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goPV

Oct. 27th

PV Modules: Bifacial technology

(14:30-16:30)

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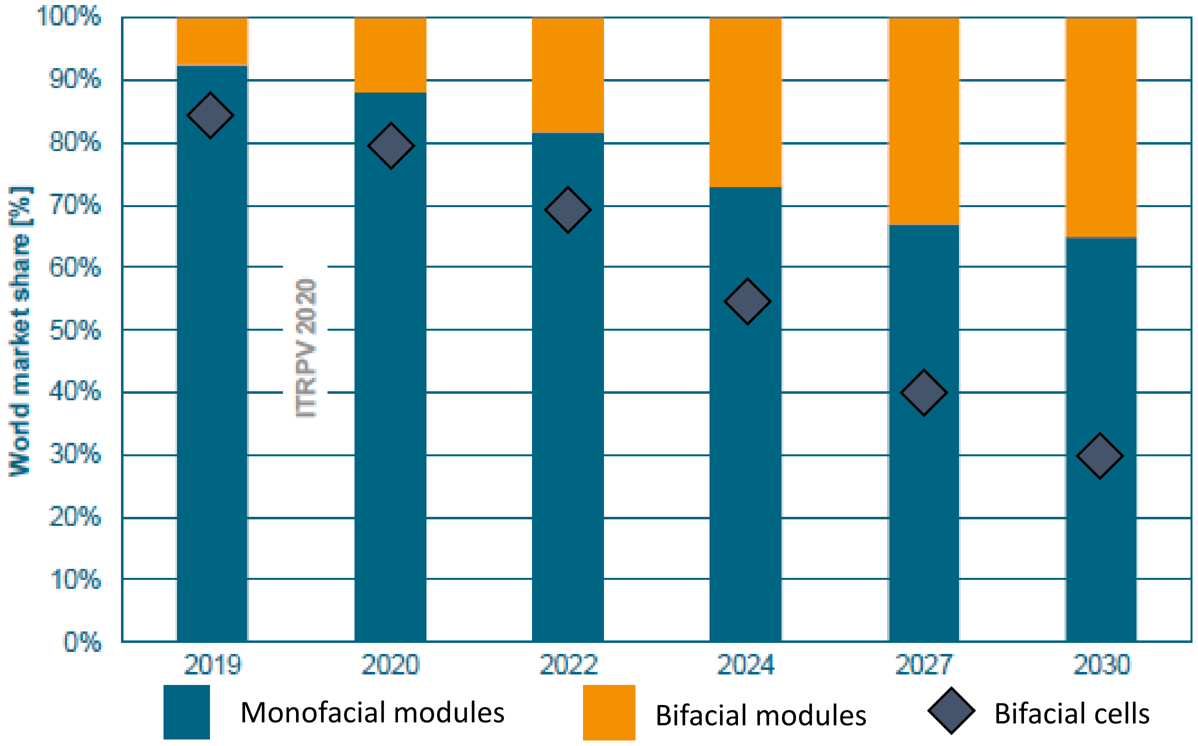
GLOBAL OPTIMIZATION OF INTEGRATED PHOTOVOLTAIC SYSTEM FOR LOW ELECTRICITY COST

Generality

280W
Glass/Backsheet
60 full M2 cells module
1,6m² - 19Kg

580W
156 ½ cells M12
2,73m² - 31 Kg

Generality



World market share [%]
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
ITRPV 2020
2019
2020
2022
2024
2027
2030
Monofacial modules
Bifacial modules
Bifacial cells

Generality

Two methods proposed by the IEC 60904-1-2 standard

<u>Method 1</u>:
Simultaneous measurement on both sides of the module with an irradiation of 1000W/m² on the front side and 100W/m² and 200W/m² on the back side:

➔ **$Pmax_{BiFi10}$ and $Pmax_{BiFi20}$.**

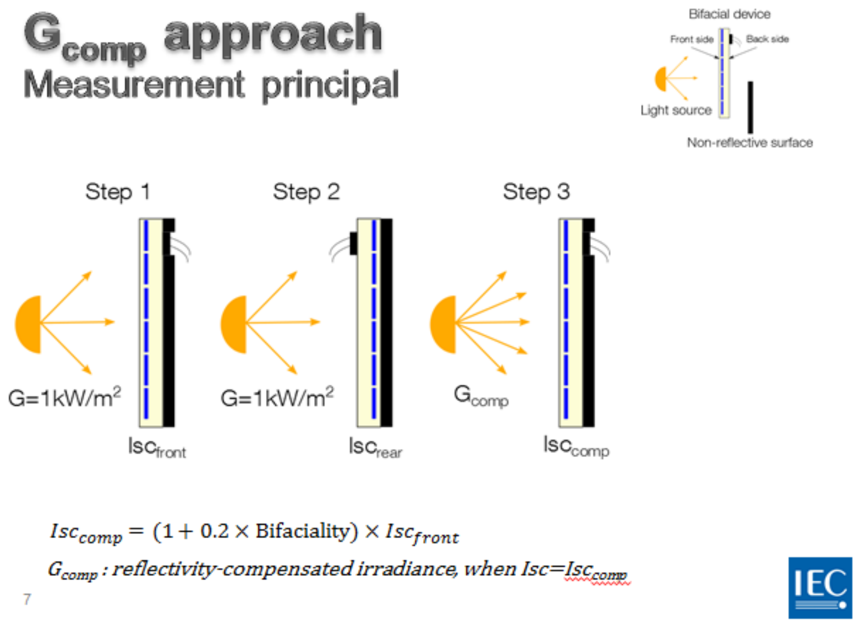
<u>Method 2</u>:
a/ Measurement under 1000W/m² of the module on the front and back side.

➔ Determination of the bifaciality coefficient

b/ Front panel measurement at a power greater than 1000W/m² determined by:

$$G_{E_i} = 1000W/m^2 + \varphi \times G_{R_i}$$

G_{Ri}= 100W/m² et 200W/m²



Generality

BIFACIAL OUTPUT-REARSIDE POWER GAIN

5%	Maximum Power (Pmax)	399Wp	404Wp	410Wp	415Wp	420Wp
	Module Efficiency STC (%)	19.49%	19.75%	20.00%	20.26%	20.52%
15%	Maximum Power (Pmax)	437Wp	443Wp	449Wp	454Wp	460Wp
	Module Efficiency STC (%)	21,35%	21,63%	21,91%	22,19%	22,47%
25%	Maximum Power (Pmax)	475Wp	481Wp	488Wp	494Wp	500Wp
	Module Efficiency STC (%)	23,20%	23,51%	23,81%	24,12%	24,42%

ELECTRICAL DATA (STC)

Peak Power Watts-Pmax (Wp)*	345	350	355	360	365
Power Output Tolerance-Pmax (W)	0 ~ +5				
Maximum Power Voltage-Vmpp (V)	39.0	39.2	39.4	39.6	39.8
Maximum Power Current-Impp (A)	8.85	8.93	9.01	9.09	9.17
Open Circuit Voltage-Voc (V)	47.4	47.6	47.8	48.0	48.2
Short Circuit Current-Isc (A)	9.47	9.54	9.61	9.68	9.75
Module Efficiency η (%)	17.4	17.7	17.9	18.2	18.4

STC: Irradiance 1000W/m², Cell Temperature 25°C, Air Mass AM1.5.
*Measurement tolerance: ±3%.

BI-FACIAL OUTPUT - Backside Power Gain

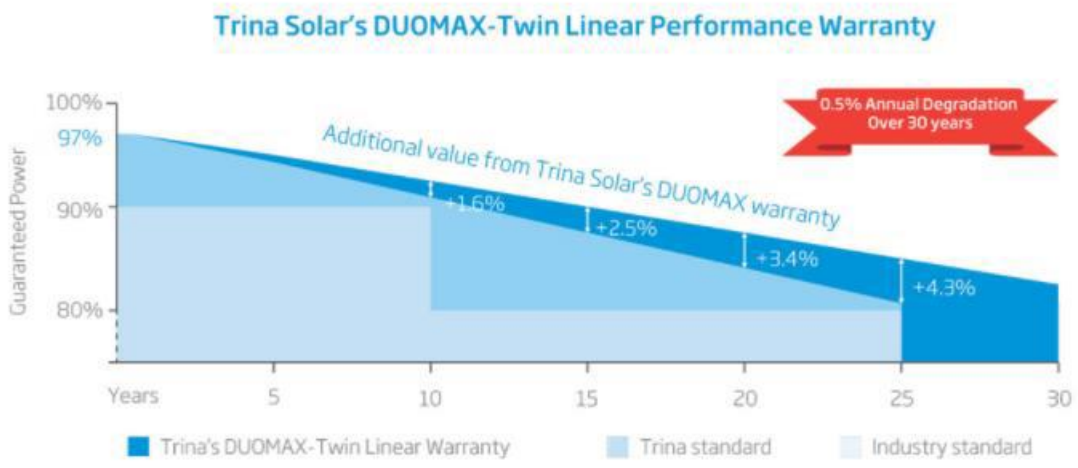
10%	Power Output(W)	380	385	391	396	402
	Module Efficiency(%)	19.1	19.5	19.7	20.0	20.2
15%	Power Output(W)	397	403	408	414	420
	Module Efficiency(%)	20.0	20.3	20.6	20.9	21.2
25%	Power Output(W)	431	438	444	450	456
	Module Efficiency(%)	21.8	22.1	22.4	22.7	23.0

With Different Power Generation Gain (regarding 405W as an example)

Power Gain (%)	Peak Power (Pmax) (W)	MPP Voltage (Vmp) (V)	MPP Current (Imp) (A)	Open Circuit Voltage (Voc) (V)	Short Circuit Current (Isc) (A)
10	437	41.8	10.46	50.1	10.98
15	454	41.9	10.84	50.2	11.38
20	470	41.9	11.22	50.2	11.78
25	486	41.9	11.60	50.2	12.18
30	502	41.9	11.99	50.2	12.57

Conférence INES – Déploiement de la technologie bifaciale – Innovation technologique et performance des modules – Y-Veschetti-13/10/2020

Generality



- The switch to the two-glass bifacial is accompanied by an improvement in the power guarantee.
    - From 25 to 30 years, which is explained by a linear **annual deterioration reduced to 0.5%/year**
- The **replacement of EVA encapsulant by POE** also supports this trend (PID link).
    - The two-glass design has a better potential in terms of reliability/sustainability
- However, this better potential is **not an absolute guarantee**.
    - The manufacture of modules glass/glass of poor quality is possible (quality defect (processes…), cells, encapsulant…)

Generality

$$\varphi_\eta = \frac{Pmax_{Rear}}{Pmax_{front}} \qquad \varphi_{I_{SC}} = \frac{I_{SC,rear}}{I_{SC,front}} \qquad \varphi_{V_{OC}} = \frac{V_{OC,rear}}{V_{OC,front}} \qquad \varphi_{FF} = \frac{FF_{rear}}{FF_{front}}$$

Parameters influencing φ

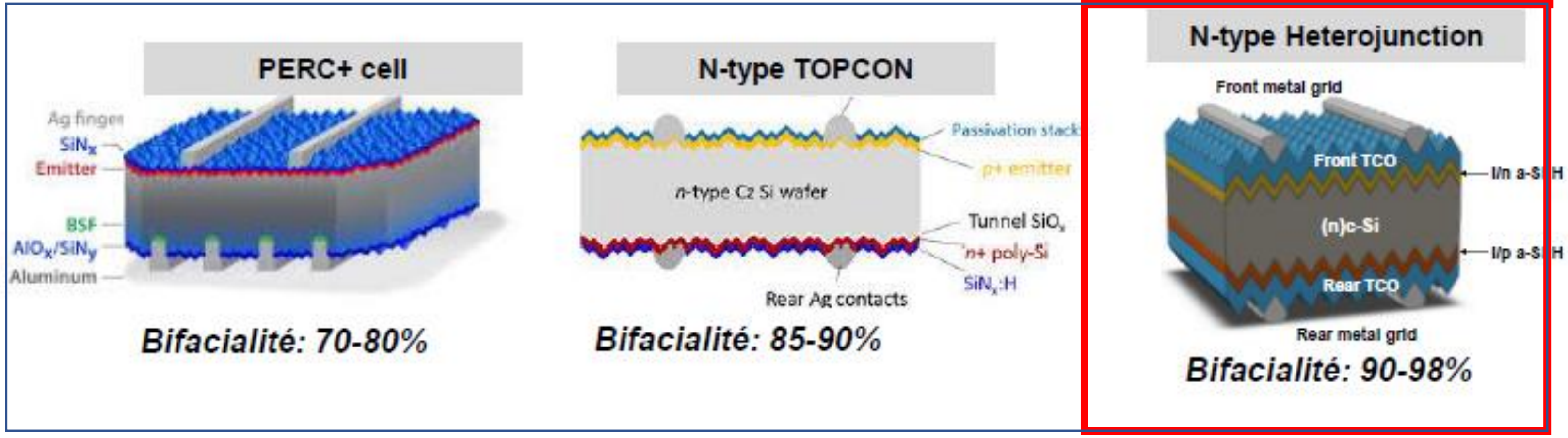
- Cell simmetry
- Metallization

Bifacial modules developed in GOPV project

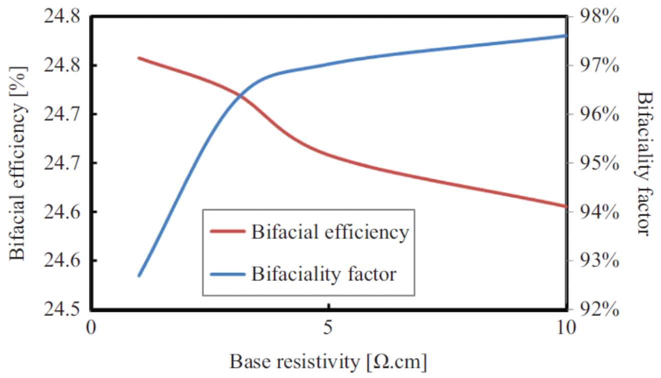
Cell Technos

- **2020 : several candidates for the next generation towards yields by 25%.**

Used for GOPV



Bifaciality = Yield Front Side/Yield Back Side

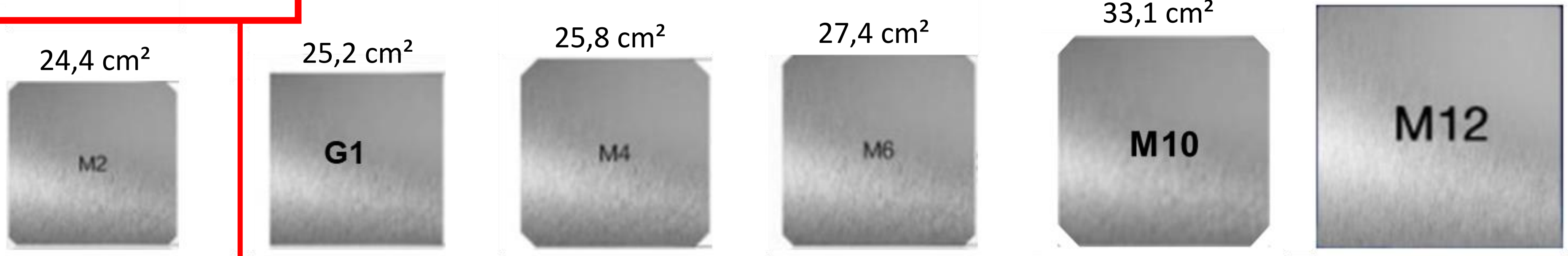


➔ **Trade-off between bifaciality and efficiency**

Bifacial modules developed in GOPV project

Cells Wafer

Used for GOPV



M2 (Used for GOPV)	24,4 cm²	156,75 mm
G1	25,2 cm²	158,75 mm
M4	25,8 cm²	161,7 mm
M6	27,4 cm²	166 mm
M10	33,1 cm²	182 mm
M12	44,1cm²	210 mm

Four main wafer sizes will coexist in the next few years:
G1, M6, M10, M12

- G1 wafer = industry standard in 2020; M2 fast decline
- 166 mm (M6) launched by Longi mid 2019
- 210 mm (G12) launched by TZS in Aug 2019
- 182 mm (M10) adopted by 7 leading companies in June 2020
- 210 mm supported through the creation of 600W+ Photovoltaic Open Innovation Ecological Alliance (57 members in sept. 2020)

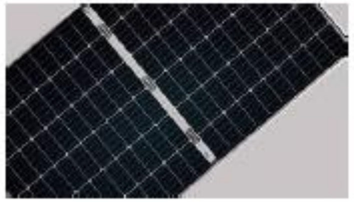
Bifacial modules developed in GOPV project

Interconnection

G/G modules

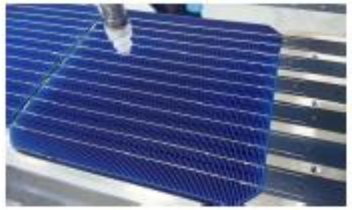
GOPV First Production campaign

½ cut cells interconnection
144 cells



GOPV Second Production campaign

4BB → 5BBs → MBB

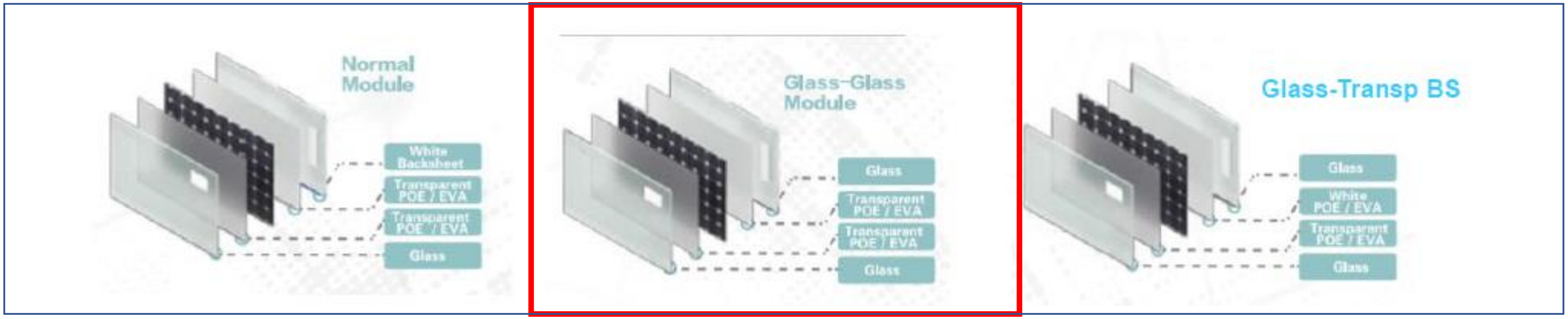


Gap less interconnection

Shingle modules

Bifacial modules developed in GOPV project

Design Evolution

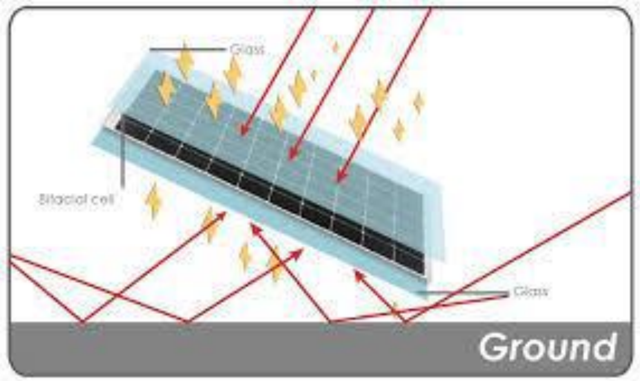


Component variations:

- Rear side: Glass (thickness 2.5mm) or Transparent Backsheet
- Periphery: Standard aluminium frame, mini frame, no frame

Analysis conducted on the bifacial modules offered on the market

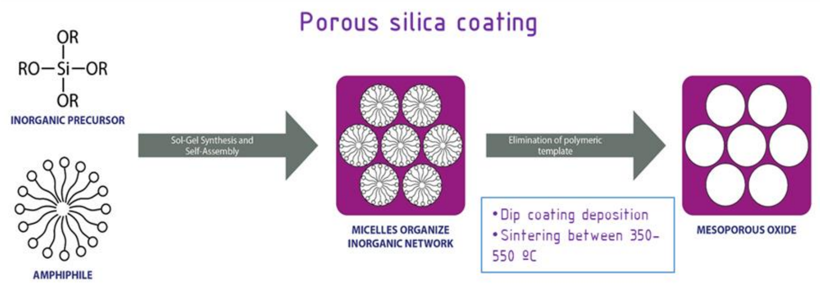
- The absence of a frame favours glass thicknesses of 2.5mm for mechanical reasons.
- Glass/Glass Design with frame is the current dominant format on the market Nevertheless, manufacturers seem to deviate from this design (breakage/fastening system compatibility).
- The use of transparent Backsheet is gaining interest (Decrease of 30 % of weight)



Bifacial modules developed in GOPV project

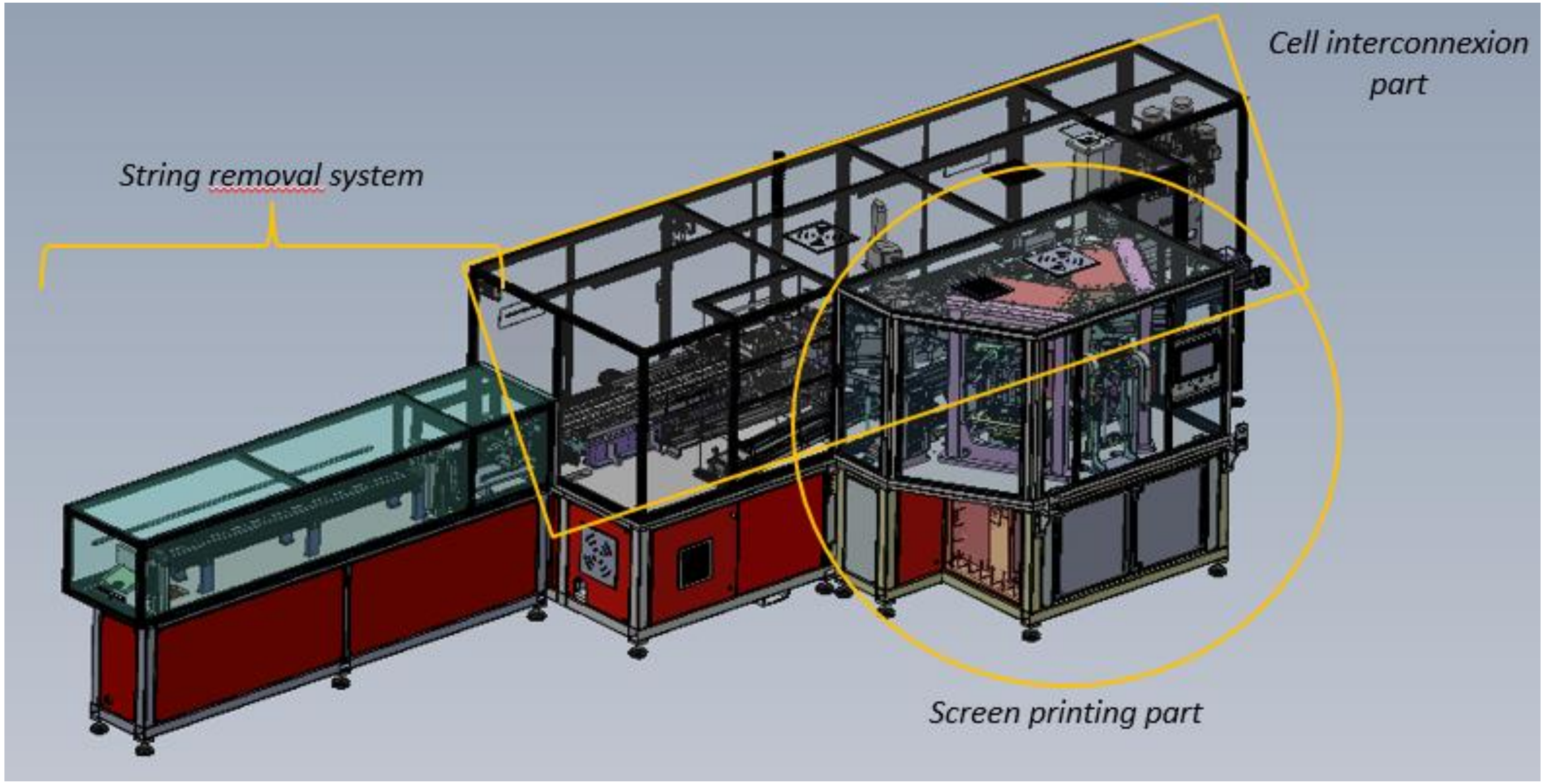
GOPV Production BOM

- Bifacial HJT module 72 cells layout (M2): 370W → CTM 96/97 % P (W)
- Cell thickness: 120 µm; Ag per cell: 140 mg; 6 BB
- Cell interconnection by glueing technology
- ECA per half-cell: 30 mg (ribbon width: 0.8 mm)
- Glass-glass encapsulation
- AR/AS coating : Closed-cell mesoporous silica



Bifacial modules developed in GOPV project

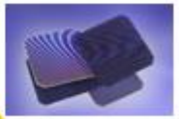
GOPV Production Stringer



Industrial stringer prototype

Bifacial modules developed in GOPV project

GOPV Production Stringer



Cell size

- M2
- Down to 120 µm thick

Busbar number

- # 6

Ribbons parameter

- 0.8 mm width, textured

Peel force > 0.5 N/mm

ECA

- Acrylic
- 10 mg/Busbar

→ Curing 15/20 s at 170°C

Interconnexion method

- Gluing/soldering with positive gap

Throughput

- Up to 1200 cells/hour

Industrial stringer prototype

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