COMPARISON OF SIMPLIFIED AND DETAILED CALCULATION METHODS FOR FORECASTING LOAD DEVELOPMENT IN LOW-VOLTAGE GRID AREAS

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Motivation and Objectives

Due to advancing sector coupling, distribution grids – especially in urban areas – are facing structural changes. Significant increases in load are to be expected, in particular due to the transition of the transport and heating sector and the corresponding increase in electric vehicles and heat pump-based heating systems. In order to ensure a future-oriented and dependable energy supply, grid expansion measures are unavoidable in many cases. In this context, reliable load forecasts are essential for the correct dimensioning of the operating equipment such as transformers and cables.

At higher voltage levels load forecasting is comparatively simple, since it is possible to utilize standard load profiles due to the high number of respective consumers (increasing accuracy with increasing aggregation, see also law of large numbers). In low-voltage grids this is much more complex due to the smaller underlying consumer base and the resulting higher probability of overlapping extreme cases. In order to achieve a reliable forecast for a high number of grids, a fundamental conflict of interest exists between result precision and computational intensity. Therefore, this work compares different approaches developed for load forecasting at the low-voltage level in terms of their accuracy and computational complexity using typical urban grid areas as examples and provides application recommendations for grid operators. A more detailed description of the different calculation variants to be compared is provided in the following section in which the methodology of this work is explained.

Methodology

To evaluate the different calculation methods, typical network areas are defined as example areas for the analysis in a first step. Based on [1], three grids representative for urban areas are utilized here: An area with dense building structure (primarily residential use), an area with loose building structure (primarily residential use), and an area primarily used for commercial and retail purposes. These networks are based on existing grid areas and are further used to compare the different modelling approaches. The approaches described in [2] and [3] are applied to calculate the resulting load of electric vehicles,

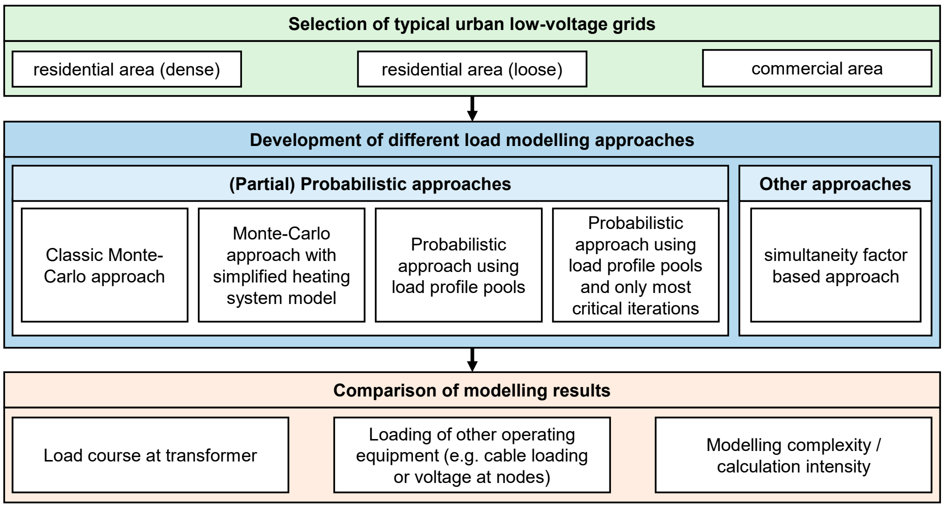

Figure 1: Overview of the chosen methodology

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households and heating systems. In the absence of more precise consumer information, the standard load profile for commercial use is utilized to model existing commercial loads. In order to determine the resulting load courses in the respective networks, both, a simultaneity-based approach – which is comparably simple and computationally less intensive – and several more complex probabilistic approaches are used. Probabilistic analyses involve classic Monte Carlo (MC) simulations as well as Monte Carlo simulations with simplified heating system modelling (MC + SHSAP). In addition to this, pooling approaches are developed, in which load profiles of a certain load type (e.g., home charging point for electric vehicles) are pre-produced once using a Monte Carlo simulation and stored in a database, from which they can later be retrieved as needed without having to regenerate the individual profiles each time. The significance of variing iteration numbers and practical strategies in order to reduce the number of iterations are also assessed here.

Finally, the results are compared in terms of modelling complexity and resulting loading of the operating equipment. Recommendations for application by distribution system operators are derived. The approach is summarized in Figure 1.

Results

In the full version of this paper, all modelling variants are applied to the defined typical network areas and the resulting deviations are compared. The following key metrics are particularly relevant here: load course at the transformer, loading of the lines, voltage at the nodes and complexity of the modelling approach. Exemplary results for the typical commercial grid area are shown in Figure 2.

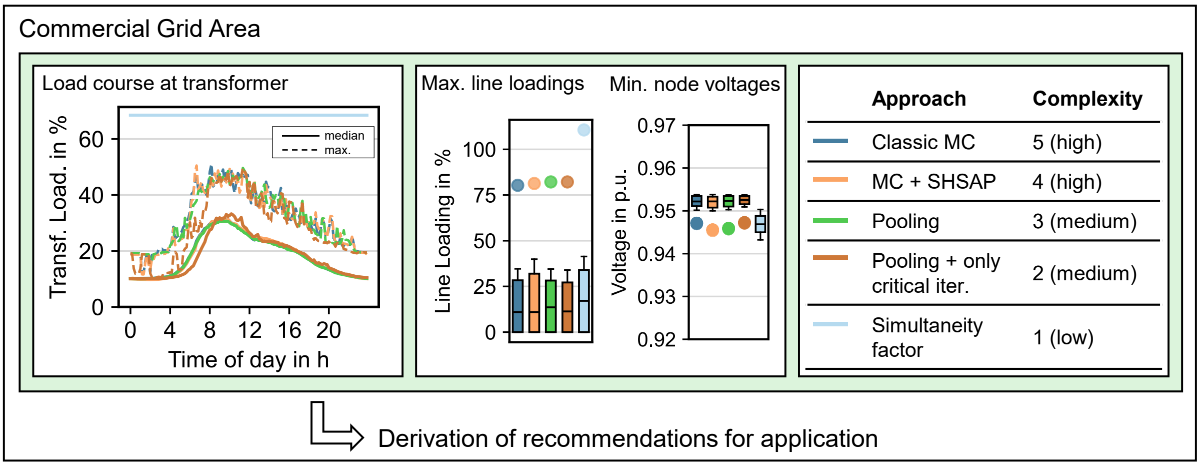

Figure 2: Exemplary results for the typical commercial grid area

There are some significant differences between the respective methods, with each method having its own advantages and disadvantages. Although approaches based on simultaneity factors can e.g. be utilized to make a worst-case analysis about the expected impact on the operating resources comparatively fast, only maximum values can be determined here, no load courses over time. Probabilistic approaches on the other hand can also be used to generate time-resolved load courses, but are much more computationally intensive, whereby the number of modelling iterations plays an important role in terms of the resulting outcome and computational complexity. The higher the number of iterations, the more likely extreme load events can be depicted - but the higher also the computational effort. Based on the comparisons made, recommendations can be drawn for the situation-dependent suitable application of the individual approaches.

References

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