METHODOLOGY FOR EXTRACTING DYNAMIC STANDARD LOAD PROFILES FROM SMART METER DATA

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Introduction

The liberalized German power market is organized in several balancing areas. Every balance responsible party (BRP) is obligated to aim for balanced portfolios by matching demand and production. Discrepancies between demand and production are handled by the grid operators. The resulting costs of the reserve energy is accounted afterwards. The electrical demand of customers in balancing areas is therefore commonly prognosticated with standard load profiles (SLP) [1].

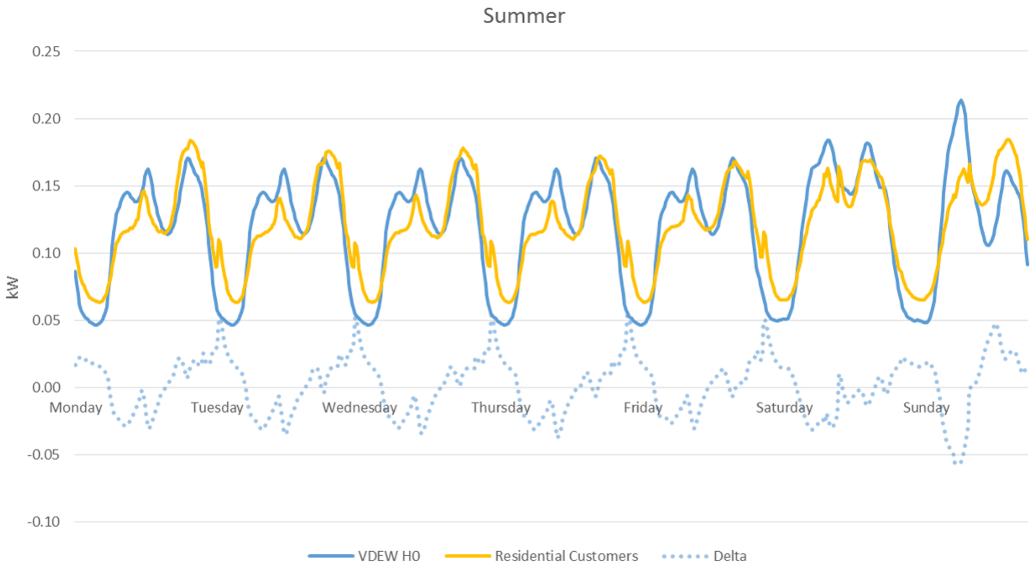

Figure 1: Comparison of the electrical demand of residential customers from a project described in [2] and the commonly used standard load profile "h0".

The German Federal Ministry for Economic Affairs and Energy published a white book for a new power market design to support the transition of the national energy system (“Energiewende”). One planed measure is to increase the balance area loyalty („Bilanzkreistreue“) [3] to keep the demand and production of electricity leveled and to decrease the demand of ancillary services and reserve energy. In addition the proposed law to digitize the “Energiewende” in Germany will make the installation of smart meters mandatory for customers with a yearly consumption of more than 6 000 kWh [4].

This surplus of detailed electrical load data may increase the accuracy of the demand forecasts for customers above 6 000 kWh/a. However, the electrical demand of customers without smart meters will still be estimated with standard load profiles. It should be noted that the commonly used SLP for the German power market are based on a small data set of 332 household profiles from 1981 for instance [1]. The Figure 1 is an example of the changed electrical demand pattern of residential customers from a recent project [2] and the need for new SLPs. In [5] the authors underline the need for new SLP. They emphasize the risk for grid operators and power traders as the decentralized generation from renewable sources increases and new tariffs may influence the electrical demand for instance. The authors propose additional SLP for households with, for instance, solar power systems [6].

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The increased roll out of smart meters allow the generation of new standard load profiles for residential households and small to medium sized enterprises (SME). Precise forecasts reduce the demand of expensive energy balancing and ancillary services [7].

Methodology

This paper proposes a standardized methodology to develop new SLP based on the data analysis of smart meter electrical demand profiles from residential and small to medium sized enterprises (SME).

First, the smart meter data is preprocessed to identify type days and to reduce the data size. Similar groups of profiles in a given data set are identified by incorporating k-means clustering. For evaluation of the methodology, synthetic loads (one year mid-term forecasts) are generated. To interpret the results, commonly used evaluation metrics and the available meta data is used.

The second part of the paper focuses on the optimization of dynamic standard load profiles for higher forecasting accuracy and the reduction of the influence of seasonal changes. An increased forecasting quality is achieved by the usage of dynamic functions. The dynamic functions are used to adjust the standard load profiles for different seasons. The parameters of the dynamic functions are identified using a least square approach and an Evolution Strategy (ES). The methodology is applied to a publicly available smart meter data set [8] and for two different customer groups for the purpose of demonstration only.

Results and Conclusion

The clustering process identified a homogeneous group of residential and SME customers each, matching the available meta data. During post processing the identified standard load profiles where optimized by applying a dynamic function.

Using an ES to find appropriate parameters for dynamic functions leads to better results than the least square approach. Improvements of up to 21% measured by the mean average percentage error (MAPE) or 28% using the normalized rooted mean square error (NRMSE) are possible using a dynamic function with a polynomial function of grade 4 (compared to using no dynamic functions). The accuracy is improved especially during the peak time range.

The described methodology may be utilized to identify new and reliable SLP also on a regional level to increase the balance area loyalty during the “Energiewende”. The proposed clustering may help to automatically identify different type of residential household demand patterns for instance.

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