Modelling District Heating Supply Patterns in a Decarbonised EU-Wide Energy System

Energieerzeugung
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Motivation and Research Question

The European Union's Climate Law and the Green Deal target to reach carbon neutrality by 2050. Heating and cooling are crucial in this target as they constitute nearly half of the EU's final energy consumption [1]. District heating (DH) has a significant potential for integrating low-carbon energy sources into the heating energy mix on a large scale [2].
We modeled the DH demand and supply mix of all Member States (MS) of the European Union (EU) to achieve carbon neutrality in 2050. In this study, we aim to answer the following research question: What are the cost-minimal decarbonized DH generation portfolios in EU-27 in 2050, considering DH grid expansion and availability of renewable energy and excess heat potentials?

Methodology

The modeling chain consists of three main steps:

1. DH expansion modeling: possible future DH areas are identified based on the distribution costs.
2. Calculation of renewable energy source (RES) and excess heat potentials: RES and excess heat potentials are calculated and mapped with a high spatial resolution. Then these potentials are mapped with the possible DH areas from step 1.
3. Clustering the DH areas and modeling the DH supply mix: DH areas are clustered into up to five groups for each MS based on the RES and excess heat potentials from step 2. Finally, the cost-minimal DH supply dispatch is calculated for each cluster.

The focus of this study is on modeling the DH supply mix. The Hotmaps District Heating Supply Dispatch model [3] is used for this purpose. The model minimizes the total cost of the DH heating supply using mixed-integer linear programming. Both installed capacities and operation of heat generators and storages are optimized within the model on an hourly basis. The model will be run for different scenarios, and sensitivity analyses will be done for factors such as electricity prices, system temperatures, etc.

Results and Conclusions

The main results consist of each cluster's cost-minimal thermal generation mix, installed capacities, and fuel use. These results will be aggregated at the MS level. Interpretations will be made based on the levelized cost of heat levels, shares of exploited RES and excess heat potentials, operation of heating plants, full load hours, and use of heat storages. Sensitivities of energy carrier prices and system temperatures will also be investigated.

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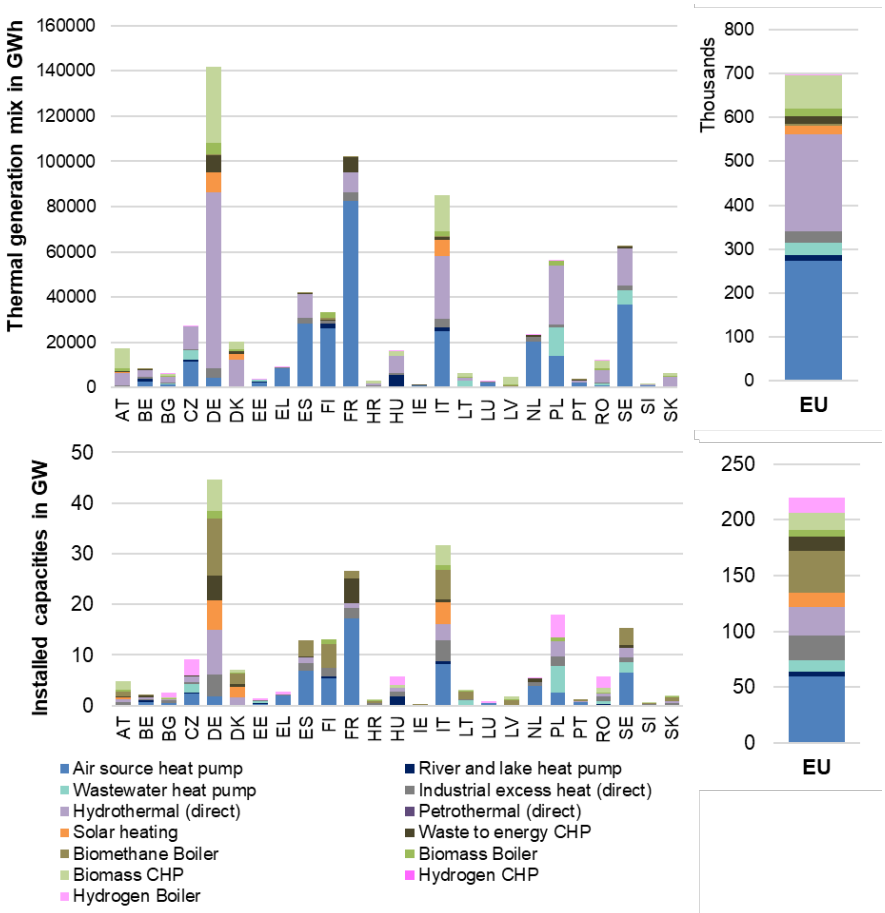

Figure 1: Installed capacities and thermal generation mix of heat generation technologies (preliminary).

Figure 1 shows the thermal generation mix and installed capacities of heat generators by MS and on the EU level based on preliminary results for one scenario. According to preliminary results, cost-optimal district heating supply in 2050 consists of a mix of heat pumps (~45%), followed by direct deep geothermal (~30%), while biomass is restricted (~13%), mainly because of its price sensitivity and our assumptions regarding resource constraints (and related EU-policies). In Figure 1, high installed capacities and low heat generation of hydrogen and biomethane boilers indicate that they are mainly used as backup technologies. The results point out that heat pumps and deep geothermal are the most dominant heat suppliers in 2050 at the EU level.

References

[1] https://energy.ec.europa.eu/topics/energy-efficiency/heating-and-cooling_en [accessed at 18/11/2022]

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[3] https://wiki.hotmaps.eu/en/CM-District-heating-supply-dispatch