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DESIGN OF COMBINED HEATING AND COOLING NETWORK WITH RING TOPOLOGY

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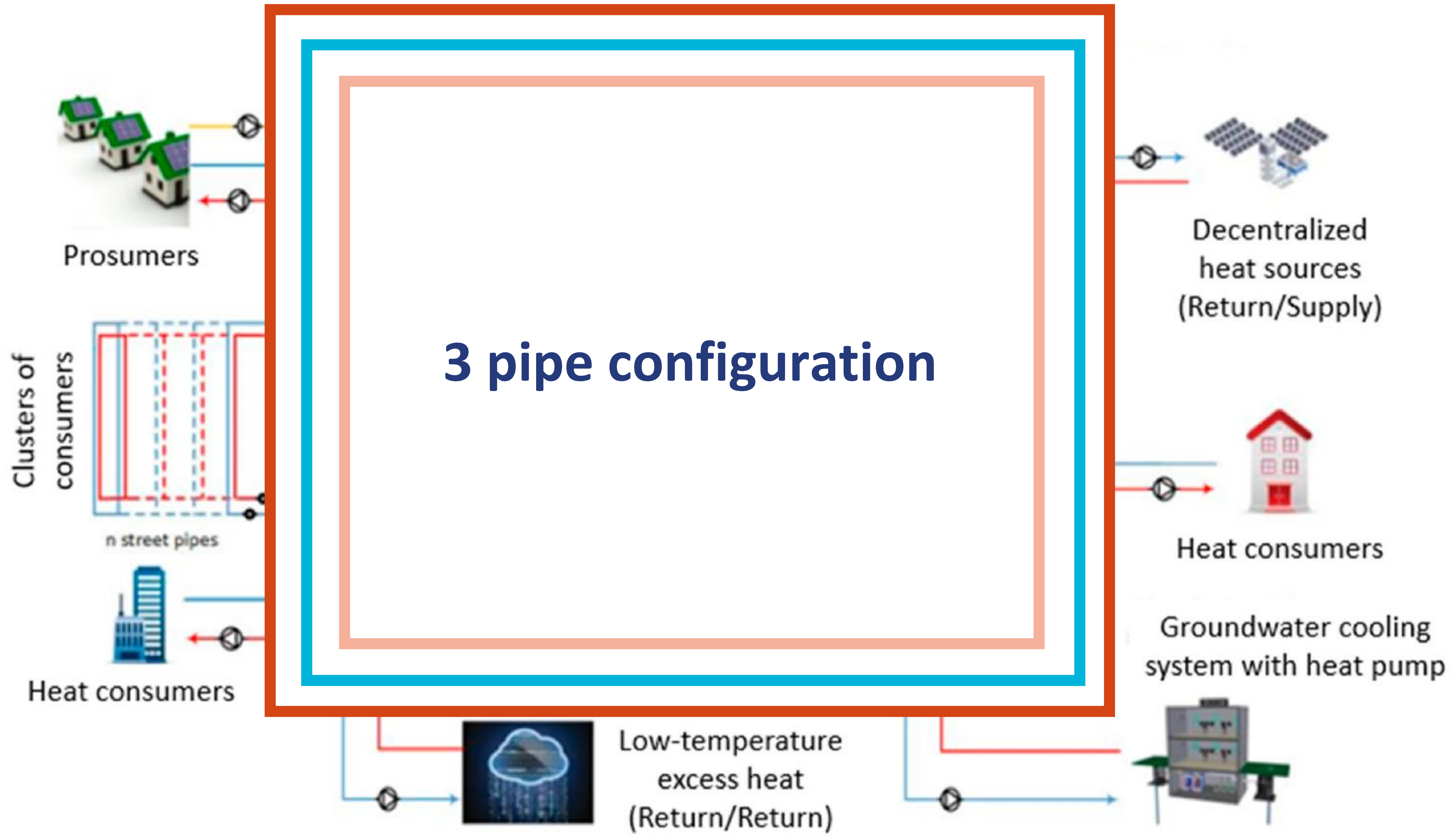
OVERVIEW

Combined DHC network - Ring topology

- Ring topology, 3-pipe configuration **(Config 1)** → Redundancy, flexibility, prosumer integration
- How much does it cost?
  - Using a case study from Kortrijk, Belgium
- Would it be better cost-wise when compared with branched network **(Config 2)**?
- Comparison of other design configurations with ring topology
  - 3-pipe configuration with ring (**Config 1**)
  - ULTDH with heat pumps and ring (**Config 3**)



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CASE STUDY - INPUTS

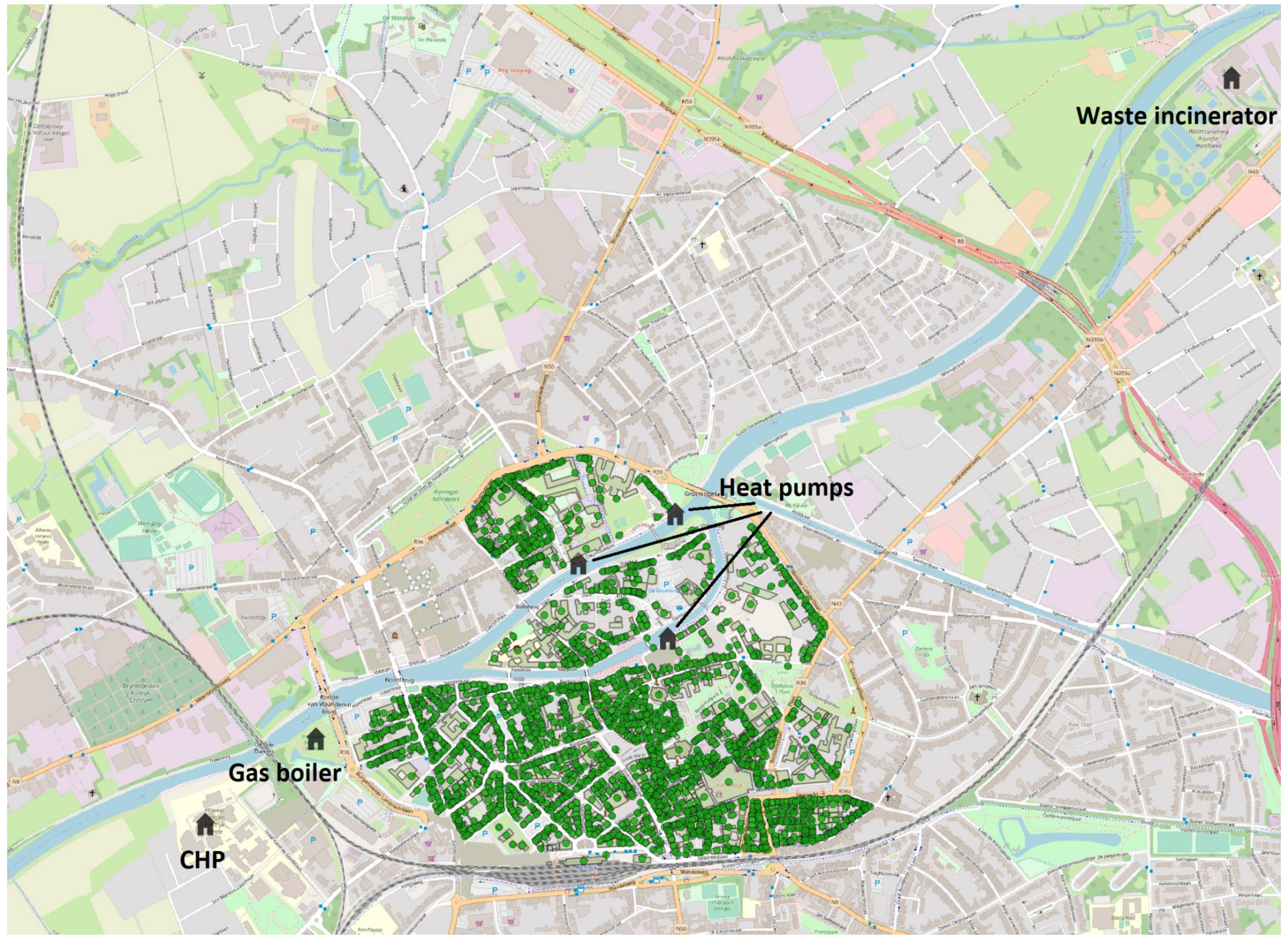
Kortrijk, Belgium – 2300 buildings, 3 heat sources, and 2 cold sources

BUILDING INPUTS:

- Open-source street level gas consumption data
  - Mapped street level to building level using building area ratio
- Building types are categorized as
  - Residential
  - Commercial (< 0.15 GWh/year)
  - Industrial (> 0.15 GWh/year)
- Synthetic load profiles → 3 building types
  - Hourly profiles, 2020

HEAT SOURCE:

- Heat source → IMOG, waste incineration plant
  - 2 km from the network
  - Incinerate 65,000 tons of municipal waste per year
  - 1 ton of municipal waste → 2 MWh heat & 2/3 MWh electricity
  - Available heat → 130 GWh / year
  - Source peak capacity → 15 MW (Continuous operation)



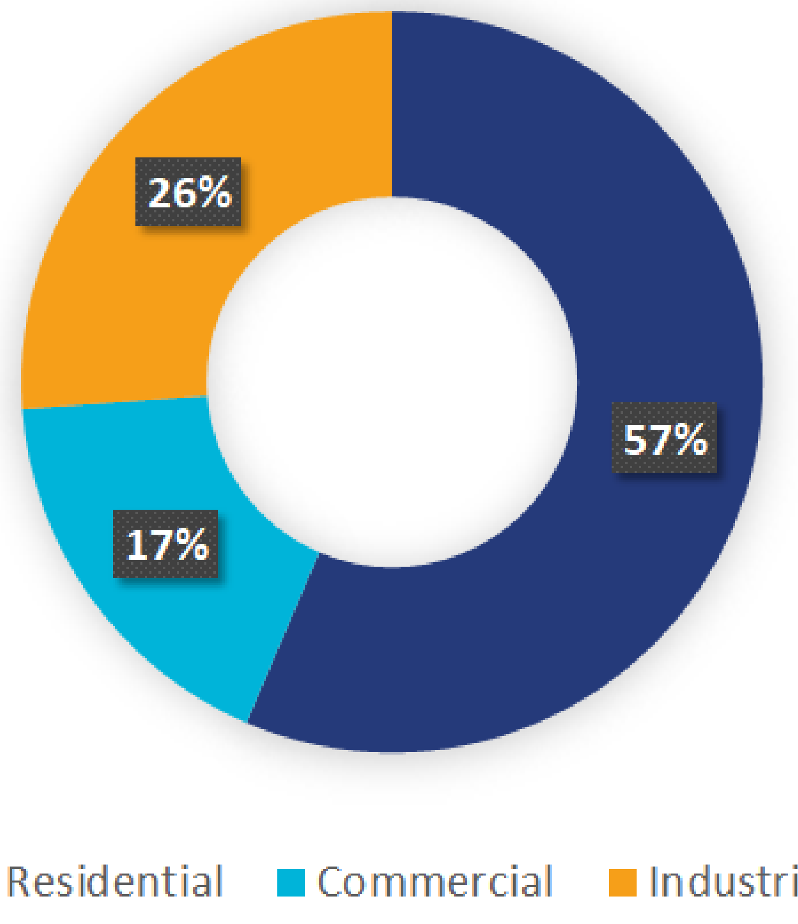
Case study area

CASE STUDY - NETWORK

Network demand and peak load

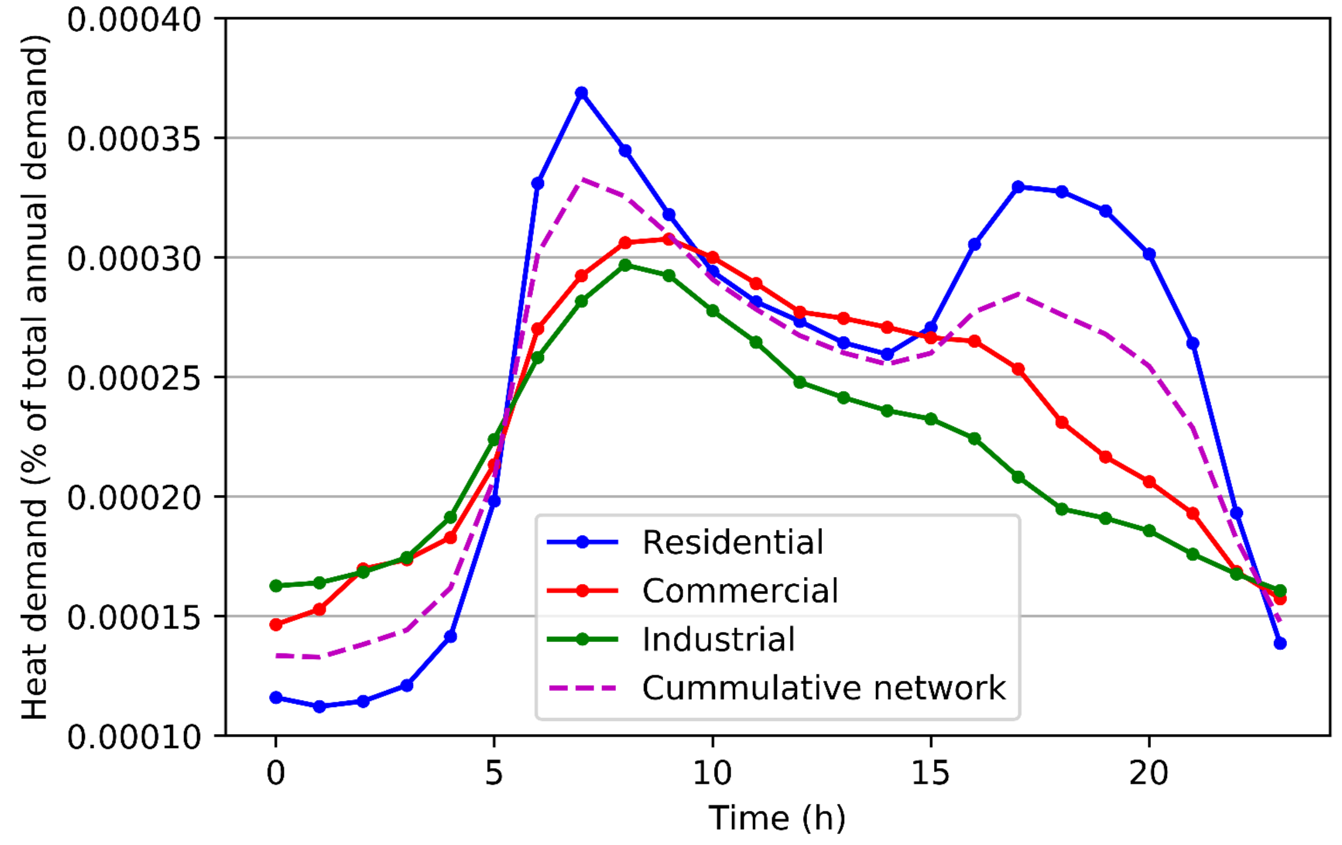
NETWORK DEMAND:

- Building demand → Load profiles, annual gas consumption data
- Network demand → Aggregation of building heat demand
- Network annual heat demand – 95 GWh/year

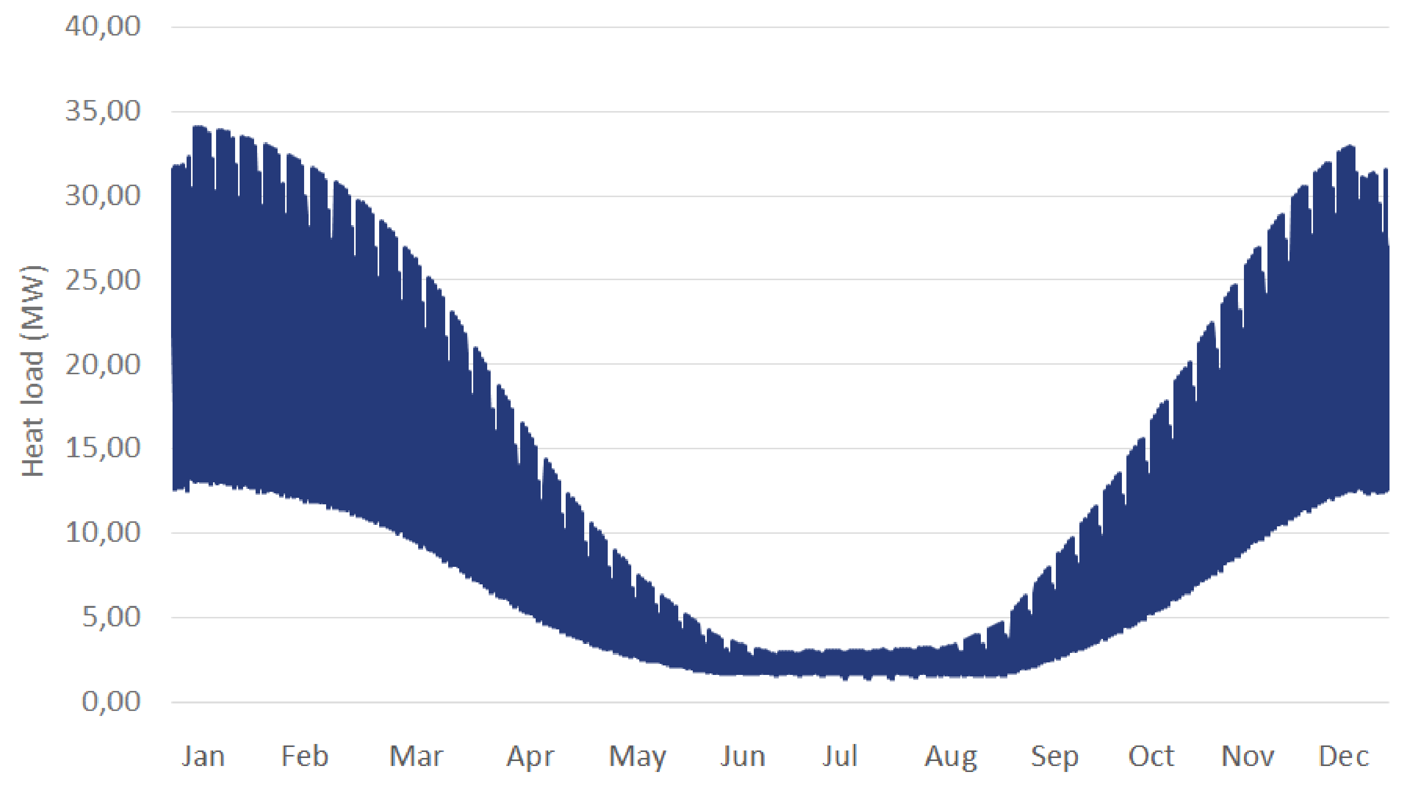


PEAK LOAD AND NETWORK LENGTH:

- Network peak load – 34 MW (without storage)
- Expected network length – 63 km



Daily profile of different building types

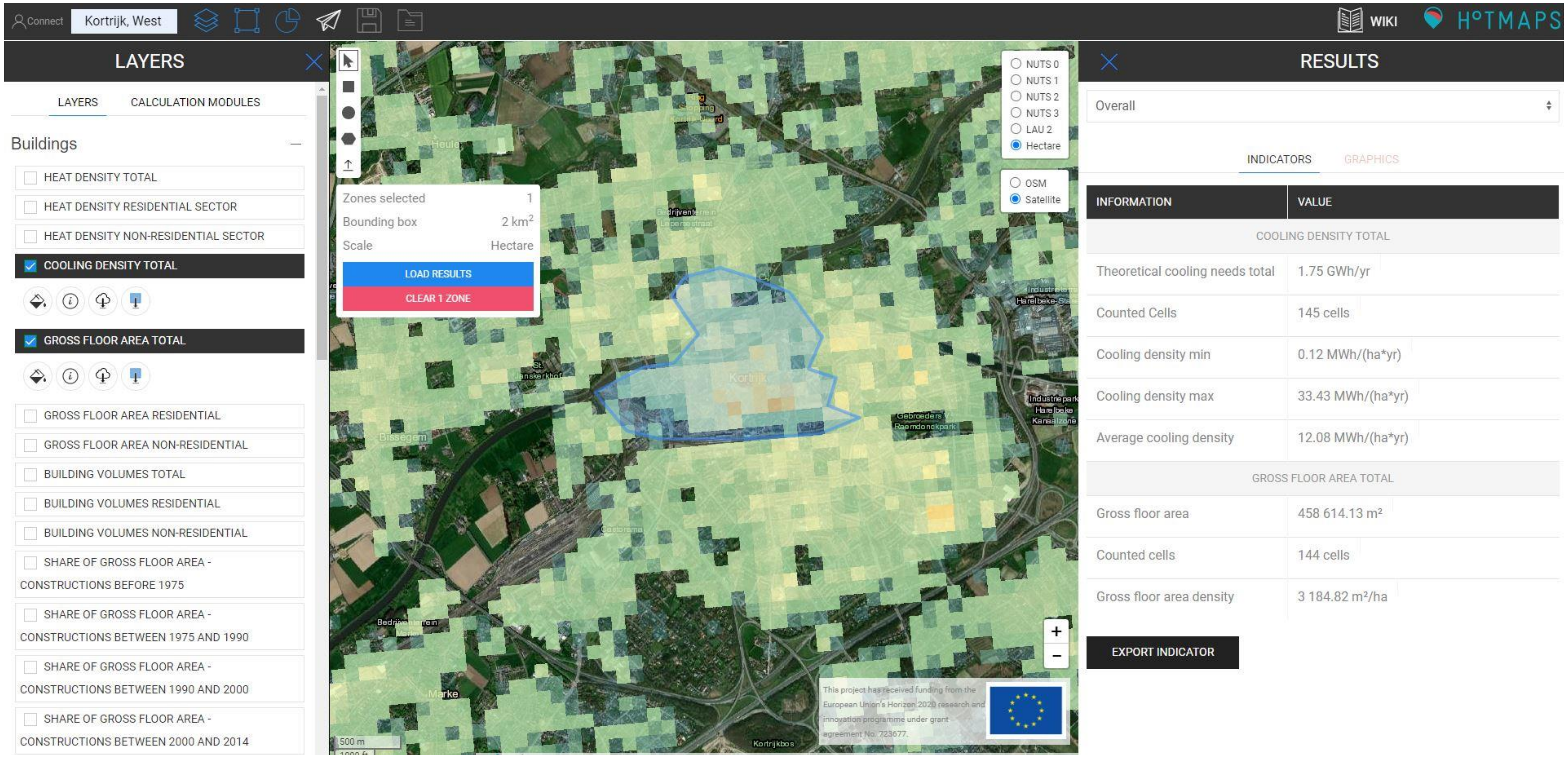


Hourly network heat demand

COOLING DEMAND DATA

Open source project – Hotmaps

- Cooling demand density and gross floor area density has been extracted from the public website (EU Horizon 2020 project) HOTMAPS.EU
- Cooling demand is calculated based on these open source data



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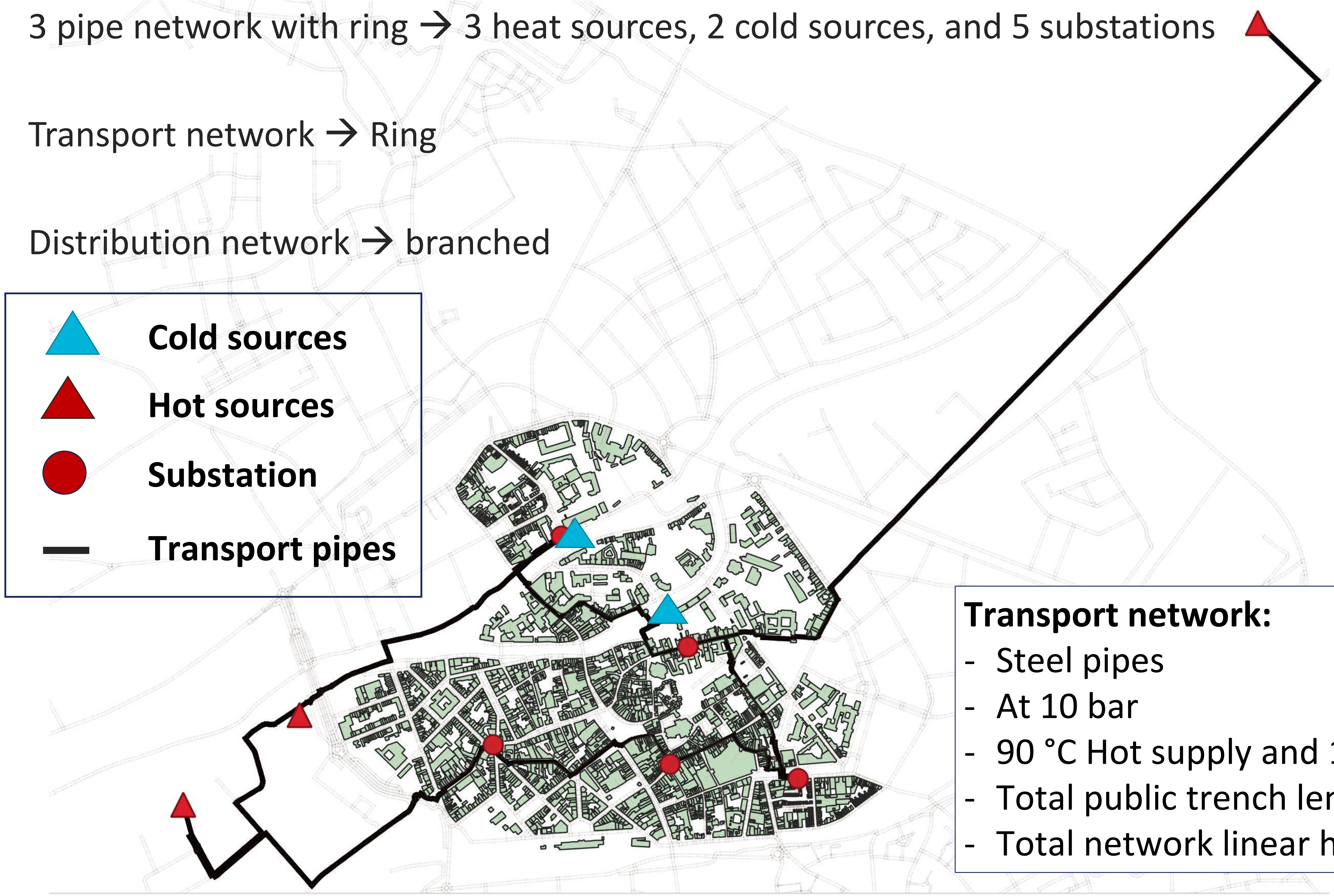
NETWORK DESIGN

Ring topology

- 3 pipe network with ring → 3 heat sources, 2 cold sources, and 5 substations
- Transport network → Ring
- Distribution network → branched



Transport network:
- Steel pipes
- At 10 bar
- 90 °C Hot supply and 15°C Cold supply
- Total public trench length: 61,040 meters
- Total network linear heat density: 1.56 MWh/m

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COMBINED HEATING AND COOLING NETWORK

Ring topology vs branched

COMSOF HEAT

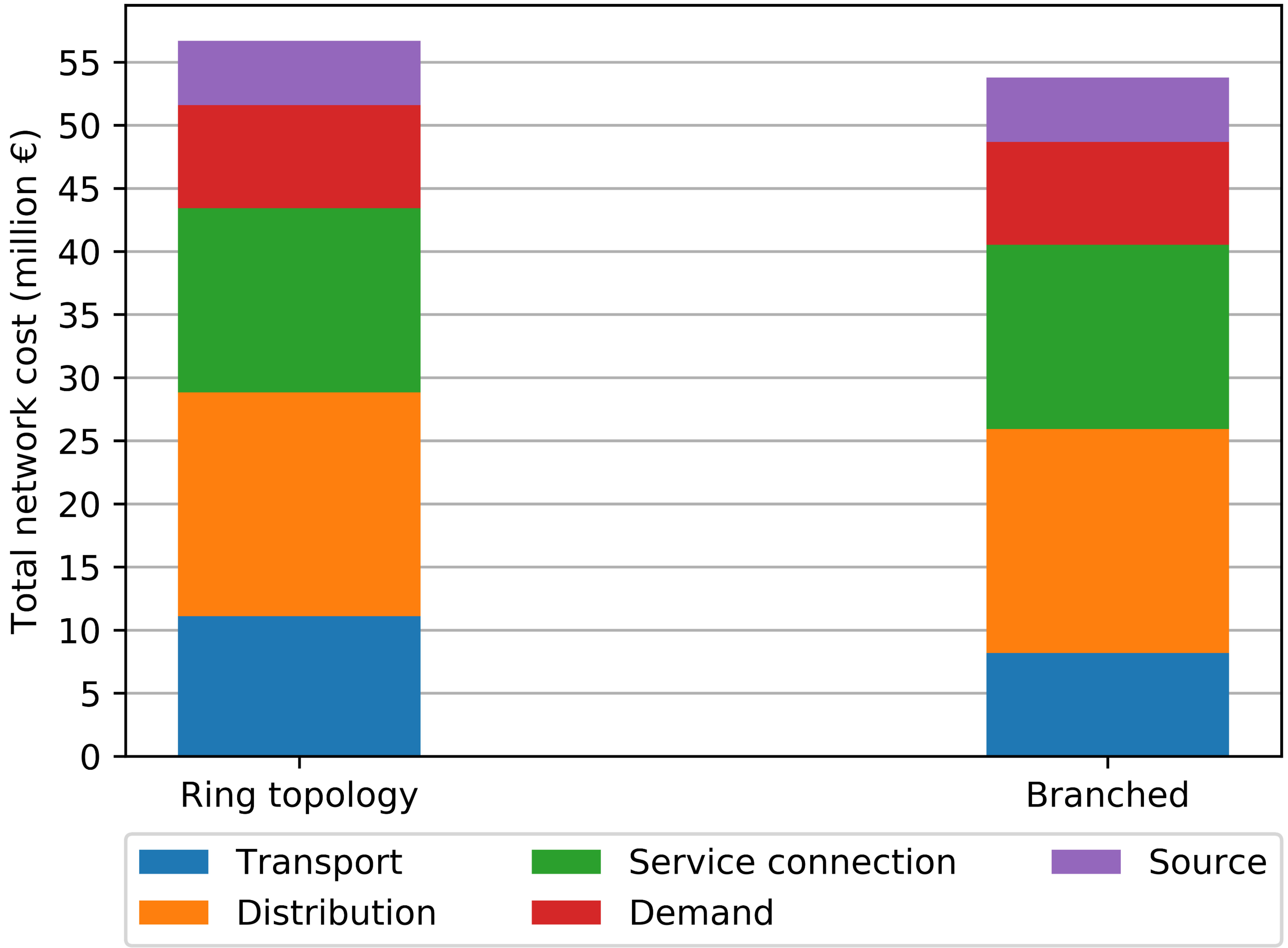
TOTAL NETWORK COST:

- Ring topology: **56.69 million €**
- Branched: **53.78 million €**

- Ring topology is **5.4% costlier** than branched
  - Ring in transport layer only

TRANSPORT LAYER

- Ring topology → **35% costlier** than branched



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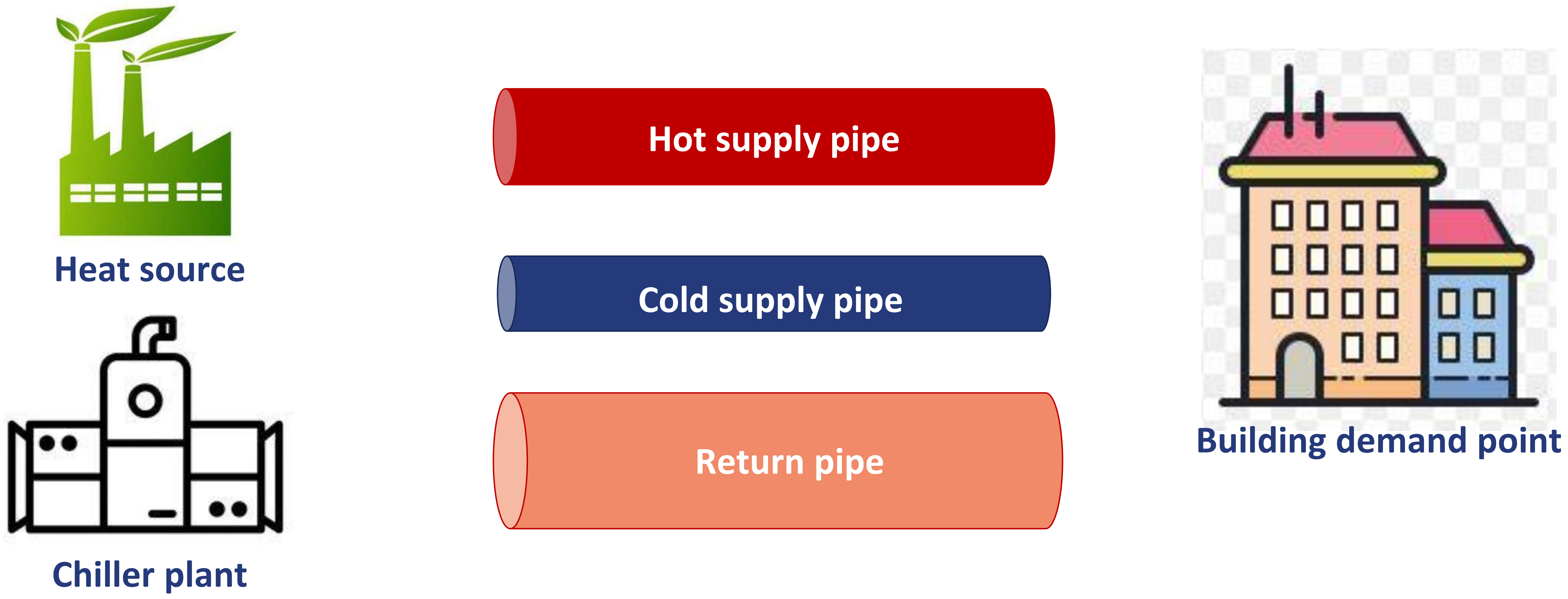
DIFFERENT NETWORK DESIGN CONFIGURATIONS

Three pipe heating and cooling network – 3rd generation (Config 1)

- Two supply pipe
  - One supply pipe circulates chilled water from cooling source (chiller plant) to the buildings
  - Another supply pipe circulates hot water from heat source to the buildings

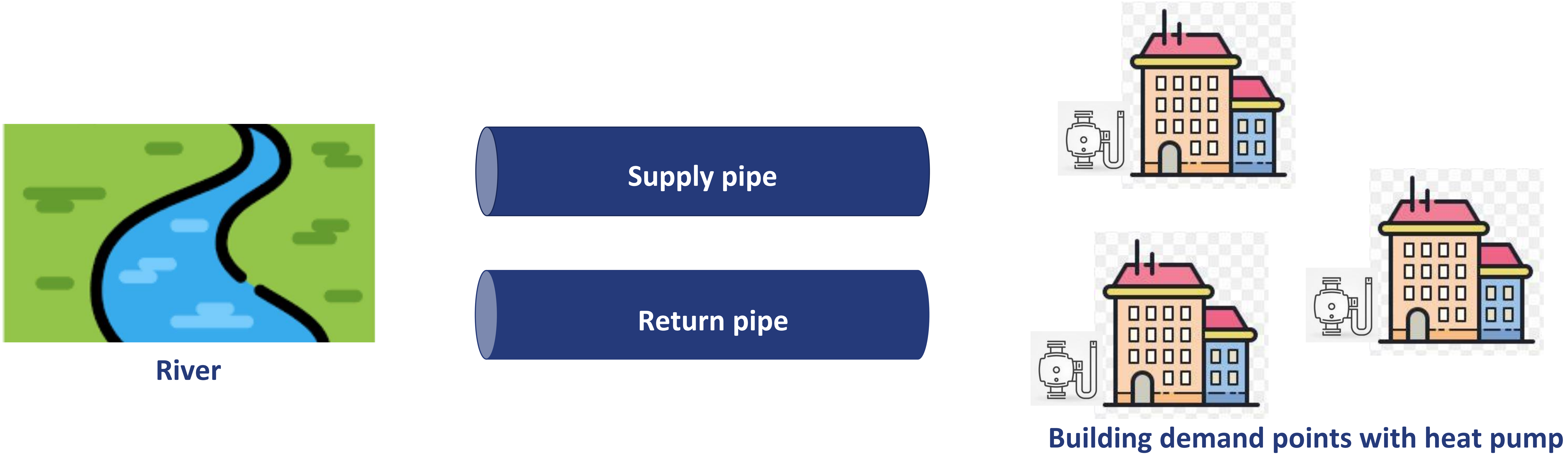
- One return pipe → Returns heated water from cooling supply pipe and cooled water from the buildings back to the sources



DIFFERENT NETWORK DESIGN CONFIGURATIONS

Two pipe heating and cooling network (Heat pumps at building side) – 5th generation (Config 3)

- One supply pipe → Circulates ambient temperature water from low temperature source to the buildings
- One return pipe → Returns cold water when heating and returns hot water when cooling from the buildings back to the sink



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DIFFERENT NETWORK DESIGN CONFIGURATIONS

3rd generation networks vs 5th generation networks

3-pipe DHC network (3rd generation):

- High temperature source
- Network temperature levels: 70 to 90 °C
- Few sources are available (Waste incinerator, geothermal, CHP)

ULTDHC network (5th generation):

- Low temperature source
- Network temperature levels: 10 to 25 °C
- Vast range of source availability (Rivers, lakes, sewage water, data centers, renewable sources, etc.)
- **Problem:** 10 to 25 °C: Not enough to heat the buildings directly → Heat pumps

DIFFERENT NETWORK DESIGN CONFIGURATIONS

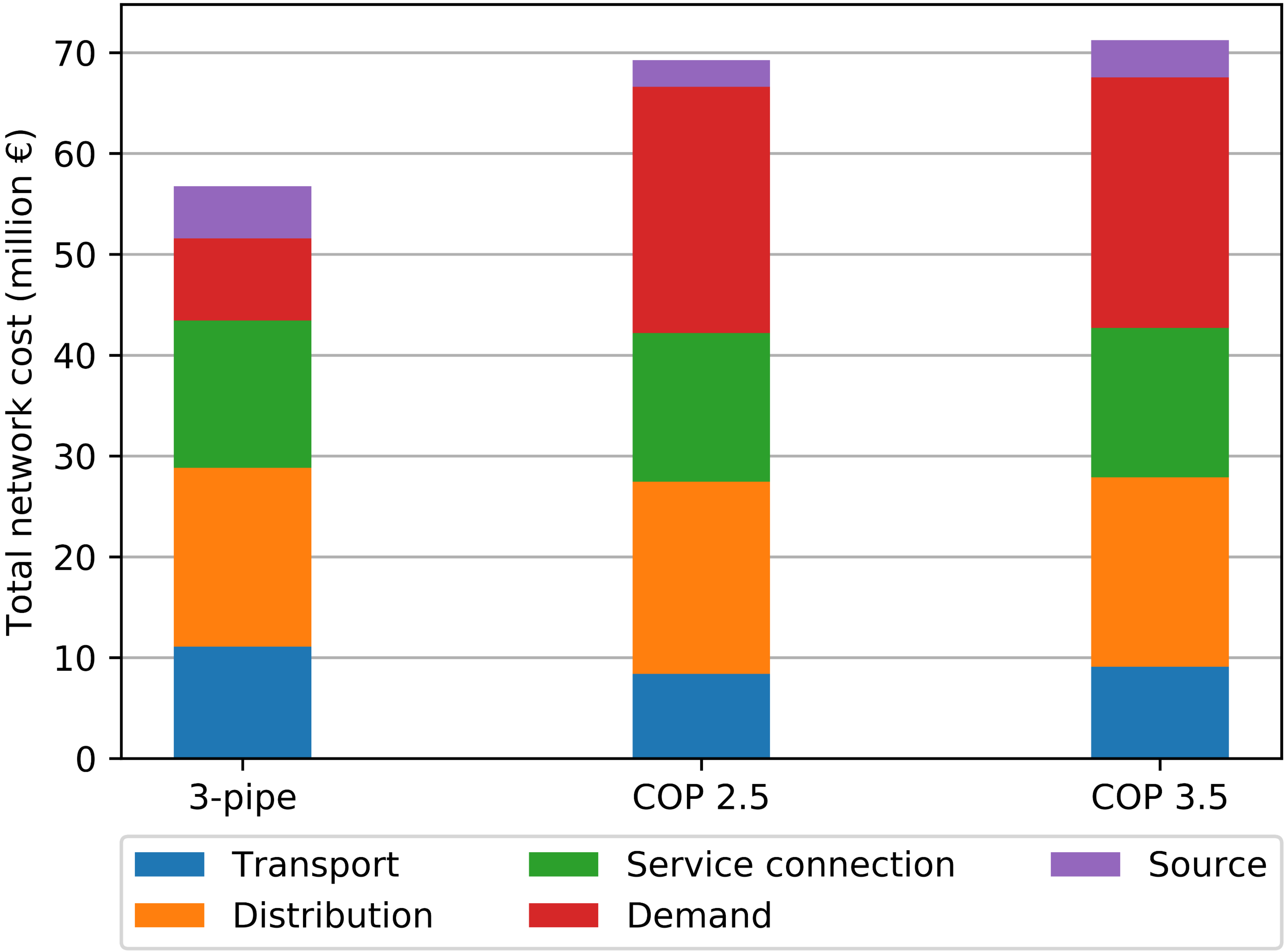
3 pipe network with ring (Config 1) vs ULTDH network with heat pumps and ring (Config 3)

Description	3 pipe network (Config 1)	ULTDH network (Config 3)
Temperature	High	Low
Ring topology	Yes	Yes
Heat pumps at buildings	No	Yes

TOTAL NETWORK COST:

- 3 pipe: **56.69 million €**
- Heat pump: **69.25 million €**

- ULTDH with heat pump is **22.2% costlier** than 3-pipe configuration
  - Ring in transport layer only



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CONCLUSION

Combined DHC network with ring topology

- Combined heating and cooling network is designed with **ring topology** using Comsof heat
- Total network cost → Ring network is **5.4% costlier** than branched network
  - However, it provides the redundancy, flexibility, and possible prosumer integration
- Transport layer network cost → Ring network is **35% costlier** than branched network
- Ultra low temperature district heating (ULTDH) with heat pump configuration → **22% costlier** than 3-pipe configuration

Config 1 (3-pipe network with ring)	Config 2 (Branched network)	Config 3 (ULTDH with heat pumps and ring)
56.69 million €	53.78 million €	69.25 million €

FUTURE WORK:

- Prosumer integration study

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