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Case study of a passive house with façade integrated photovoltaic system

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Outline

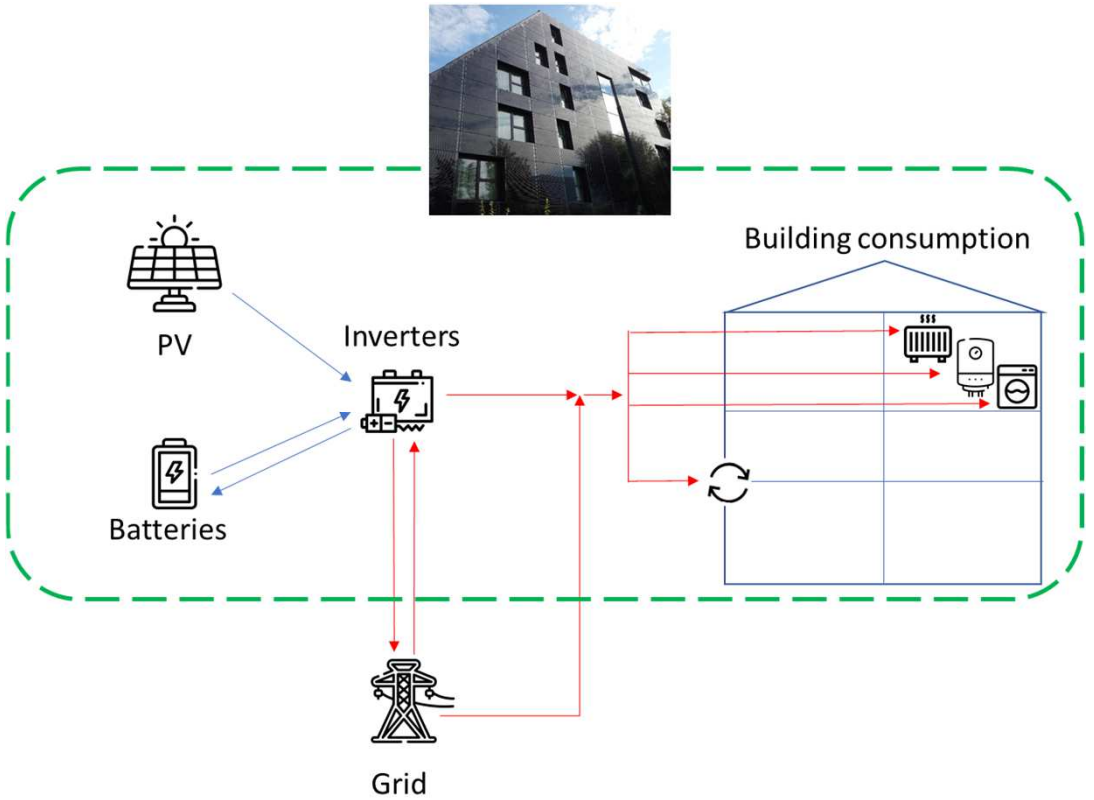
- Building case study
- Concept and motivation
- Methods
- Results
- Conclusions and outlooks

Building case Study

South view of the building case study

- Innsbruck (Austria)
- Passive house standard
- 999.96 m^2 (14 studio flats + common rooms)
- Decentralised-electric system (SH+DHW)
- South façade covered by PV (32.0 kWp)
- 3 electric batteries (total capacity of 20 kWh)

Building case Study



Scheme of the energy fluxes (DC in blue, AC in red) among the PV system, the building and the grid. Icons made by Freepik from www.flaticon.com

Concept and motivation

Datasets:

1. Monitoring data: 2019 – 2020
2. Passive House Planning Package (PHPP) integrated with PVecon[a]
3. Dynamic simulations: Simulink model with CARNOT library

Cases:

- System with batteries (as in reality)
- System without batteries

Outputs:

- ❖ PV production
- ❖ PV self-consumption

[a] *IEA SHC Task 56, 2020. PHPP sheet for HP monthly calculation and PV self consumption.*

Concept and motivation

- Comparison tools – monitoring
- Evaluation adoption of the electric batteries

Methods

1. Monitoring data: 2019 – 2020
2. Passive House Planning Package (PHPP)
3. Dynamic simulations

Inputs:
- Monitored building energy consumption (2019 – 2020)
- Monitored climate (2019 – 2020)

Methods

Index	Description	Purpose	Recommended thresholds in ASHRAE Guideline 14-2014
NMBE [%] Normalized Mean Bias Error	$\frac{\text{Average of the monthly differences}}{\text{Monitored annual energy}}$	Annual-balance difference	± 5%
NRMSE [%] Normalized Root Mean Square Error	$\frac{\sqrt{\sum \text{monthly difference}^2/12}}{\text{Annual average monitored energy}}$	Monthly-balance difference	15%

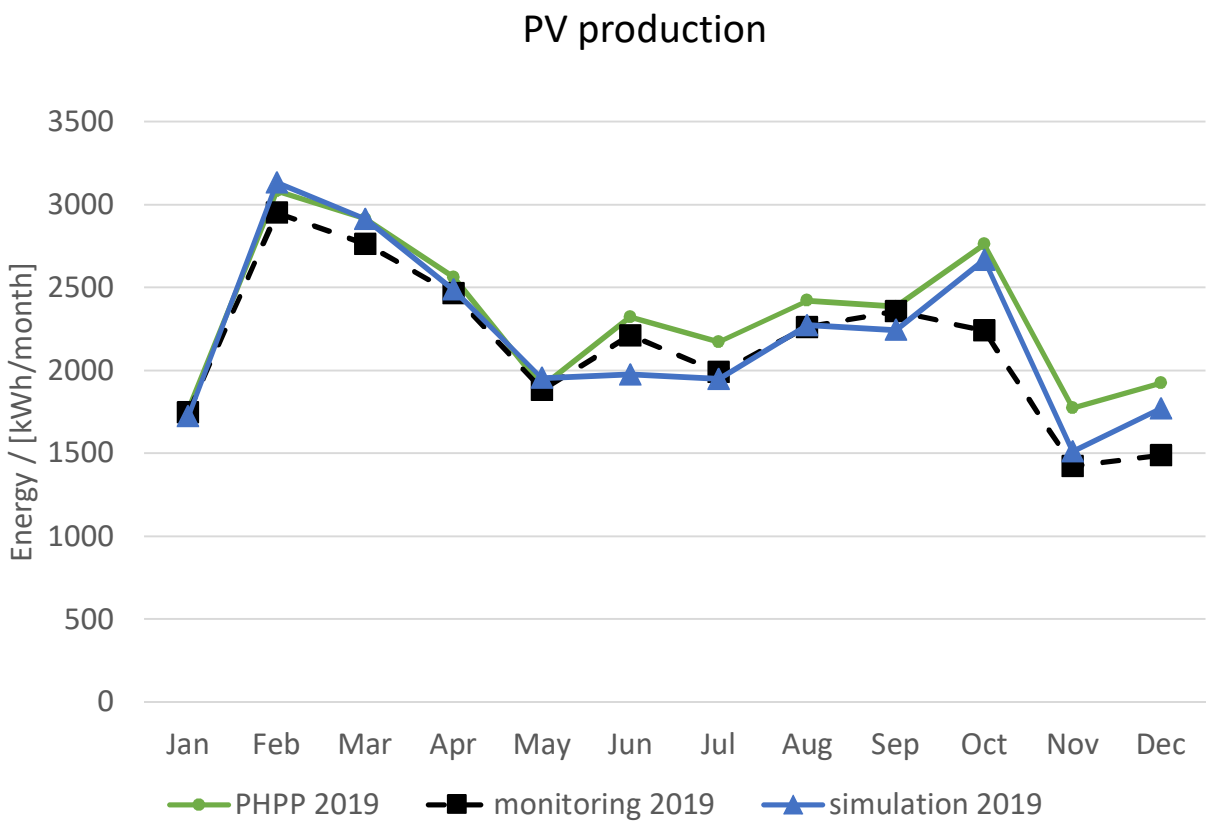
Magni Mara, Fabian Ochs, and Wolfgang Streicher, 2022. Comprehensive Analysis of the Influence of Different Building Modelling Approaches on the Results and Computational Time Using a Cross-Compared Model as a Reference. Energy and Buildings. https://doi.org/10.1016/j.enbuild.2022.111859.

Methods

Load Cover Factor: $$LCF = \frac{PV\ self\ consumption}{building\ energy\ consumption}$$

Supply Cover Factor: $$SCF = \frac{PV\ self\ consumption}{PV\ production}$$

Results

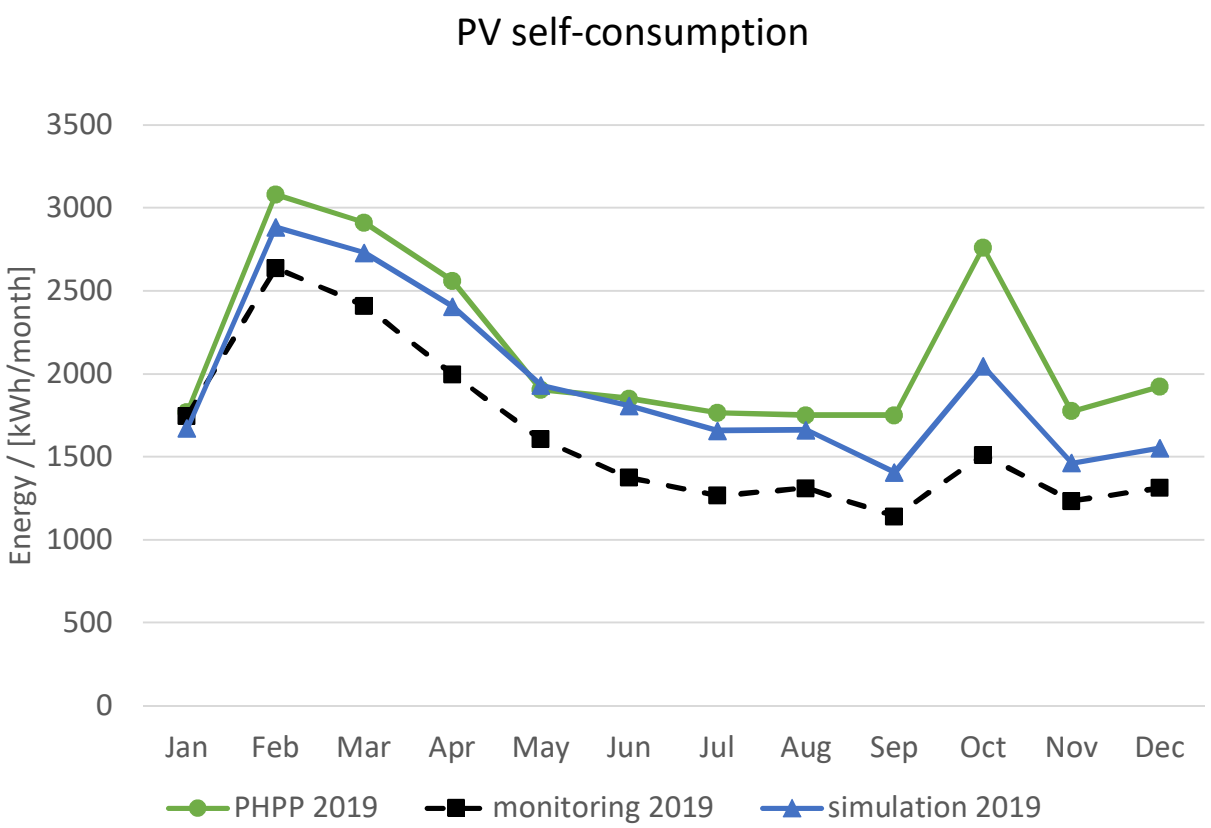


PV production

	PHPP	Simulation
NMBE	0.7 %	0.4 %
NRMSE	10.6 %	8.9 %

Average values 2019-2020

Results



PV self-consumption (with battery)

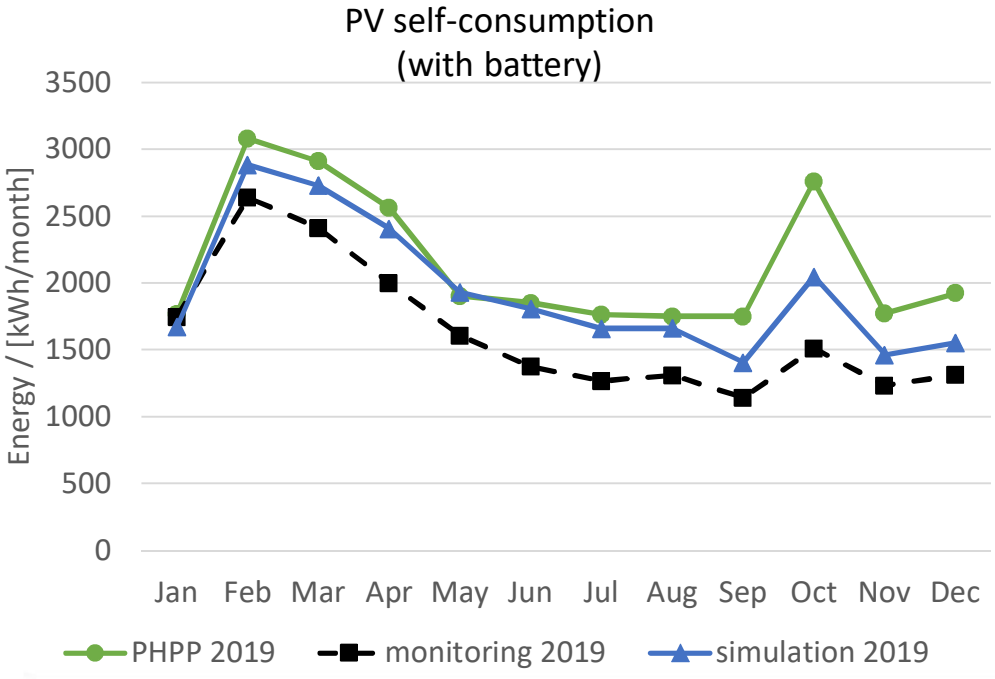
	PHPP	Simulation
NMBE	2.7 %	1.7 %
NRMSE	35.2 %	21.3 %

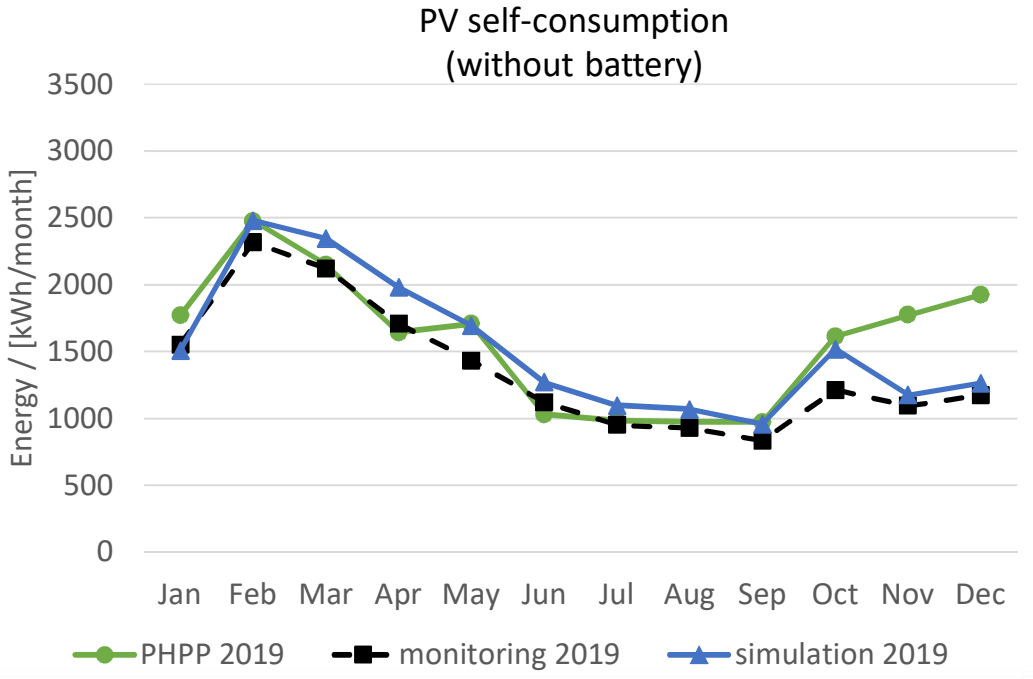
Average values 2019-2020

Results

	PV self-consumption (with battery)		PV self-consumption (without battery)	
	PHPP	**Simulation**	**PHPP**	**Simulation**
NMBE	2.7 %	1.7 %	1.6 %	1.1 %
NRMSE	35.2 %	21.3 %	29.5 %	13.9 %

Average values 2019-2020





Results

	LCF		SCF	
	With batteries	**Without batteries**	**With batteries**	**Without batteries**
Monitoring (2019)	30%	25%	76%	64%
PHPP (2019)	41%	30%	92%	68%
Simulation (2019)	35%	28%	87%	69%

Conclusions and outlooks

- Good match between monitoring and tools results
- Battery adoption: +5% LCF, + 12% SCF
- With battery: lower monitored self-consumption than tools results
  - Uncertainty on monitoring data
  - Assumption on the batteries properties and control
  - Simplified battery models in PHPP and Simulink

- PHPP, PVecon: monthly factors of self-consumption
- Simulink, CARNOT library: effect of temperature and cycle of charge and discharge

Thank you for your attention

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