Generation of industrial electricity and heat demand profiles for energy system analysis

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Overview

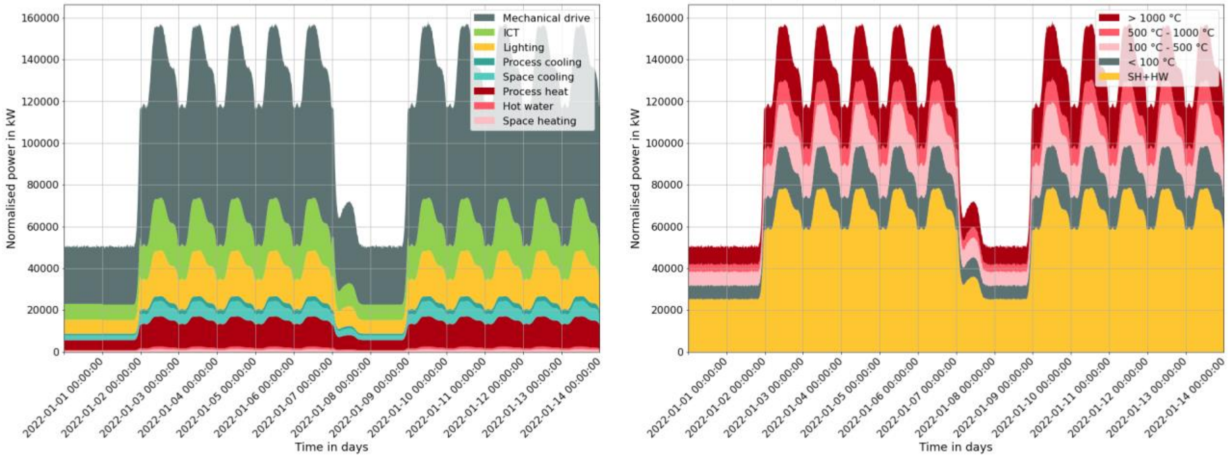
In the coming two decades, German industry must make a transformation to renewable energies in order to achieve its climate targets. In order to analyze this transformation in energy system models, the industrial electricity and heat demand must be available in a high temporal and sectoral resolution. To date, this is not the case due to a lack of open source data. In this paper, a methodology for modeling synthetic industrial load profiles for electricity and heat is described and applied to 14 industrial sectors. The generation of the electric profiles is based on normalized load profiles for eight electric end-use applications and for five different day types. The profiles are then further refined using base and peak load factors, which are calculated by real load data. The final daily profiles are then assembled into an annual profile and can be scaled by the total annual energy demand. In the last step a fluctuation range is calculated from real load data and applied to the synthetic load profile as white noise. The normalised total load profile of the thermal heat demand equals the one from the electrical, whereas the total demand is subdivided according to five temperature levels.

Methods

The modeling of generic electricity and heat demand for one year builds on a method recently submitted by the author [1]. In this paper the generation of industrial synthetic electricity load profiles for a typical working day is decribed. These daily load curves are composed based on normalized profiles for different electricity end-use appliances like lighting, ICT and mechanical drive. A fluctuation is applied to the profile as a stochastic attribute. Starting from this paper, the electrical load profiles were further developed. As a supplement to the working days, normalized daily load profiles were generated for the additional four day types Saturday, Sunday, short and long holiday. The five daily profiles are then assembled into an annual profile. This can be done for any given year. By analyzing real electricity profiles, industry type-specific base and peak load factors are calculated, which are used to vertically adjust the annual profiles. Finally, the resulting annual load profile is scaled based on the regional electricity demand.
The overall course of the thermal profile is equated to the electrical one, since the course of the temporal energy demand depends mainly on the shift system of the industrial sector [2] and process heat load data is hardly available open source. Unlike the electricity profiles, the heat profile was not divided based on end-user applications, but rather on the process heat shares of five temperature levels that vary for the different industries [3].

Results

Load profiles were generated for 14 industry sectors (e.g. basic chemicals, paper, metals and mechanical engineering). Figure 1 shows the first two weeks in 2022 for the normalized electrical (a) and thermal (b) load profiles, exemplary for the machinery sector. The electrical load profile is distributed into the end-use appliances and the thermal load profile into the amounts of temperature range. Both annual load profiles are normalized to a total energy demand of 1000 MWh/year. The applied operating hours during the week are clearly displayed, as well as the demand for continuous processes on weekends.



(a) (b)

Figure 1: (a) Electrical and (b) thermal load profile for the machinery sector. The laod is normalised to annual energy demand of 1000 MWh respectively. Displayed are the first two weeks of the year 2022.

Conclusions

This paper presents a methodology for the generation of electrical and heat load profiles for different industries. A major advantage of these generated profiles is that, in addition to the total demand, further information about the electrical applications and the temperature levels of the industrial sector are reflected. This makes the profiles applicable for a variety of scenario analyses, such as the electrification of process heat applications and the flexibilization of mechanical drives. The applied fluctuation makes the profiles more realistic and short time flexibility modelling can be realized in energy system analysis. Additionally, it serves as a stochastic attribute in the method. Every time a load profile is generated, the random numbers ensure a unique synthetic load profile per industry type.

References

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