District heating distribution grid costs: a comparison of two approaches

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7th International Conference on Smart Energy Systems
21-22 September 2021
#SESAAU2021
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Motivation

The 16th International Symposium on District Heating and Cooling

Energy Procedia
Volume 149, September 2018, Pages 141-150

Impact of distribution and transmission investment costs of district heating systems on district heating potential

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How well the obtained values for pipe costs and pipe length based on the effective width concepts fit the reality?
What did I do in my paper?

- Input GIS layers:
  - Heat demand density map – 1ha resolution
  - Gross floor area density map – 1ha resolution

- Consideration of evolving market share and heat demand on DH areas

- Use the concept of effective width for the calculation of investment costs in each hectare.
  - **Effective width**: relationship between a given land area (plot ratio, e) and the length of the district heating pipe network within this area.

- Calculate potential DH areas (coherent areas) with
  - an average distribution grid costs below a certain level, and
  - annual heat demand of above a given threshold.
Approach I: Effective Width

Possible answer to the raised question

Get Potential DH areas

Compare with Existing DH grids

Source: Austrian Heatmap

Source: Energie Graz
Approach I: Effective Width

What’s the challenge?

- Data of DH grid is not available everywhere.
- Having sufficient data on grid, I still need to estimate the costs… and…

What if I also need to find and calculate the optimal pipeline routes?
**Approach II: DHMIN Model**

**DHMIN**

- MILP model for single-commodity energy infrastructure network systems
- It finds maximum revenue tradeoff for the size of network

**I/O & main features:**

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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<tbody>
<tr>
<td>- Peak loads</td>
<td>- Grid topology</td>
</tr>
<tr>
<td>- Heat source availability &amp; redundancy</td>
<td>- Heat sale [MWh]:</td>
</tr>
<tr>
<td>- Existing pipelines</td>
<td>supply – heat_losses</td>
</tr>
<tr>
<td>- Oblige pipe construction on certain routes,</td>
<td>- Revenue made via heat sale [€]</td>
</tr>
<tr>
<td></td>
<td>FED * heat_sale_price</td>
</tr>
<tr>
<td></td>
<td>- Distribution grid investment (annuity) [€]</td>
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Approach II: DHMIN Model

DHMIN Model

Calculation by DHMIN

Edges’ Peak Demands [kW]

Max Power Flow [kW]
Comparison of results

Steps take for the case study

- Case study: Brasov, Romania.

- Inputs:
  - Horizon: 16 years
  - Market share: start → 16% ; end → 62%
  - Grid cost ceiling: 27 EUR/MWh

- Run the model for DH potential areas obtained by approach based on the effective width concept.

- To do the calculation by DHMIN in a reasonable time, coherent areas obtained by the first approach were broken to smaller areas with a minimum peak load of 3.5 MW (for a substation).
Results

Coherent areas & distribution grid

- Blue regions are obtained from the first approach (15 areas).

- Based on the 1st approach, the DH potential in these areas are set to 62% of the total demand.

- For each region, DHMIN was run separately.

- Red lines show the extension of grids and line capacities obtained from DHMIN.

- The grids are extended as long as they are economic.
Results

Indicators

Total heat demand Vs. DH potential

TU Wien – Energy Economics Group
Results

Trench length

- DHMIN extend the pipelines as long as they are profitable (not all demand segments are covered)

- Both approach closely follow the same trench length pattern.

- The difference is larger in smaller areas
  - Impact from street routes.
Results

Specific distribution grid costs

- Two methods have different cost components, making their comparison difficult.
  - E.g. although DHMIN leads to higher pipe line length, it’s lower specific costs:
    - Due to different input parameter structure.
    - Due to the optimization approach.

- The comparison would be easier if we normalize the specific costs to the average value of each set.
  - Both approaches follow similar pattern.
Two approaches were compared in this presentation:

- Approach I: based on the effective width concept
- Approach II: based on detailed infrastructure optimization model

The differences in the required input parameters, makes the comparison of two models difficult. However, it can be concluded that:

“The results follow similar patterns and values.”

The approach I:
- requires less data and no optimization solver.
- can be applied to a large area while using approach II for large areas is time consuming.
- Is suitable for quick analyses and provides acceptable results.
- If cost parameters are tuned for the case study, provides more accurate results

Approach II:
- provides more detailed metrics and more accurate results
- But requires more data as well as an optimization solver

The results of this presentation needs to be confirmed by further data collection and analyses.
Thank you for your attention!

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