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Downscaling European decarbonization scenarios of the heating sector to the Austrian community level

Assessing the heat density gap of centralized heat networks between 2050 and today

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The scope of changes in the European heating sector

- The average share of renewables in the heating & cooling sector is only just above 20% on average in all EU member states[1]
- In Austria it is 34% - but fossil fuels continue to dominant the provision of heating and cooling services here as well
- $900{,}000$ dwellings are heated with natural gas and $500{,}000$ with oil (Austria 2020)
- Retrofitting of $50{,}000$ appliances per year, or more than 130 per day since the viability of green gas is uncertain at the end-user device level[2]
- Requires to a massive expansion of centralized heating (and cooling) networks to…
  - …ensure a highly efficient usage of renewable heat sources (e.g., biomass/waste, hydrogen)
  - …achieve significant retrofitting rates by high connection rates
  - …unburden the electricity sector (high electrification of different energy service needs)

[1]Eurostat https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20200211-1
[2]Zwickl-Bernhard & Auer, *Energy*, (2021). doi: 10.1016/j.energy.2021.121805

The core objective of this work

- The core objective is the downscaling of decarbonization scenarios[1] of the heating sector, taking into account the infrastructure/network requirements of heat generation technologies/sources, from the country to the community level.
- In particular, the prioritized preference of heat sources in centralized heat networks plays a crucial role, ensuring highly efficient usage of heat sources.
- The assessment of centralized heat networks using heat density as a criterion is important in this analysis.
- An Austrian case study is conducted, downscaling cost-minimizing heat generation portfolios 2050, obtained from the large numerical energy system model GENeSYS-MOD[2], from the country to the grid level.

[1]Developed in the European H2020 project openENTRANCE aiming for the 1.5/2.0°C global warming climate target

[2]Löffler et al., *Energies*, (2017). doi: 10.3390/en10101468

Methodology

NUTS classification	Description	Number	Example (population)
NUTS0	Country level	1	AT Austria (8.86 millions)
NUTS1	Major socio-economic regions	3	AT3 Western Austria (2.78 millions)
NUTS2	Basic regions for the application of regional policies (federal states)	9	AT31 Upper Austria (1.48 millions)
NUTS3	(Small) sub-regions for specific diagnoses (political/court districts)	35	AT312 Linz-Wels (529 thousands)
LAU (former NUTS4/5)	Subdivision of the NUTS 3 regions (communities)	2095	Enns AT312 Linz-Wels (11 thousands)

Spatial levels

- Three different scenario-independent downscaling techniques
  1. **Proportional downscaling** using population as a proxy (NUTS0 to the LAU level)
  2. **Sequential downscaling** algorithm using population density and infrastructure requirements of heat technologies/sources as additional criterion (NUTS0 to the NUTS3)
  3. **Iterative downscaling** algorithm based on graph-theory benchmarking (NUTS3 to the LAU level)

Reference technique

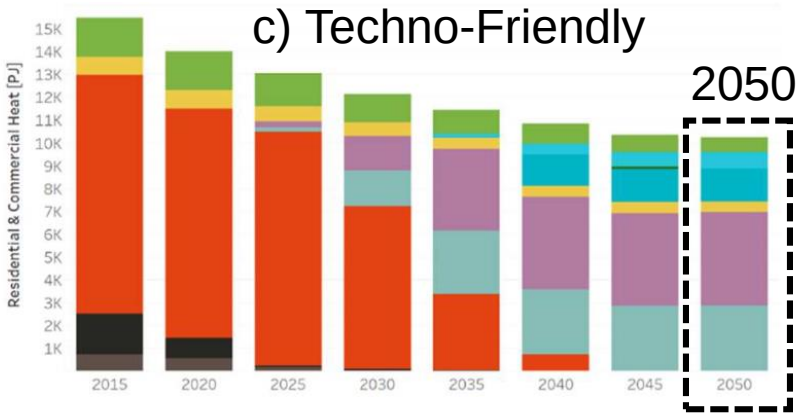
Techniques developed

The Nomenclature of Territorial Units for Statistics (NUTS) were created by Eurostat in order to define territorial units for the production of regional statistics across the European Union.

Numerical example and scenarios

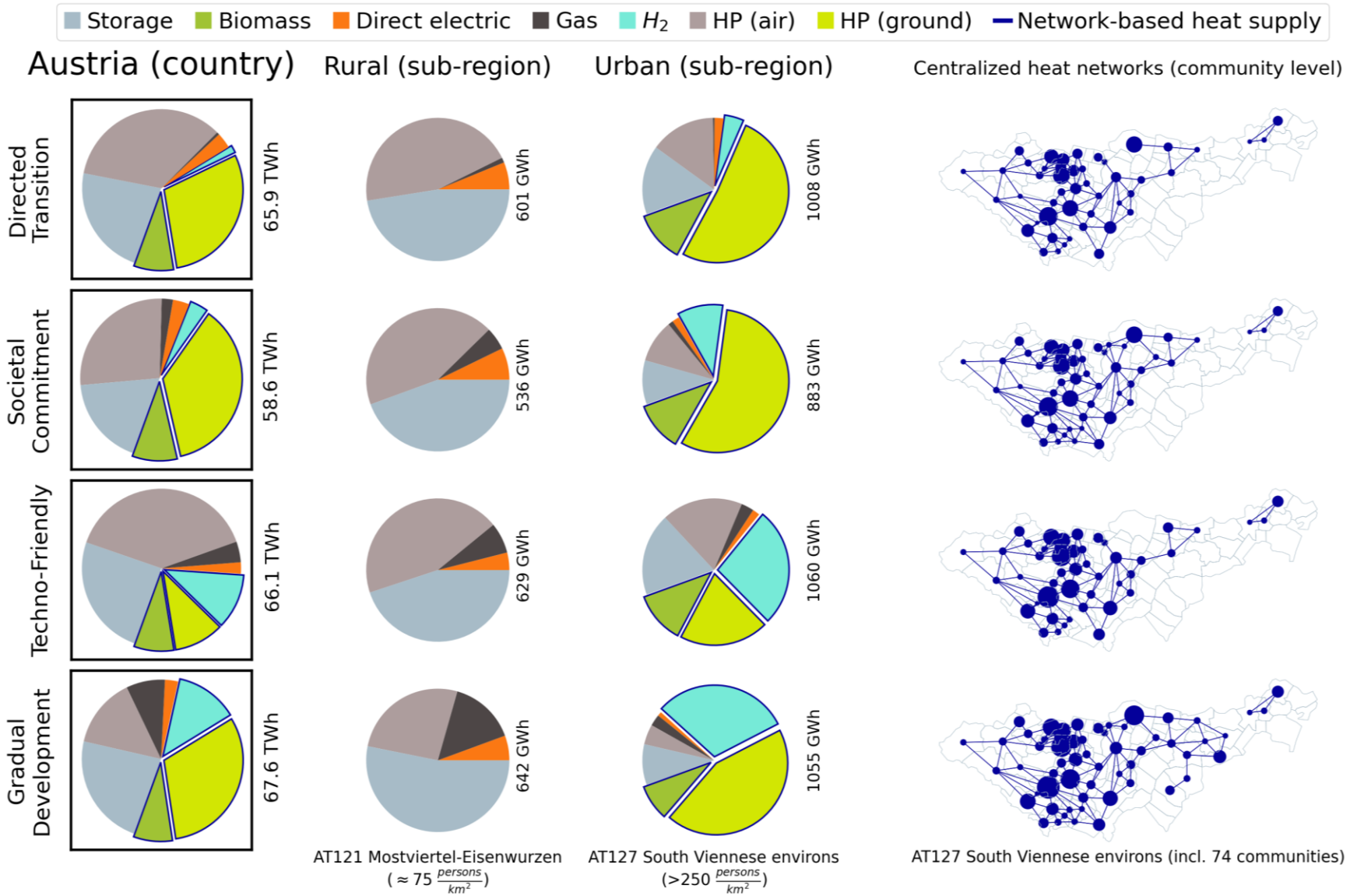
- Four different decarbonization scenarios of the European energy system aiming for the 1.5/2.0°C global warming climate target[1]
  a) Directed Transition scenario (strong policy incentives)
  b) Societal Commitment scenario (strong societal acceptance, decentralized renewables)
  c) Techno-Friendly scenario (market-driven breakthrough of renewables)
  d) Gradual Development scenario ("little of each")

- Values of the decarbonized heating sector in Austria 2050 obtained by the large-numerical energy system model GENeSYS-MOD

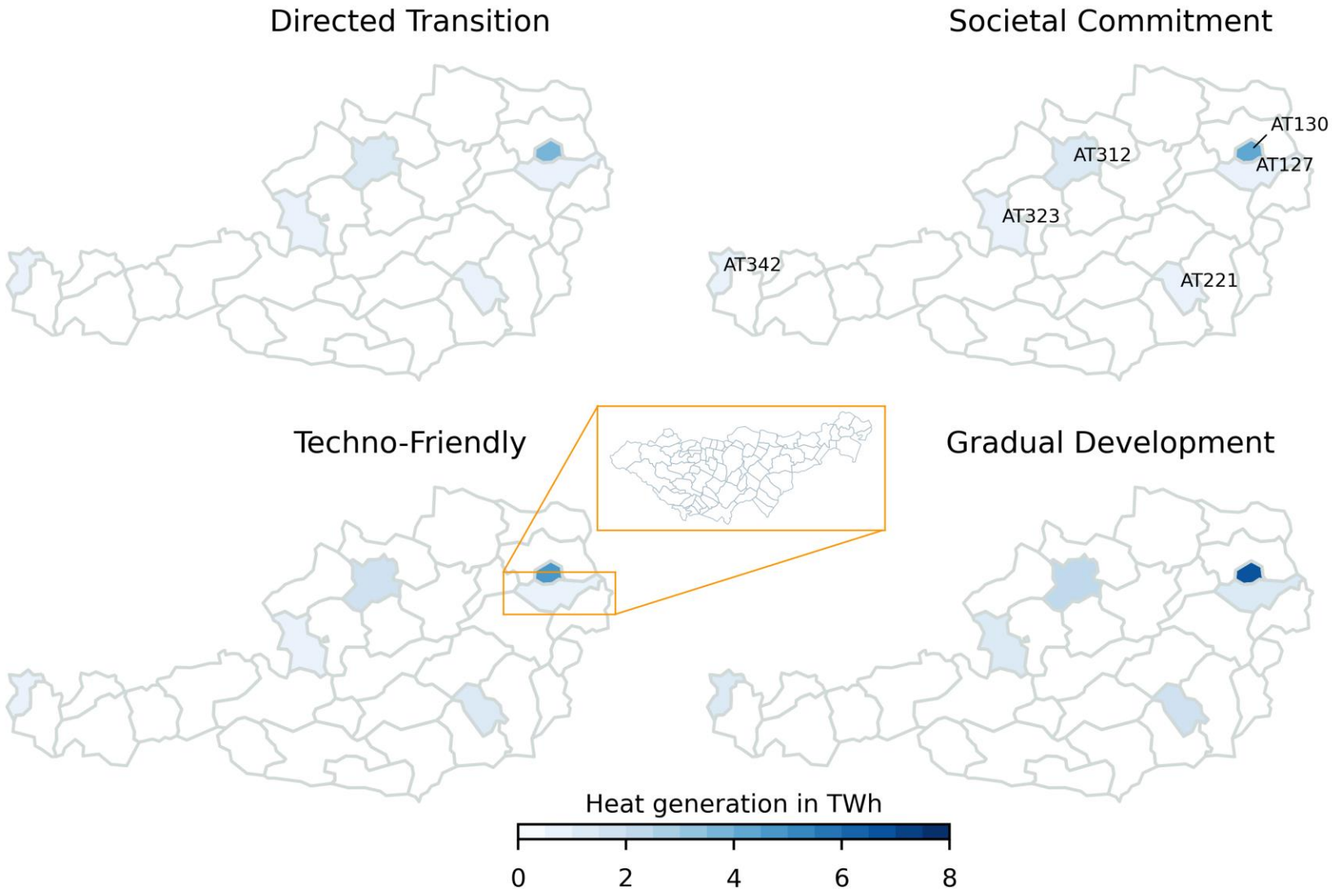


[1]Scenario a) to c) considers the 1.5°C global warming target and d) the less ambitious 2.0°C.

Heat generation on the country, sub-region, and community level

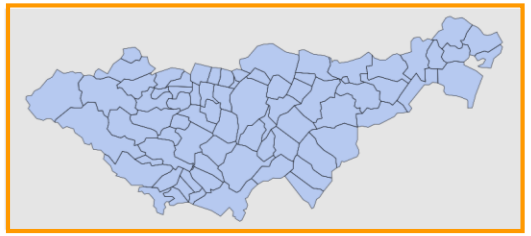


Centralized heat supply in Austrian NUTS 3 regions 2050 in TWh



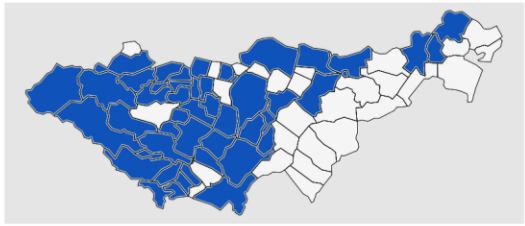
Centralized heat network topology improves by reducing supply area

Initial condition
(large area - difficult topology)

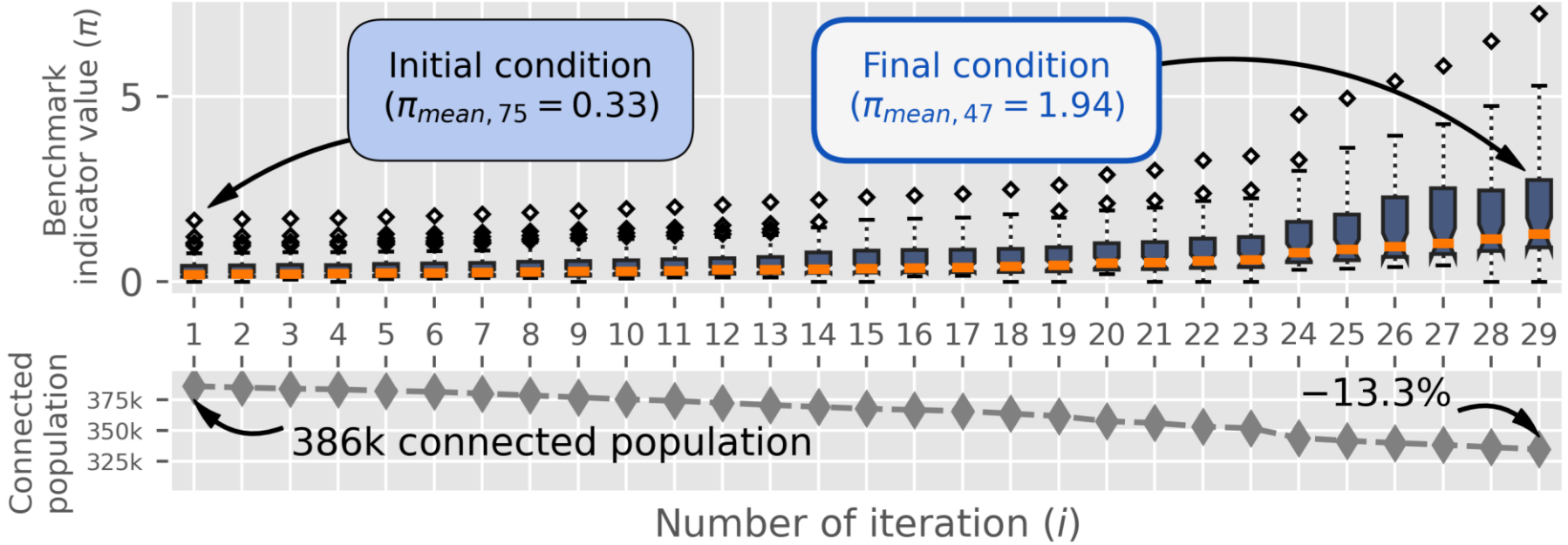


75 communities ($i = 1$)

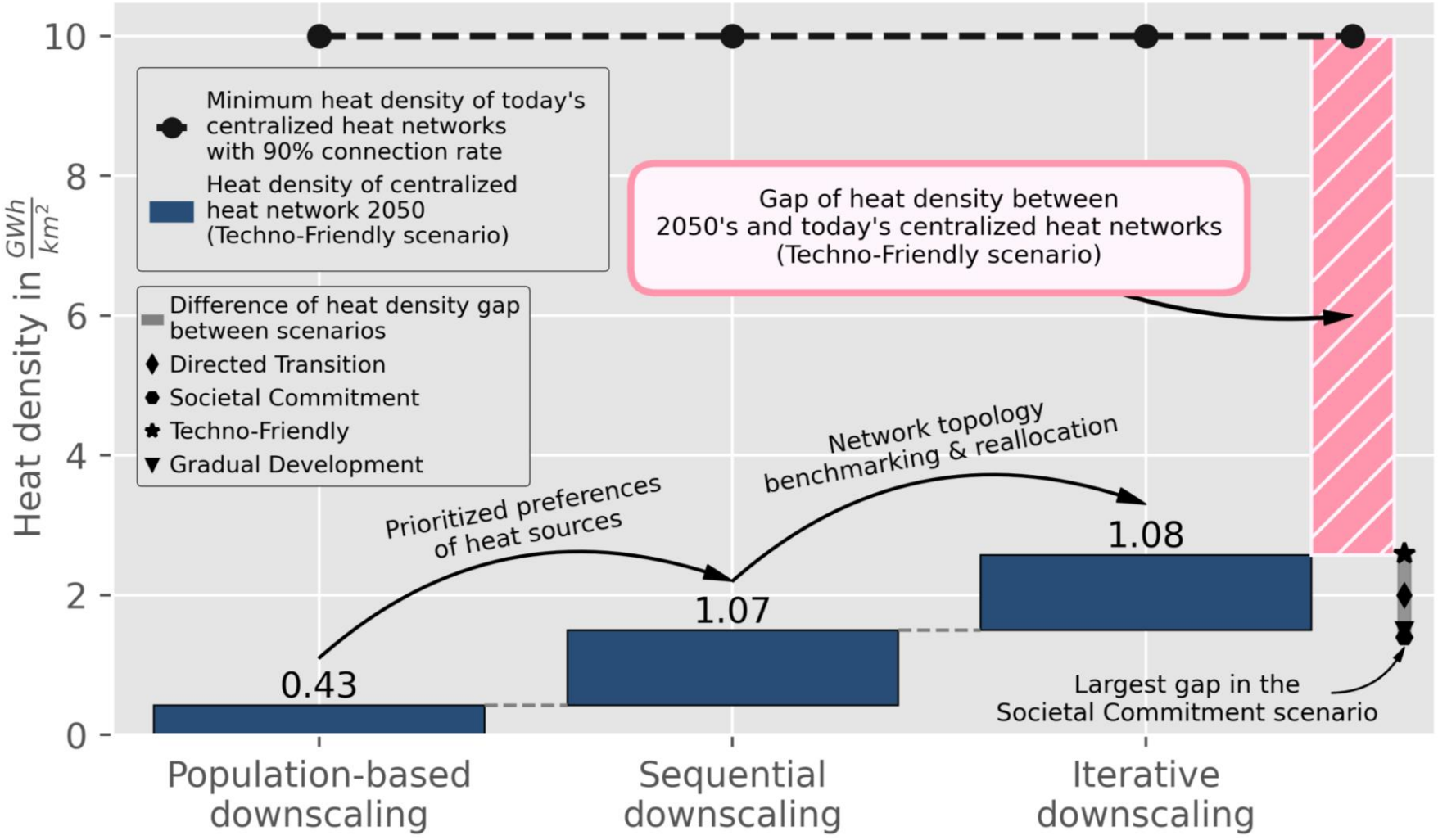
Final condition
(smaller area - improved topology)



47 communities ($i = 29$)



Heat density of the centralized heat network in Graz (AT221) 2050 obtained by different downscaling techniques



http://www.austrian-heatmap.gv.at/karte/

Conclusions

- Downscaling values of the **heating sector** require more **advanced techniques** than proportional downscaling
- Otherwise, misinterpretation of heat generation portfolios and **misestimating** the potentials of **centralized heat networks** on the local level
- In particular, prioritized preferences and graph theory-based benchmarking can improve the projections of downscaled values of the heating sector
- Despite improved accuracy, a significant **reduction** of **heat densities** of centralized heat **networks** compared to today's networks is expected by 2050 (heat density gap)
- **Incentives** to **provide** heat network **infrastructure** are likely be needed in areas which today would not be connected/supplied today

Acknowledgments / References

Collaborators

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References

H. Auer et al. (2020). Development and modelling of different decarbonization scenarios at the European energy system until 2050 as a contribution to achieving the ambitious 1.5°C climate target – establishment of open source/data modelling in the European H2020 project openENTRANCE, *e&i Elektrotechnik und Informationstechnik*, 1-13. doi: 10.1007/s00502-020-00832-7

open ENTRANCE