Hochschule für Technik und Wirtschaft Berlin

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IMPACT OF THE PV GENERATOR'S ORIENTATION ON THE ENERGETIC ASSESSMENT OF PV SELF-CONSUMPTION SYSTEMS CONSIDERING INDIVIDUAL RESIDENTIAL LOAD PROFILES

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Motivation and Approach

Electricity from residential photovoltaic systems is already cheaper than the price of the electricity from the grid. Therefore PV systems with high shares of self-consumed energy are economical preferable.

For calculating the benefit of a PV system, reference results for the self-consumption rate and the degree of self-sufficiency have already been presented. Thereby the load demand, PV generator and battery size are also taken into account.

However, there could be non-negligible impacts of the individual seasonal and diurnal variations of the load and PV profile on the energetic assessment of those systems.

With the support of 74 representative measured domestic load profiles, this contribution shows up three characterization methods for the electric demand.

Further on, basic relationships between PV system size and optimum orientation will be presented by various parameter variations. Finally, calculations for typical installed PV battery systems are conducted to highlight the sensitivity of all possible PV generator orientations on the energetic performance.

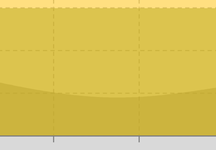
Reference PV self-consumption system and impacts on the energetic performance

- The biggest impacts are caused by seasonal and diurnal variations of the load demand and the PV generation.
- Furthermore, the system technology and the models as well as the assumptions of the simulation are affecting the calculated results.

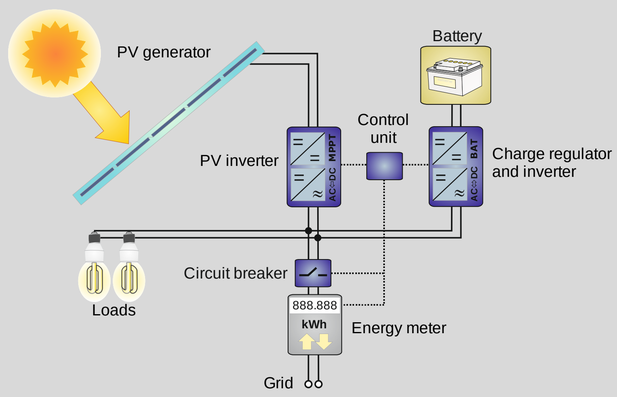
PV generation profile

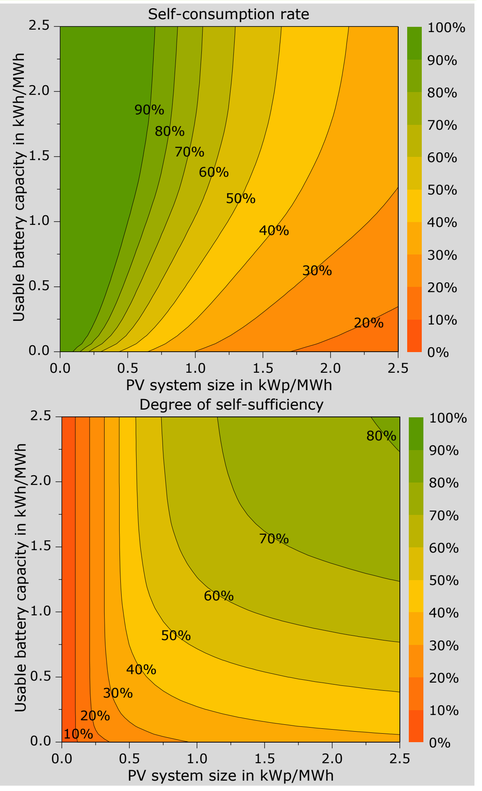
- Yearly irradiation
- Generator's azimuth angle
- Generator's tilt angle
- Location
- Shading
- Future development

Load profile

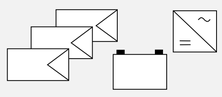


- Yearly load demand
- Type of household
- Size of household
- Electric appliances
- User behavior
- Future development





System technology



- Rated PV power
- Battery capacity
- Battery power
- Charging method
- System topology

Simulation

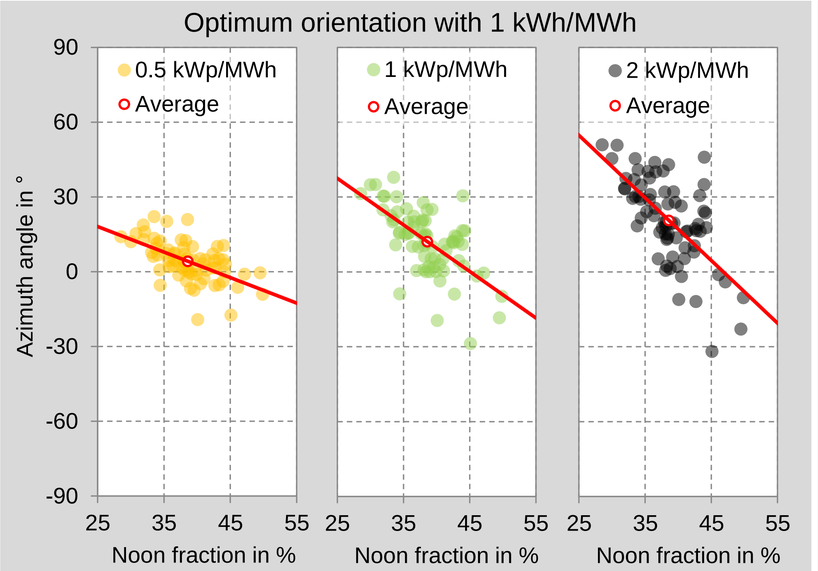
- Time resolution
- Battery model
- PV model
- Inverter model
- Assumption for losses

General conditions for the reference system:

Simulation step size:	1 Minute
Weather data:	BSRN, DWD-Station Lindenberg, Germany
Load profile:	used from VDI 4655
PV system:	south-oriented, 35° tilt angle performance ratio 83%,
Battery storage:	AC-coupled lithium-ion-battery round-trip-efficiency 84% max. inverter power 1 kW/kWh

Self-consumption rate and **degree of self-sufficiency** can be visualized by normalization the system size to the yearly load demand in MWh, see figures on the right-hand side.

Influence on the optimum azimuth angle

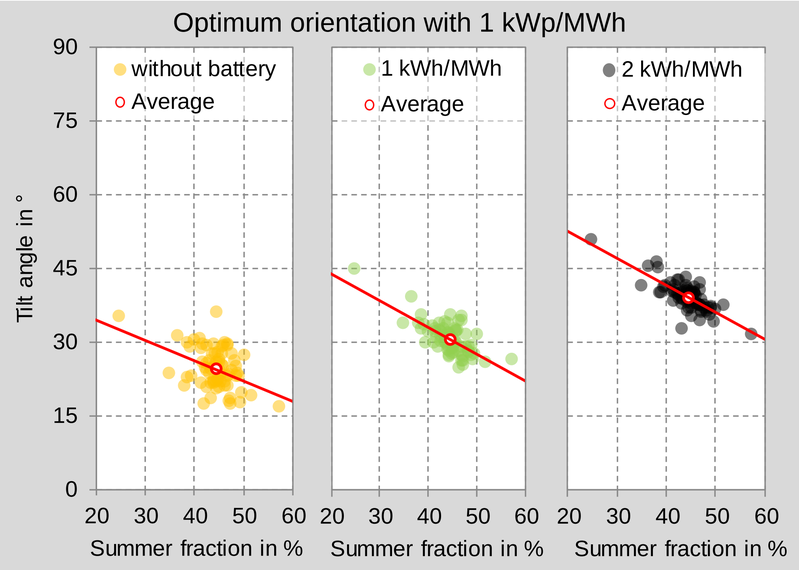


- Optimum azimuth angle in dependency of the noon fraction for 74 load profiles using a PV battery system with 1 kWh/MWh and different generator sizes.
- Low noon fractions result in stronger orientation to the west. Larger-sized PV systems amplify this sensitivity and concurrently shift the optimum azimuth even more to the west.

← Characterization of load profiles →

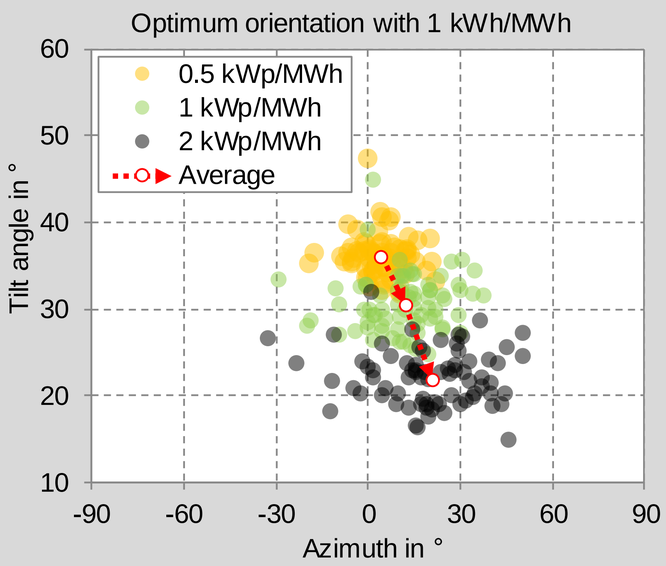
- Definition of three energetic fractions for the 74 electrical load profiles to characterize the load demand regarding seasonal und diurnal differences.
- Presumptions Low noon fractions: optimal azimuth more to the west
  Low summer fractions: optimal tilt more to higher angles

Influence on optimum tilt angle



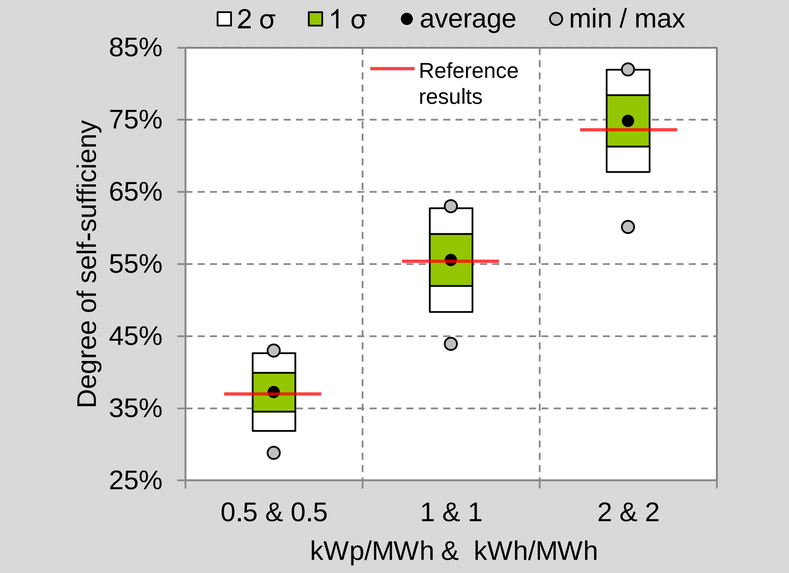
- Optimum tilt angle in dependency of the summer fraction for 74 load profiles using a PV battery system with 1 kWp/MWh and different battery sizes.
- High summer fractions result in lower tilt angles. Larger-sized battery systems don't change that sensitivity but shift the perfect tilt angle to higher levels.

Optimal orientation regarding PV size



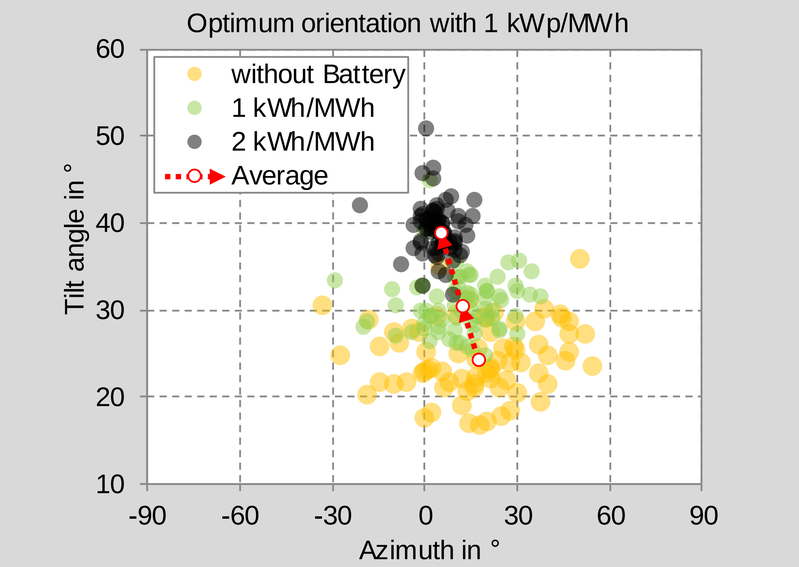
- Optimum orientation for 74 load profiles using a PV battery system with 1 kWh/MWh and different generator sizes.
- Larger-sized PV generator sizes result in lower optimal tilt angles and at the same time to a stronger azimuth orientation regarding the diurnal load demand.

Self-sufficiency of measured load profiles



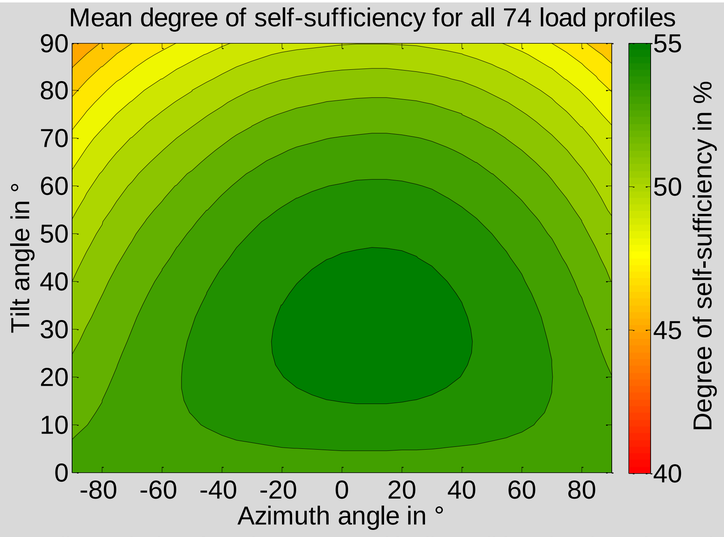
- Mean degree of self-sufficiency and statistical abbreviation for three relevant PV self-consumption system sizes as a result of 74 load profiles.
- The mean degrees of self-sufficiency deviate less than 2% from the reference results which can be seen as an approval of their general validity.

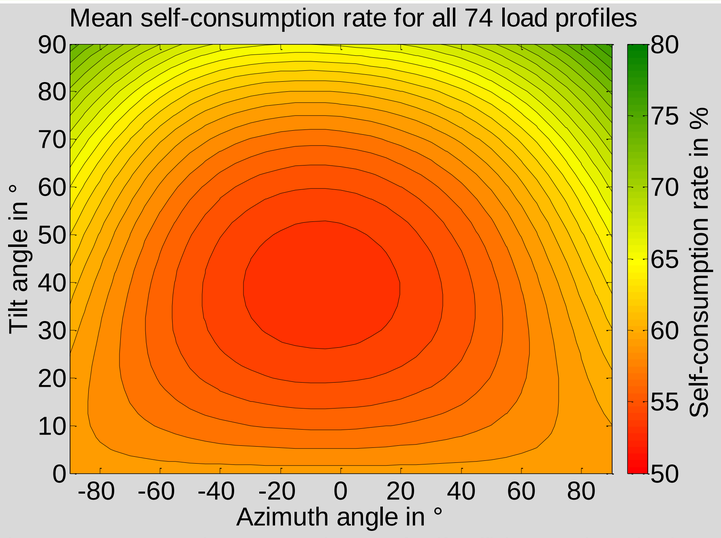
Optimal orientation regarding battery size



- Optimal orientation for 74 load profiles using a PV battery system with 1 kWp/MWh and different battery sizes.
- Larger-sized batteries result in higher optimal tilt angles and at the same time in a stronger azimuth orientation regarding the energetic PV yield optimum.

Mean energetic performance for all load profiles with 1 kWp & 1 kWh per MWh





- Regarding typical rooftops in Germany with all possible azimuth angles and tilt angles between 10° to 60° the average degree of self-sufficiency only varies between 55 and 50%. Due to the average noon fraction, which is below 50%, the optimal azimuth angle is shifted slightly to the west.
- The mean self-consumption rate is more sensitive to changes in the orientation. Furthermore, higher self-consumption rates result in lower degrees of self-sufficiency and therefore shouldn't be maximized by orientation optimization.

Summary

- **Individual load profiles together with the orientation of the PV generator have a significant impact on the energetic assessment of PV self-consumption systems.**
- **The presented characterization methods for the individual load profiles (noon & summer fraction) result in a better understanding for differences in the optimal orientation.**
- **In general, for achieving high degrees of self-sufficiency, larger-sized PV generators result in lower tilt angles and different azimuth angles, triggered by the noon fraction.**
- **Despite of that, larger-sized battery systems result in higher tilt angles and an azimuth orientation concentrating on the energetic optimum of the PV yield.**
- **Hence, the impact of the PV generator's orientation on the energetic assessment is lower than the influence of individual load profiles.**
- **The presented reference results are still reliable for a first estimation of the energetic assessment of PV self-consumption systems.**

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