



DESIGNED FOR SUCCESS

Bifacial PV Power Plants built to last
and for Lowest LCoE



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Market Trends. Bifacial Share

Bifacial Technology. Principles

Bifacial PV plant. Main components

Bifacial System design. Key parameters

Case Studies

Conclusions / Summary

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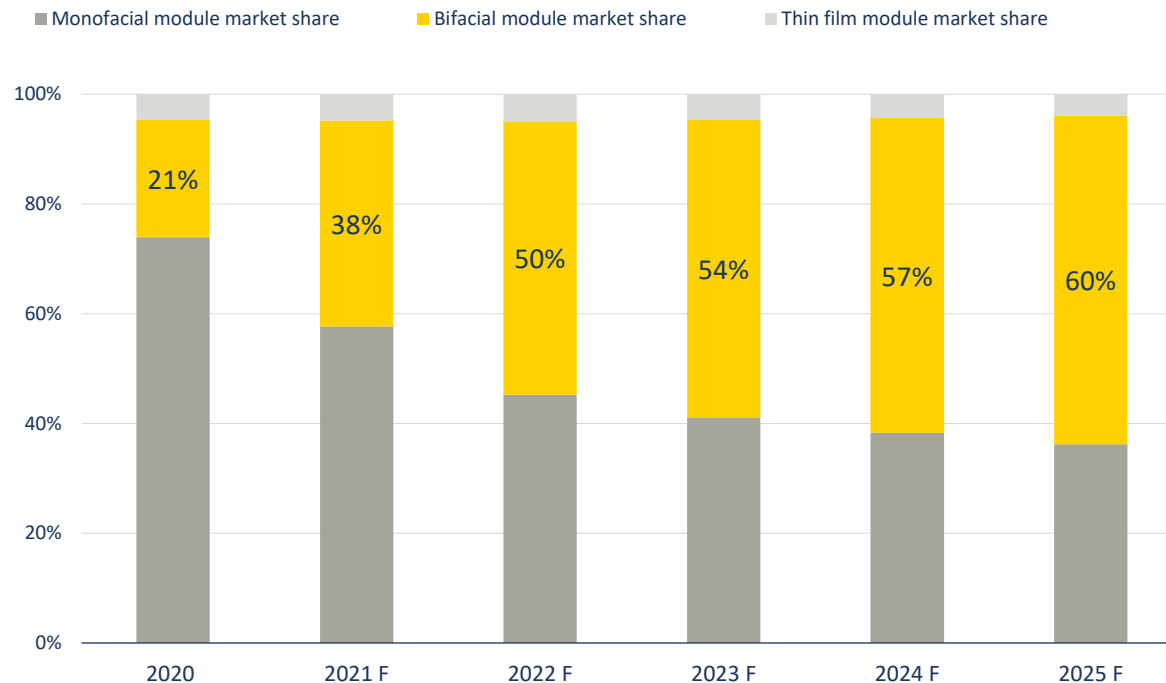
Case Studies

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1. Market Trends - Bifacial Share

PV InfoLink

Monofacial, bifacial module market share, Unit: %



- MS 2019 → 9%
- MS 2020 → 21%
- MS 2021 → 38%
- MS 2022 → 50%
- MS 2023 → 54%
- Even higher MS if only utility-scale segment is considered

Trina Solar has 20 GW cumulative shipments of bifacial modules

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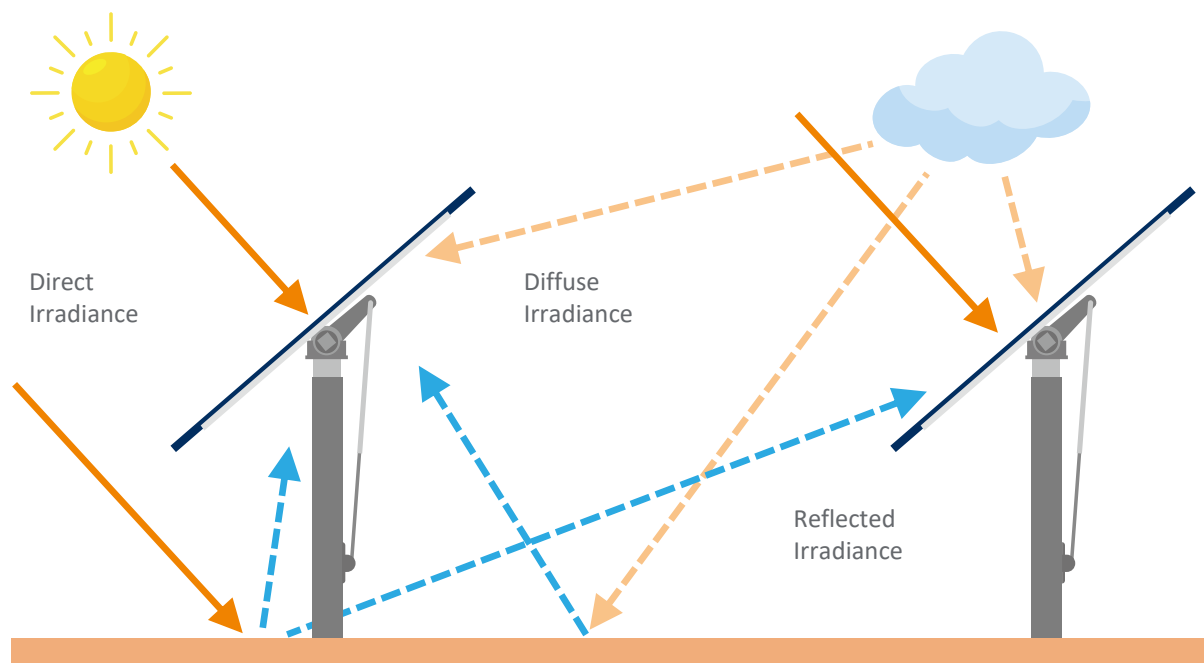
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2. Bifacial Technology - Principles

Bifacial Gain, Bifacial Ratio & Bifaciality



$$E_{bifacial} = E_{front} + E_{rear}$$

Bifacial Gain

$$Bifacial\ Gain = E_{rear} / E_{front}$$

Bifacial Ratio

$$Bifacial\ Ratio = G_{rear} / G_{front}$$

Bifaciality

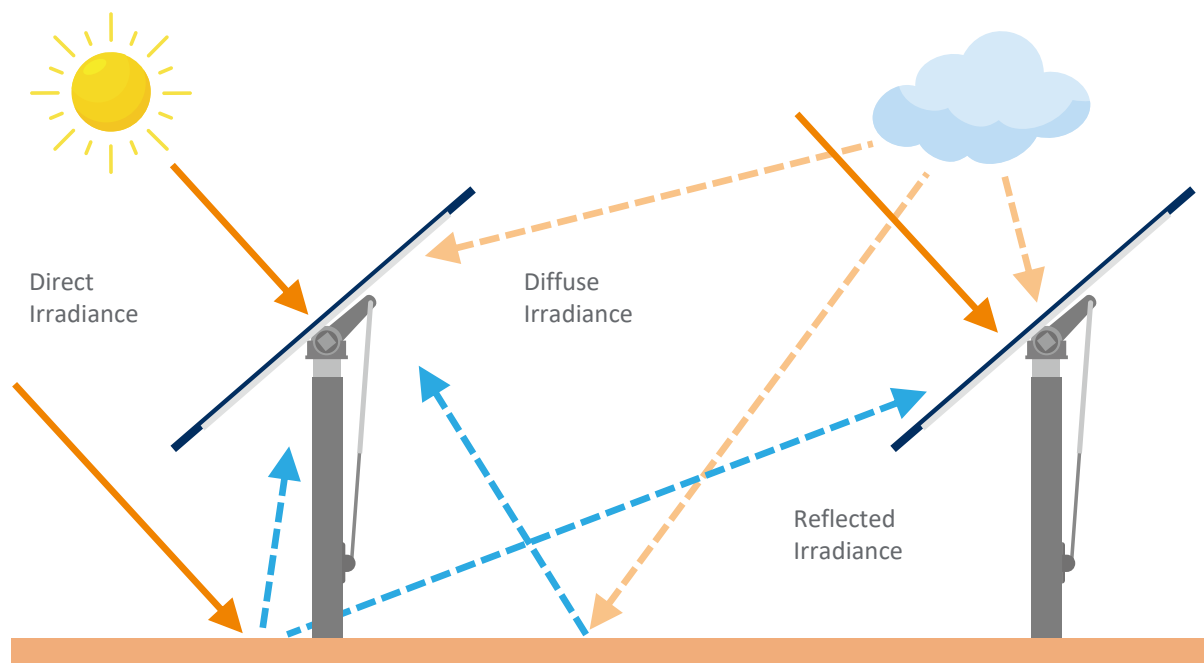
$$Bifaciality = Bifacial\ Gain / Bifacial\ Ratio$$

$$E_{bifacial} = E_{front} \times (1 + Bifacial\ Gain)$$

$$E_{bifacial} = E_{front} \times (1 + BifacialRatio \times Bifaciality)$$

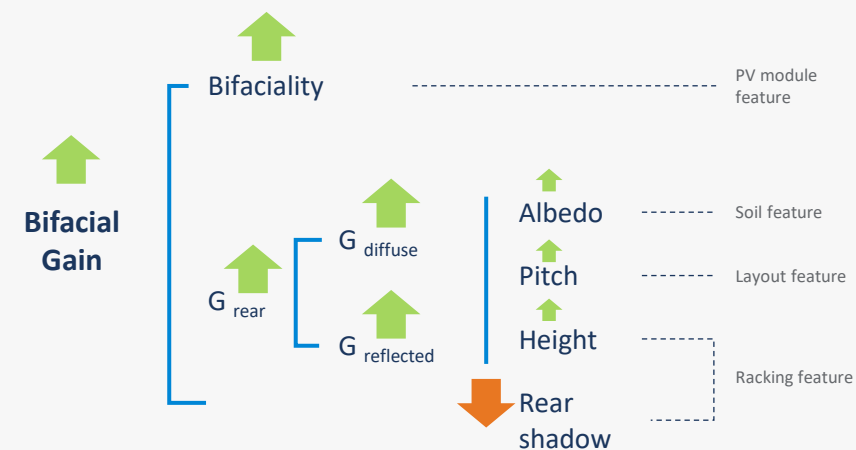
2. Bifacial Technology - Principles

Increasing Energy generated by rear side



Diffuse Irradiation vs Reflected Irradiation

$$G_{rear} = G_{diffuse} + G_{reflected}$$



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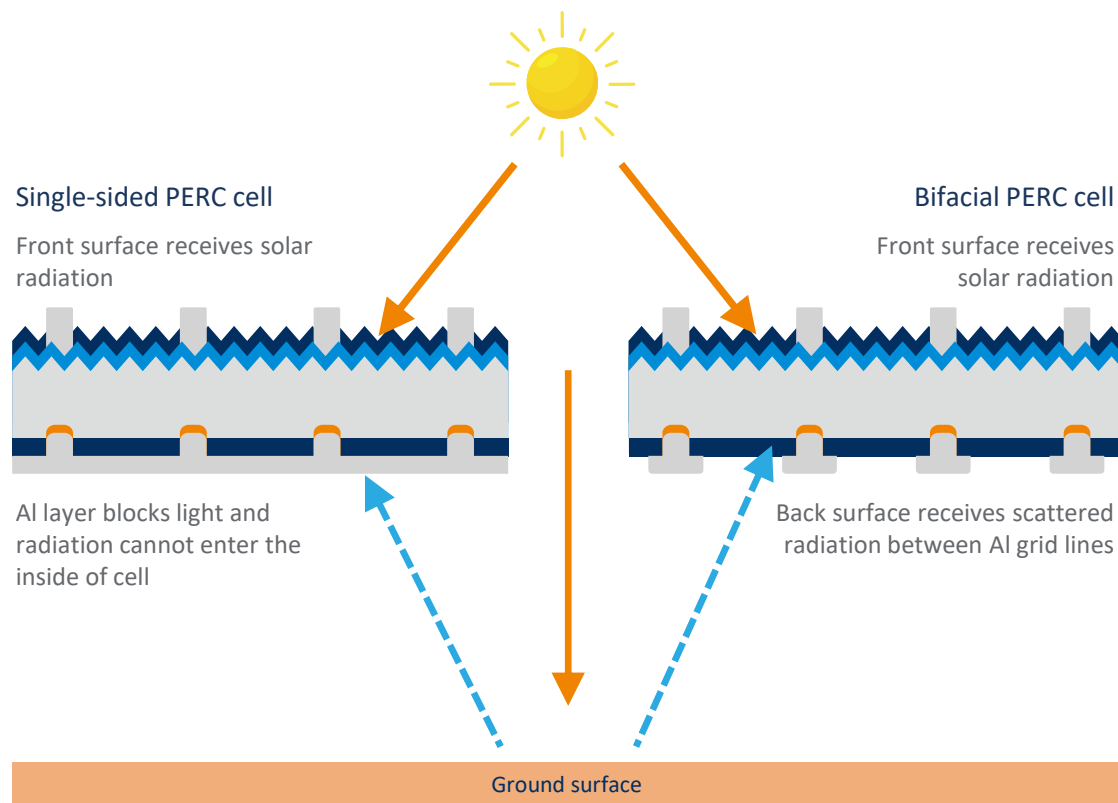
Case Studies

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3. Bifacial PV Plant - Modules

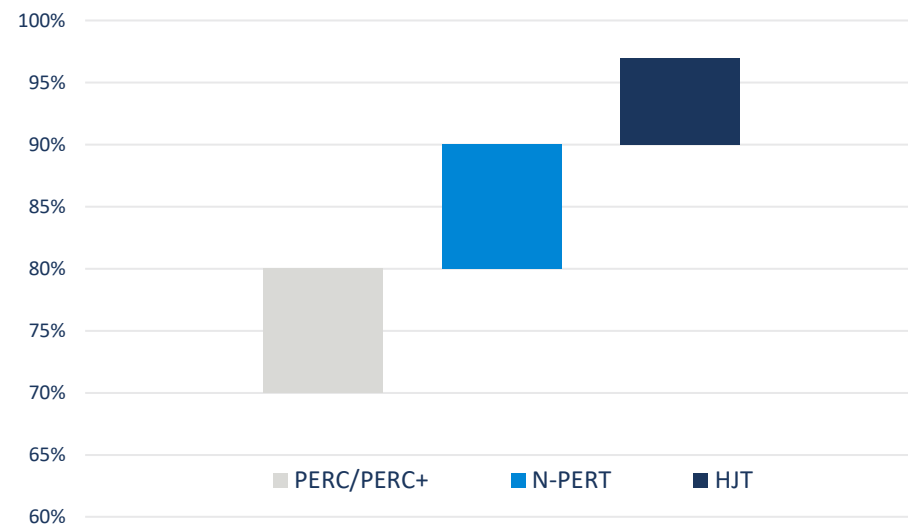
Bifacial Cell Structure. Bifaciality vs Cell Technology

Bifacial Cell Structure



Bifaciality vs Cell Technology

Bifaciality range by Cell Technology



Source: HIS Markit

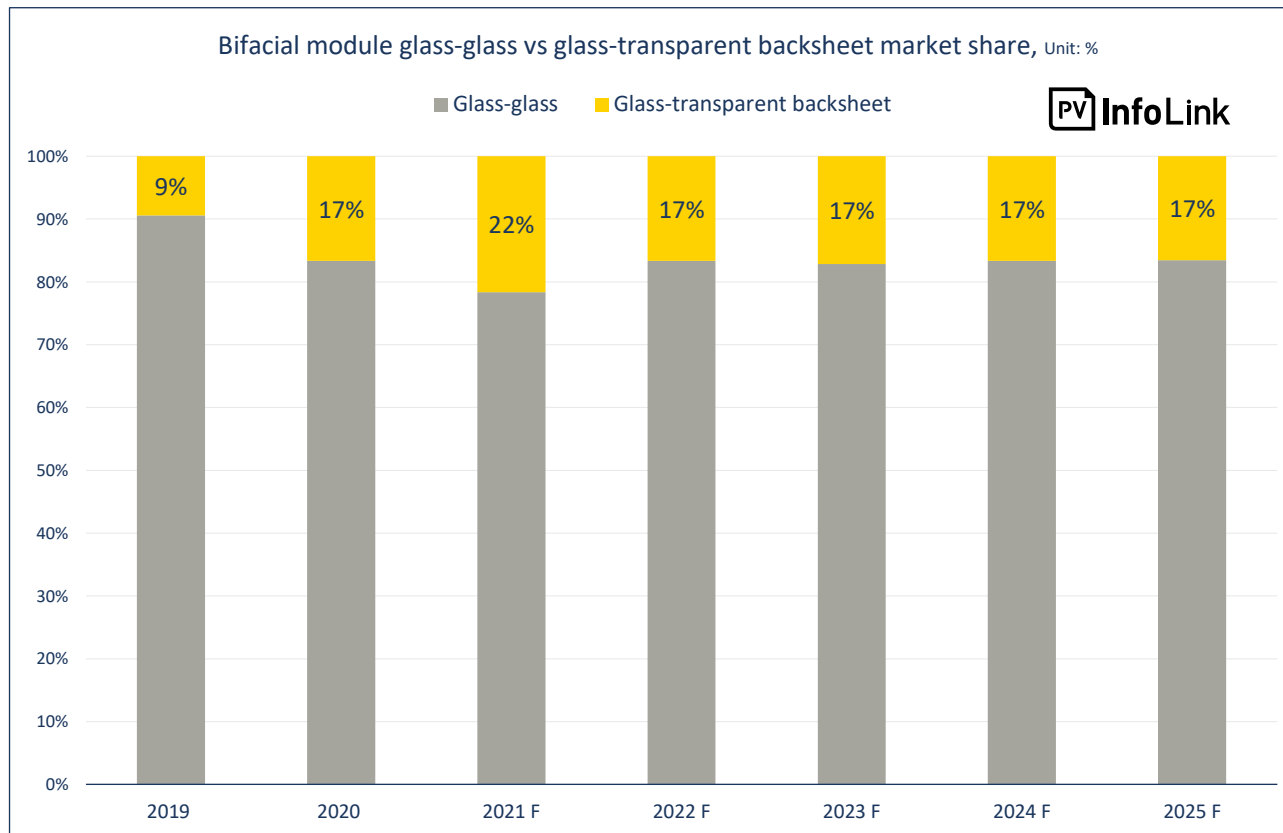


@2020 HIS Markit

3. Bifacial PV Plant - Modules

Module Materials: Glass-glass vs Transparent backsheet

Glass-glass vs Transparent Backsheet



Trina Solar = Glass-Glass

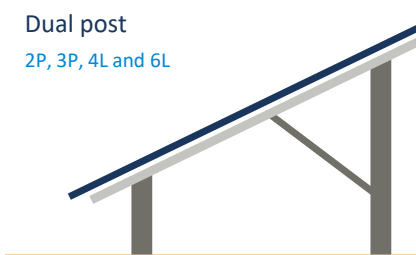
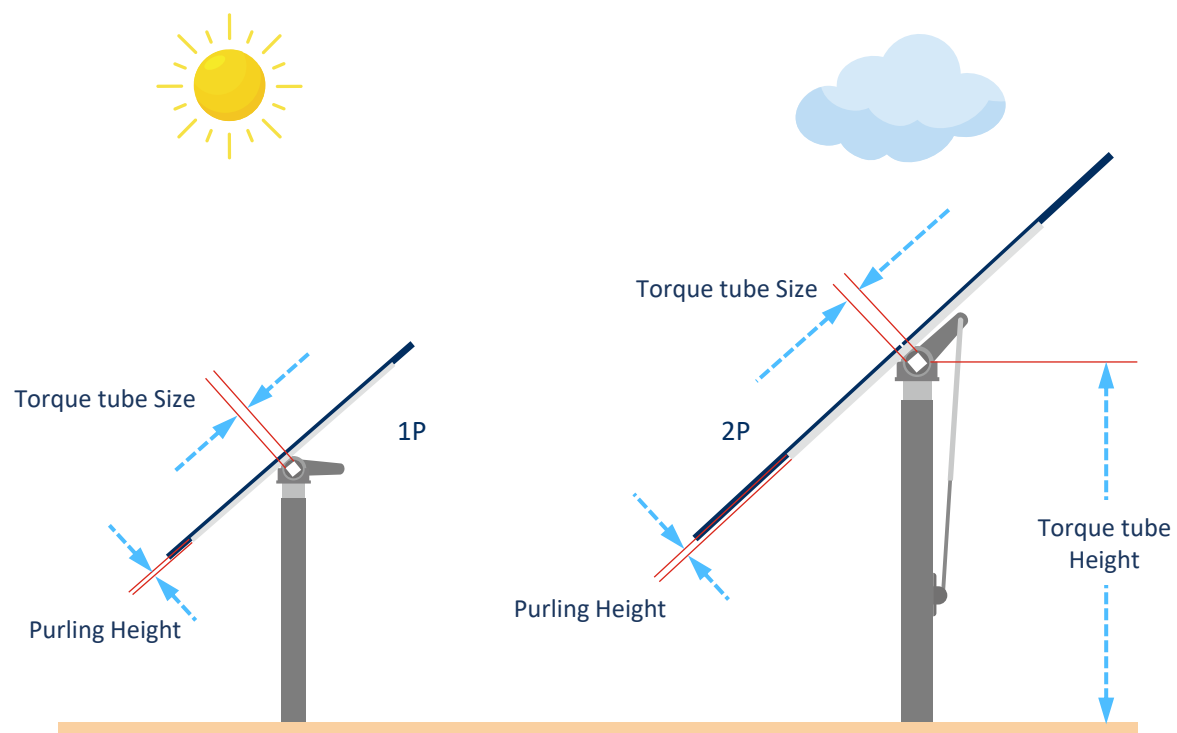


BENEFITS

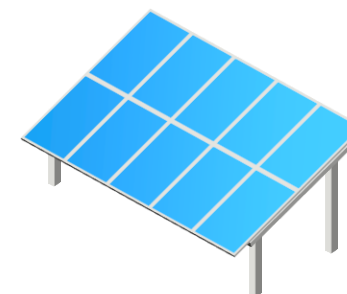
- Resistance to salt spay, acids & alkalis
- Zero moisture penetration
- Reduce invisible cell cracking
- More excellent mechanical load ability

3. Bifacial PV Plant - Mounting Systems

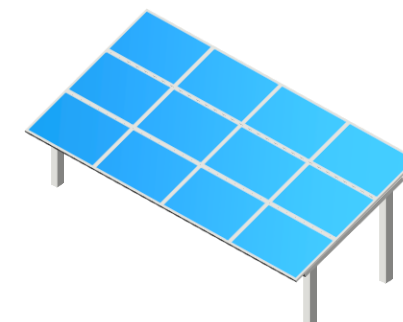
Rear side Irradiation vs Main mounting system parameters



Portrait configuration
Portrait configurations are recommended for high E-W slopes terrains.

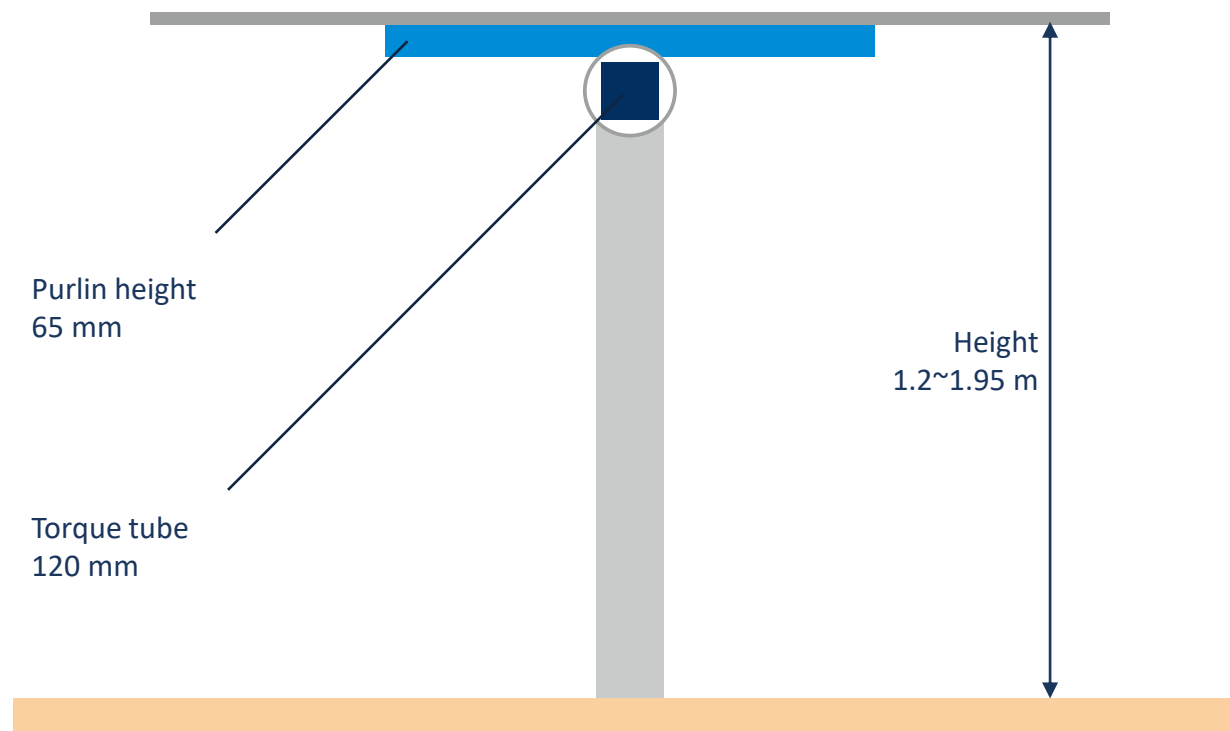
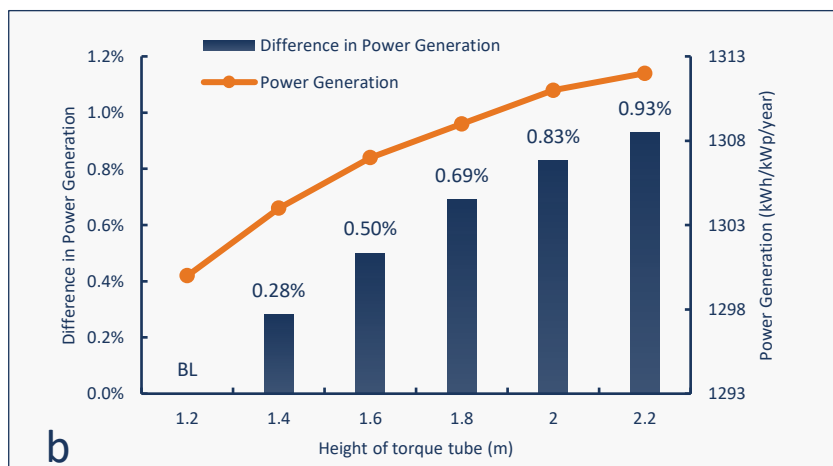
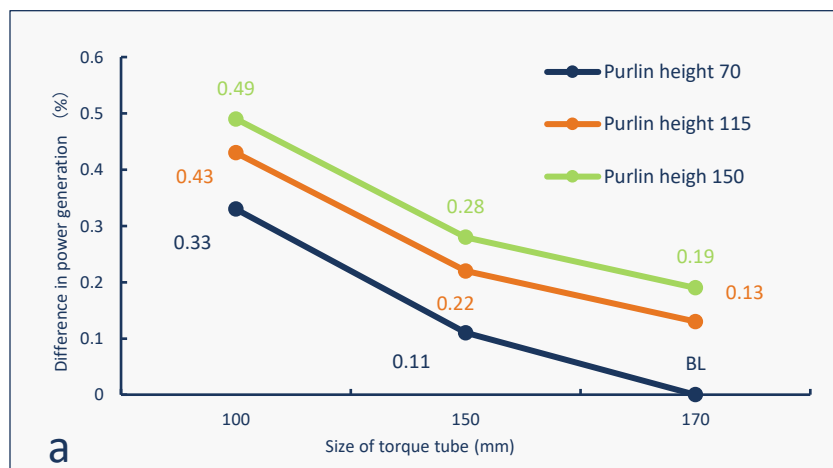


Landscape configuration
Landscape configurations are recommended for bifacial modules to minimize shading on the rear part of the solar panels.



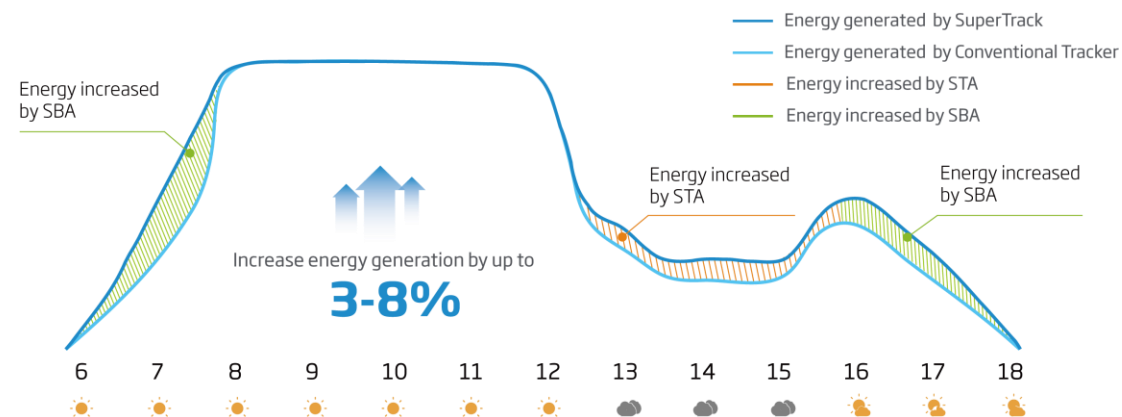
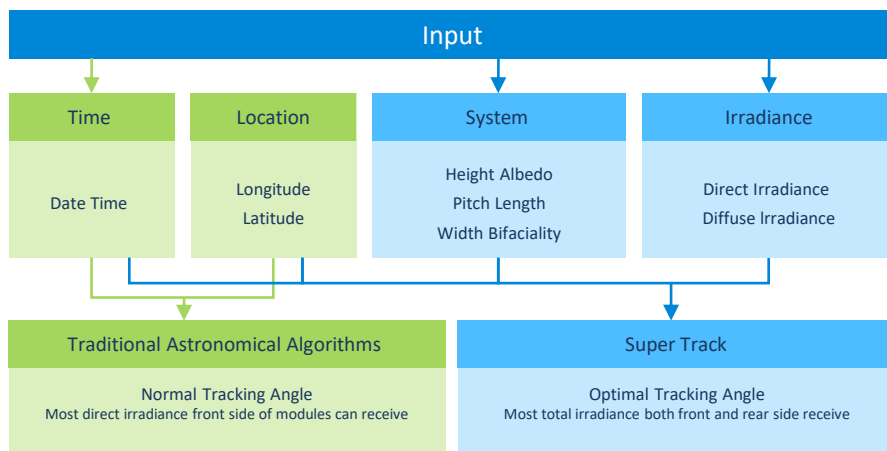
3. Bifacial PV Plant - Mounting Systems. 1P trackers

Power generation vs Main 1P tracker parameters

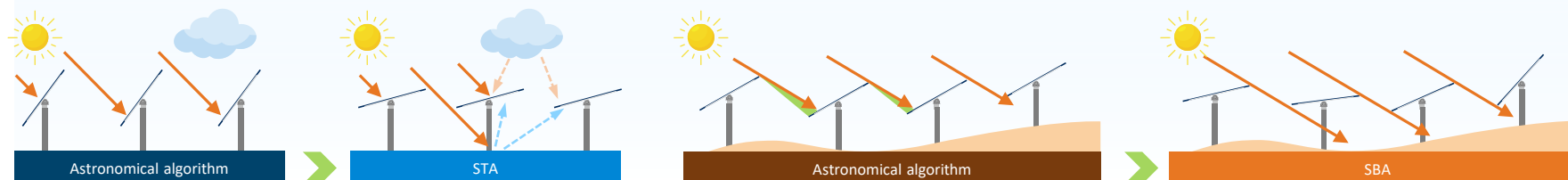


3. Bifacial PV Plant - Mounting Systems. Smart Tracking

SuperTrack smart tracking technology



SuperTrack = Smart Tracking Algorithm + Smart Backtracking Algorithm

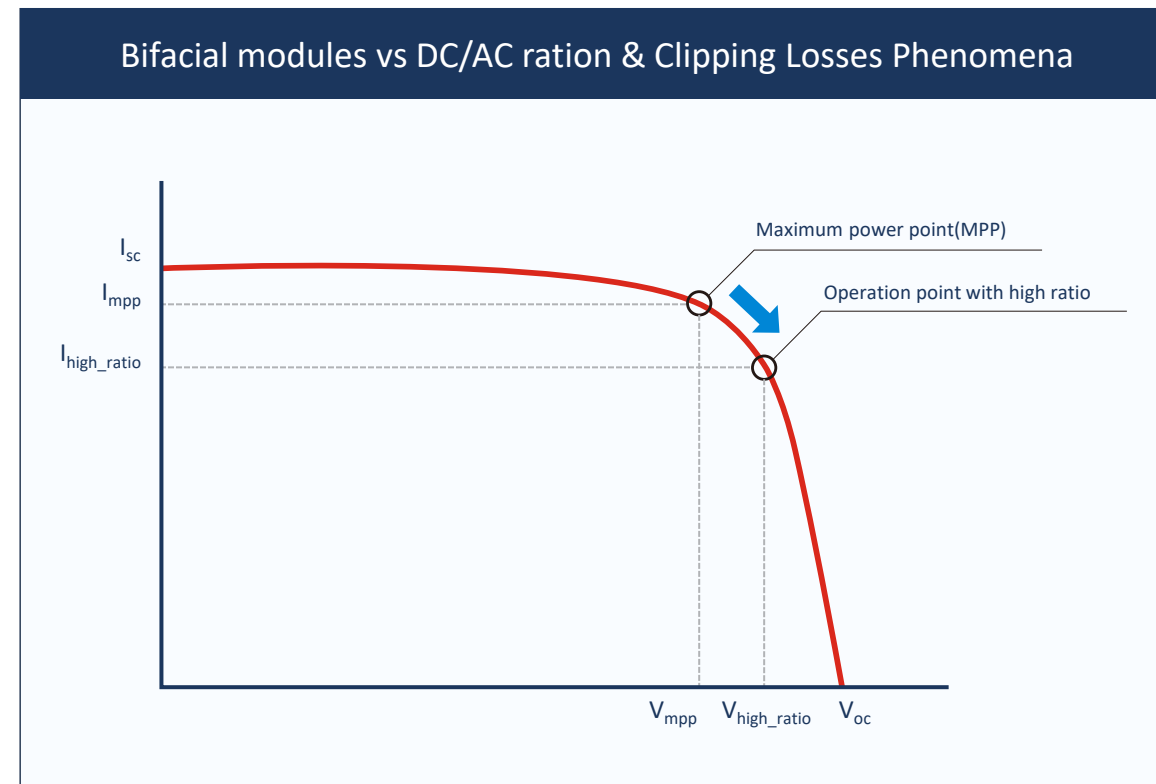
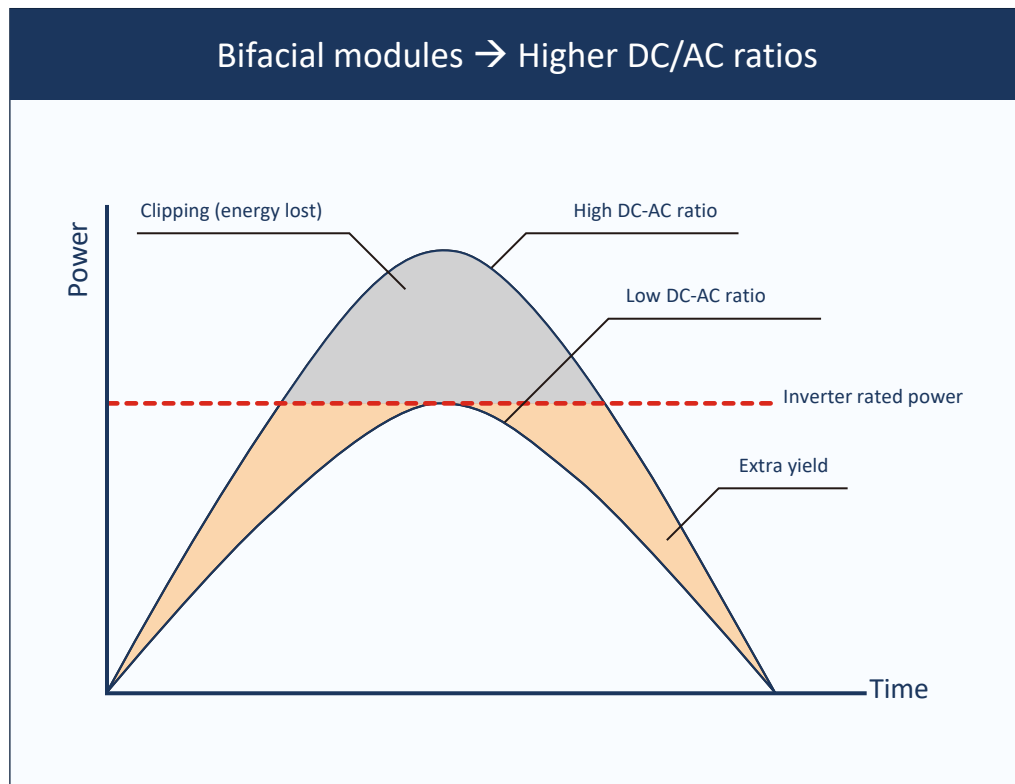


SuperTrack is developed to increase yield gain:

- Sunrise and Sunset
- Cloudy
- Overcast Weather
- Uneven Terrain

3. Bifacial PV Plant - Inverters

Bifacial PV plant means bigger DC/AC ratio



DC-AC ratios between **1.2 and 1.4** used to be the most common choice for designers

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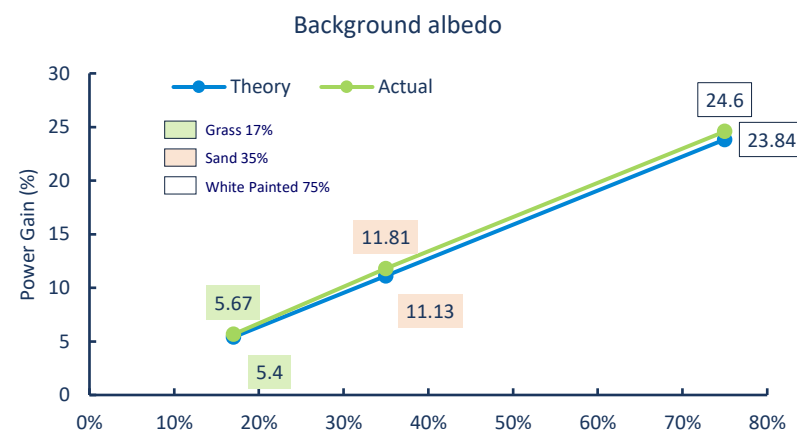
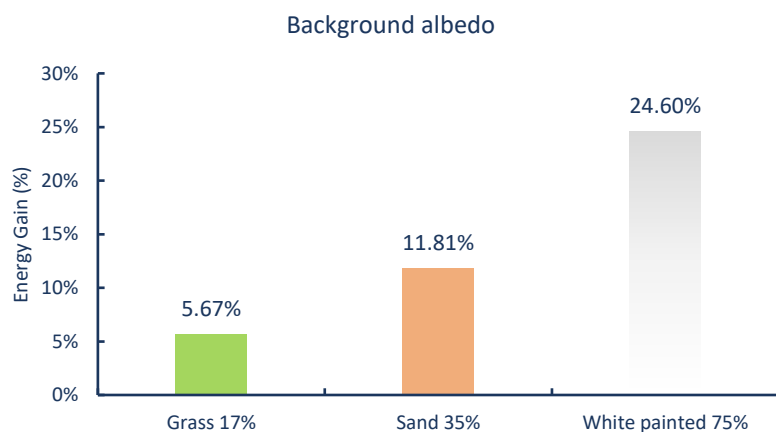
Bifacial System design. Key parameters

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4. Bifacial System Design - Albedo

Albedo is the ratio between Reflected Irradiance (RI) and the Global Horizontal Irradiance (GHI) received by a ground surface

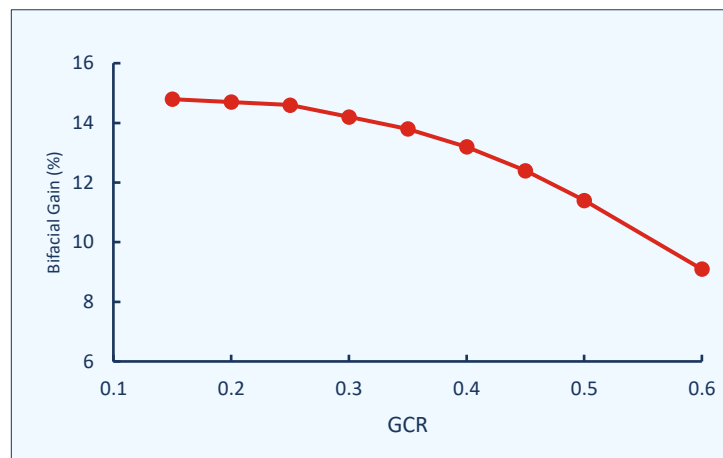
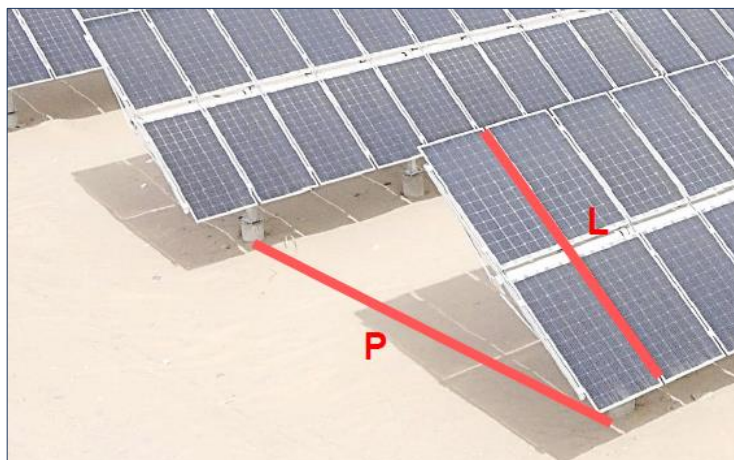


- Fixed-tilt configuration
- Tilt angle: 27°
- Module height: 0.4 m

Types of ground	Albedo (%)	Estimated Bifacial Gain (%)
Grass	17	5.67
Sand	35	11.81
White Painted	75	24.6

4. Bifacial System Design – Pitch / GCR

Lower GCR means higher Bifacial Gain but higher CAPEX too

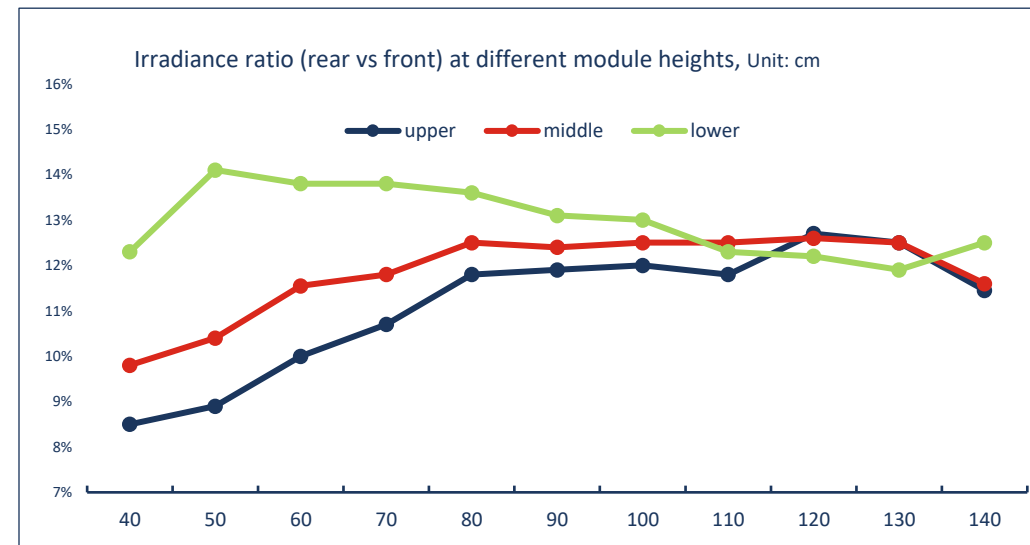
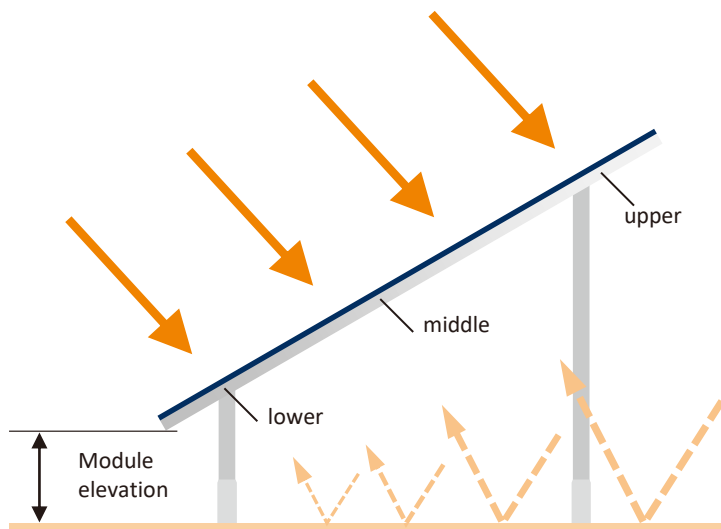


$$GCR = \frac{\text{module area}}{\text{ground area}} = \frac{L}{P}$$

Bigger Pitch (Lower GCR) means Higher Bifacial Gain

4. Bifacial System Design - Module Height

Higher module elevation increases radiation on rear side



Modules higher off the ground see more diffuse radiation

Higher Bifacial Gain

Modules higher off the ground receive more reflected radiation

Higher Bifacial Gain

Modules higher off the ground normally work at lower temperature

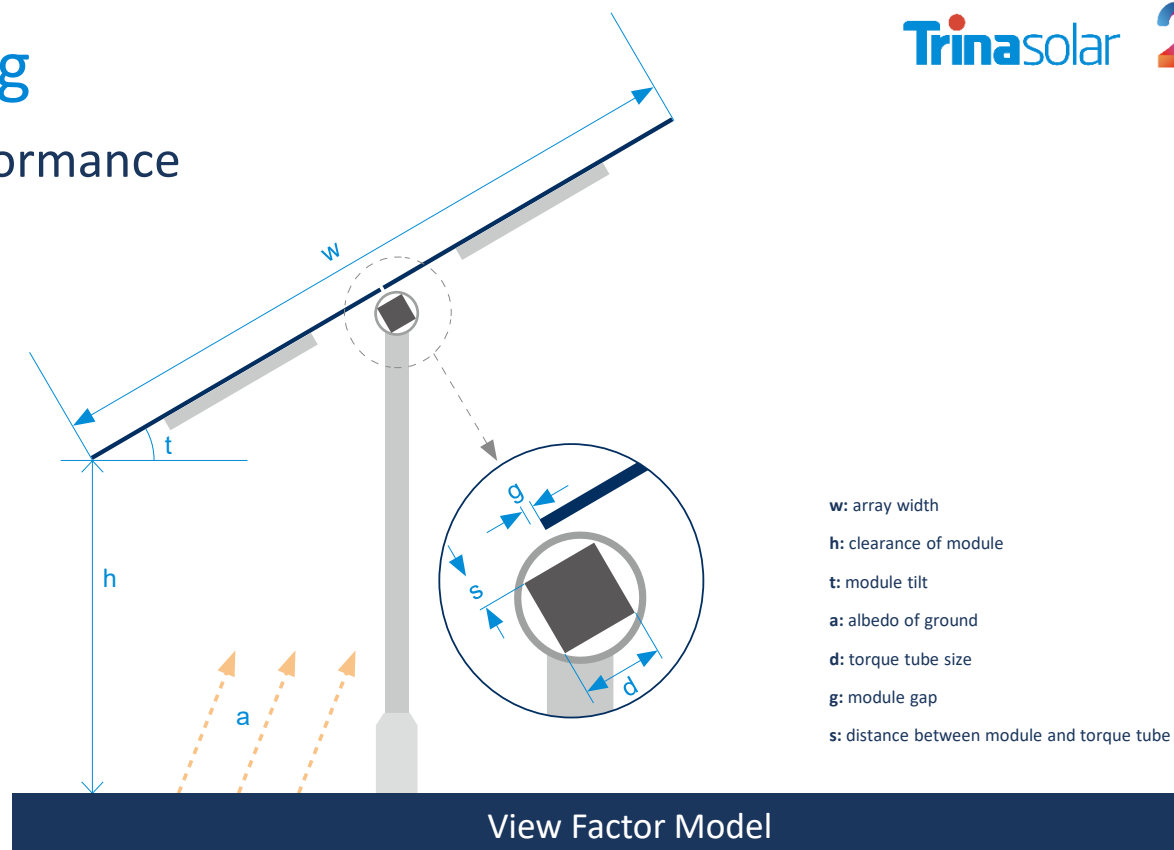
Better Performance

4. Bifacial System Design - Shading

Shading needs to be avoided to maximize performance



- Shading always impact negatively module performance
- Torque tube is the major source of module shading
- Shading modelling is relevant to estimate accurate Bifacial Gain



Structure Shading Factor
(SSF)

Mismatch Loss Factor
(MLF)

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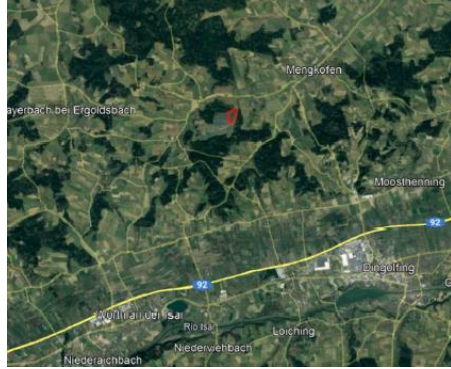
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5. Case Studies

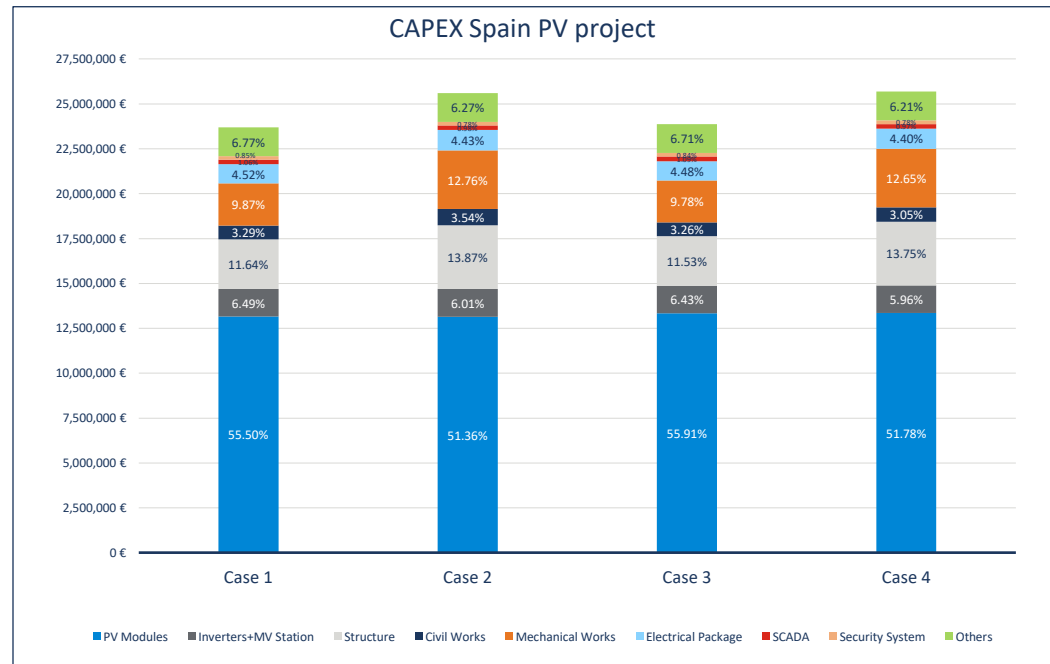


PV Project	Spain				Germany			
	 SEVILLE- 50 MWp (GHI = 1850.3 kWh/m²)				 HOFDORF- 10 MWp (GHI = 1176.4 kWh/m²)			
Module	TSM670DE21		TSM670DEG21C.20		TSM670DE21		TSM670DEG21C.20	
Structure	Fixed-Tilt Structure	Single- axis Tracker	Fixed- Tilt Structure	Single-axis Tracker	Fixed-Tilt Structure	Single- axis Tracker	Fixed- Tilt Structure	Single-axis Tracker
Inverter	Power Electronics HEMK FS3430K				Huawei SUN2000-215KTL-H3			
Case #	1	2	3	4	1	2	3	4
Mounting Structure	Tracker: Trina Tracker Agile 1P – 96 modules/tracker - Fixed-tilt structure 2P – 64 modules/shed (25° tilt)				Tracker: Trina Tracker Agile 1P – 96 modules/tracker - Fixed-tilt structure 4L – 64 modules/shed (20° tilt)			

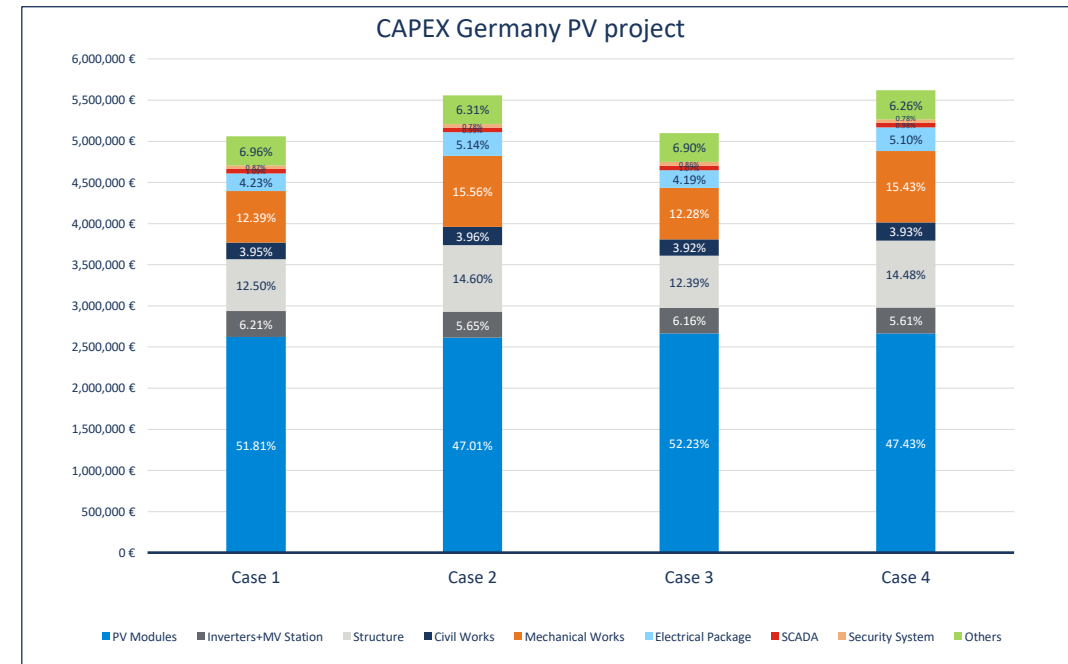
5. Case Studies. CAPEX



SPAIN
SEVILLE- 50 MWp (GHI = 1850.3 kWh/m²)



GERMANY
HOFDORF- 10 MWp (GHI = 1176.4 kWh/m²)

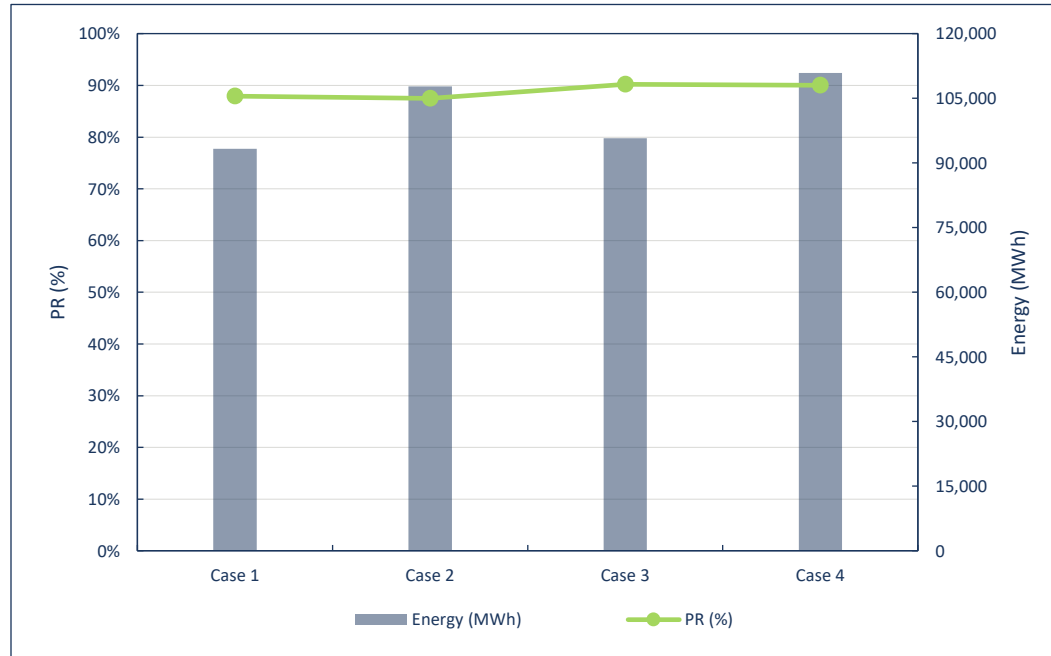


- Configurations with tracker (2 & 4) are more expensive CAPEX wise for both locations
- Germany projects show higher split cost on mounting structure and mechanical works

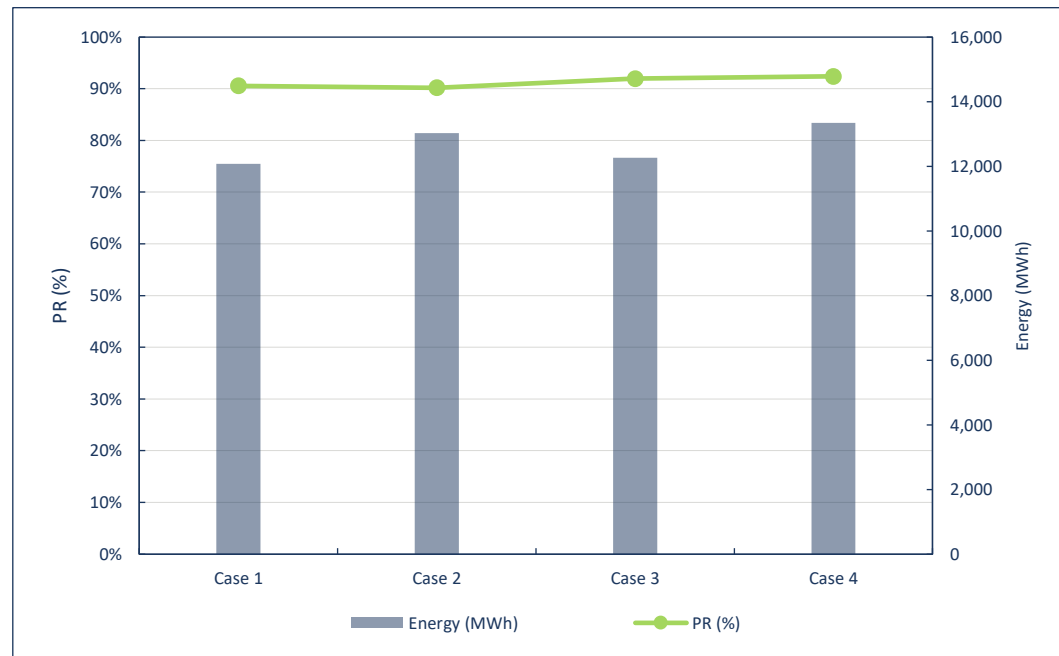
5. Case Studies. Yield



SPAIN
SEVILLE- 50 MWp (GHI = 1850.3 kWh/m²)



GERMANY
HOFDORF- 10 MWp (GHI = 1176.4 kWh/m²)



- Spain & Germany. Configurations with tracker (**Case 2 & 4**) generate more energy than with fixed-tilt structure
- Spain & Germany. Configuration with tracker + bifacial module (**Case 4**) is the one achieving more energy generation
- Spain. Gain using tracker instead of fixed-tilt is higher than gain of using bifacial instead of monofacial technology

5. Case Studies. LCoE



SPAIN SEVILLE- 50 MWp (GHI = 1850.3 kWh/m²)

Case	1	2	3	4
Year-0 Energy production (MWh)	93,296	107,779	95,747	110,981
CAPEX (MEUR)	23.62	25.51	23.84	25.71
Unitary CAPEX (EUR/MWp)	0.472	0.510	0.477	0.515
OPEX (EUR/MWp/y)	15,798	15,598	14,801	15,601
LCOE (EUR/MWh)	23.89	22.15	23.43	21.65
	BL			-9.5%
		BL		-2.3%

GERMANY HOFDORF- 10 MWp (GHI = 1176.4 kWh/m²)

Case	1	2	3	4
Year-0 Energy production (MWh)	12,025	13,028	12,260	13,345
CAPEX (MEUR)	5.164	5.6667	5.208	5.711
Unitary CAPEX (EUR/MWp)	0.506	0.5558	0.510	0.562
OPEX (EUR/MWp/y)	16,141	17,455	16,145	17,458
LCOE (EUR/MWh)	34.35	341.73	34.00	34.07
		BL	-2.1%	
	BL		-1.1%	

- Spain. **Bifacial PV module + tracker (Case 4)** is the optimal configuration for a 50 MW project in Spain, obtaining lower LCoE
- Germany. **Bifacial PV module + fixed-tilt (Case 3)** is the optimal configuration for a 10 MW project in Germany, obtaining lower LCoE
- The greater the albedo, structure height and module spacing, the greater the energy production

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7. Summary / Conclusions

Basic principles:

- Bifacial Ratio
- Bifaciality
- Diffuse Irradiation
- Reflected Irradiation

System parameters:

- Albedo
- GCR
- Module Height
- Shading

Bifacial Gain

System Energy Yield

Dominant Technology

Above 50% Market Share

Lower LCOE

Main components

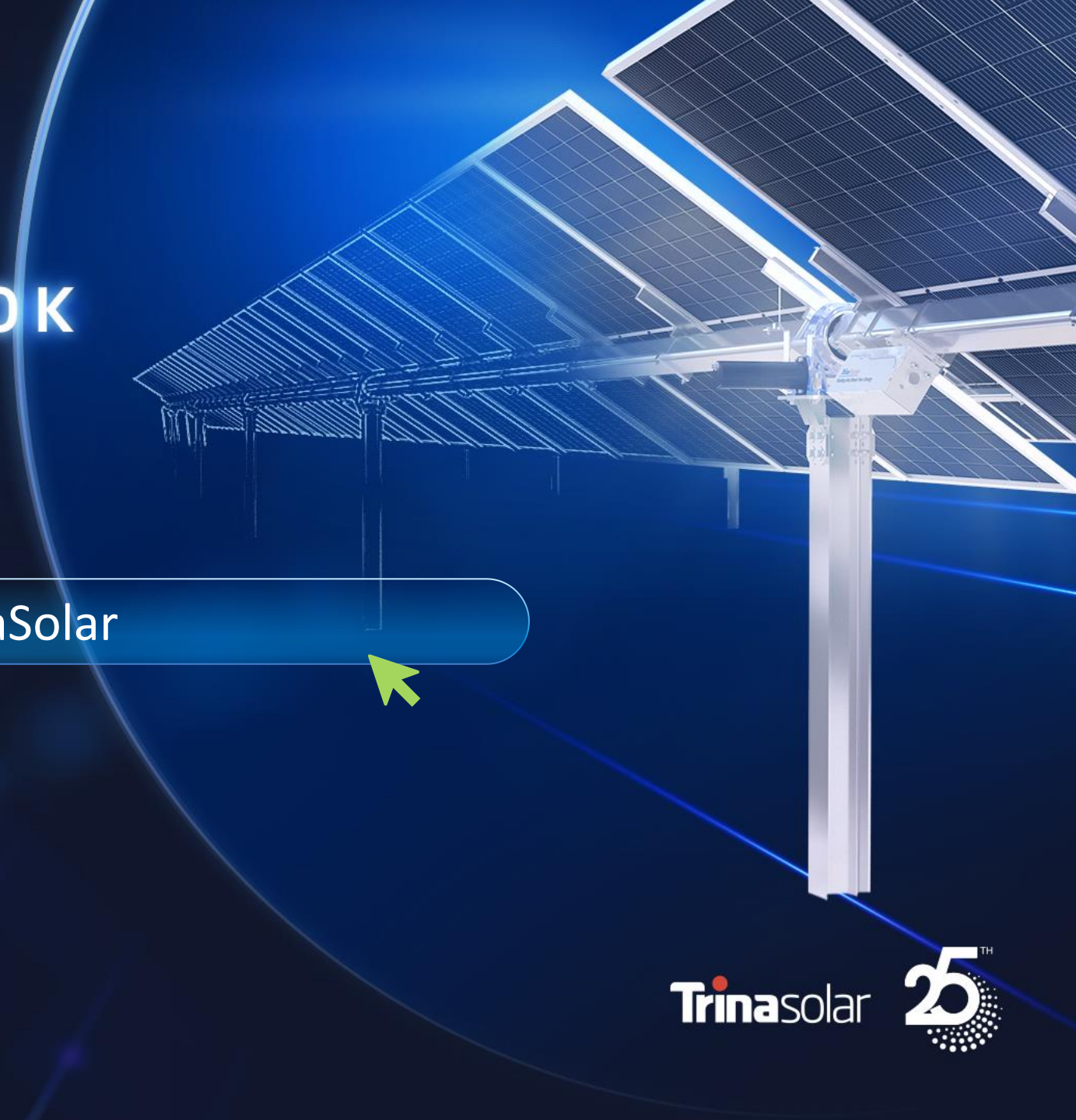
- Case studies
- Tracker + Bifacial module
- Sensitivity Analysis

- Modules - Glass-glass configuration
- Mounting systems - Torque tube size & height, purling & central gap
- Inverters - DC/AC ratio & string configuration

Trina solar

DISCOVER THE ULTIMATE GUIDEBOOK FOR BIFACIAL SYSTEM DESIGN

<https://bit.ly/BifacialSolutions-TrinaSolar>





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