7th International Conference on

Smart Energy Systems

4th Generation District Heating, Electrification, Electrofuels and Energy Efficiency

21-22 September 2021, Copenhagen

#SESAAU2021

ONLINE PROGRAMME

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energy CLUSTER DENMARK

AALBORG UNIVERSITY

Smart energy system analyses, tools and methodologies

Lorenzo Cassetti: Realization and energy assessment algorithm of a Horizontal Packed Bed Regenerator for Thermal Energy Storage

Mostafa Fallahnejad: District heating distribution grid costs: comparison of two approaches

Tao Feng: Companies' acceptance of innovative energy facility: Results of a simultaneous equation approach

Thanh Huynh: Local Energy Markets for Thermal-Electric Energy Systems considering energy carrier dependency and energy storages

Jia[illegible]: Emerging Tec[illegible] d Business Models for Smart Energy Systems

Nicola Kleppmann: ML4Heat - Tools for the optimized operation of existing district heating networks based on machine learning

Marko Mimica: A stochastic model for smart energy systems analysis

Adrian Ostermann: Forecasting charging station occupancy using supervised learning algorithms

Martin Lindgaard Pedersen: Digital tools for refurbishment planning based on facts and choice of pipe system based on Total Cost of Ownership and CO2 emission

Morten Karstoft Rasmussen: Connecting the DH value chain with smart meter data

Dmitry Romanov: District heating systems modelling: A gamification approach

Costanza Saletti: A hierarchical control algorithm with yearly and daily horizons for optimally managing district energy systems

Salman Siddiqui: District heating and the GB electricity system in a zero-emission scenario

District heating distribution grid costs: a comparison of two approaches

Mostafa Fallahnejad

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Motivation

HOTMAPS

The open source mapping and planning tool for heating and cooling

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

Mostafa Fallahnejad [a], Michael Hartner [a], Lukas Kranzl [a], Sara Fritz [b]

How well the obtained values for pipe costs and pipe length based on the effective width concepts fit the reality?

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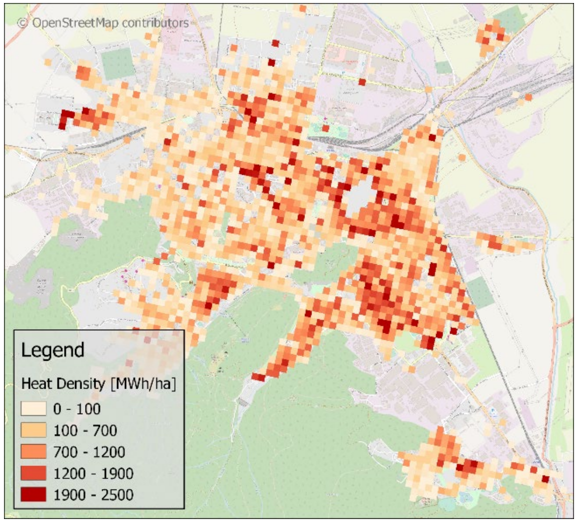
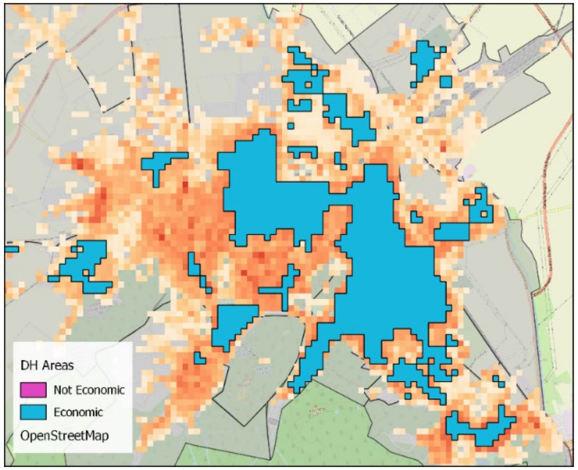
What did I do in my paper?

- 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.





* Persson U, Wiechers E, Möller B, Werner S. Heat Roadmap Europe: Heat distribution costs. Energy 2019;176:604–22. doi:10.1016/j.energy.2019.03.189.

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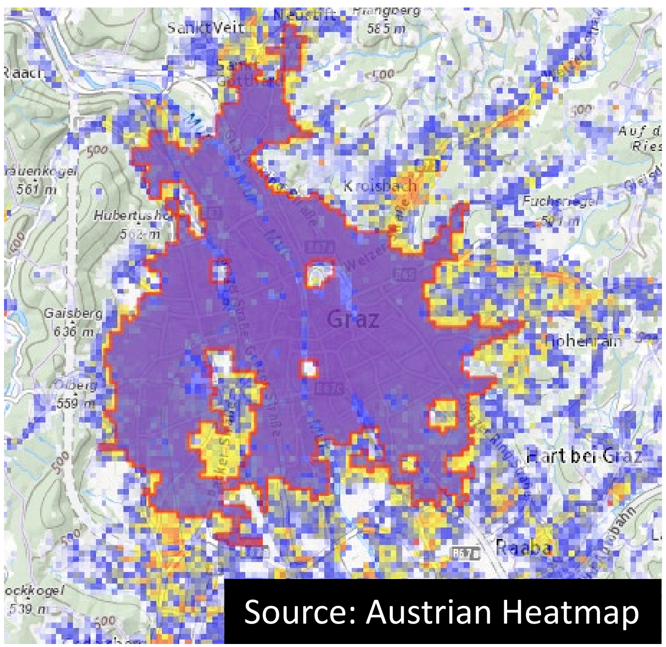
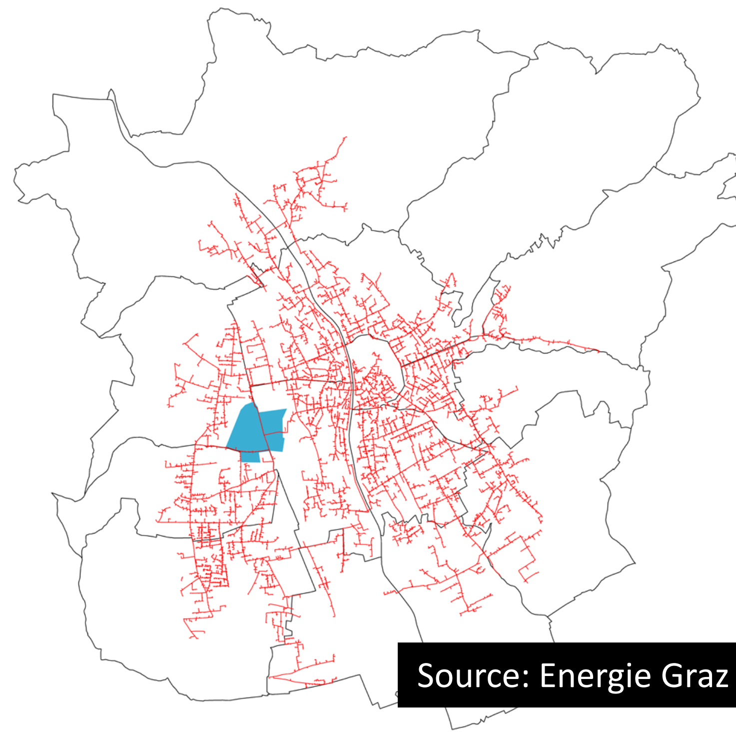
Possible answer to the raised question

Get Potential DH areas → **Compare with Existing DH grids**

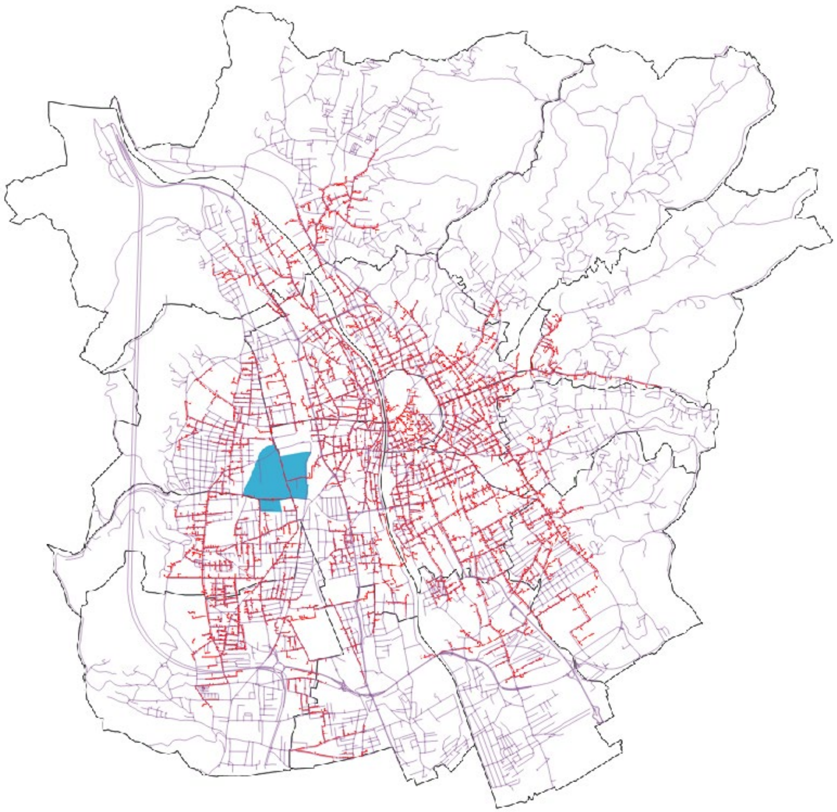


Source: Austrian Heatmap


Source: Energie Graz

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?

DHMIN*

- MILP model for single-commodity energy infrastructure network systems
- It finds maximum revenue tradeoff for the size of network
- I/O & main features:

Inputs

- Peak loads,
- Heat source availability & redundancy,
- Existing pipelines,
- Oblige pipe construction on certain routes,

Outputs

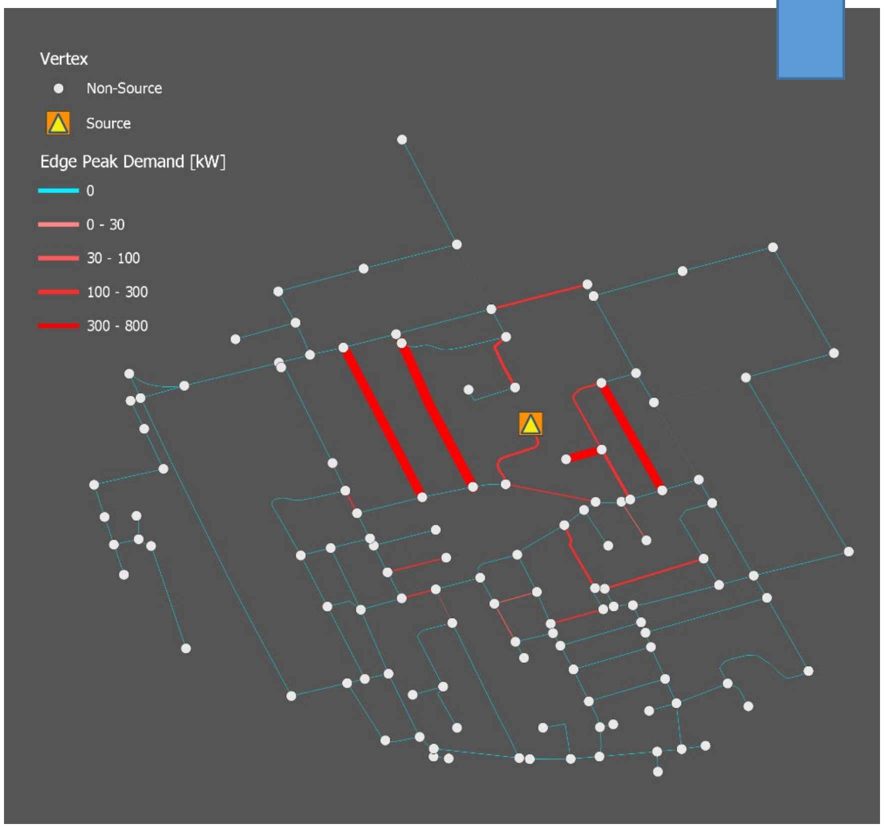
- Grid topology
- Heat sale [MWh]:
  supply – heat_losses
- Revenue made via heat sale [€]
  FED * heat_sale_price
- Distribution grid investment (annuity) [€]

* Reference: Dorfner, Johannes."Open Source Modelling and Optimisation of Energy Infrastructure at Urban Scale", 2015.

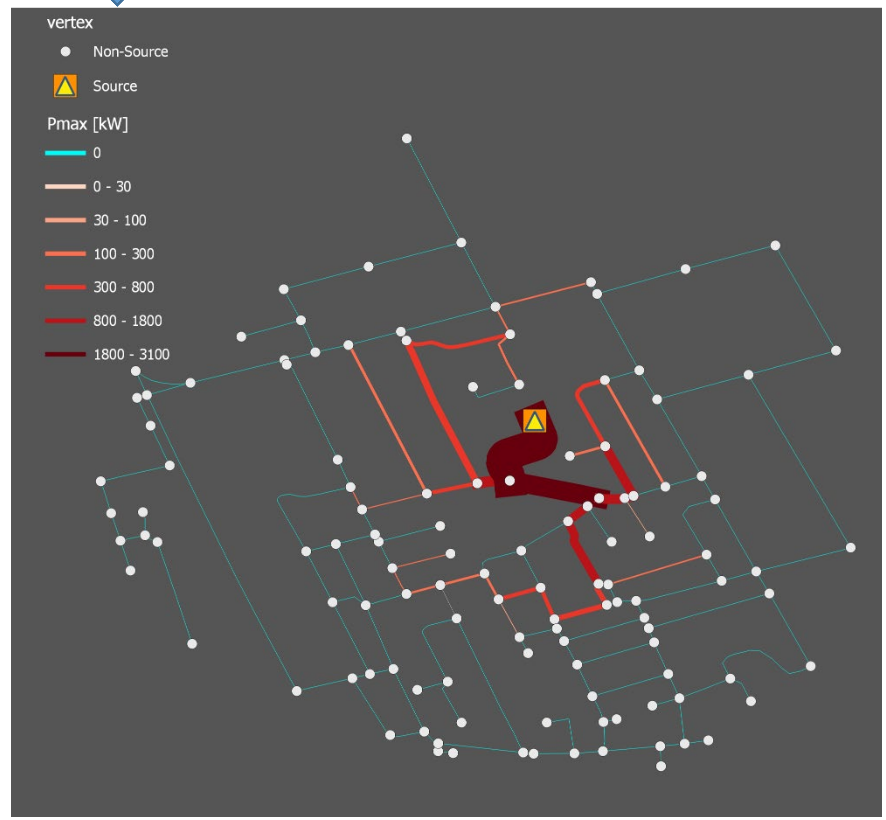
DHMIN Model

Calculation by DHMIN

Edges' Peak Demands [kW]



Max Power Flow [kW]



Steps take for the case study

- Case study: Brasov, Romania.

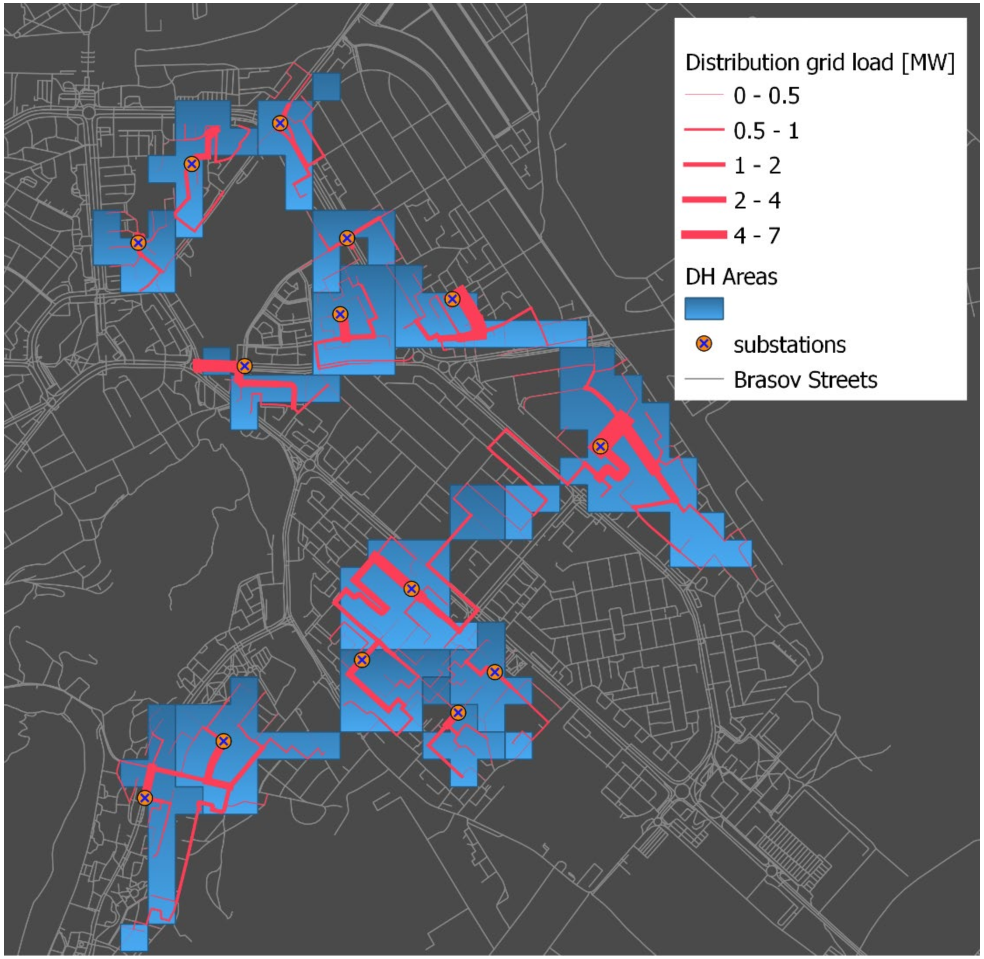
- Inputs:
  - Horizon: 16 years
  - Market share: start → 16% ; end → 62%
  - Grid cost ceiling: 27 EUR/MWh

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

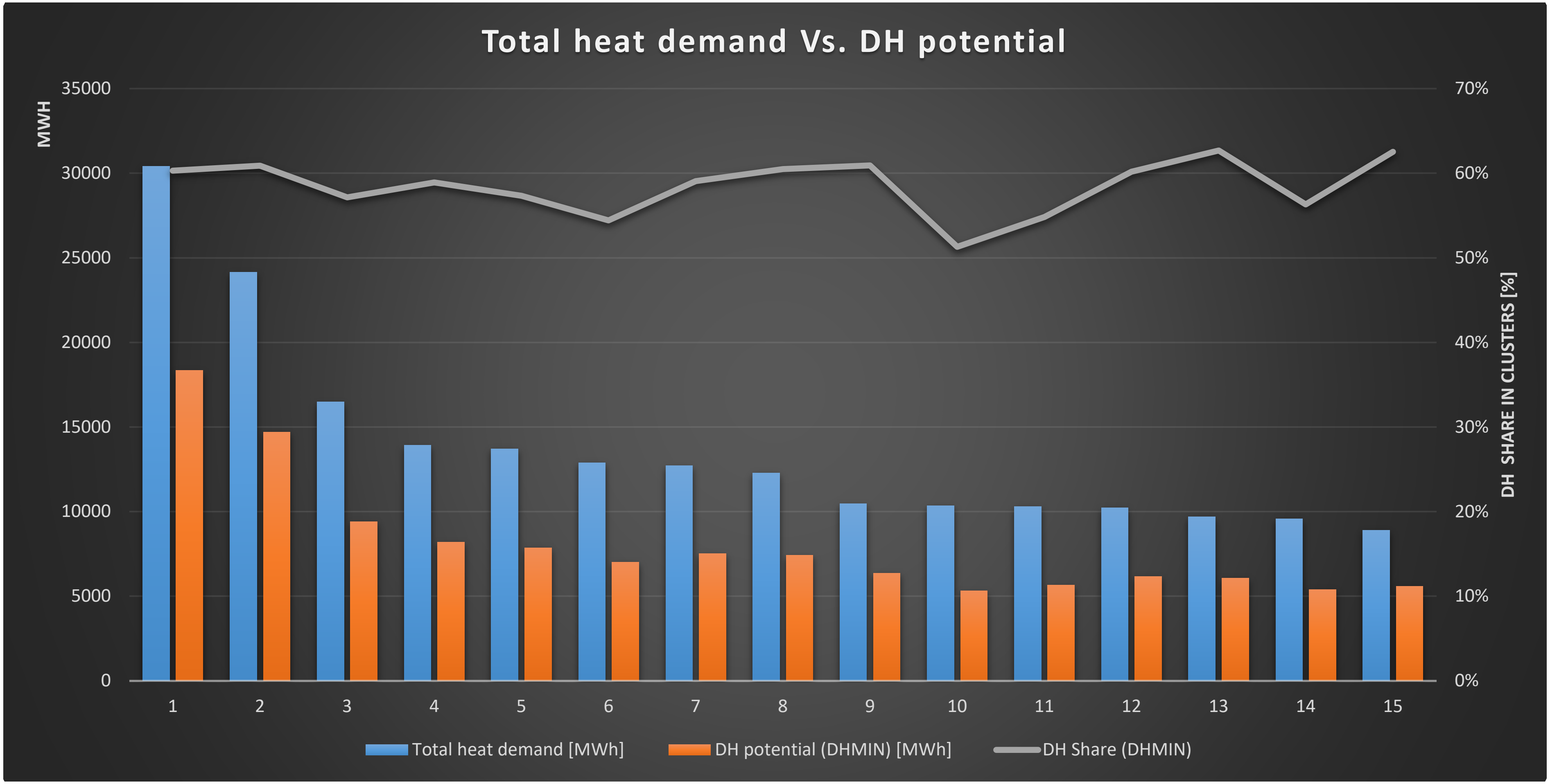
- To do the calculation by DHMIN in a reasonable time, coherent areas obtained by the first approach were broken to smaller areas with a minimum peak load of 3.5 MW (for a substation).

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.



Indicators

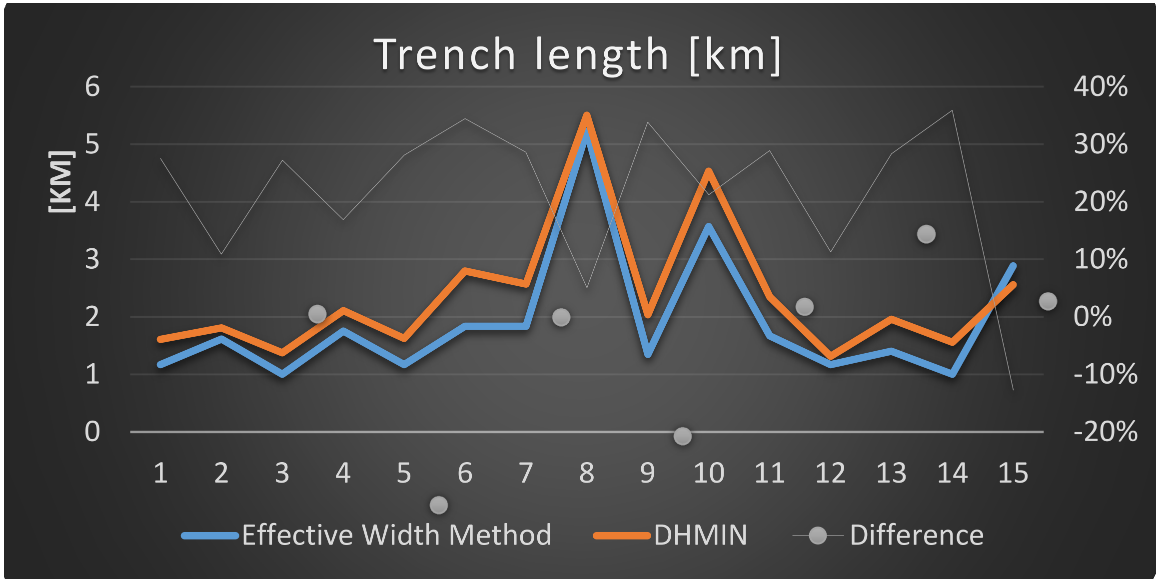

Total heat demand Vs. DH potential
MWH
35000
30000
25000
20000
15000
10000
5000
0
70%
60%
50%
40%
30%
20%
10%
0%
DH SHARE IN CLUSTERS [%]
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Total heat demand [MWh]
DH potential (DHMIN) [MWh]
DH Share (DHMIN)

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.

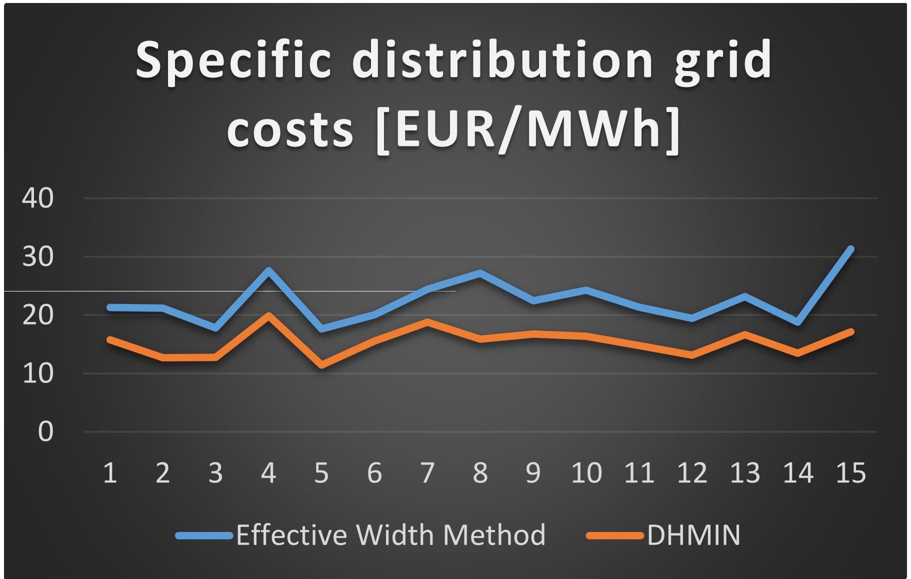
- The difference is larger in smaller areas
    - Impact from street routes.

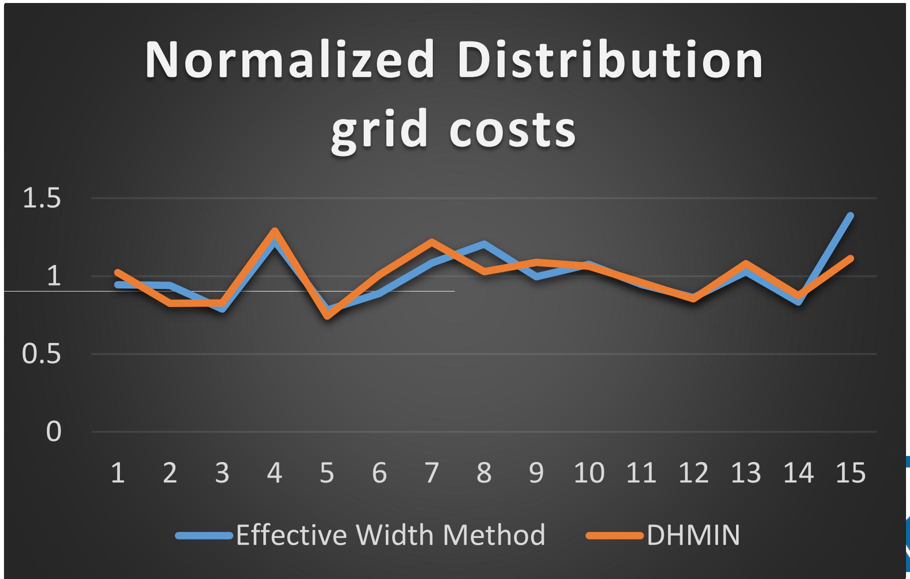


Specific distribution grid costs

- 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.





Conclusion

- 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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Orig. Photo: Patrick Stargardt