

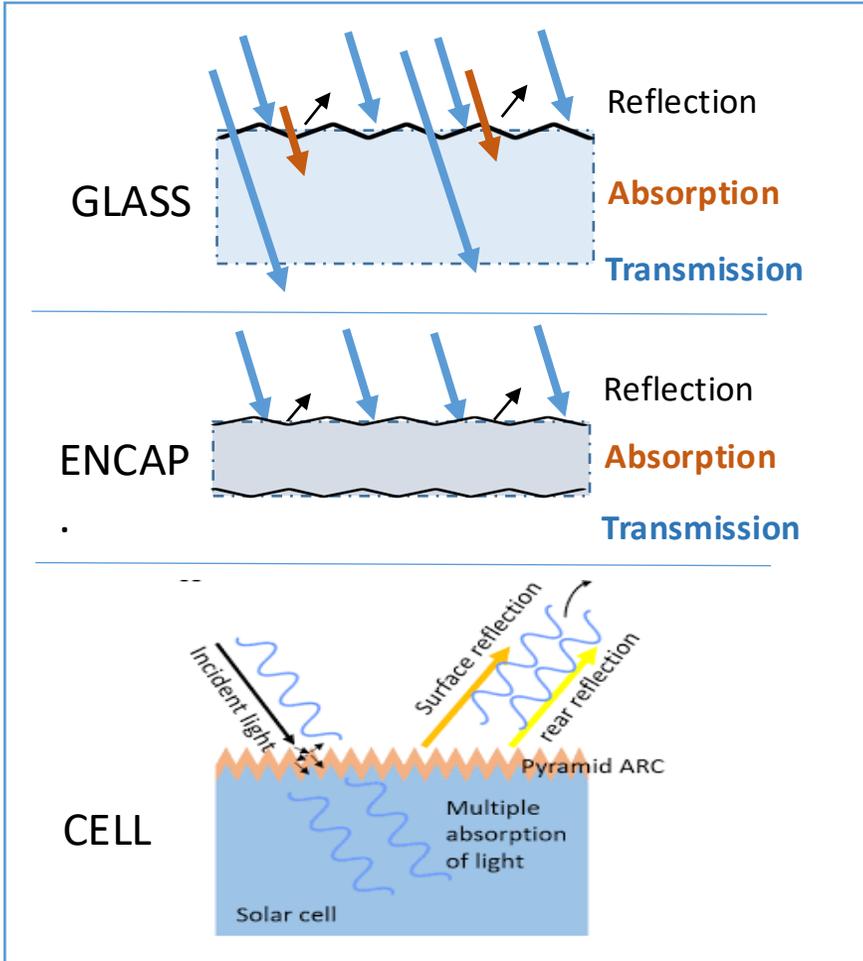
Solar Technology Conference India 2026

— Scaling & Sustaining India's Giga-Scale PV Manufacturing Ecosystem

TOPIC: Advancing Solar Module Performance and Reliability Through the Right Bill of Materials (BOM)

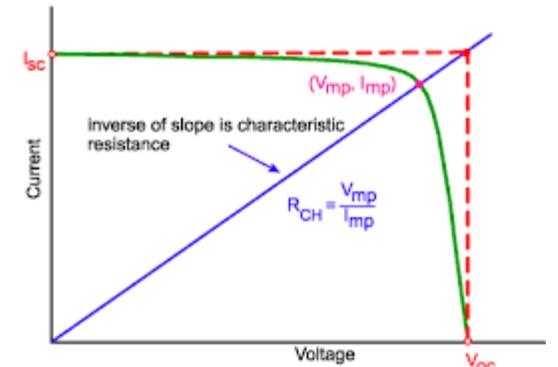
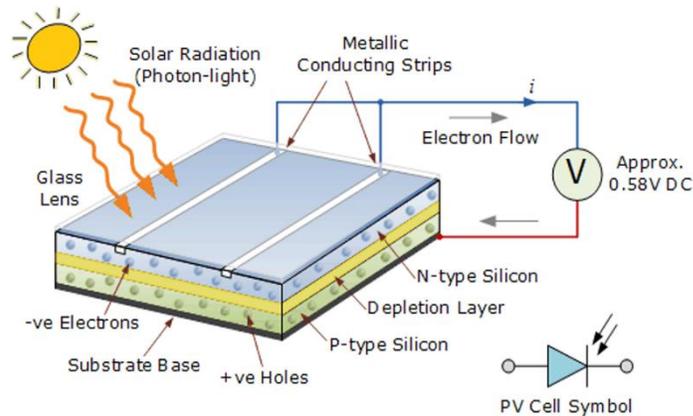
Rajesh Singh
CTO - Renewsys

Light Management

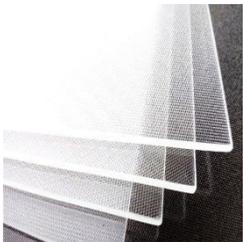
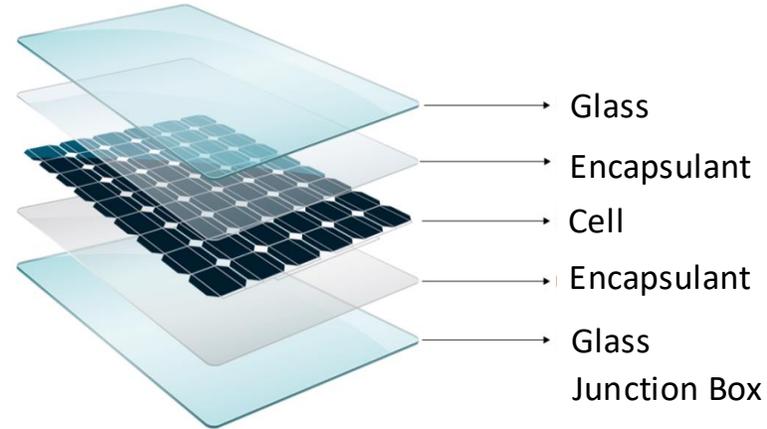
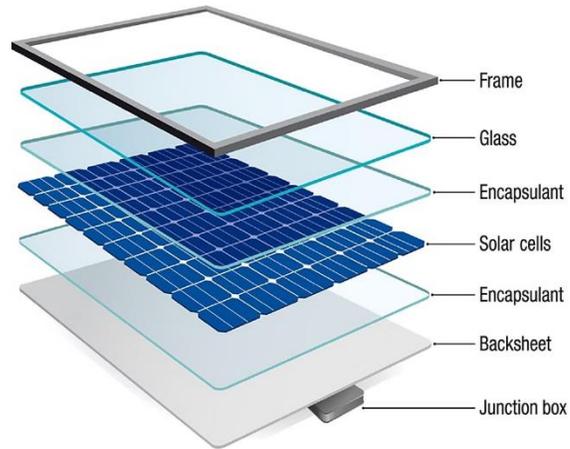


Passivation/Resistance Management

- Recombination Losses – Maximise Passivation
- Resistive Losses – Minimise Resistance



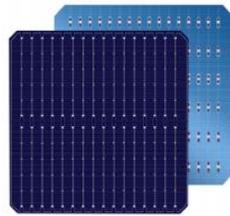
Bill of Materials (BOM)



Glass



Encap.



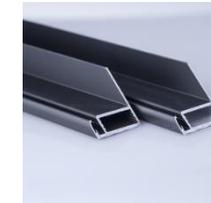
Cell



Junction Box



Interconnects



Frame



Sealant

Performance

Power Generation

Reliability

Longevity

PV Cell Performance & Reliability Matrix

Properties	PERC	TOPCON	HJT	IBC	PERV.
Bi-faciality %	70	85	95	70	75-95
Avg. Efficiency %	23	25.3	25.5	26.2	~28
1 st Year Degradation %	2	<1	<1	<1	2
Annual Degradation	0.45	0.4	0.35	0.4	0.8-1.2
Temp. Coefficient / °C	-0.35	-0.32	-0.24	-0.26	-0.15
Seasonal Performance (Rain, Snow, Mist, Morning)	Moderate	High	Low	Low	Very High
UV Stability	High	Moderate	Low	High	Moderate

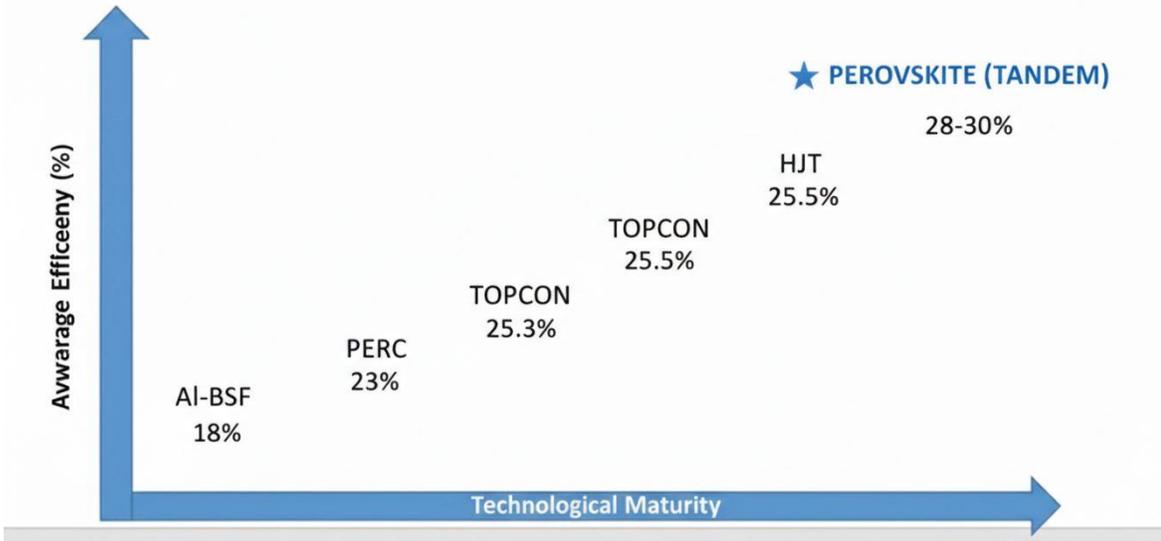
- **TOPCon:** 1.5nm tunnel oxide; Moisture and Chemical Sensitive – **Requires Inert Encap**
- **HJT:** Low-Temp Process; Superior Heat Performance, High UV sensitivity - **Requires DC Encap**
- **IBC:** Eliminates shading; higher theoretical efficiency but complex patterning – **Can be G2B modules**
- **Strategic Note:** Eliminating Boron-Oxygen defects (LID) is the primary driver for N-type adoption

N-Type wafers over P-type wafers

- No boron-oxygen related LID
- Higher PID resistance
- Lower impurity-driven degradation
- Greater long-term electrical stability
- Suitability for high-voltage systems

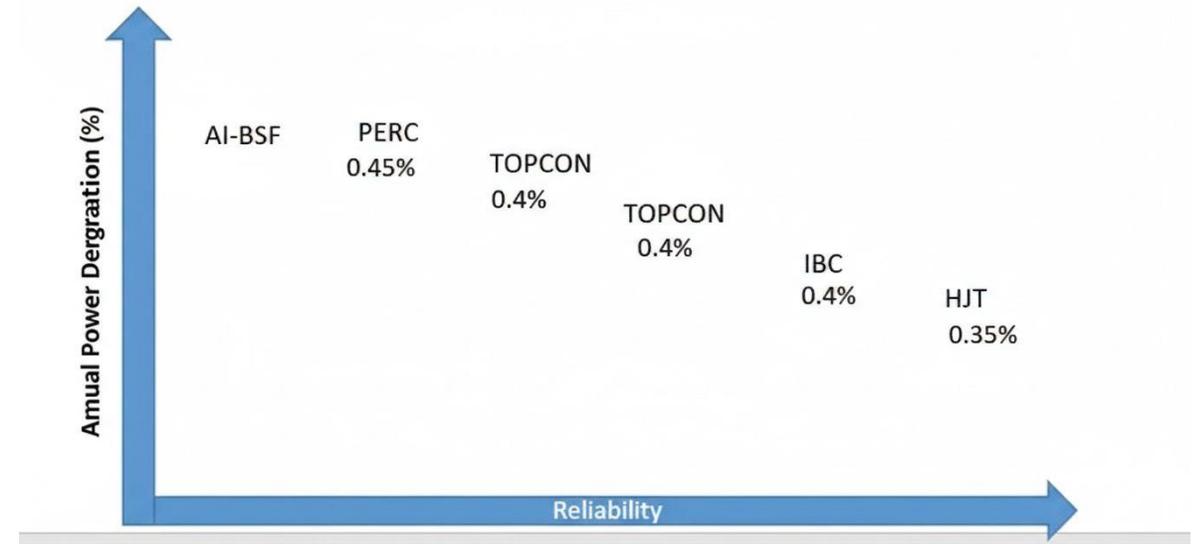
Efficiency Comparison

Sunlight to Power Conversion (%)

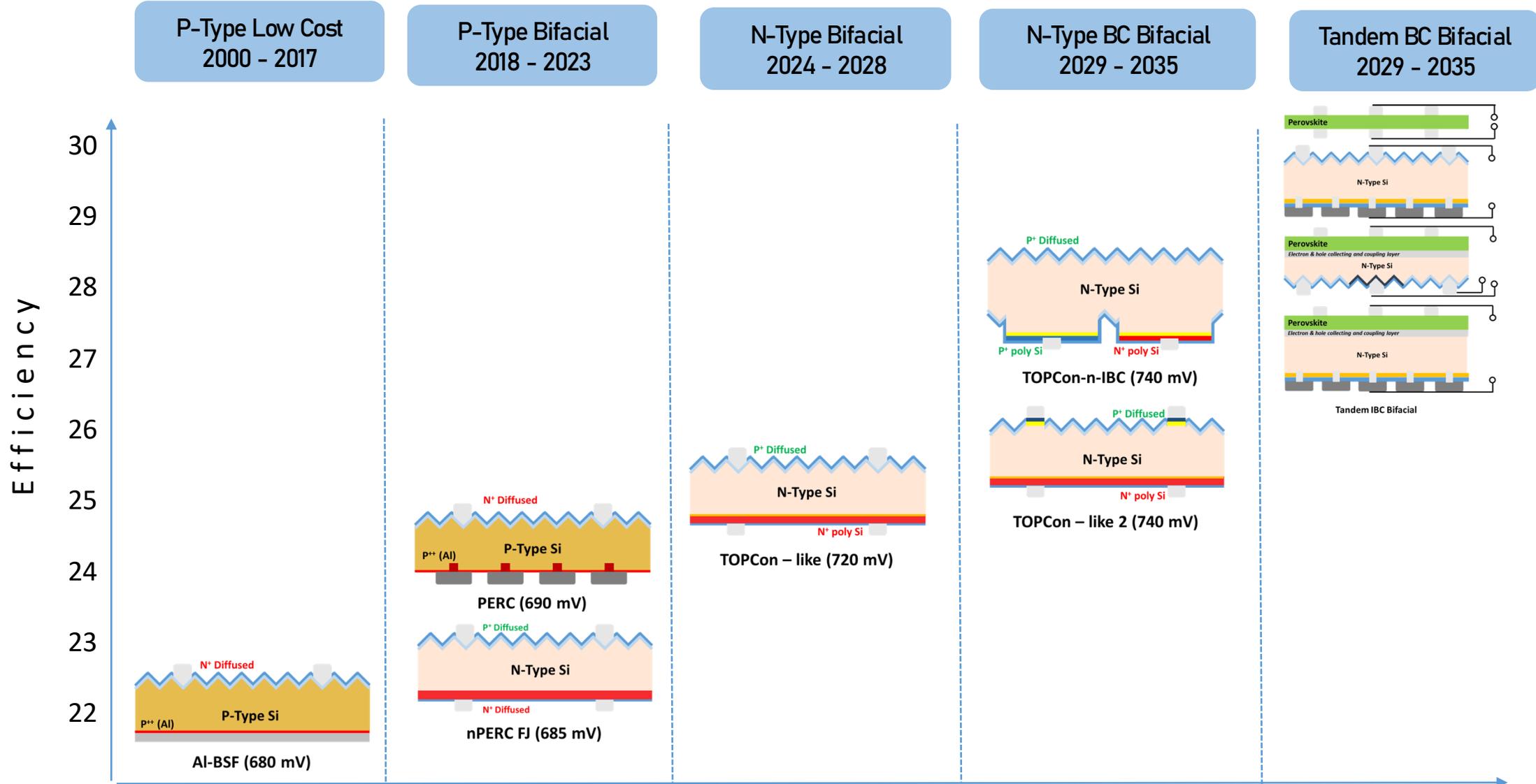


Degradation Comparison

Annual Power Loss Over Time



PV Cell Technology Roadmap



Encapsulants' Inherent PROS & CONS

EVA

PROS

- Excellent Adhesion
- High Optical - Transparency
- Easy Processing
- Cost Effective

CONS

- Acid Formation
- High WVTR
- High PID

POE

PROS

- No Acid Formation
- Low WVTR
- Low PID

CONS

- Cost
- Complex Processing
- Higher Lam Cycle Time

EPE

PROS

- Low WVTR
- Excellent Adhesion
- Cost Performance Optimization

CONS

- Possible Interlayer Separation

POLYOLEFIN

PROS

- No Acid Formation
- Low WVTR
- Low PID
- Lower Lamination Temperatures

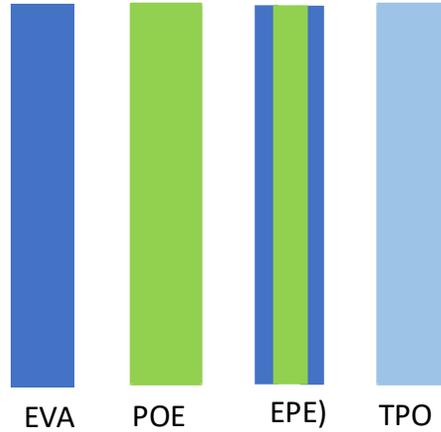
CONS

- Higher cost
- Lower Adhesion

Encapsulant Comparison Matrix

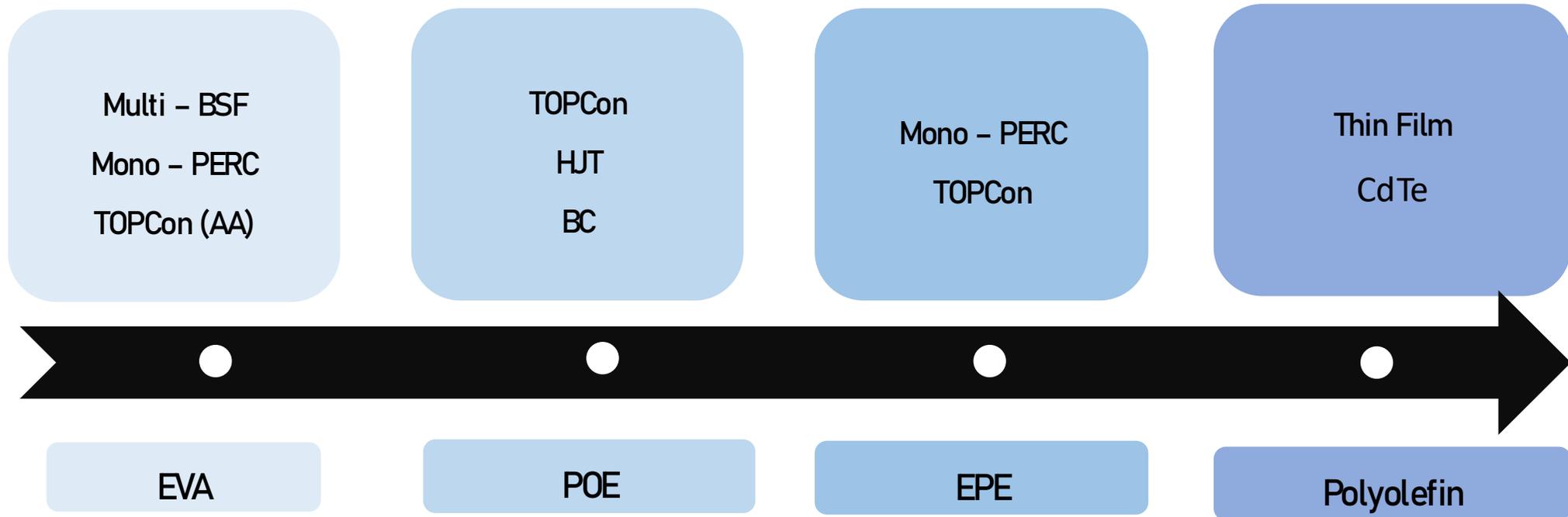
Attributes	EVA	POE	EPE
PID	<ul style="list-style-type: none"> VR 10^{15} to 10^{16} Ohms May deplete over time 	<ul style="list-style-type: none"> VR: 10^{16} to 10^{17} A permanent phenomenon 	Moderate
Moisture Permeability	<ul style="list-style-type: none"> High 40 	<ul style="list-style-type: none"> Low 4 -6 	<ul style="list-style-type: none"> Moderate 15-20
Moisture Sensitivity	<ul style="list-style-type: none"> High 	<ul style="list-style-type: none"> Low 	<ul style="list-style-type: none"> Moderate
Chemical Reactivity	<ul style="list-style-type: none"> Conduit to metal ions Leaching out of chemicals Susceptible to a chemicals 	<ul style="list-style-type: none"> Non-carrier to metal ions Relatively inert 	<ul style="list-style-type: none"> Intermediate
Possibility / Productivity	<ul style="list-style-type: none"> Easy / High 	<ul style="list-style-type: none"> Easy with a learning curve 	<ul style="list-style-type: none"> Moderate / Moderate

Encapsulants' Choice Maker

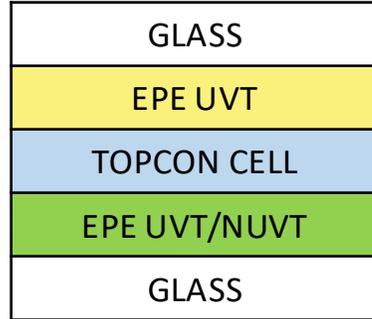


Particulars	Attributes
Material	EVA, POE, EPE, TPO
Transparency spectrum	UV Blocked, UV Transparent, UV Down Converted
Resistivity	PID Resistant
Colour	Transparent, White, Black
Chemical Resistance	Anti Acid, Free Radical Scavenger

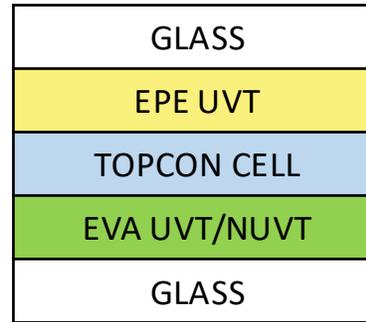
Encapsulants' Type & Cell Technologies



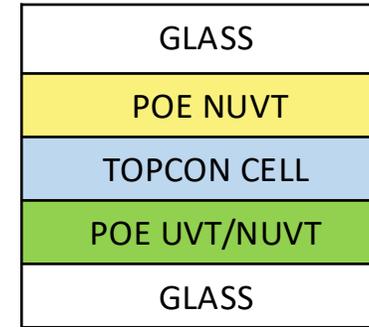
Targeted Pairing



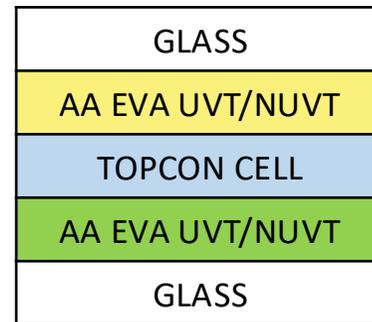
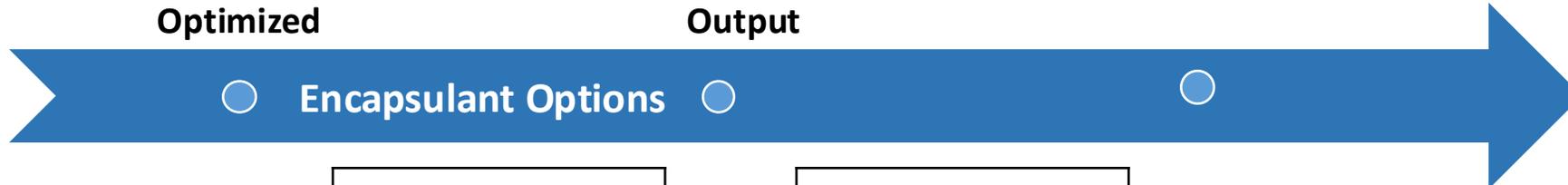
Most Cost & Performance Optimized



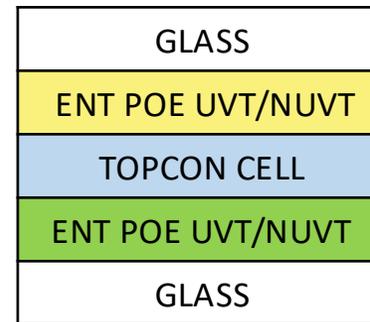
Economical, Higher Output



Reliable



Most Cost Effective



Most Reliable

Next Generation

BACKSHEET



White Backsheet
Fluoro & Non-Fluoro



Transparent Backsheet
Fluoro & Non-Fluoro



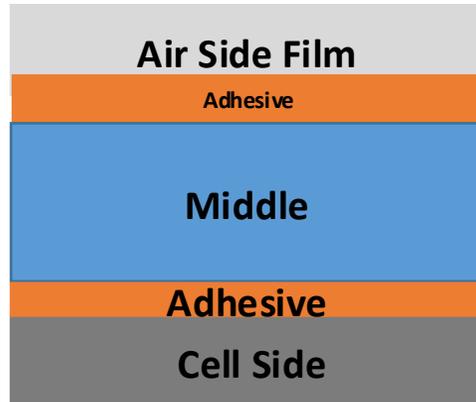
Black Backsheet
Fluoro, Non-Fluoro



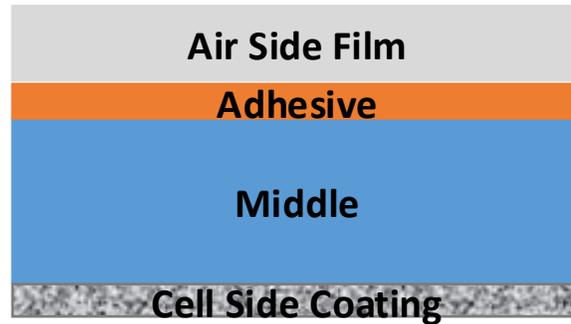
Metallic
Backsheet

PV Backsheet Construction Types

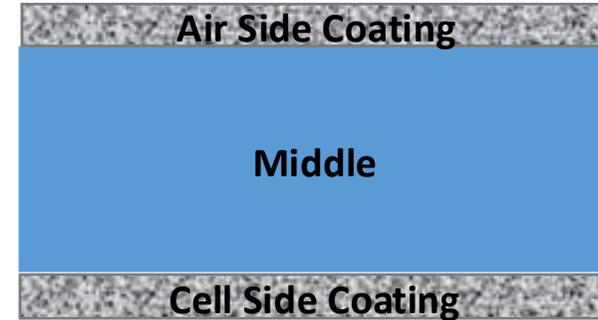
Laminated



Laminated-Coated



Both Side Coated



Coated Vs Laminated Backsheets

Parameters	Laminated BS	Coated BS	Impact on Backsheet
Molecular arrangement and compactness	Good	Poor	Degradation is faster and it may be exponential - Backsheet chalking is the one case
Porosity	Negligible, WVTR: : <1.5 : <0.35	Very high – WVTR >2.5g	No protection to core layer from moisture and it can reduce life of BS
Cohesive bond between molecules	Very high	Very poor	Chalking effect or erosion of coating possible
Surface Abrasion (Taber Test)	Strong: (0.3 mg loss)	Very poor (8-9 mg)	Coated surface is highly abrasive, leads to scratches – poor moisture barrier

PV Backsheet: Fluoro Vs Non- Fluoro

Comparison of individual material

Backsheet materials	UV Resistance	PCT Resiatnce	MVTR	Tensile strength	Electrical insulation
PVDF	> 3000 hrs	> 360 hrs	++	+++	+++
PVF	> 3000 hrs	>360 hrs	++	+++	+++
HPET/PET	2100 hrs	72 hrs	++++	+++++	+++++

PV Glass Choice Makers

Float Glass

- Heat Treatment
- Plain Surface

Application:

Mono & Bifacial Modules

Rolled Glass

- Fully Tempered
- Embossed Surface

Application:

Mono & Bi-facial Modules

FEATURES/OPTIONS:

- ARC Coated
- Single & Double Textured
- Grid Printed
- Reflective Ribbons
- Low Iron

ABOUT RENEWSYS

RenewSys is the first integrated manufacturer of Solar Modules (5.5 GW) and its key components.

- **Solar Modules** - 5.6 GW
- **Encapsulants** (EVA, POE, & EPE) - 30 GW*(17 GW Under Operation+13 GW Planned)
- **Solar PV Cells** (TOPCon) - 4.5 GW* (2.5 GW Under Execution+ 2 GW Planned)
- **Backsheets** - 4 GW

(*FY 2026-27)

Supply To Date

PV Modules
4.1+ GW

PV Cells
500+ MW

Encapsulants &
Backsheets
30+ GW

(*inception till date)



Thank you!

RenewSys = Peace Of Mind