Modeling District Heating Supply Patterns of EU-27 in a Decarbonized Energy System in 2050

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Overview

The EU Climate Law and the Green Deal aim to reach carbon neutrality by 2050. Heating and cooling are crucial in this target, constituting nearly half of the EU's final energy consumption [1]. District heating (DH) could play a significant role in integrating low-carbon energy sources into the heating energy mix on a large scale [2]. However, the DH supply of EU-27 is highly based on fossil fuels. We modelled the DH demand and supply mix of EU-27 to achieve carbon neutrality in 2050. In this study, we aim to answer the following research question: What are the cost-minimal decarbonized DH supply portfolios in EU-27 in 2050, considering DH grid expansion and availability of renewable energy sources (RES) and excess heat potentials? To the best of our knowledge, our study is the first to model the DH supply of EU-27, considering these two aspects.

Methods

We used a four-step modelling chain to answer our research question:

1. Building stock modelling
2. DH expansion modelling
3. Calculation of RES and excess heat potentials
4. DH Supply Dispatch

The focus of this study is on modelling the DH supply mix. The Hotmaps 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 investments and operation of heat generators and storage are optimized within the model on an hourly basis. The two main scenarios for 2050 are designed based on the system temperatures: low and high-temperature DH systems. These system temperatures affect the dispatch model directly through the heat pumps and indirectly through the RES potentials.

Results

For the high-temperature scenario, the preliminary results show that heat pumps could contribute up to 54 % of DH generation, whereas biomass (combined heat and power (CHP) and heat-only boiler (HOB) combined) has a share of 18%, followed by 13% geothermal (direct use) and 12% waste to energy (WtE). In the low-temperature scenario, the share of heat pumps in DH generation decreases to 40%, while geothermal (direct use) increases to 34%, followed by 14% WtE. The contribution of biomass (CHP and HOB combined) slides down to 8% because of the higher uptake of geothermal. In both scenarios, solar thermal, biomethane and hydrogen technologies have a marginal contribution.

We will further interpret our results 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 storage. We will also investigate the sensitivities of energy carrier prices for hydrogen and biomass.

Conclusion

The preliminary results indicate the clear impact of the temperature levels on the DH supply mix. Heat pumps and geothermal heat are essential in decarbonizing the European DH sector in both high- and low-temperature scenarios. The results also indicate that lower temperature levels do not necessarily lead to a higher share of heat pumps because lower temperature levels mean a higher potential for low-temperature excess heat and geothermal.

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