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## VIABILITY OF DISTRICT HEATING NETWORKS IN TEMPERATE CLIMATES: BENEFITS AND BARRIERS OF COLD AND WARM TEMPERATURE NETWORKS

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# Index

- Background
- Research questions
- Methodology and assumptions
- Results
- Conclusions



# Background

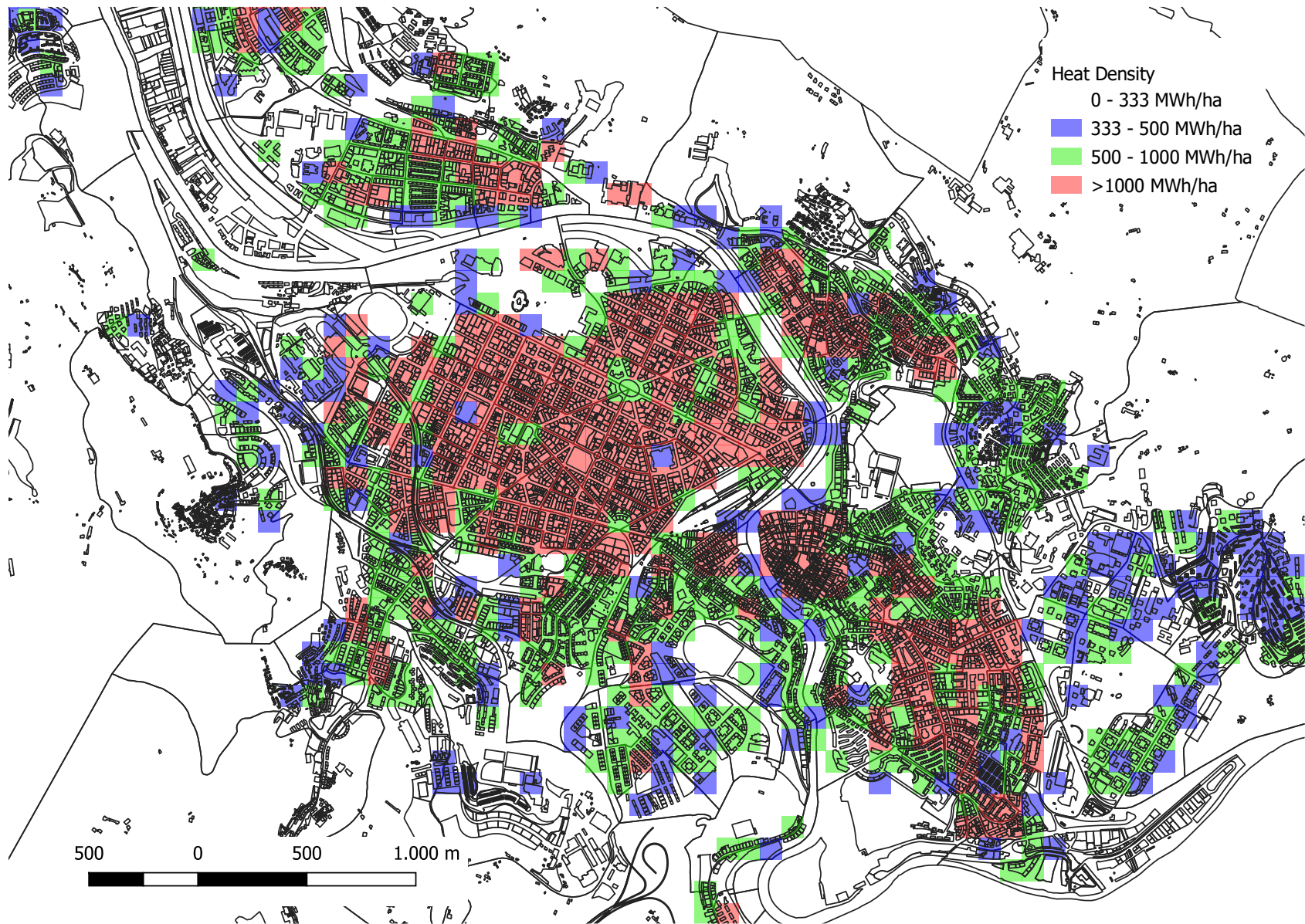
**Bilbao** → city of 346 405 inhabitants located in northern Spain.

**Mild climate:** 1 147 heating degree-days (13°C/17°C).

**Relatively low specific heat demands:** ~60 kWh/m<sup>2</sup><sub>floor</sub>

**High population density:** 54 662 p/km<sup>2</sup> (population-weighted).

**High heat densities.** Most of the city above 500 MWh/ha.



# Background

**Demand: 806 GWh**

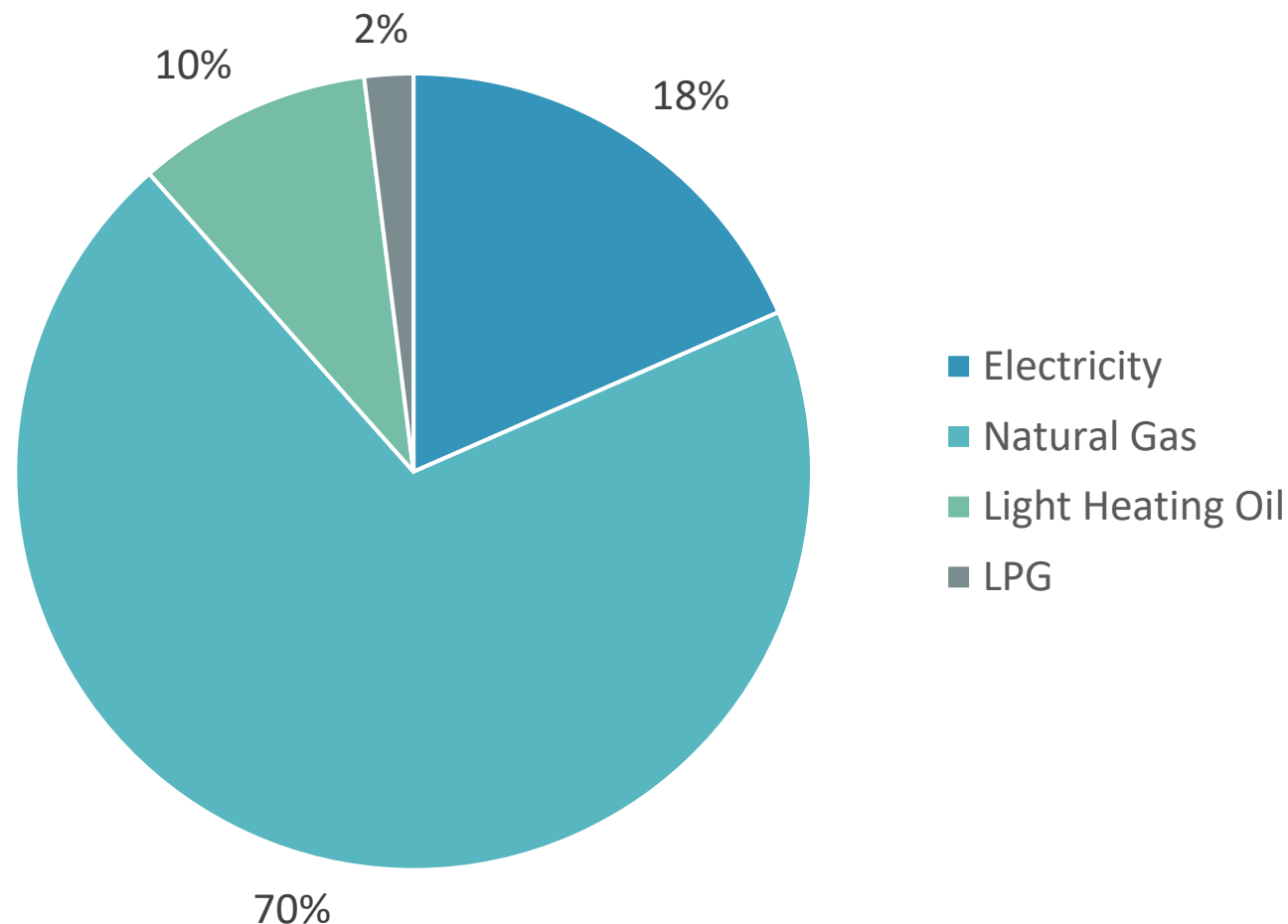
**Current heat supply: mostly based on fossil fuels and a small share of Joule electric heating.**

**Less than 30% of the buildings have centralized heating systems.**

**No District Heating system.**

**Abundant industrial waste heat (~400 GWh) in the vicinity of the city and ambient heat from river, sea and WWTP (~600 GWh).**

Bilbao's current heat supply



# Research questions

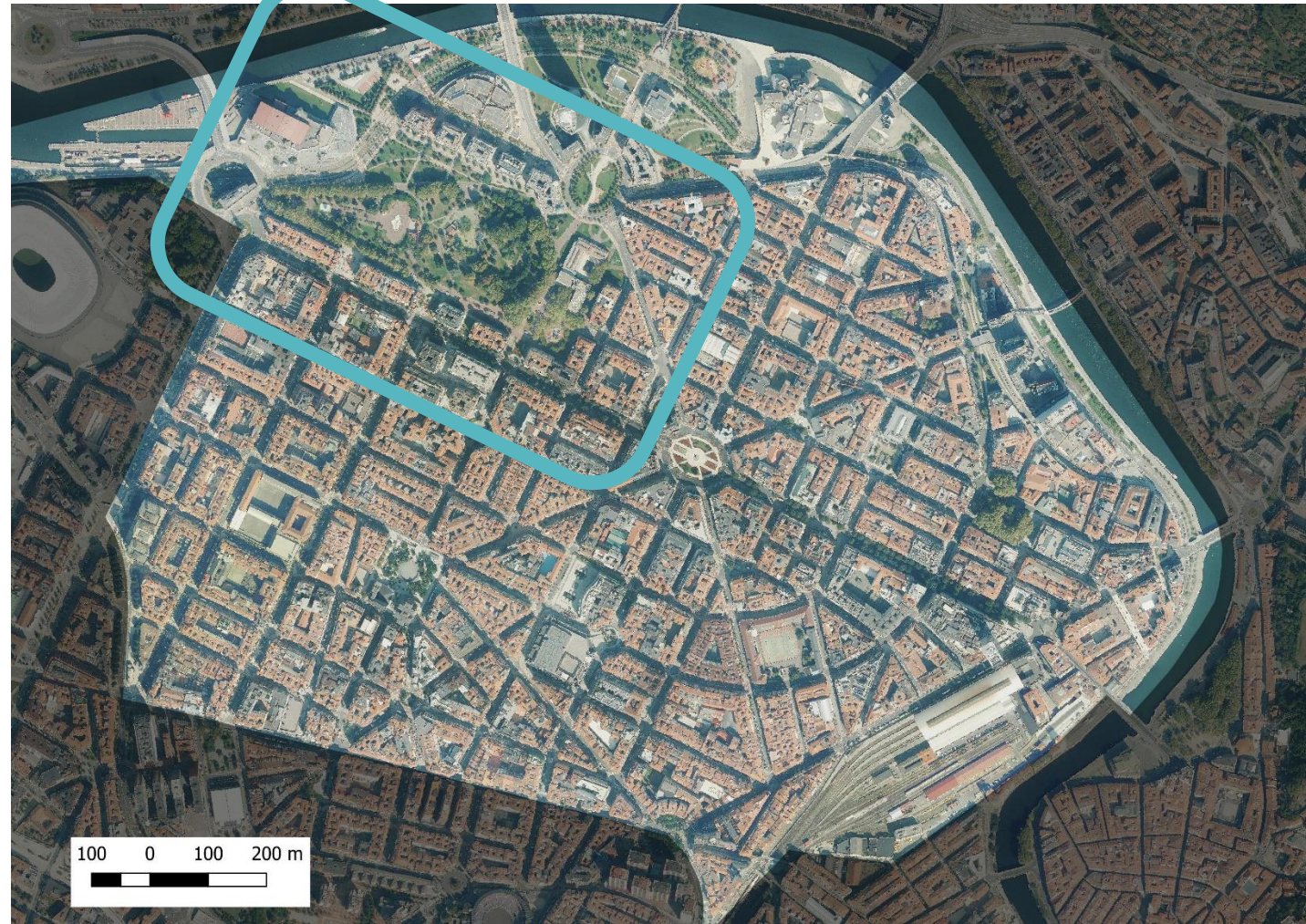
Area of study: 20 GWh  
heat & 3 GWh cold

- Is a District Heating system feasible in such a mild climate?
- What are the benefits and costs for Cold and Warm District Heating?

Case study in the District of Abando

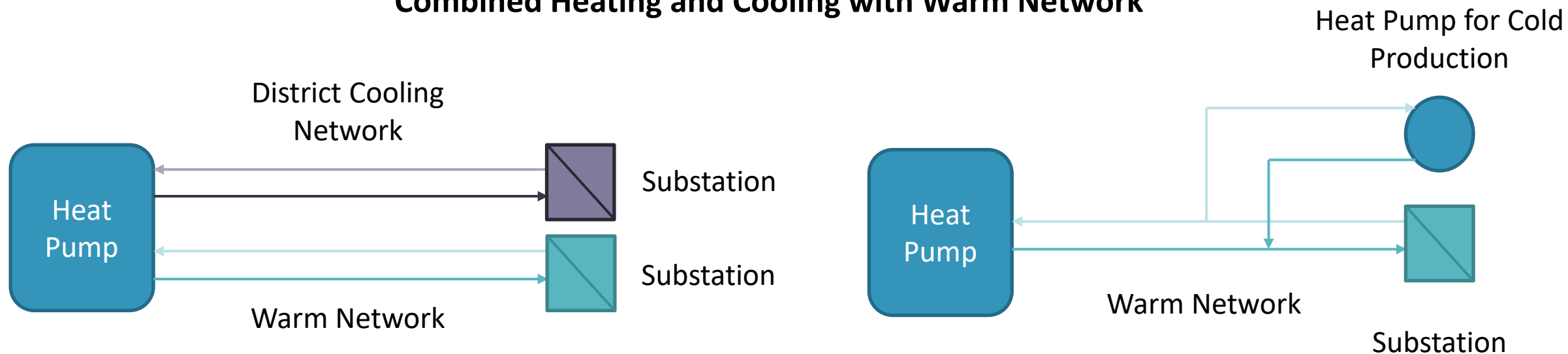
Focus 2022 → Network

Focus 2023 → Production

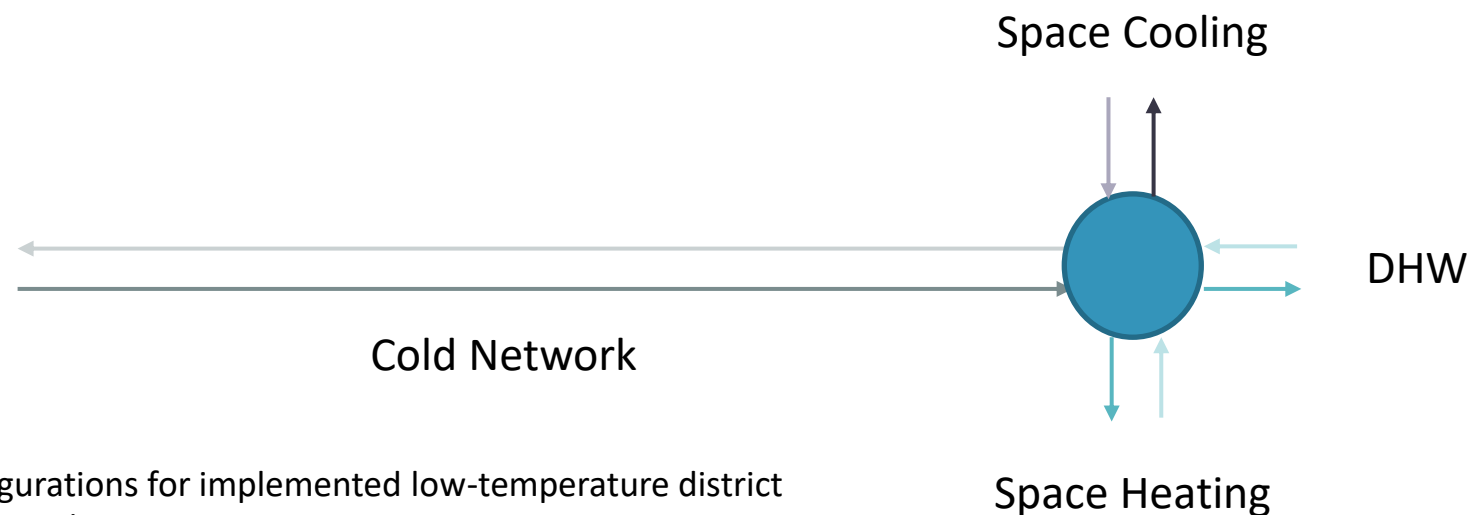


# Studied Solutions

## Combined Heating and Cooling with Warm Network



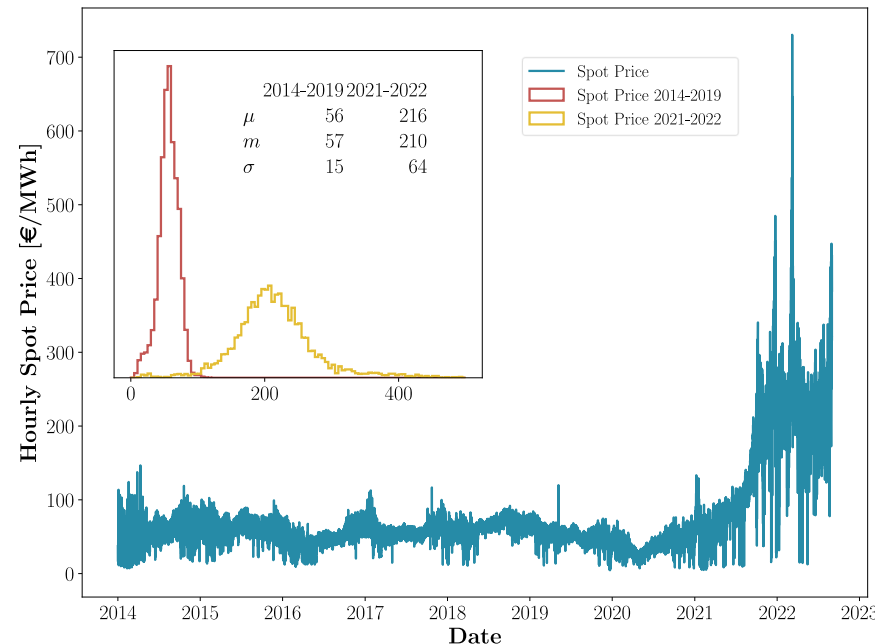
## Combined Heating and Cooling with Cold Network\*



\*Terms after: Werner, Sven. (2022). Network configurations for implemented low-temperature district heating. *Energy*, 254, 124091. <https://doi.org/10.1016/j.energy.2022.124091>

## Combined Heating and Cooling with Warm Network

- Heat Pump + TES + Gas Boiler
- Mixed Integer Linear Programming. All linear except for heat pump dispatching. (MATLAB & Gurobi)
- Heat Pump & TES → Danish costs
- Circular pit for TES → Estimated based on Spanish costs
- Spanish spot prices for 2014-2019 and spanish, grid losses, fees and charges.

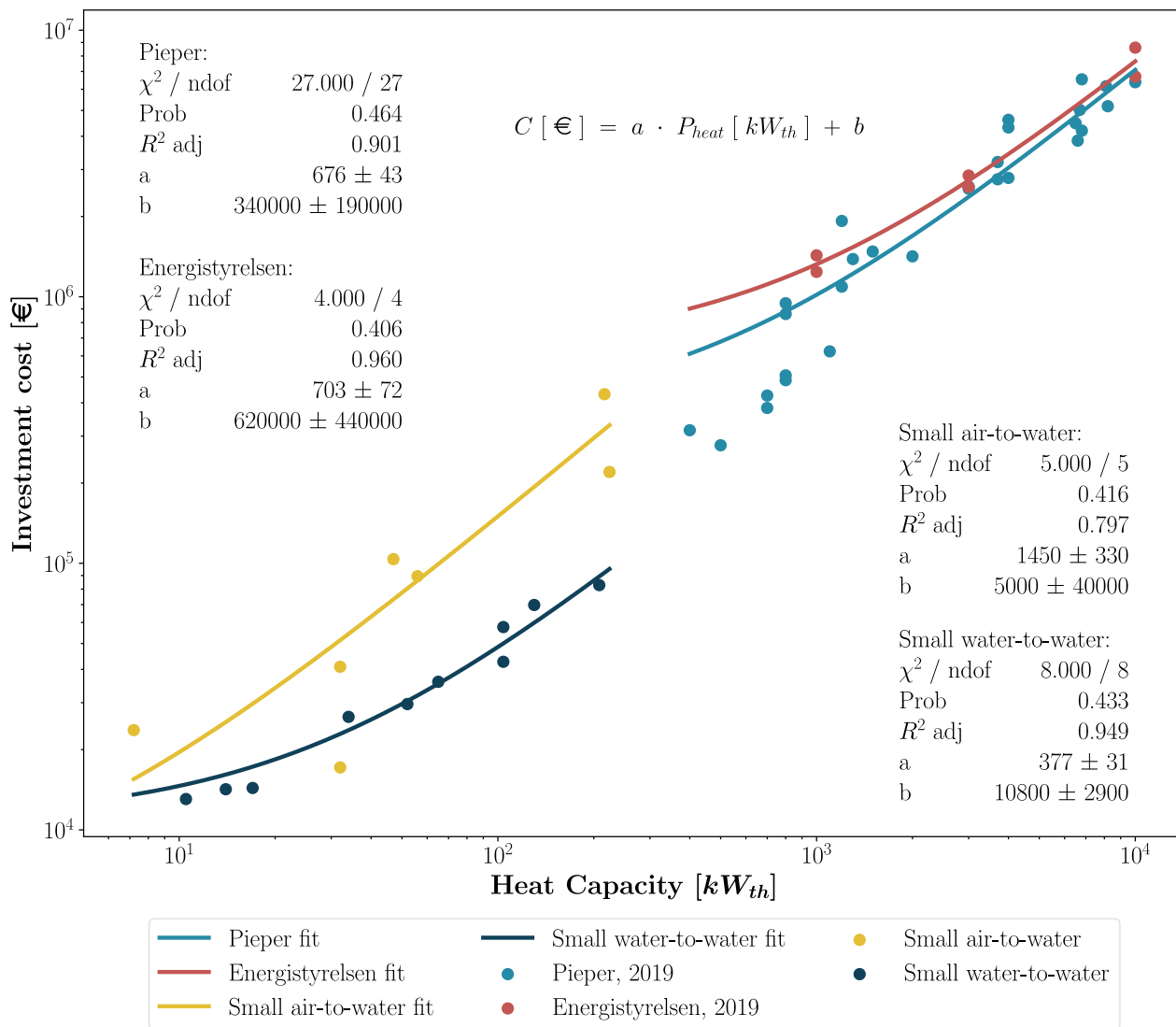


## Combined Heating and Cooling with Cold Network

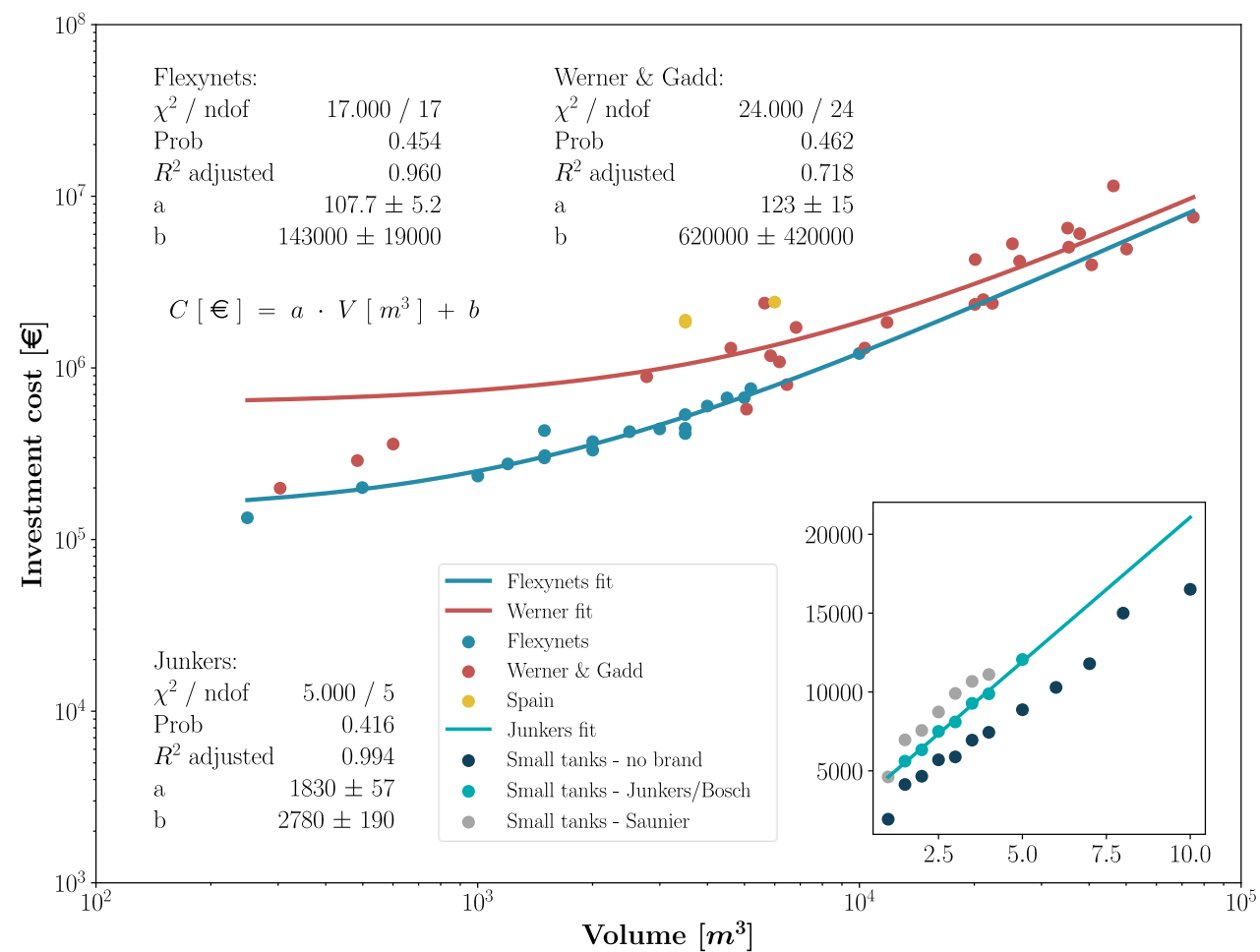
- Heat Pump + SH TES + DHW TES + (Cold TES)
- Thermal storages limited to 5000 L each.
- Mixed Integer Linear Programming → One sole heat pump supplies both DHW and space heating (different COPs) (MATLAB & Gurobi)
- Investment costs → Spanish sources
- Spanish spot prices for synthetic year of 2014-2019 and spanish, grid losses, fees and charges.



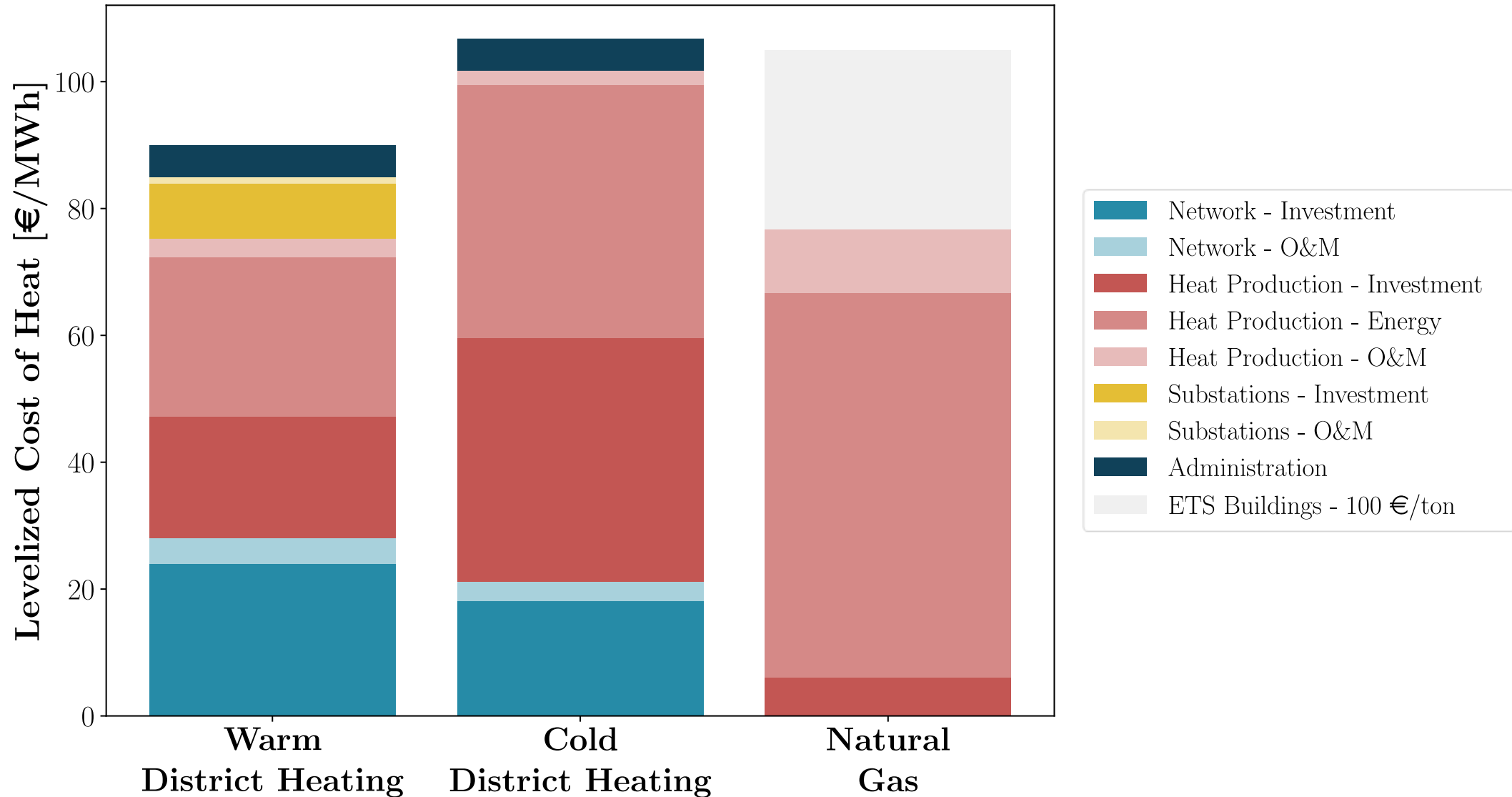
## Cost of Heat Pumps



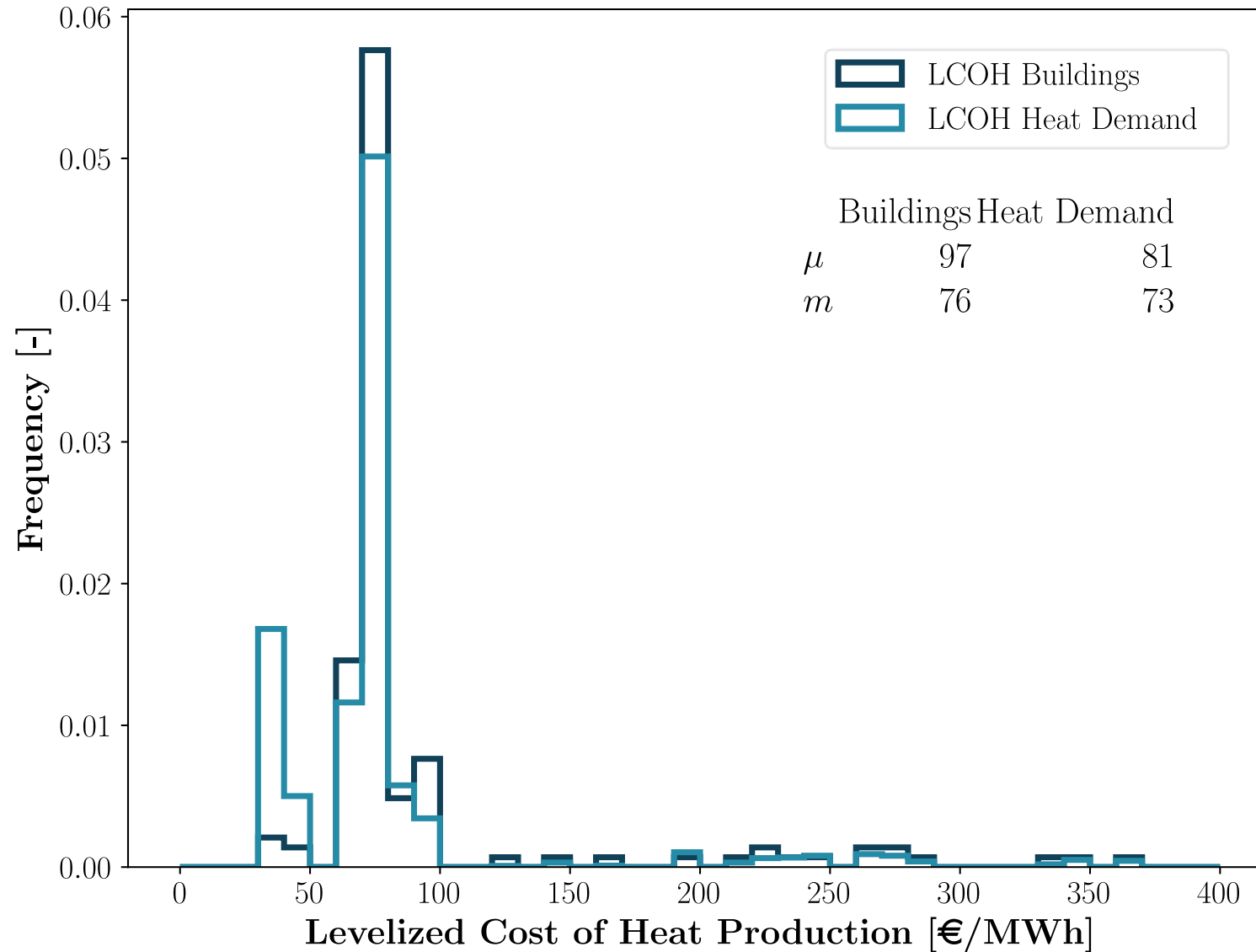
## Cost of TES



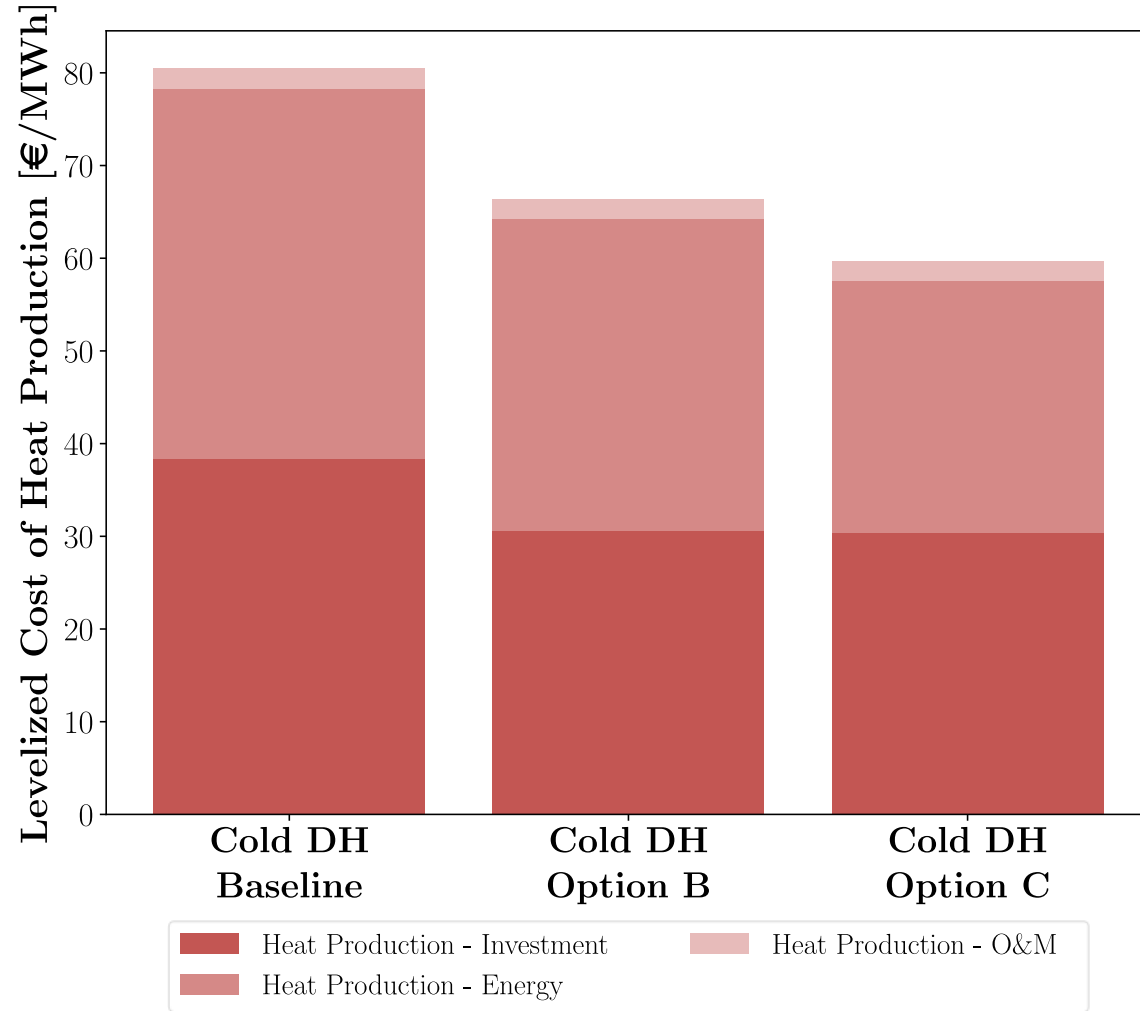
# Results – LCOH Comparison



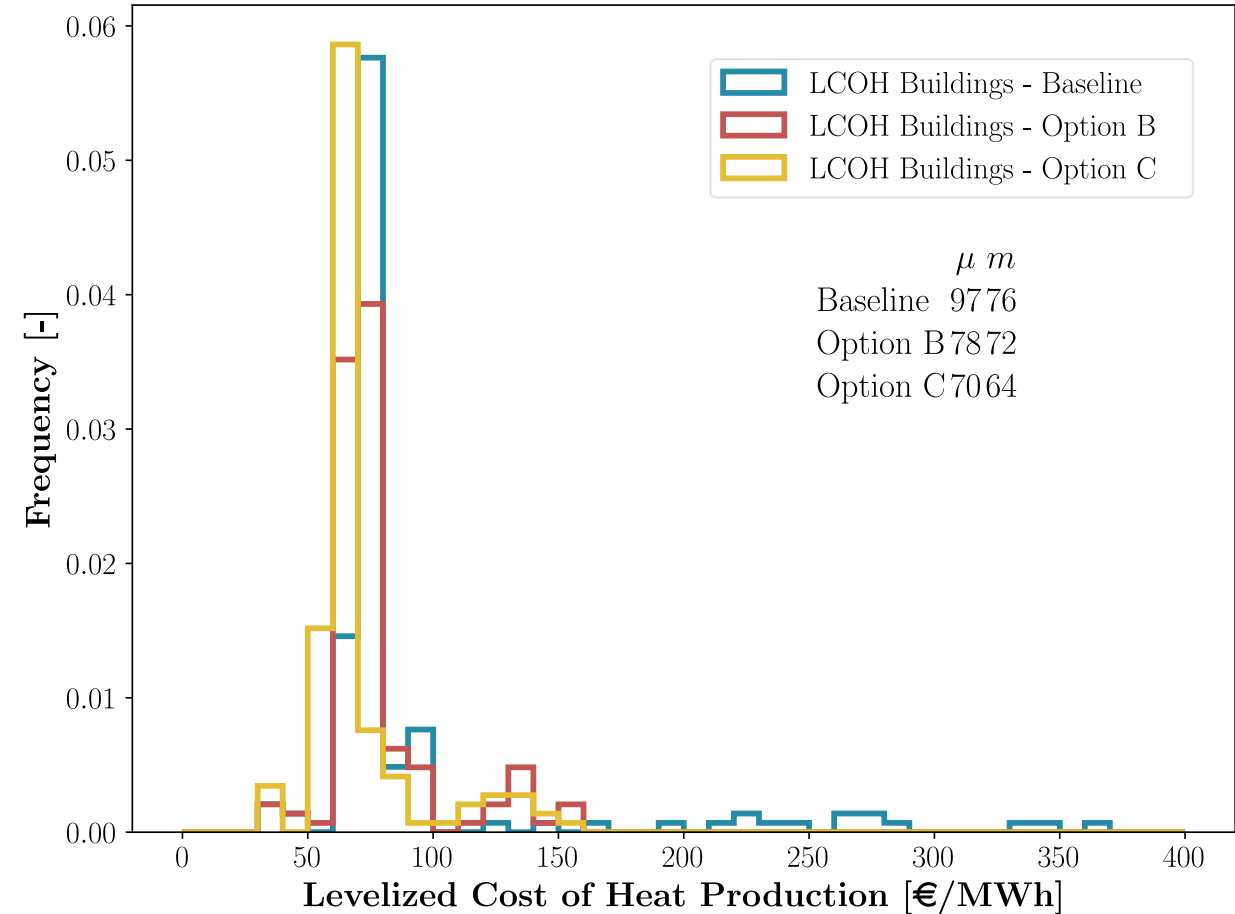
# Results – Cold DH LCOH Production



# Results – Cold DH Impacts

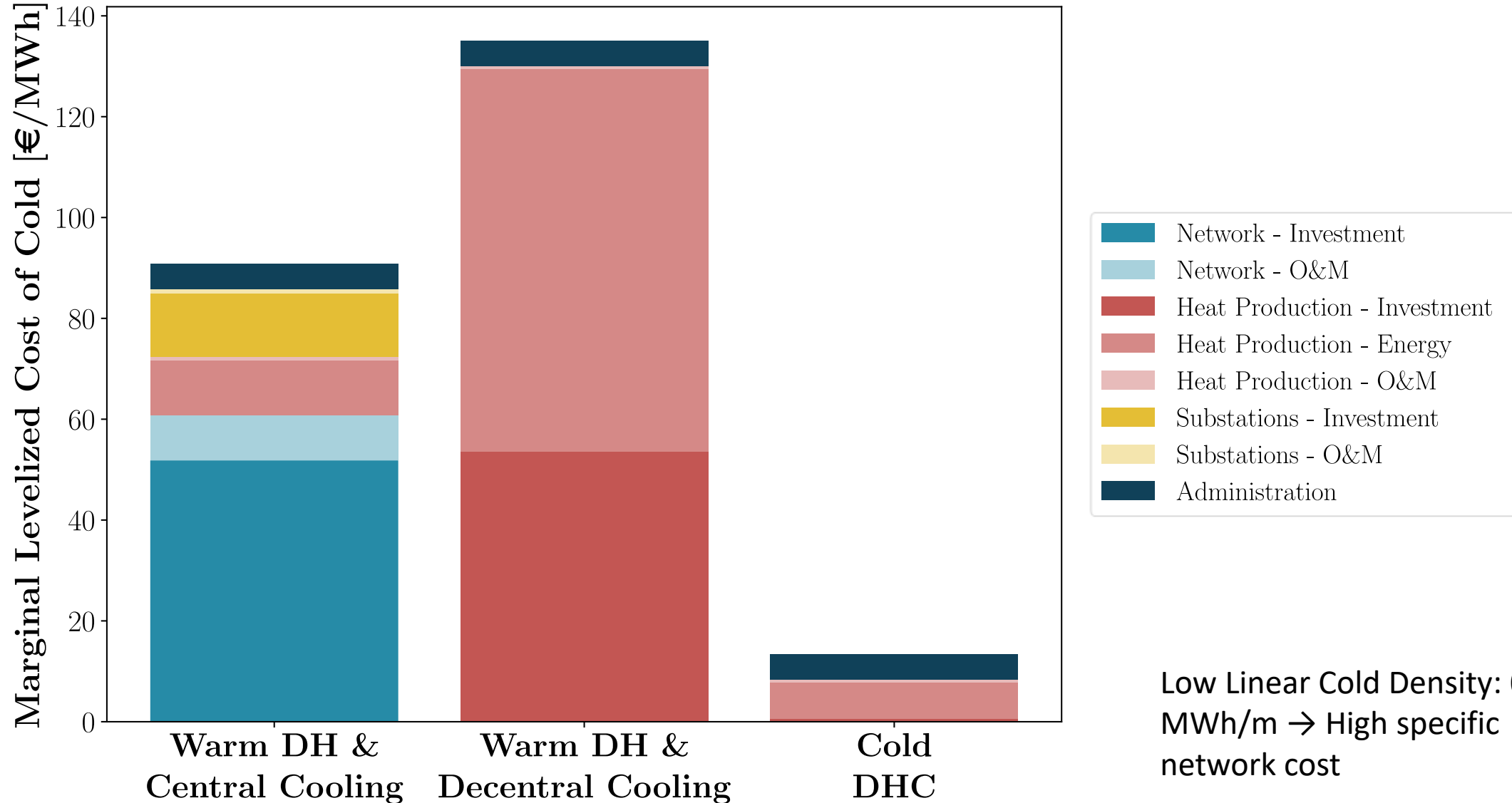


**Option B → Limitless storage for SH and DHW**

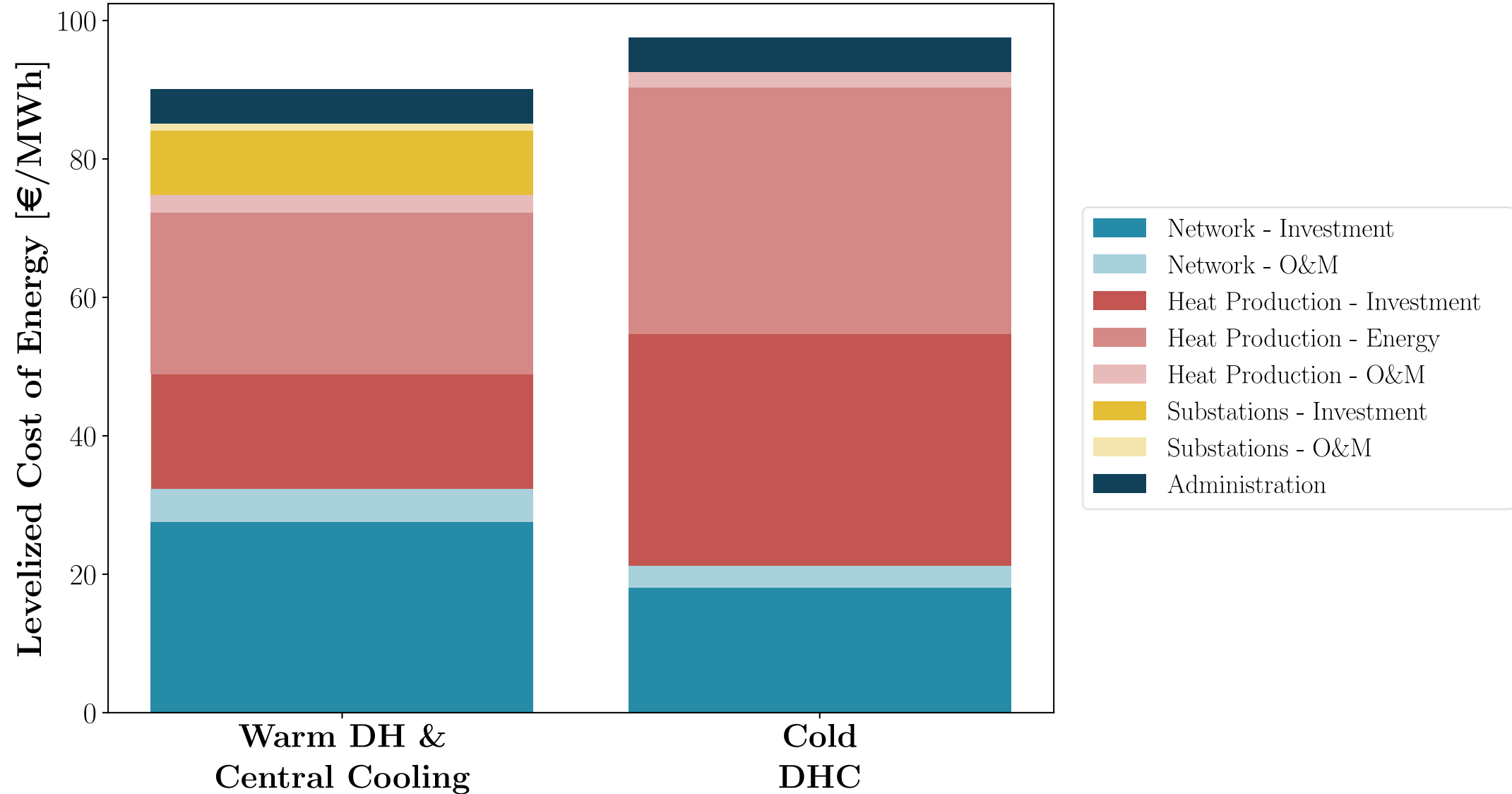


**Option C → Option B + High Voltage grid fees & losses**

# Results – Marginal Cost of Cooling



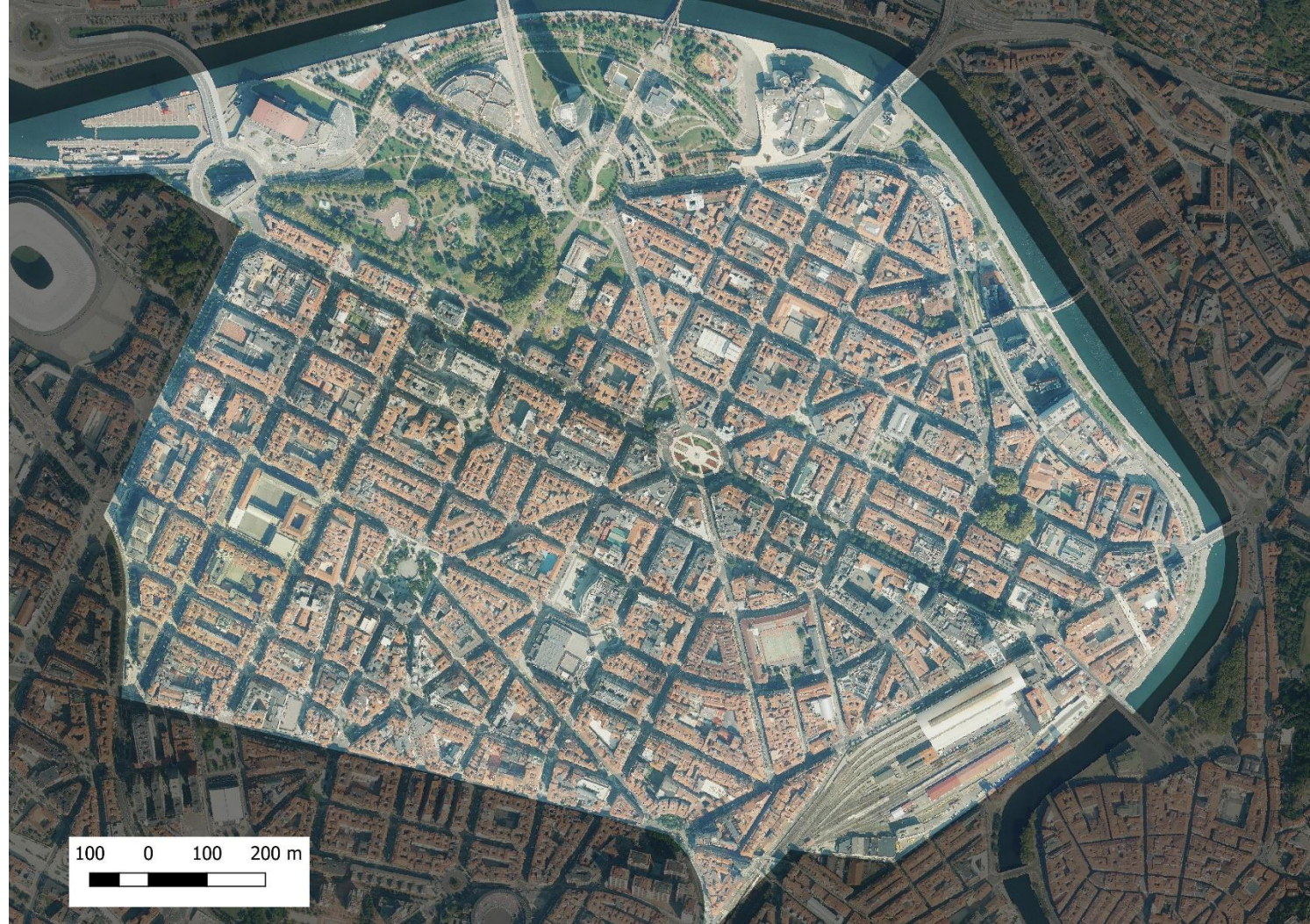
# Results – Cost of Heating and Cooling



# Results – Benefits of extending area

- All Abando District
- Heat Demand: 20 GWh → 74 GWh (or 130 GWh with individual systems)
- Feasible to transport waste heat from incineration plant (7 km & 125 GWh) or cement factory (9 km & 200 GWh).
- Waste heat @ 15 €/MWh & pipeline @ 7 €/MWh → LCOH-production from 47,1 €/MWh to 28,5 €/MWh
- Cost of district cooling ?

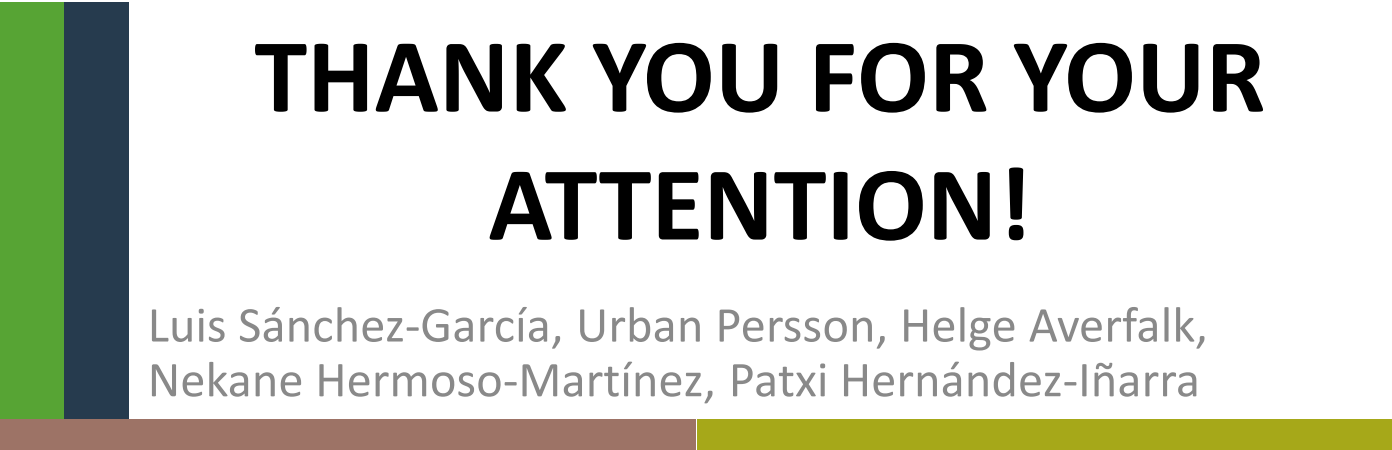
Cost of cold district heating ?



# Conclusions

- Only Heating (20 GWh heating) → Warm District Heating is slightly cheaper than Cold District Heating
- Heating (20 GWh) & Cooling → Nearly same cost
- Cost of cold district heating → very dependent on building characteristics & presence of outliers.
- Cost of cold district heating → cost could be lowered by 17% with limitless storage (feasible?) & an additional 10% with high voltage grid tariffs.
- Use of waste heat → viable with warm DH, viable with cold DH?

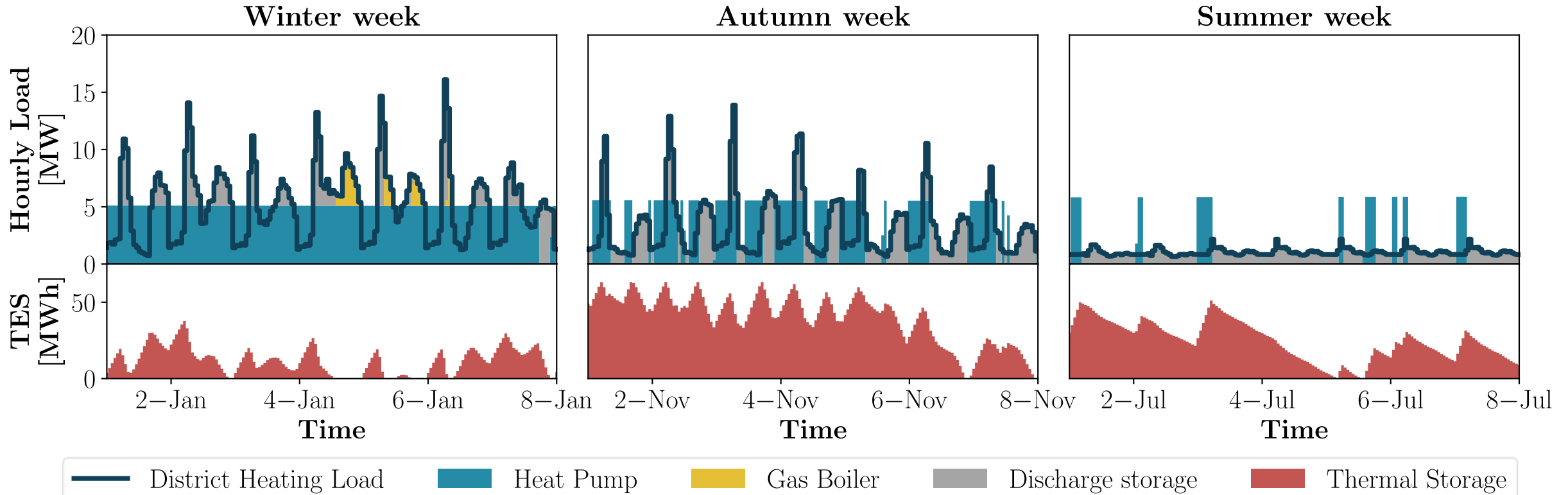
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# THANK YOU FOR YOUR ATTENTION!

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# Results – Warm DH



164 storage cycles



AALBORG UNIVERSITY  
DENMARK

# Results – Cold DH

