



Integrated
Photovoltaic
Conference

25 – 26 November 2025
Chamber of Commerce
Florence, Italy

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CSEM, Officina del Sole

Reliability Challenges of BIPV Products and Systems in Operation



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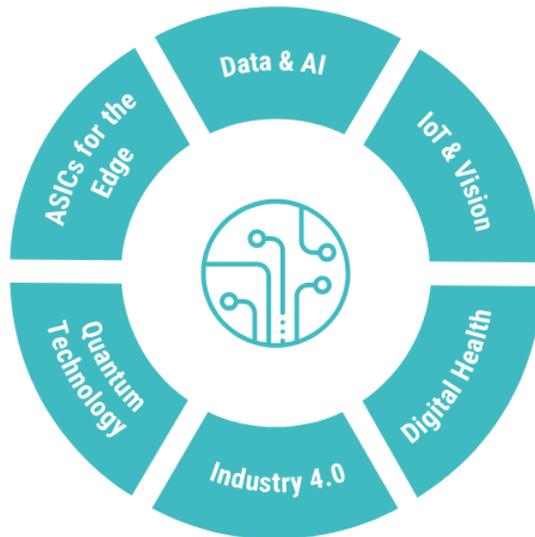
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CSEM: at a glance

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Public-private innovation center based in CH
with international reach.

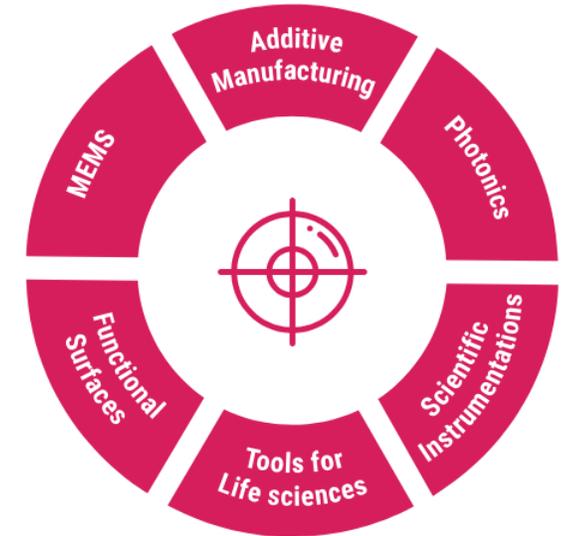
Digital Technologies

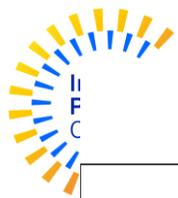


Sustainable Energy



Precision Manufacturing





Building-Integrated PV (BIPV)

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Usage

Residential

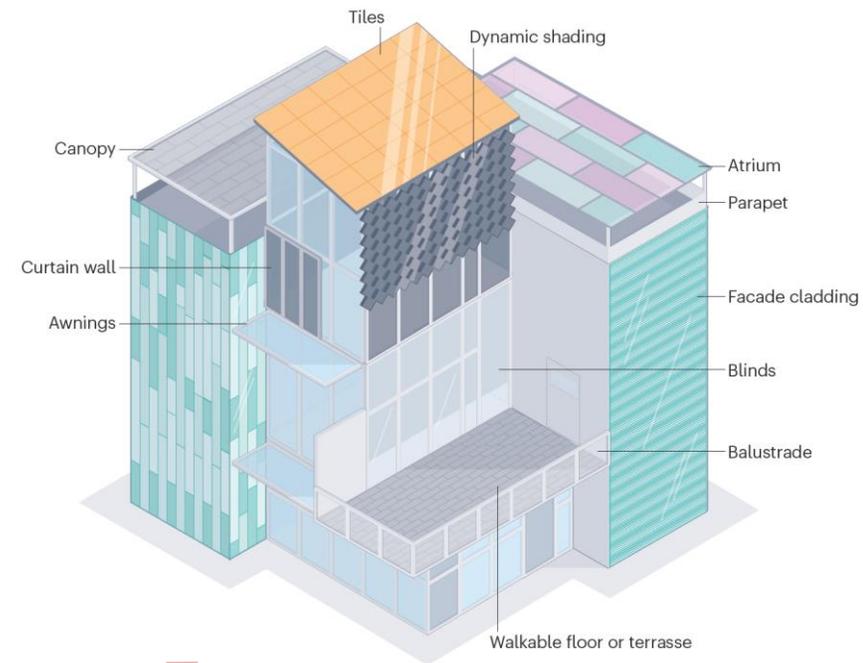
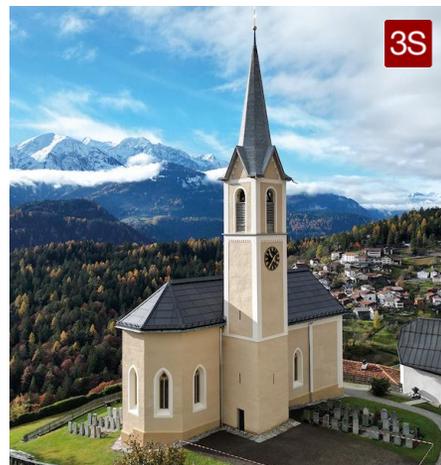
Industrial

Heritage

Building-Applied



Building-Integrated



Reliability?

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 Faes, A., Virtuani, A., Quest, H., et al. (2025), *Building-integrated photovoltaics*. Nature Reviews Clean Technology.

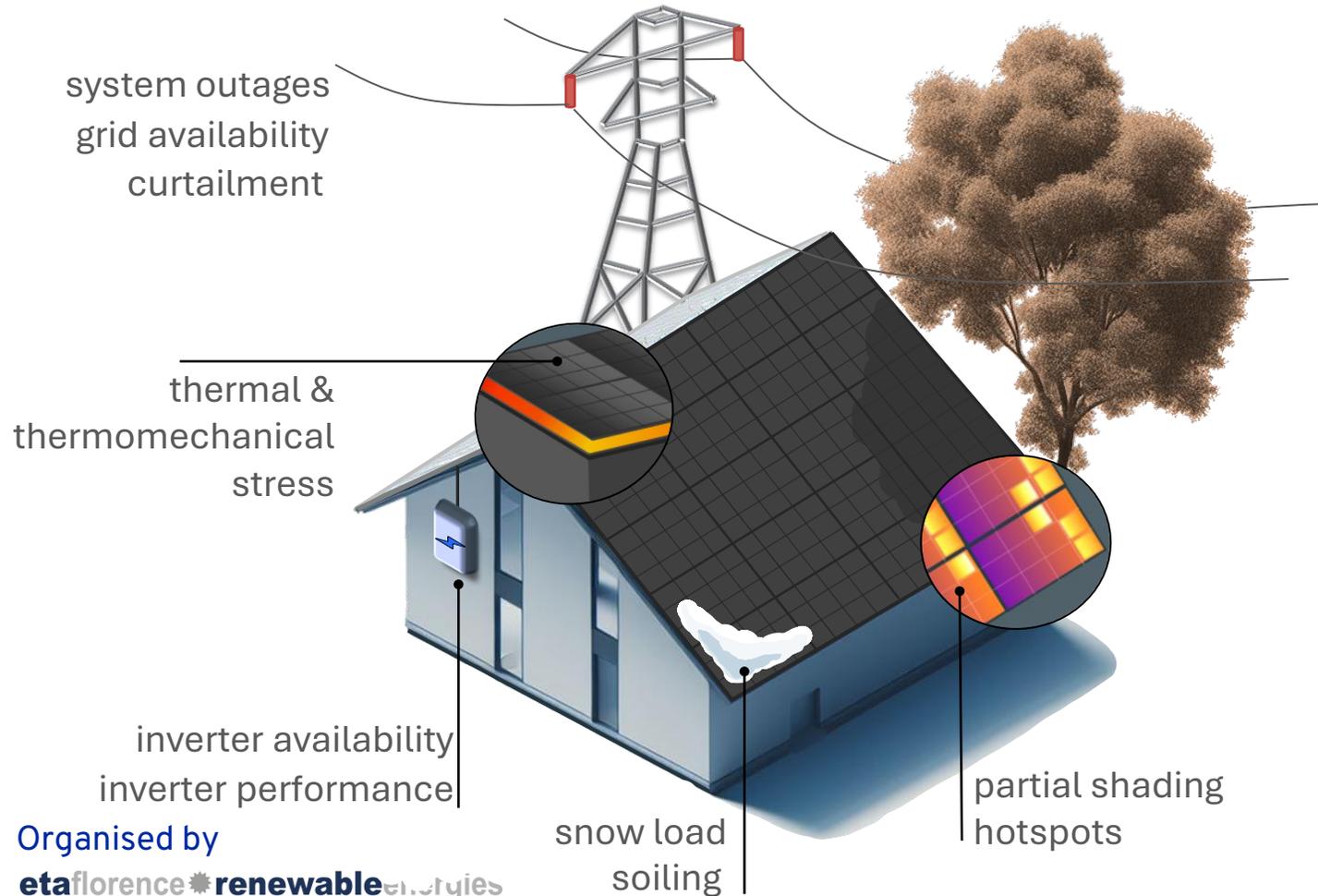
Reliability of BIPV

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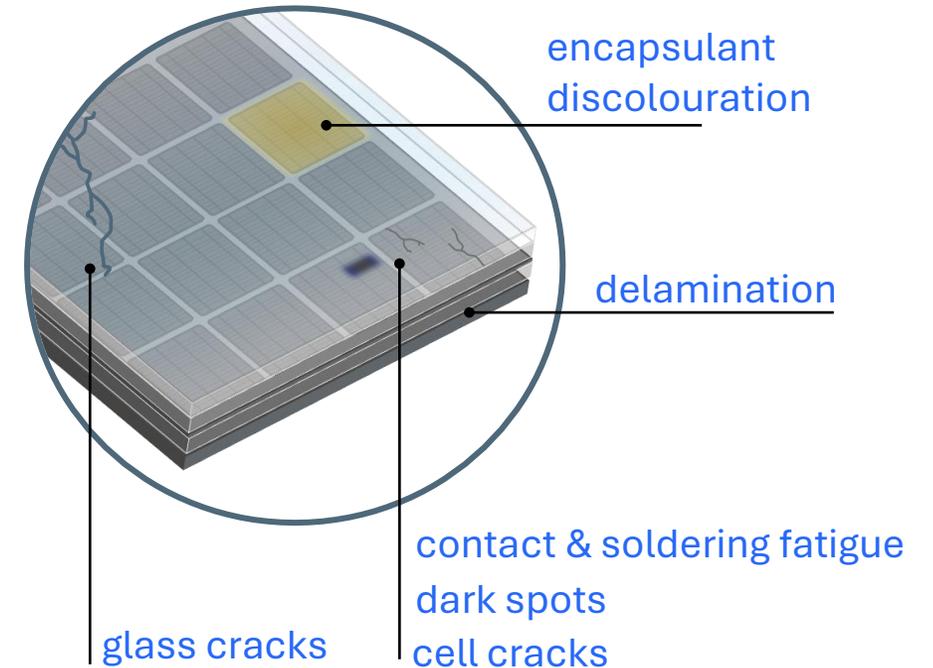


Reliability: the likelihood that a component or system will carry out its intended function without failure under specified conditions for a given period of time.

System reliability



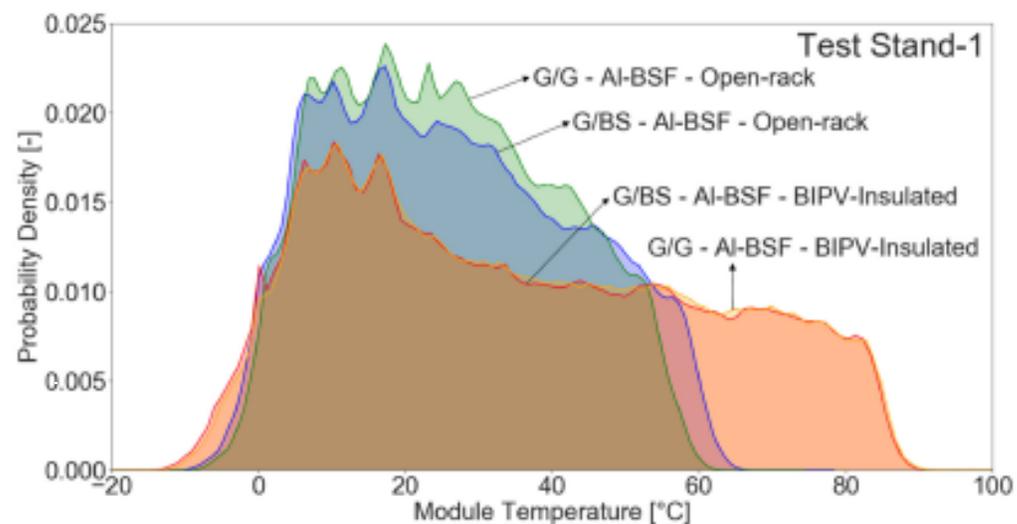
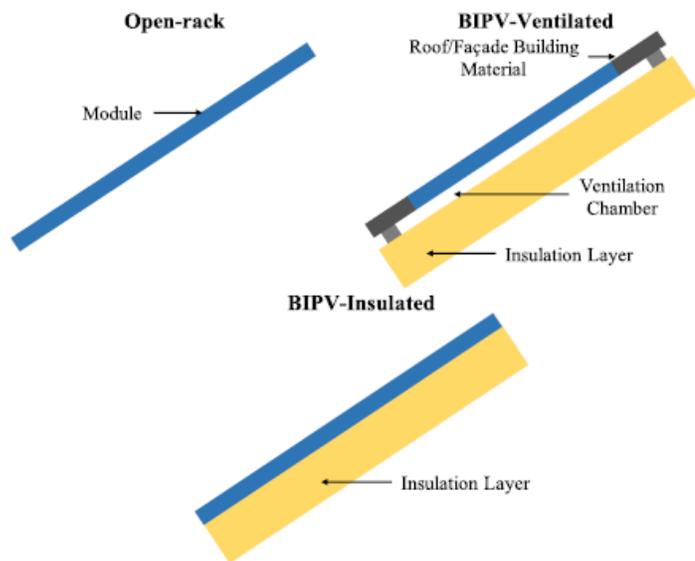
Module reliability



Faes, A., Virtuani, A., Quest, H., et al. (2025), *Building-integrated photovoltaics*. Nature Reviews Clean Technology.

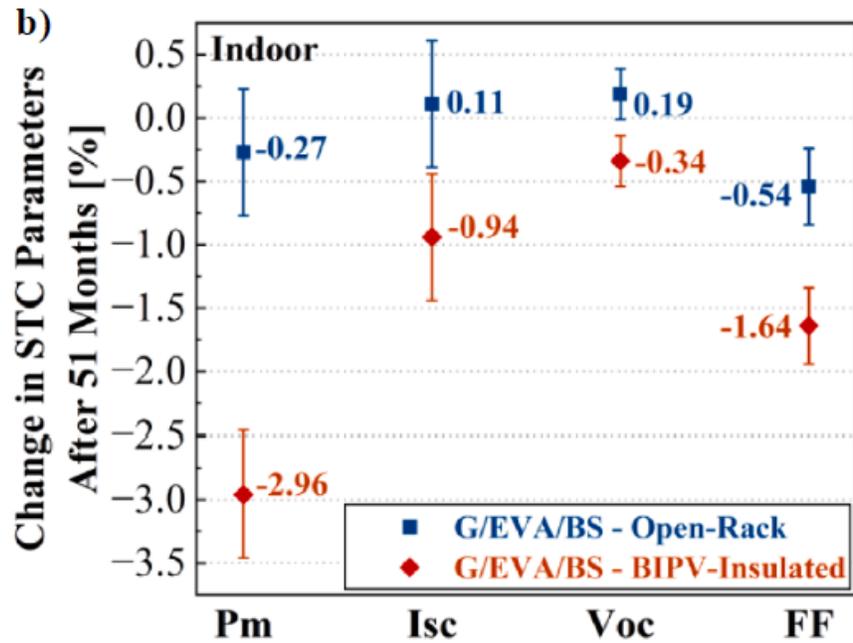
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1. Temperature distribution of BIPV vs open-rack (OR)

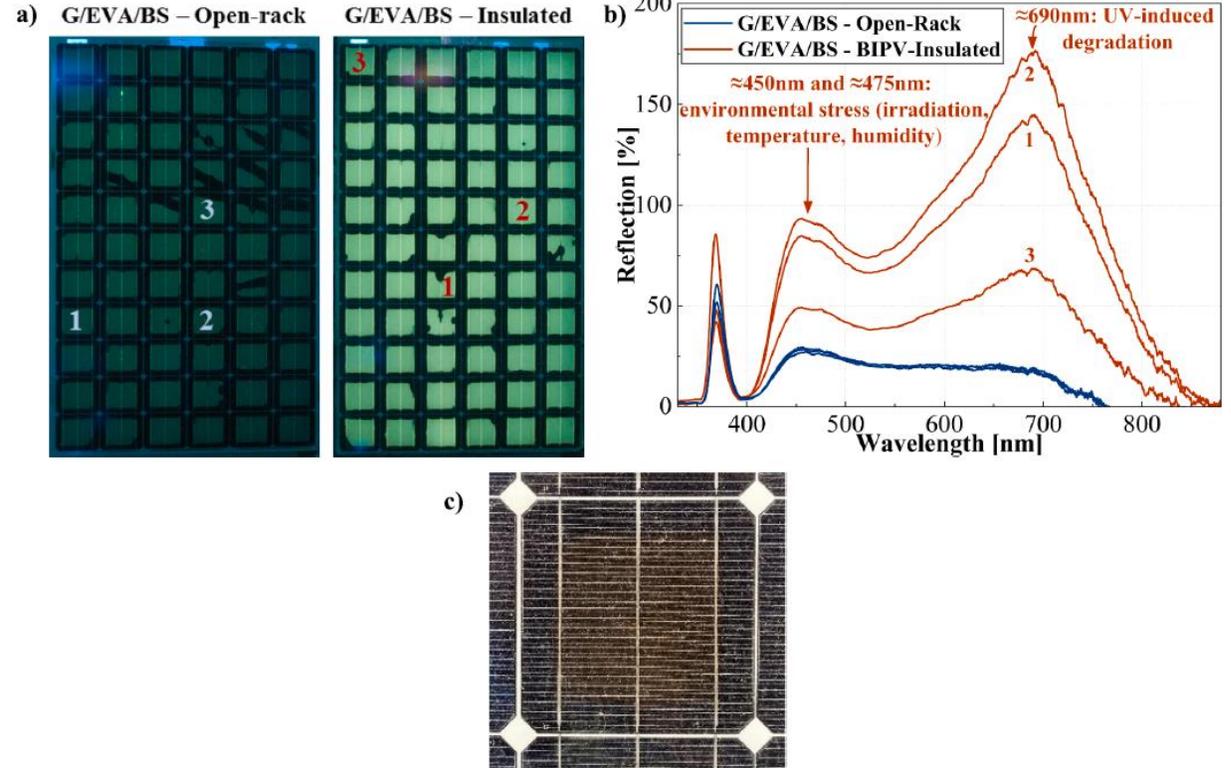


Test Stand	Cell and Module Technologies	Tilt Angles	Open-Rack		BIPV-Ventilated		BIPV-Insulated		Temperature Difference (BIPV – Open-rack)	
			T_{98} [°C]	T_{max} [°C]	T_{98} [°C]	T_{max} [°C]	T_{98} [°C]	T_{max} [°C]	T_{98} [°C]	T_{max} [°C]
1	Al-BSF - G/EVA/BS	6°	57	66	-	-	80	92	23	26
	Al-BSF - G/PVB/G	6°	53	62	-	-	80	91	27	29
2	HJT - G/G	20°	50	64	71	83	-	-	21	19
	PERC - G/EVA/BS	20°	-	-	63	77	-	-	-	-
3	PERC - G/PVB/G	90°	-	-	59	68	-	-	-	-

2. Effect of higher temperatures on performance & polymer degradation



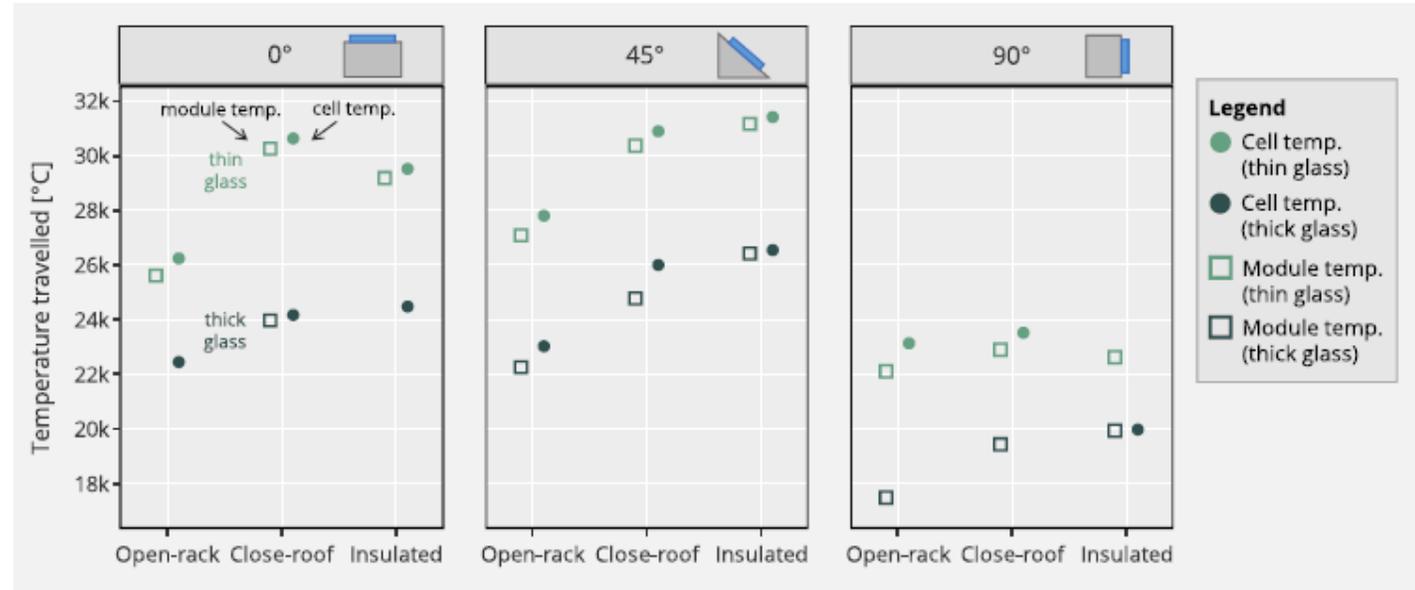
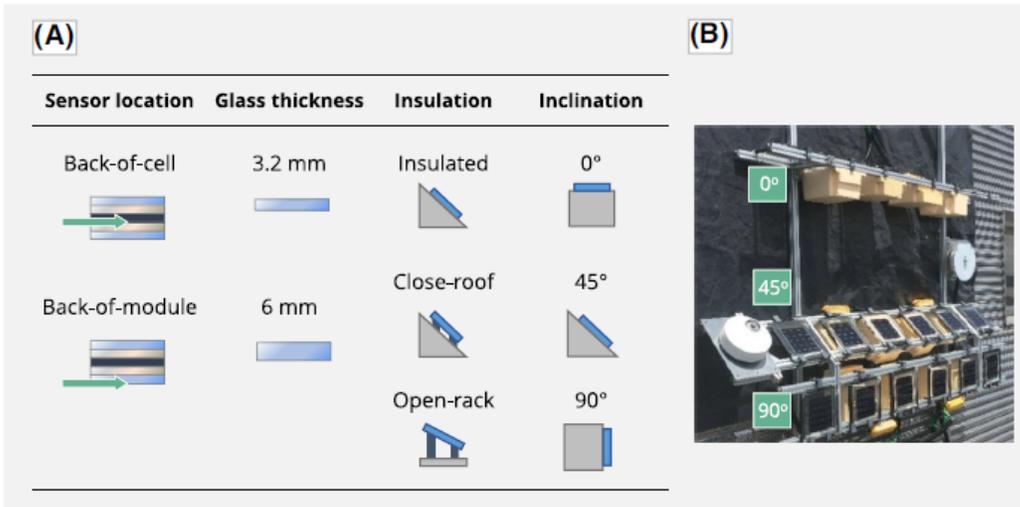
Indoor measurements after 51 months outdoors.



UV-F (UV Fluorescence) imaging & spectroscopy and polymer browning.

Mock-up: influence of tilt, typology of installation and glass thickness on “*temperature travelled*”.

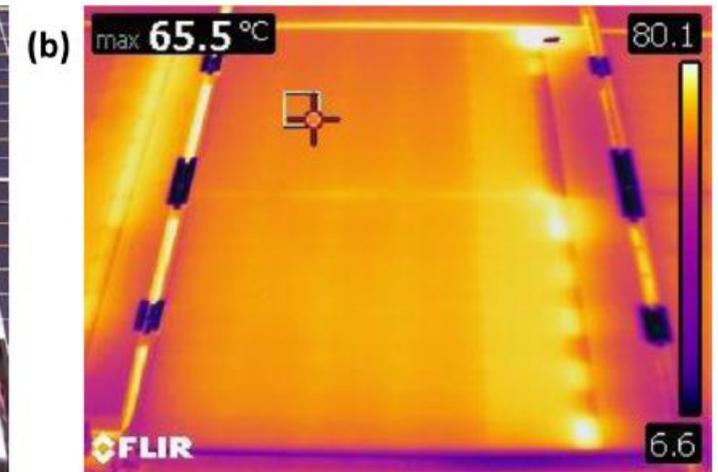
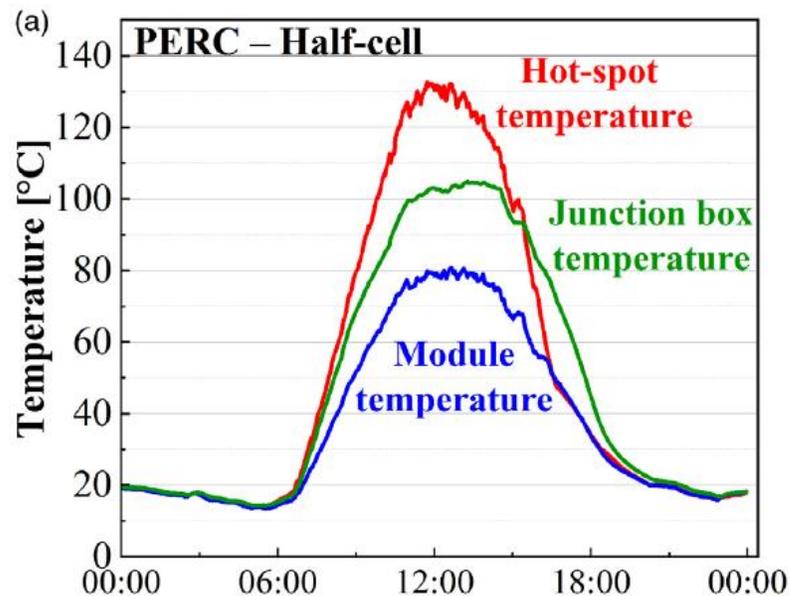
Close-roof (BAPV) vs insulated (BIPV)
Temperature travelled is higher for close-roof for horizontal/vertical installation.
Slightly higher for BIPV at 45° tilt.



4. Shading (1)

In the built environment, shading events are more frequent.

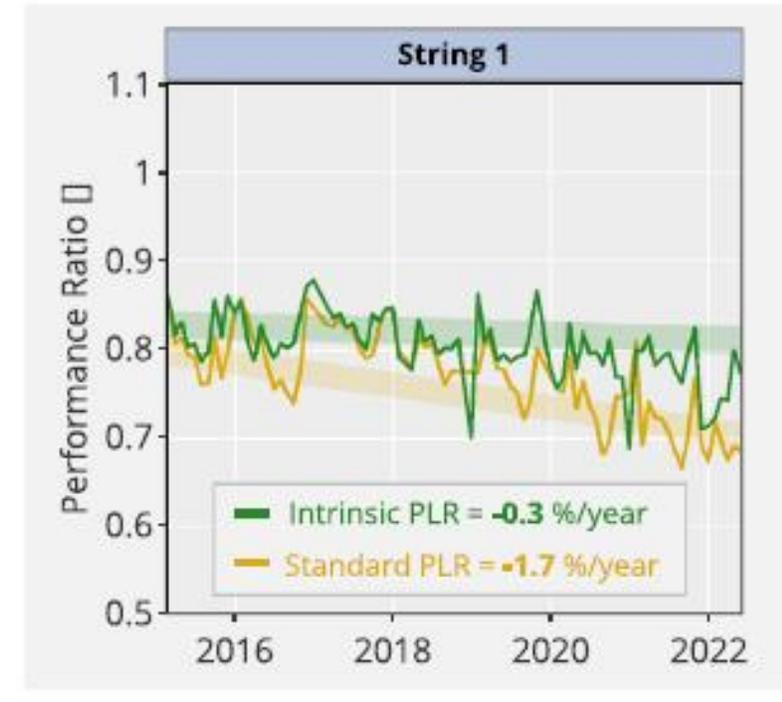
- **Performance:** small shadows, big losses!
- **Reliability:** more frequent solicitation of by-pass diodes (BPD), high stress on BPD, defective BPDs can lead to hot-spots (HS), which may lead to several degradation modes and safety threats.
- Defective BPD or solder joints may induce arcing and pose a fire threat.



4. Shading (2)

A novel metric to decouple system performance in the event of shading (and other reversible failure modes).

- Performance loss rate (PLR)
- Intrinsic-PLR (i-PLR)





Standards, norms, etc.

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20 years ago:

- Just industry standards for PV (IEC 61215/61646/61730)
- Lot's of «missing gaps» to account for operations under harsher conditions

Today:

- Standards for PV (IEC 61215/61730)
- Several missing gaps have been integrated in qualification/safety standards (e.g. dynamic mechanical load, ...).
- Possibility to apply higher stressors to account for operation at higher temperatures (BIPV, hot climates: IEC TS 63126:2020)

[IEC TS 63126:2025 RLV](#)

Guidelines for qualifying PV modules, components and materials for operation at high temperatures

[IEC 62892:2019](#)

Extended thermal cycling of PV modules - Test procedure

The operations of PV in the built environment is characterized by:

1. Exposure to higher temperatures >> aging of materials/polymers.
2. Higher “*temperature travelled*” >> higher stress/fatigue on solder joints.
3. Frequent shading: higher stress on BPD, with defective BPD higher risk of hot-spot occurrence.
4. With defective BPD and solder joints, higher risk of arching >>> overheating and fire threat.

We propose novel metric to decouple performance of PV systems when impacted by shading.



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Thank you!



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