Is the European energy system decarbonization driving district heating in Norway?

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Scope and core objective

- The scope of this work is to address one of these simplifications often made in the representation of the heat sector in large-scale energy system models.
- We focus on district heating and its role in large-scale energy system models because this centralized heat supply option is often neglected and not explicitly considered in these models.
- The focus here is therefore on the trade-off between district heating (centralized) and building heating (decentralized). The problem with large-scale energy system models is that they cannot separate these two types of heating infrastructure.
- The core objective is to examine district heating in Norway at the local network level until 2050. For this, we consider the cost-optimal network expansion and energy technology dispatch of district heating in Oslo, Norway.

Novelties and own contribution

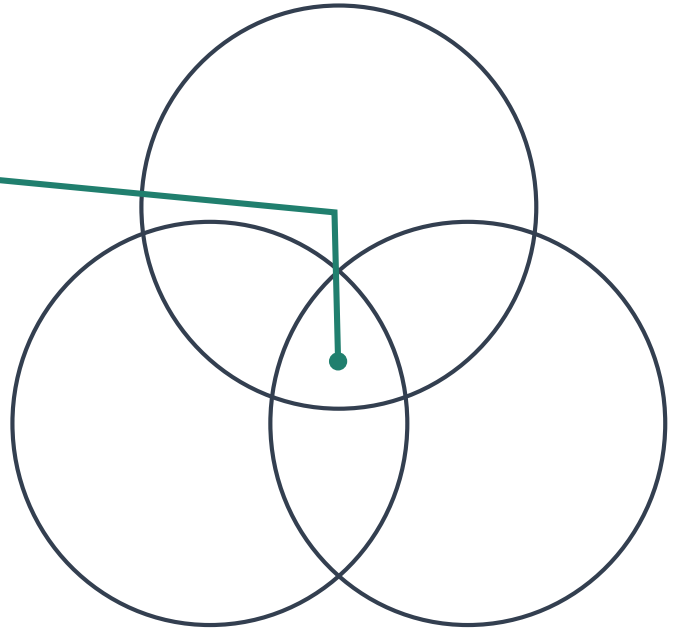
European Levels

Local Levels

A. Trends of the European Energy System

Obtained from results of large-scale energy models

Implement-ability and stress-testing



B. District Heating Network Optimization

Granular representation of both generation units and pipelines

C. Open-Source Data Linkage and Local Characteristics

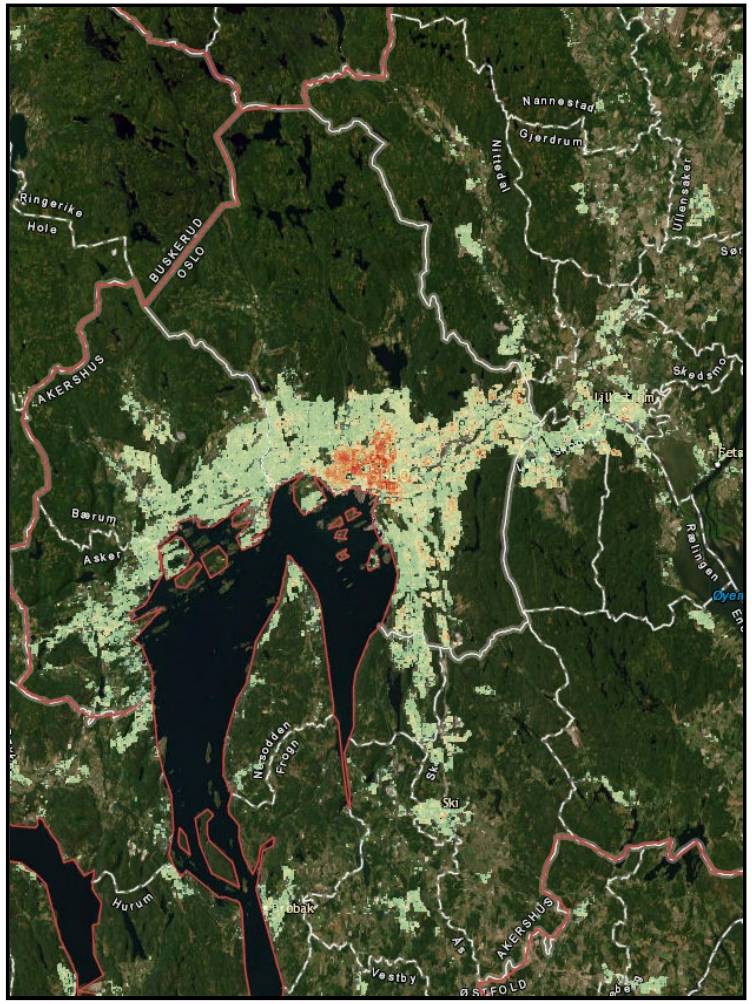
Highly-spatially resolved input data of heat demand and sources

Methodology

- We build upon **two existing optimization models** (local district heating planning model and large-scale energy system model) and combine them to get a single framework given the typical approach to minimize total system costs over time (from the network operator's perspective).
- We consider the **existing district heating infrastructure** (i.e., heat generation capacities and network pipelines) as a starting point.
- We introduce tailor-made restrictions and constraints to the model framework about vital determining parameters derived from the cost-optimal solution at the European level of the **large-scale energy system model EMPIRE** ("the European Model for Power System Investments with Renewable Energy").
- Moreover, we use the electricity prices generated in the optimal case by EMPIRE as a further parameter in the modeling.

Spatial granularity and heat density clustering

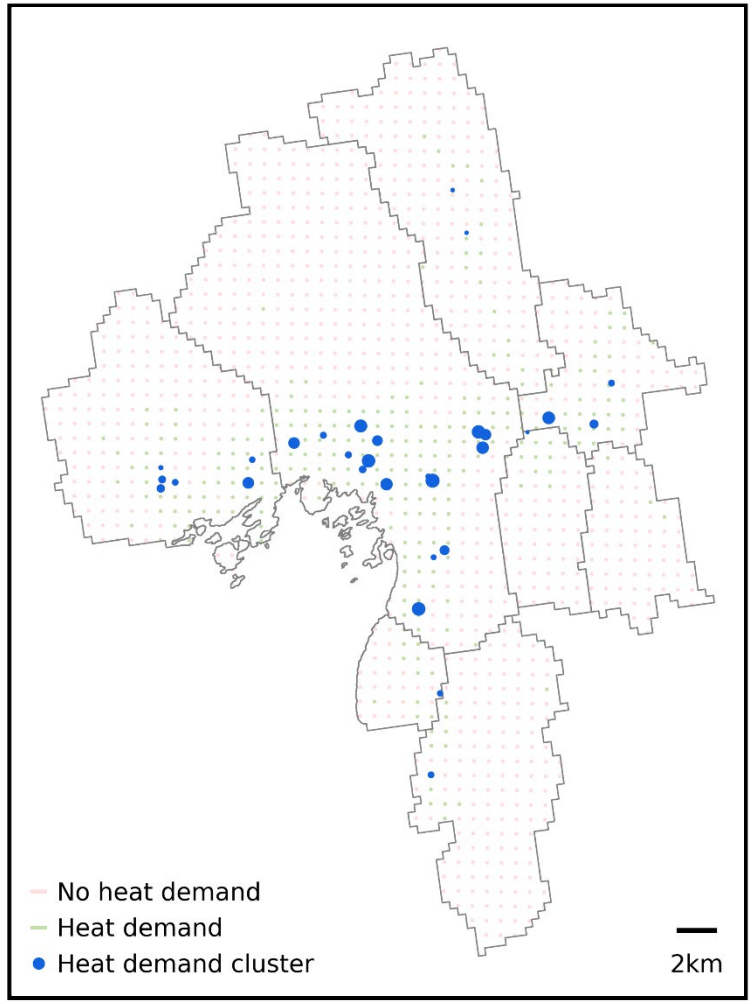
Heat demand at hectar level



Toolbox (hotmaps.eu)

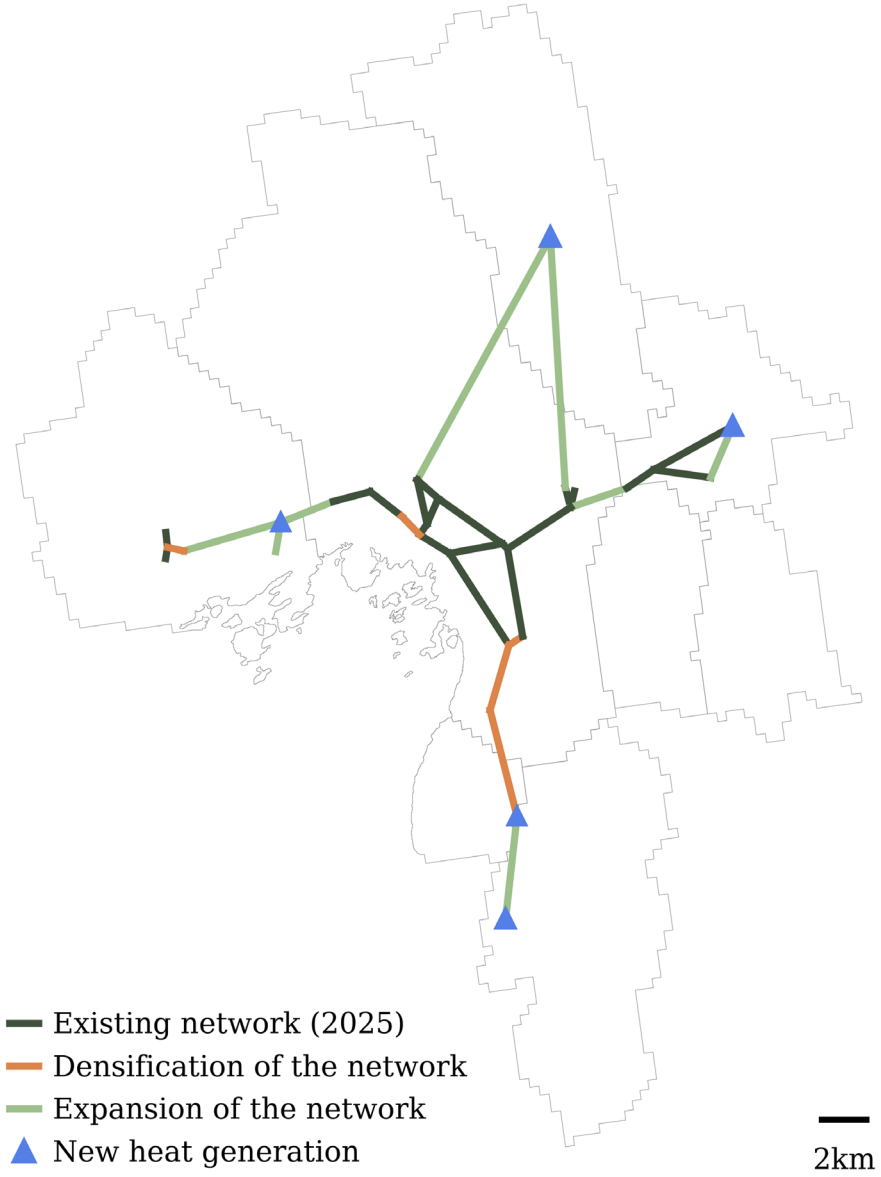
Clustering Heat density

Clustered Demand



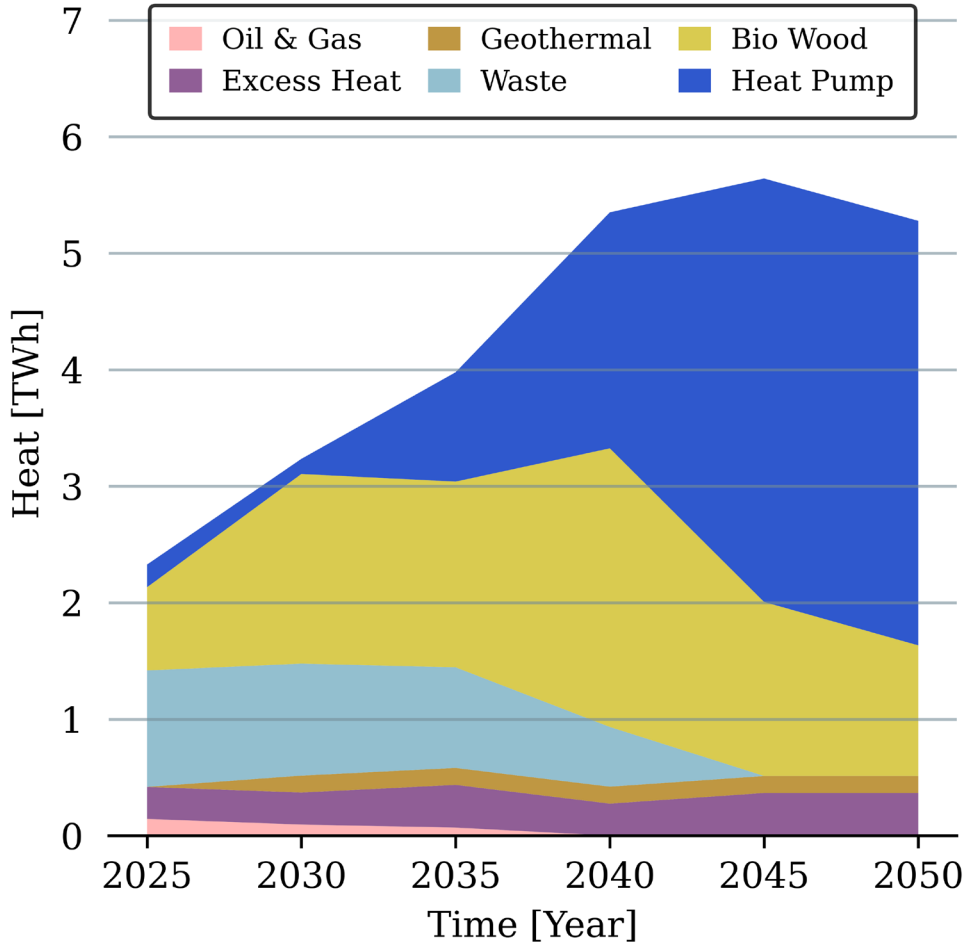
District heating 2050 (Results 1 / 3)

- The first group (shown in **dark green**) consist of pipelines that are already in the network today and will **still be in use in 2050** (i.e., with no increase in transport capacity)
- The second group (shown in **orange**) consists of pipelines that are already in the network today and will **increase their transport capacity** by 2050
- The third group (shown in **light green**) shows pipelines that do exist in the current network and will therefore be **newly installed**.



District heating 2050 (Results 2 / 3)

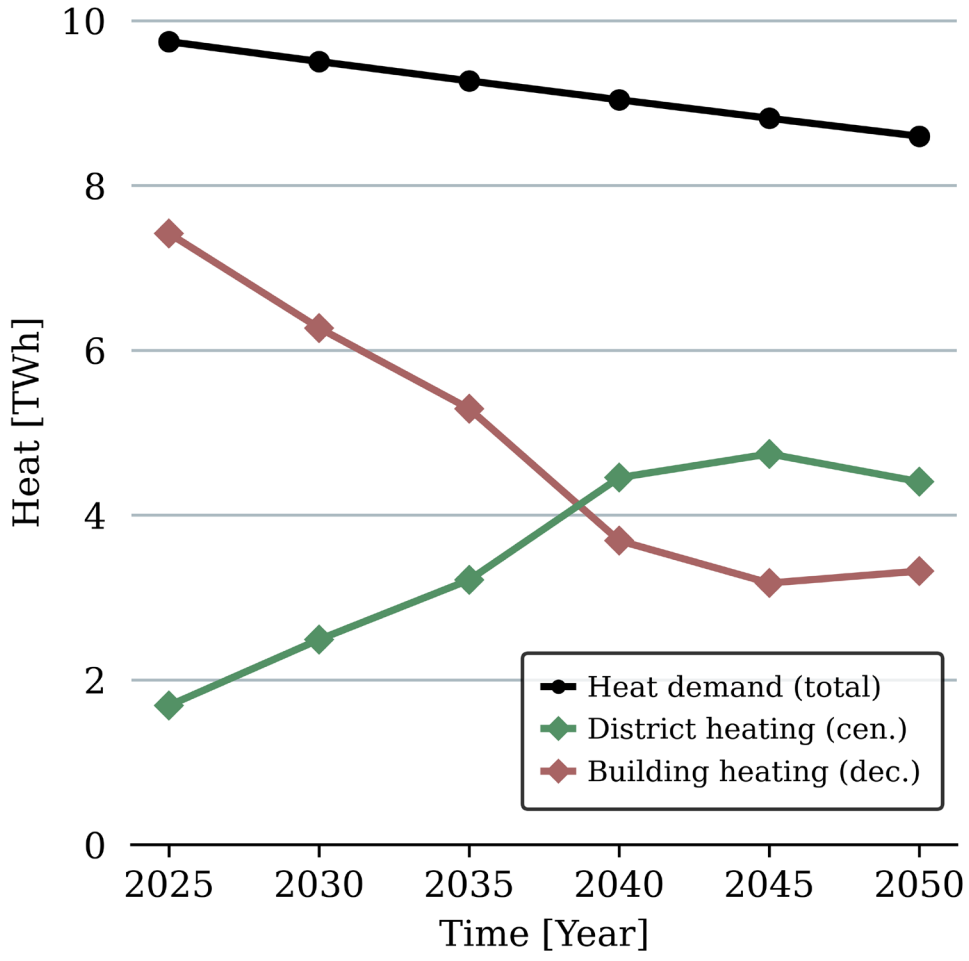
- By 2050, large shares of district heating is based on large-scale heat pumps. They are significantly used and integrated in the network from 2035.
- In particular, the heat generation from large-scale heat pumps reach in 2050 with 3.65 TWh annual generation their maximum. This is almost 70% of total district heating.
- The share of geothermal sources in meeting heat demand is only small (around 0.2 TWh).
- Heat generation from waste (incineration) is reduced from 2035 and ends in 2045.*



*This is because in EMPIRE waste is (almost) not used in the decarbonization of the European energy system to achieve net zero emissions.

Heat demand and supply 2050 (Results 3 / 3)

- The **share of district heating** (centralized heat supply) **increases** significantly **between 2025 and 2050**. This change in the way the heat demand is met starts in 2025, develops linearly, and reaches a peak around 2040. At the same time, the share of building heating
- **From 2040**, both district heating and building heating **reach their maximum and minimum** supply respectively. It becomes clear that further expansion of the district heating may not be cost-optimal with the assumed empirical setting which is why building heating still supplies about 3 TWh (e.g., building heating covers 3.3 TWh in 2050).



Key-Takeaways, synthesis and outlook

- In our **case study** of the district heating network in **Oslo, Norway**, we find that **district heating will** approximately **double** by 2040 compared to 2025, and that district heating will be the main heat source in 2040

- There is a need to **extend the existing district heating network**, not only to meet more heat demand (i.e., densification) but also to **connect renewable heat sources**, such as large-scale heat pumps and geothermal sources

- **Lessons learned** and recommendations for EMPIRE and other similar large-scale energy systems can be made (e.g., how to deal with heat pumps, geothermal)

- **Future work**: how the share of district heating, and in particular of electricity-based heat sources, changes if instead of a monthly resolution, a weekly or hourly resolution of electricity prices is considered. This could make it possible to gain further insights into the role of district heating in providing flexibility in energy systems.