Integrated Photovoltaic Conference

25 – 26 November 2025
Chamber of Commerce
Florence, Italy

Alvaro de Gruijter
Eurac Research

Curtain Wall Façade Designs Integrated with PERC and Shingled HJT Technologies

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NEST NETWORK FOR ENERGY SUSTAINABLE TRANSITION

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FOCCHI SINCE 1914

APPLIED MATERIALS make possible

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Presentation Overview

Introduction

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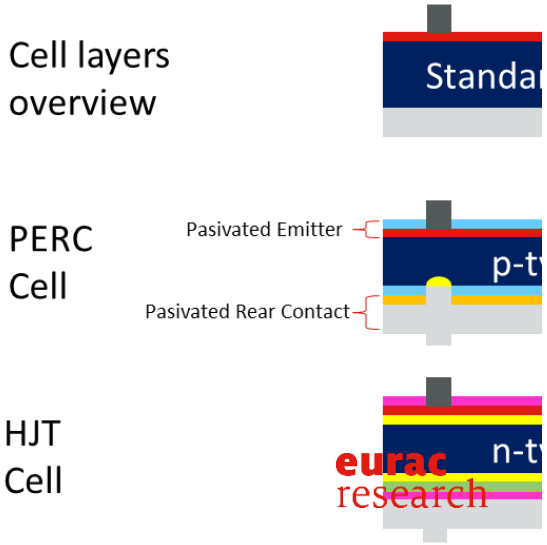

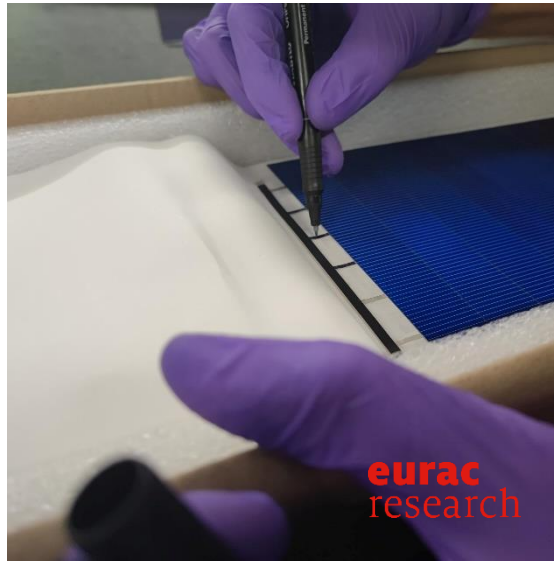

Introduction

Building Integrated Photovoltaics
Insulated Glass Units
PERC & HJT (Shingled) Cells

MC2.0 Curtain Wall Designs

Reliability
& Installation Process

FOURIER Curtain Wall Designs

Performance
in a controlled environment

Conclusions

Design findings
for next generation curtain wall BIPV systems

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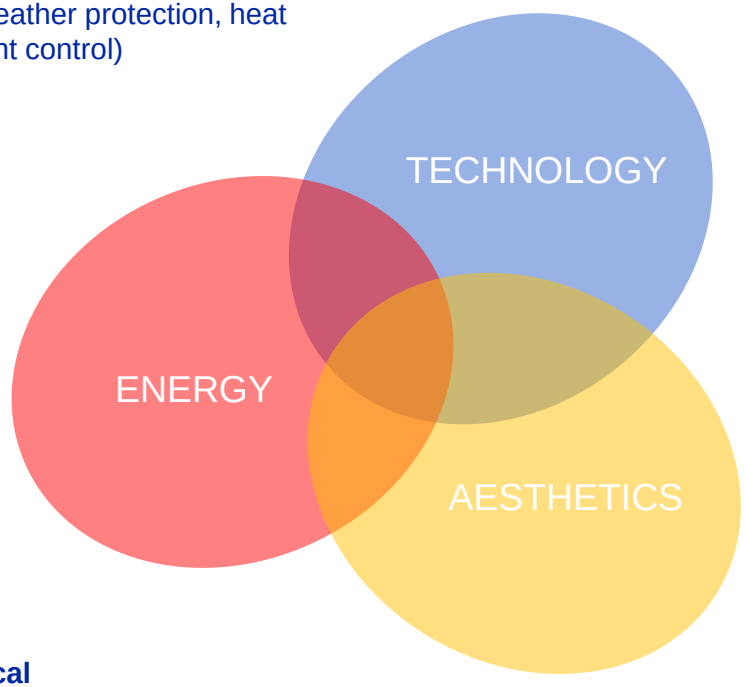
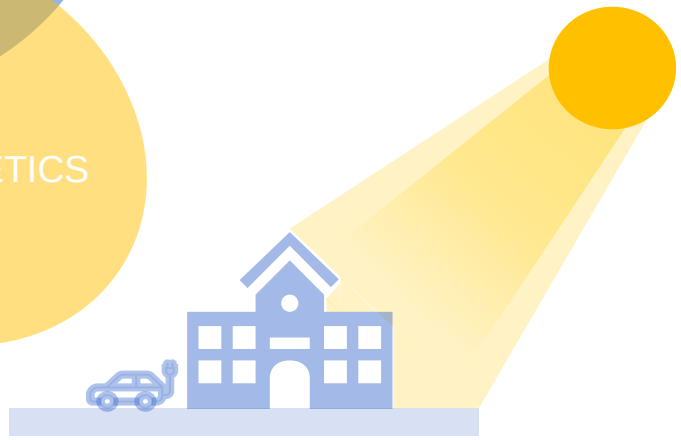
BIPV

Building Integrated Photovoltaics

Replacing traditional building components, and fulfilling other functions required by the building envelope (such as weather protection, heat insulation and sunlight control)

In harmony with the architectural language, and the overall image of the composition the context





To maximize the local use of the produced electricity (conceiving the buildings as micro energy hubs)

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Where are we standing?

BIPV

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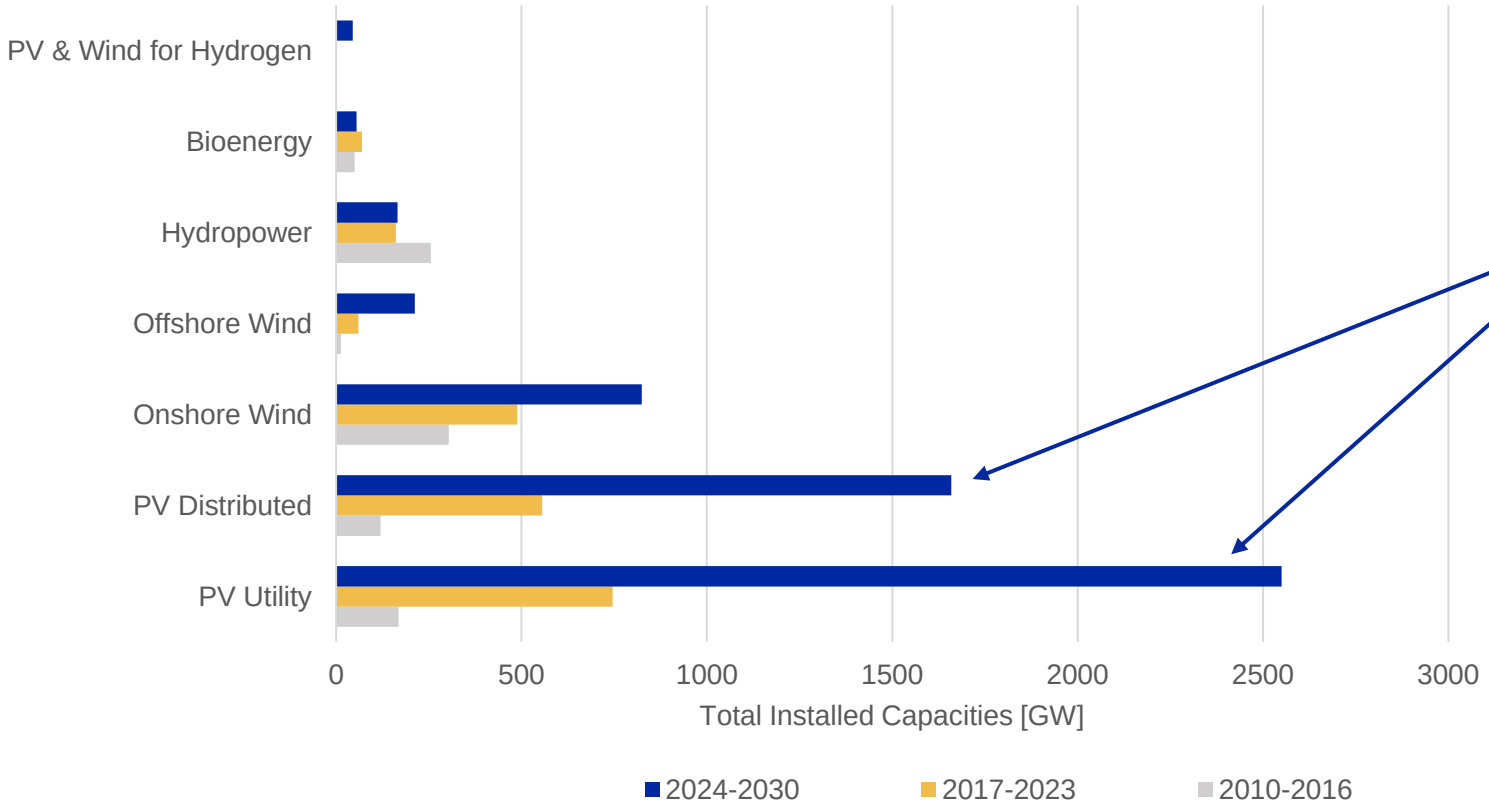

PV Distributed: Encompasses residential, commercial, industrial and off-grid projects

By 2030:
39% of the total solar capacity!

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Source: IEA (2024), Renewables 2024, IEA, Paris https://www.iea.org/reports/renewables-2024, Licence: CC BY 4.0

BIPV within Insulated Glass Units

Curtain Wall Systems

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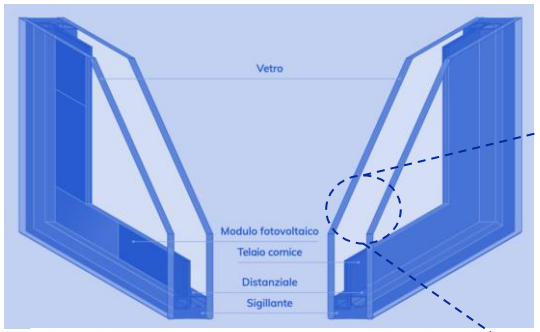

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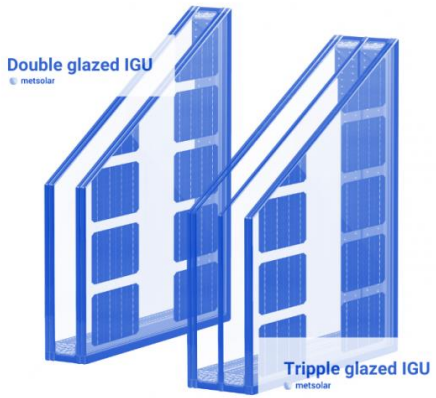

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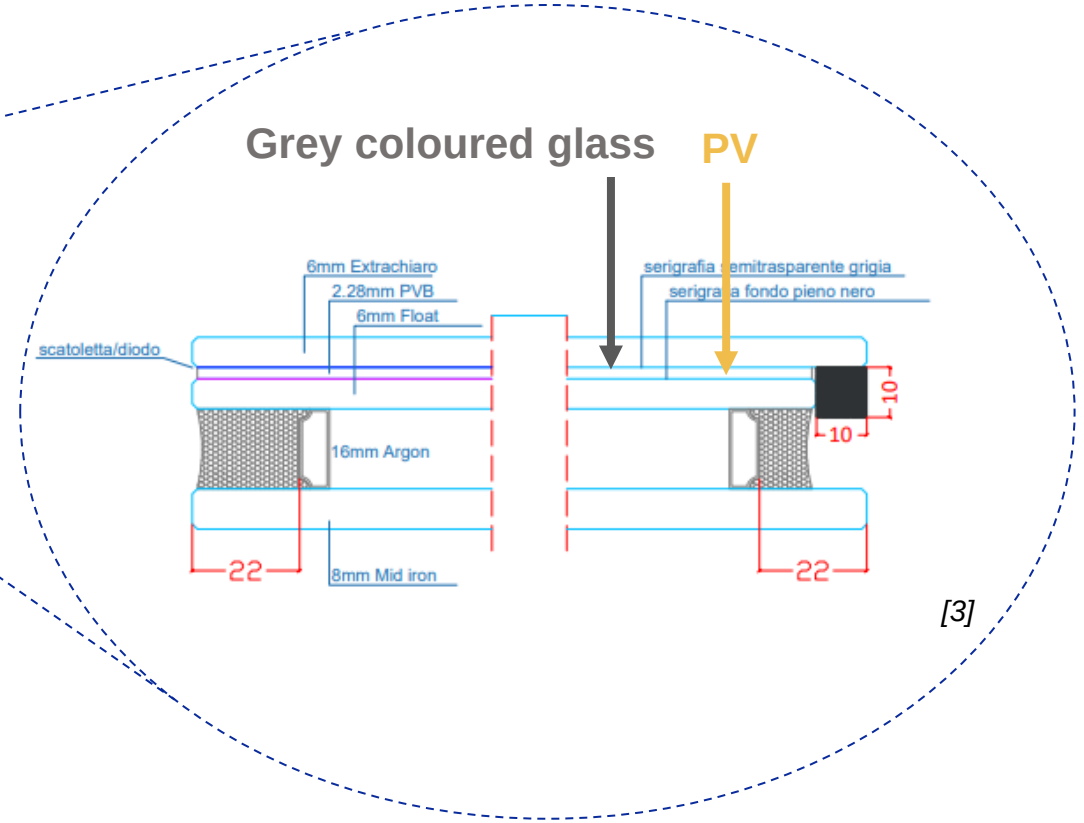

[3]

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Sources:
[1] Heli-On: Vetrata Isolante Fotovoltaica – Glass to Power,
[2] Tauras Skylight - Photovoltaics Insulated Glass Unit (PV IGU) | Metsolar - Custom solar panels from EU manufacturer
[3] GruppoSTG – FOURIER Project RdS

Technologies of interest

Integrated within IGUs

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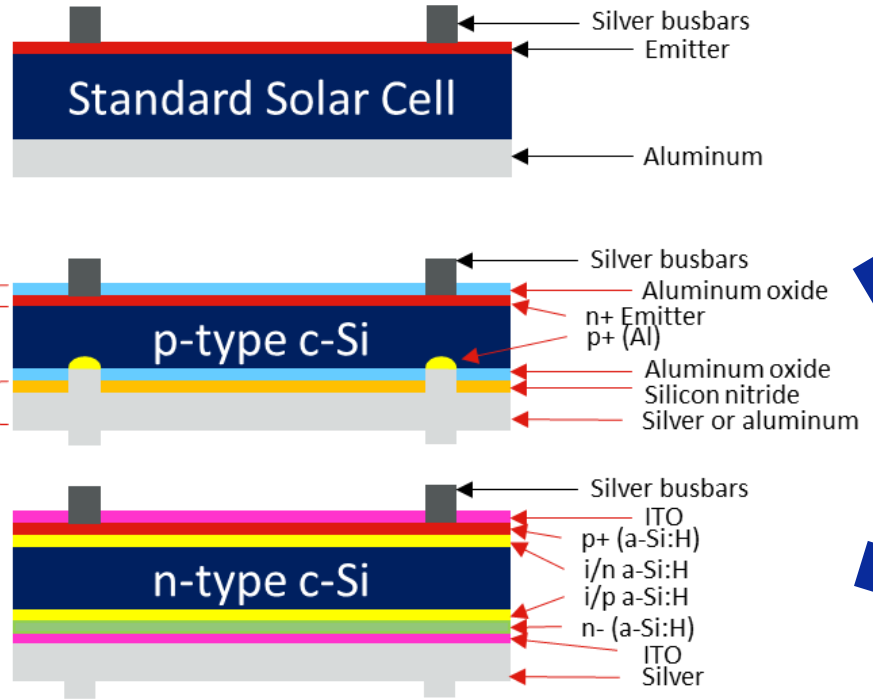
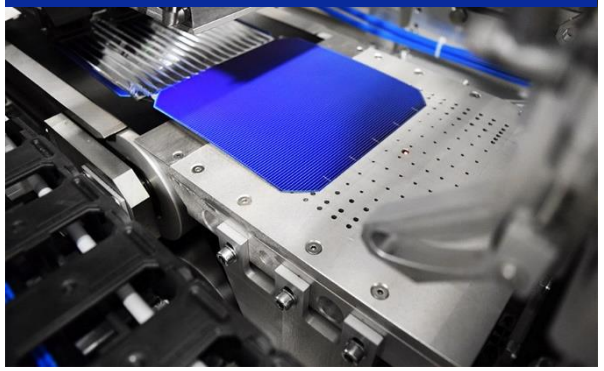
Technologies selected within IPV façade

- PERC Cell
- HJT Cell

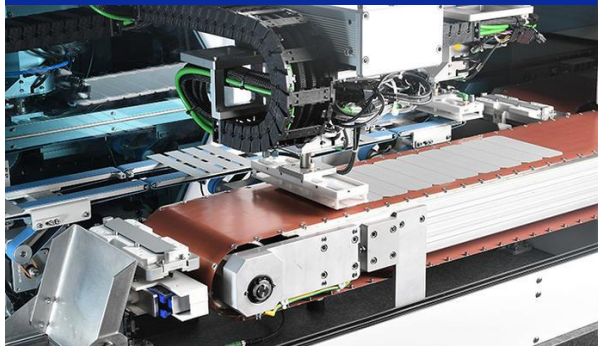
Cell layers overview



PERC Cell [1]



HJT Shingling Cell [2]



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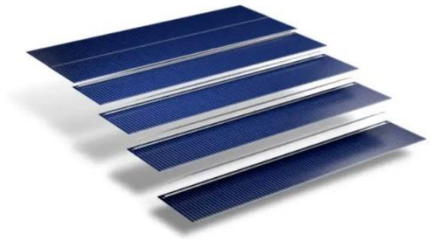
Sources:
[1] perc-cell.jpg (864×576) (solartechuniversal.com)
[2] Sonetto Shingling (appliedmaterials.com)

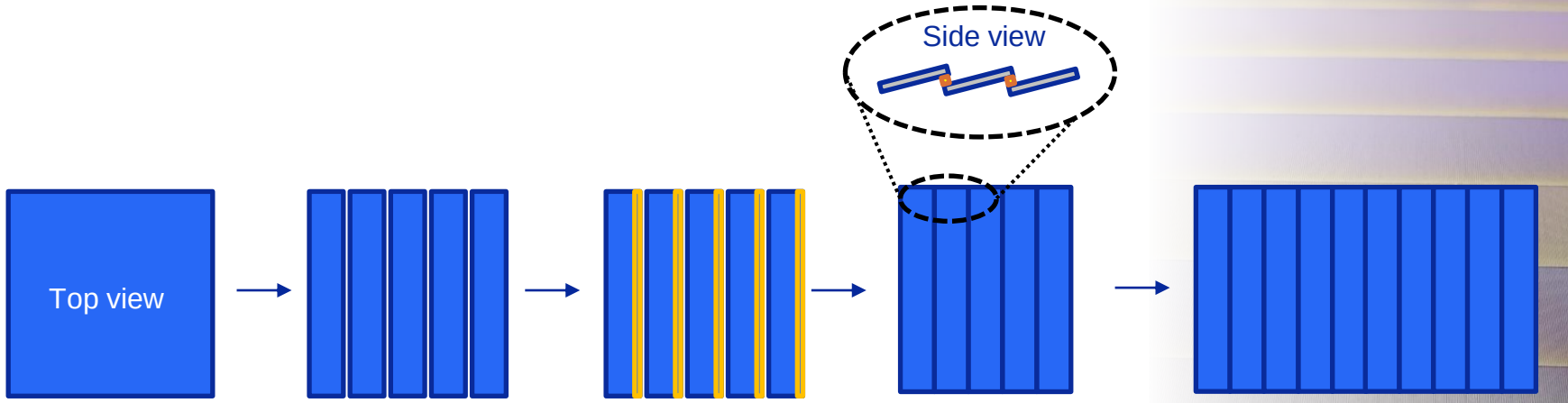
Manufacturing

HJT Shingled Cells

HJT Shingling Cell [1]

HJT Shingling Strips [2]





HJT M2 Cell

Laser cut into strips

Apply Electrically Conductive Adhesives

Overlap in a shingled layout

Ability to size the cell
With potential to increase area efficiency
Customized sizes for BIPV

Sources: [1] Sonetto Shingling (appliedmaterials.com) , [2] Shingled Technology All Black 420W 425W 430W Solar Panel For Home Manufacturer

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Curtain Wall Designs

1. Reliability of BIPV (PERC) integrated with Insulated Glass Units (IGU)

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Curtain wall design from Glass To Power

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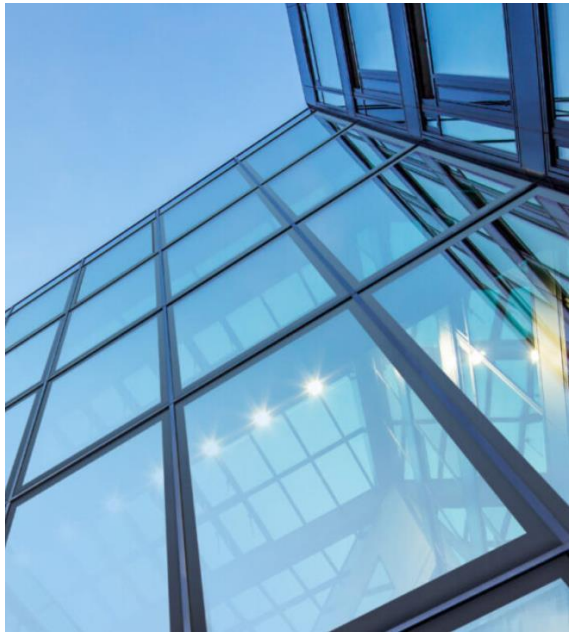

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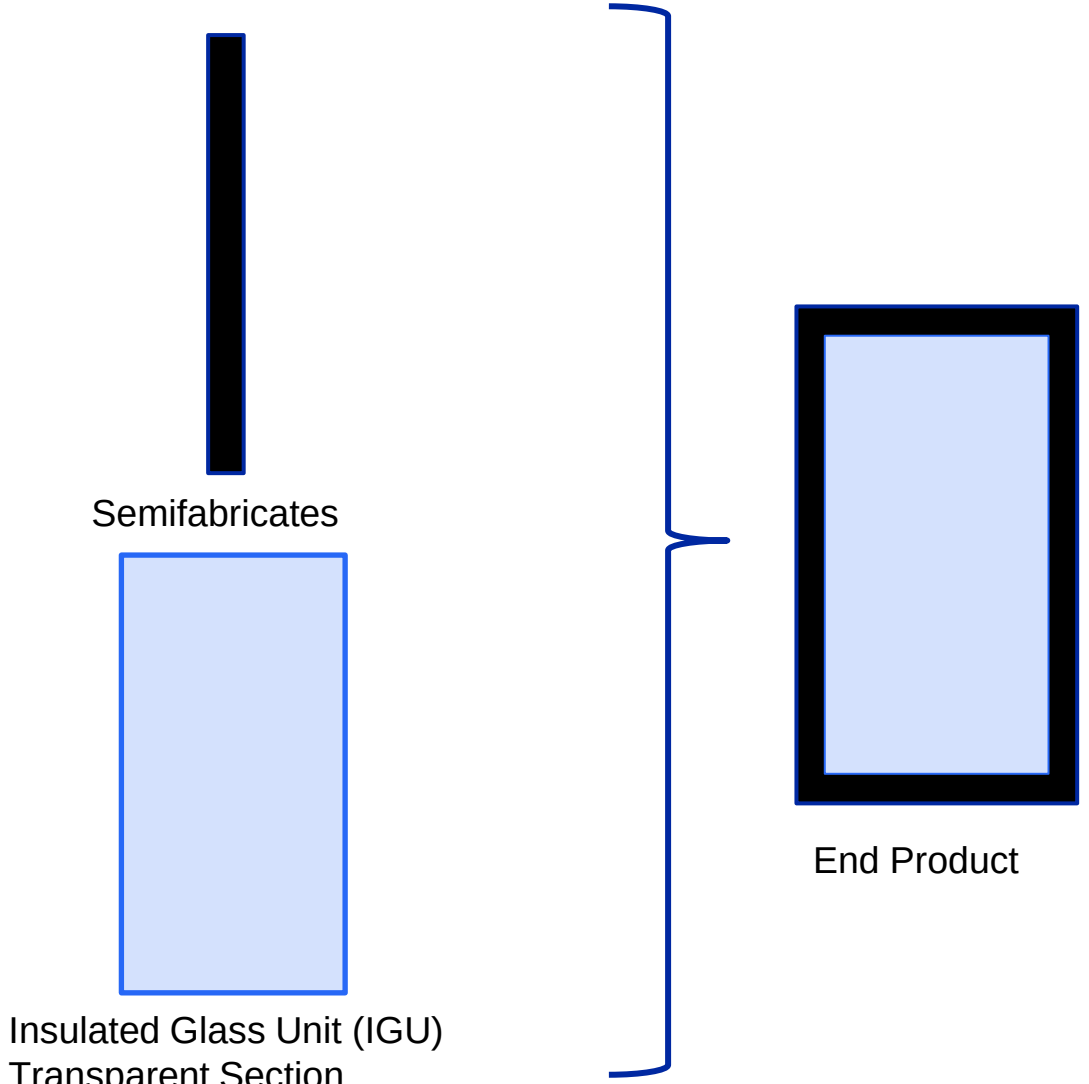

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Reliability of BIPV within IGUs

Performance: Damp Heat Tests

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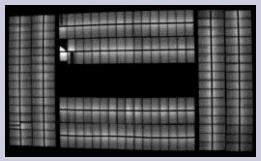
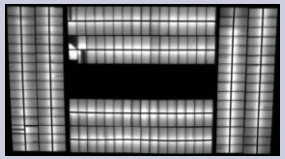
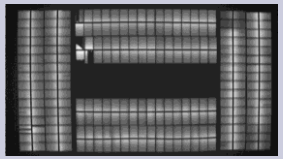
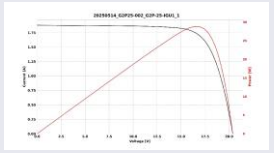
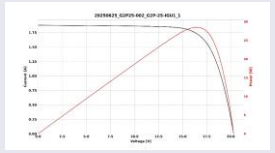
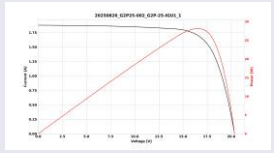
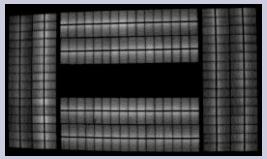
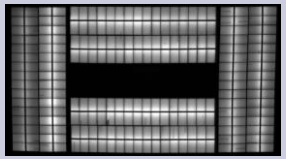
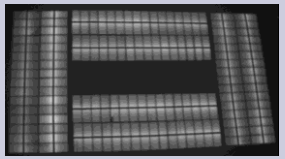
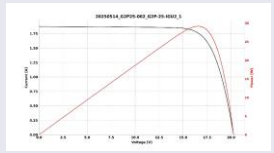
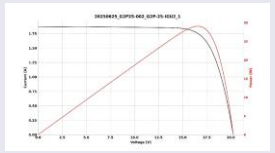
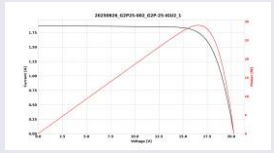
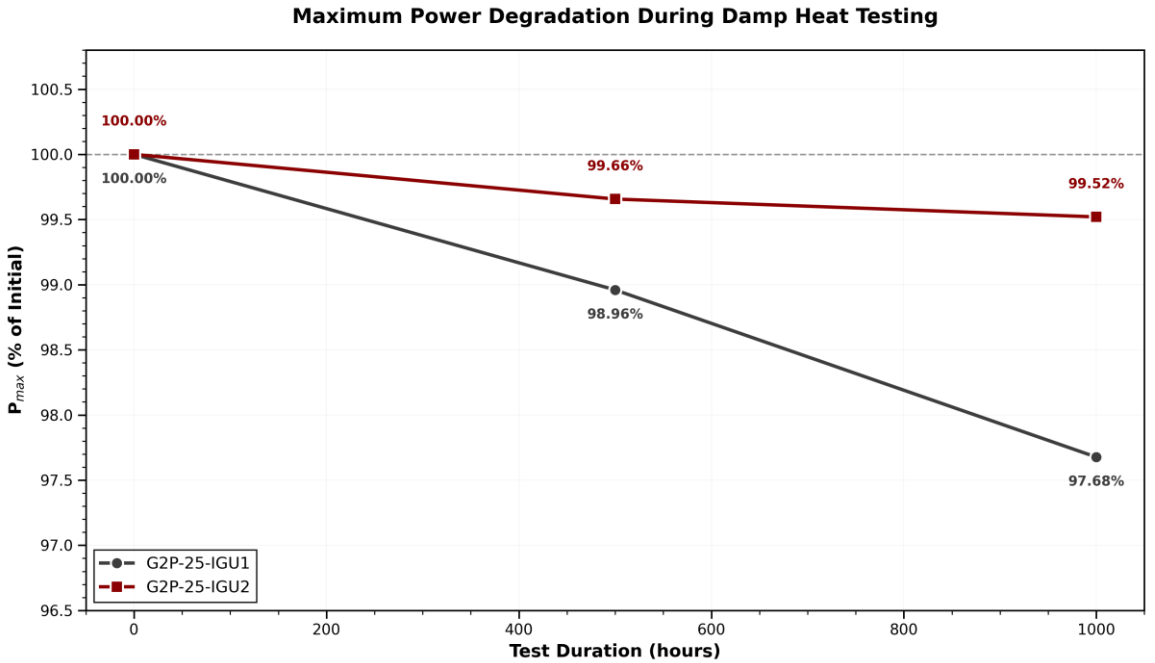
N. 1	Initial	500h DH	1000h DH
EL @ 100 % Isc			
IV Curve			

N. 2	Initial	500h DH	1000h DH
EL @ 100 % Isc			
IV Curve			



End Products (IGU + BIPV)

PV frame:

- Number of PV mini modules glued to an aluminum frame. Setup to be integrated between glasses for IGU

Integrated glass unit (IGU):

- Prototype of PV window
- PV frame mounted between two glass layers with Silicon.

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Reliability of BIPV within IGUs

Performance: Damp Heat, Thermal Cycling & Humidity Freeze Tests

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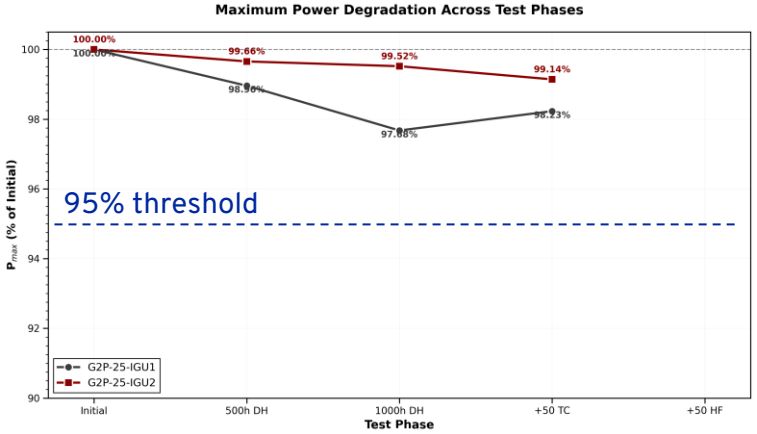
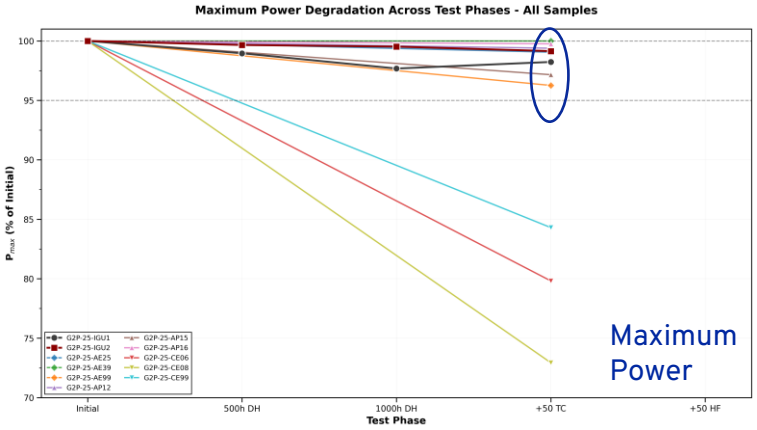
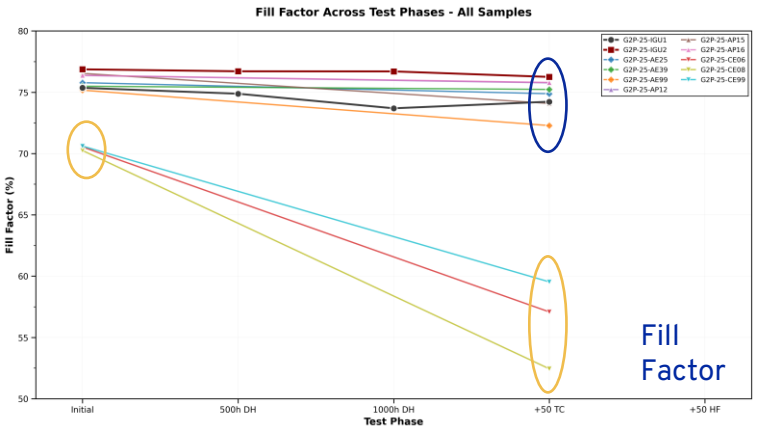
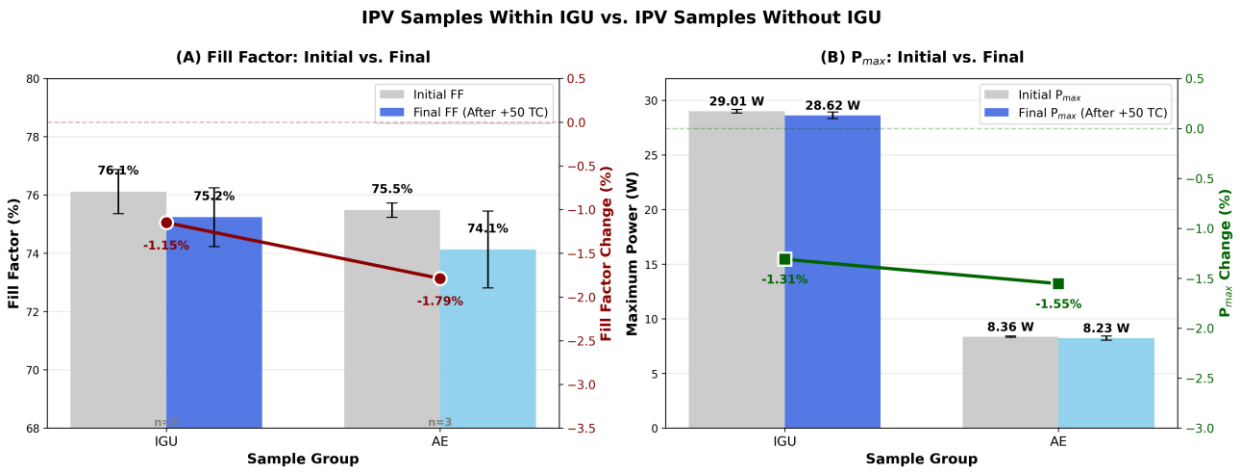
IGU with BIPV integration



PV integrated in IGU Vs PV (no IGU)







- BIPV integration within an IGU does not negatively affect performance after thermal cycling tests (50TC)

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Installation Procedures

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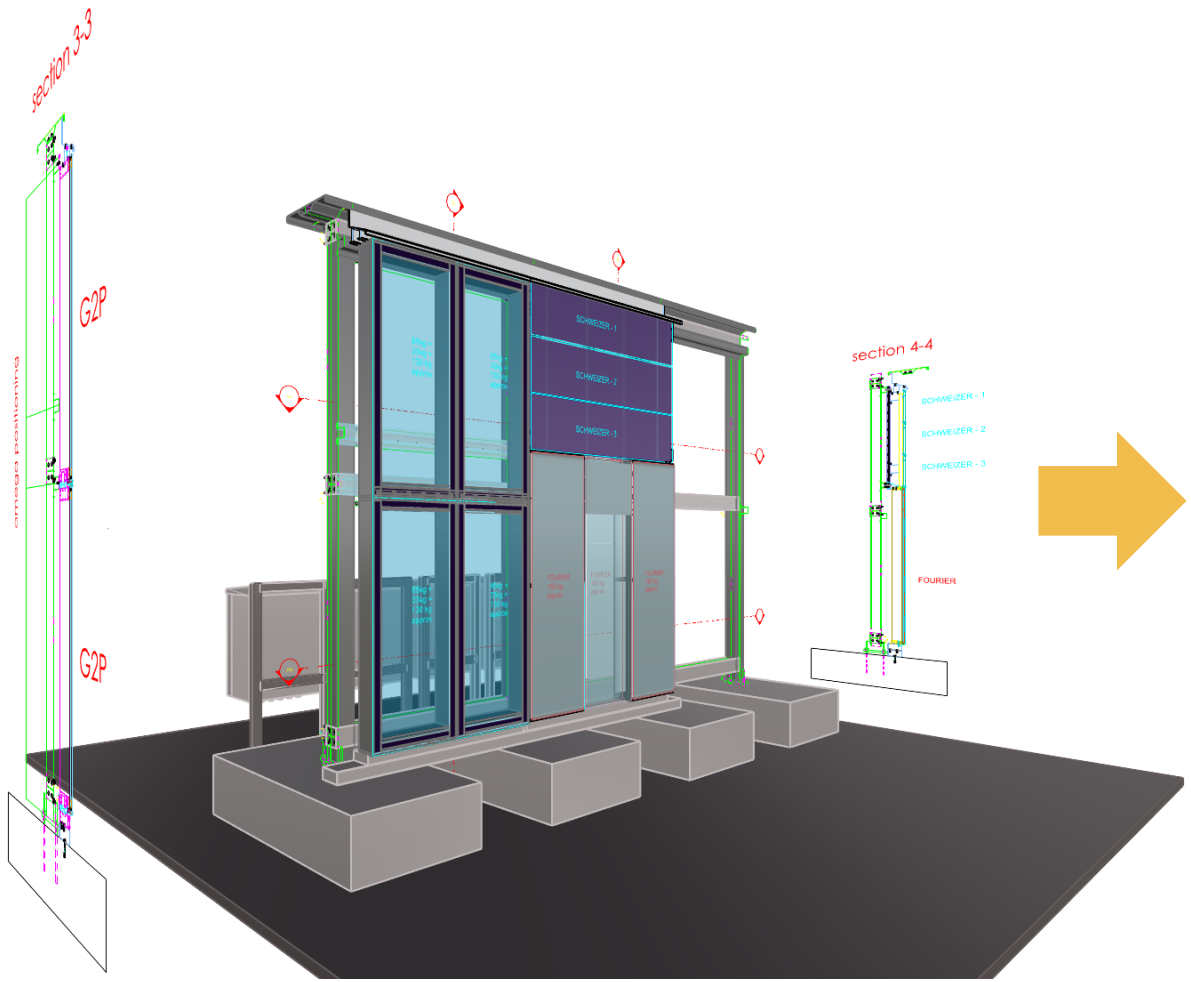

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Curtain Wall Designs

2. Outdoor performance in a controlled environment

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Methodology

Controlled laboratory environment

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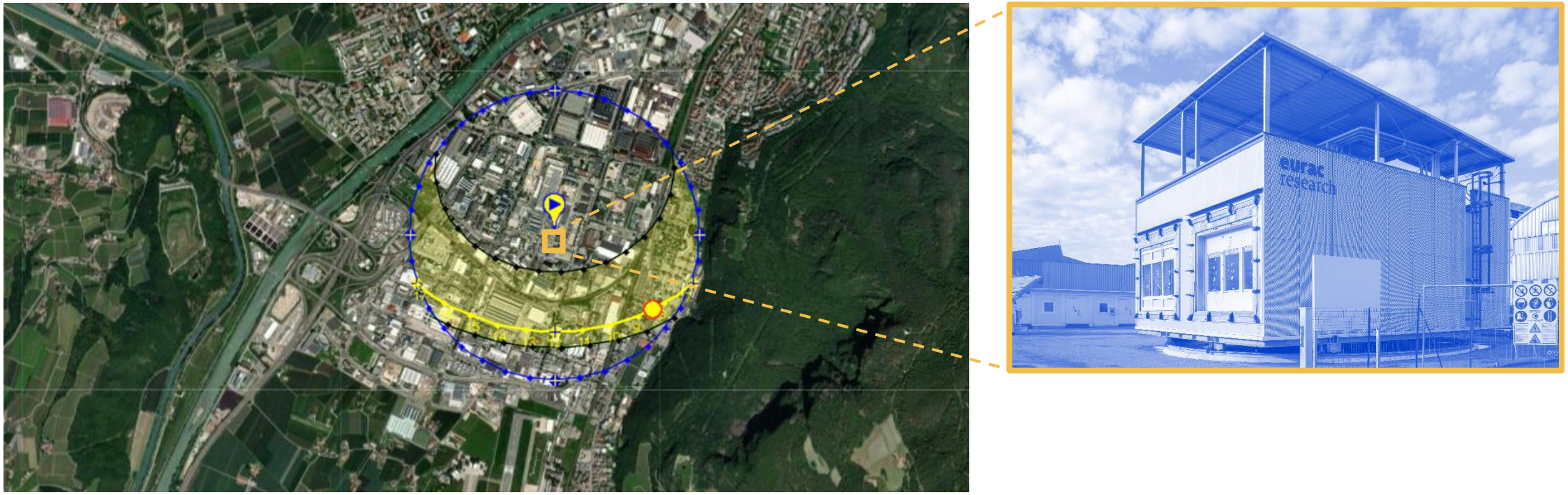

Test location: Eurac Research Outdoor Laboratories, Bolzano, Italy

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Methodology

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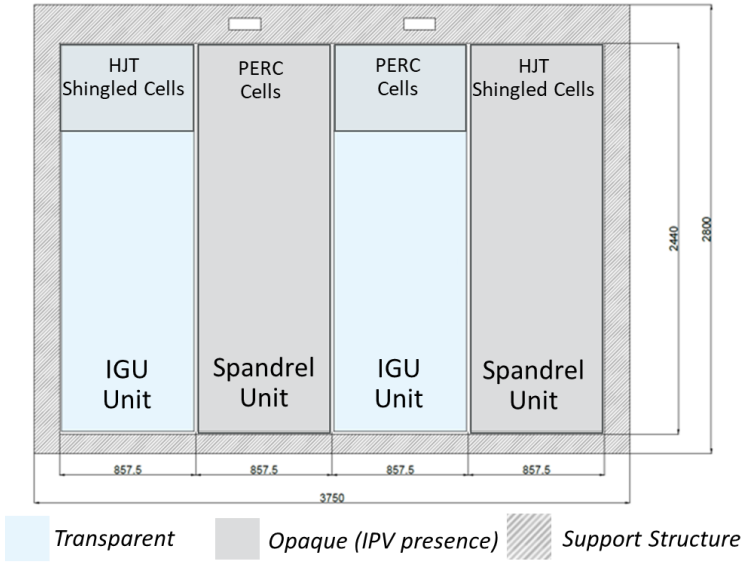
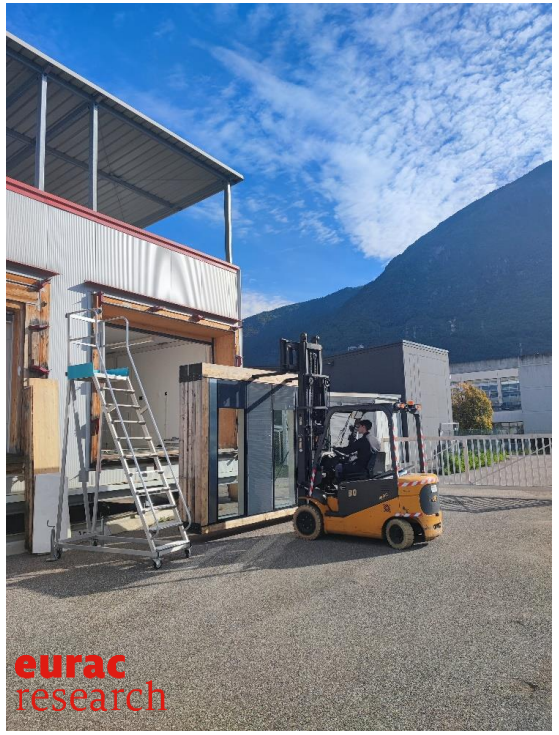


Façade design



Façade installation

Sensors installation

Outdoor measurement campaign

Power curves on a clear sunny day & PR obtained

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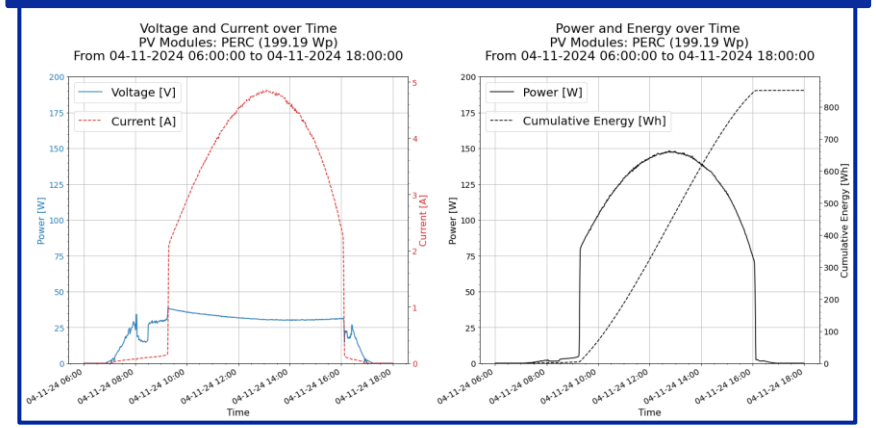
PR: 92%

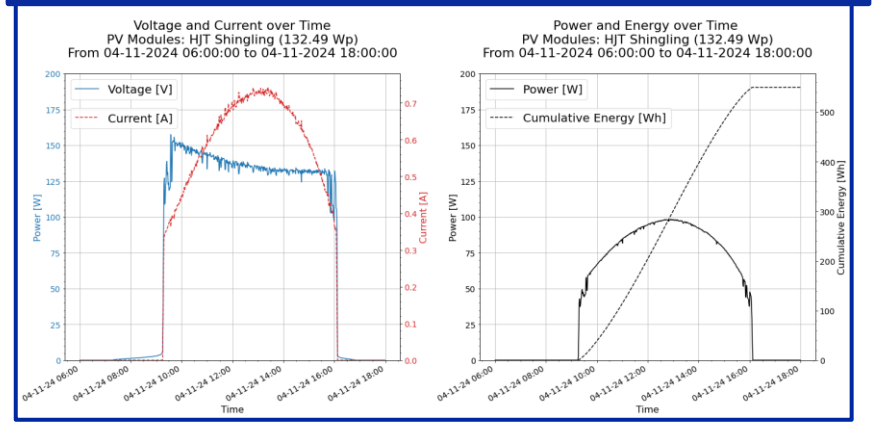
IPV PERC MODULES



- Pmpp (STC): 199.19 Wp
- 2 IPV PERC modules connected in series (large & small)

PR: 88%

IPV HJT (SHINGLING) MODULES



- Pmpp (STC): 132.49 Wp
- 2 IPV HJT Shingling modules connected in series (large & small)

$$PR = \frac{Y_f}{Y_r} = \frac{\frac{E_{Out}}{P_0}}{\frac{H_i}{G_{STC}}}$$

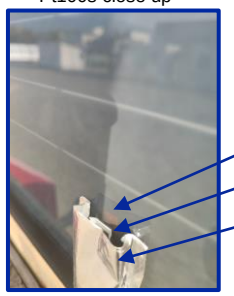
Following IEC 61724: timesteps values discarded when irradiance POA < 100 W/m2 and PR values >1.

Outliers were also checked from the dataset based on the Interquartile Range (IQR) method:

$$IQR = Q3 - Q1$$
$$Lower\ Bound = Q1 - 1.5 * IQR$$
$$Upper\ Bound = Q3 + 1.5 * IQR$$

- Temperature gradients & the effect of PV are also important for the IGUs annealed glass!

Pt100s close up



1. Back PV Sensor (not visible in image)
   Controlled indoor temperature at 25°C
2. Laminated Sensor (inter-layer)
3. Front PV Sensor

Reflective tape

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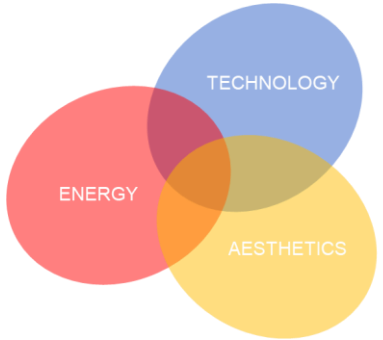
Conclusions

BIPV Curtain Wall Façade Designs



Reliability

- BIPV IGUs retained power > 97% after 1000 h DH & 50 TC
- TC tests showing BIPV integration within an IGU does not negatively affect performance

Outdoor Performance

Integration with IGUs and Spandrel Façade systems achieved with:

- Grey coloured glass (aesthetics)
- IGU and spandrel systems (technology)
- PR ratios for facade clading systems found at 92% (PERC) & 88% (HJT Shingled Cells) (energy)

Additional observations:

- Temperature gradients across layers and PV active and non-active areas require close monitoring to meet the facade requirements

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Reliability of BIPV within IGUs

Appendix: Tests overview

Tests

Thermal cycles (TC) in cycles:

- Temperature cycles between -40 °C and 85 °C following times given by IEC61215 (total time around 3-5 hours, typically **100** or 200 cycles)
- Compared to typical test: here no current injection.

Damp heat (DH) in hours (h):

- 85 °C and 85 % relative humidity (RH) (typically for 500, **1000** or 2000 h)

Humidity Freeze (HF) in cycles:

- 85 °C and 85 % RH for 20h → cycle to -40 °C (typically **10** or 50 cycles)
- Compared to typical test: here no current injection

Characterization:

- IV curve (performance measurement using A+A+A+ flash tester)
- Visual image
- Electroluminescence (EL) image

Samples

End Products (IGU + BIPV)

PV frame:

- Number of PV mini modules glued to an aluminum frame. Setup to be integrated between glasses for IGU

Integrated glass unit (IGU):

- Prototype of PV window
- PV frame mounted between two glass layers with Silicon.