Stochastic generation of household electricity load profiles in 15-minute resolution on building level for whole city quarters

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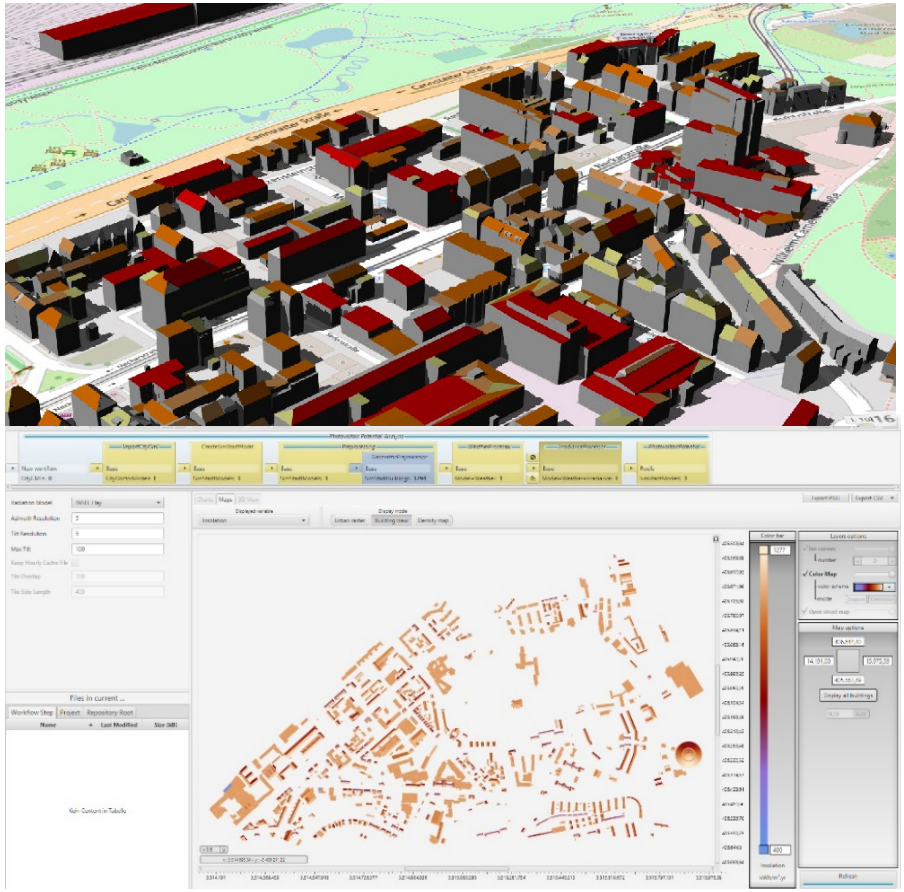
Simulation platform SimStadt

Simulation tool for energetic city quarter planning based on 3D-CityGML files *Nouvel et al. 2015*:

- Photovoltaic and solar potential per roof area and financial feasibility
- Heat demand analysis based on DIN ISO 18599
- Refurbishment scenarios
- Environmental analysis
- District heating network

Soon to come:

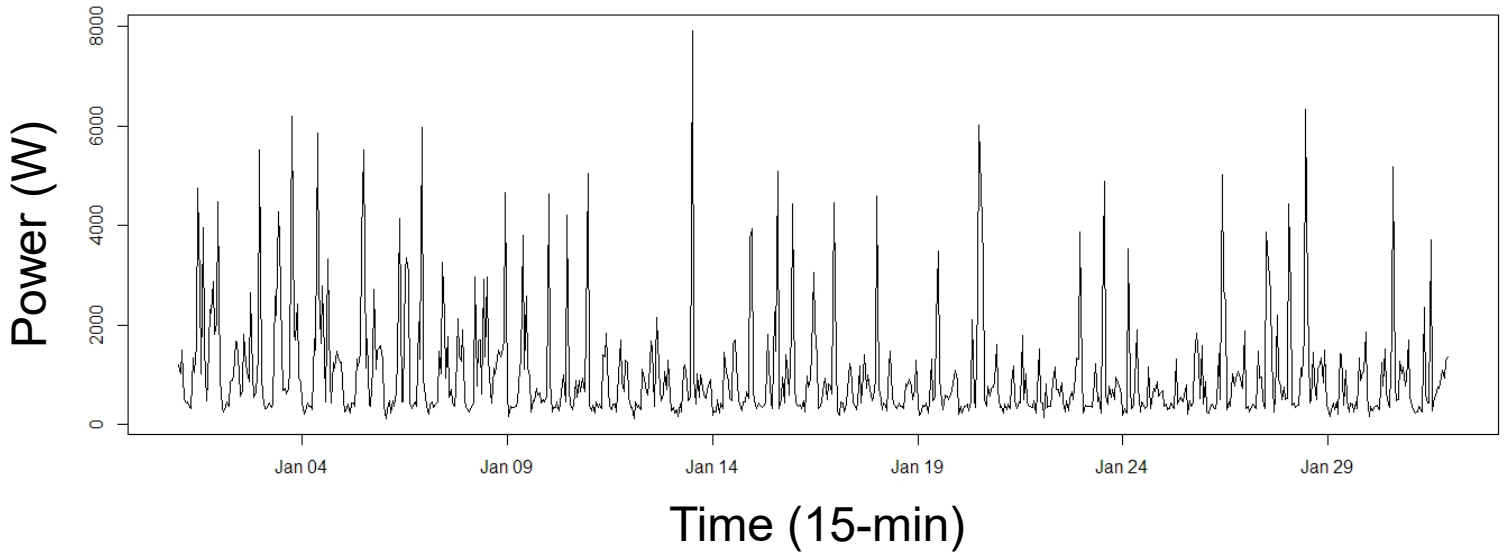
- Household electricity demand analysis
- Heat pump scenarios
- Biomass scenarios
- CHP-plants



Objectives and requirements

Based on 3D-CityGML files synthetic load profiles should be:

- Generated on building level for all types of residential buildings
- Profile generator should have no problem computing several 100 buildings
- Vary stochastically such that peaks vary in time and in magnitude
- Variable in their resolution (15-minute, hourly, daily, weekly, monthly, yearly)



Methods for generating load profiles (LPs)

Grandjean et al., 2012 & Swan and Ugursal, 2009

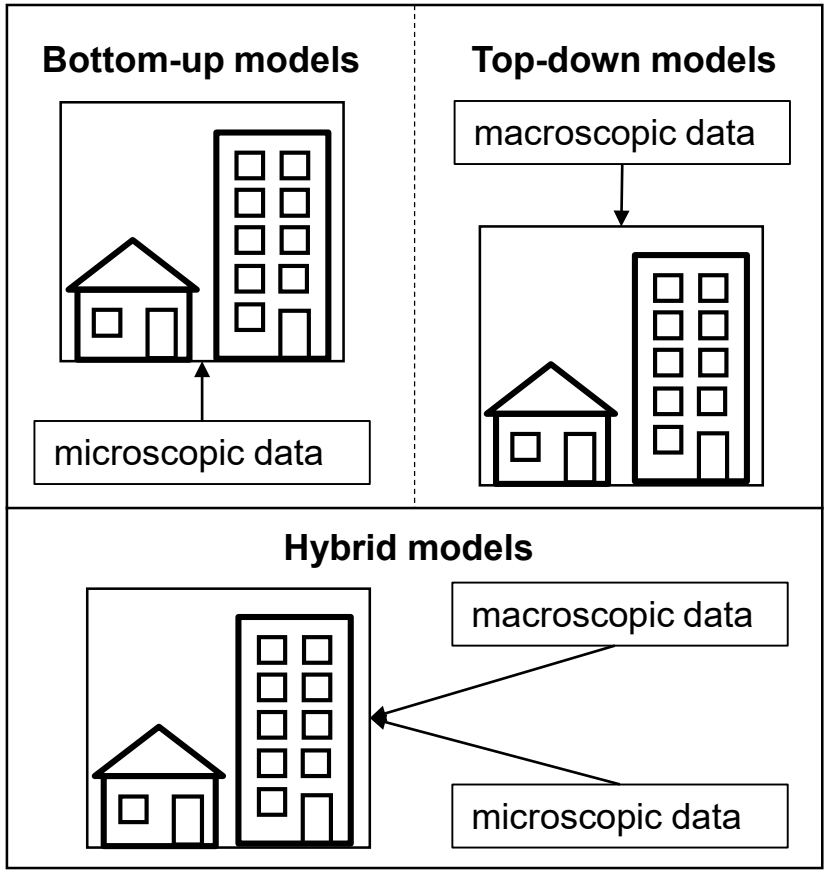
Bottom-up: Considering appliances and occupancy

- ✚ High level of detail, able to consider new technologies
- ▬ Detailed information of dwellings as input, LP generation often just for few households, complex

Top-down: Scaling down aggregated data

- ✚ Simple, trend evolutions can be generated with Status Quo
- ▬ General statistical data as input, not able to simulated impact of technical advancements

Hybrid-Models: Combine advantages of both methodologies



Source: own representation adapted from [1]

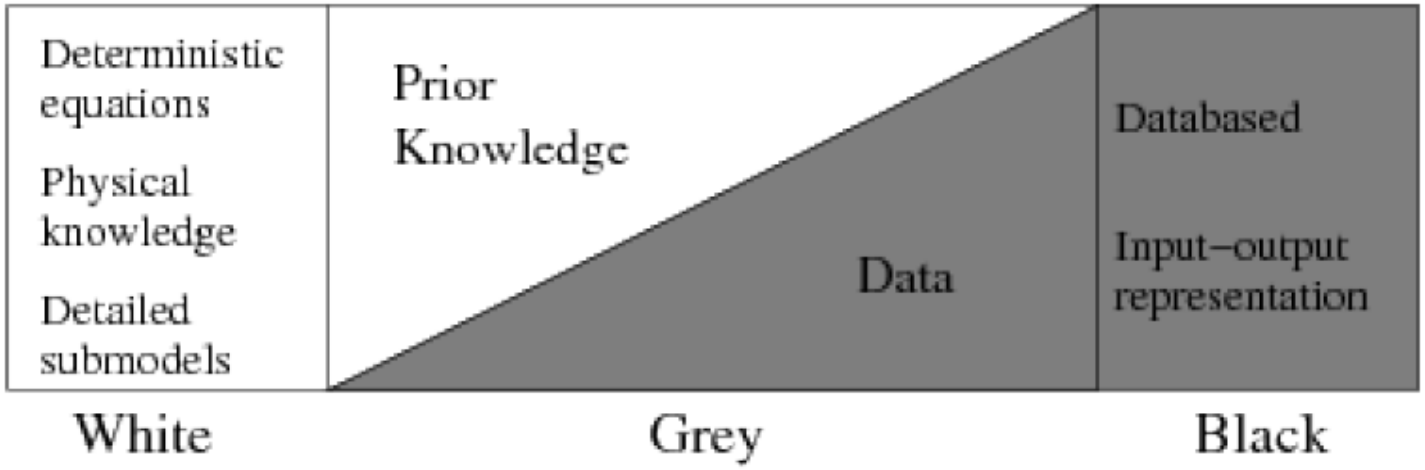
Methods for generating load profiles (LPs)

Madsen and Holst 2018

Black-box modelling: based on measured data

White-box modelling: based on physical model

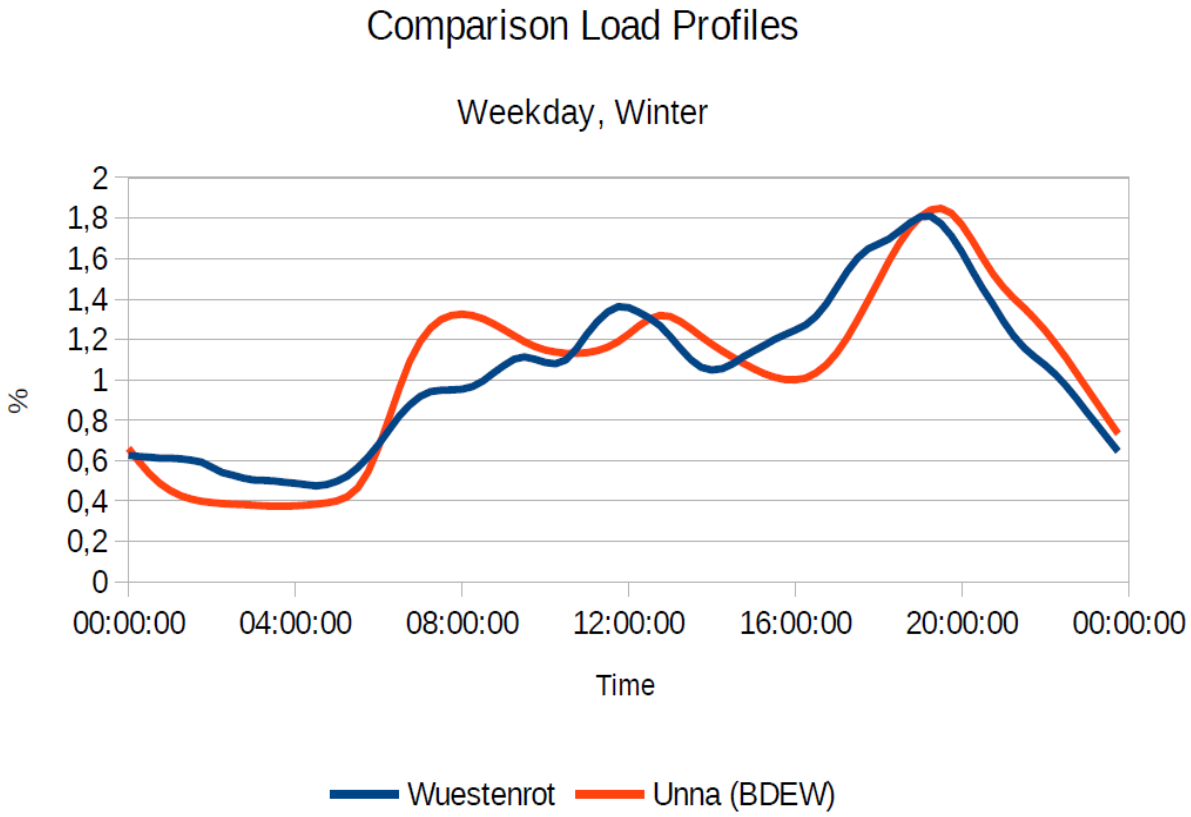
Grey-box modelling: based on measured data and physical model



Source: Madsen and Holst 2018

Data characteristics

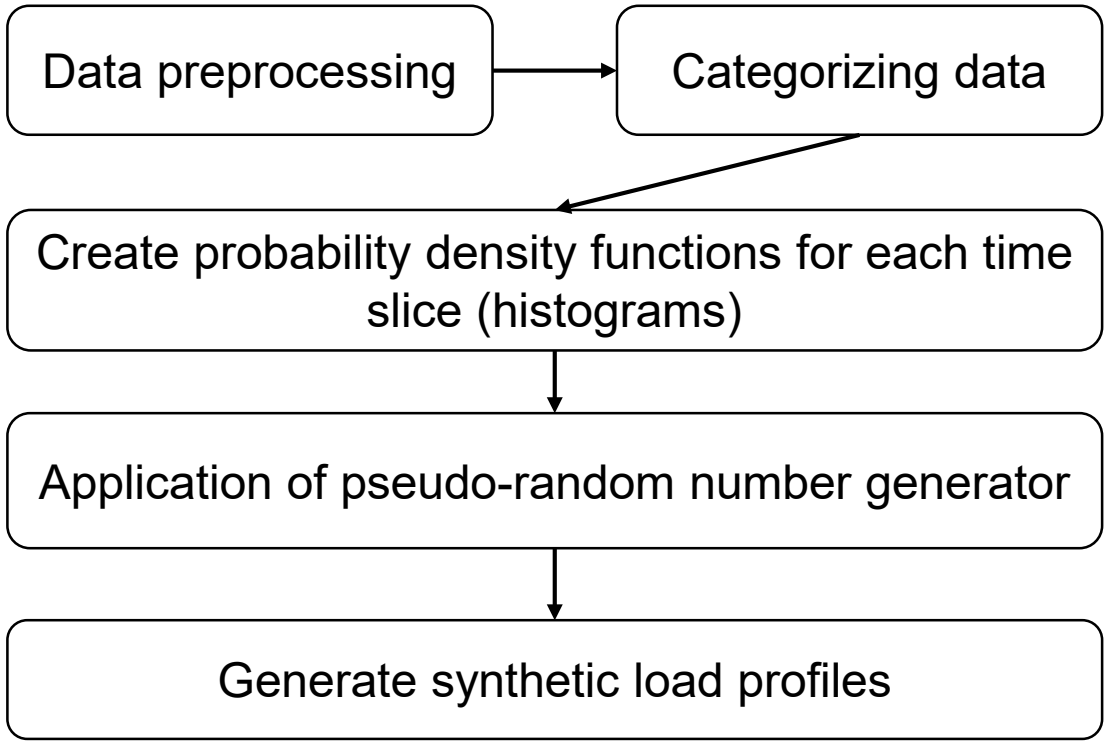
- Six single-family houses measured with smart meters
- Data used from June 2016 till April 2018
- 15-minute resolution
- Average yearly demand 3.800 kWh
- Validation of measured data through comparison to standard load profiles

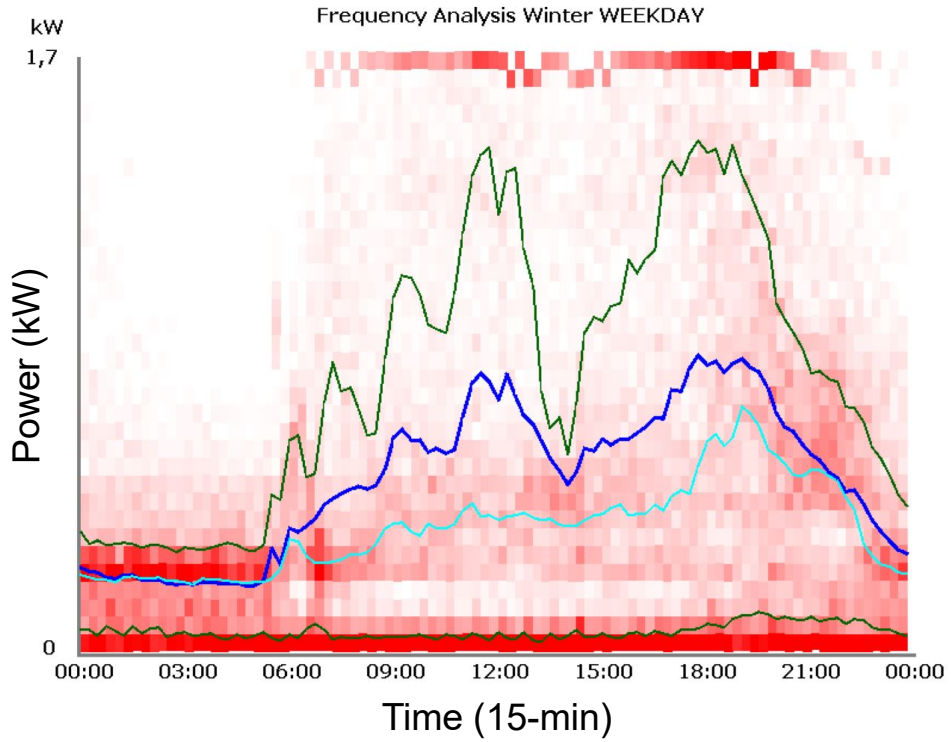


Source: Betz, Matthias: Deriving schedule information from electricity load profiles, Masterthesis, 2018

Black-box modelling approach in SimStadt

Methodology for synthetic electricity load profile generator



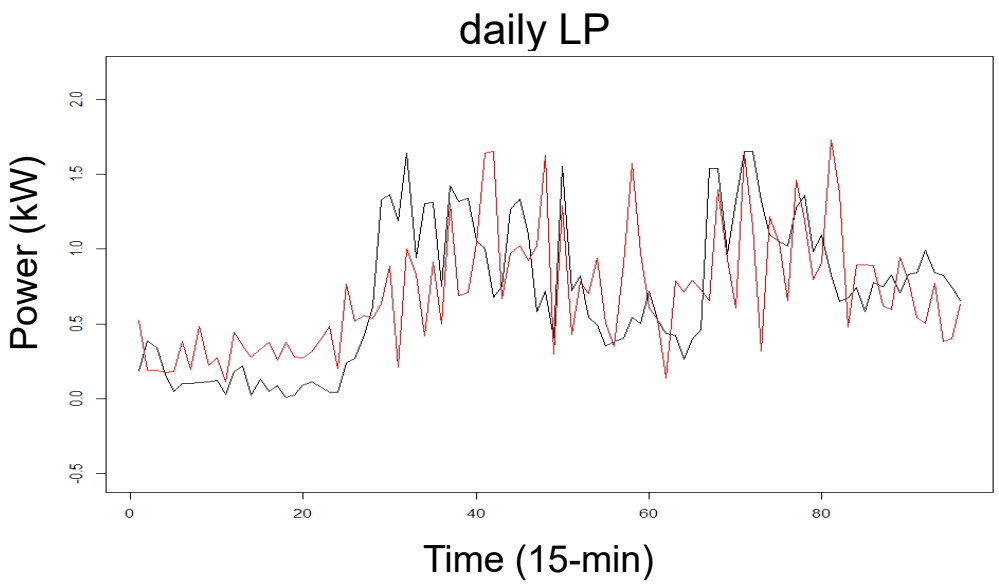


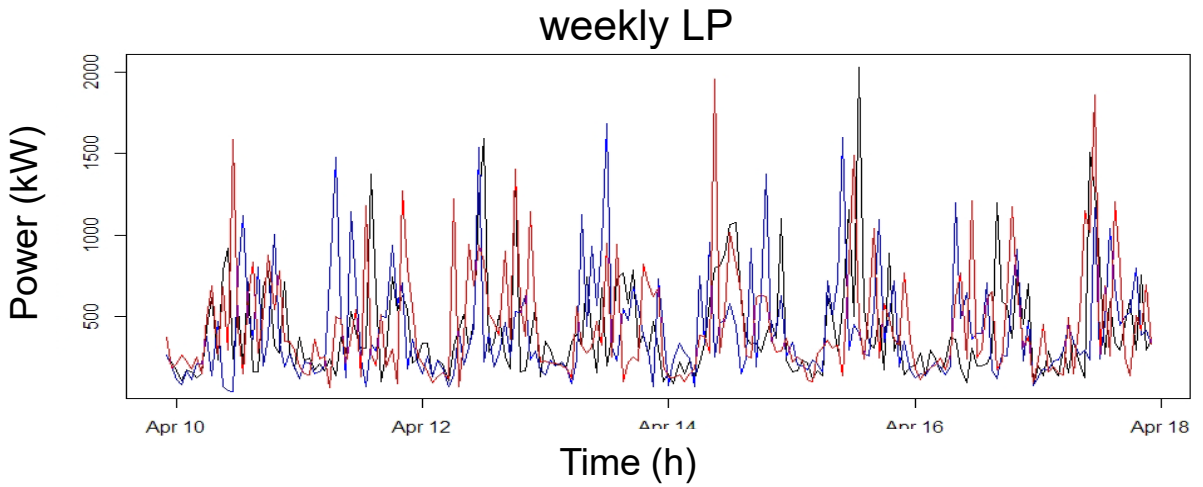
Source: Betz, Matthias: Deriving schedule information from electricity load profiles, Masterthesis, 2018

Results & Validation

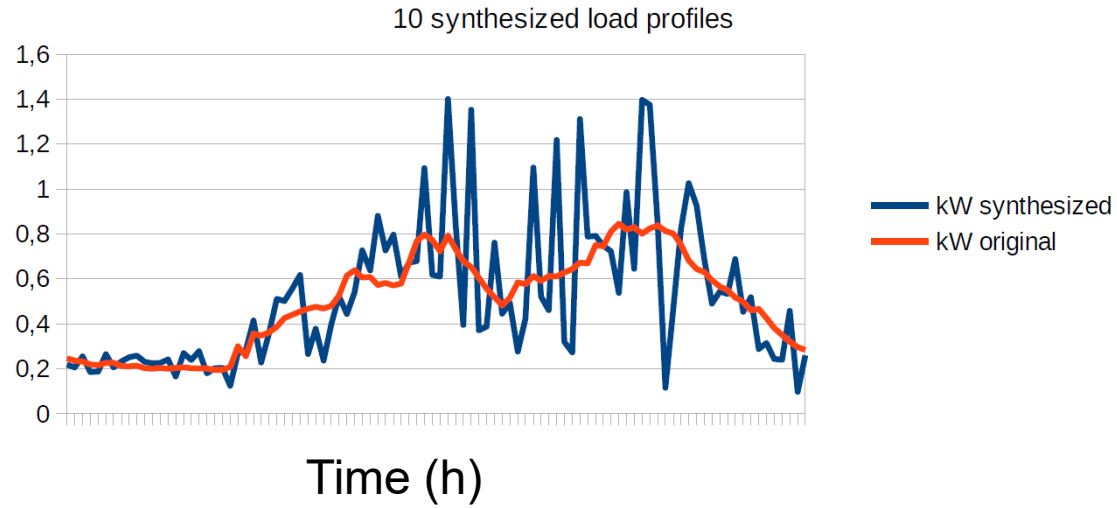
- Synthetic load profiles show desired shift in spikes and change of magnitude of the peaks
- Seasonal influence is taken into account
- Yearly demand is met

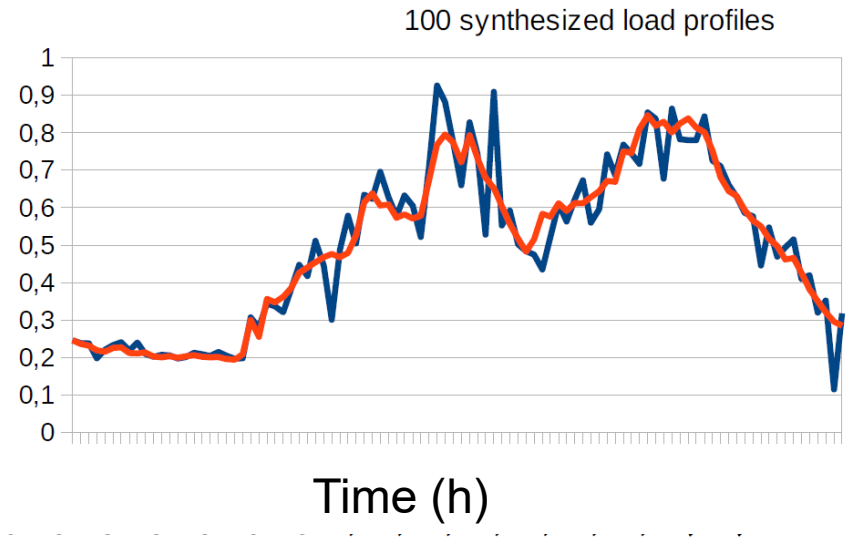
- Average number of spikes of the synthetic load curve is up to 40% higher
- Average length of the synthetic curve is 3,8 times higher

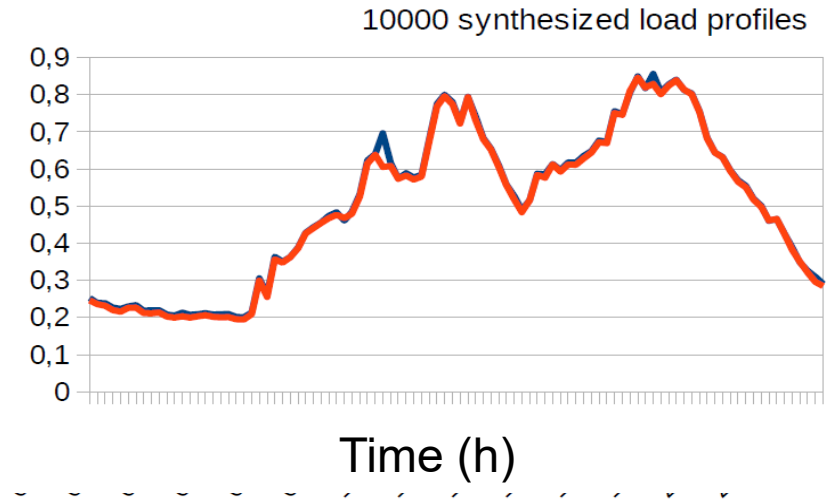




Results & Validation







Validation of synthesized load profiles through:

- Convergence to original data
- Comparison of measured electrcity demand of single-family houses
- Comparison of annual duration curves

Conclusions

- Creating a load profile generator with a relatively small data set is possible
- Load profiles show the desired stochastic variation for single-family households
- Yearly demand, seasonal influences and special daily properties are taken into account
- Computing time is fast, also possible for hundreds of buildings

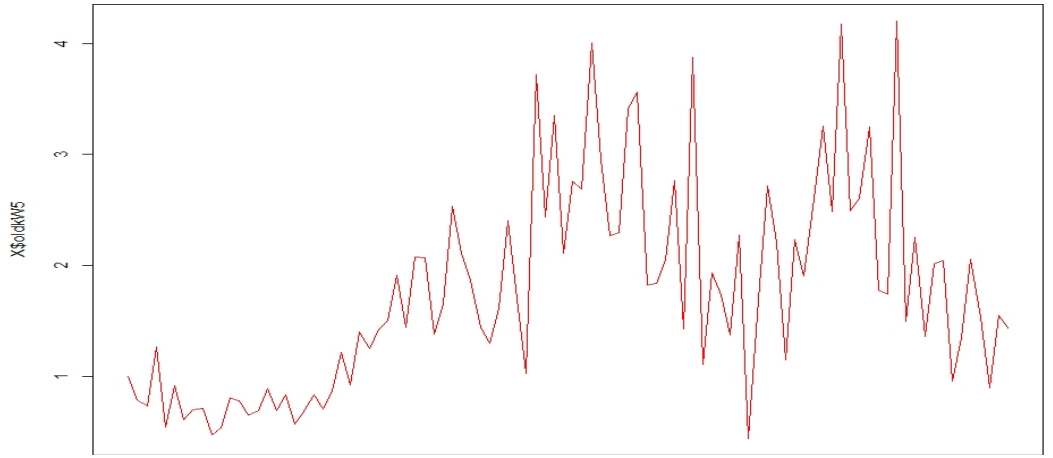
But:

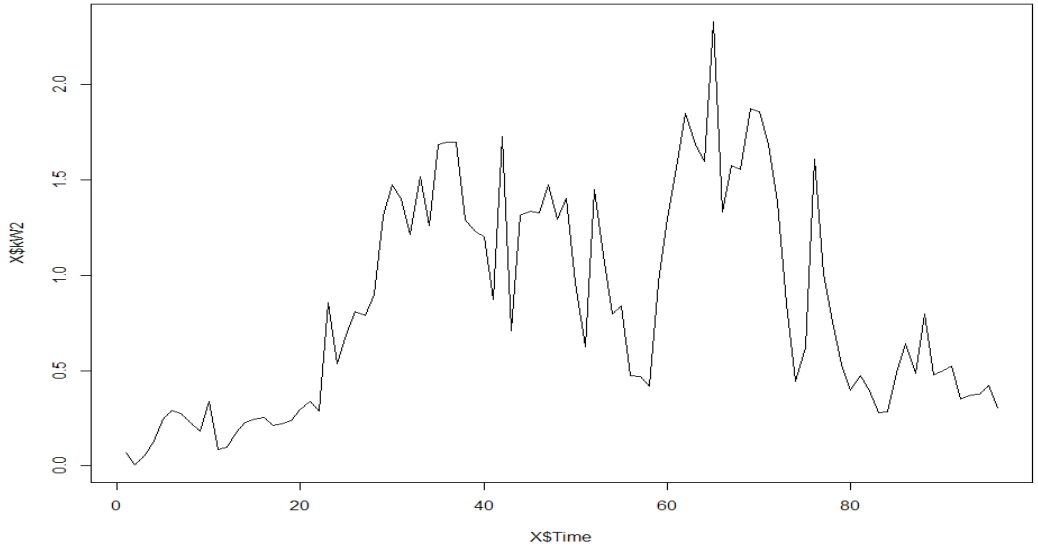
- Curves are to spiky on a high resolution
- Different building types or different households not considered yet

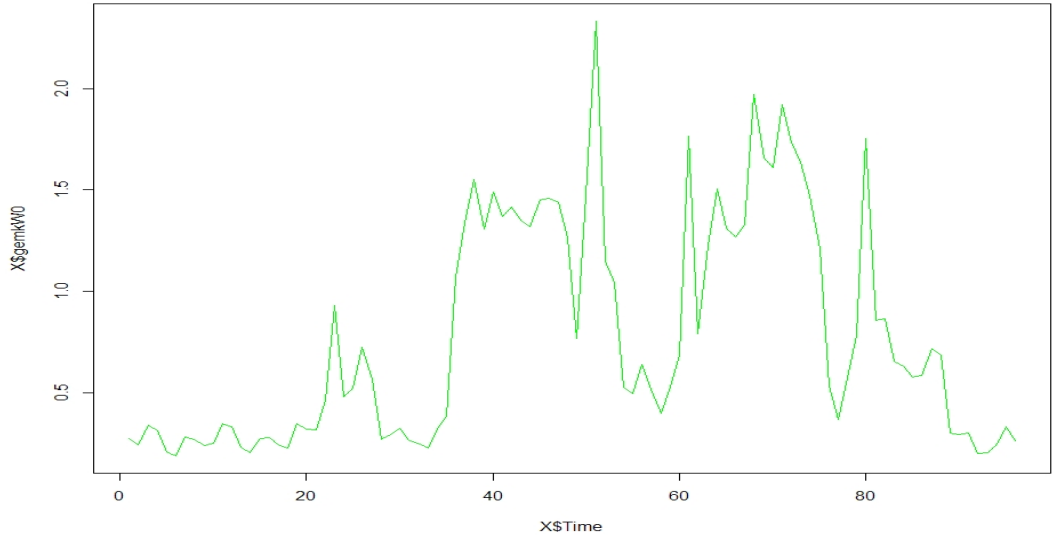
Further Plans

Including autocorrelation ✔

- Results: LPs are more „stable“ , have less spikes and a shorter curve length







Further Plans

Considering different building types and varying household demand ✓

- Validation still ongoing
- Adaption of the usage-preprocessor

- Working on measures and metric how to rate the similarity of curves
- Couple demand with electricity prices
- Simulate residual load curves for households considering consumer-technologies (heat pumps, boilers etc.) and producer-technologies (PV, CHPs etc.)

Thank you!

Questions and Comments?

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