Heating with PV Façade in a Passive House

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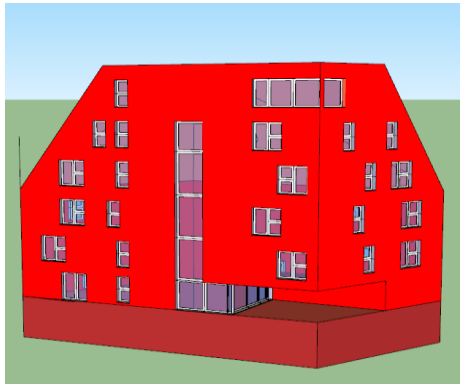
ADVANCED BUILDING SKINS

Outline

- Building and concept
- Method and results
- Primary energy evaluation

Building & Concept

- MFH in Innsbruck, Austria for temporary assisted living environment
- **Passive House** (9 kWh/m²a)
- 14 flats (~35 m² each) + common areas
- **PV** on the **south façade** 27.3 kWp
- **Electric radiators** for space heating
- **Electric boilers** for DHW
- Mechanical ventilation with heat recovery



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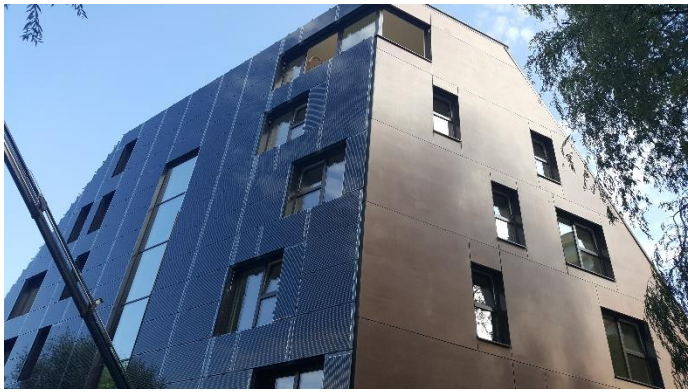

Building construction

Construction through prefabricated concrete elements

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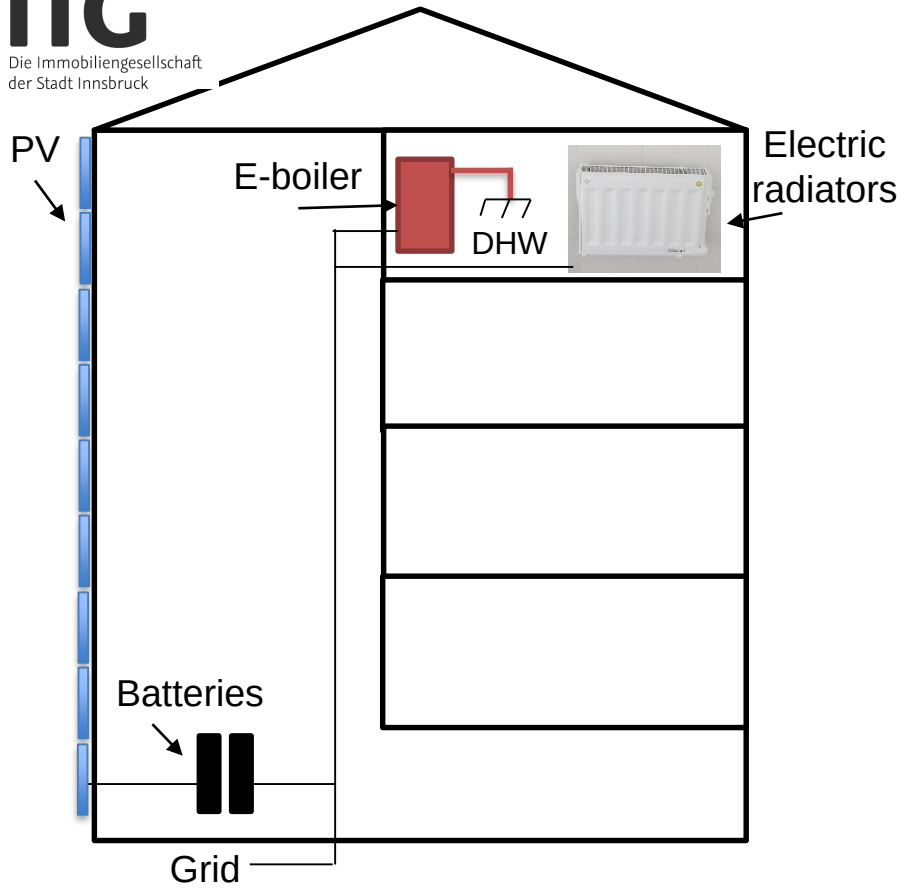
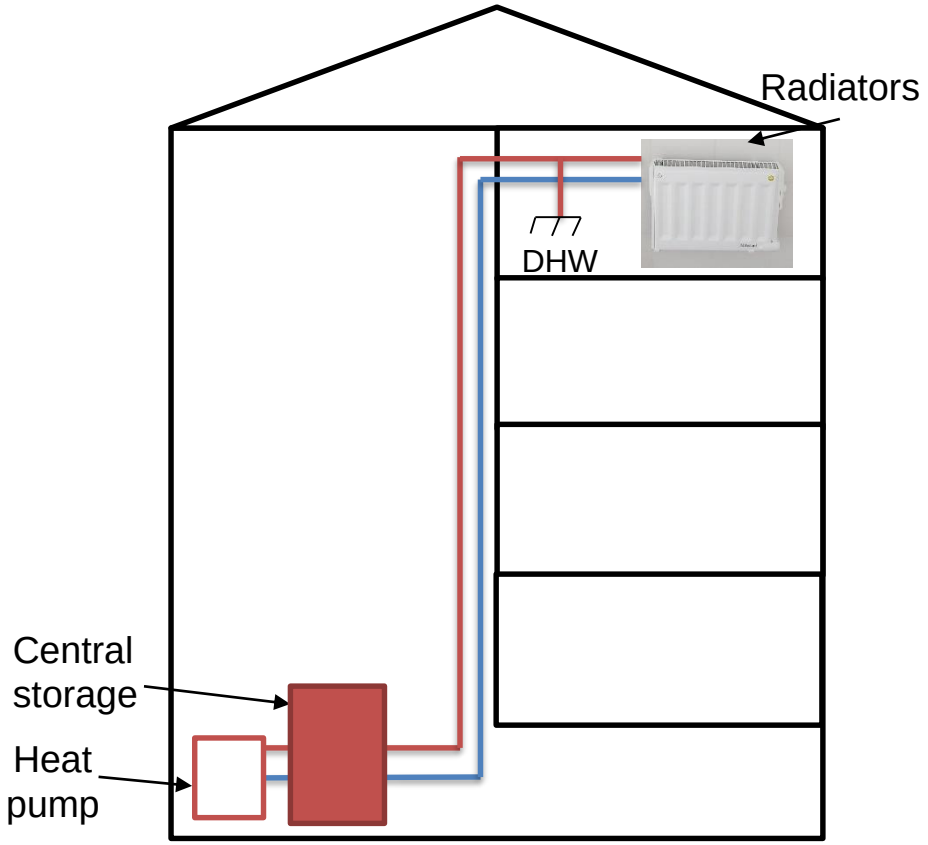
Concept

Installed decentralized system:
Direct electric heating & DHW
Almost no pipes



Centralized system
2- or 4-pipe distribution system



Motivation

Investigate a **direct electric** system in **combination** with **PV** on the **façade**

- keep the investments costs low
- minimize the installation effort
- eliminate the distribution losses
- increase the share of on-site renewable energy production using the available space in the façade

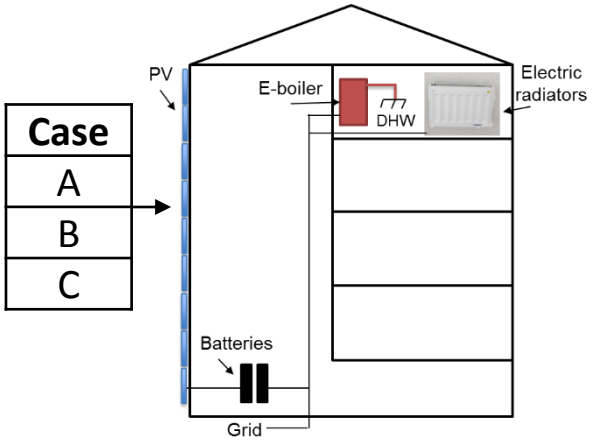
Method

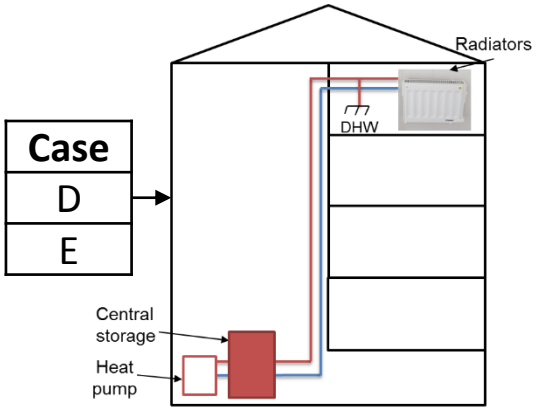
Calculation tool: **PHPP**

1. Compare the PV algorithm in PHPP vs Matlab/Simulink
2. Perform a **parametric study** in PHPP
   Installed decentralized system vs centralized heat pump systems by comparing:
   a. Final energy (here electricity)
   b. Primary energy (PE) using:
      i. annual PE factors
      ii. monthly PE factors

Parametric study

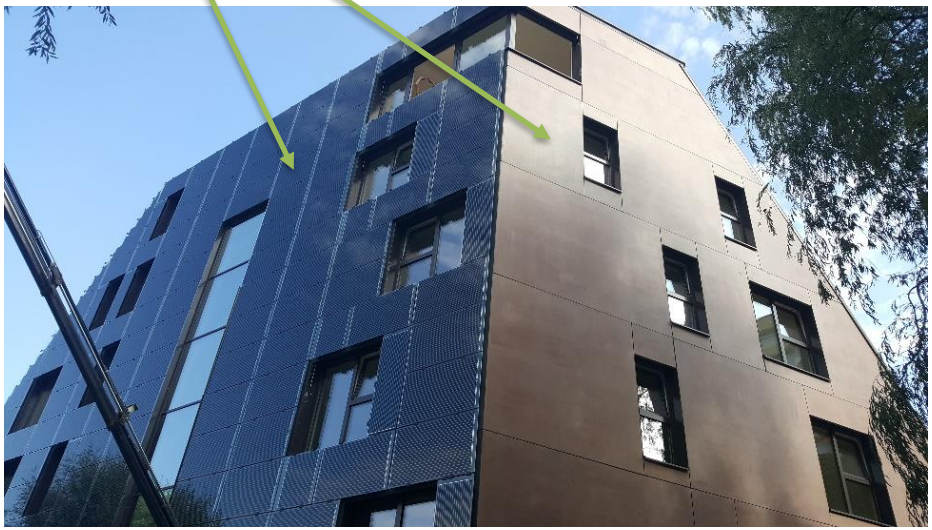
Case	System description	PV
A	**Direct electric system with PV in the South façade**	27.3 kWp – South facade
B	System of case A plus shower **drain-water heat recovery**	27.3 kWp – South facade
C	System of case A plus **PV** in the **East and West façade**	57.9 kWp – South, East & West facade
D	Reference centralized **air-source heat pump** (4-pipe distribution system)	-
E	Reference centralized **groundwater-source heat pump** (4-pipe distribution system)	-



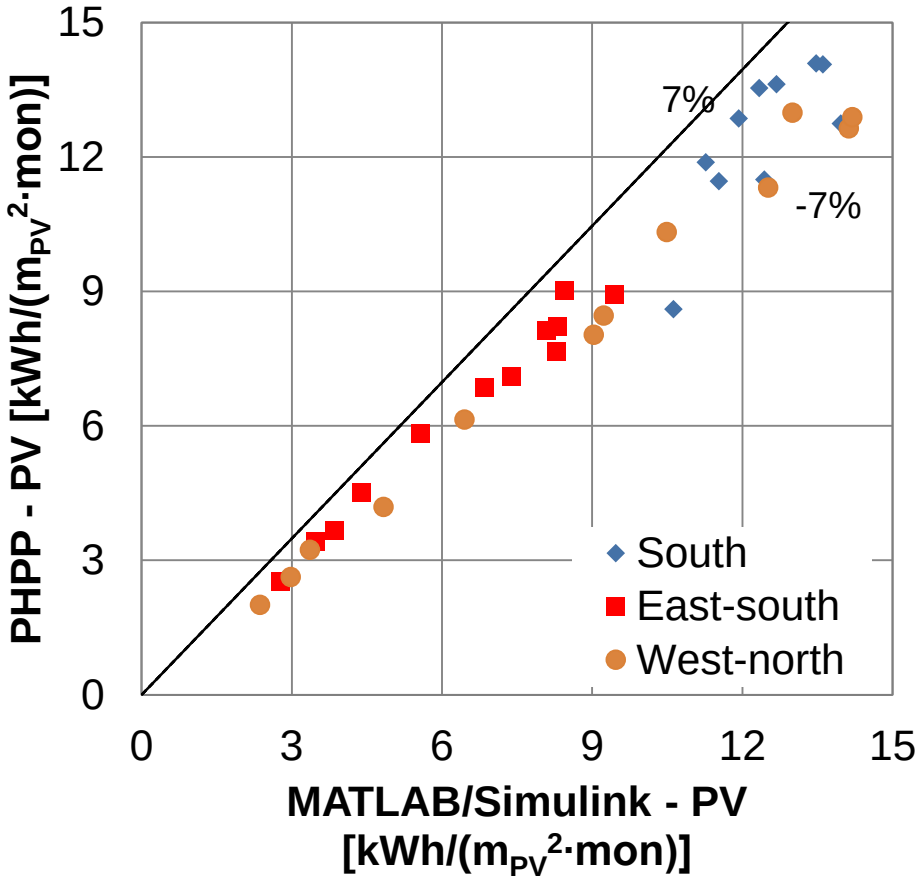


Parametric study - PV on the facades

	Area [m^2]			
	Façade	**Façade without windows**	**PV**	**Covering percentage**
South	374	285	211	74%
East	184	144	104	72%
West	242	215	133	62%



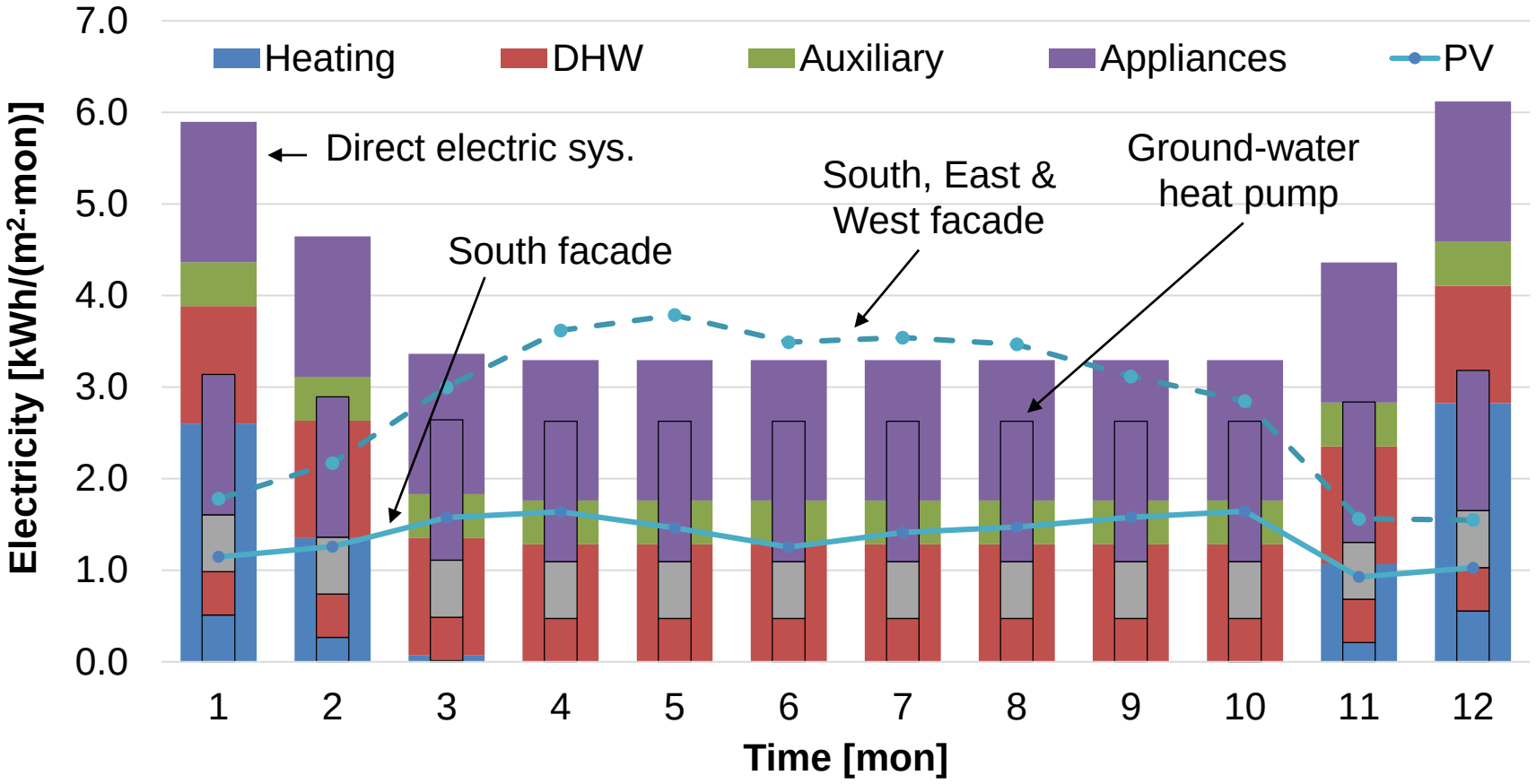
PV yield - PHPP vs Matlab/Simulink



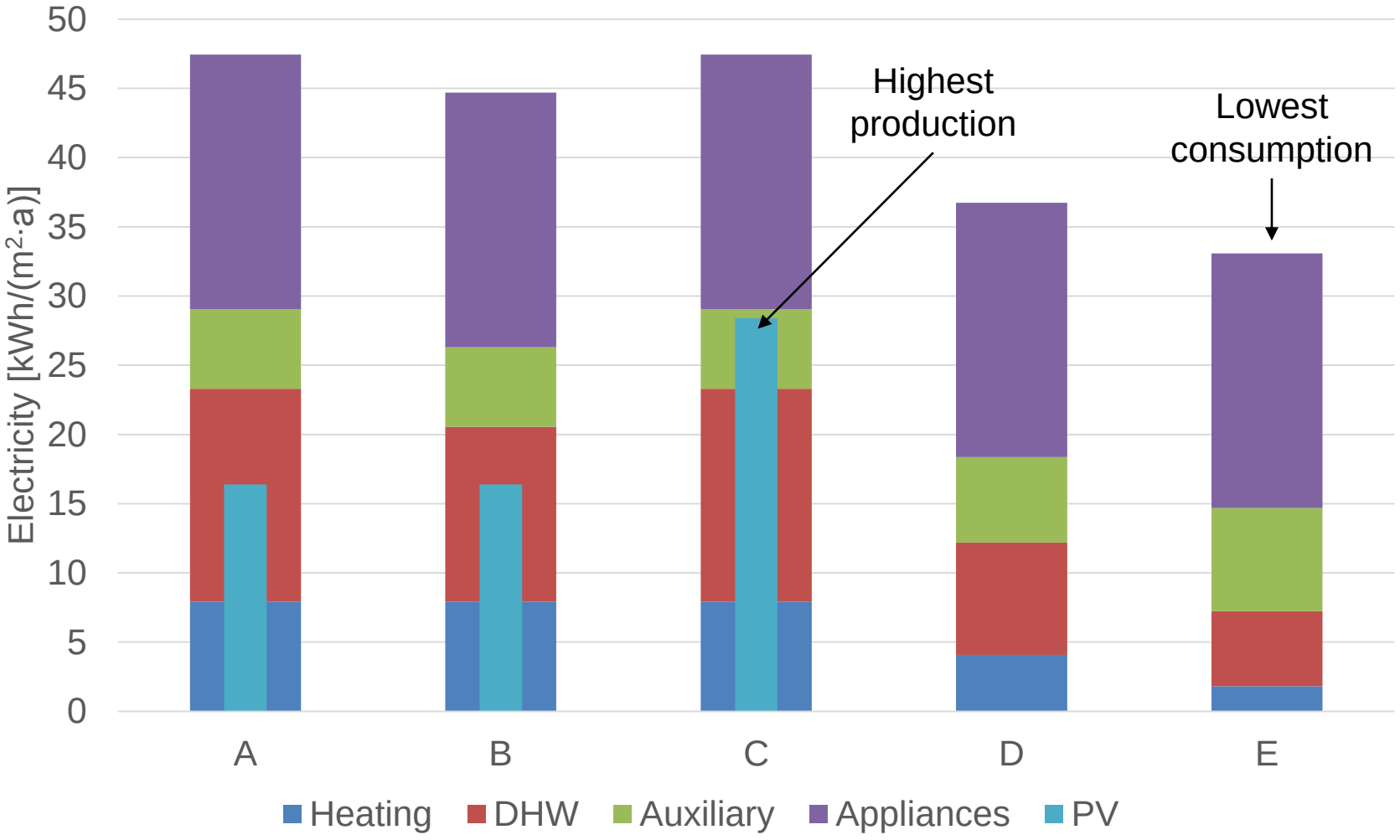
Annual values	Difference PHPP Matlab/Simulink	
	South façade	South, east & west façades
Solar radiation	-1%	-3%
BIPV yield	1%	-1%

Good agreement between the tools

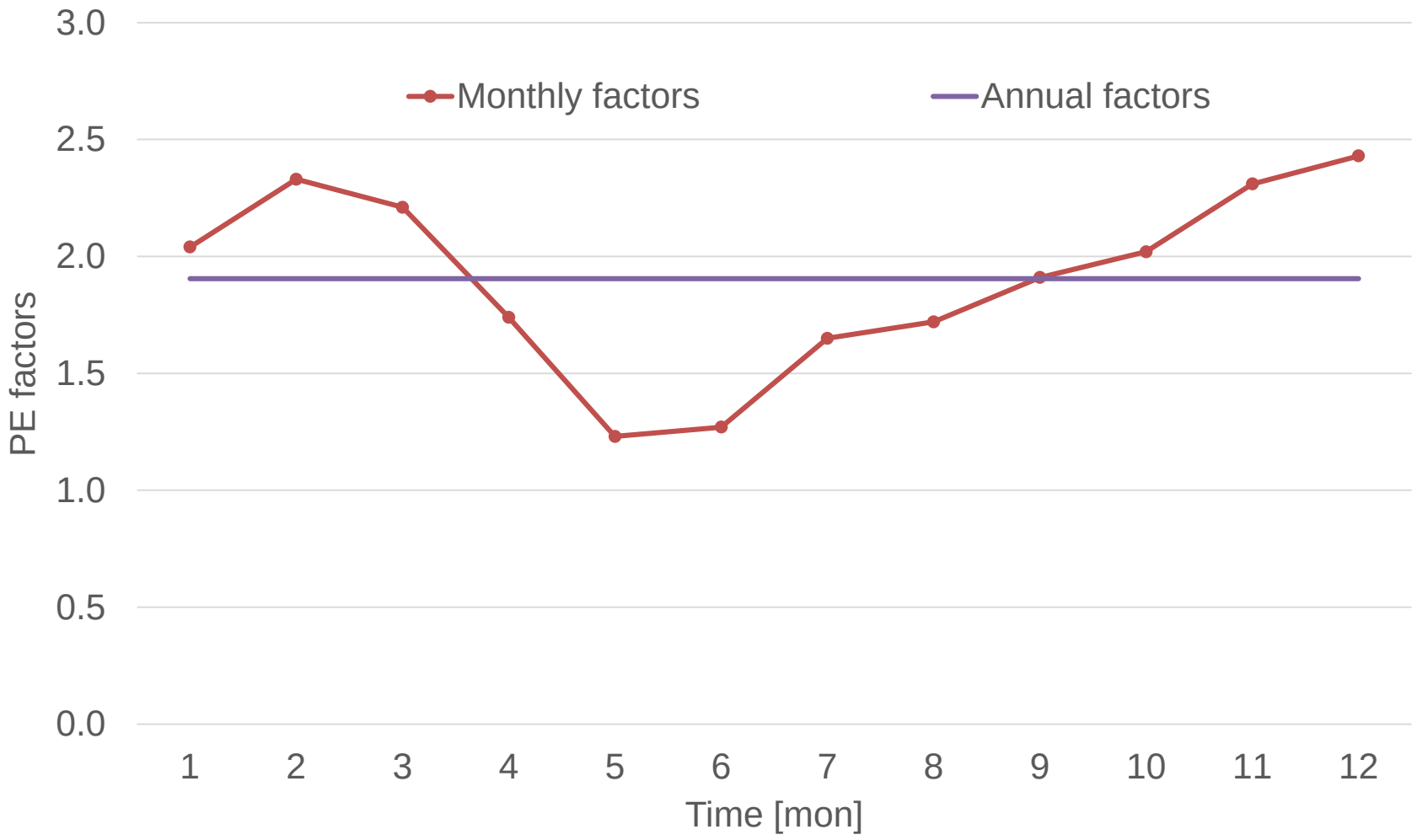
Monthly electricity balance



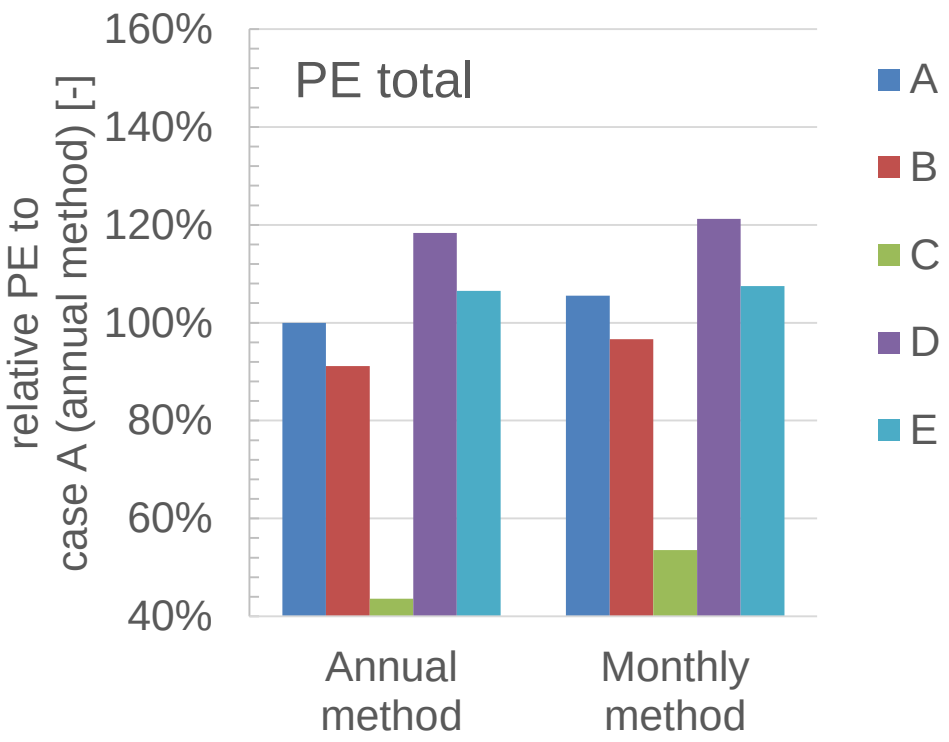
Annual electricity balance



Primary energy factors



Primary energy results



- The most beneficial: Case C (dir. Electricity with PV on the South, West and East façade)
- Monthly instead of annual PE factors:
  - In cases with PV the PE increases more than in cases with HP

  Because **PV** have **low contribution** during the **heating** period

Conclusions

Concept of a **Passive House** building using **direct electricity** for **heating** and **DHW** combined with **PV** on the **façade**

- The **direct electricity** systems combined **with PV** have **similar or better** (in case of PV on the South, West and East façade, assuming **shadings** losses of **10%**) performance to **heat pump** systems **without PV**, because PV can cover the additional electricity required**.**

- **Monthly** instead of **annual PE factors l**eads **different ranking** of the investigated concepts, since **renewables** have **low contribution** in winter, when **demand** is **high**.
  - E.g.: In case E (**ground-water heat pump**), in order to have the **same PE** as case A (reference), a **PV system** of **3.7 kWp** is required using **annual** PE factors and **1.5 kWp** using **monthly** PE factors.

Outlook

- In-situ detailed monitoring
  - Energy performance
  - Comfort conditions

- Dynamic simulations
  - Calculate the part of PV electricity that is used directly
  - Investigate grid interaction (load in winter, PV in summer)
  - Investigate electric storage

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Thank you
for your attention

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