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MODELLING DECARBONIZATION PATHWAYS FOR A METROPOLITAN AREA – BERLINS ENERGY TRANSITION INTEGRATED IN AN EUROPEAN ENERGY SYSTEM

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Overview

The current energy crisis poses major challenges, especially for the heating sector. The European gas price increased from 16€/MWh in March 2021 to 227€/MWh in March 2022 (OECD 2022), which has led to a rethinking about the future of heat supply. Nevertheless, the complexity, uncertainty, and often ignorance in the heating sector makes many actors reluctant to make the necessary investments to reduce dependence on natural gas. An independence from natural gas and other fossil energy imports by 2045 would be possible with a switch to a 100% renewable heat supply for Berlin. The present paper investigates the feasibility of a 100% renewable energy system with focus on the heating sector in Berlin.

Method

The heating sector lacks good quality data. In Germany, cities are obliged to prepare plans for the heating system in the coming years, which should represent heat demand and renewable heat potentials (BMWK 2022), however, the data is not yet fully available. We therefore conduct sensitivity analyses for relevant input parameters to map possible developments in heat supply. The input parameters include renovation rates, renewable heat potentials, and the availability of hydrogen imports. The sensitivity analysis accounts for uncertainties on the input side and reflects this in different decarbonization pathways.

For the analysis, we use the open-source, cost-optimizing, techno-economic energy system model GENeSYS-MOD which covers the electricity, building, industry, and transport sectors. This enables the assessment of sector coupling in energy systems and its impact on electricity, hydrogen and other energy carriers.

We apply GENeSYS-MOD to the area of Berlin. Hence, we adapt the existing data set and connect it to scenarios for Europe from the H2020 research project openENTRANCE (Auer u. a. 2022). Relevant data points are extracted from the scenarios (e.g. demand forecasts, transmission capacities) and implemented in the disaggregated model. The paper focuses on the challenges of the heat transition in the building sector and the associated phase-out of coal and fossil gas. For this purpose, the modeling of district heating in GENeSYS-MOD is refined and additional technologies, especially different types of large-scale heat pumps, are added.

Results

The goal of the sensitivity analysis is to develop robust decarbonization pathways for Berlin´s heating sector that are both technically and economically feasible and meet the climate targets for Berlin. From the results, "no-regret solutions" can be identified which are necessary steps for the decarbonization and should be implemented despite any current uncertainty regarding e.g. renovation rates and hydrogen availability. The results will provide an investment strategy that allows the identification of bottlenecks, e.g. in terms of workers needed for building refurbishments and heating retro-fitting. The consideration of a sector-coupled energy system also allows an estimation of how the heating market will change with respect to the availability of hydrogen. Through the involvement at the European and German level, Berlin's current plans to replace fossil gas with hydrogen can be evaluated in a larger context.

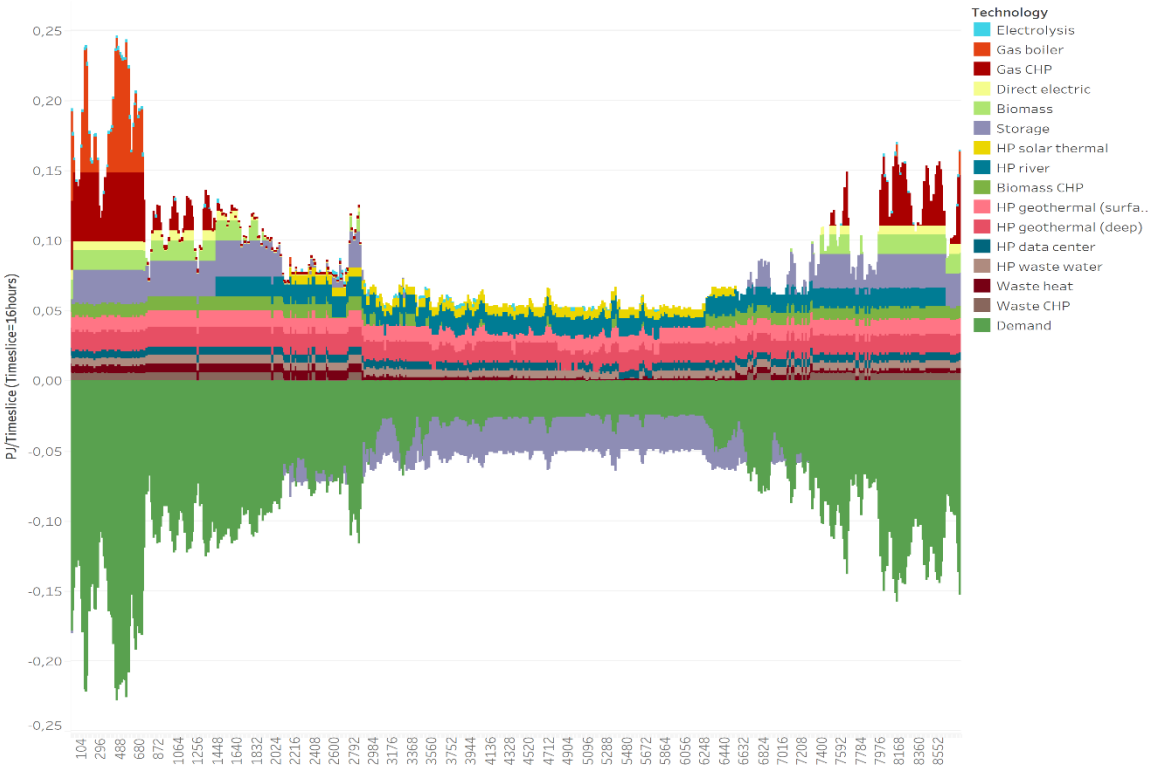

Figure 1: Preliminary results of early model runs for district heat supply in 2045 for Berlin

Preliminary results show that CHPs will play a minor role in district heating because CHP power generation has limited compatibility with a power system based on solar and wind. Instead, heat will be replaced predominantly by large-scale heat pumps and heat generation by boilers with hydrogen/synthetic gases to provide peak heat (see Figure 1).

For decentralized heat generation, the importance of gas-fired heating is declining significantly. Nevertheless, depending on the availability of hydrogen, bivalent heat systems consisting of heat pumps and boilers might contribute to heat supply.

References

Auer, Hans, Konstantin Löffler, Karlo Hainsch, Thorsten Burandt, Ingeborg Graabak, Sarah Schmidt, Ahmet Yucekaya, Emre Celebi, Gokhan Kirkil, und Sebastian Zwickl-Bernhard. 2022. „Quantitative Scenarios for Low Carbon Futures of the European Energy System on Country, Region and Local Level“. Deliverable 3.2. https://openentrance.eu/wp-content/uploads/openENTRANCE-D3.1.pdf.

BMWK. 2022. „Diskussionspapier des BMWK: Konzept für die Umsetzung einer flächendeckenden kommunalen Wärmeplanung als zentrales Koordinierungsinstrument für lokale, effiziente Wärmenutzung“. Berlin: Bundesministerium für Wirtschaft und Klimaschutz. https://www.bmwk.de/Redaktion/DE/Downloads/Energie/diskussionspapier-waermeplanung.pdf?__blob=publicationFile&v=4.

OECD. 2022. „Energy Prices Are Spiking“. 17. März 2022. https://www.oecd.org/coronavirus/en/data-insights/energy-prices-are-spiking.