



# PERFORMANCE EVALUATION OF A PHOTOVOLTAIC SHUTTER SYSTEM

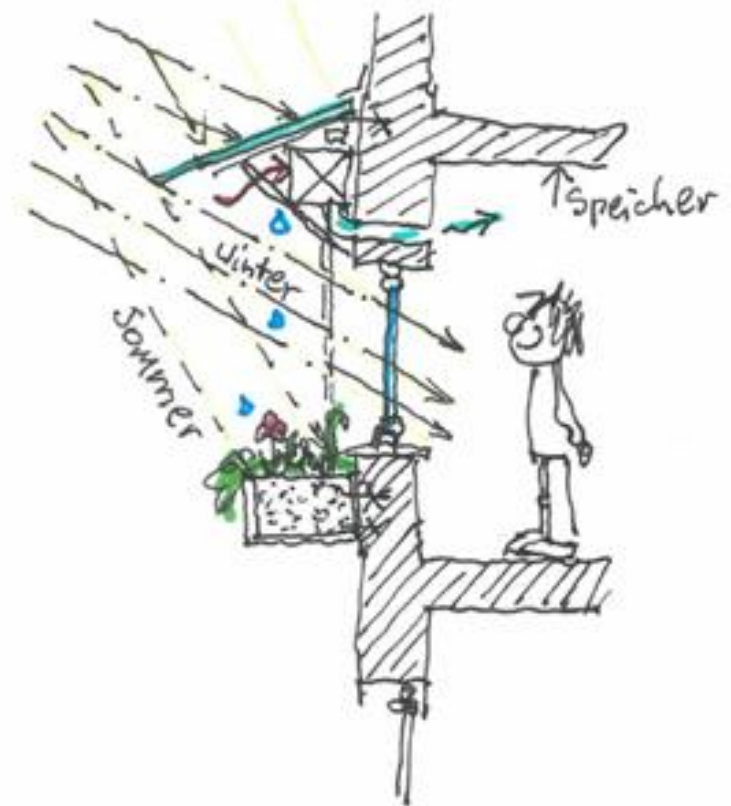
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# MOTIVATION

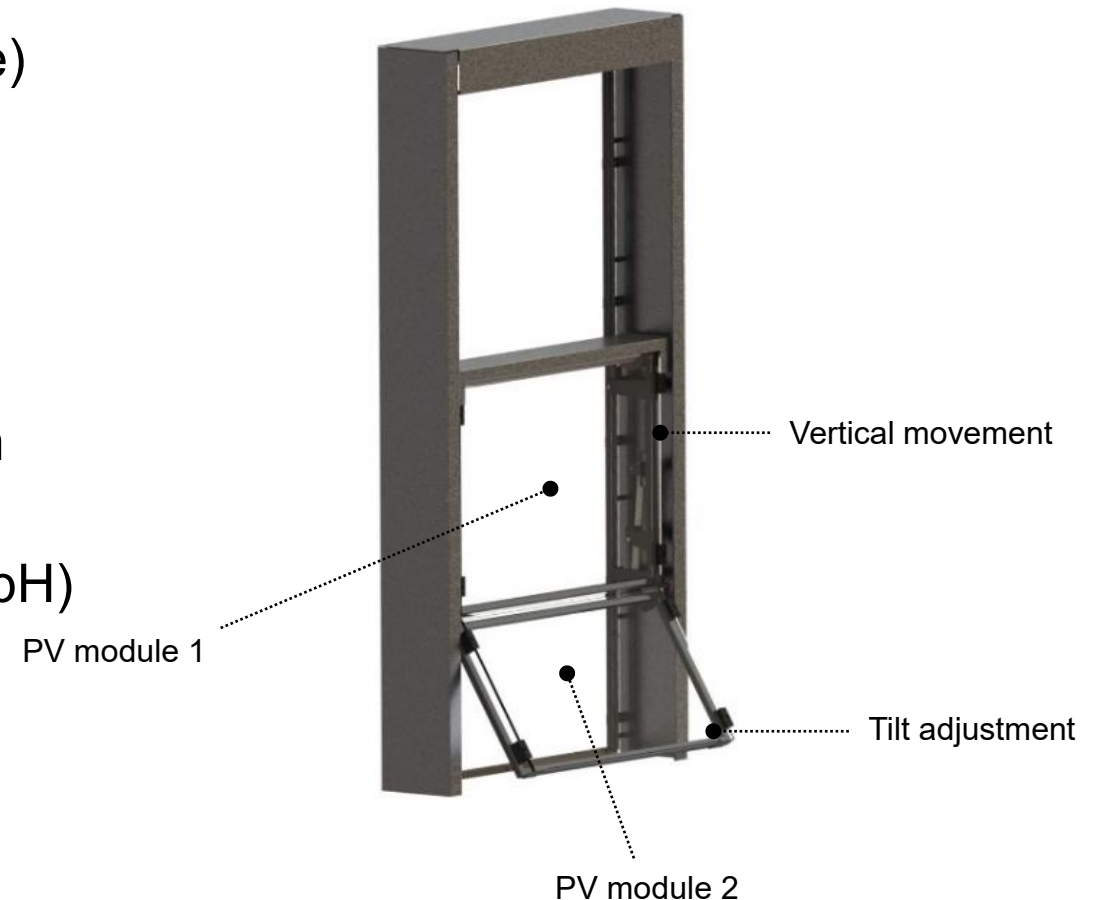
- Buildings are major energy consumers
- Large glass façades increase cooling demand
- Need to reduce overheating and glare
- Opportunity to generate renewable energy
- Develop PV shutter demonstrator
- Combine shading, daylight control and energy generation



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# PV-SHADING SYSTEM DESIGN

- Two PV modules (upper fixed, lower movable)
- Functions:
  - Vertical movement of both PV modules
  - Tilt adjustment of the lower PV module
- Independent control via two motors
- Controllable with ONYX Smart Home System of HELLA
- Total power ~311 Wp (ertex solartechnik GmbH)



# EXPERIMENTAL SETUP

- Installed at AEE INTEC test facility
- Two test chambers (comparison possible)
- Sensors measure:
  - PV power output
  - Surface temperatures
  - Indoor illuminance
  - Outside weather stations
  - Inside room temperature





12/05/2026



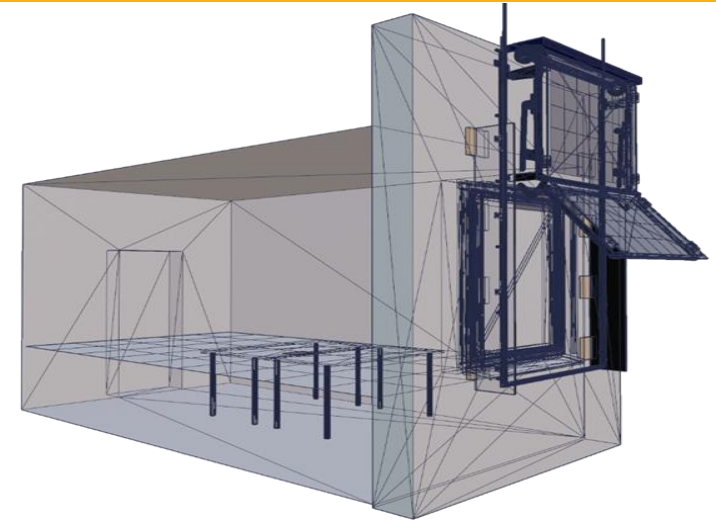
**CFS4LowCarb**



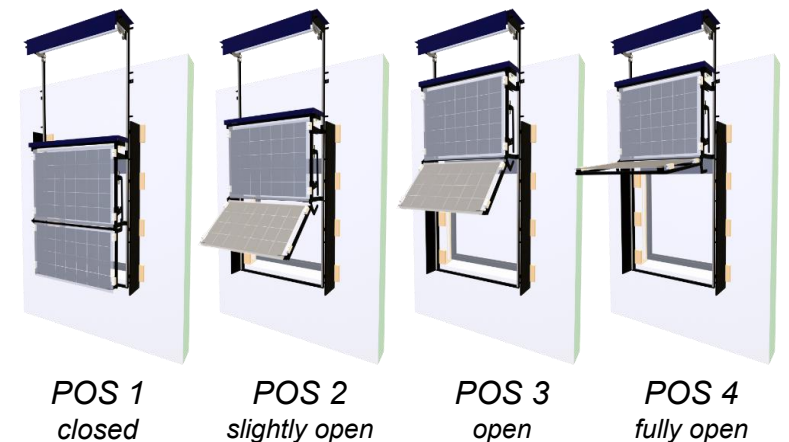


# DIGITAL TWIN

- Based on RadiCal simulation framework
  - Rüdissler, D. (2023), RadiCal - A novel method to model energy flows induced by solar radiation. Graz University of Technology
- Detailed 3D model:
  - Geometry + materials
  - Layers of the PV-module (front glass, rear glass, silicon cells, encapsulant EVA films)
  - Glazing (glass panes, low-E coating)
  - Window + room

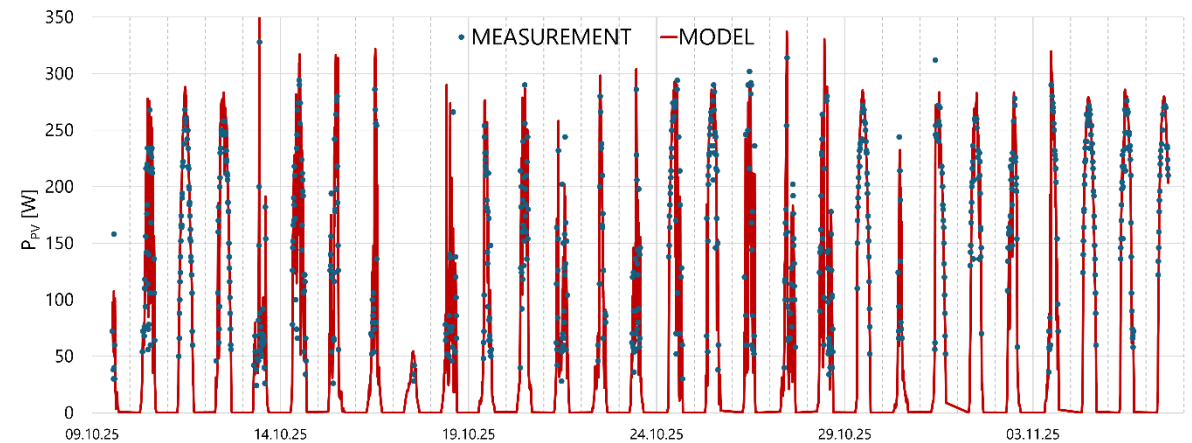


3D model used for the RadiCal ray-tracing scan



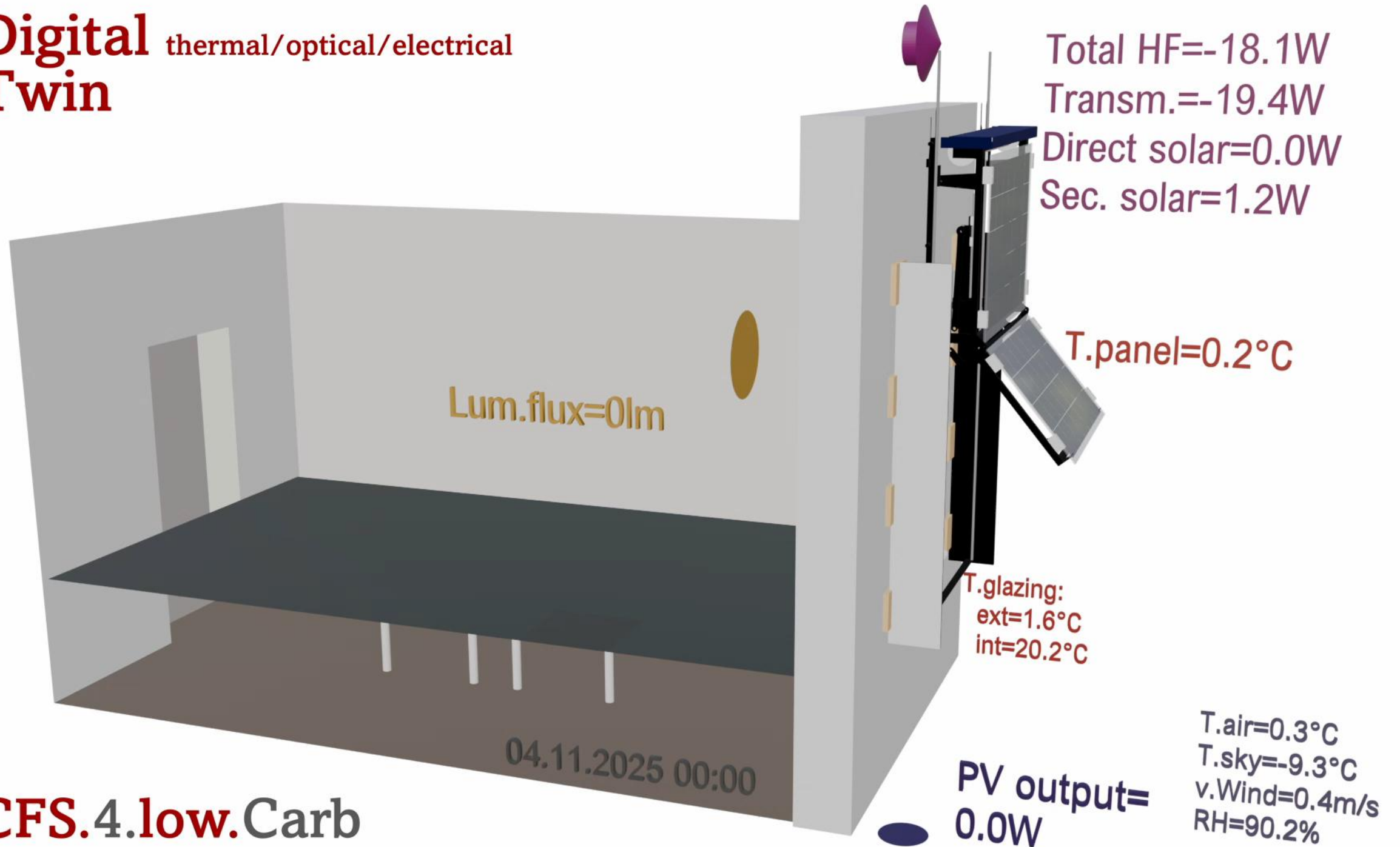
# MODEL-MEASUREMENT COMPARISON

- Strong agreement between simulation & measurements
  - PV power:  $R^2 \approx 0.98\text{--}0.99$
  - Temperature:  $R^2 \approx 0.96\text{--}0.97$
  - Illuminance:  $R^2 \approx 0.93$
- Small deviations
  - Reflections
  - Measurement limitations



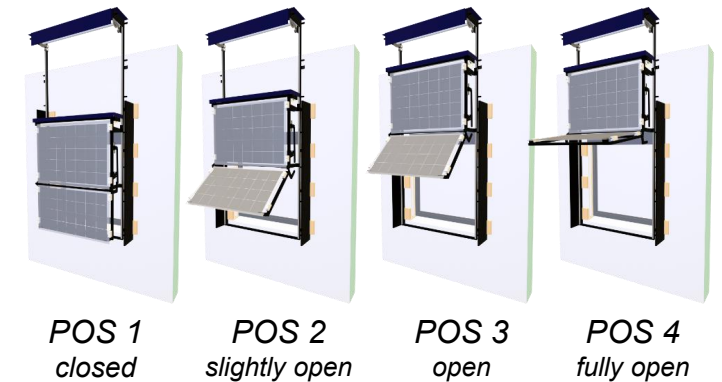
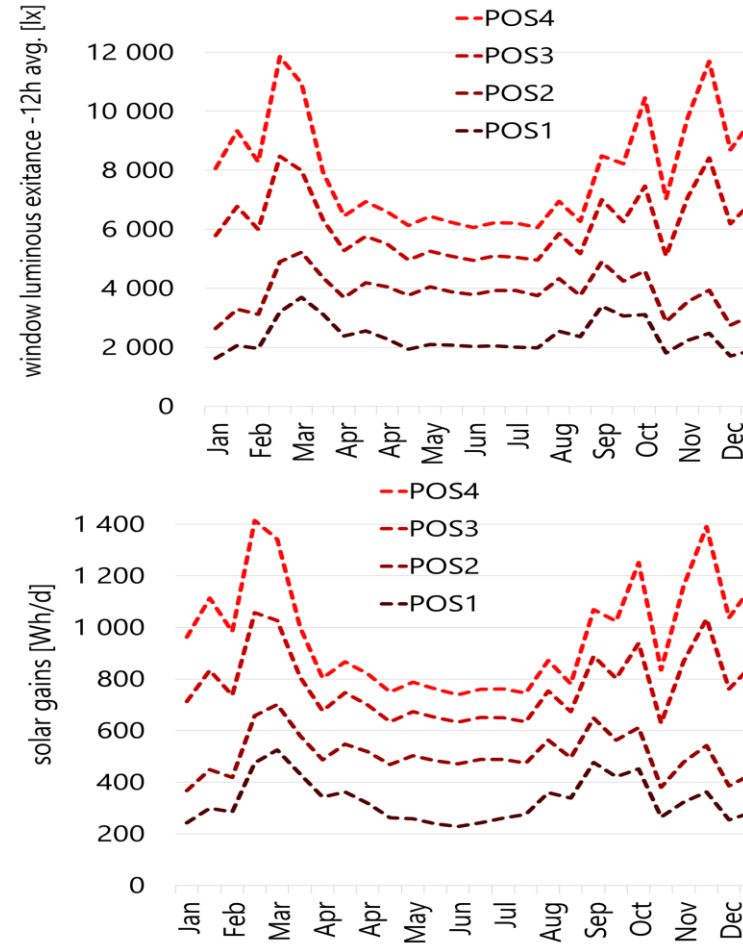
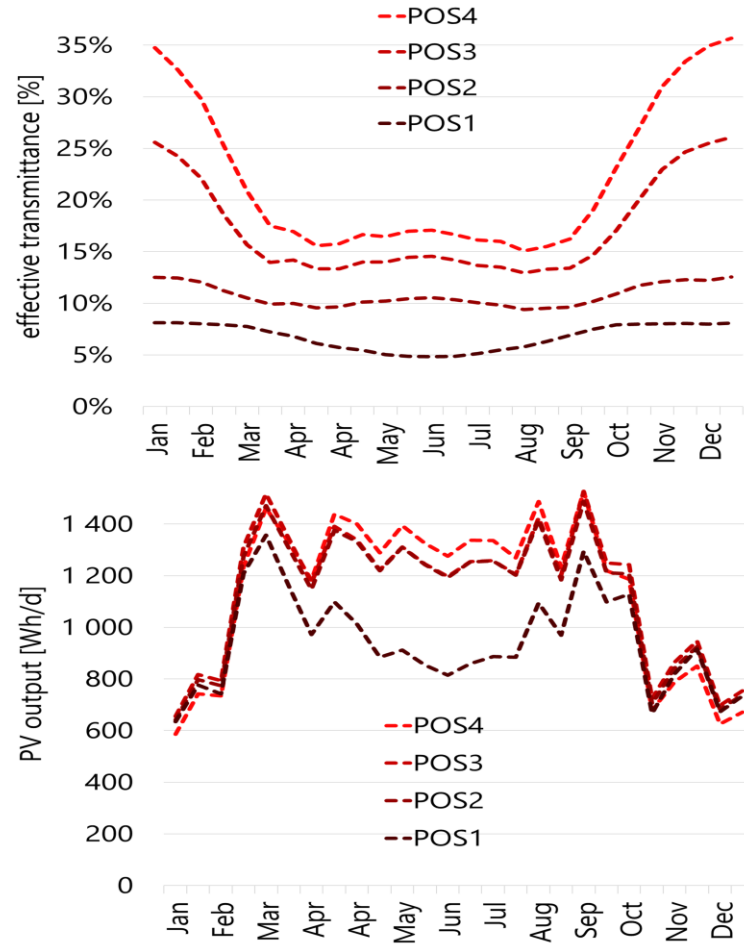
*Time series comparison between modelled PV power output (red line) and measured values (blue dots) for position 3*

# Digital Twin thermal/optical/electrical



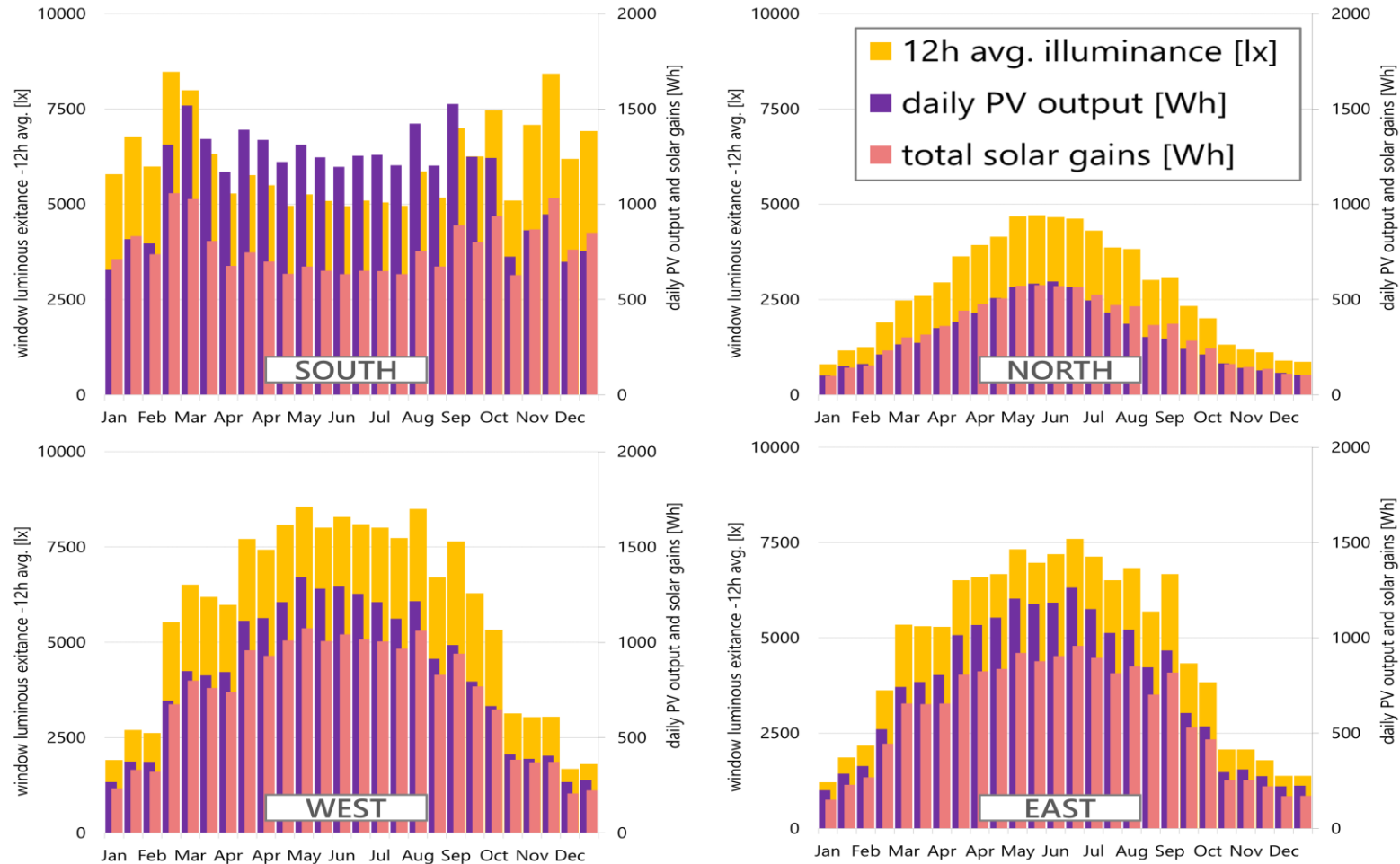
**CFS.4.low.Carb**

# PERFORMANCE POTENTIAL



Annual analysis based on bi-weekly averages of window systems' transmittance, indoor illuminance, PV electricity generation and solar heat gains

# PERFORMANCE POTENTIAL



*Bi-weekly averages of PV electricity generation, solar heat gains, and indoor illuminance for four different façade orientations*

# CONCLUSION

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- PV shutters are multifunctional façade elements
- POS 3 balance summer shading with winter solar heat gains and daylight availability
- Adaptive control is essential
- Digital twin accurately predicts performance
- Strong potential for:
  - Energy efficiency
  - Indoor comfort
  - Renewable energy integration

# ACKNOWLEDGMENT

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This work is part of the international research project and is funded by the Austrian Research Promotion Agency (FFG) through project (879131):

**CFS4LowCarb** - Integrated Light-Thermal Solutions for Complex Fenestration Systems

 Federal Ministry  
Republic of Austria  
Climate Action, Environment,  
Energy, Mobility,  
Innovation and Technology



# THANK YOU FOR YOUR ATTENTION QUESTION?



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