MODELLING THE ELECTRICAL POWER DEMAND OF DIFFERENT HEAT PUMP SYSTEMS: APPROACHES FOR SIMPLIFIED AND DETAILED LOAD ASSESSMENT

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Motivation and Objectives

According to the German government's legislative resolution, the heat supply in Germany is to be completely climate-neutral by 2045. To achieve this goal, the German government is currently introducing several measures. For example, from 2024, a minimum share of 65 % renewable energy will be mandatory for heating systems in new buildings in development areas in Germany. [1] In the field of decentralized heat supply, the transition will particularly accelerate the ramp-up of electrical heat pumps, with the German government aiming to achieve at least 500,000 newly installed heat pumps per year from 2024 [2].

The growing share of heat pumps will lead to a substantial increase in decentral loads in electrical distribution networks. Especially in urban areas, where load density is high, this can pose significant challenges to distribution grid operators, which is why a reliable planning basis is required. The objective of this paper is to present approaches for determining the electrical power demand of heat pumps for individual buildings and thus estimate the resulting additional grid load caused by them. Both a simplified model for average load assessment and a detailed model for generating high-resolution daily load profiles are presented. Different factors influencing the electric power demand of heat pumps are considered, and exemplary results for typical buildings are shown.

Methodology

There are multiple factors (e.g. outdoor and heat source temperature, heating load and heating curve of the building, heat pump technology and heating system configuration, …) influencing the electrical power demand of heat pump systems. These are analysed in a first step, and typical values are determined. If the factor differs locally, characteristic values for the city of Munich are utilized.

Two models are then developed in order to assess the electrical load of heat pump-based heating systems. Since high-resolution modelling requires a comparatively high computational effort and detailed information about the heating object, both an easy-to-apply simplified heating system model and a high-resolution heating system model are presented. The simplified heating system model does not consider the hydraulic design

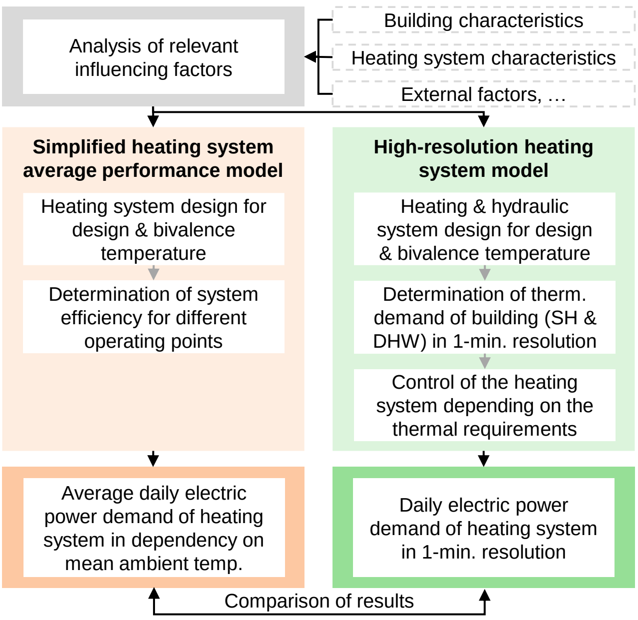

Figure 1: Schematic methodology for the determination of the electrical power demand of heat pump systems

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of the heating system but determines solely the system efficiency of the heat pump (and, if applicable, heating rod) for different operating points. The model allows to estimate the heating system's average daily electrical power demand in dependency on the mean ambient temperature. This information can, for example, be utilized by grid operators as a reference value for grid dimensioning.

The high-resolution heating system model enables a building-specific assessment of the minute-by-minute load profile. For this, the hydraulic system and a heat-controlled operating mode are modelled. A simplified thermal building model and a tap profile generator are used to derive the building's thermal space heating (SH) and domestic hot water (DHW) demand. Characteristic load profiles can be determined for individual buildings, and a comparison with the results for the average daily power demand of the simplified heating system model is carried out. The entire procedure is summarized in Figure 1.

Results

Figure 2 shows the abstracted results of the two modelling approaches. The simplified heating system model examines the heating system's average, stationary operating points and thus enables the assessment of the average daily power demand in dependence on the mean ambient temperature. In the high-resolution heating system model, a typical hydraulic system is first replicated, and individual daily load profiles are modelled on this basis. The individual daily load profiles are then reproduced for a large number of iterations so that average daily load profiles can be derived. A final comparison of the modelling approaches illustrates the differences caused by the simplifications in the heating system average performance model.

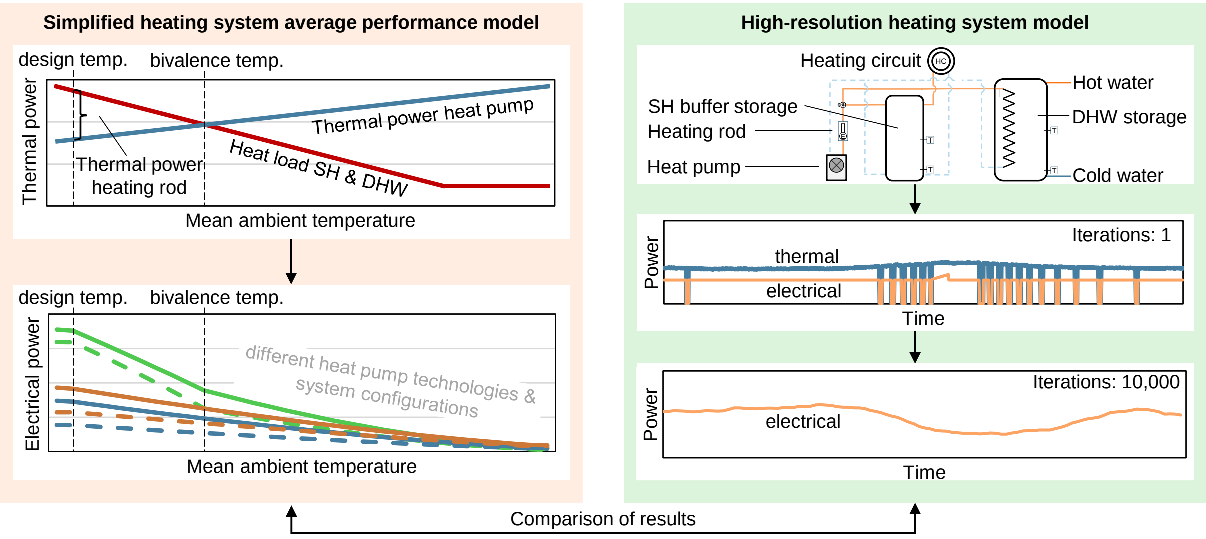

Figure 2: Abstracted results of the presented modelling approaches

In addition to a more in-depth description of the influencing factors and the modelling approaches, (standard) load profiles for different heating system configurations and buildings are derived in the full paper based on building and heating system characteristics typical for Germany. The profiles can be used by grid operators to estimate the additional load resulting from the heat transition.

References

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