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Power to heat flexibility in Austria's electricity system in 2030

(Open source) electricity market modelling, flexibility, sector coupling

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Motivation and research question

Decarbonizing our energy system is a profound transition requiring rising shares of renewable electricity generation and their integration in the overall system as well as electrification of former fossil-fueled processes. Increasing shares of fluctuating renewable generation increase the need for flexibility options whereas increased sector coupling like power to heat offers potential flexibility to the system. The decarbonisation of the heating sector requires increasing capacities of heat pumps or electric heating. Besides heating purposes, these technologies can be used in future energy systems to provide flexibility to the electricity by using the heat storage potential of the building stock or combined buffer tanks to shift electricity demand to hours of higher renewable energy production in the electricity grid. The goal of this paper is to identify the potential flexibility that heat pumps can offer to the Austrian electricity system in 2030. There have been several studies done on the potential role of heat pumps and electric heating as flexibility options in the electricity system [1], [2]. We identify the role for Austria and focus especially on the impact of storage time for the flexibility potential.

Method

There are three main methodical steps in this work, two preparatory steps and the energy system modelling, which is the focus of this paper. The first step is to identify the inflexible heating demand covered by heat pumps and direct electric heating in Austria, which is dependent on several factors, most importantly the temperature. We develop an OLS regression model to derive the future heating demand covered by heat pumps and direct electric heating depending on climate data. This approach enables us to derive specific heat demand profiles for different climate change scenarios. Secondly, the flexibility potential of the building stock heated by heat pumps and electric heating is modelled to identify the central characteristics of the flexibility provided: the electricity load of electric heating that can be used as a flexibility option and the time constraints for shifting this load. The information derived from the first two steps is then integrated with the bottom-up energy system modelling. We model the electricity and district heat sector as well as decentral heat pumps and direct electric heating in Austria. The investment and dispatch optimization of the electricity system is done using the open-source energy system modelling framework Balmorel [3][4] minimizing overall system cost in hourly resolution for the year 2030 in Austria. As output, we derive required investments in generation and storage technologies, overall system cost, electricity spot prices, and emission levels.

Preliminary results and conclusions

Since electricity spot prices are generated endogenously in the energy system model, the flexibility potential provided by the heat pumps and electric heating and utilized by the energy system can be determined from the simulation. Sector coupling facilitates the integration of variable renewable electricity generation [5], [6]. The benefits of flexible heat pumps and electric heating in Austria in 2030 can be determined in terms of

- reduced system cost,
- reduced needed investments in other flexible generation technologies
- reduced curtailment of renewable electricity generation and
- reduced greenhouse gas emissions in the energy system

compared to a system with inflexible heat pumps and electric heating. A further outcome of our analysis is the comparison of the effect of shorter, but higher and longer, but lower flexibility provision in terms of economic and environmental effects on the electricity system. This allows us to derive policy recommendations on how heat pump and electric heating flexibility can be implemented and used best for the electricity system in Austria in 2030.

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