Modeling the technical and economic feasibility of district cooling networks under scenarios of increasing cooling demand

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Motivation and key research question

The rising tendency of the European Cooling demand urges the need to plan and implement decarbonization pathways for the cooling sector. District cooling, which until now has not been a common energy carrier in the cooling sector, unlike its counterpart in heating, could show improved feasibility and possibility for sustainable supply considering the rise in the cooling demand. The paper aims to develop a methodology to identify potential areas for district cooling networks and analyze the sensitivity of technical and economic parameters on the overall feasibility of the network and their coverage.

Method

We formulate the district cooling feasibility model that aims to maximize the coverage of district cooling area with its cost constrained against decentral solutions at the local and national levels. The results are presented at its present version on a hectare cell (100 X 100 m) resolution.

The model comprises of 3 components.

- Anchor Definition
- Transport grid model
- Distribution gird model

Grid cells with certain demand density exceedance are defined as the **anchor customers (**non-residential consumers with consistent demand) around which the network centers [1]

The transportation grid model deals with the supply side, considering different free cooling sources. Based on temperature requirements of both supply and demand potential transportation pipe size and pressure requirements are calculated for each pair. All anchors within technically feasible distance from a source are defined as the feasible anchor.

The distribution grid model further calculates the feasibility of expansion of the grid around these anchors. This is based on the grid expansion ceiling (calculated in comparison to individual supply [2]), demand, and cooling floor area (in reference to [3] for heating). The final output is a map showing cluster of cells each representing a potentially feasible district cooling network.

Assumption:

- 100% cell demand in a cell is connected if they have the feasibility for connection.
- For any specified region under evaluation, the model does not take into consideration district cooling regions if there are any.

Results and conclusions

The result of the geospatial model is a map illustrating a cluster of hectare cells with feasibility for district cooling. The sensitivity of the coverage area is assessed against demand density in different scenarios, consumer demand temperatures, and available supply source temperatures. The influencing parameters are identified. In addition, the impact of the plot ratio on the feasibility area will be assessed and compared against its influence on the heating network.

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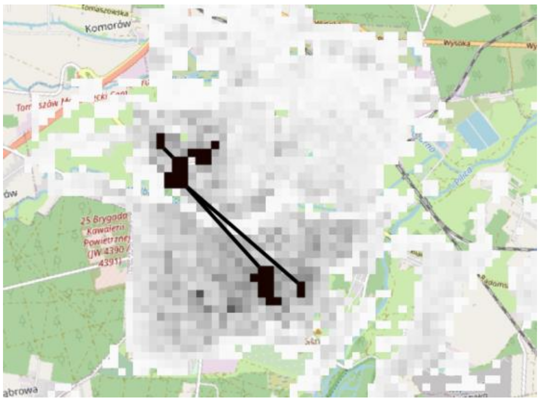

Figure 1: District cooling network connected to the free supply source via the transport grid (envisioned model output for sample cells in Vienna)

The improvements will further look into the integration of the connection rates less than 100% within a cell, as well as consideration of existing grid and the feasibility of its expansion. In addition, the possibility of intermingled use with district heating will be assessed with the use of the heat from the return pipe of the heating network as waste heat. As a follow-up of this conference contribution, we intend to further improve the spatial granularity of the model to either a building block or a building level to provide more detail for actual network pipe design.

The model will be tested for a case study of Vienna. The outputs seen in figure1 will be replicated for all data sets of Vienna (LAU2 region)

Literature

[1] A. Volkova, A. Hlebnikov, A. Ledvanov, T. Kirs, U. Raudsepp, and E. Latõšov, “District Cooling Network Planning. A Case Study of Tallinn,” *IJSEPM*, vol. 34, pp. 63–78, May 2022, doi: 10.54337/ijsepm.7011.

[2] D. F. Dominković and G. Krajačić, “District Cooling Versus Individual Cooling in Urban Energy Systems: The Impact of District Energy Share in Cities on the Optimal Storage Sizing,” p. 21, 2019.

[3] M. Fallahnejad, M. Hartner, L. Kranzl, and S. Fritz, “Impact of distribution and transmission investment costs of district heating systems on district heating potential,” *Energy Procedia*, vol. 149, pp. 141–150, Sep. 2018, doi: 10.1016/j.egypro.2018.08.178.