CENER | NATIONAL RENEWABLE ENERGY CENTRE

ADItech

OPTIMIZE YOUR BIFACIAL PV TRACKER PROJECT TO DELIVER EXTRA ENERGY GAINS

FACTORS AFFECTING ENERGY GENERATION

Webinar
July 8th, 2020
Javier Díaz Berrade

GOBIERNO DE ESPAÑA
VICEPRESIDENCIA CUARTA DEL GOBIERNO
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO
MINISTERIO DE CIENCIA E INNOVACIÓN

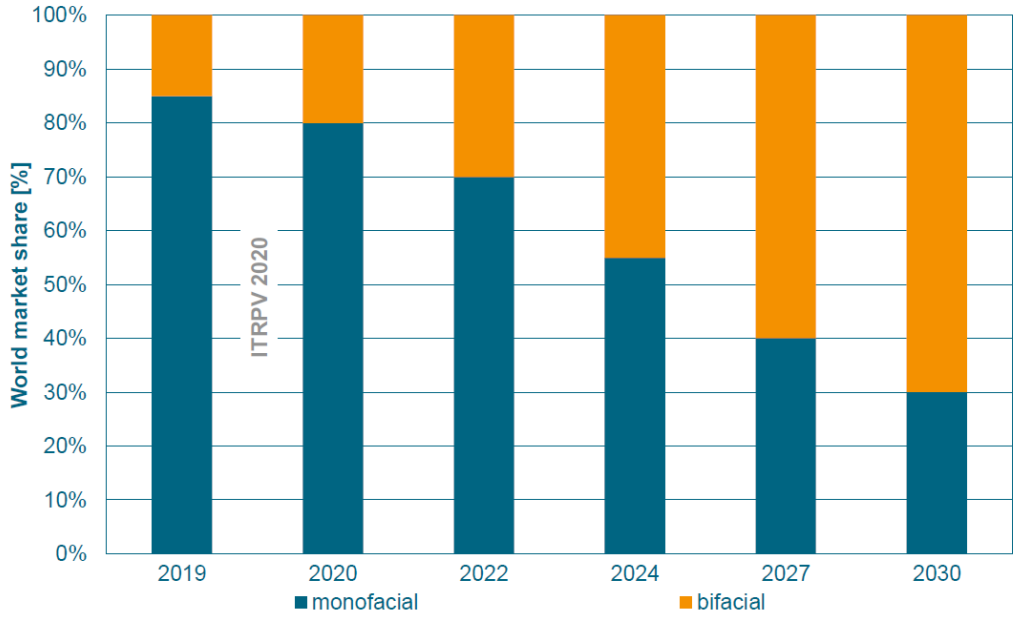
Ciemat

Gobierno de Navarra
Nafarroako Gobernua

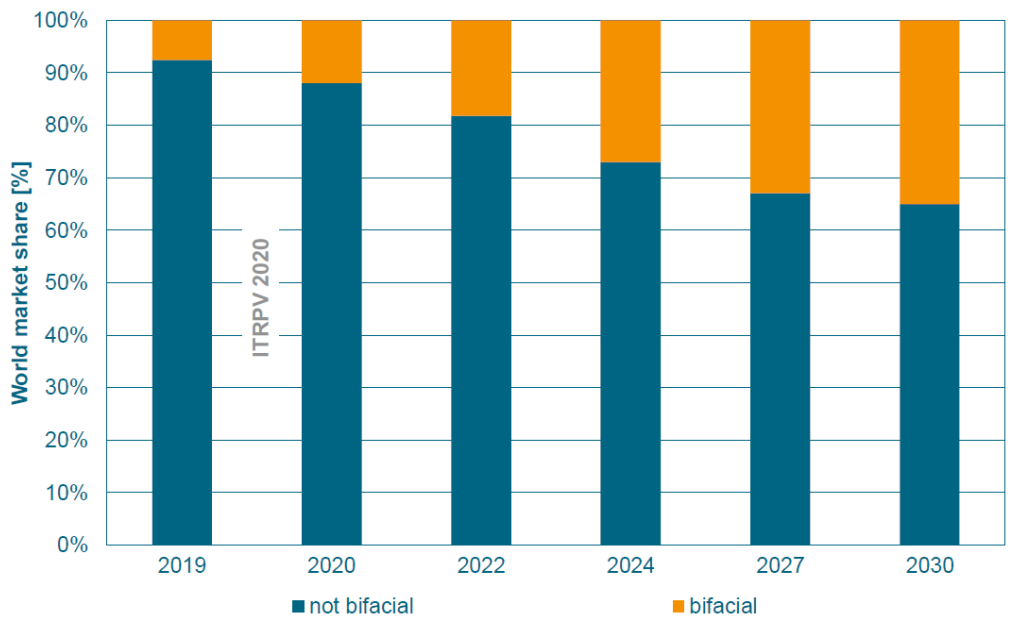
Introduction

- Bifacial PV Installations – Present & Future
- Hot topic in PV industry

Bifacial cell in world market



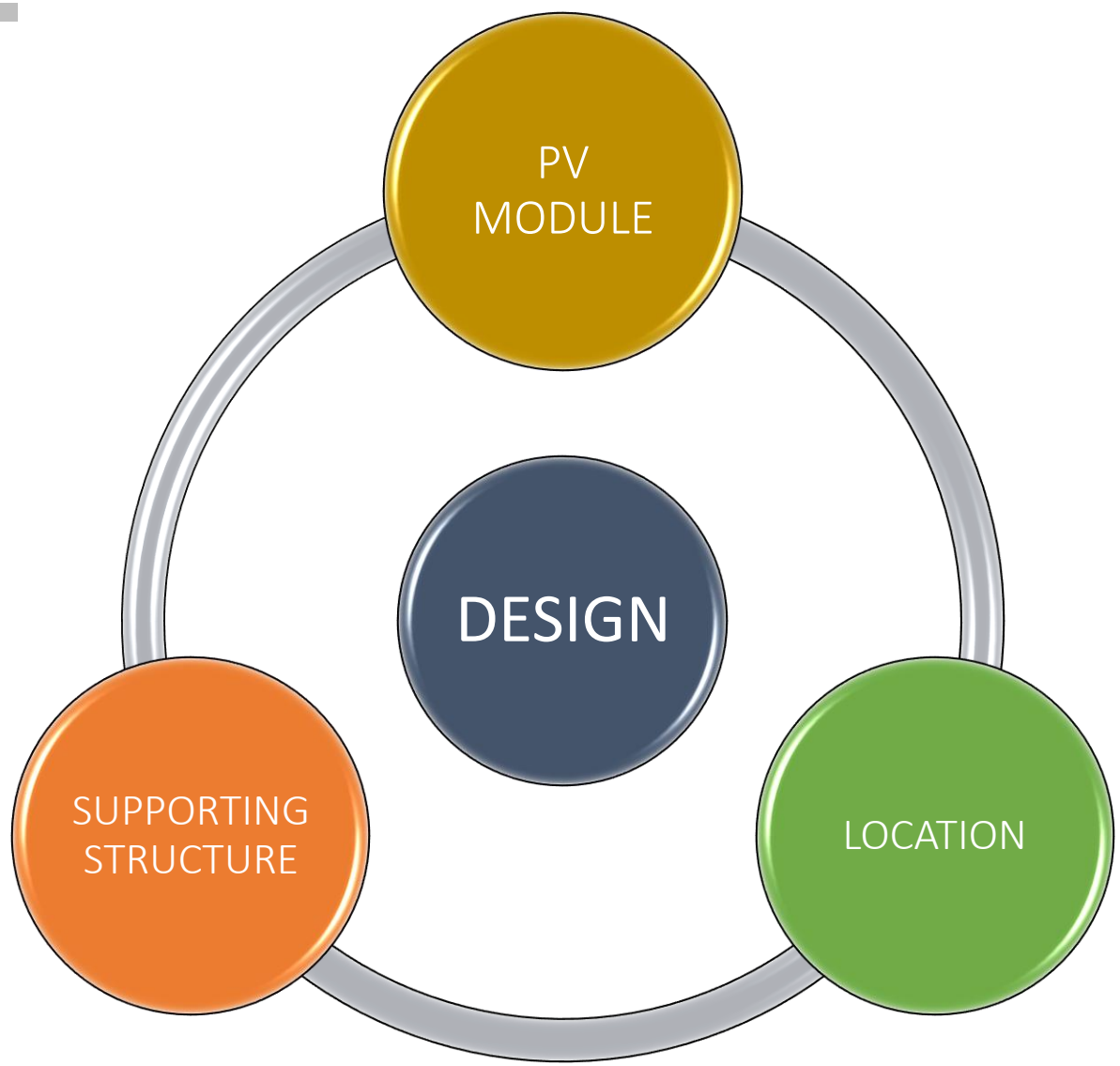
Bifacial Module Technology



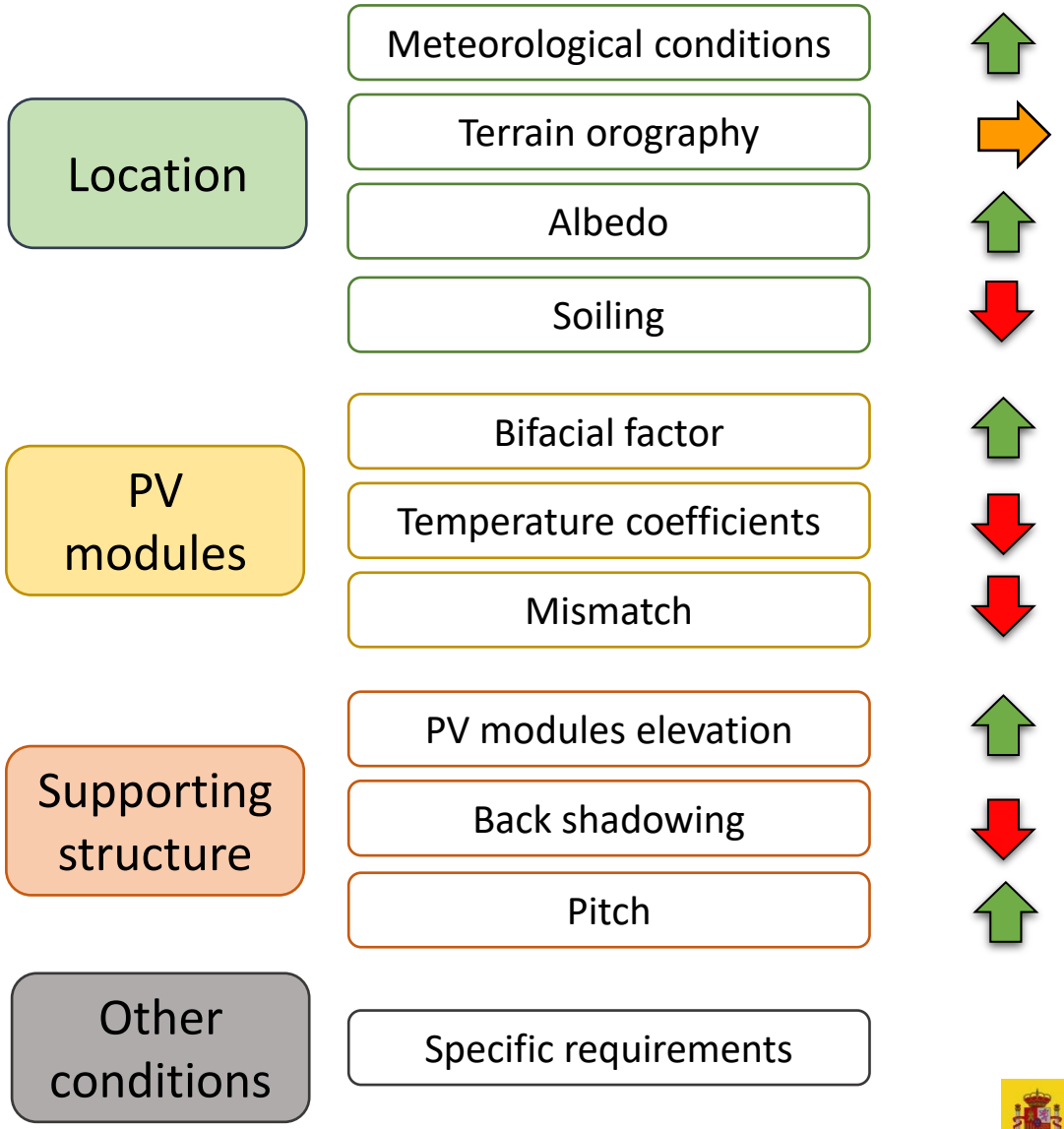
CENER experimental PV plant

CENER experimental PV plant

Target → Increase energy generation



PV generator aspects



PV generator aspects

Location + PV module +
Supporting structure =

PV generator Design

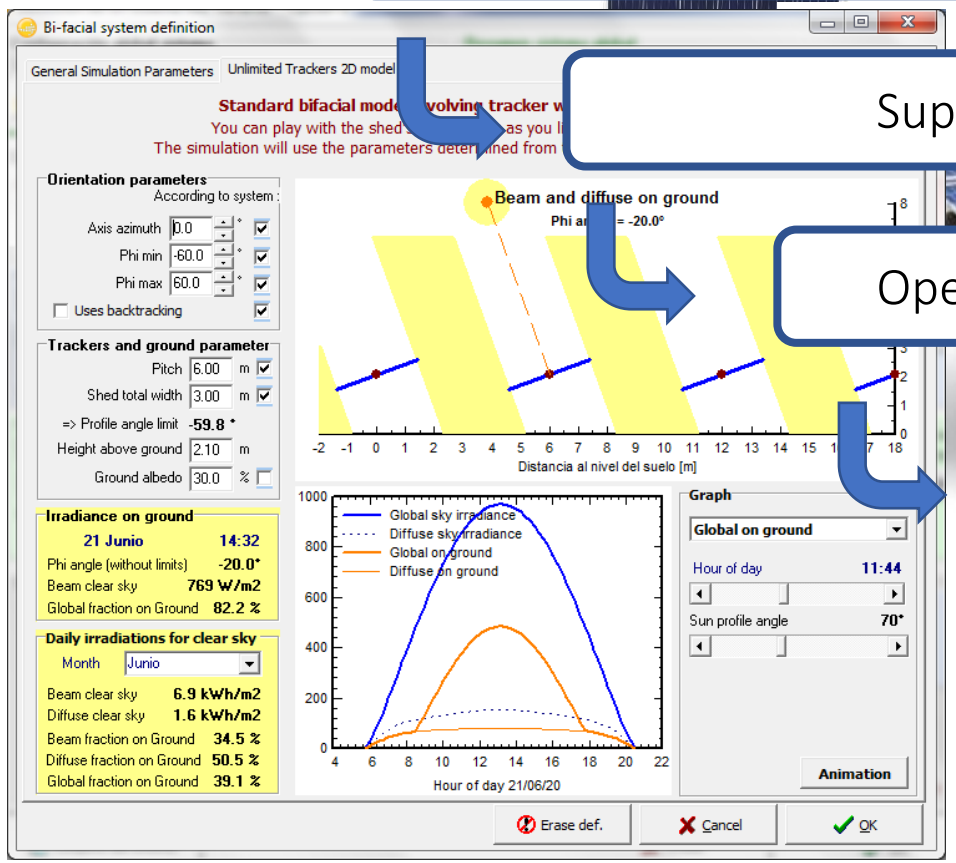
Other conditions

Specific requirements

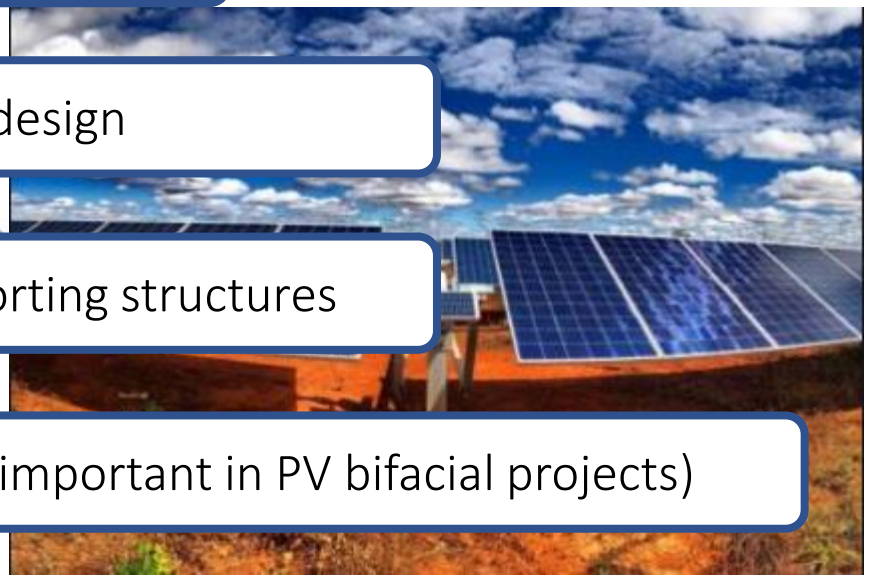
Process: PV generator design

PV module

Type of supporting structure (fixed tilted plane or tracking system)



Supporting structure mechanical design

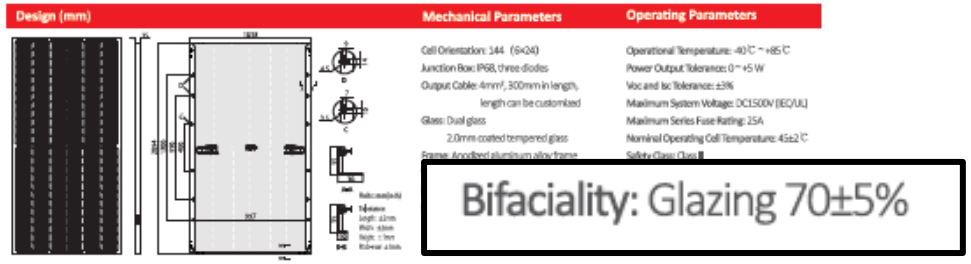


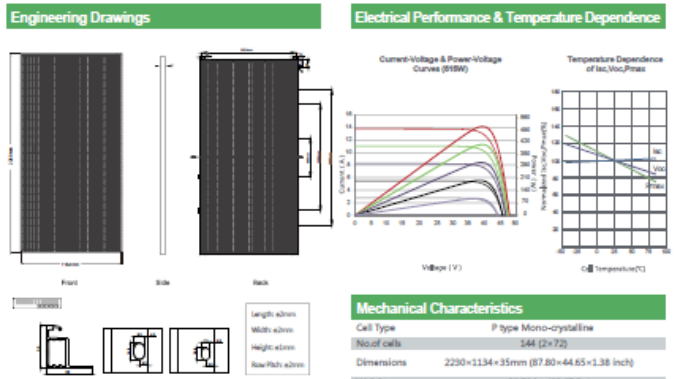
Operating conditions of the supporting structures

Electrical connections (important in PV bifacial projects)

Simulation of PV generator (PVSYST, SAM, …) => LCOE estimation

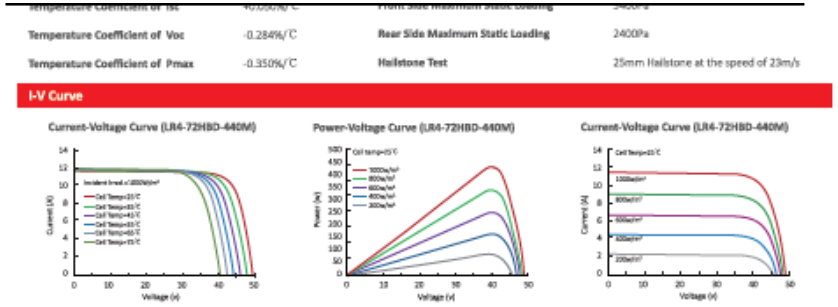
Bifacial PV module specifications





Electrical characteristics with different rear side power gain (reference to 445W front)

Pmax /W	Voc/V	Isc /A	Vmp/V	Imp /A	Pmax gain
467	49.4	12.09	41.2	11.34	5%
490	49.4	12.67	41.2	11.88	10%
512	49.5	13.24	41.3	12.42	15%
534	49.5	13.82	41.3	12.96	20%
556	49.5	14.40	41.3	13.50	25%



BIFACIAL OUTPUT-REARSIDE POWER GAIN

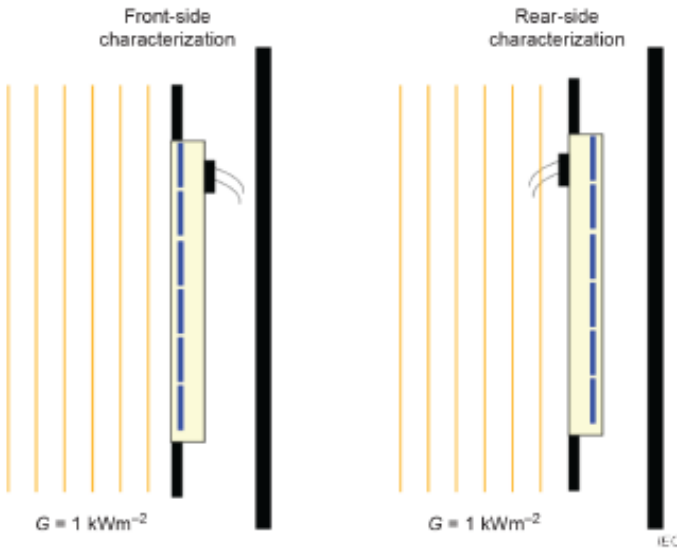
5%	Maximum Power (Pmax)	536Wp	541Wp	546Wp	551Wp	557Wp
	Module Efficiency STC (%)	21.18%	21.38%	21.59%	21.80%	22.01%
15%	Maximum Power (Pmax)	587Wp	592Wp	598Wp	604Wp	610Wp
	Module Efficiency STC (%)	23.19%	23.42%	23.65%	23.87%	24.10%
25%	Maximum Power (Pmax)	638Wp	644Wp	650Wp	656Wp	663Wp
	Module Efficiency STC (%)	25.21%	25.46%	25.70%	25.95%	26.20%

NOCT: Irradiance 800W/m² Ambient Temperature 20°C AM=1.5 Wind Speed 1m/s

* Power measurement tolerance: ± 3%

Maximum power measurement

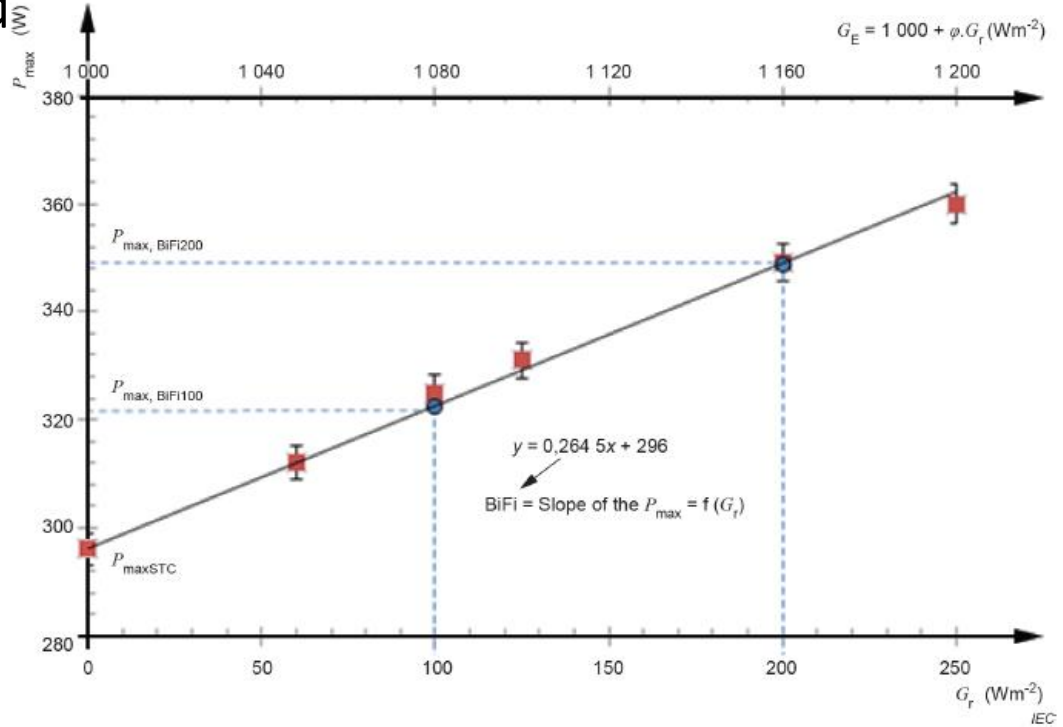
- Defined in IEC 60904-1-2 standard



$$\varphi_{Isc} = \frac{Isc_r}{Isc_f}$$

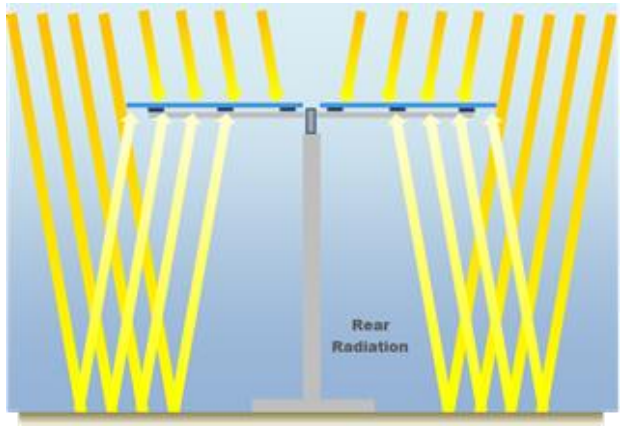
$$\varphi_{Pmax} = \frac{Pmax_r}{Pmax_f}$$

$$\varphi_{Voc} = \frac{Voc_r}{Voc_f}$$



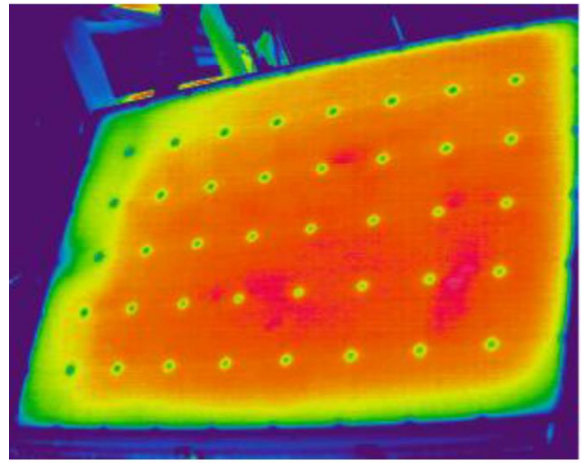
- Bifaciality: φ_{Isc}, φ_{Pmax}, φ_{Voc}
- BiFi: Rear irradiance driven power gain yield
- BSTC: $(1000 + min(\varphi_{Isc}, \varphi_{Pm}) \cdot 135)$Wm^{-2}, 25 ºC, AM1.5

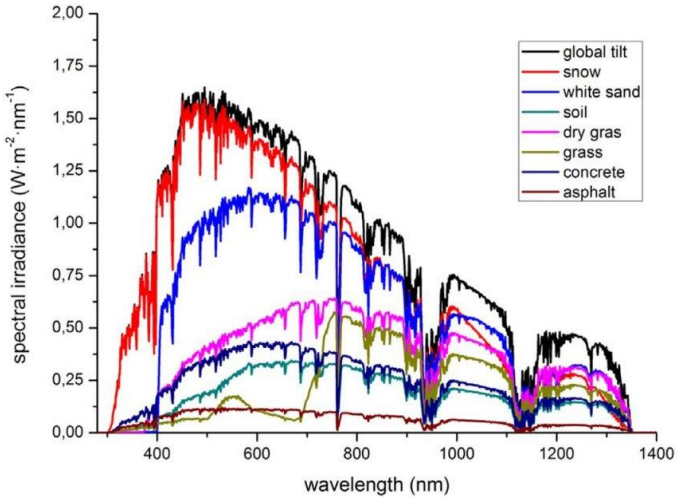
Factors affecting energy generation



IRRADIANCE

MODULE TEMPERATURE





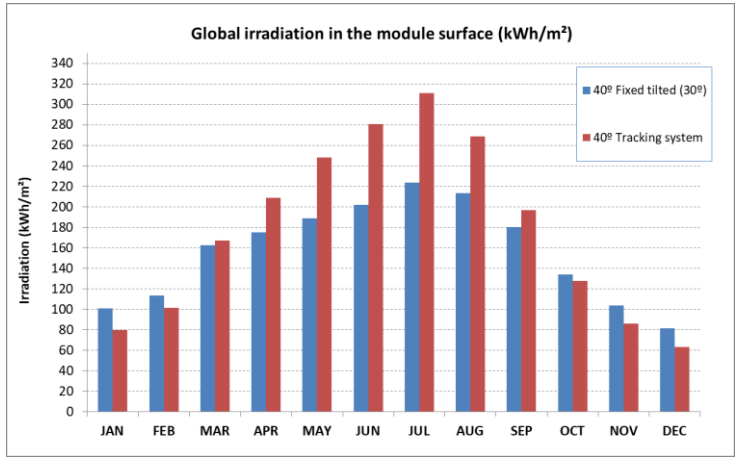
SPECTRAL DISTRIBUTION

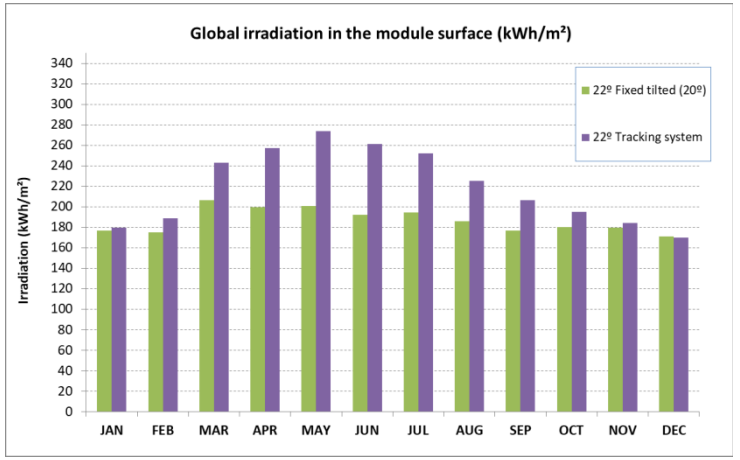
Factors affecting energy generation

IRRADIANCE

FRONT IRRADIANCE

REAR IRRADIANCE





1. ALBEDO:
   - Depends on soil
   - Variability
2. MODULE ELEVATION:
   - Increases bifacial gain
3. PITCH:
   - Increases bifacial gain
4. NON-UNIFORMITY:
   - Caused by shadows
   - Higher rear irradiance in the edges of the tracker
   - Rear soiling

Factors affecting energy generation

MODULE TEMPERATURE

- Modelled in IEC 61853-2 standard:
  - $T_m - T_{amb} = \frac{G}{u_0 + u_1 \cdot v}$
- u_0, u_1 depends on module type and mounting system
- Higher irradiance – Higher module temperature
  - Not necessarily higher than monofacial ($\neq u_0, u_1$)
- Irradiance non-uniformities – Localized heating
- Higher elevation – Higher wind speed (in open field)
  - Lower module temperature. Relevant?
- Max. Power temperature coefficient ≈ (–0,35 - –0,40) %/ºC

Conclusions

- Clear growing trend for bifacial PV installations
- Higher complexity in project design
- Parameters for bifacial module characterization: Bifaciality, BiFi
- Many factors to be considered in the project design:
  - Albedo, Module elevation, pitch, Non-uniformities…

Thank You Very Much!

info@cener.com

www.cener.com