A cross-country model for end-use specific aggregated household load profiles

SYSTEMANALYSE
FORSCHUNGSNETZWERKE
ENERGIE

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Motivation

Modelling the transition of the European energy system towards renewable energies requires various input data assumptions. We developed a model for synthetic household load profiles with the following features benefitting its usage in energy system models [1]:

- Seasonality based on weather data: Using fluctuating profiles of both supply and demand based on the same datasets allows researchers to analyze their interaction
- Consider end-uses/appliances: Energy system models often consider time horizons until 2050 or later and use assumptions on the development of electric consumption per end-use (e.g., decreasing consumption for space heating due to better building insulation)
- Cross-country: Energy system models spanning multiple countries require country-specific load profiles
- Effort necessary to extrapolate a model to larger regions: Large input data requirements or calculation times deter users from the extrapolation to larger regions

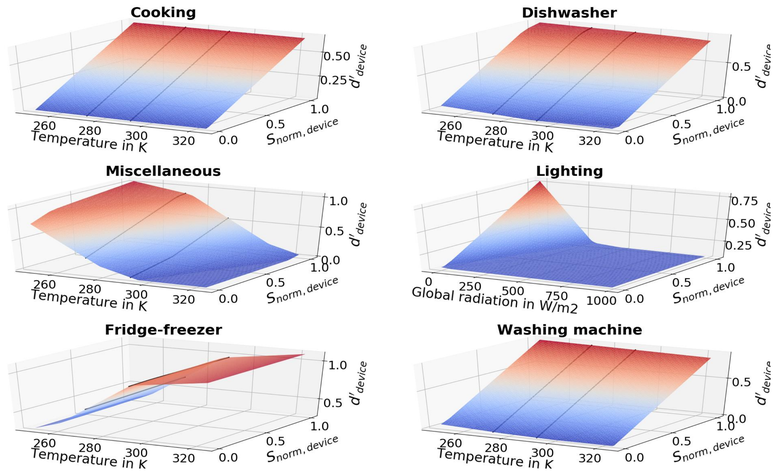

Figure 2. Output of the trained neural networks, showing the correlation between weather data (x-axis), human activity and the device specific power profile (y-axis) and the electricity consumption (z-axis)

Methodology

- Modelling of the total load curve as a sum of seven end-use specific load curves
- Training of neural networks to correlate weather data, device specific power profiles and human activity with electricity consumption measurements from the UK
- Usage of time-use surveys (TUS) and weather data to generate country-specific load profiles with the trained neural networks
- Modelling of heat consumption via the standard load profile gas and heat pump COPs
- Scaling of each end-use profile with real consumption data

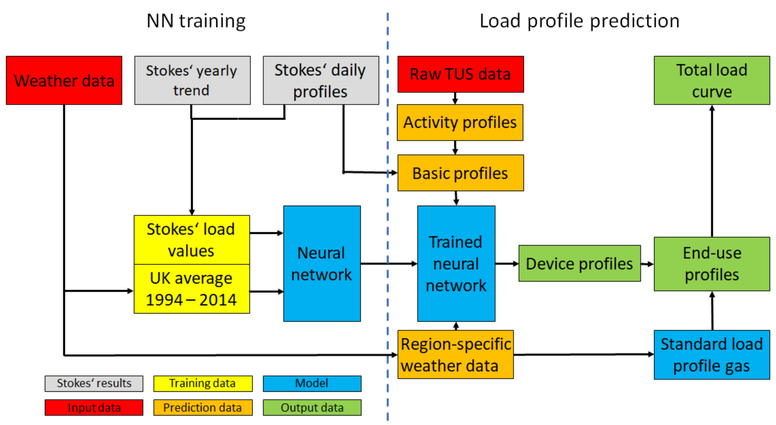

Figure 1. Structure of the model

Results: Seasonality

- Different seasonalities depending on the end-use
- A general yearly trend is visible
- Peaks (e.g., during late January and early February) occur and considerably deviate from the yearly trend
- Enables the analysis in energy system models of interactions between fluctuating demand and supply (from renewable energies) based on the same weather data

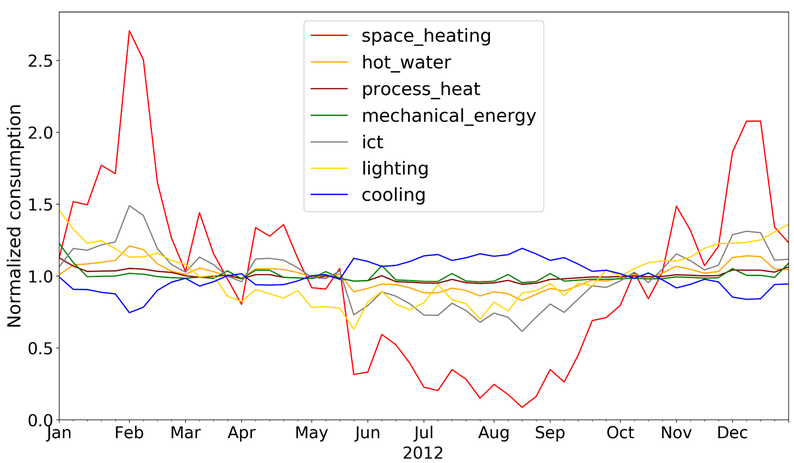

Figure 3. Seasonality of weekly mean between end-uses in the United Kingdom for the weather year 2012

Results: German load curve

Comparison of our simulation results for Germany to the standard load profile H0 [2] and measurements of the HTW Berlin [3]:

- Similar shapes with troughs at night and peaks in the evening
- The morning peak of our model takes place one to two hours earlier compared to the SLP while the HTW profile does not show a strong morning peak at all
- Lower winter evening peak of our simulation
- Close standard deviations of 3 to 3.8 GW between all three profiles at an average load of 15.3 GW

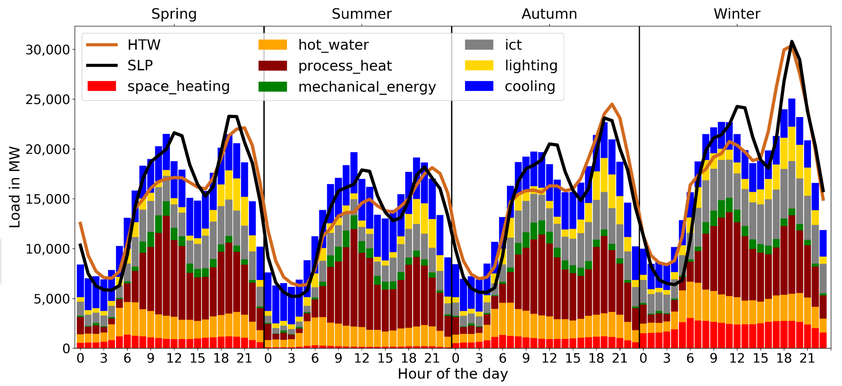

Figure 4. End-use specific seasonally average load curve for Germany compared to the SLP and measurements from the HTW Berlin

References

1. Schlemminger et al. (2021): A Cross-Country Model for End-Use Specific Aggregated Household Load Profiles. Energies, 14, 2167
2. Meier et al. (1999): Repräsentative VDEW.Lastprofile. Available at: https://www.bdew.de/media/documents/1999_Repraesentative-VDEW-Lastprofile.pdf
3. Tjaden et al. (2015): Repräsentative Lastprofile für Wohngebäude in Deutschland. Available at: https://pvspeicher.htw-berlin.de/veroeffentlichungen/daten/lastprofile/

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Useful links
The corresponding paper:
https://doi.org/10.3390/en14082167

Data repository:
https://doi.org/10.25835/0043305

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