ETIP Photovoltaics

Eco-positive bifacial module design

Kay Cesar, Bas van Aken

15 June 2023

Start presentation

TNO innovation for life

Eco-positive bifacial module design

The business opportunity of transmitted light

Kay Cesar, Bas van Aken

München, Intersolar

15 June 2023

Agenda

1. Solar park development in the Netherlands
2. Soil quality and land lease
3. Bifacial panel and eco-positive park design
4. Value of partial transparency of bifacial panels
5. Conclusion & recommendation

Image credit: Mark Osborne, January 21, 2019 , PV-tech,
12MWp Jolywood bifacial panels, installed 2019 by Unisun,, Rilland, the Netherlands
Roadtrip 2021:

Solar development in the Netherlands

- NL globally ranked 2nd PV capacity/capita
- Ground lease 6-8 k€/ha/year and rising
- Ground coverage ratios 0.65 – 0.95
- Park installation often in agricultural setting
- Political climate is changing – opposition grows
- Permit requirements increase
- Business case under pressure
- Call for multiple land-use → Eco-positive design

Solar development in the Netherlands

- NL globally ranked 2nd PV capacity/capita
- Ground lease 6-8 k€/ha/year and rising
- Ground coverage ratios 0.65 – 0.95
- Park installation often in agricultural setting
- Political climate is changing – opposition grows
- Permit requirements increase
- Business case under pressure
- Call for multiple land-use → Eco-positive design

Land lease and soil quality

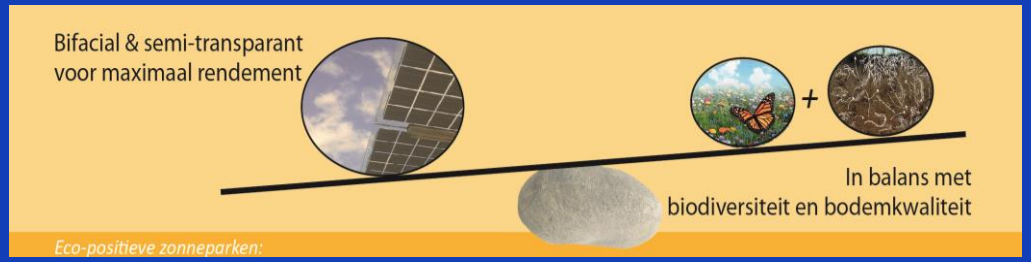
Lease contract with agricultural landowners

- Maintain soil quality!

First version of design rules for soil quality is drafted

- Link between vegetation growth and ground irradiance in existing solar parks [1]

Transparent bifacial panels can play a key role



1) Kay Cesar, Bas van Aken, Luuk Scholten, Ron de Goede en Alex Schotman, Bodem, no 2, April 2022

Land lease and soil quality

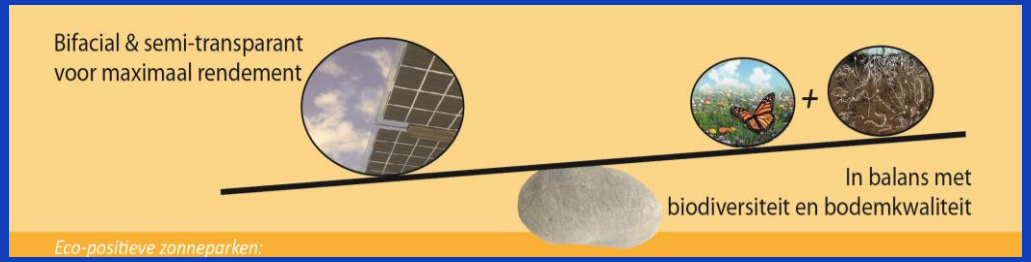
Lease contract with agricultural landowners

- Maintain soil quality!

First version of design rules for soil quality is drafted

- Link between vegetation growth and ground irradiance in existing solar parks [1]

Transparent bifacial panels can play a key role



1) Kay Cesar, Bas van Aken, Luuk Scholten, Ron de Goede en Alex Schotman, Bodem, no 2, April 2022

Land lease and soil quality

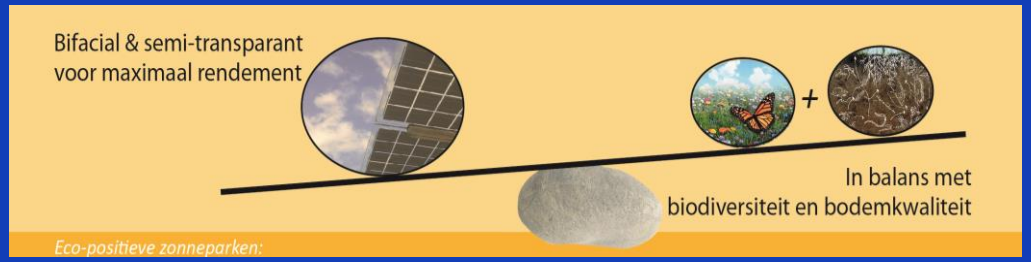
Lease contract with agricultural landowners

- Maintain soil quality!

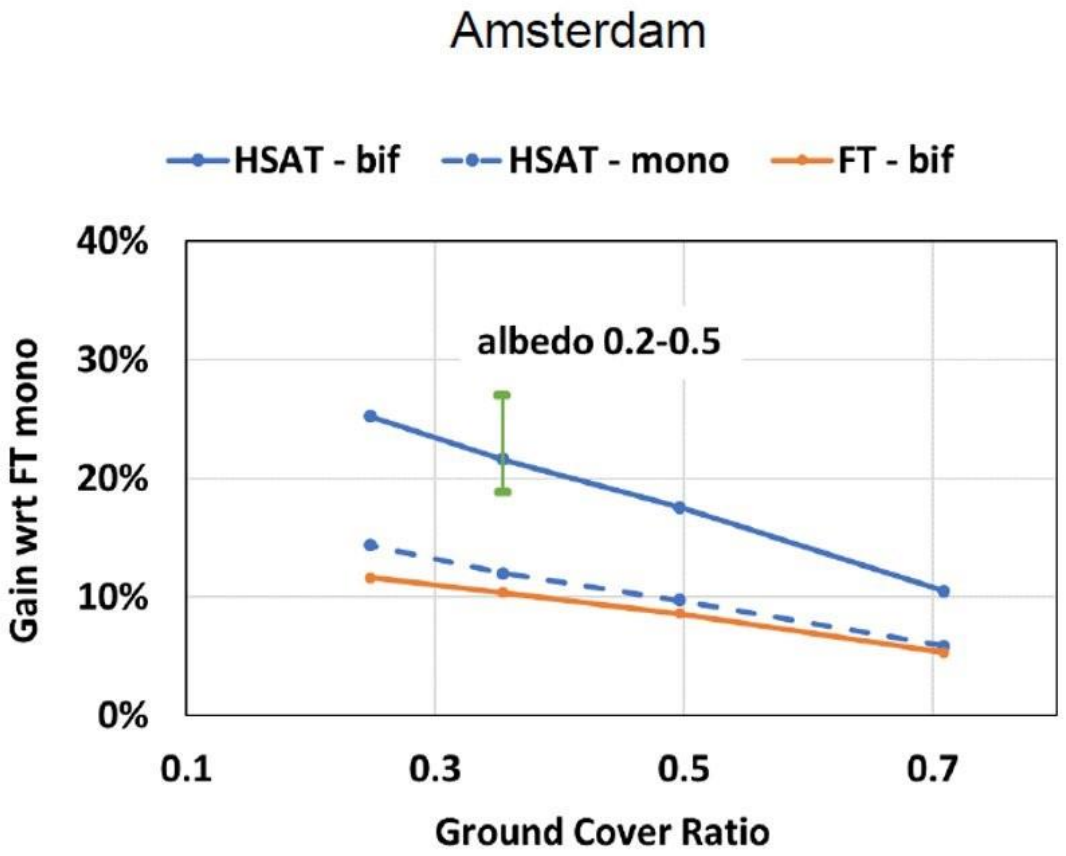
First version of design rules for soil quality is drafted

- Link between vegetation growth and ground irradiance in existing solar parks [1]

Transparent bifacial panels can play a key role



1) Kay Cesar, Bas van Aken, Luuk Scholten, Ron de Goede en Alex Schotman, Bodem, no 2, April 2022



Bifacial gain increases at lower coverage

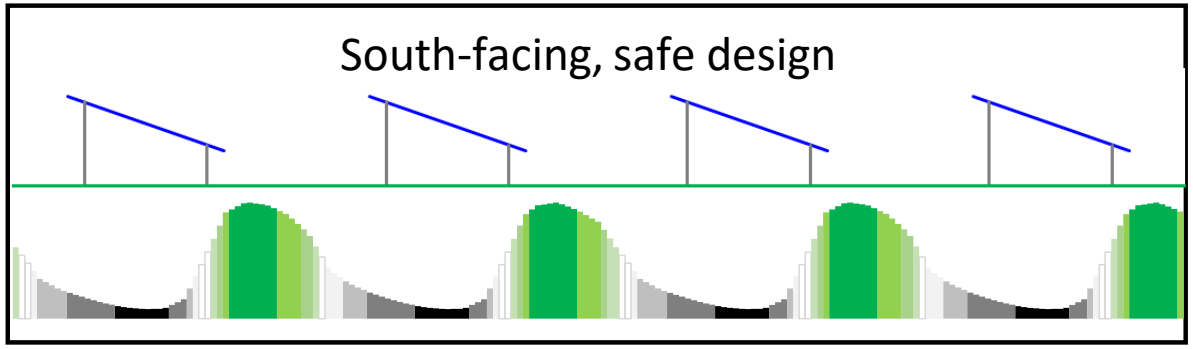
+

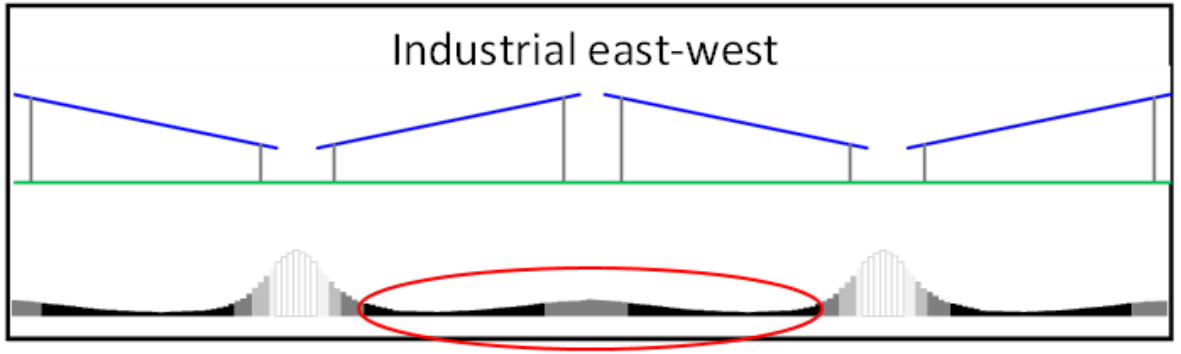
ITRPV 2023 - no premium for bifacial panels

=

Higher ecological potential at same business case

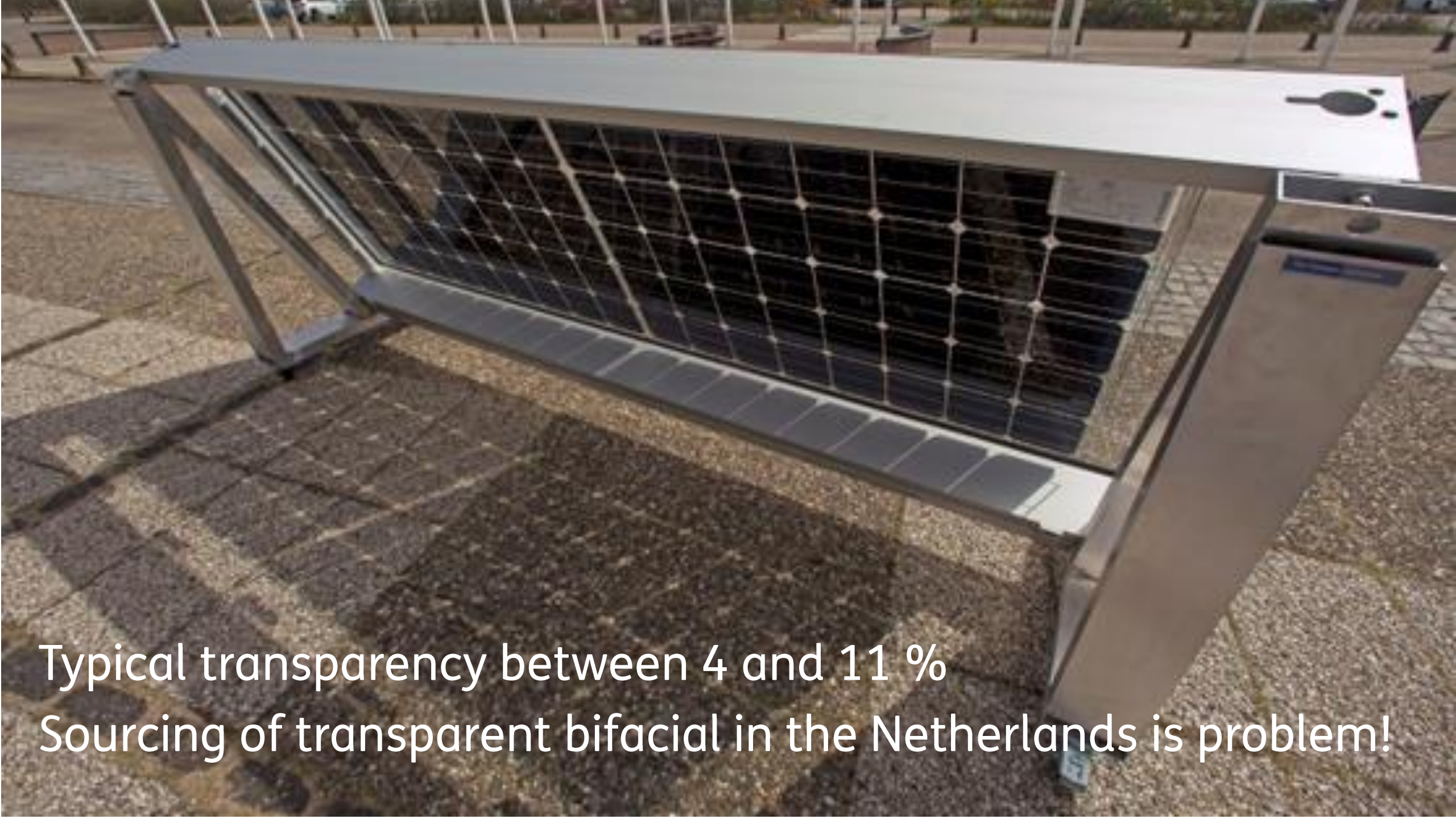
LINK GROUND IRRADIANCE TO SOIL QUALITY





TNO innovation for life

WAGENINGEN UNIVERSITY & RESEARCH

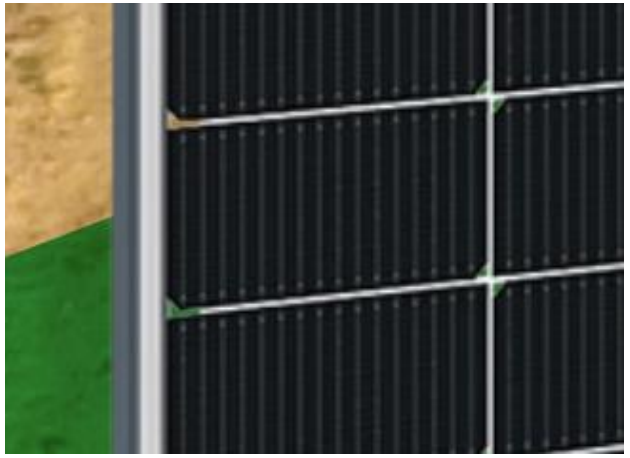


Typical transparency between 4 and 11 %

Sourcing of transparent bifacial in the Netherlands is problem!

Reflector foil in bifacial modules

New trend based on known technology to increase front side efficiency

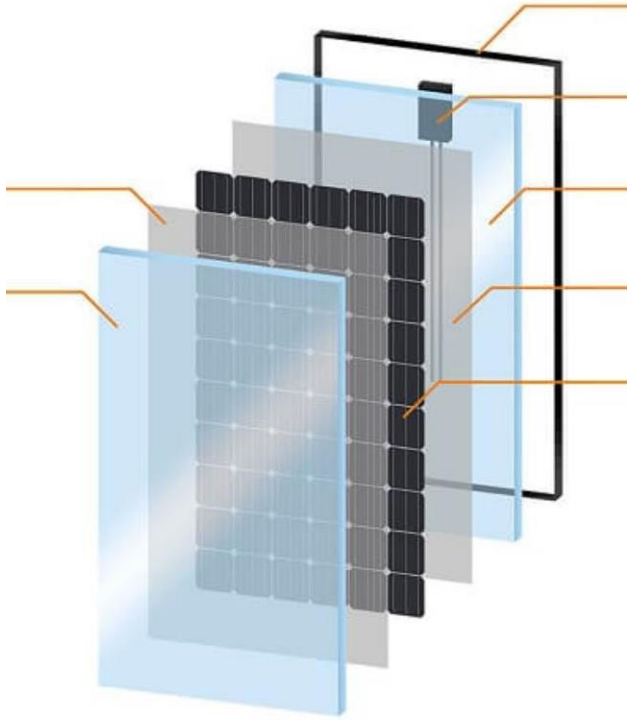


Examples of current products

Astronergy: ASTRO-N5-605_625W-182-78-Bifacial-Module.pdf (astronergy.com)

Trina: Datasheet - Trina Solar - 500 W - Mono Bifacial Half Cut - India (solarbay.com.mx)

Integrated reflector in encapsulant “white” bifacial



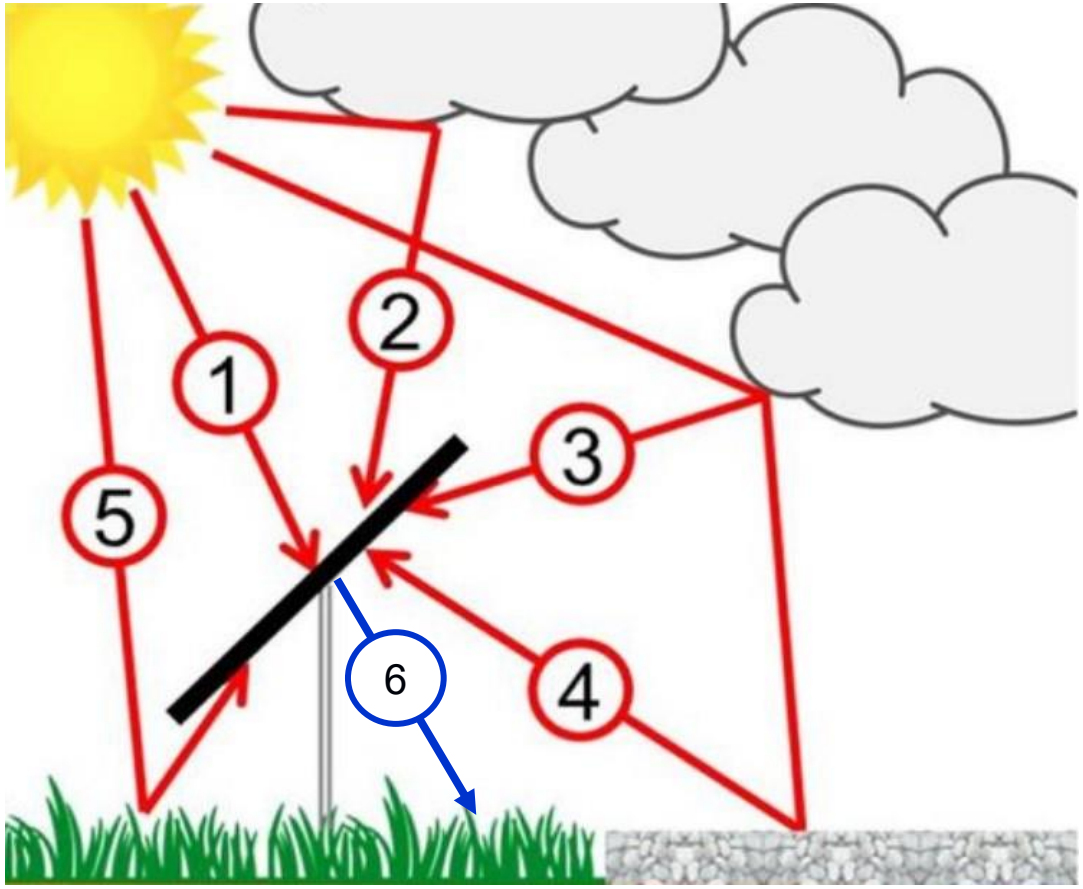
https://pv-manufacturing.org/bifacial-solar-cells-and-modules/

[4] – Michael Schmela 2019, ‘TaiyangNews First Combined Market Survey on Solar Backsheets & Encapsulation Shows New Products & Trends That Have Convinced Module Makers to Offer 30 Year Performance Warranties’. Available: http://taiyangnews.info/opinion/innovation-in-module-backsheets-encapsulation/

Annual yield & ground irradiance

- Simulation considers:
  - Direct beam and diffuse components
  - Module transparency
  - Albedo 25%
  - Module 540 Wp, 144 half cells

  Effect reflector
  - + 2% Isc
  - 6.5% module surface – no transparency
- Critical soil test norm:
  - Ground irradiance > 10%

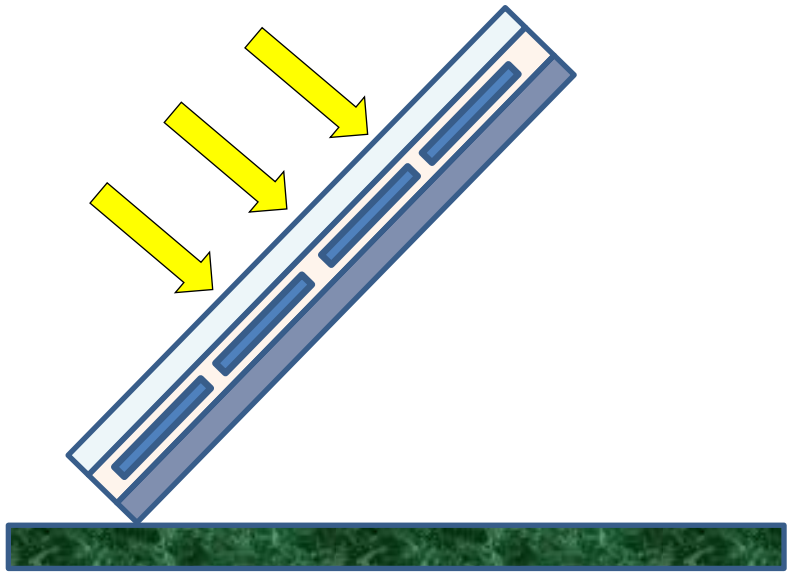


Monofacial

Module 144 half-cell - 540Wp

0% Transparency

Reference case



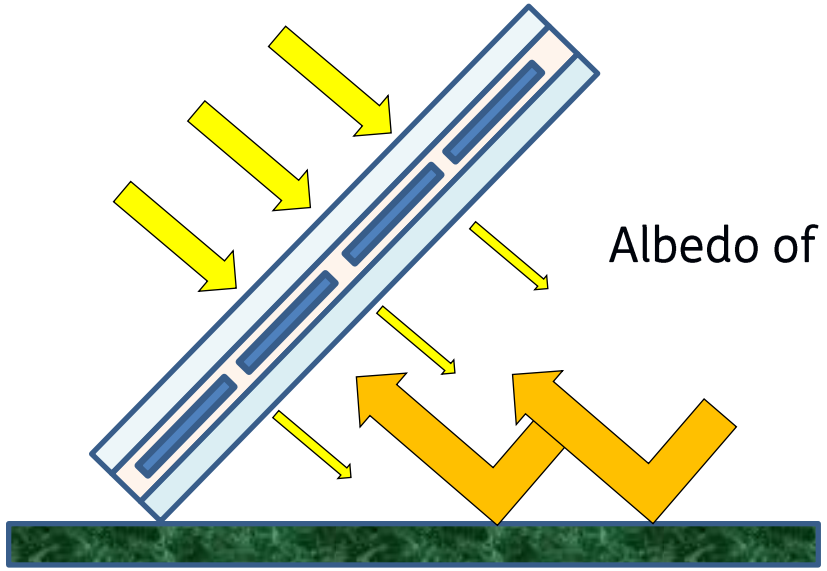
Bifacial

Partially transparent

Has 2% lower WP

6.5% transparency

Annual – yield gain



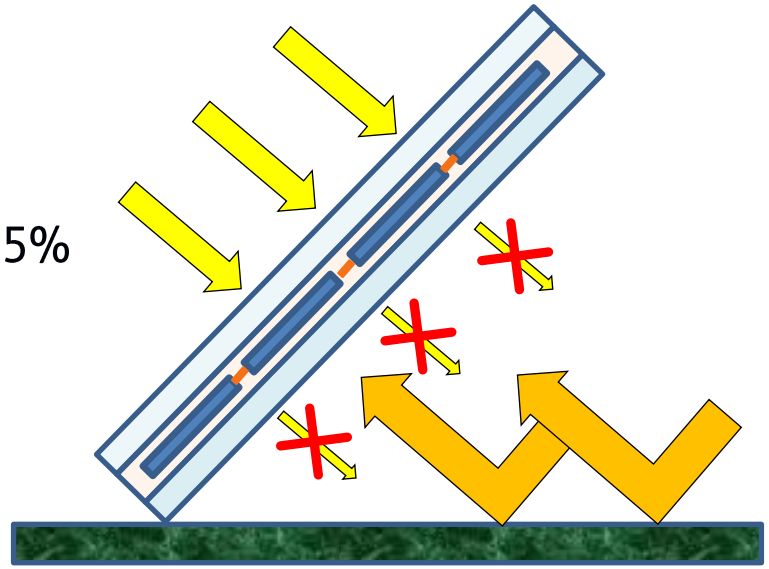
Albedo of 25%

Non-transparent

Has same Wp as monofacial

0% Transparency

Annual – yield gain



Park design	GCR	MF	BF	WBF	Gain foil
NL East-West	0.9	0	+0.9%	+1.9%	+1.0%
NL South	0.7	0	+2.0%	+3.4%.	+1.4%
Spain South	0.6	0	+2.2%	+3.5%	+1.3%

Gain annual yield reflector foil =1.0- 1.4%

Extra foil cost (material and processing)

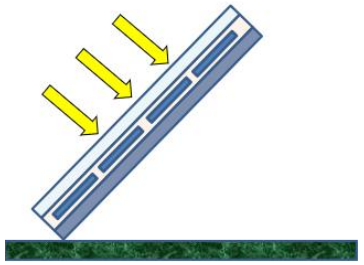
Extra recycling effort

Aesthetics?

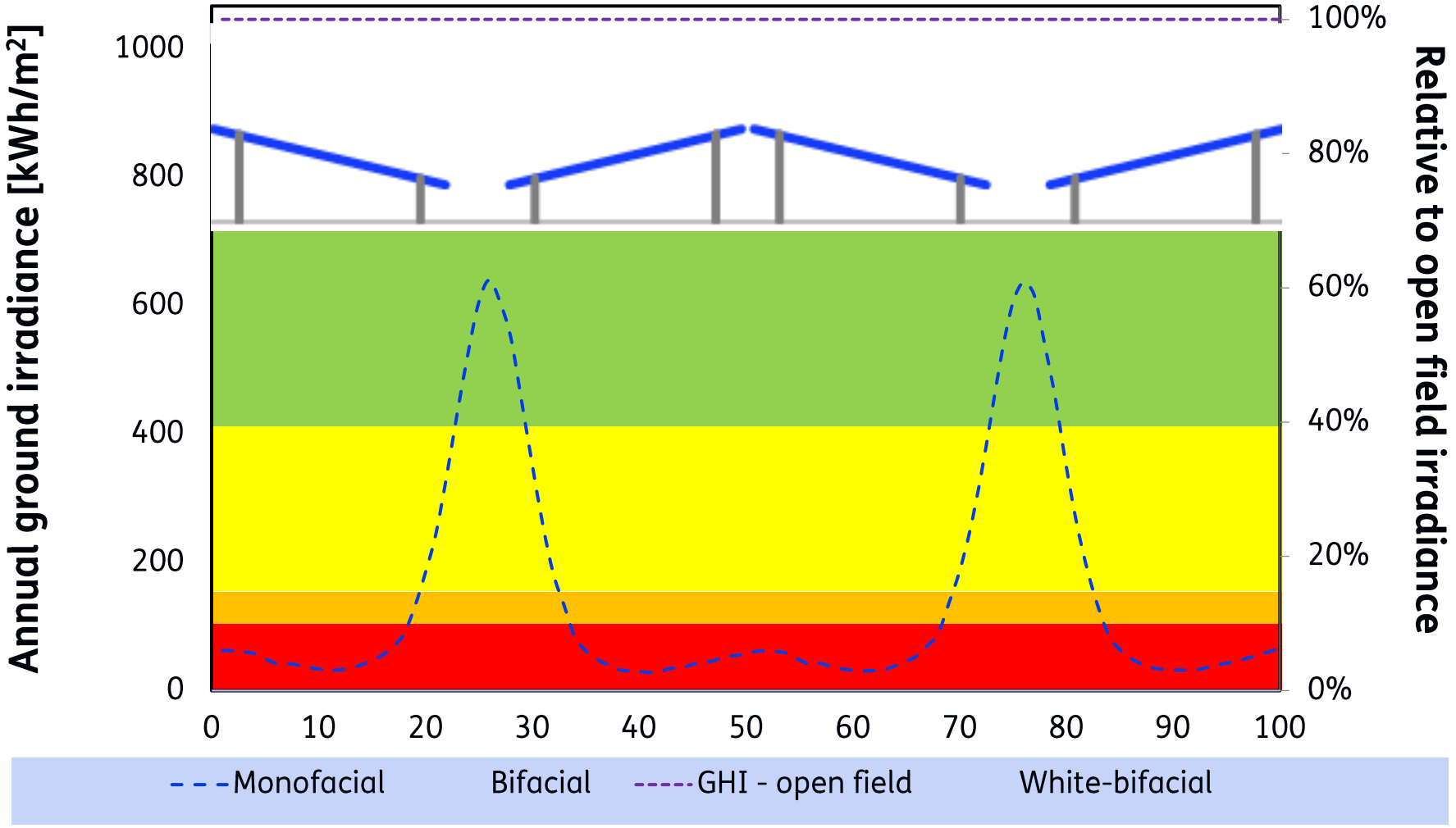
TNO innovation for life

Performance not optimized !

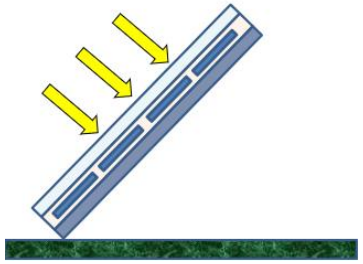
Soil test evaluation – East-West NL – GCR 0.9



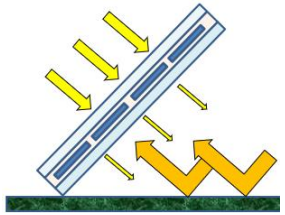
Monofacial



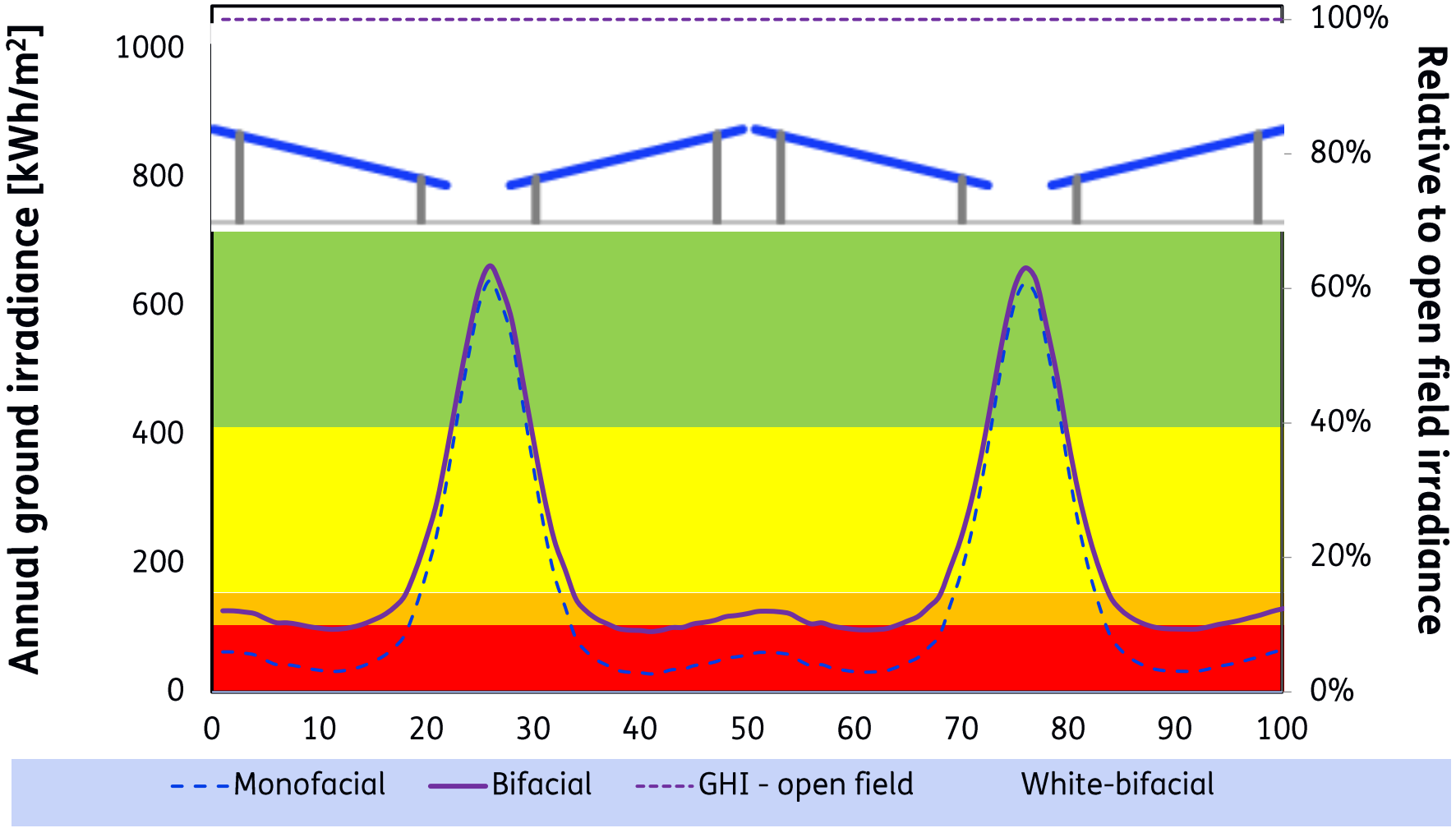
Soil test evaluation – East-West NL – GCR 0.9



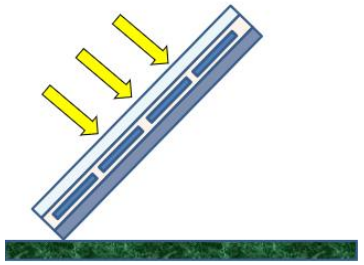
Monofacial



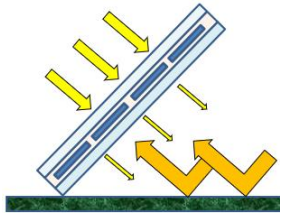
Bifacial



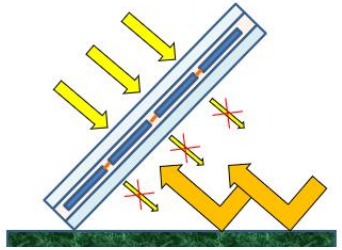
Soil test evaluation – East-West NL – GCR 0.9



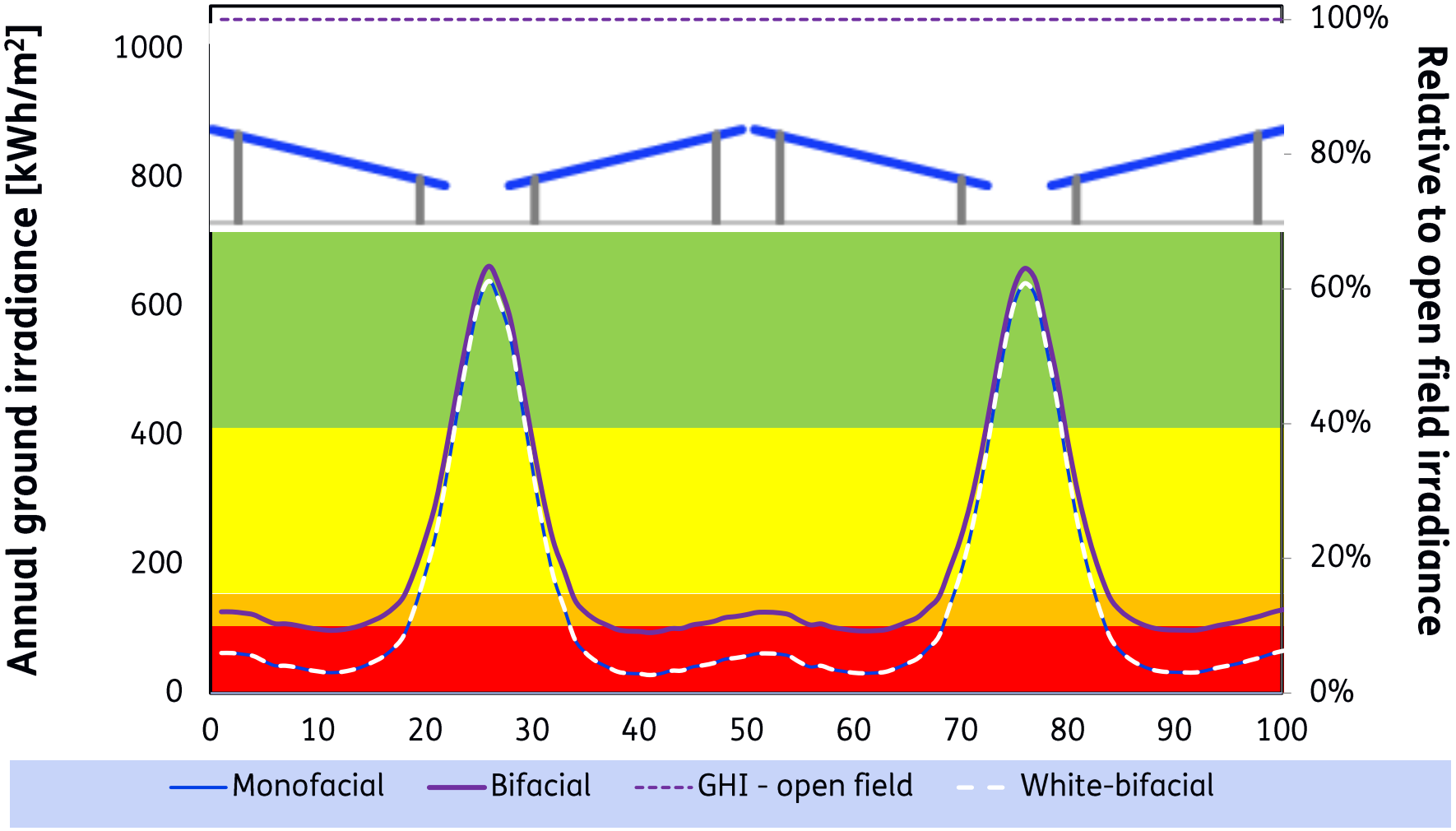
Monofacial



Bifacial

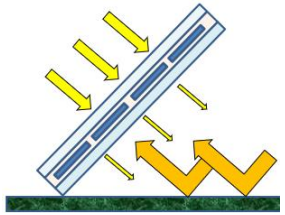


White bifacial

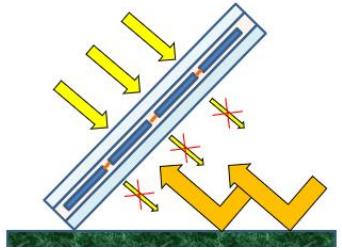


Transparency of (bifacial) modules enables sustainable East-West designs in Netherlands

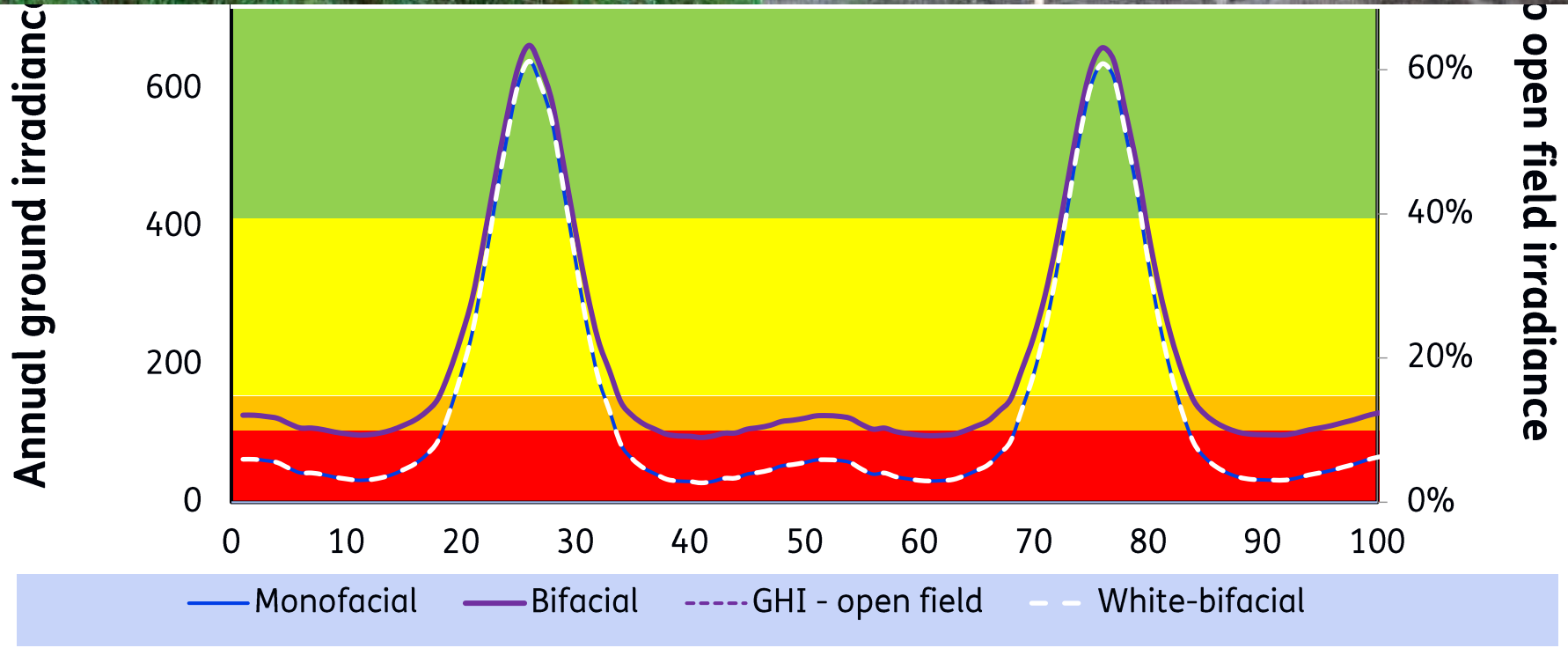
Monofacial



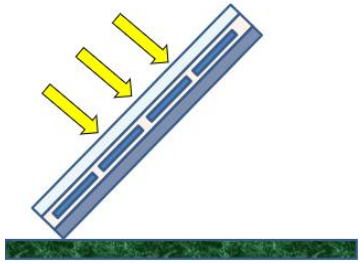
Bifacial



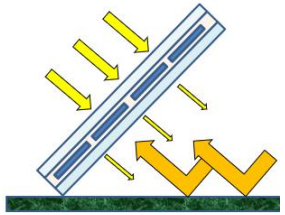
White Bifacial



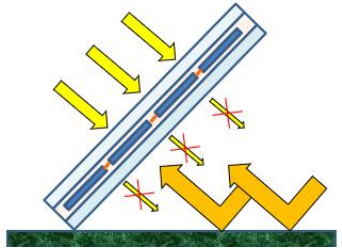
Soil test evaluation – South NL – GCR 0.7



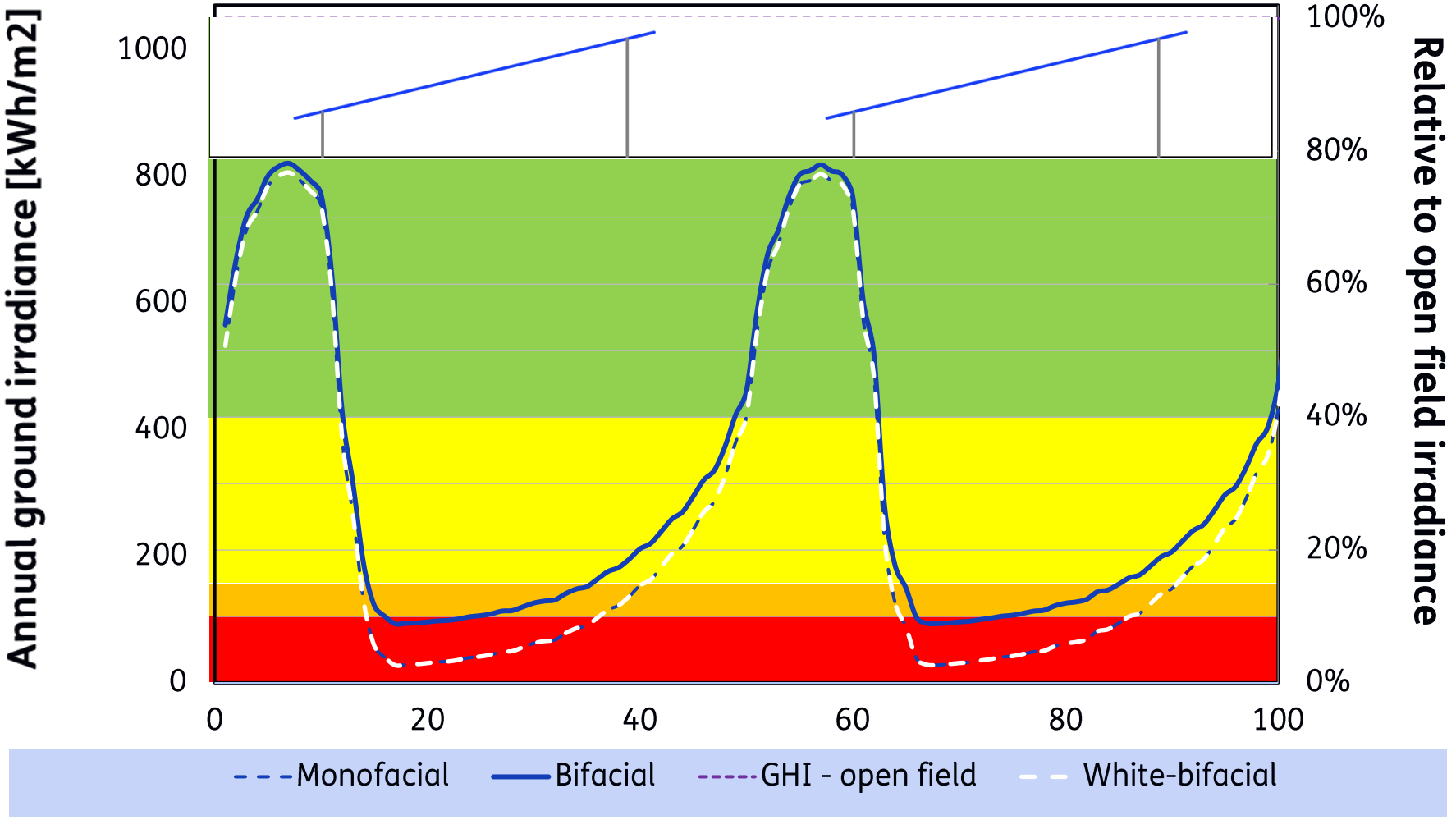
Monofacial



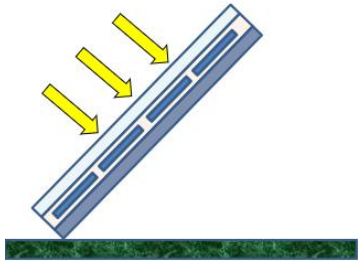
Bifacial



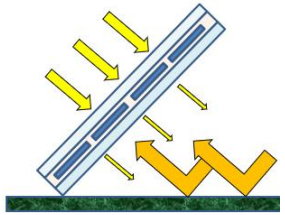
White Bifacial



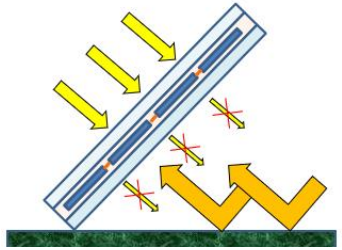
Soil test evaluation – South Spain – GCR 0.6



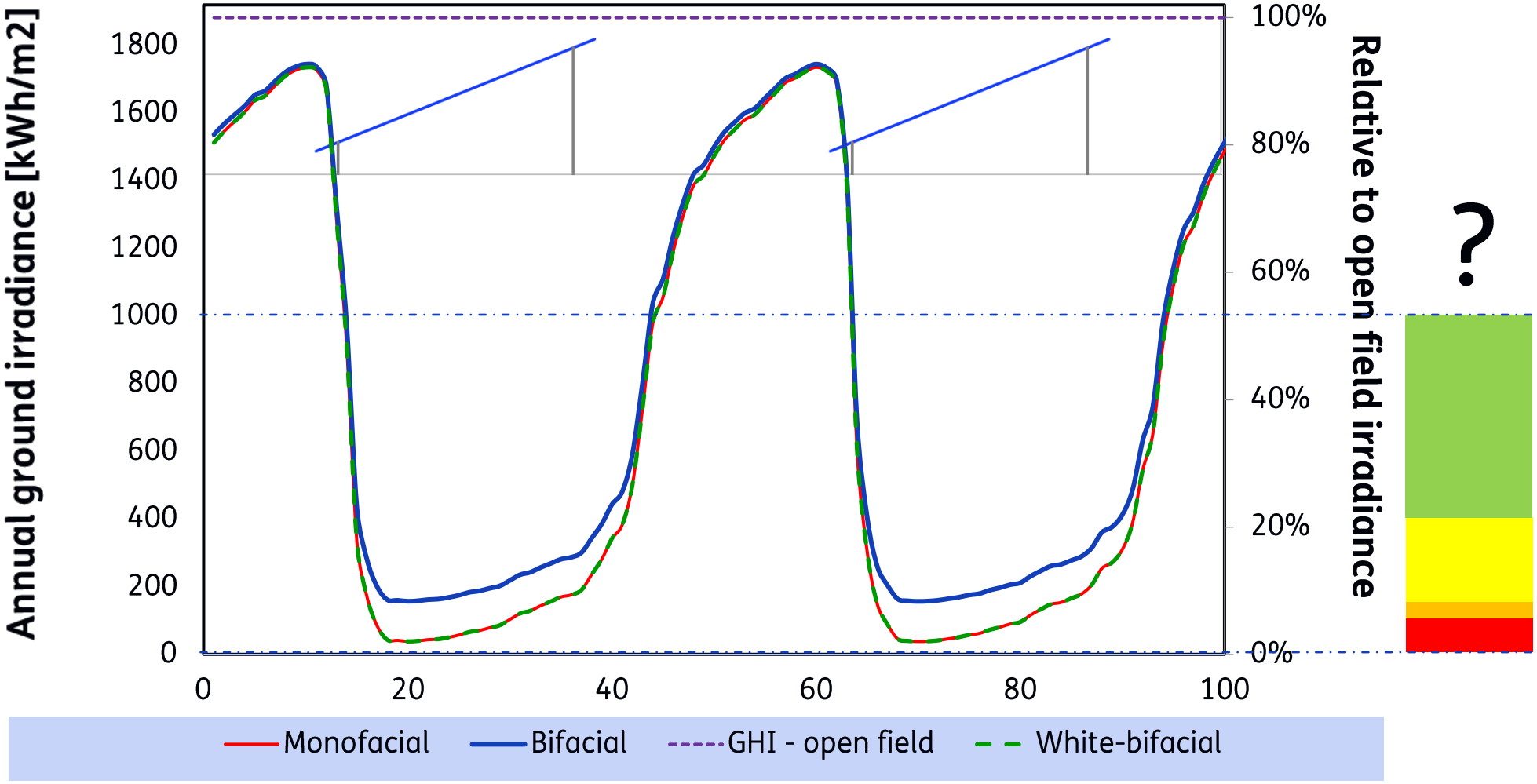
Monofacial



Bifacial



White Bifacial



Soil test limits are not yet determined for Spain → to do list

Other climates?
PV for terraforming?

A rendering of what the 20 GW solar farm would look like a

Image: Sun Cable / Screenshot

Conclusion

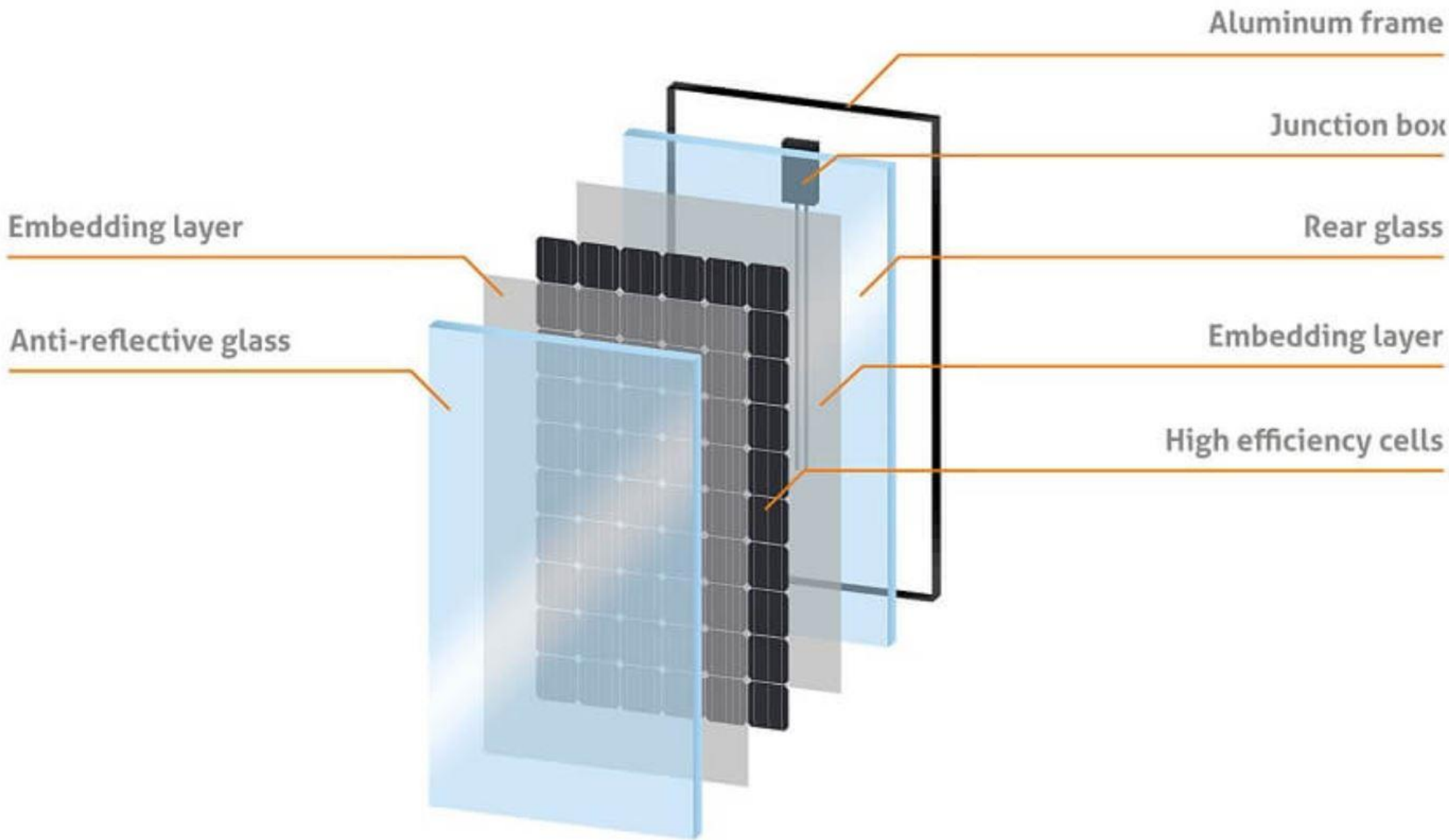
- Soil quality is import for land lease contracts
- Transparency bifacial panel can be critical to maintain soil quality
- Effect reflector foil “white” bifacial:
  - Gain annual yield is 1- 1.4% vs. transparent bifacial
  - More production and recycling costs
  - Reduces 50-100% of critical ground irradiance in NL
- Recommendation:
  - Please improve availability of transparent bifacial modules!
    - Eco-positive & more sustainable alternative
    - Establish soil test in other climate regions

Questions

Discussed availability of transparent bifacial panel with manufacturers

White border: Manufacturer with
Partial transparent bifacial panel in production

Black border: Manufacturer can produce depending on demand


Aluminum frame
Junction box
Rear glass
Embedding layer
High efficiency cells
Embedding layer
Anti-reflective glass

SolarEcoPlus

- 6 x pilot parks as part of commercial solar parks

Soil types

- 2-3x Sand
- 2-3x Clay
- 0-2x Peat

Pilot park design
Bifacial systems

- Tracking
- Vertical
- South
- East-west
- 700 kWp bifacial modules
  - PERC+,
  - TOPCON

- On 10 000 m^2 as part of commercial solar power plant