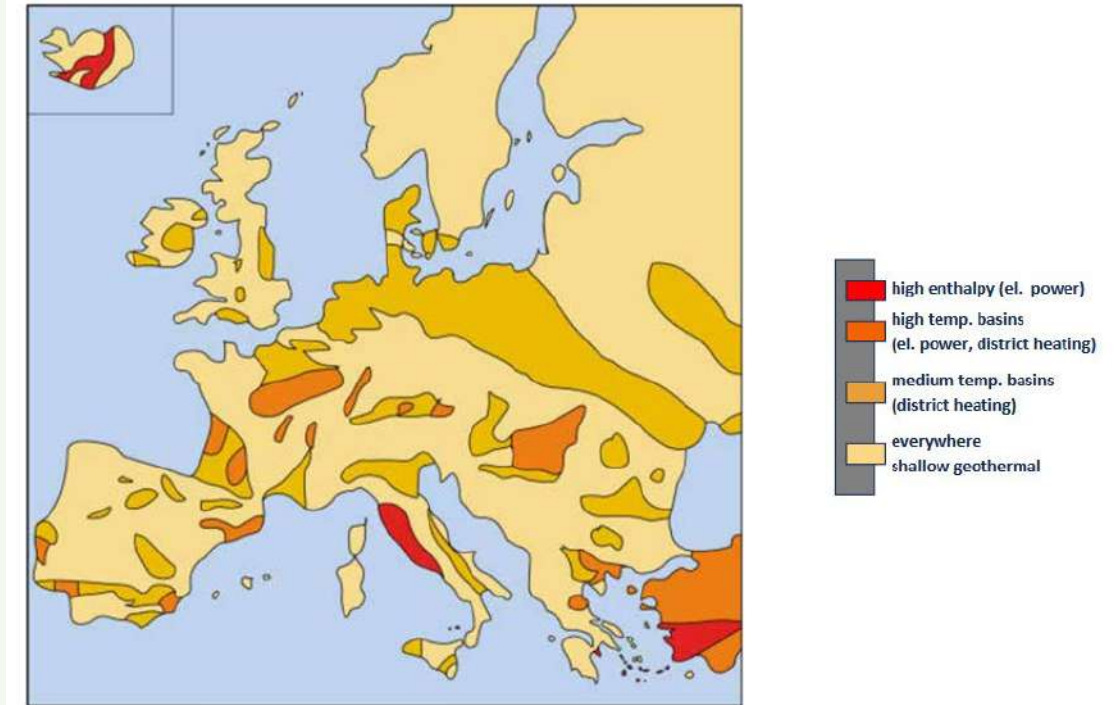


Source: Goetzl et al, 2022

Key directions of modern urban geothermal

- Combined with heating and cooling networks
- Foster low temperature use
- Use geothermal as a storage option (“geothermal 2.0”)
- Reduce dependency on specific hydrogeological conditions – engineered solutions

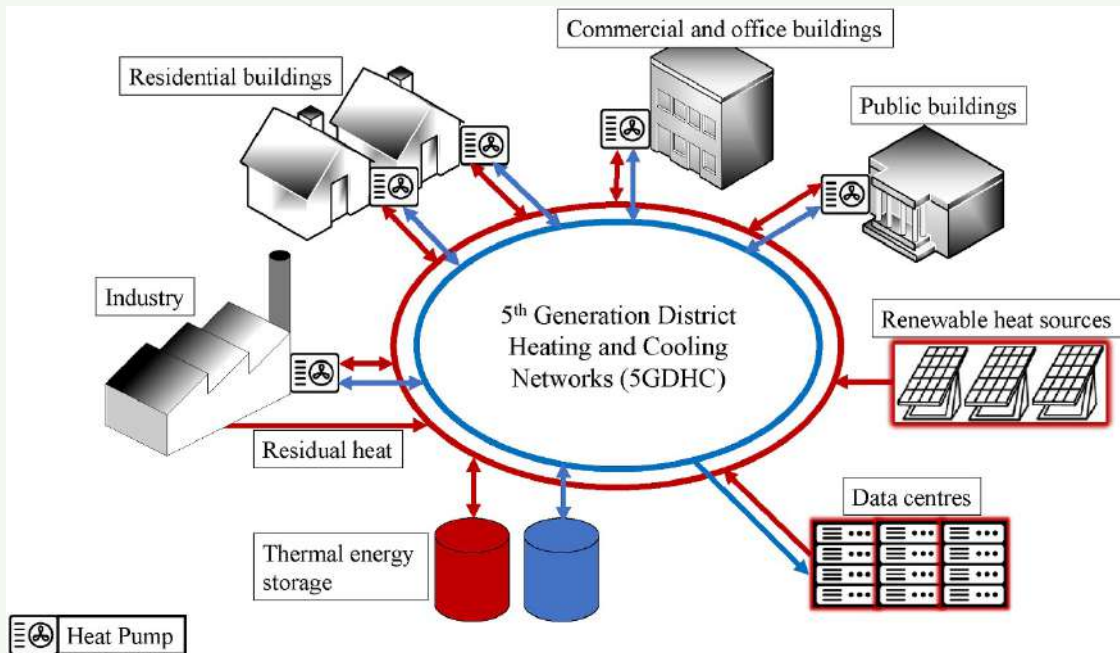
Figure 3. Main geothermal provinces of Europe (source: EGEC)



Source: GeoDH project (<http://geodh.eu/>)

Fifth generation district heating and cooling – a promising concept

Unconventional approach (5G): Unstructured networks



Source: Meibodi & Loveridge (2022)

Share geothermal ~60%

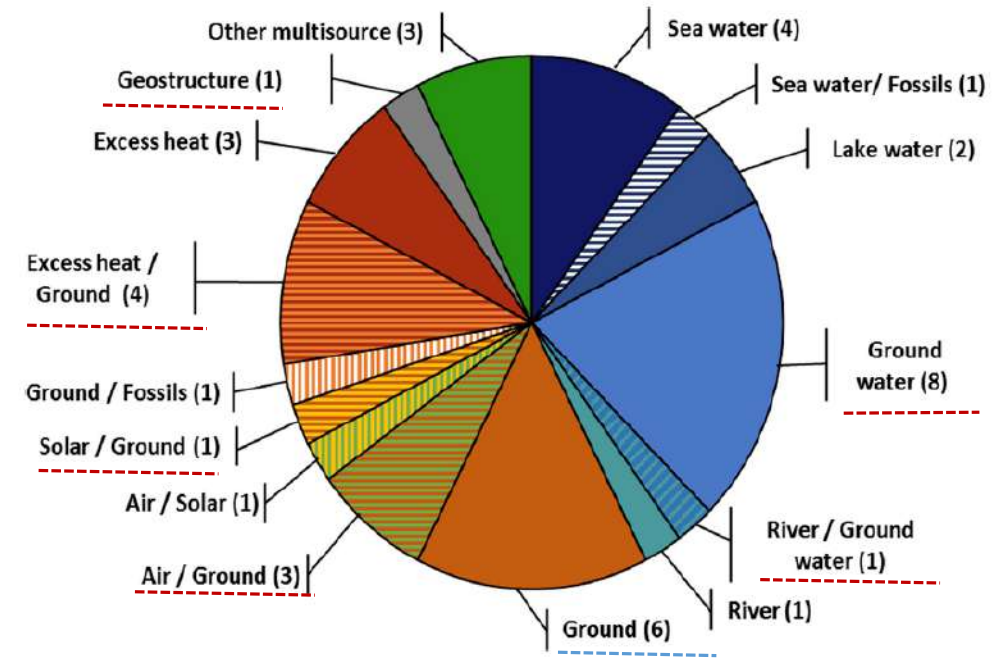
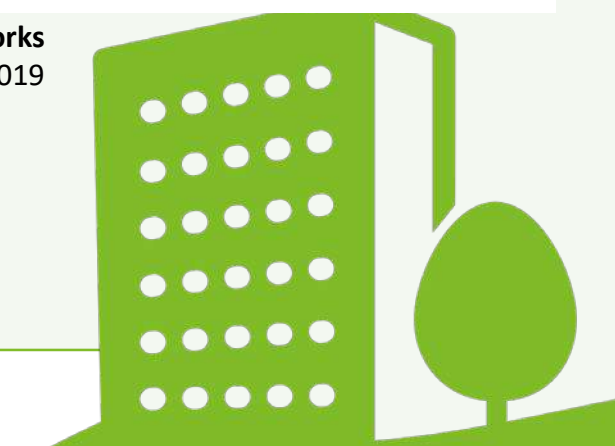


Fig. 4. Surveyed 5GDHC case studies by source.

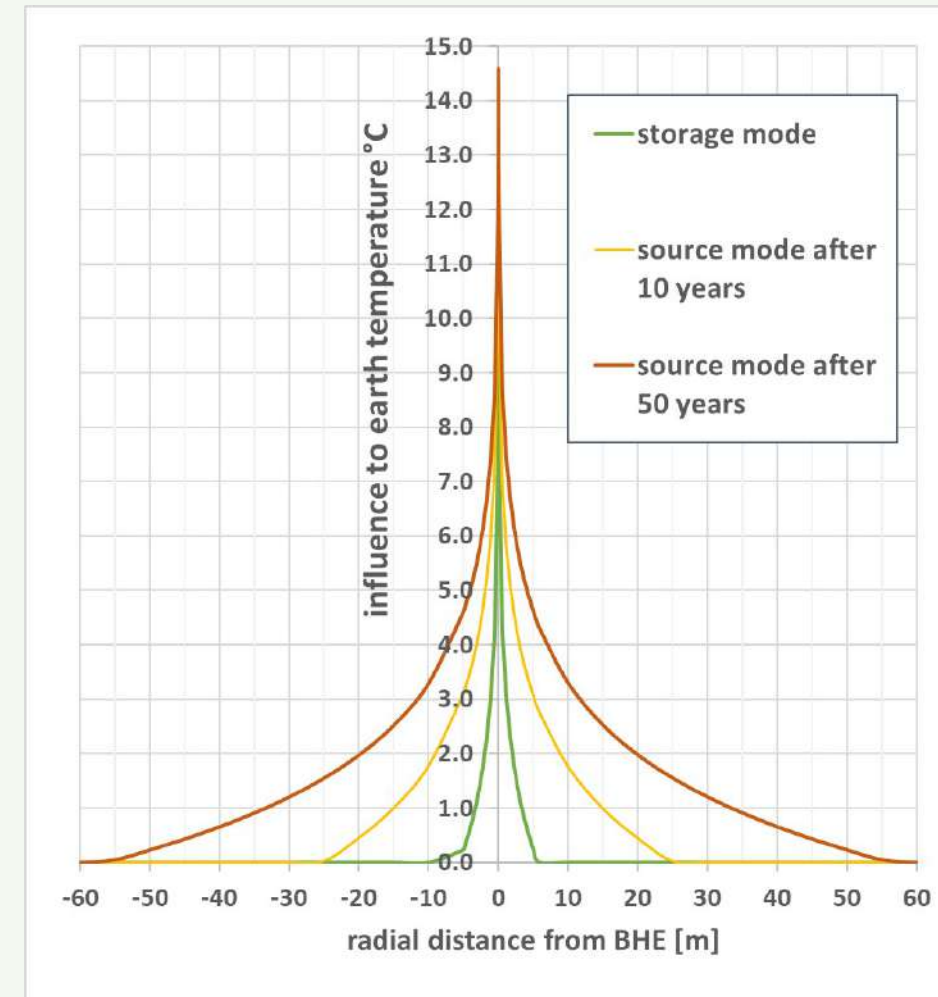
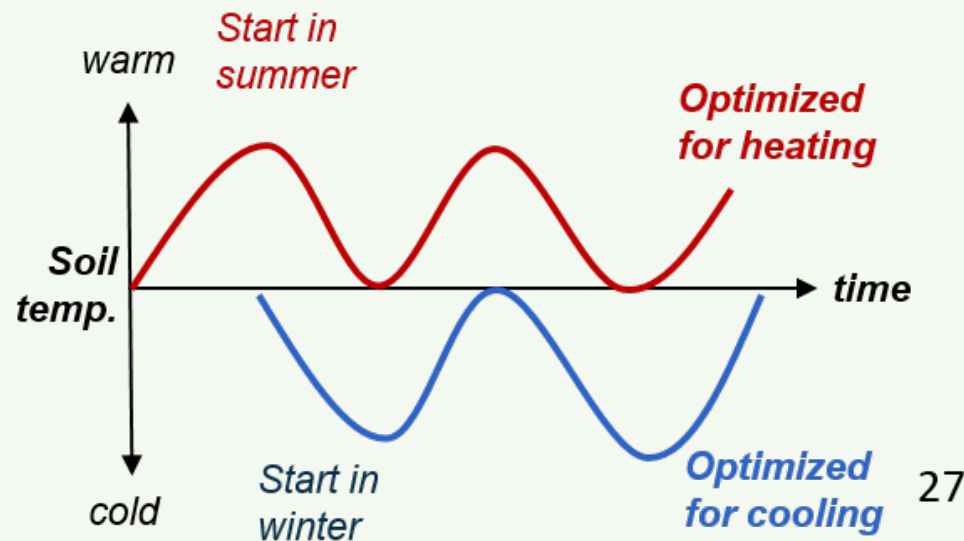
Heat sources of 5G networks
Source: Buffa et al., 2019



Fifth generation district heating and cooling – a promising concept

Why using BHE for storage

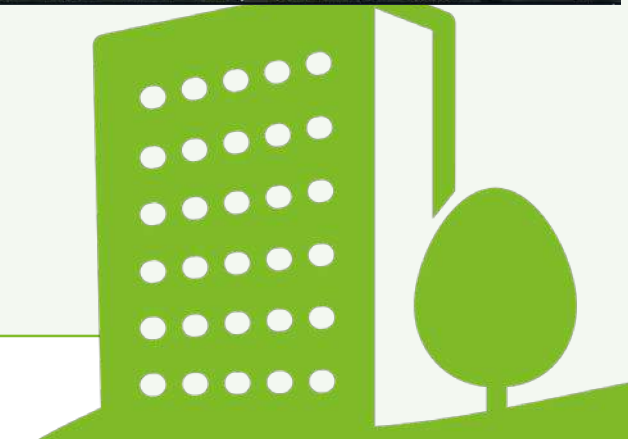
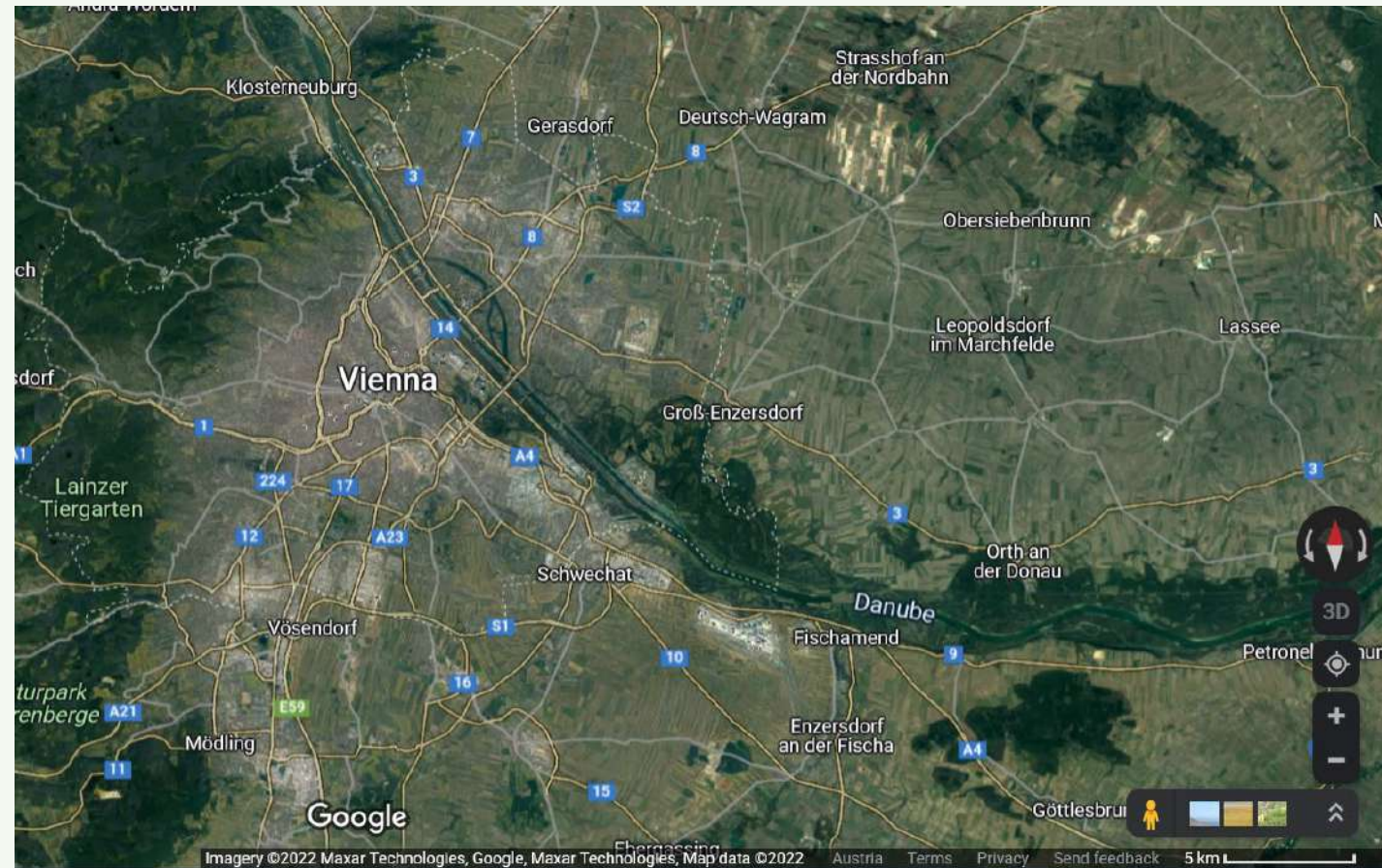
- Higher efficiency and significantly **increased specific energy transfer**
- Reduced surface space consumption
- Increased adaptability to different supply modes



The Vienna case study

The challenge

- 120k buildings, whereof 27% built before 1919
- 3rd largest DH network in Europe, 80% supplied by natural gas
- ~2300 ground source heat pumps (50% BHE, 50% GWHE) supplying individual homes
- Vienna is still growing ~ 10k inhabitants per year

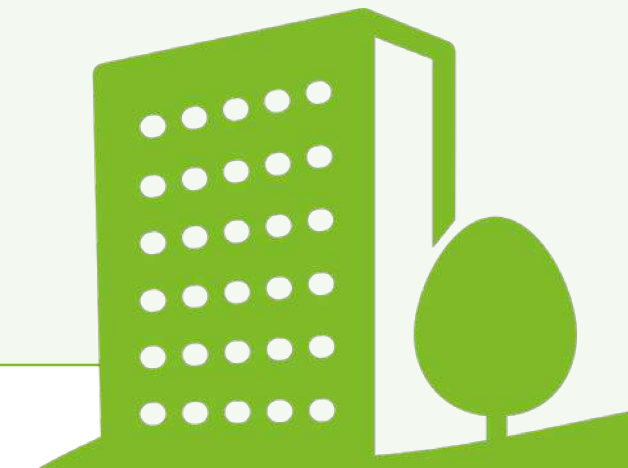
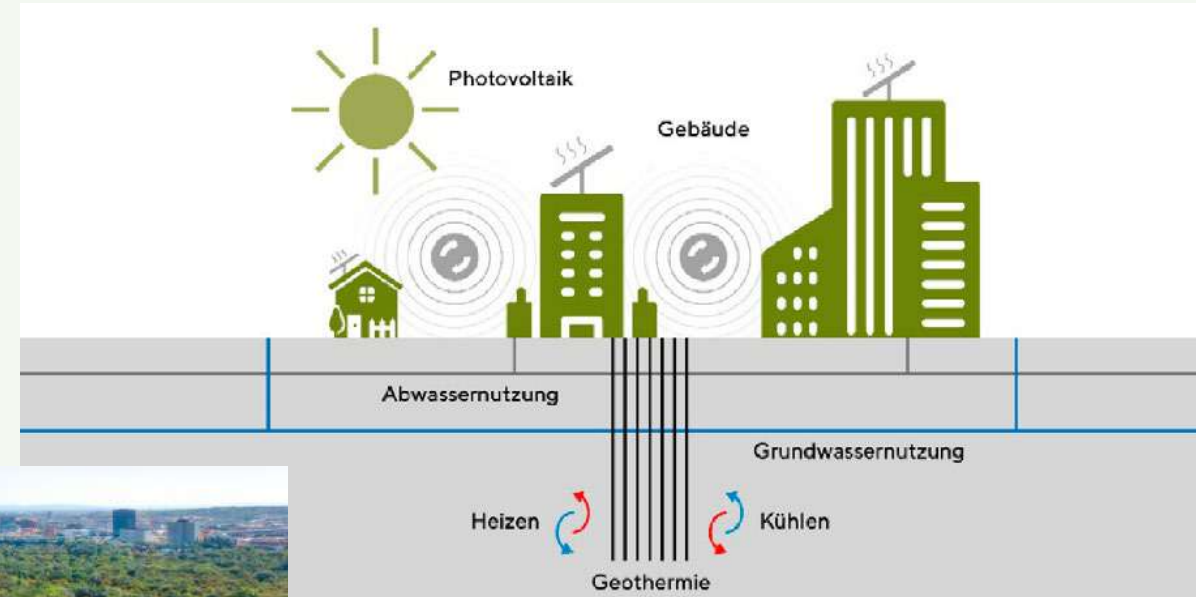


The Vienna case study

5th generation starts to become a state of the art greenfield solution

Example “Vierte2Plus”

- 5000 apartments supplied by a low temperature HC network
- Sources: GWHE, PVT collectors, space cooling, natural gas (peak load)
- Storage: BHE fields



The Vienna case study

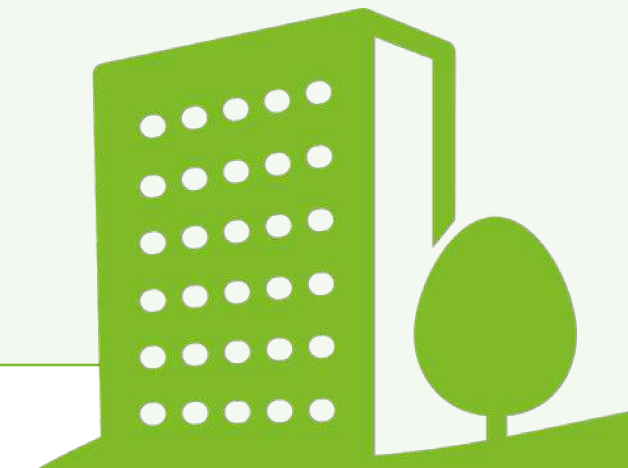
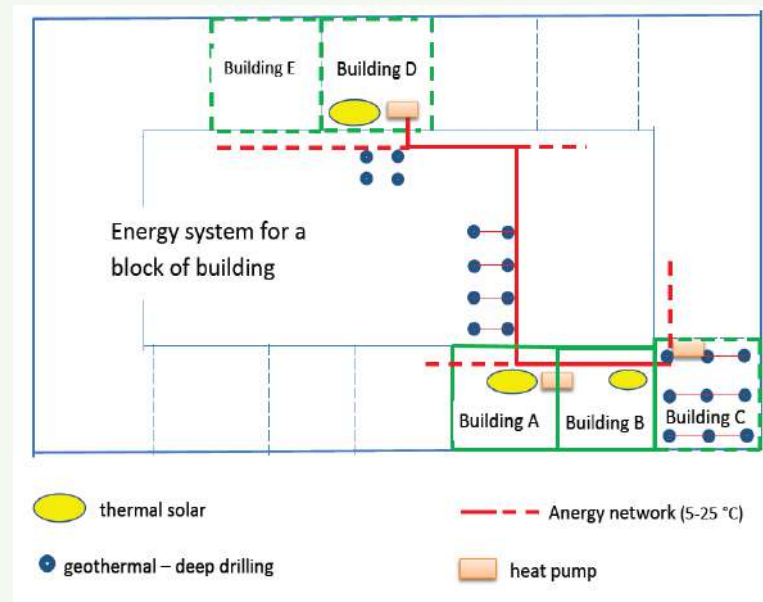
5th generation DHC networks to supply the existing building stock

Pilot site “Smart Block Geblergasse”

- Retrofitted buildings from early 1900s (HED 30-50 kWh/m².a)
- 18 BHEs (100 m) combined with solar thermal, SPF ~ 6
- Space heating and moderate cooling supply, panel heating



Source: Project Energie Urban (ÖGUT)



The Vienna case study

5th generation DHC networks to supply the existing building stock

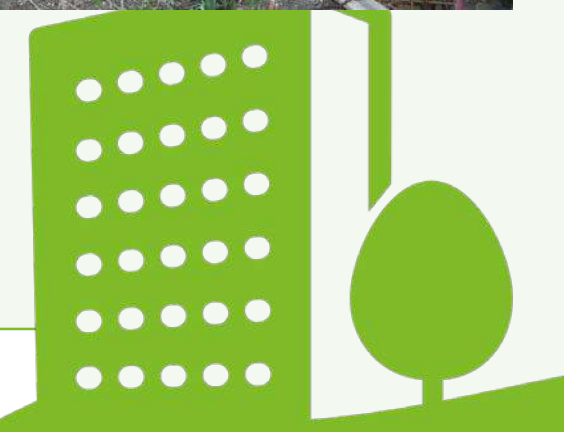
Pilot site “Smart Block Geblergasse”



Drilling rig in the inner yard, Source: Gerhard Bayer, ÖGUT



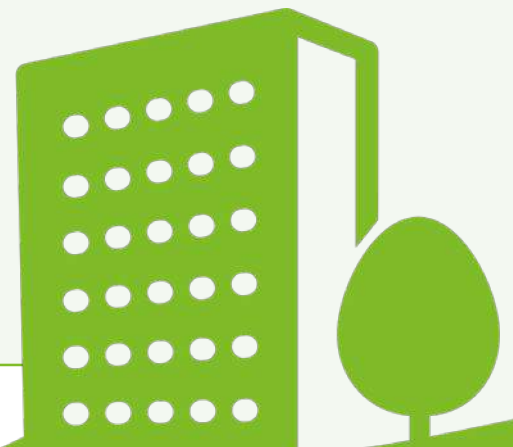
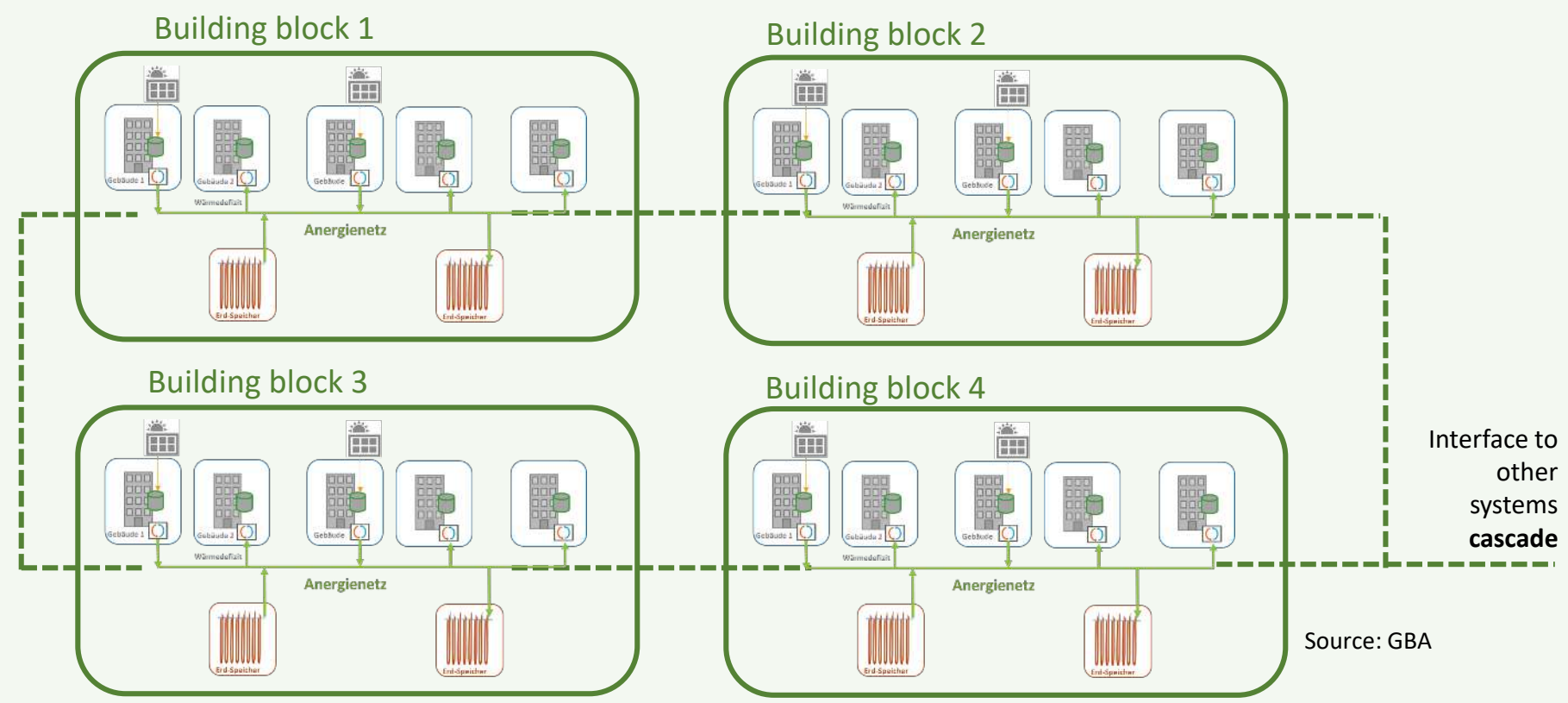
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The Vienna case study

Outcomes of the project „Anergy Urban“ (2019 – 2022)

Expanding individual 5G networks to meshes and cascades



The Vienna case study

Outcomes of the project „Anergy Urban“ (2019 – 2022)

City quarter based analyses in the densely settled, built environment



Case study “Lerchenfelder Gürtel”

Profile

- Most buildings from the early 1900s
- High building density
- High density of population
- Low free space for drilling
- Mixed use (residential and small businesses)



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The Vienna case study

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City quarter based analyses in the densely settled, built environment

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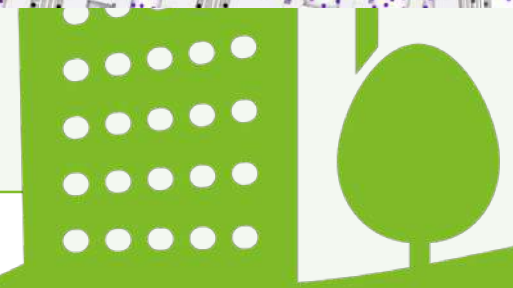
- **GIS-based workflow** to map technical potentials for the use of geothermal energy (inner yards, parks, streets & pathways)
- Evaluation of mapping workflow by **on-site checks**
- **Mapping** of energy demand and load profiles for retrofitted buildings (**basic assumption**)
- **Spatial analyses** to align heat demand & heat supply (energy, capacity) -> **balances**



Randomly assigned locations of BHEs at given boundary conditions (e.g. minimum distances to buildings, trees, neighbouring BHEs...), source: TU Wien



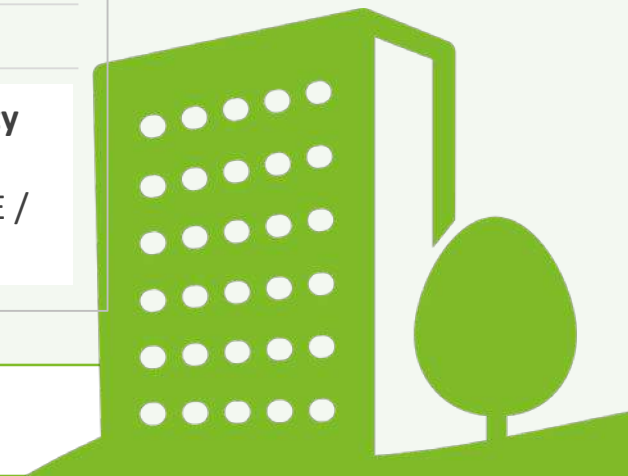
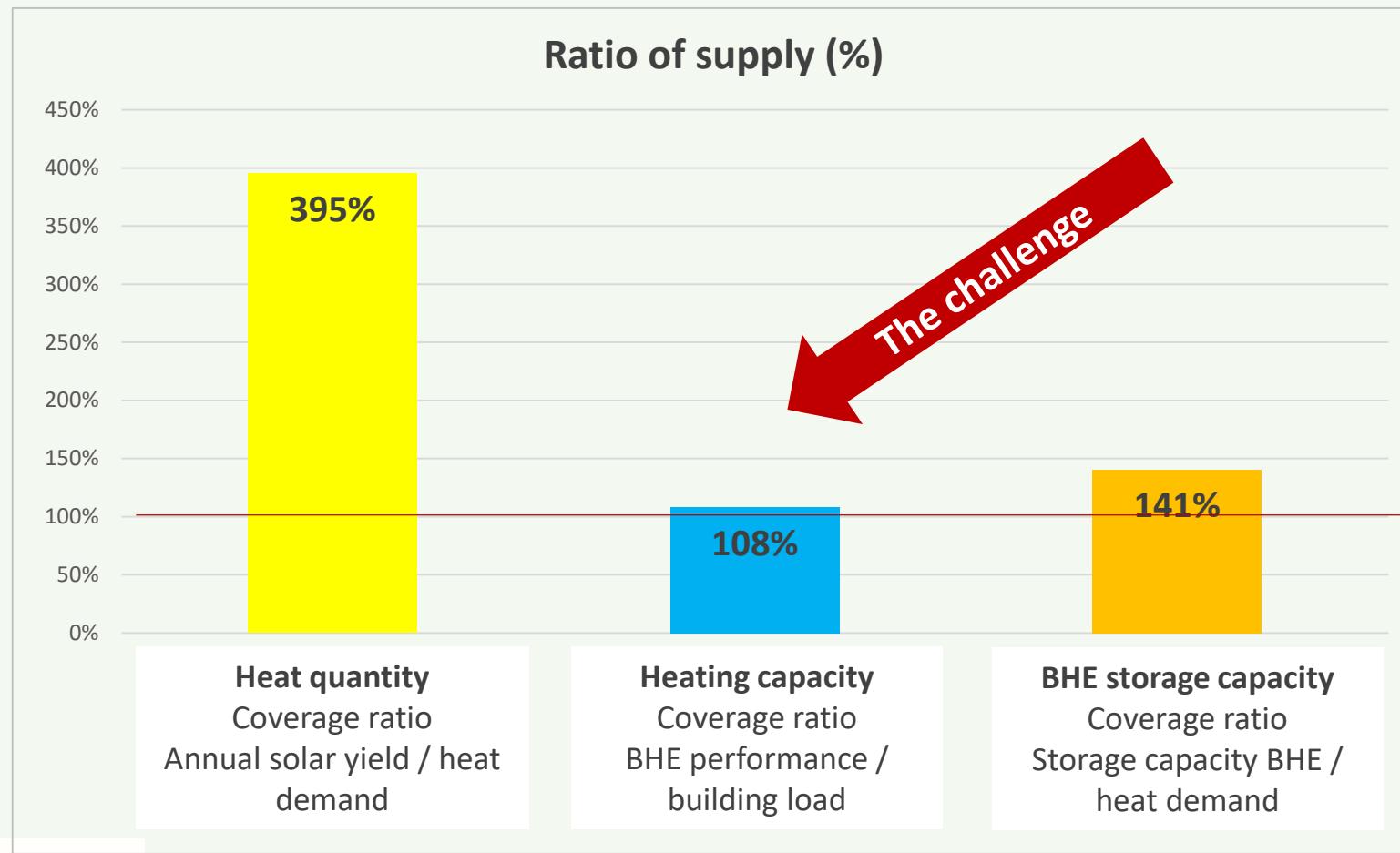
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The Vienna case study

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Case study „Lerchenfelder Gürtel“ - balances

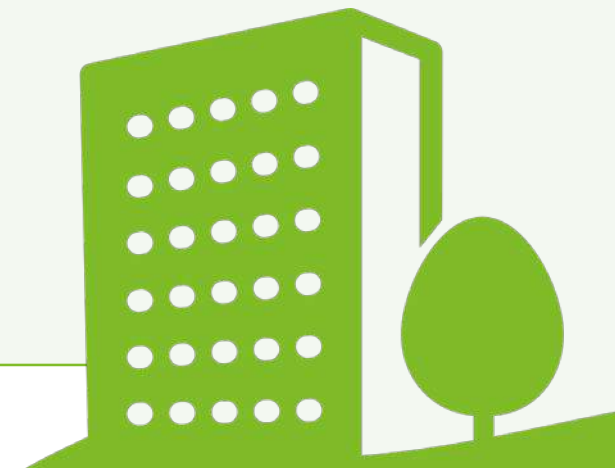
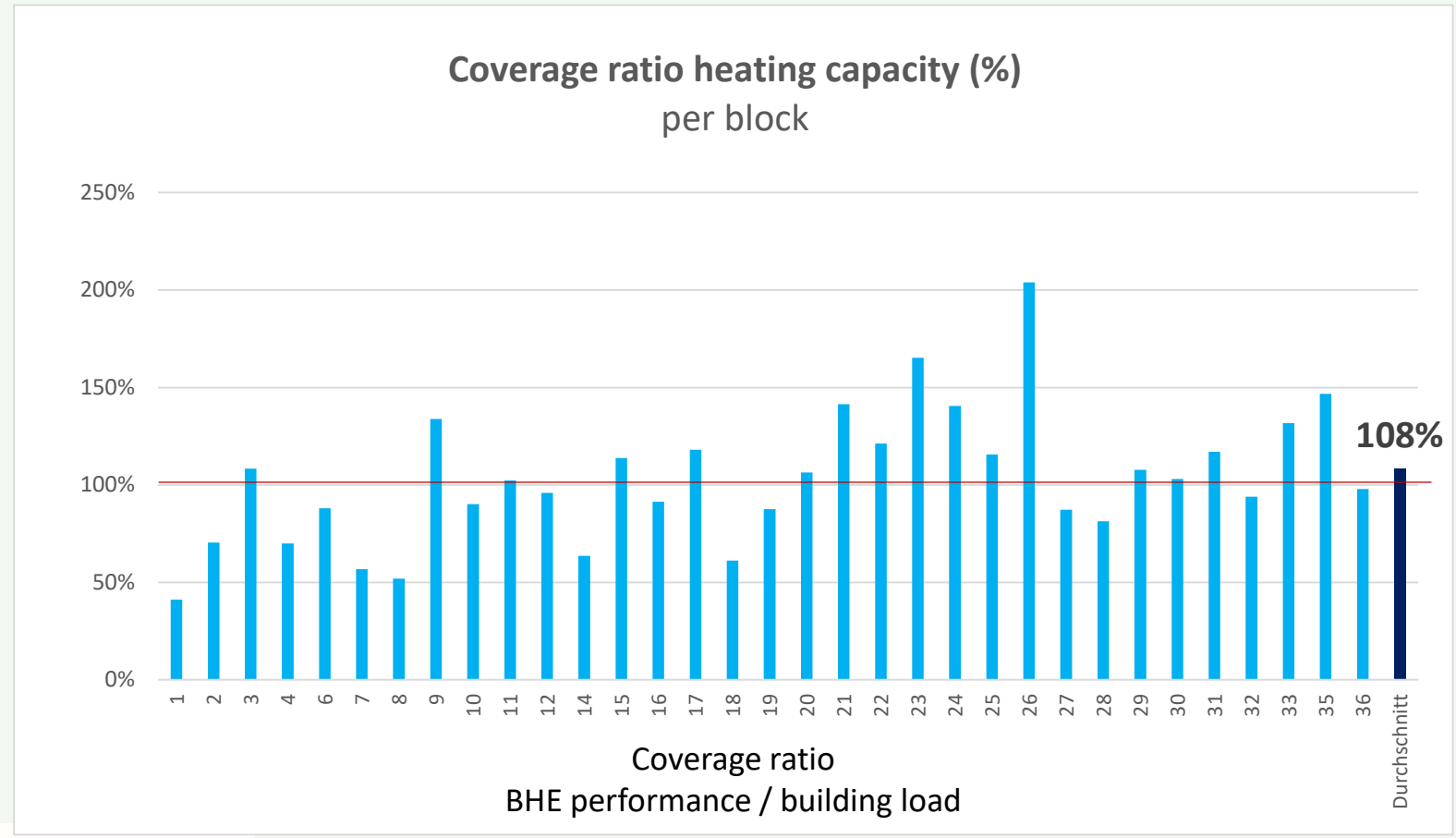




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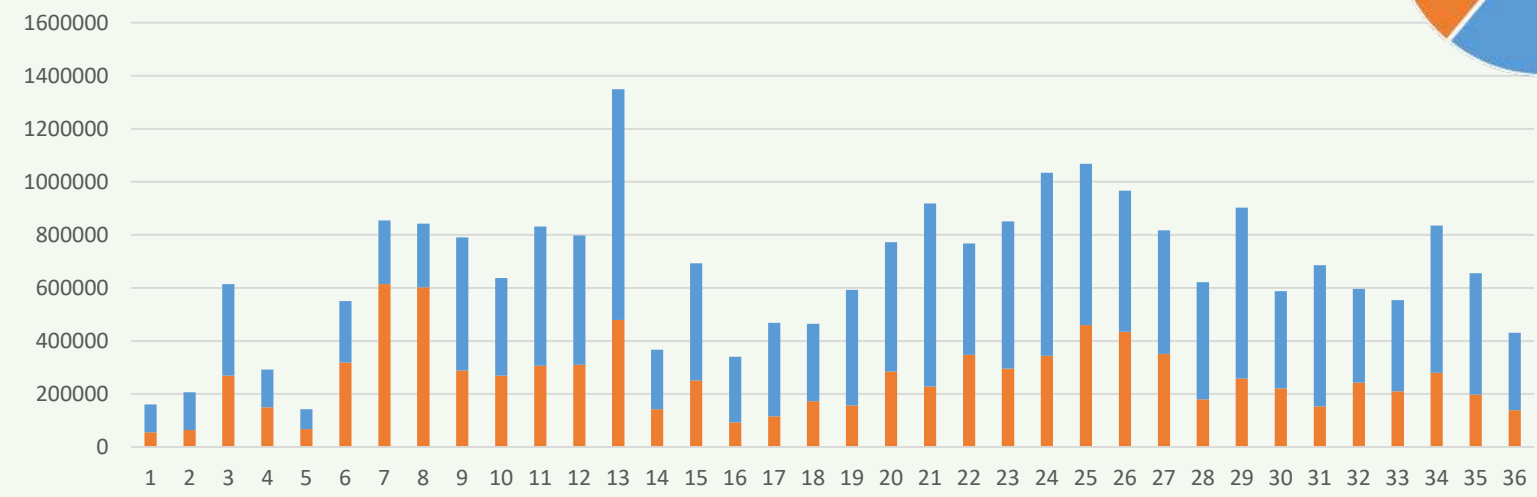
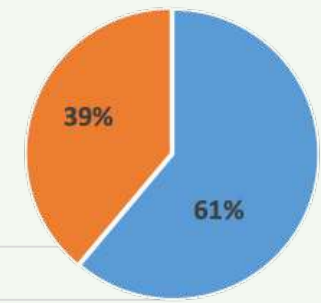


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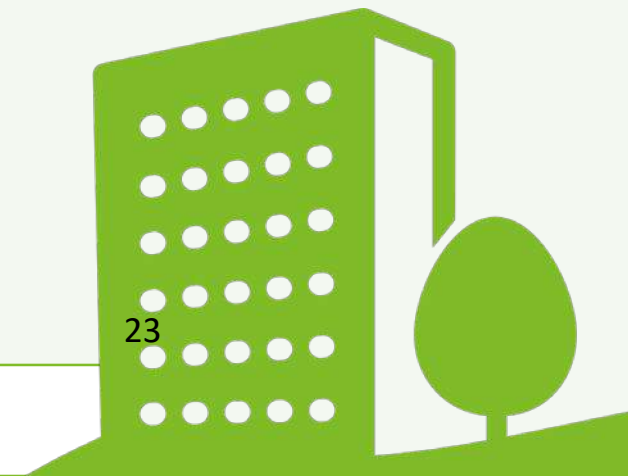
Outcomes of the project „Anergy Urban“ (2019 – 2022)

Case study „Lerchenfelder Gürtel“ - balances

BHE storage capacities,
Private space and public space per block



Private space (courtyards) Public space (streets)



Conclusions & outlook

5th generation DHC networks offer a vital solution for decarbonizing buildings even in the built environment and BHE fields are a central component

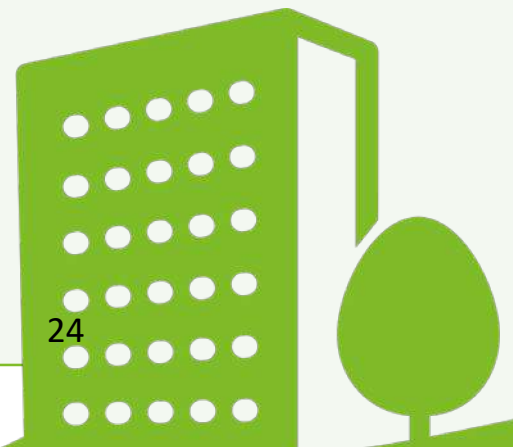
Cities are local energy hubs - we need to rethink urban planning in order to unleash the sustainable heating and cooling potential in cities

Exergy first - we should not waste enthalpy sources for low enthalpy consumption



“Cascade pattern”

- More than one individual networks connected in a cascade order
- Hierarchical compounds controlled by temperature levels ($T1 > T2$)
- Organic growth possible
- Energy balance via heat exchangers (no hydraulic connection)





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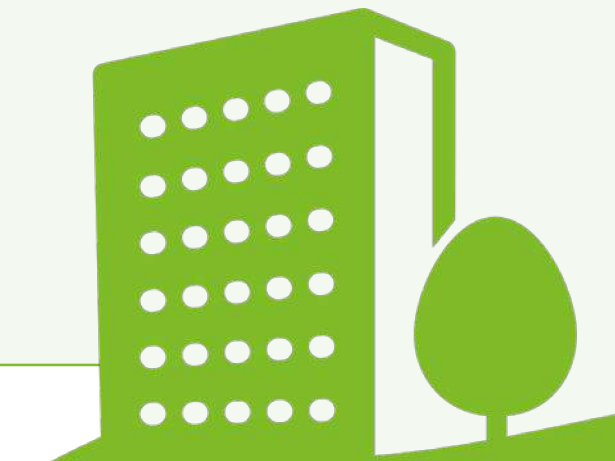
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Thank you for your attention!

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