ENERGY GAIN THROUGH TEXTURED MODULE GLASS

31st International PV Science and Engineering Conference

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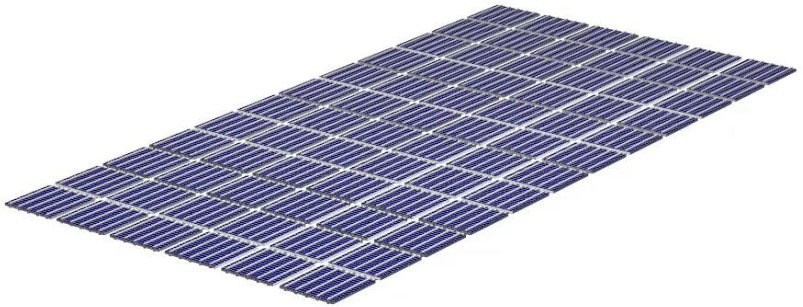
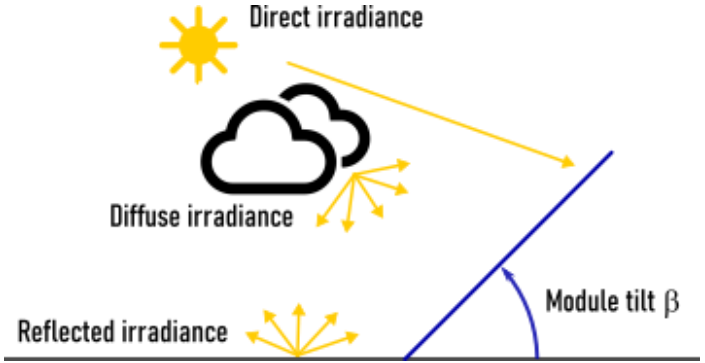


Australian National University

Impact of Glass Textures on the Energy Yield in Field-Installed Solar Modules

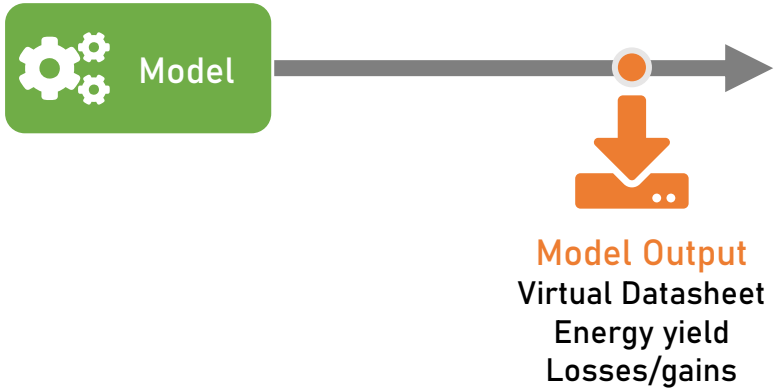
- Solar modules face a large range of illumination and temperature condition under outdoor exposure
- Illumination conditions also depend, for example, on installation type (e.g. tracking system or fixed-tilt installations)



Aims:

1) Quantify potential energy yield gains of different module glass textures.
2) How strongly does the type of installation affect the achievable gain?

CTMY model (Cell-To-Module-Yield)



I. Haedrich, D. C. Jordan, and M. Ernst, Solar Energy Materials and Solar Cells 202, 110069 (2019)

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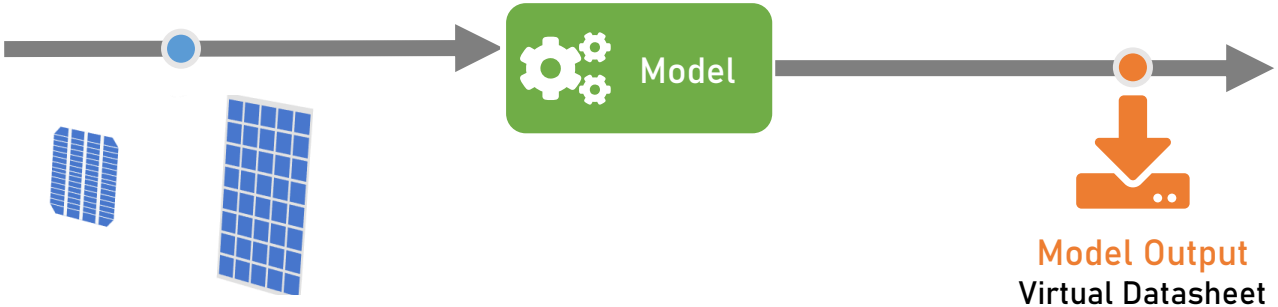

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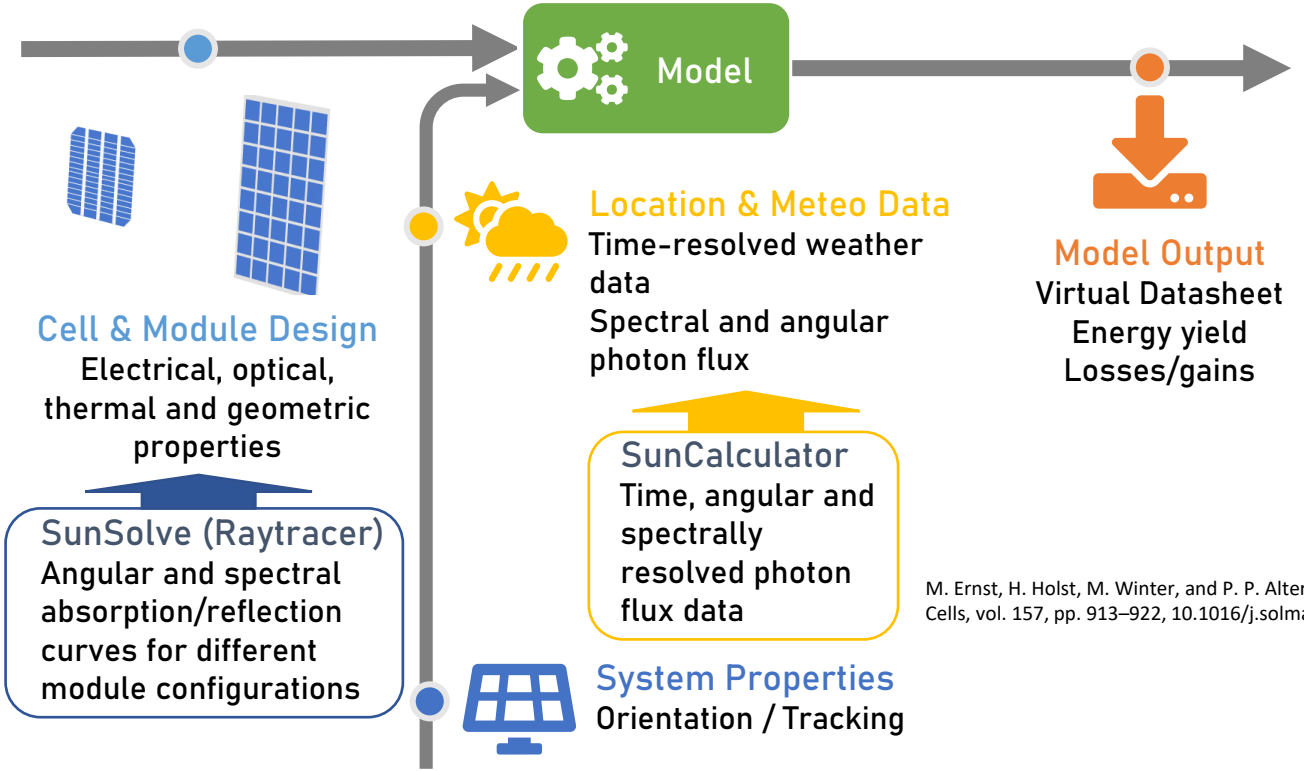
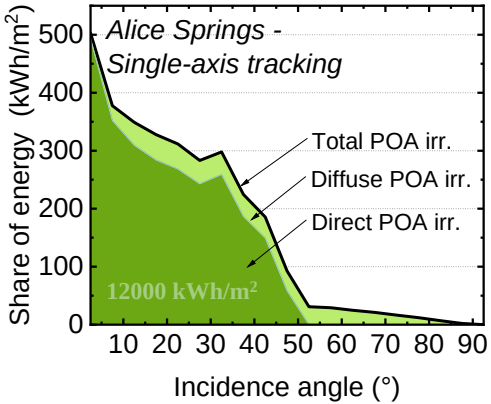


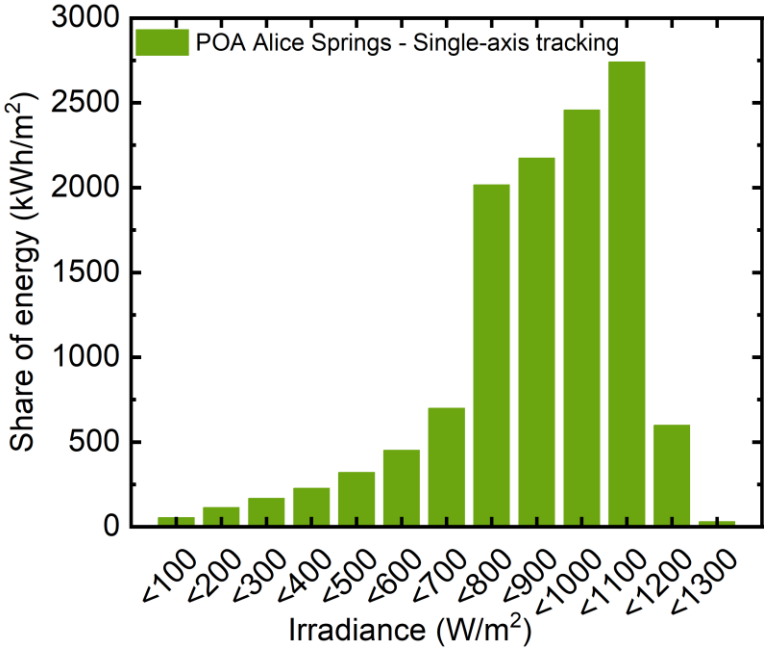
M. Ernst, H. Holst, M. Winter, and P. P. Altermatt, Sol. Energy Mater. Sol. Cells, vol. 157, pp. 913–922, 10.1016/j.solmat.2016.08.008, 2016.

Irradiance Data

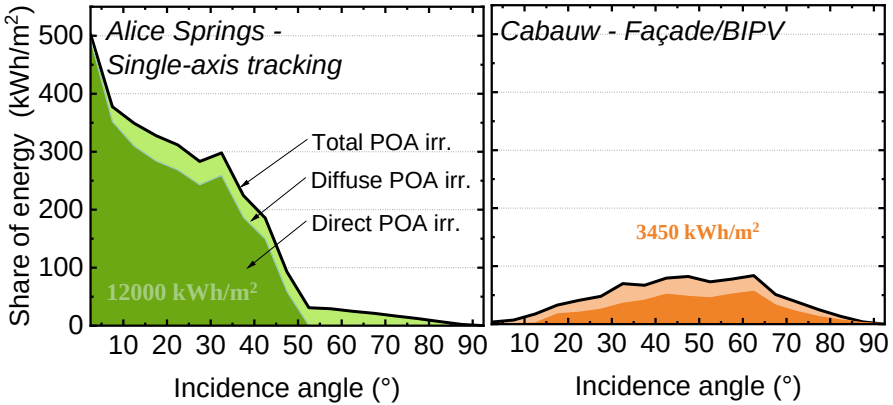
https://www.wallgroup.com/3d-world-map-black.html

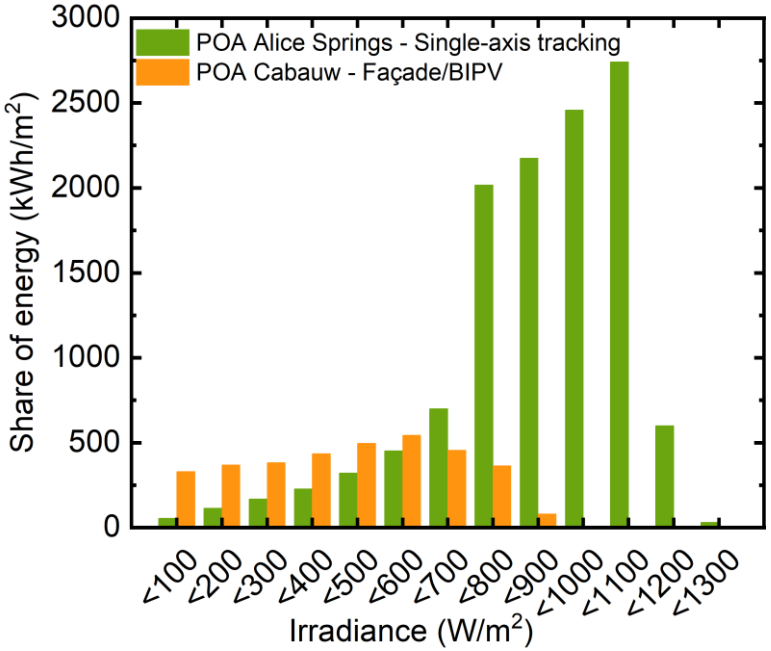
Irradiance Data





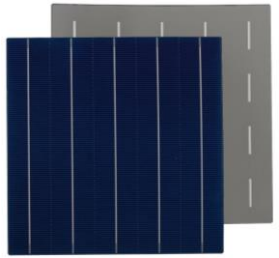
Irradiance Data

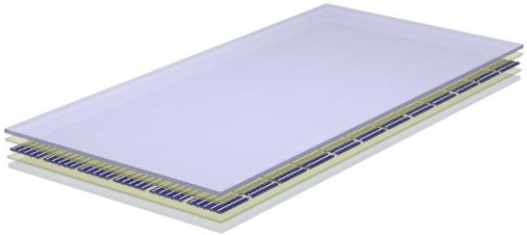




Module Designs

- All modules identical except for front glass
- Five busbar PERC solar cell with 20.7% efficiency

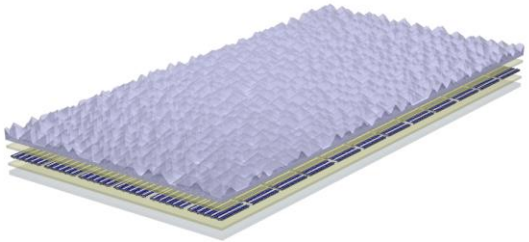




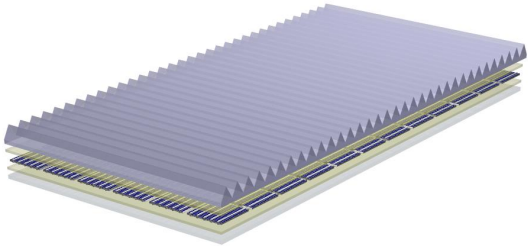
Reference: Planar front

Rough: Lambertian surface

Modelled with a 110 nm thick anti-reflective coating (ARC)



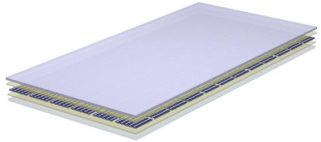
Pyramid: 45° base angle and height of 1 mm



V-Grooved: V-grooves parallel to short edge with a 50° base angle

Incidence Angle Modifier (IAM)

- IAM corresponds to the decrease in irradiance as function of the incidence angle compare to normal incidence.



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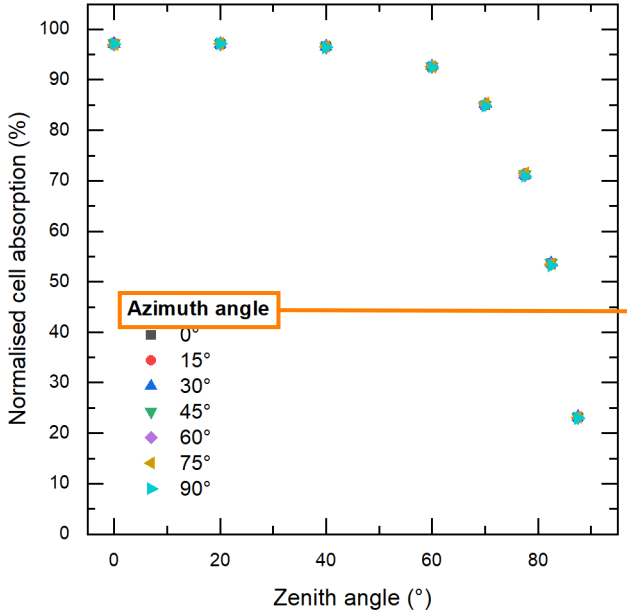
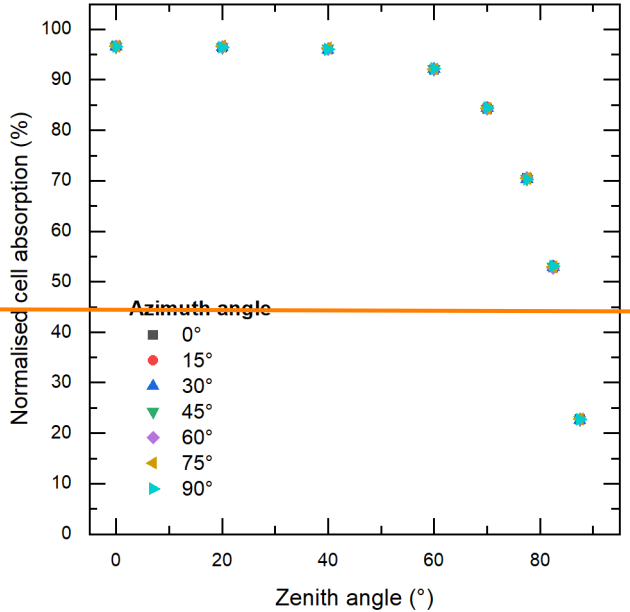
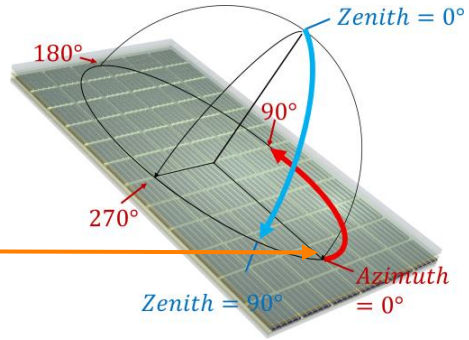


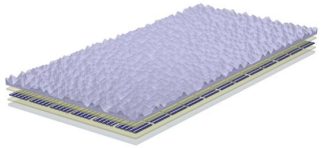
Rough: Lambertian surface



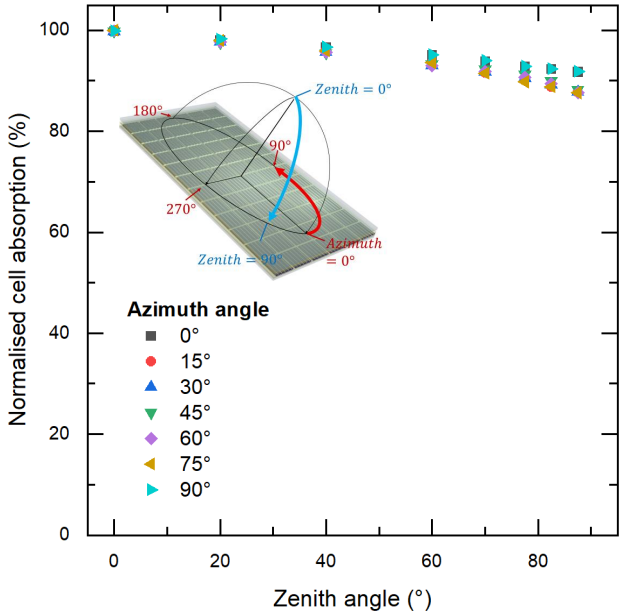


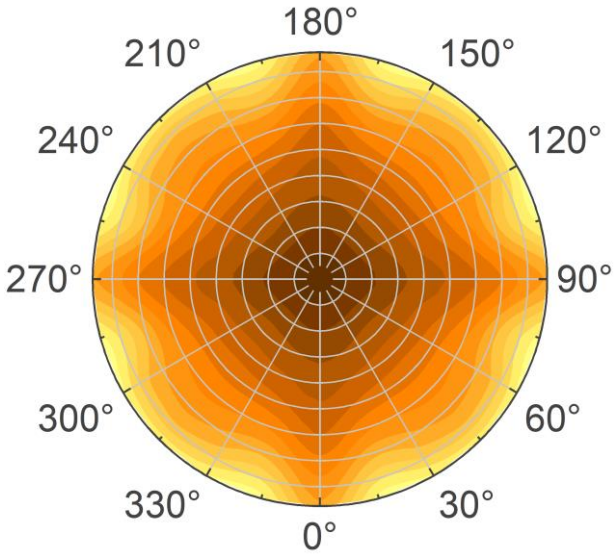
IAM for Pyramids

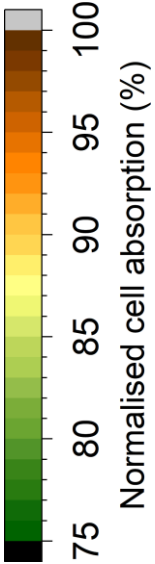
- For non-rotational symmetrical surface structures azimuth angle needs to be considered



Pyramid front texture

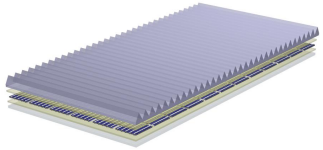




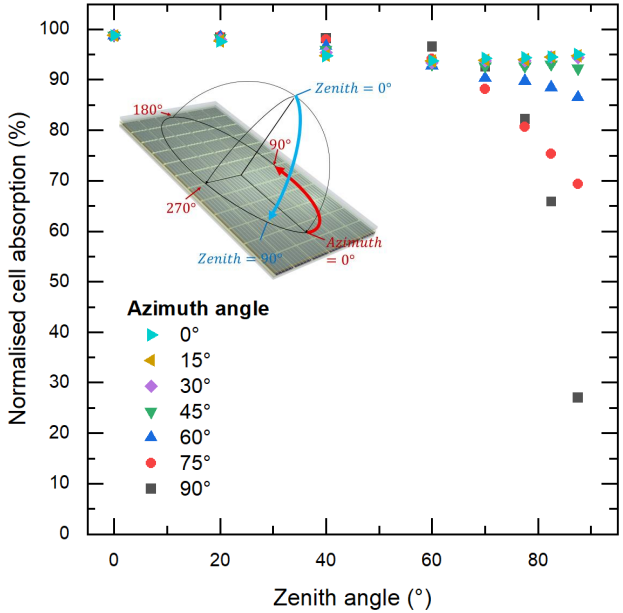


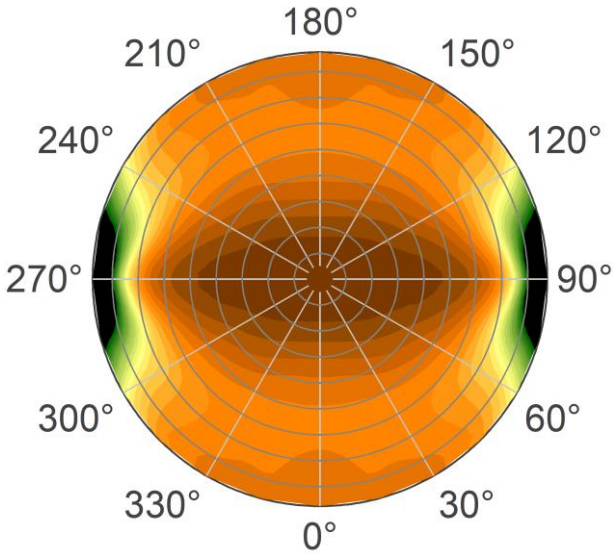
IAM for V-grooves

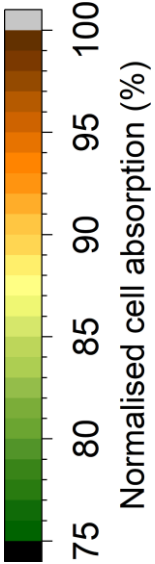
- Grooves texture show a very strong rotational asymmetry

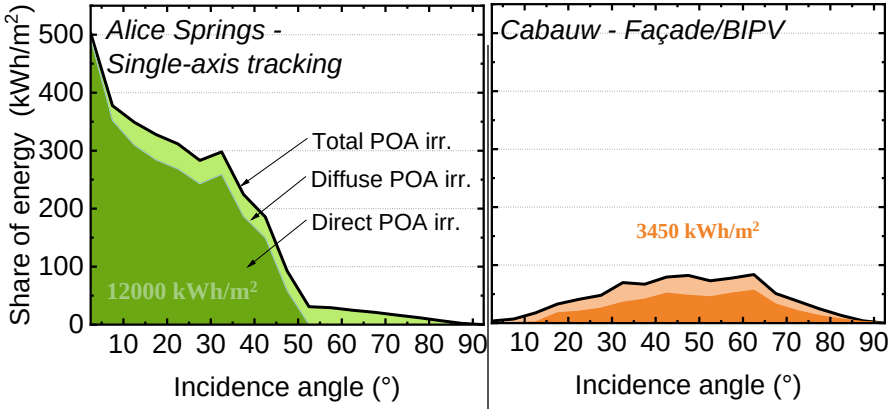


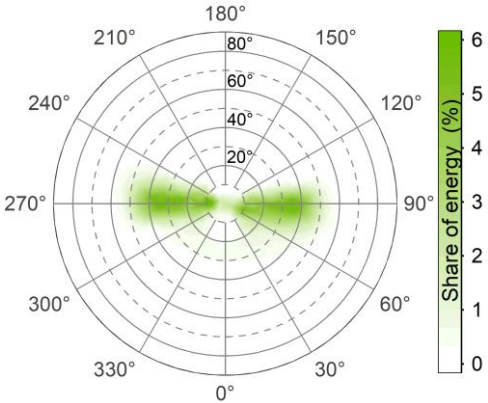
V-groove front texture

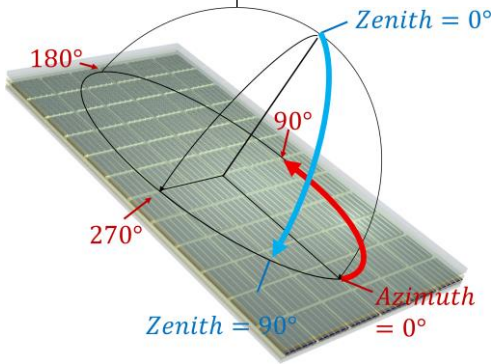


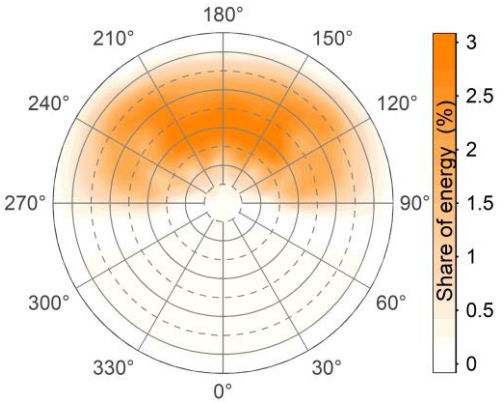




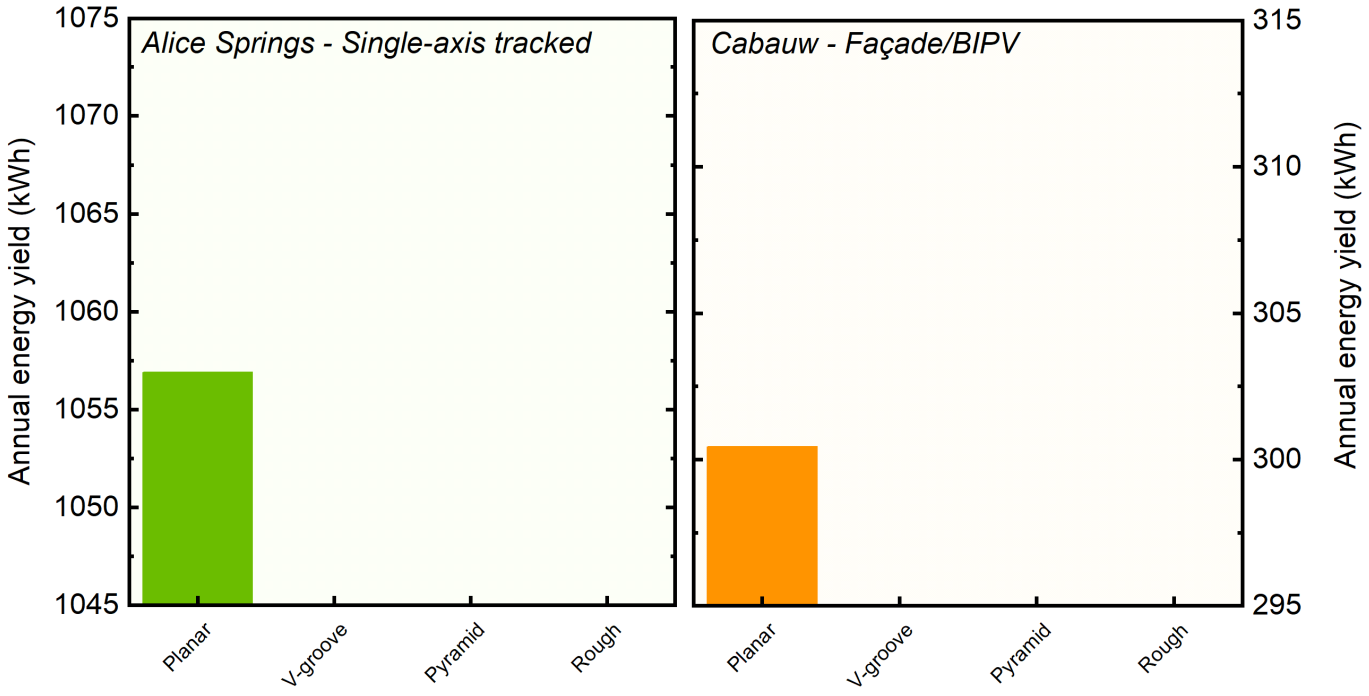

Alice Springs -
Single-axis tracking
Share of energy (kWh/m²)
500
400
300
200
100
0
Total POA irr.
Diffuse POA irr.
Direct POA irr.
12000 kWh/m²
10 20 30 40 50 60 70 80 90
Incidence angle (°)
Cabauw - Façade/BIPV
3450 kWh/m²
10 20 30 40 50 60 70 80 90
Incidence angle (°)


180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
80°
60°
40°
20°
Share of energy (%)
6
5
4
3
2
1
0

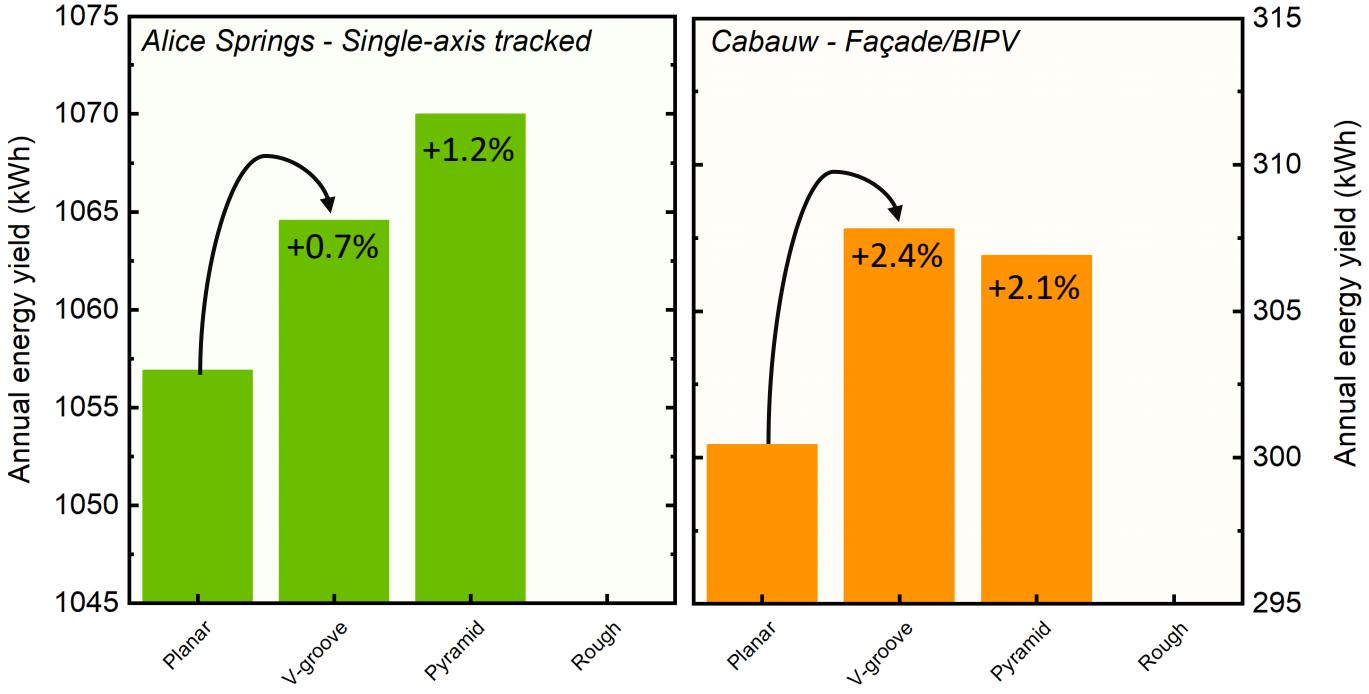

Zenith = 0°
180°
90°
270°
Azimuth
= 0°
Zenith = 90°


180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
Share of energy (%)
3
2.5
2
1.5
1
0.5
0

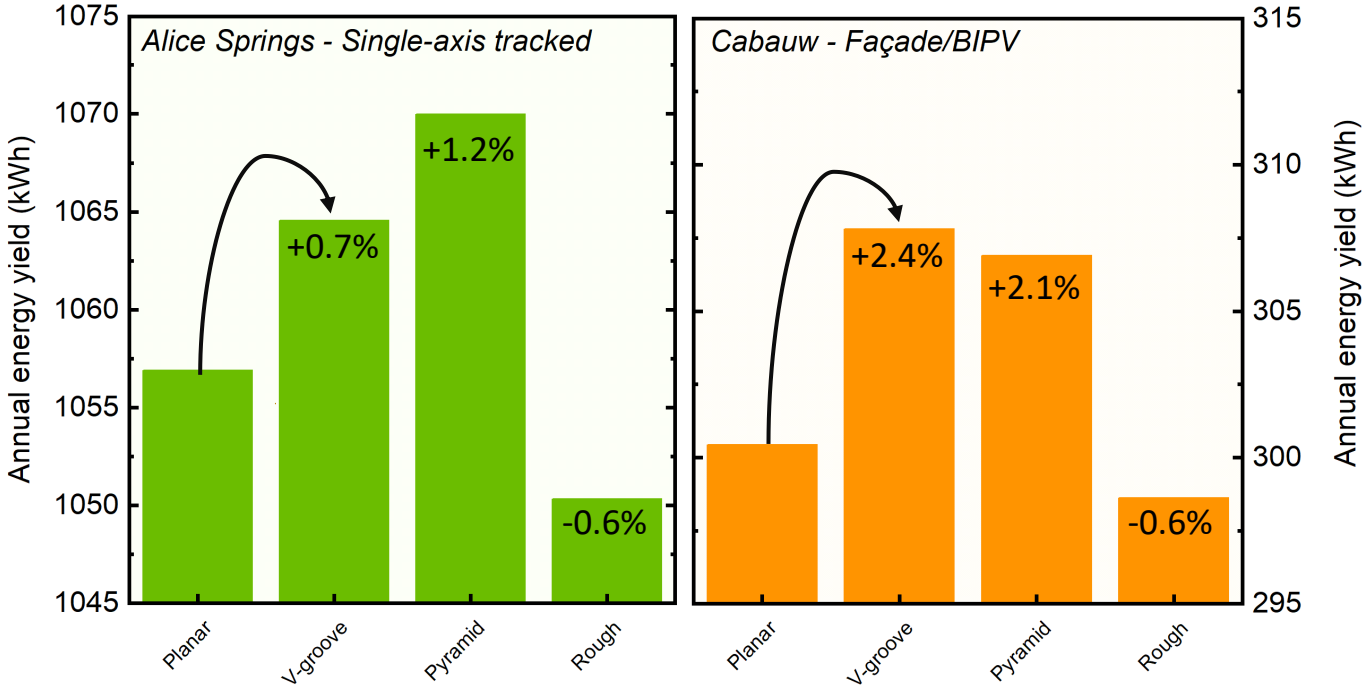
Modules in portrait orientation



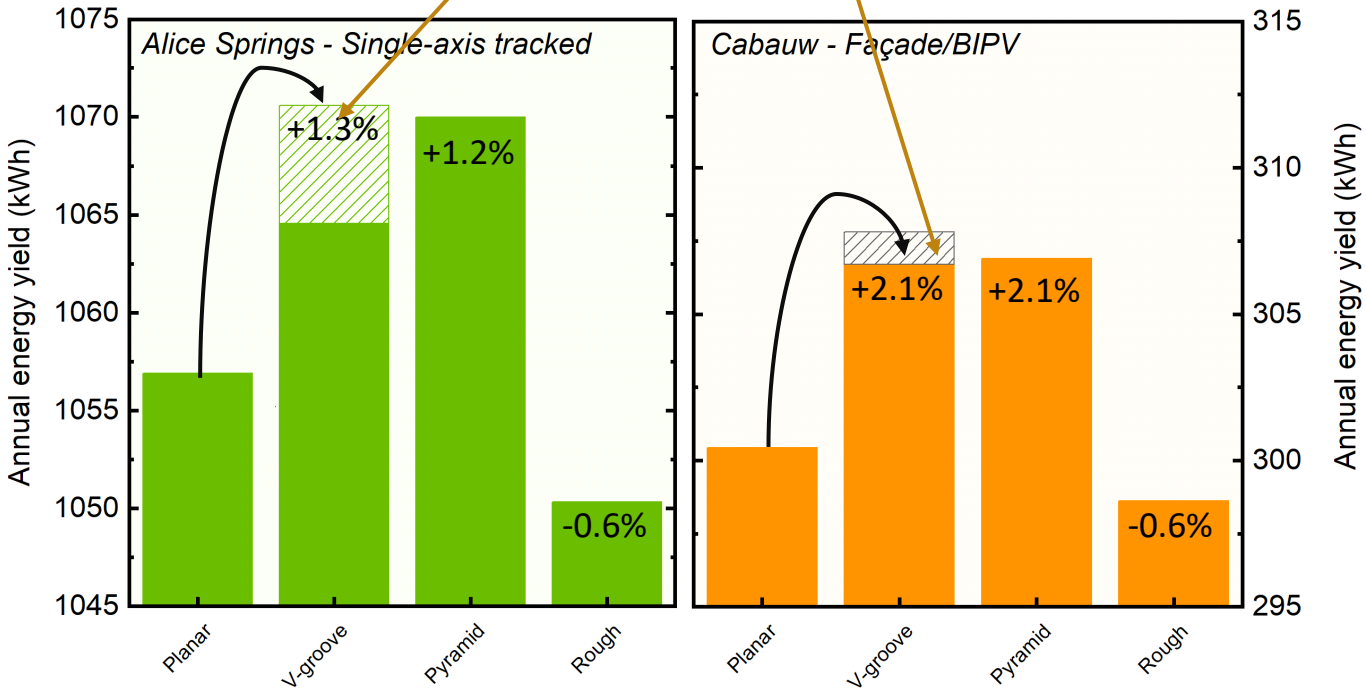
Modules in portrait orientation



Modules in portrait orientation

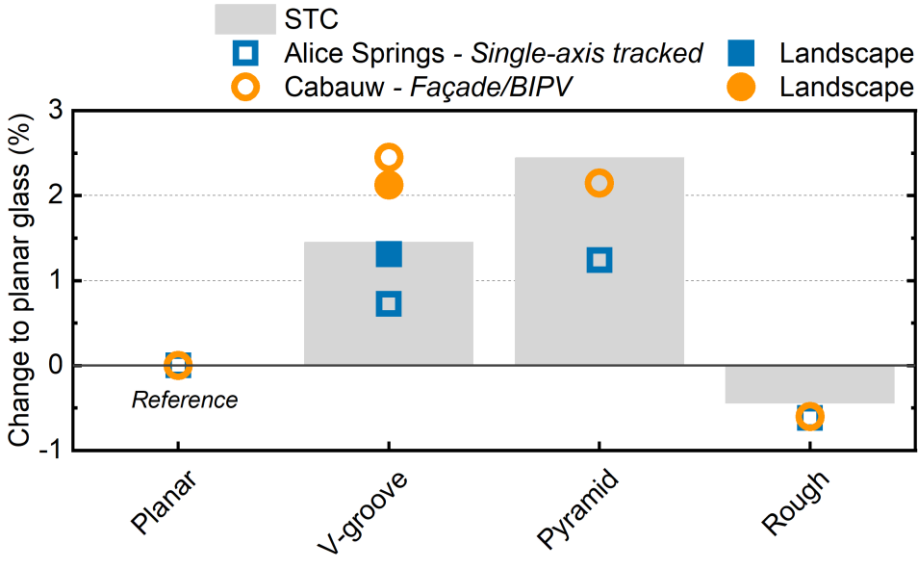


Landscape orientation



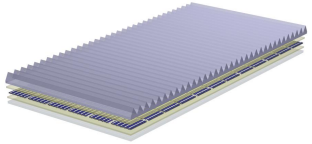
Impact of Glass Texture on Yield

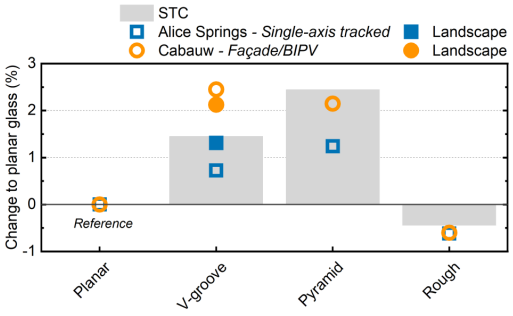
- Yield gains vary with location / installation type
- STC gains can over- or underestimate the energy yield gain

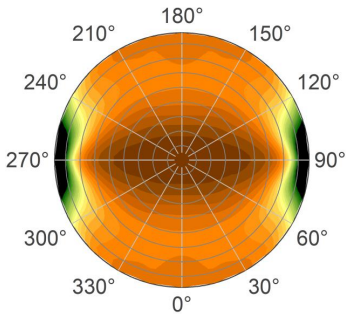


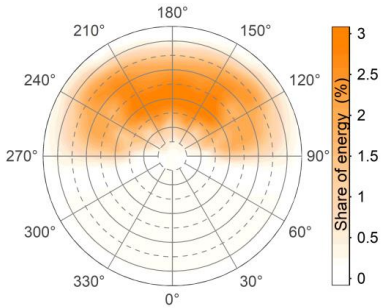
Summary

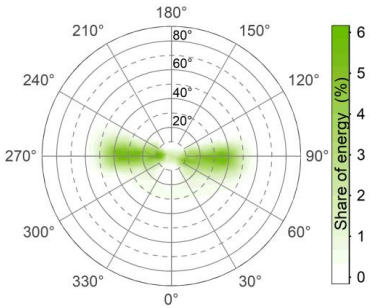
1) **Quantify potential energy yield gains of different module glass textures.**
   - CTMY model considers angular, spectral and temperature effects to provide realistic estimates of module energy yield
   - V-groove and Pyramid textures achieve 2.4% and 2.1% yield gain in the BIPV scenario
   - In the single-axis tracking scenario the yield gain for these textures is 0.7% and 1.2%
2) **How strongly does the type of installation affect the achievable gain?**
   - Comparing the two scenarios, the relative energy yield gain between locations & installation type varied by more than 300% for the same glass texture
   - We attribute this difference largely to the different irradiance distributions











THANK YOU

Contact Us

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