Modelling decarbonised district heating in EU-27: What are the main factors influencing the technology mix?

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 modelled 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 questions: What are the cost-minimal decarbonized DH generation portfolios in EU-27 in 2050? What are main factors influencing this mix? In particular, we consider different patterns of DH grid expansion, availability and costs of renewable energy and excess heat potentials as well as DH grid temperature levels.

Methodology

According to Figure 1, the modeling chain consists of following main steps, where the different steps are carried out on different spatial resolution:

1. Modelling the demand data set: Scenario development of space and water heating demand applying the model Invert [4]
2. DH expansion modeling: possible future DH areas are identified based on the distribution costs of DH and scenarios for future heat demand density.
3. 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 2.
4. Clustering the DH areas: DH areas are clustered into up to five groups for each MS based on the RES and excess heat potentials from step 3 for each MS
5. Modeling the DH supply mix: Finally, the cost-minimal DH supply dispatch is calculated for each cluster.

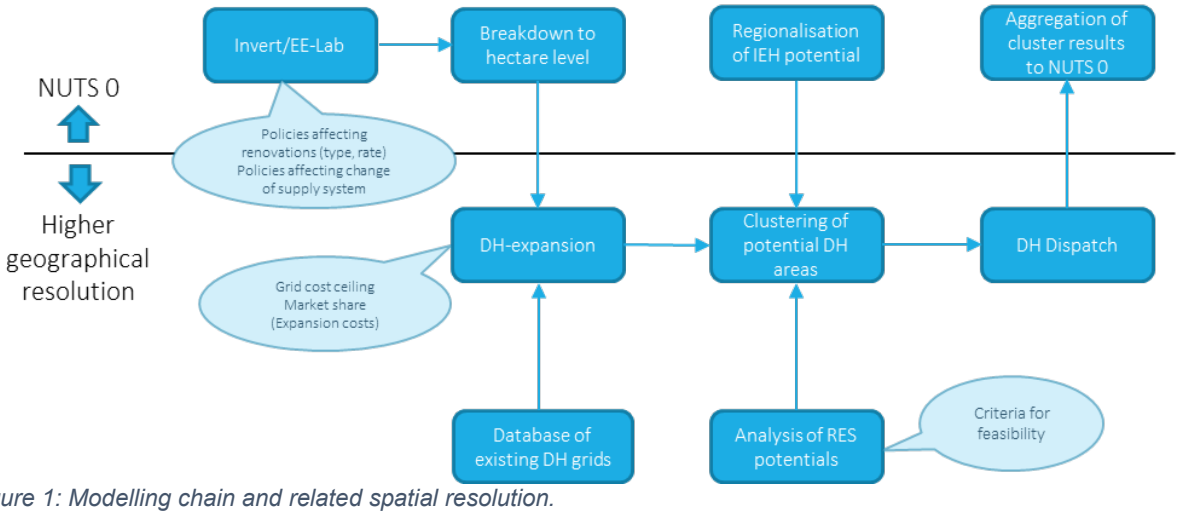

Figure 1: Modelling chain and related spatial resolution.

The focus of this study is on modeling the DH supply mix. The Hotmaps DH 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 is applied for different scenarios. A

special focus is put on a set of parameter variations regarding key impact factors such as DH system temperature levels, costs and availability of RES, energy prices etc.
In this abstract, we show results for following parameter variations: For DH system temperature levels, we applied a variation of the standard temperature settings (flow temperature 95-85°C and return temperature 60°C) to decreased temperature levels (flow temperature 65-55°C and return temperature 30°C). For geothermal investment costs, we assumed a 100% increase of specific investment costs in the "high costs" scenario.

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, shares of exploited RES and excess heat potentials, operation of heating plants, full load hours, and use of heat storages. The parameter variation showed that in particular two parameters are important to be considered: DH system temperature and – due to its potential relevance – the cost of geothermal heat generation, mainly affected by investment costs.

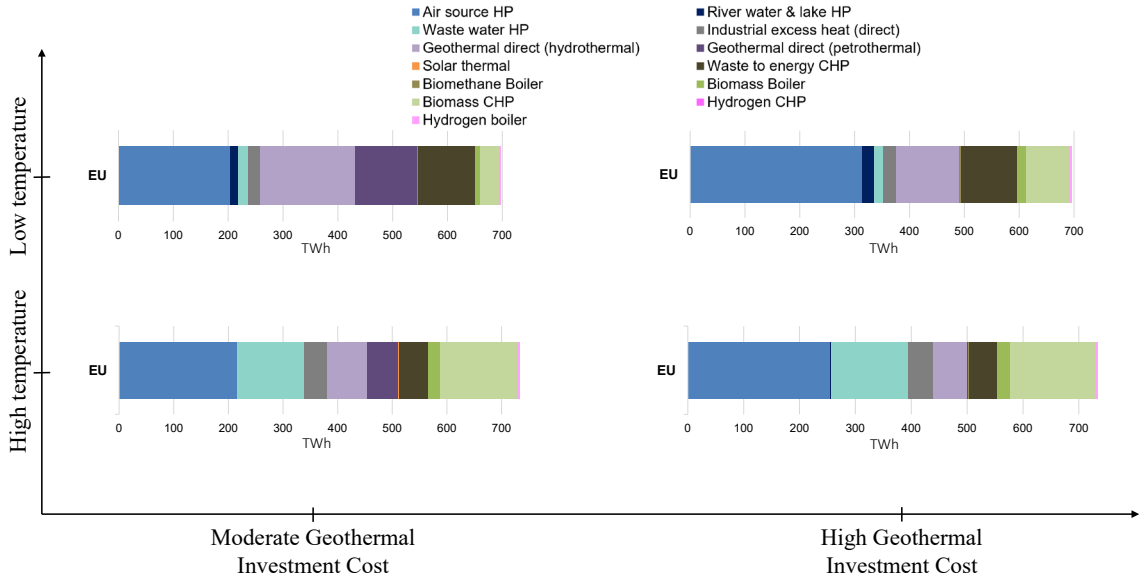

Figure 2: District heating generation mix in EU-27, 2050 under four different settings of system temperature and costs of geothermal investment costs (preliminary, exemplary results).

Figure 2 shows the thermal generation mix and installed capacities of heat generators on the EU level based on preliminary results for an exemplary scenario and four settings varying the parameters as described above.
The results point out that heat pumps and deep geothermal are the most dominant heat suppliers in 2050 at the EU level. However, in case of lower system temperature levels, a higher potential geothermal resource is available, which would be tapped under "moderate geothermal investment costs". At the same time, under higher geothermal investment cost assumptions, only a smaller share of this resource is exploited by the cost-minimization algorithm, which requires a higher share of heat pumps and biomass to cover the total district heating demand.
The full paper and presentation will show more scenarios and parameter variations, selected MS-results and related policy conclusions.

References

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