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)
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 → IMOIG, 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 - 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
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
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
COMBINED HEATING AND COOLING NETWORK

Ring topology vs branched

**COMSOOF 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

![Graph showing total network cost comparison between ring topology and branched network.](image-url)
DIFFERENT NETWORK DESIGN CONFIGURATIONS

Three pipe heating and cooling network – 3\textsuperscript{rd} generation (Config 1)

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

• One return pipe \(\rightarrow\) Returns heated water from cooling supply pipe and cooled water from the buildings back to the sources

![Diagram of three pipe heating and cooling network]

Heat source

Chiller plant

Hot supply pipe

Cold supply pipe

Return pipe

Building demand point
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
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)

<table>
<thead>
<tr>
<th>Description</th>
<th>3 pipe network (Config 1)</th>
<th>ULTDH network (Config 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Ring topology</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Heat pumps at buildings</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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
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
  o 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

<table>
<thead>
<tr>
<th>Config 1 (3-pipe network with ring)</th>
<th>Config 2 (Branched network)</th>
<th>Config 3 (ULTDH with heat pumps and ring)</th>
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</thead>
<tbody>
<tr>
<td>56.69 million €</td>
<td>53.78 million €</td>
<td>69.25 million €</td>
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FUTURE WORK:

• Prosumer integration study
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