PV and Battery models within IBPSA

Current developments and future strategy

Laura Maier

EBC | Institute for Energy Efficient Buildings and Indoor Climate

E.ON Energy Research Center

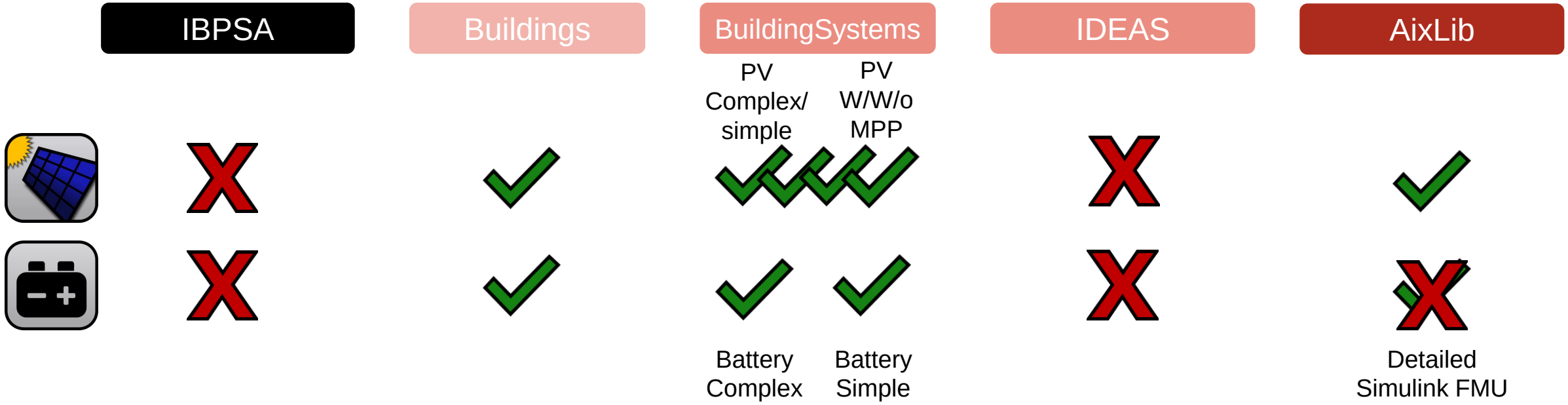
RWTH AACHEN UNIVERSITY

Overview over developments within IBPSA-related libraries

- Interconnected/grid-connected BESs become more important+ their integrated management

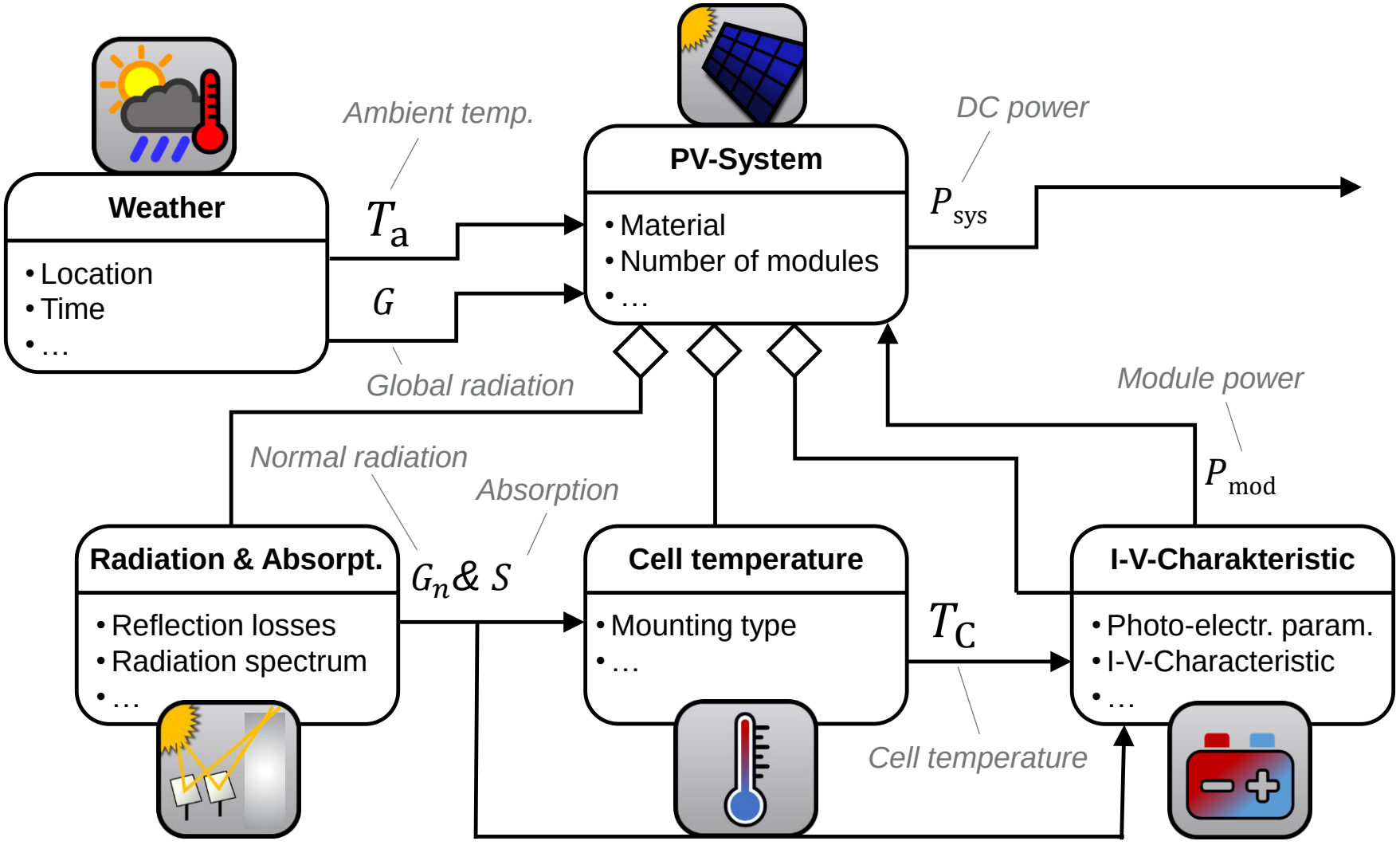
- IBPSA libraries so far mainly focused on BES itself
  - Yet, some libraries already implemented own PV and/or battery models

    → **Do we want to reinforce the integration of electricity-based components in the IBPSA context?**



Methodology – Modeling framework

- Model is easy to parameterize
  - Typical information in technical data sheets was used as parameter base
- The mounting has a huge influence on the system‘s performance
  - We included different popular cell temperature approaches to consider the effects
- We provide validation of the model based on NIST data



Modeling methods of the I-V-characteristic

Methods	Accuracy	Robustn.	Speed	Parameters
Empirical Models	✓✓(✓)	✓✓	✓✓	👎
Single-diode	✓✓	✓✓	✓✓	👍
Multiple-diode	✓✓✓	👎	👎	👍

Single-diode models offer best trade-off regarding KPIs and in the context of early-stage design!

Methodology – NIST Mono-Si plants measurement data

Ground: tilt 20°
1152 modules

Roof: tilt 10°
312 modules

Boyd, Matthew: Performance Data from the NIST Photovoltaic Arrays and Weather Station. In: Journal of Research of the National Institute of Standards and Technology 122 (2017).

Methodology – NIST Mono-Si plants measurement data

Ground: tilt 20°
1152 modules

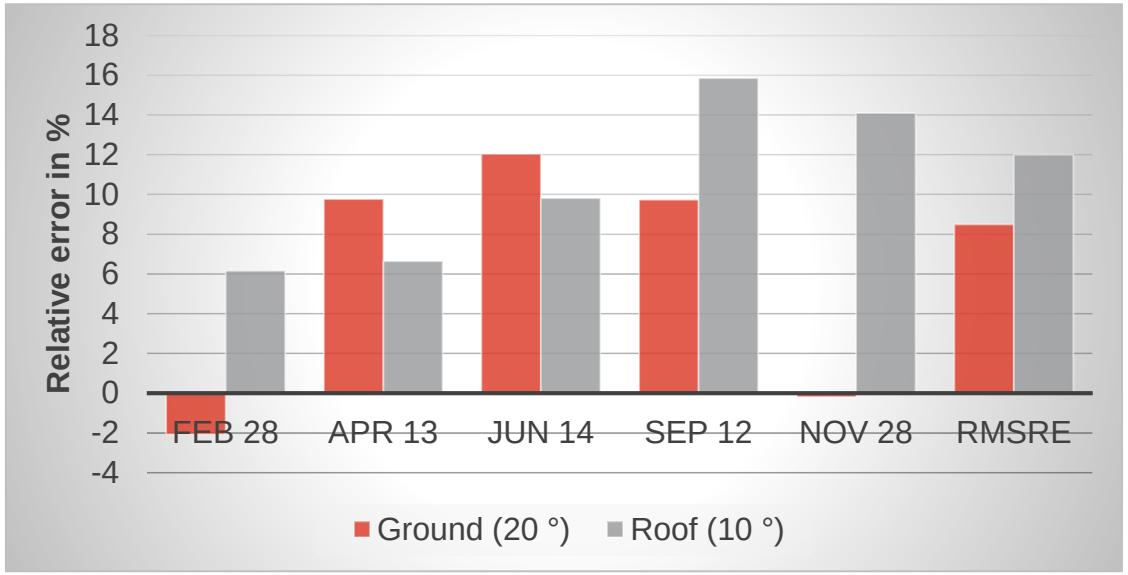
Wind shield

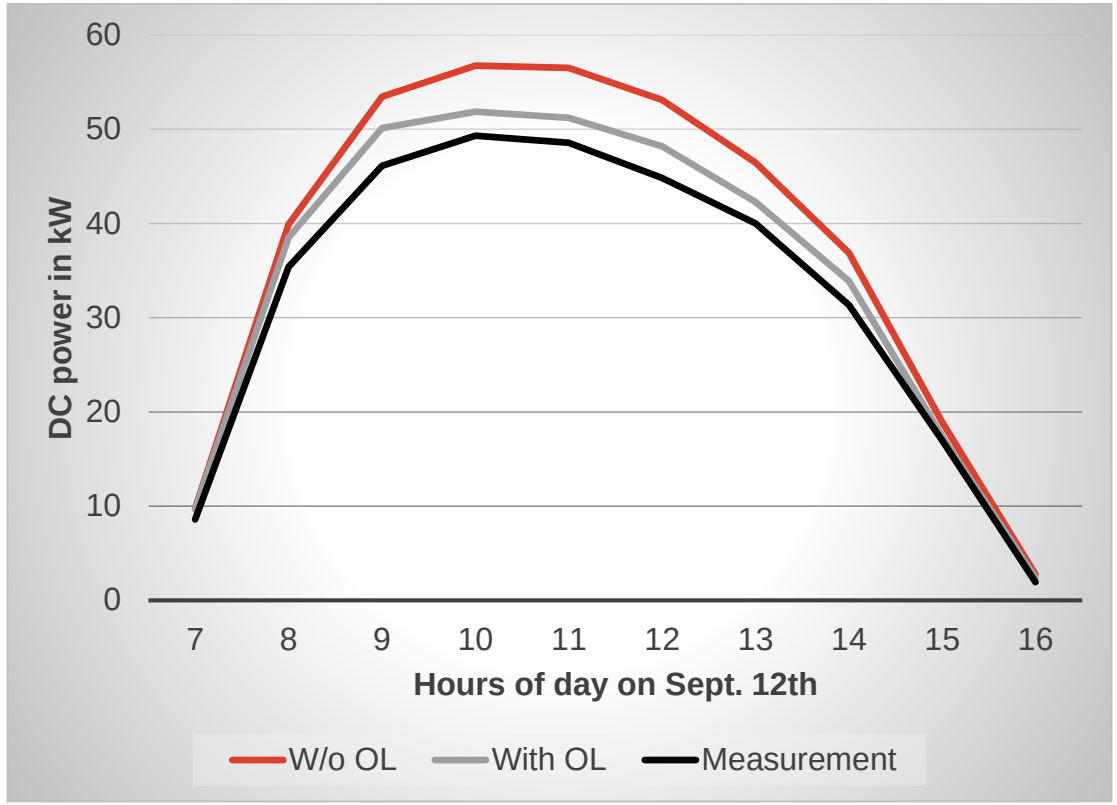
Roof: tilt 10°
312 modules

Wind shield might influence cell temperature and lead to efficiency losses!

Results – Comparison of roof and ground plant

- Model overestimates power output
  - Neglection of operation losses (staining, shading, ageing, etc.)
- Ground plant results are better than roof plant ones
  - Wind shield might influence results
- When Ohmic line losses are considered
  - Model error decreases from 16 to 7 %!





Ohmic losses are not considered due to increased conplexity!
Maybe include a „tuning“ factor to integrate further losses?

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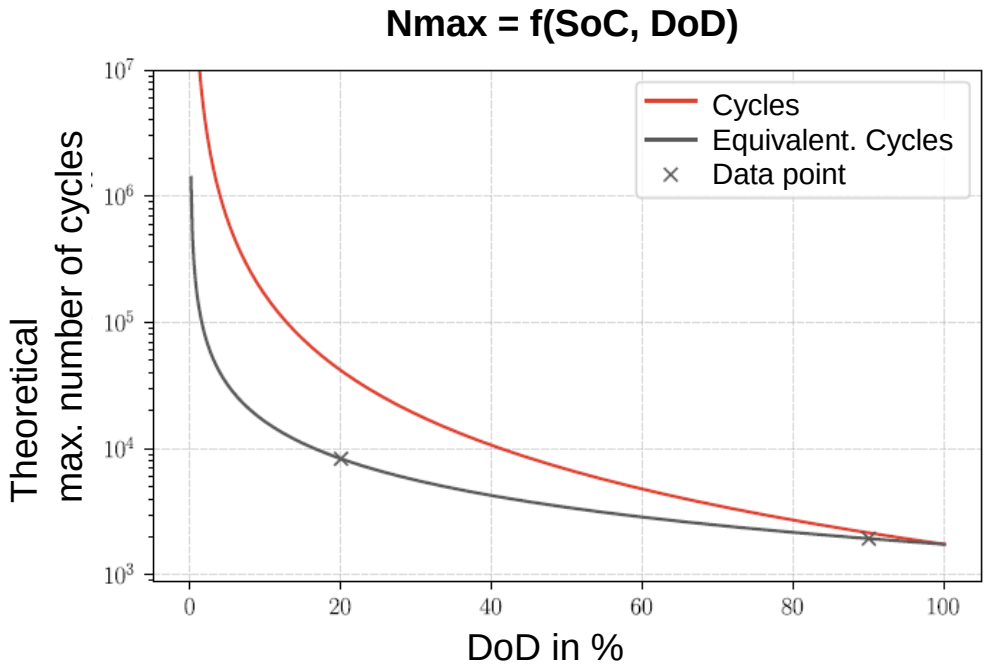
Preceding developments at RWTH Aachen: M5BAT

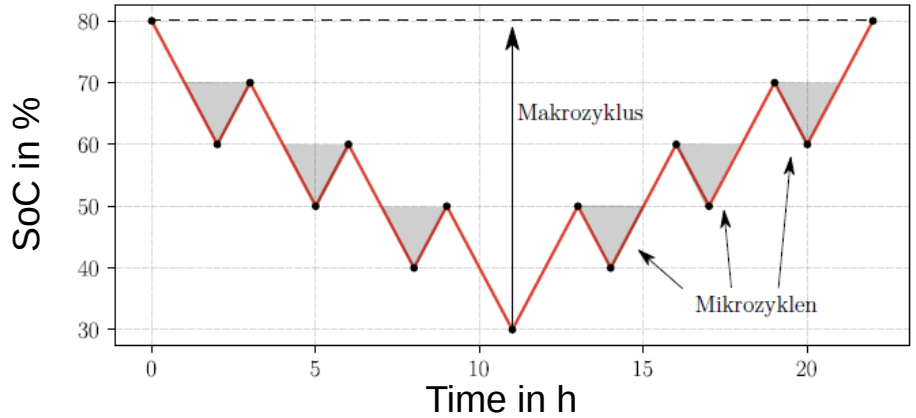
Why do we need a detailed battery model?

- Often battery as part of building load management such as MPC
  - Too simplified battery models lead to wrong sizing and operation of BES components
- Batteries‘ exhaust heat can be used as part of BES concept

Features of RWTH Aachen model:

- Lithium Ion battery
- Validated based on 3 MW battery test bench
- Load dependent efficiencies
- Calendrical and cyclic ageing (State of Health)
- Exhaust heat model





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Outlook and future research questions

- **Do we want both a PV and battery model in the IBPSA Modelica library?**
  - As a combination of all preceding and ongoing research efforts

- **Future steps:**
  - Form task force to include PV and battery model and other electricity-based components?
    - Maybe as part of Project 2?
  - Agree on needed features of models and uniform model/package structure
    - PV with degradation: yes or no?
    - Include battery ageing: yes or no?
  - Agree on validation data
    - Maybe use E(lectrical)-HiL from EBC RWTH Aachen?

  - What about wind turbines (see Buildings library)?
  - What about electric vehicles?

Laura Maier
Mail: laura.maier@eonerc.rwth-aachen.de
Tel.: +49241 80 49795
RG: https://www.researchgate.net/profile/Laura-Maier-3

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