SunPower Performance Panels

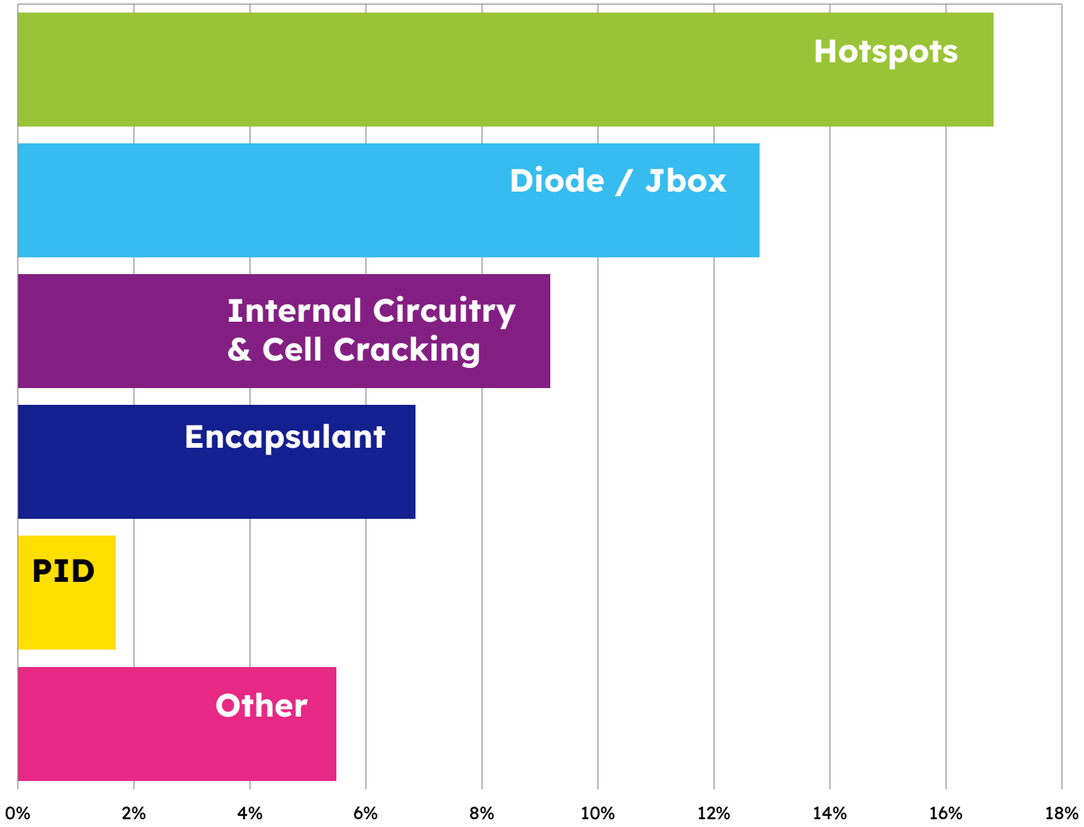
SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

Engineering a better panel

Focusing on reliability to protect against known failure points in standard solar panels.

Common causes of solar panel degradation

Dupont estimates that up to 30% of panels may see reliability issues within their first 10 years of operation[1]

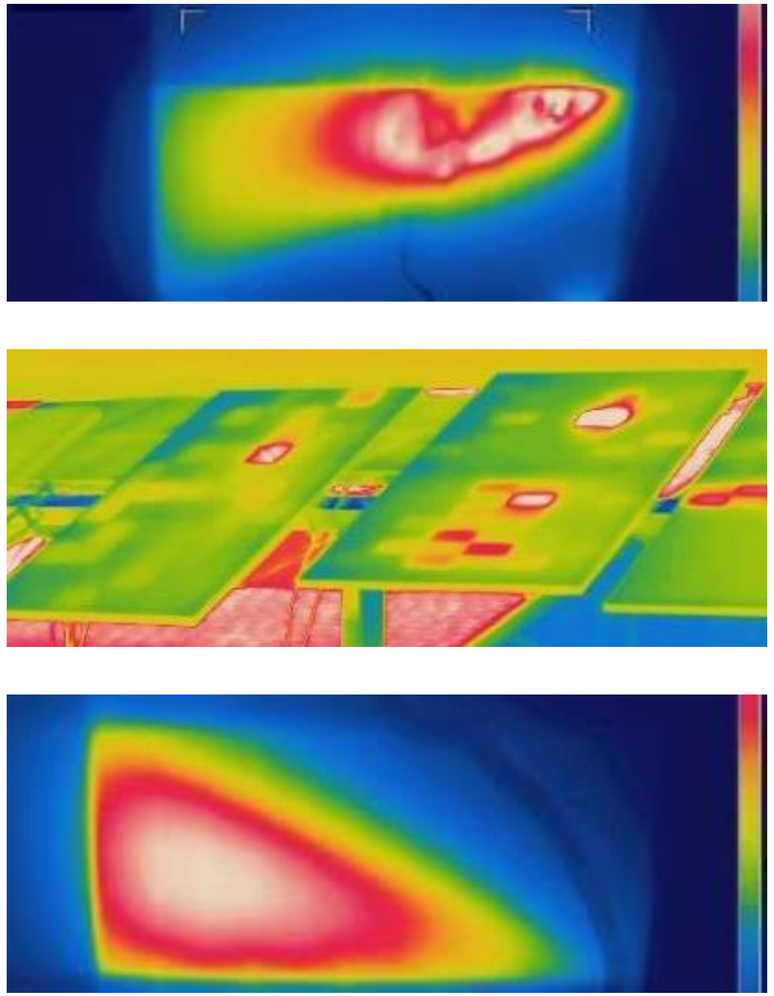


The research of Jordan et. al. has gone a bit further to quantify the presence of key degradation modes in the field—finding hotspots and related electrical infrastructure problems to be the predominant issues affecting solar panel reliability.

The impact can be significant, including energy yield losses, inverter uptime issues, and even outright panel failure.

Maxeon panels are uniquely designed and engineered to target these key degradation modes that affect solar panel performance over their initial 10 years of operation.

1. DuPont global PV reliability study (2020). Inspection observations based on 3GW in field. DuPont Global-Field-Reliability-Report-2020.pdf 2. Chart source information: Jordan, D. C., Silverman, T. J., Wohlgemuth, J. H., Kurtz, S. R., and VanSant, K. T. (2017) Photovoltaic failure and degradation modes. Prog. Photovolt: Res. Appl., 25: 318– 326. doi: 10.1002/pip.2866. Study assessed field data from more than 150 project reports, representing more than 28,000 panels. Chart presented here focuses on degradation modes observed in the first 10 years of operation for projects installed post-2000.



Thermal imagery of hotspot formations

HOTSPOTS

A common cause of solar panel degradation

Hotspots are localised overheating in solar panels, compromising a panel's efficiency and lifespan.

Hotspots are primarily caused by shade on solar panels. Shading disrupts uniform current flow, ultimately leading to increases in cell temperatures and hotspot formation.

Bypass diodes are built into solar panels as the main defence against hotspots. Fundamentally, diodes aim at preventing hotspots from developing by shutting down certain sections of the panel when shaded. However, repeated diode activation can lead to diode failure and subsequently, unmitigated heating of cells.

Performance panels feature one-third cut cells with innovative parallel circuitry that reduces the cell current to mitigate hotspots and increase energy production in shade.

Image of bypass diode failure[1]

Fire damage following bypass diode failure

[1] Image of diode failure in a standard panel. sourced from: https://scorecard.pvel.com/failures/

BYPASS DIODES

A common cause of solar panel degradation

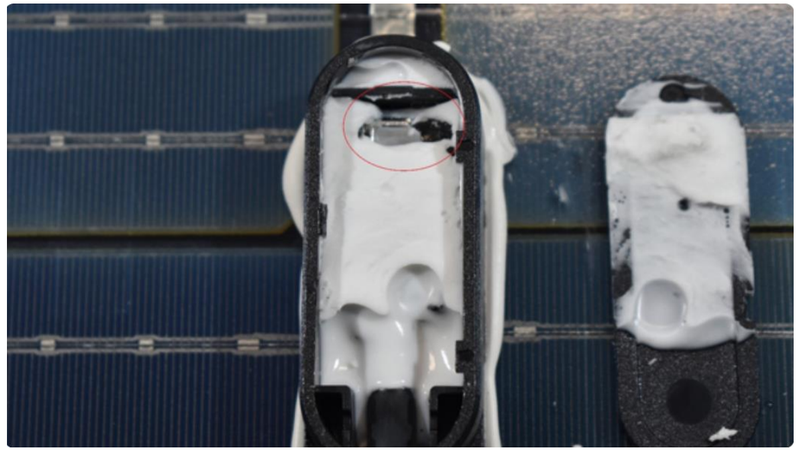
Within solar panels, bypass diodes quietly protect against shading and overheating. They regulate current flow, keeping energy flowing and the cells safe.

Despite their vital role, bypass diodes can be a reliability risk. Material quality, manufacturing flaws, harsh environments and electrical overload can compromise their effectiveness.

When bypass diodes fail, the consequences can be significant. Power drops, hotspots form and even fire hazards become potential threats.

Performance panels handle shade better than standard panels. Manufacturing experience, clever cell design and circuitry are utilised to reduce bypass diode activation, resulting in less stress on bypass diodes. Additionally, one-third cut cells enable Performance panels to operate with lower current (helping to mitigate high panel temperatures and overheating).

Image of extreme junction box failure[1]



Manufacturing defect in junction box[1]

[1] Images of jbox failure and defects in standard panels. sourced from: https://scorecard.pvel.com/failures/

JUNCTION BOXES

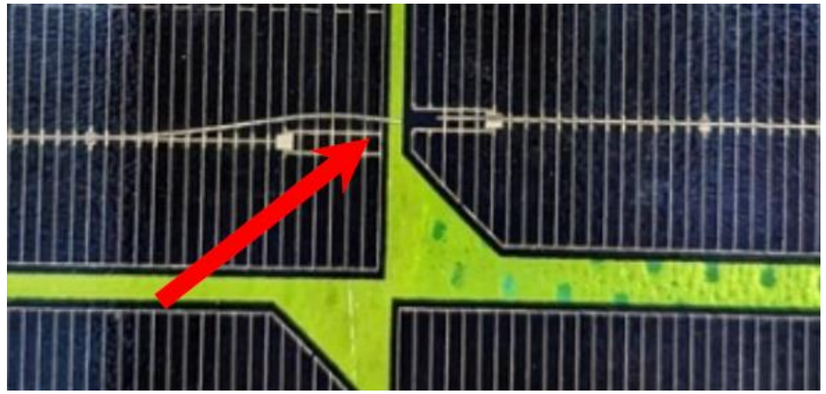
A common cause of solar panel degradation

Junction box failures in solar panels can stem from environmental exposure like water intrusion, extreme temperatures and long-term UV radiation.

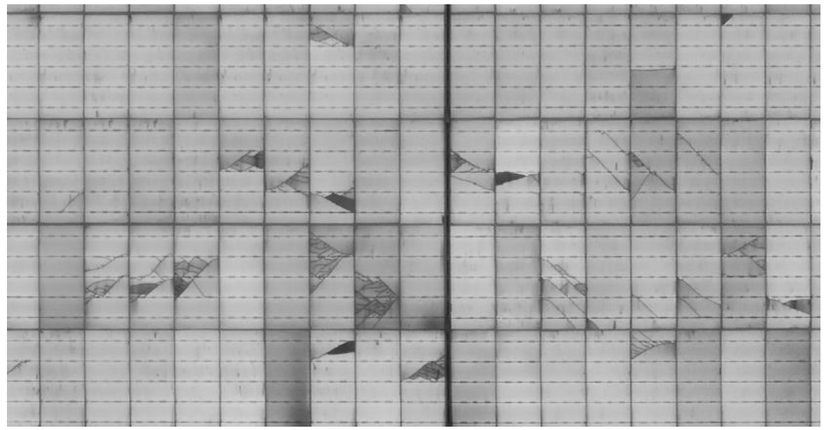
In addition, failures can be caused by internal issues like bypass diode failure, poor connections or manufacturing defects.

External factors like physical damage or extreme weather conditions can also lead to junction box failures.

Performance panels mitigate junction box vulnerabilities through experienced manufacturing and high-quality materials. In doing so, junction boxes featured on Performance panels safeguard against environmental risks, fire hazards and extend panel lifespans.



Stringing wire/ribbon defect[1]



EL image shows evidence of cell cracks[1]

[1] Image sourced from 'CEA Solar PV Module Quality Risks' 2023 report.

INTERNAL CIRCUITRY & CELL CRACKING

A common cause of solar panel degradation

Rough handling in manufacturing and installation, subpar materials and design flaws can leave solar panels vulnerable to cell cracks and internal circuitry failures/breakdowns.

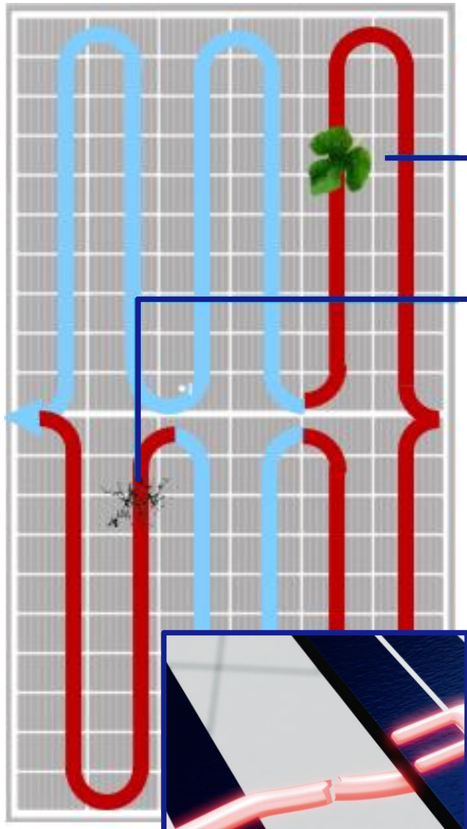
Additionally, harsh environments with extreme temperature swings, hail, humidity and chemicals can crack, corrode and degrade solar panels.

These product defects can be avoided through rigorous material selection, a robust design to handle environmental stresses and meticulous handling throughout manufacturing and installation.

Performance panels address these failure modes through experienced engineering, high quality materials and a robust design. The flexible joint connections featured in Performance panels protect against wire and cell cracking defects.

Common causes of solar panel degradation

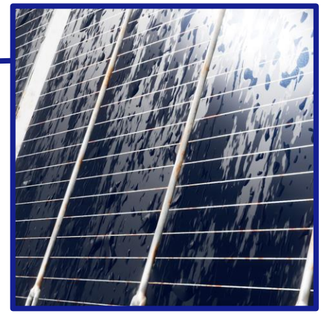
How standard panels degrade and fail



Power flow is blocked by shade or soiling

Cells crack from manufacturing quality, installation and transport, or snow and wind loads

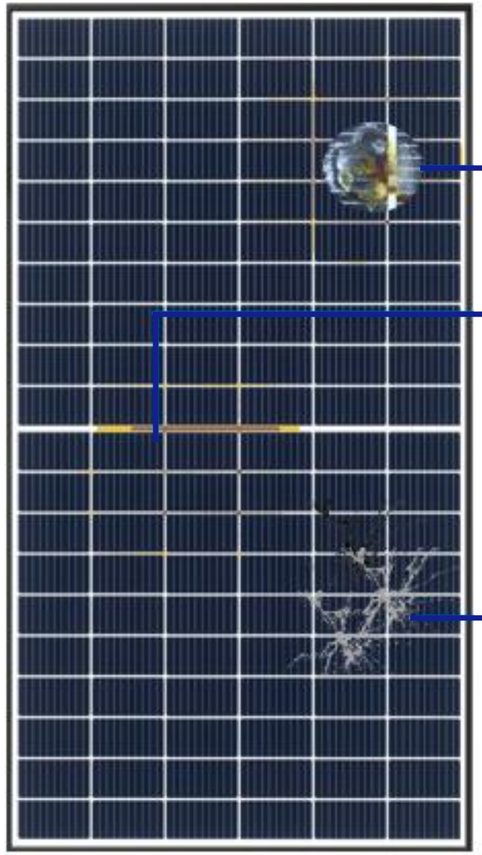
Ribbon soldering corrodes or fails from manufacturing quality, temperature swings, humidity, or snow and wind loads



Cell goes into reverse bias

Diode activates to isolate section of panel with the affected cell

Over time, this diode wears out and affected cells are allowed to run in reverse bias



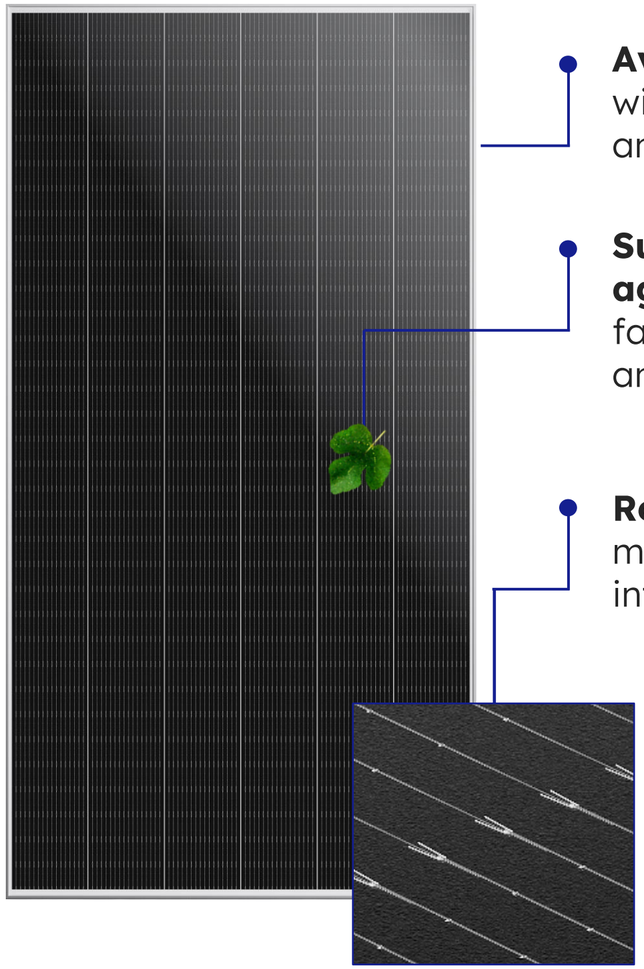
Hotspots

Burned backsheet and discoloration

Glass breakage

Engineering a more reliable panel

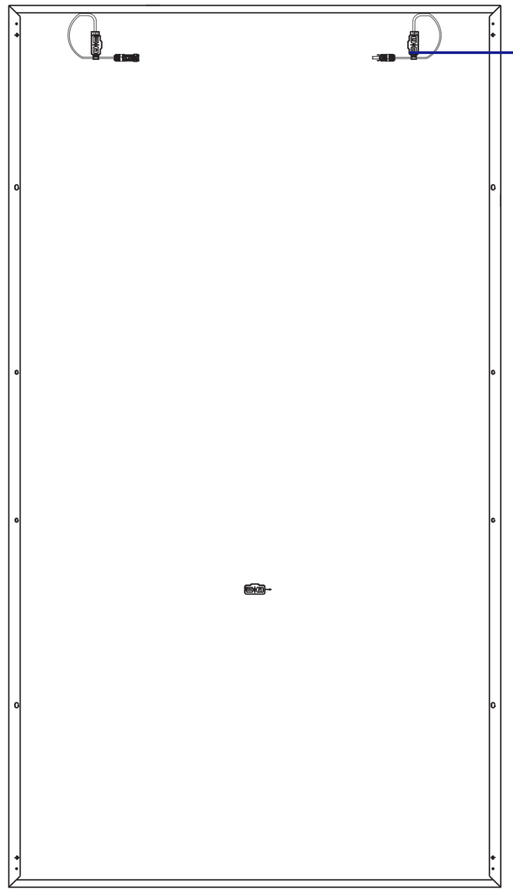
Performance panels are engineered to eliminate common degradation modes



Avoids corrosion
with higher-quality materials and manufacturing processes

Superior performance against shade from soiling, falling leaves, obstructions and more

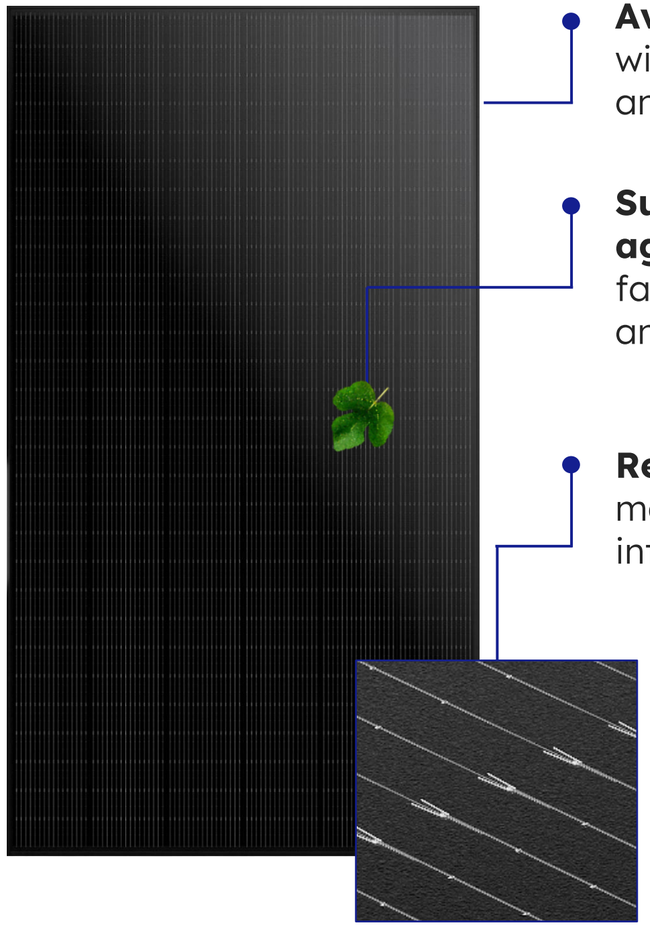
Reliable interconnect
metallic wire, flexible joint interconnection at cell overlap



Hot-spot mitigation by limiting heat build-up in cells and minimising bypass diode activation

Engineering a more reliable panel

Performance panels are engineered to eliminate common degradation modes



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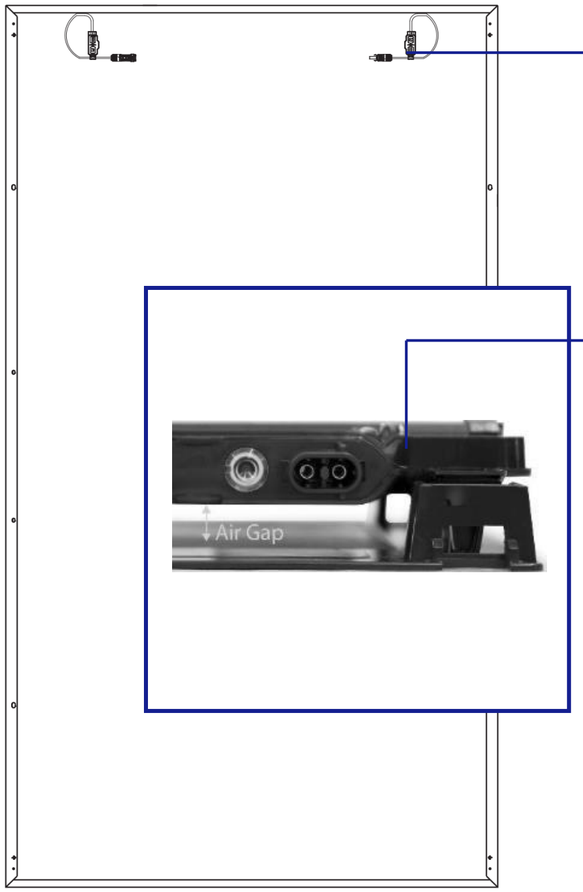

Hot-spot mitigation by limiting heat build-up in cells and minimising bypass diode activation

Factory-integrated microinverter for better quality control and reliability over field wiring[1]

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[1] Performance 7 AC modules with factory-integrated microinverters not yet released.

Independent reliability validation

Performance panels are a consistent Top Performer in PVEL Reliability Scorecard[1]

Performance panels have been regularly recognised as a Top Performer in the PVEL PV Module Reliability Scorecard.

Based on data from its Product Qualification Program (PQP), the PVEL Scorecard highlights the exemplary reliability performance of solar panel manufacturers worldwide.

PVEL (PV Evolution Labs) PV Module Reliability Scorecard: https://modulescorecard.pvel.com/

Independent reliability validation

Reliability testing that PVEL perform for the Top Performer Reliability Scorecard[1]

PVEL member of group kiwa

Thermal Cycling (TC)

Checks panels can endure temperature swings, especially crucial in areas with high irradiance and large day-night temperature changes, as internal stresses from components expanding and contracting at different rates can damage components and impact performance.

Damp Heat (DH)

This test stresses modules in hot, humid conditions, revealing weaknesses that could lead to power loss and safety hazards.

Mechanical Stress Sequence (MSS)

Examines solar panels for crack vulnerability and field-relevant power loss under extreme weather like snow and wind, simulating stresses from everyday factors like manufacturing and installation to hail events.

[1] PVEL (PV Evolution Labs) PV Module Reliability Scorecard > Tests: https://modulescorecard.pvel.com/

Independent reliability validation

Reliability testing that PVEL perform for the Top Performer Reliability Scorecard[1]

PVEL member of group kiwa

Potential Induced Degradation (PID)

Ungrounded solar systems with high voltage can damage cells, cutting power up to 30%, especially in hot, humid areas. PID can occur within weeks of commissioning a system. This test checks a panel's susceptibility to PID.

Light-Induced Degradation (LID)
Light-and-Elevated Temperature-Induced Degradation (LETID)

LID and LETID are light-triggered solar cell efficiency losses. LID is fast and mild, while LETID is slower and climate-dependent. Testing for these losses helps to ensure long-term energy production by catching hidden efficiency losses due to light and heat.

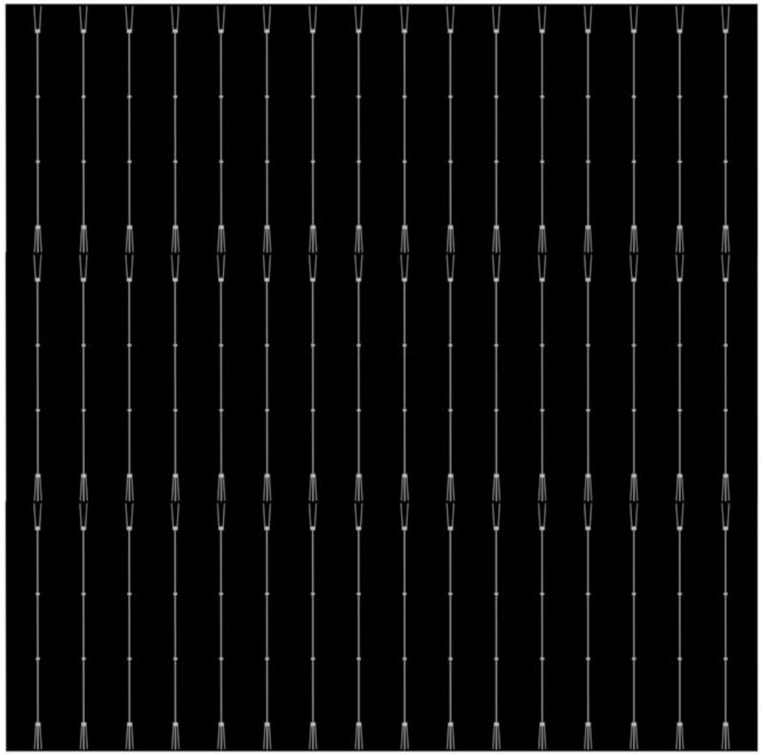
PAN Performance

Measuring solar panel performance data in PAN files boosts energy prediction accuracy, especially for extreme conditions, compared to manufacturer estimates.

[1] PVEL (PV Evolution Labs) PV Module Reliability Scorecard > Tests: https://modulescorecard.pvel.com/

Performance has evolved

Our latest solar innovations, defining the new standard.

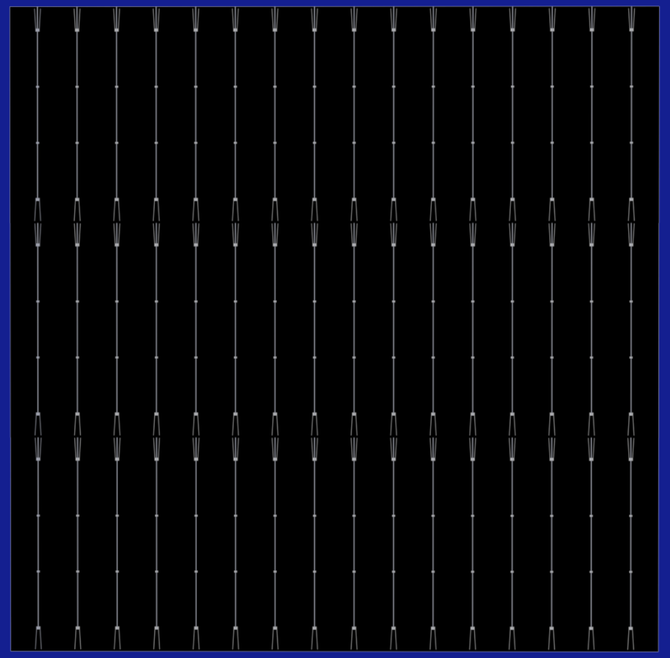


Performance 7 panels feature:

N-type TOPCon Solar Cells

CELL TECHNOLOGY

TOPCon Solar Cells: The next evolution of solar cells



While traditional PERC solar cells have dominated the market, a new contender has emerged: **TOPCon (Tunnel Oxide Passivated Contact)**.

This cutting-edge technology is the next evolution of the solar industry, with its high efficiency and specifications that enable strong solar generation.

CELL TECHNOLOGY

TOPCon Solar Cells: What makes them stand out?

High Conversion Efficiency

Converting more sunlight into electricity with high efficiency. TOPCon cells generally outperform previous technologies, meaning you can generate more power from the same amount of sunlight.

Reliable Production

The cell design makes them more resistant to efficiency losses caused by heat and light. Resulting in better long-term solar production in real-world conditions.

Low degradation rates

Standard cells lose efficiency more rapidly over time, TOPCon cells boast impressively low degradation rates (0.40%)[1]. This translates to higher energy output over a longer period.

Temperature Coefficient

The low temperature coefficient (0.29%)[2] of TOPCon solar cells offers a distinct advantage: minimised efficiency loss in high temperatures resulting in better energy generation in increasingly hot climates.

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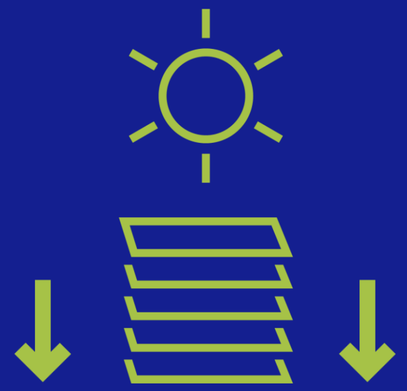
[1] Warranted power degradation rate for Performance 7 modules.
[2] Temperature coefficient as specified on P7-COM-S datasheet.

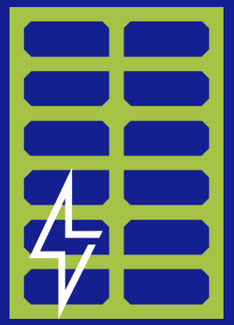
CELL TECHNOLOGY

N-type TOPCon solar cells

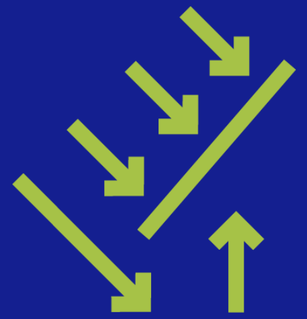
Additional benefits of the new TOPCon cells include…



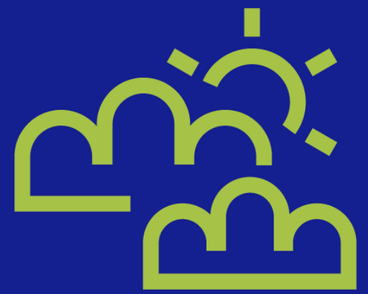
Lower Light-Induced Degradation



Potential-Induced Degradation Resistance



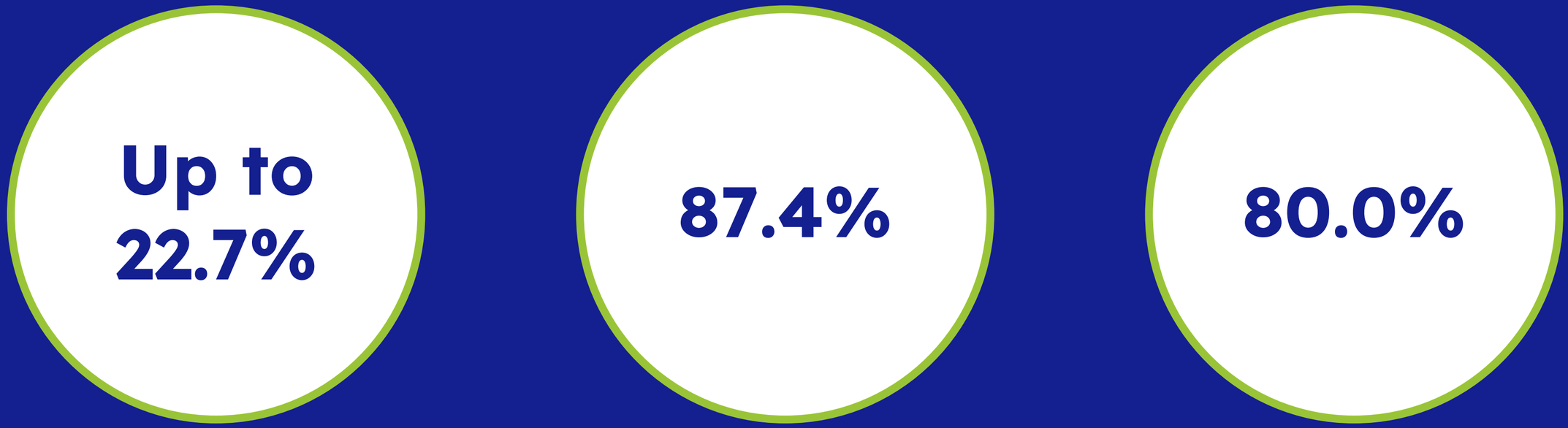
Increases to Bifaciality



Improved Low-Light Production

CELL TECHNOLOGY

TOPCon Solar Cells: When integrated with Performance modules



Module efficiency[1]

Power at 30 years[2]

Bifacial factor[3]

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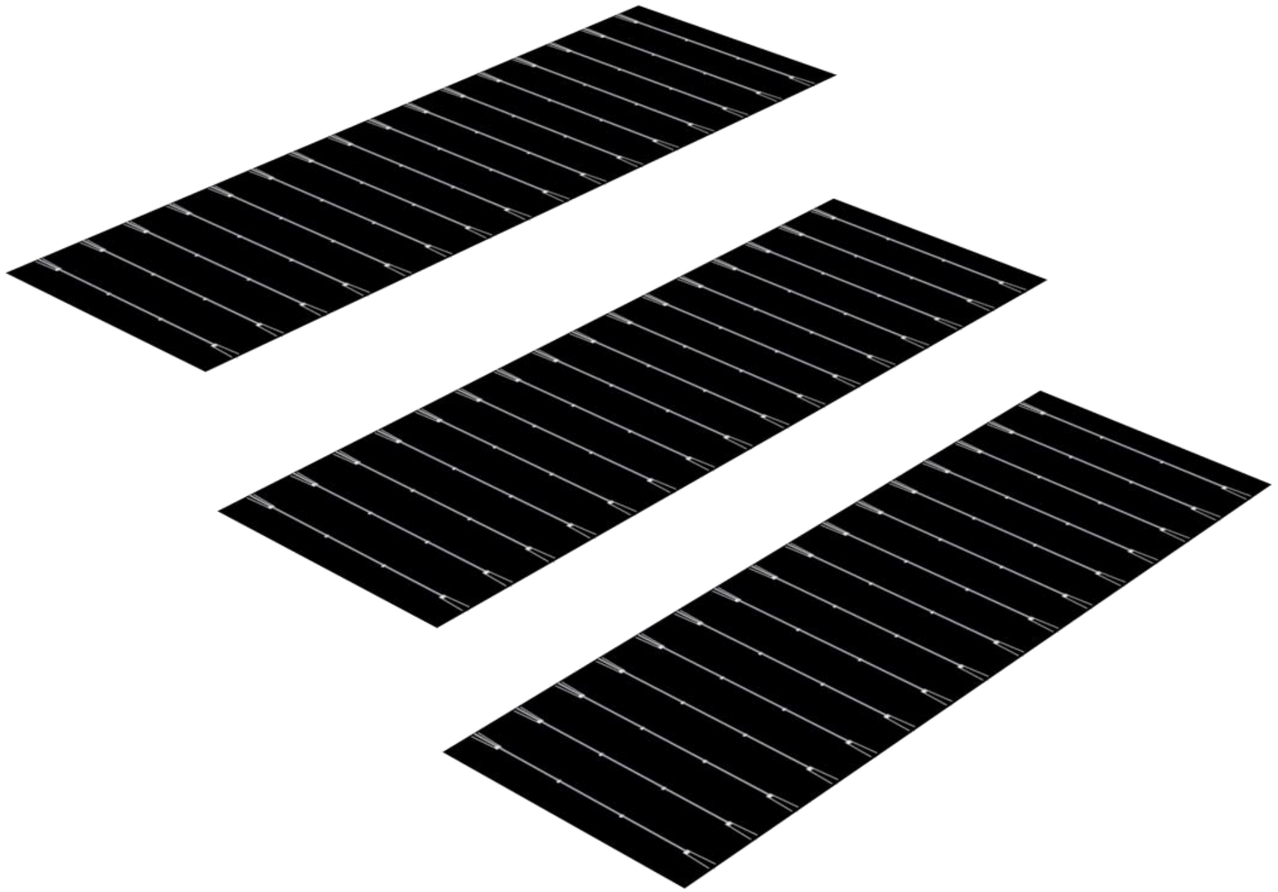
[1] Based on P7-COM-S panel.
[2] Based on Performance panels warranted power at 30 years. Refer to warranty for details.
[3] Applicable to Performance Commercial panel SKUs only. ± 10%.

CELL DESIGN

One-third cut cells



Bigger isn’t always better

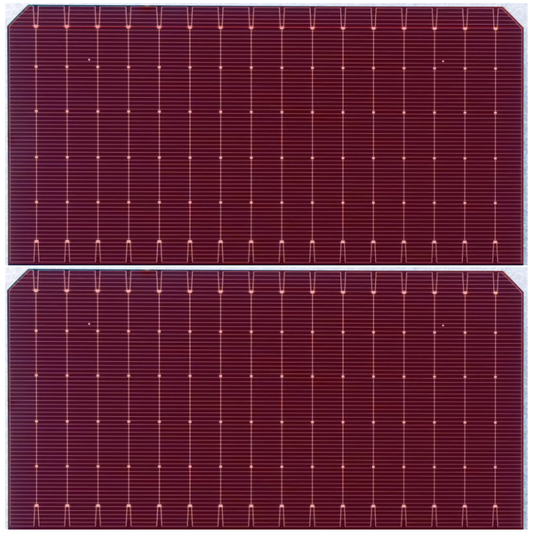
Smaller cells have shorter paths for the electricity to flow, so less gets lost on the way. This means less wasted energy and more usable power.

Smaller one-third cut cells improve shade tolerance over standard solar. Think of smaller cells as independent workers. If one gets shaded, the others keep working hard, so the whole panel doesn't suffer as much. Plus, there's less chance of burning hotspots from shade.

CELL DESIGN

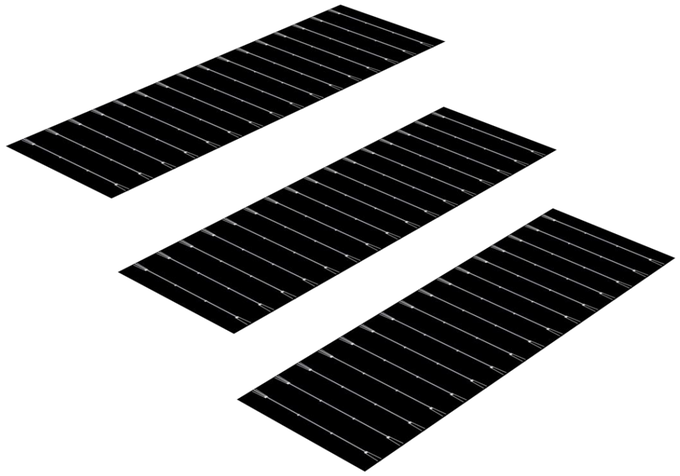
One-third cut cells

Standard Cells
Half Cut TOPCon



Reached temperatures of up to 192°C during hotspot testing.[1]

Performance 7 Cells
One-third cut TOPCon



Operating temperatures were up to 40°C cooler during the same hotspot testing.[1]

Temperature coefficient is only half of the story

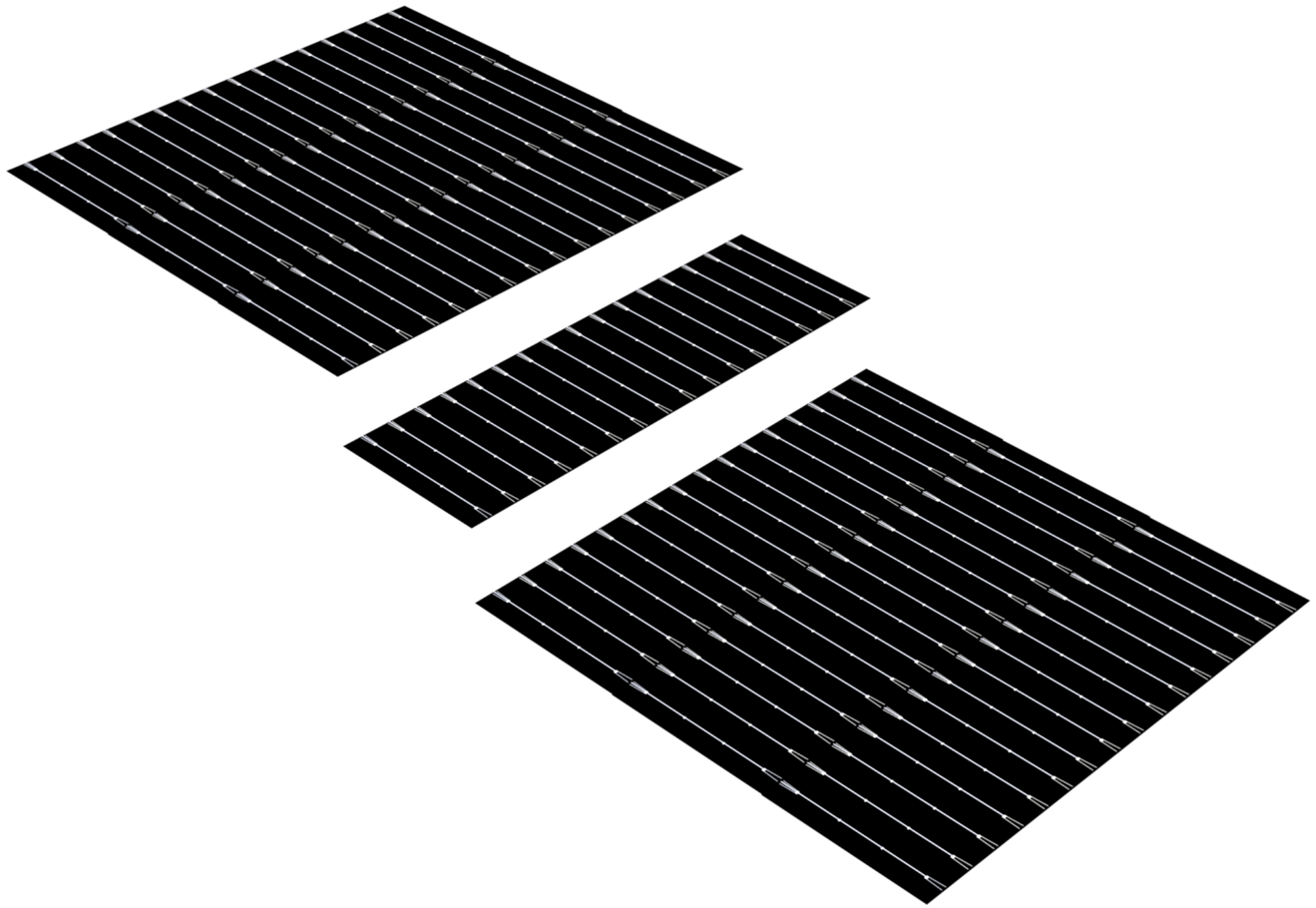
In high-irradiance conditions, smaller solar cells exhibit superior thermal performance compared to their larger counterparts. This advantage stems from reduced internal current density, meaning less heat generation within the cell. Consequently, power degradation due to thermal effects is minimised, resulting in enhanced efficiency during peak sun hours.

Additionally, the lower operating temperatures promote extended panel lifespans and assist in mitigating hotspot damage.

[1]Based on internal R&D hotspot and shade testing vs standard half cut TOPCon panels.

CELL DESIGN

Shingled-cell design



Bringing it all together

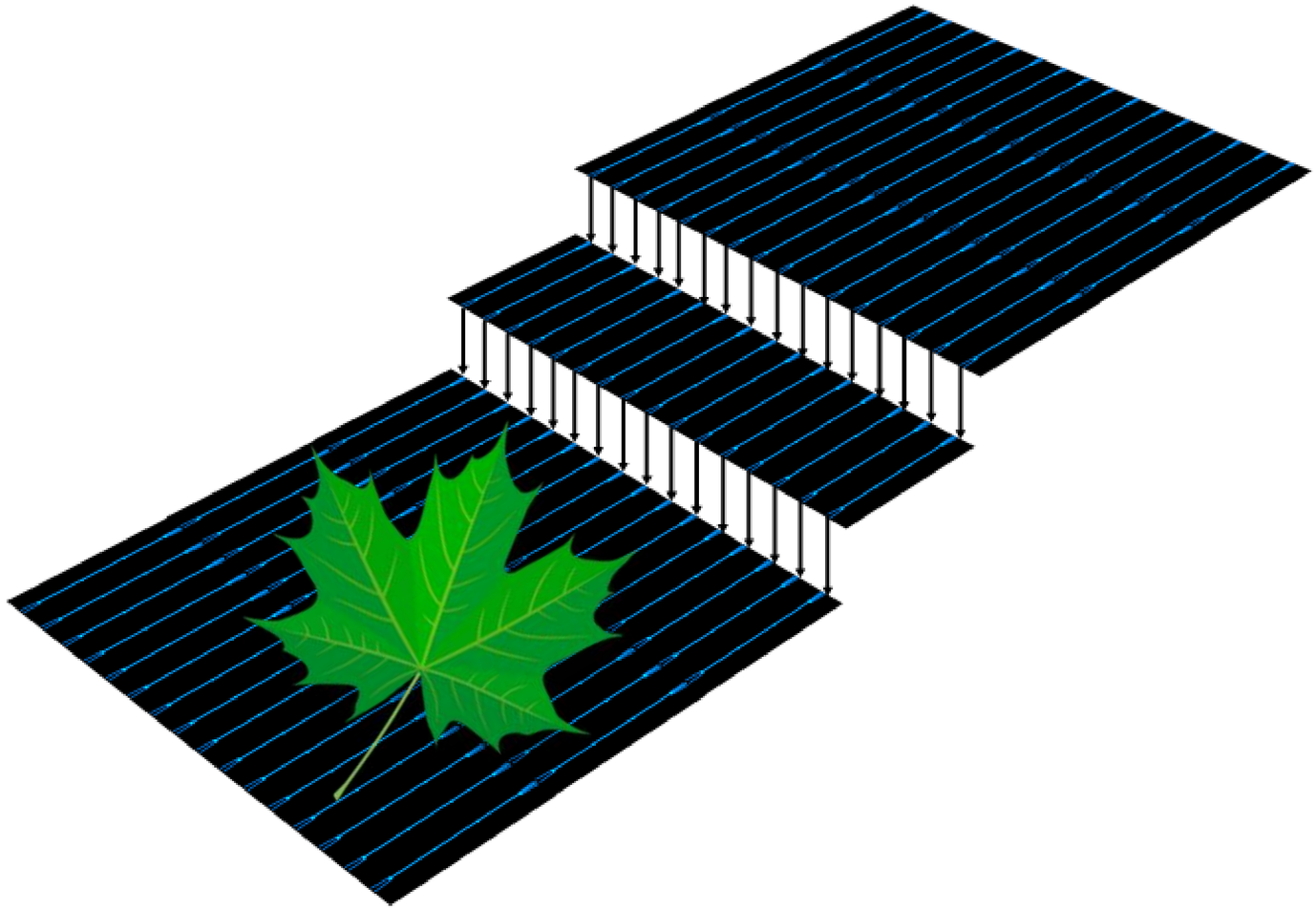
Performance’s shingled-cell panel design weaves together individual solar cells to achieve harmonious results.

The overlapping shingles eliminate inactive "dead zones" between cells, capturing more light and boosting overall panel output. This translates directly to increased energy production.

Unlike standard half cut panels, where shading across a single cell can significantly impact output, shingled panels’ more independent cells minimise power loss in shaded areas.

CELL DESIGN + CIRCUITRY

Shade management



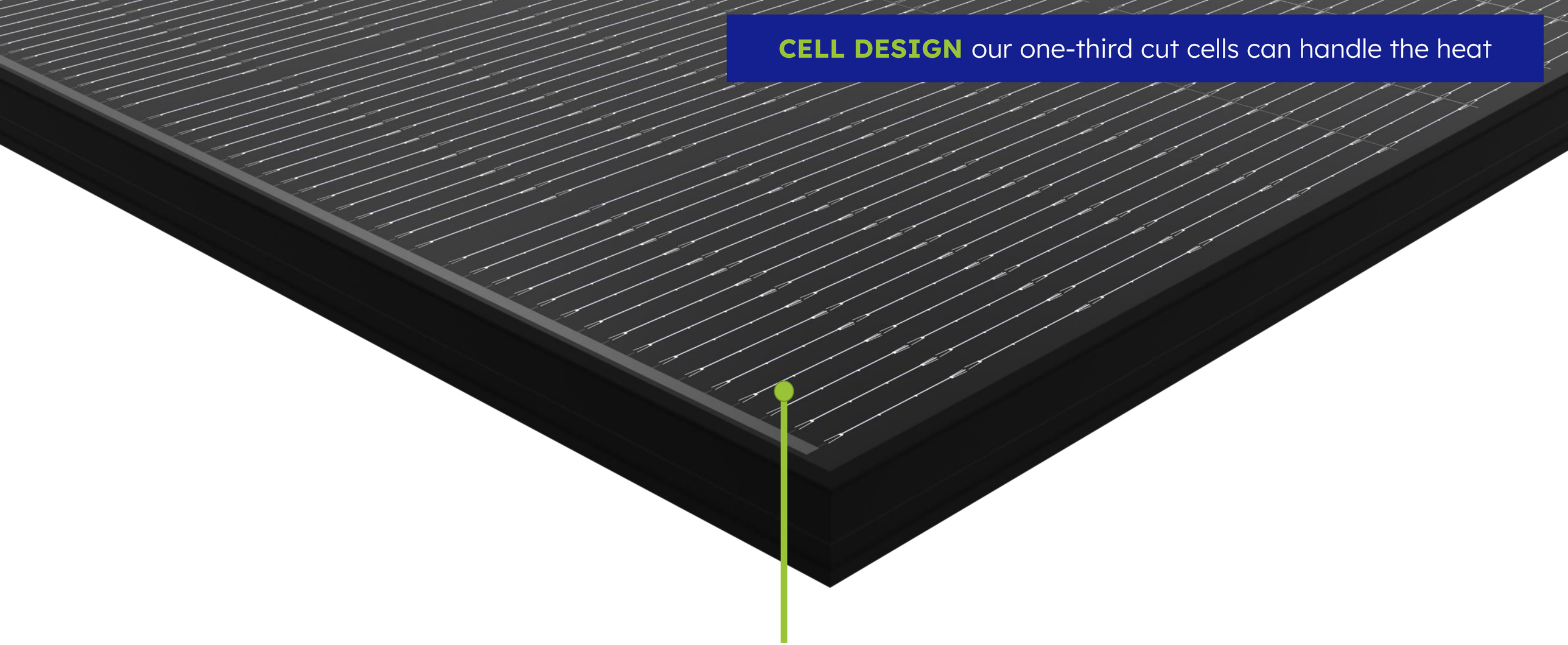
Staying cool when shaded

Integrating smaller cells minimises shading impacts and helps to isolate affected areas of the panel. As a result, shade has less impact on overall panel efficiency.

Bypass diodes create alternative paths for electric current, reducing the risk of uncontrolled heating and the formation of hotspots.

Reduced internal cell temperatures prolongs the lifespan of panels while optimising energy generation (even in suboptimal lighting conditions).

CELL DESIGN our one-third cut cells can handle the heat



Performance 7 panels operate 20-40°C cooler than standard panels in shade.[1]
Lower cell temperatures help higher solar production to be achieved.

[1]Based on internal R&D hotspot and shade testing vs standard half cut TOPCon panels.

CIRCUITRY + CELL INTERCONNECT

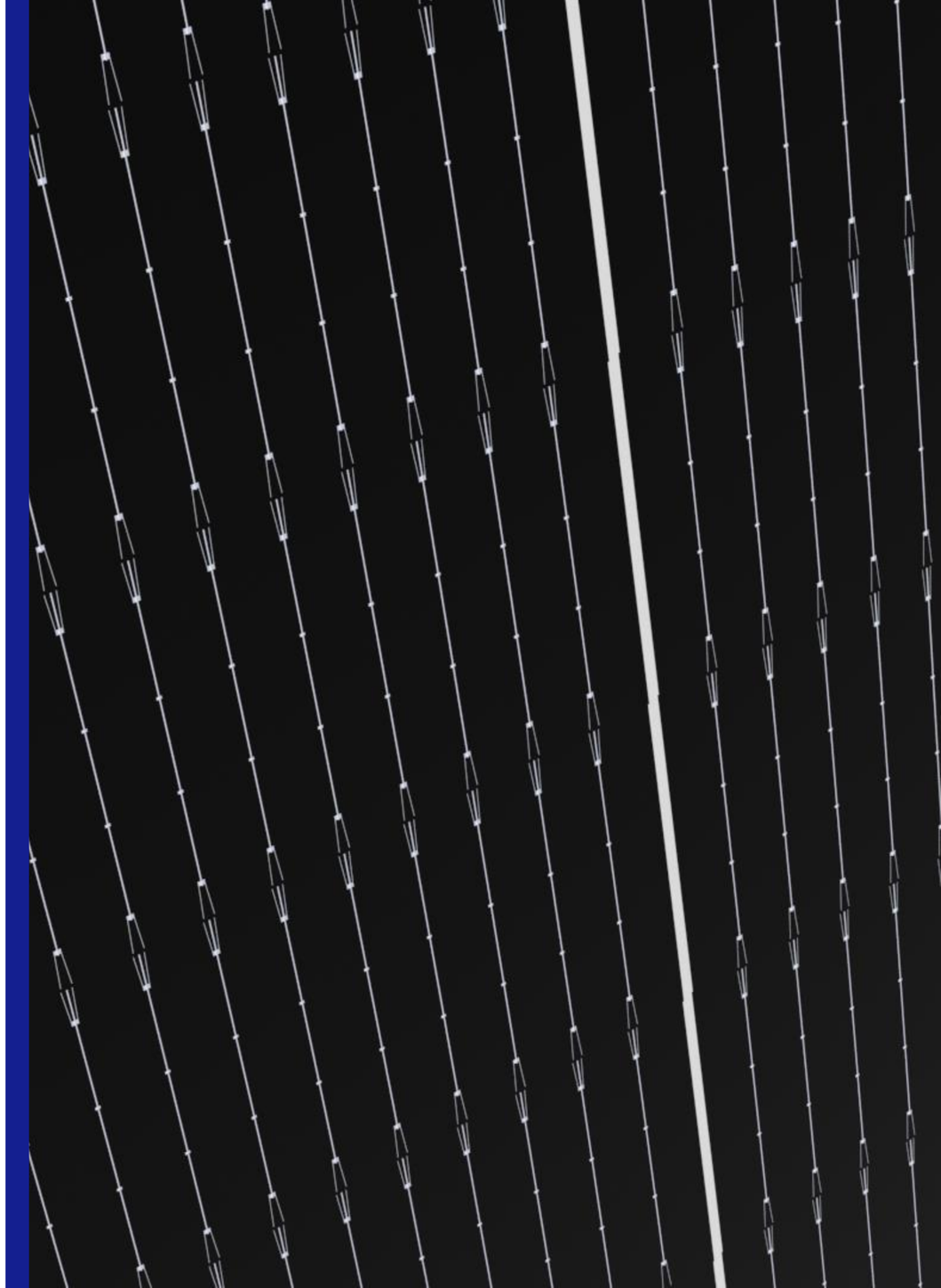
Metallic wires

Performance 7 sees the addition of more metallic wires. Now featuring sixteen of these mini power highways per cell.[1]

The metal wires collect electricity from the cells and adding more of them means shorter distances for current to travel, resulting in **reduced power loss** and a **more efficient panel**.

The wires are tinned copper and 200 micron in size, smaller than wires seen on standard panels, this helps to **maintain the elegant design** that Performance panels are known for.

In addition to these metal wires being used to increase solar production, they are also being used for the cell interconnection. The flexible joint interconnection technology being used has been **engineered for reliability**.



[1] Based on G10 cells used in P7-COM-S and P7-BLK panel SKUs.

CELL INTERCONNECT

Cell connections are an industry-wide weak spot

Most major competitors to Performance panels (across several cell technologies) rely on metallic wires to move energy through their panels and that can be a reliability issue because of:

Thermal Cycling

These metal wires repeatedly expand and contract as roof temperatures rise during the day and cool at night.

Wire Failure & Cell Cracks

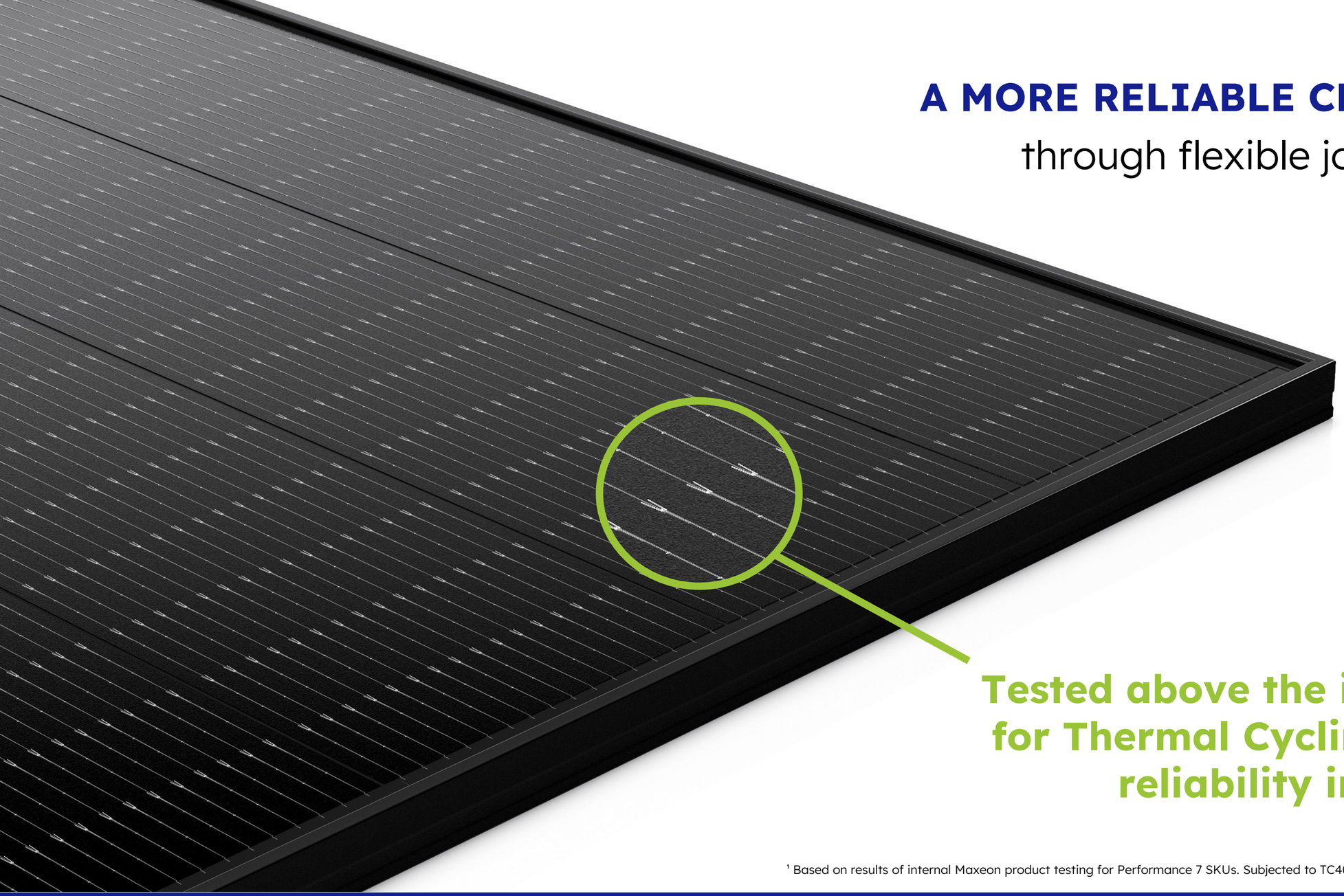
The repeated stress of daily temperature swings can break these fragile metal wires—cracking the cells they're supposed to connect in the process.

Panel sections bypassed

As cells break and energy flow is disrupted, larger sections of the panel will shut down to protect against further damage. Bypass diodes activate to "bypass" the affected portion of the panel.

Panel shutdown and hotspots

Bypass diodes aren't meant to be a permanent solution. Once they break down from overuse, it's just a matter of time before hotspots begin to form and head down a path toward complete panel failure.



A MORE RELIABLE CELL CONNECTION

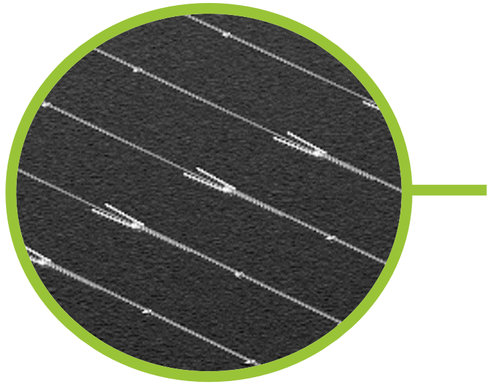
through flexible joint cell connections

Tested above the industry standard for Thermal Cycling (TC) to ensure reliability in the field.[1]

[1] Based on results of internal Maxeon product testing for Performance 7 SKUs. Subjected to TC400 testing, an extra 200 cycles above IEC standard of TC200.

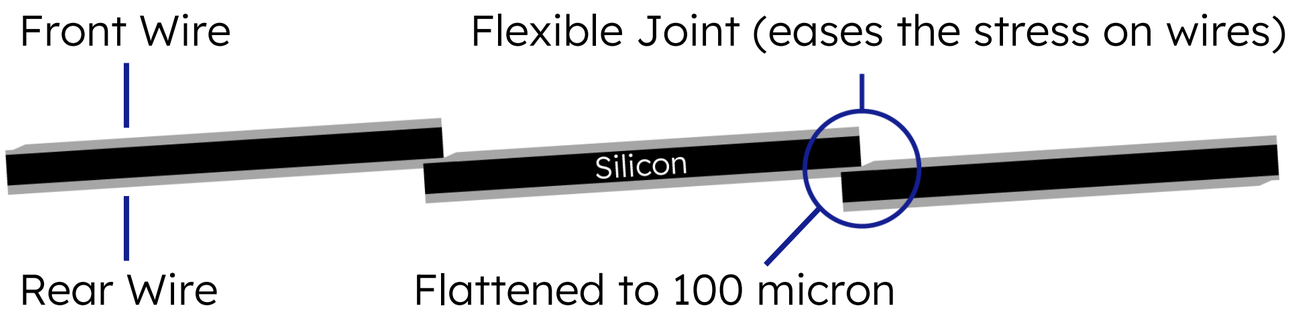
CELL INTERCONNECT

Flexible joint cell connections



Points of interconnection between cells.

Cross-section of Performance interconnect:



Connections that last

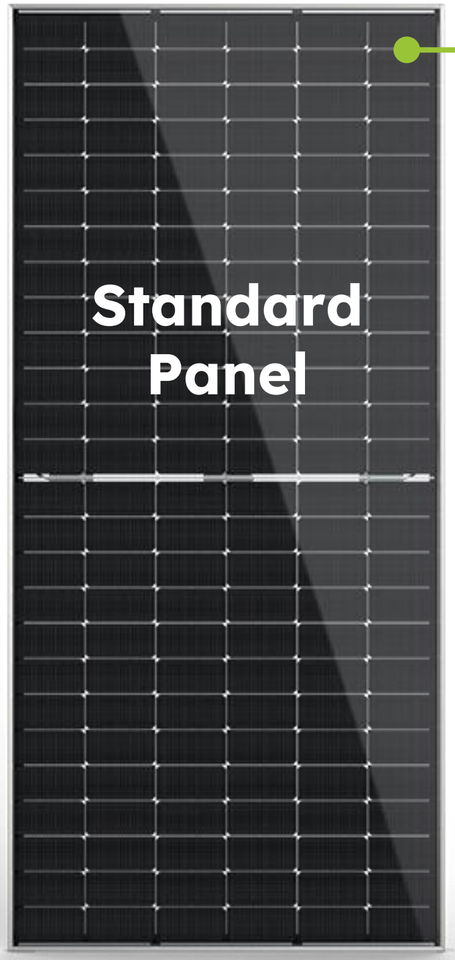
The metal wires that can be seen on Performance panels connect each overlapping shingled-cell. This forms a strong but flexible cell interconnect which helps **mitigate ribbon failure and cell cracking** generally caused by thermal cycling or excessive movement.

The wires run from the rear of one cell and connect to the front of the neighbouring overlapped cell.

The wires are flattened at the cell interconnect point to form a flexible joint. This provides **reliability advantages over standard panels**.

CELL INTERCONNECT

Comparative look at the technology



Standard half cut panel ‘S’ curve interconnect

Susceptible to temperature swings

Prone to ribbon failure and cell cracks.

Rigid joint leading to more stress.

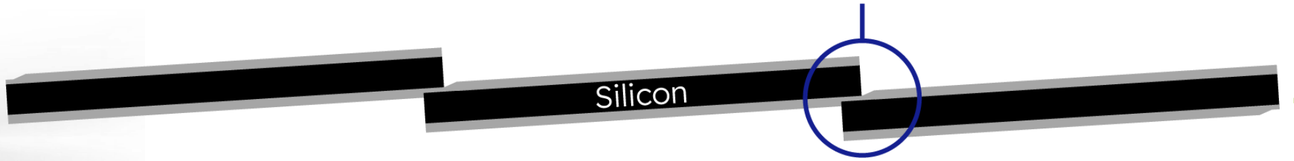
VERSUS

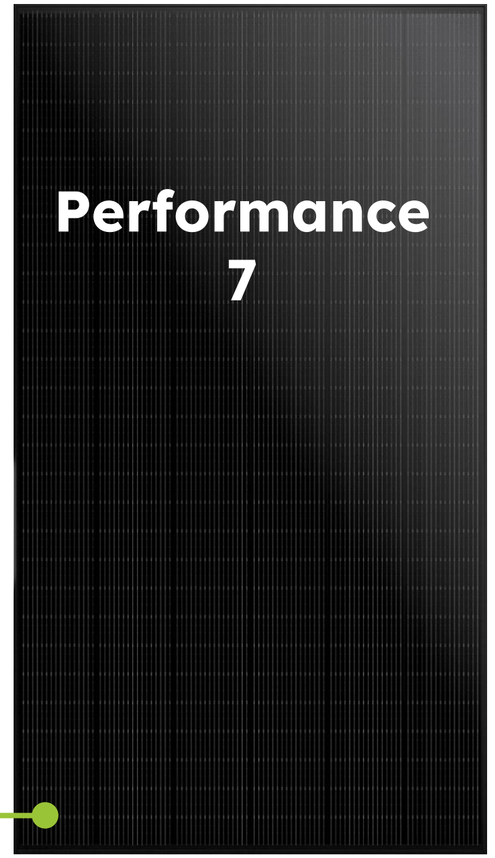
Resilient to temperature swings.

Resistant to ribbon failure and cell cracks.

Flexible joint resulting in less stress.

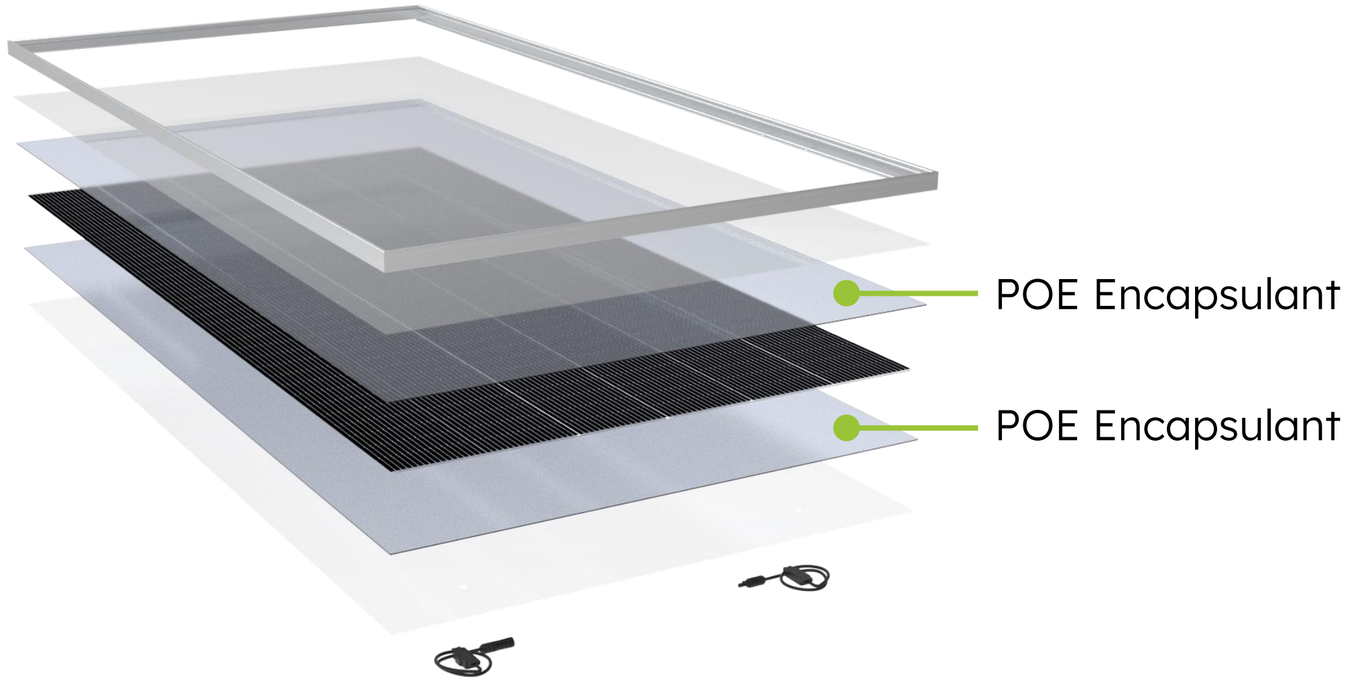
Performance flexible joint cell interconnect





MATERIALS

Premium Encapsulant



Premium panel protection

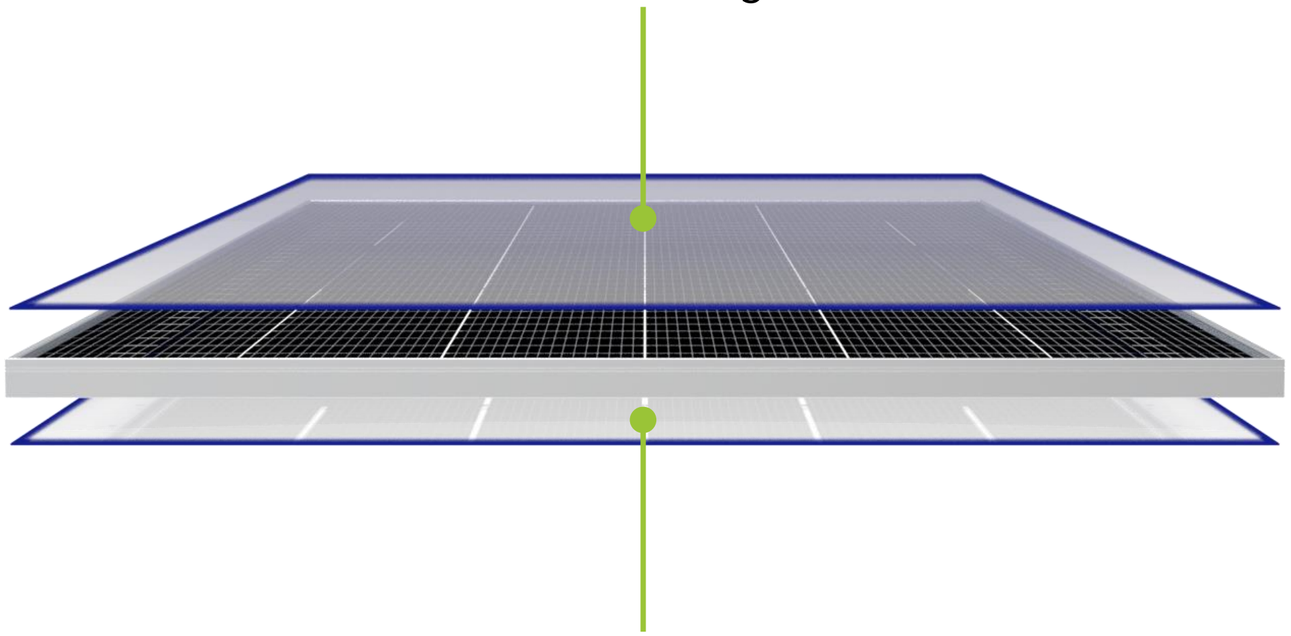
Performance retains the Polyolefin Elastomer (POE) encapsulant that has been utilised in previous generations.

POE encapsulant excels in protecting solar panels with its superior durability and weatherproofing. It boasts exceptional moisture resistance, keeping out harmful water and humidity-induced moisture, boosting long-term production (especially in harsh environments).

CONSTRUCTION

Glass/Glass (no backsheet)

2.0 mm, high transmission heat strengthened anti-reflective glass



2.0 mm, high transmission heat strengthened glass

Robust panel construction

Performance 7 modules are a robust glass-glass construction.

Their double-layered glass construction enhances durability, safeguarding against environmental factors, installation stresses and ensures a longer lifespan.

The environmentally friendly design minimises waste and simplifies future recycling, contributing to a sustainable energy future.

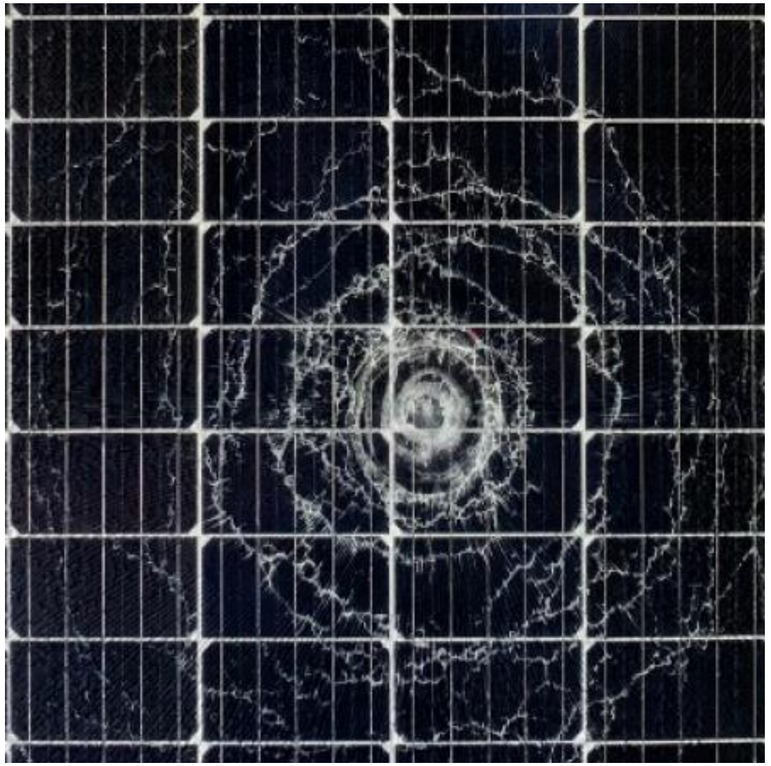
CONSTRUCTION

Glass/Glass – Impact Resistance

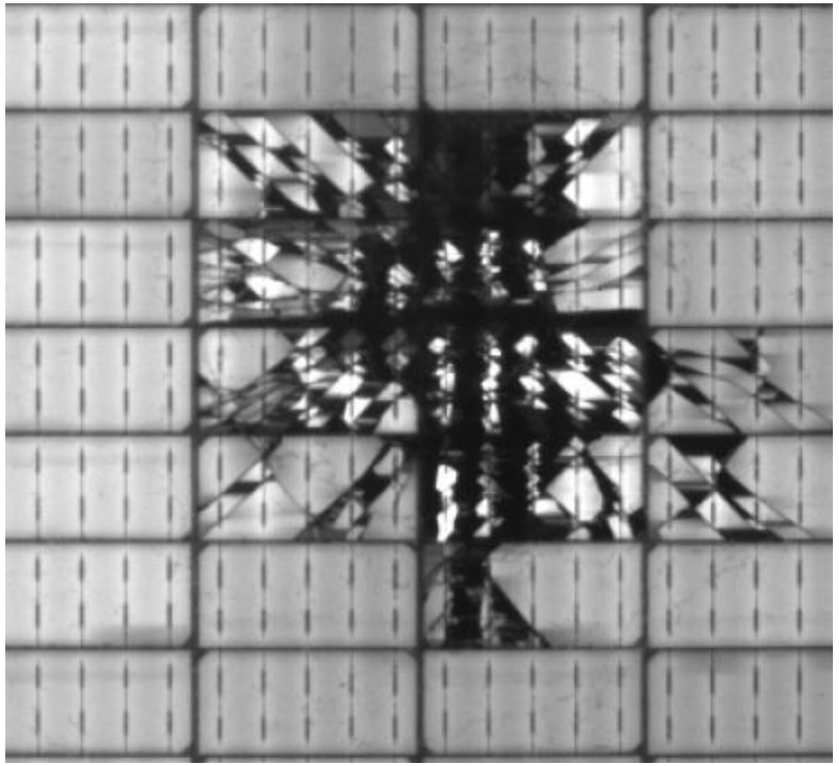
The world is seeing more frequent, and more powerful hail events.

Media pick-up surrounding hailstorms has led to heightened awareness across the solar industry.

Performance panels have heat strengthened glass that provides resilience against impact from damaging hailstorms.



Catastrophic hail impact on front glass of a standard solar panel



Electroluminescent scan of catastrophic hail impact on a standard solar panel

SO, WHAT ABOUT HAIL?

Performance panels have impact resistance up to 40 mm hail, representing one of the most durable panels on the market.

Impact resistance summary

Performance Panels		Sample Competitive Panels	
40 mm	Performance 7 • BLK (2mm glass) • COM-S (2mm glass)	Aiko	25 mm (All Panels)
40 mm	Performance 6 • BLK (3.2mm glass) • BLK-AC (3.2mm glass) • COM-XS (3.2mm glass) • COM-S (2mm glass) • COM-M (2mm glass)	REC	35 mm (All Panels)
25 mm	Performance 7 • BLK (1.6mm glass)	Jinko	25 mm (All Tiger Neo/Pro Assumed) *Noted in IEC 61215 certificates* 25-55 mm (Eagle) *Varies by model, e.g. G/G is 25 mm, G/BS is 45-55 mm*
		Longi	25mm (All Panels) *January 2024 article cited 45mm for Hi-MO X6 panels; yet to materialize on website or in datasheets*
		Qcells	35mm (All Panels Assumed) *Noted in IEC 61215 certificates*

As of February 2024

SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

WARRANTY

A better product, a better warranty

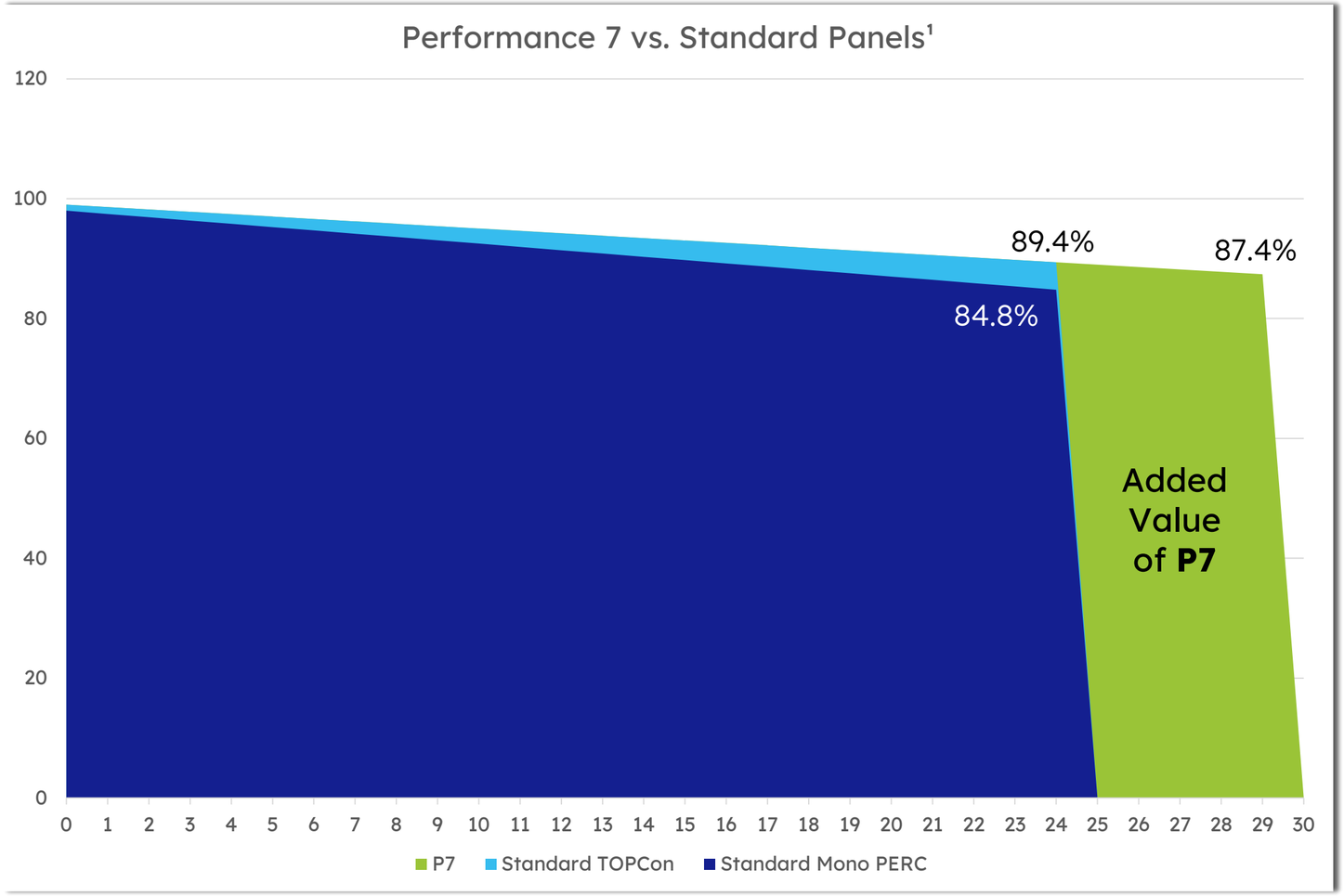
Comprehensive
Power, Product & Service
coverage for 30 years

SunPower Performance 7 panels are manufactured for long-term durability—covering defects related to workmanship and materials for a full 30 years, versus some manufacturers that can go as low as 12 years on their warranty.

Performance 7 panels also account for the repair, replacement or refund of any defective panel for 30 years, with removal, shipping and installation included in applicable countries.

WARRANTY

Low panel degradation rates



SunPower Performance 7 panels have improved on year one warranted output, which is now **99.0%**.

Additionally, maximum annual degradation has decreased, and is now **0.40%** per year.

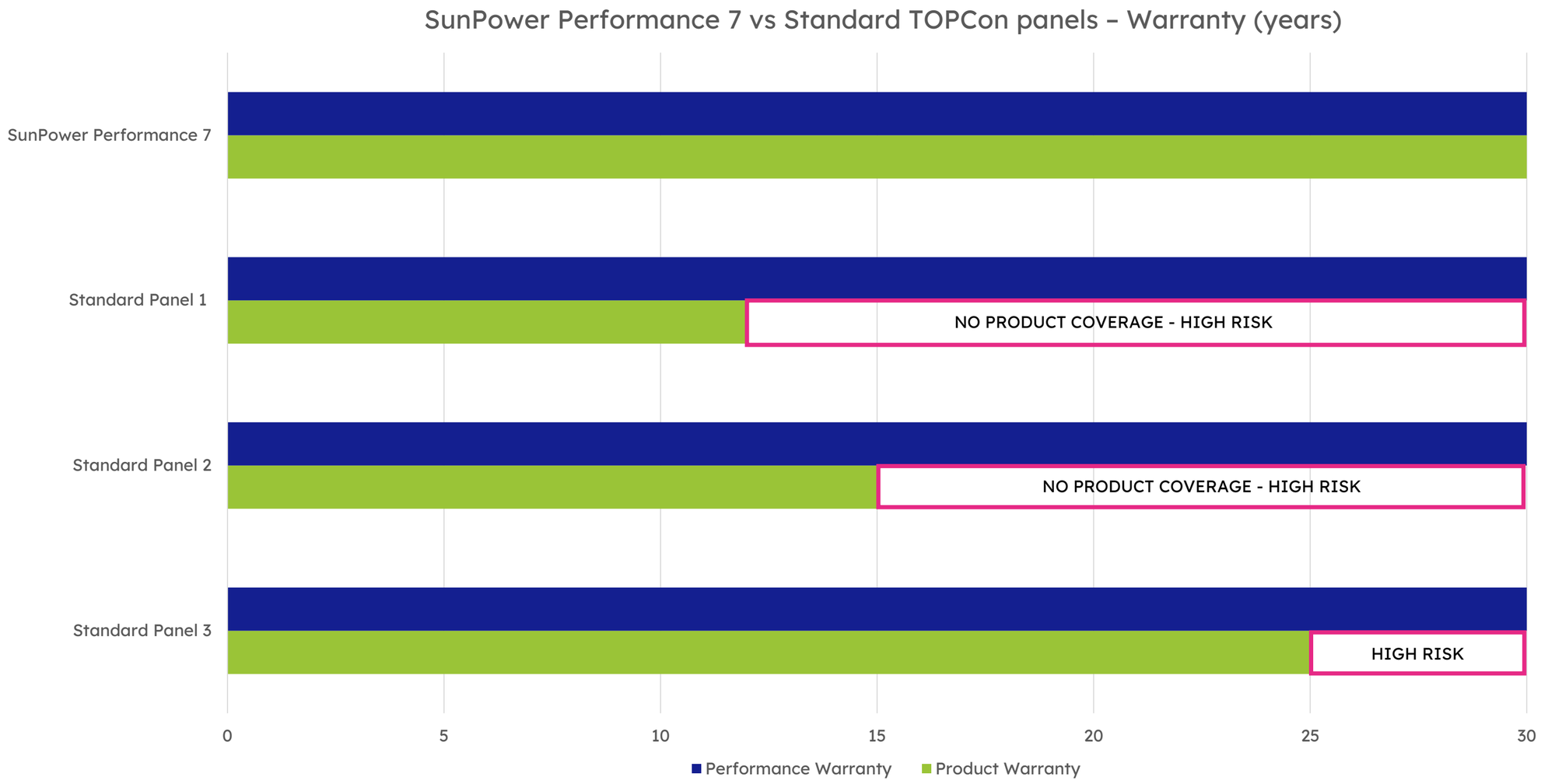
Lower panel degradation rates are a key benefit of N-type TOPCon solar panels. Allowing Performance panels to **produce more energy** over **a longer period** in comparison to standard panels.

Low panel degradation and long warranted product life help to drive **best market value** for the Performance product line.

[1] Comparisons are drawn over 'Warranted Product Life'. P7 = 30/30. CT1 TOPCon = 25/30. CT1 Mono Perc = 25/25. 'Annual Power Attenuation' taken from CT1 competitor datasheets.

Better coverage and less risk

Typical product warranties can expose you to manufacturer defect risks



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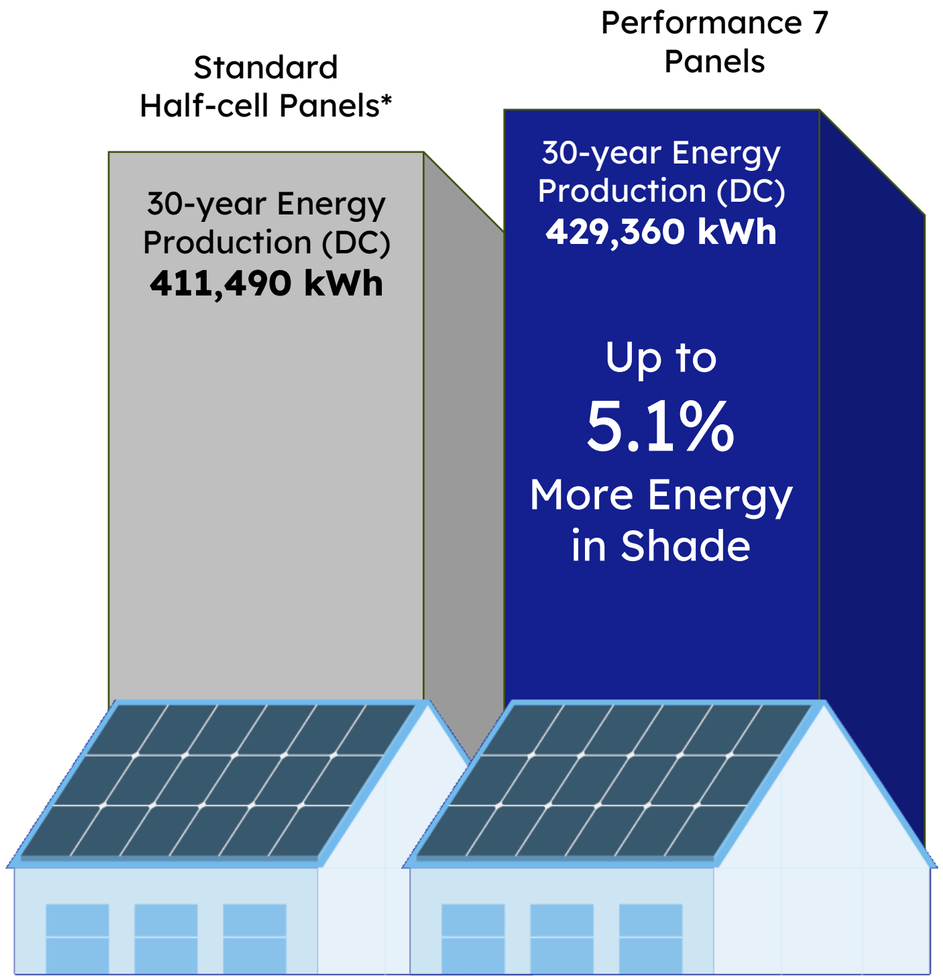
Generate more energy in shade

Performance 7 panels deliver more energy in shade



Energy output (kWh) provides a better indicator of panel performance compared to power loss.

It's challenging to quantify the impact of shaded solar panels, but we took a shot at it—and have even shared the results at the May 2024 PV Performance Modeling Workshop.

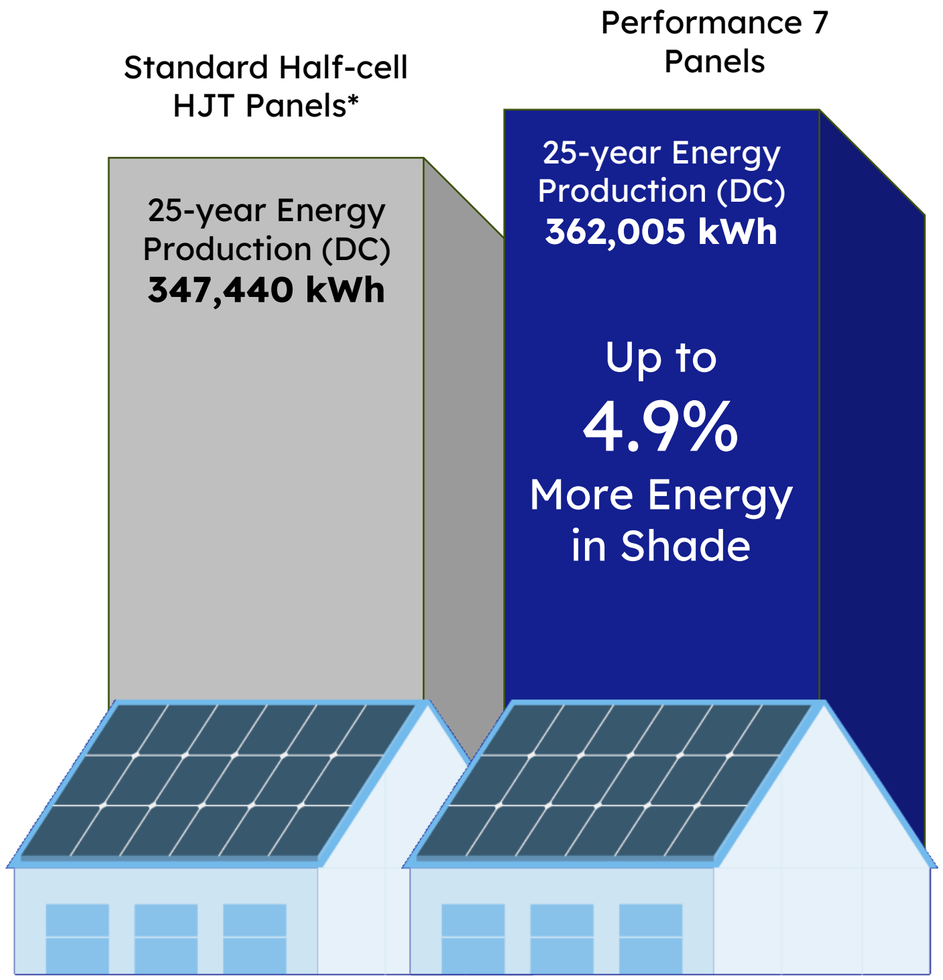
Shade behavior was modelled from active residential installations, which were used to establish energy loss rates (ELR) based on over 3.9 million data points that consider common shade patterns, alongside differences in panel orientation, irradiance, and shade location/movement.

Technology-specific shade loss differences were shown to be as large, or larger than the impacts of module temperature coefficient, low light, and IAM losses.

SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

Energy advantage based on PVsyst simulation of 30-year energy production combined with average energy loss rates in shade. Energy production assumptions: Approx 40 m2 residential roof modeled from two locations featuring 1460 GHI and 1900 GHI with 30 deg tilt. Performance 7 455W (1% Year-1 degradation, 0.4% annual degradation rate thereafter based on warranty terms and conditions + SMA String Inverter). TOPCon monofacial 450W panel (1% Year-1 degradation, 0.4% annual degradation rate thereafter based on warranty terms and conditions + SMA string inverters. Energy loss rates in shade source: Balasubramanian, Kiran & Hoffman, Adam. (2024, May 7). An Updated Modeling Framework for Technology- and Market-Specific Shading Impacts on Annual Energy Yield [Conference presentation]. PVPMC Workshop, Salt Lake City, UT, United States. https://pvpmc.sandia.gov/download/7616/?tmstv=1720543068.

Performance 7 panels deliver more energy in shade



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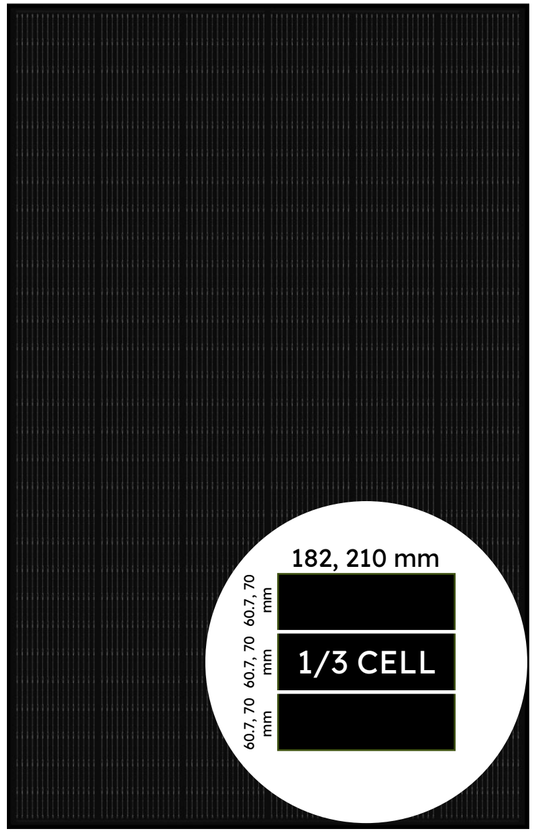
SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

*HJT panel reflects horizontal series stringing, with four bypass diodes

Energy advantage based on PVsyst simulation of 25-year energy production combined with average energy loss rates in shade. Energy production assumptions: Approx 40 m2 residential roof modeled from two locations featuring 1460 GHI and 1900 GHI with 30 deg tilt. Performance 7 455W (1% Year-1 degradation, 0.4% annual degradation rate thereafter based on warranty terms and conditions + SMA String Inverter). HJT monofacial 470W panel (2% Year-1 degradation, 0.83% annual degradation rate thereafter based on field data + SMA string inverters. HJT deg rate source: Arriaga Arruti O, Virtuani A, Ballif C. Long-term performance and reliability of silicon heterojunction solar modules. Prog Photovolt Res Appl. 2023;31(7):664-677. doi:10.1002/pip.3688ARRIAGA ARRUTIET AL.677. Maxeon Energy loss rates in shade source: Balasubramanian, Kiran & Hoffman, Adam. (2024, May 7). An Updated Modeling Framework for Technology- and Market-Specific Shading Impacts on Annual Energy Yield [Conference presentation]. PVPMC Workshop, Salt Lake City, UT, United States. https://pvpmc.sandia.gov/download/7616/?tmstv=1720543068.

Performance 7 shade resilience stems from its design

Smaller Cell Size



Smaller cells improve panel efficiency by distributing current and lowering resistive losses (power lost during electrical current transit).

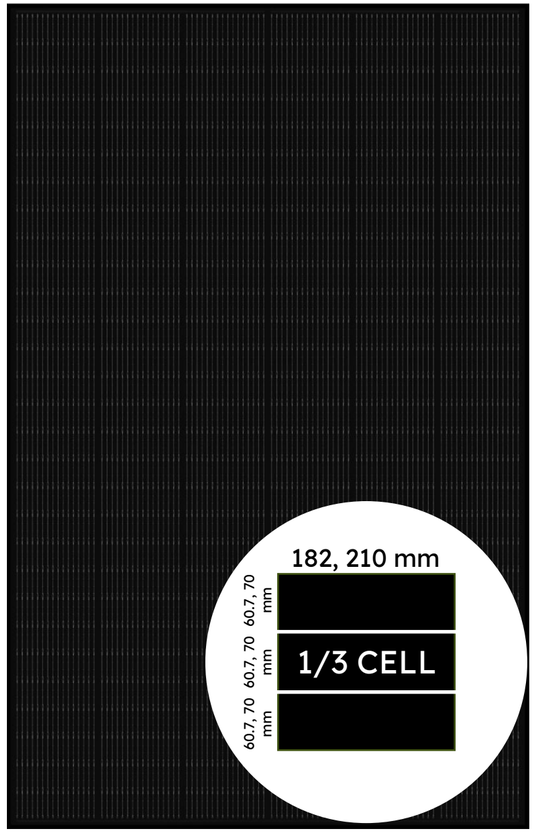
With each individual cell contributing a smaller portion of current to the string, panels experience less power loss in shade compared to those with larger cells.

Performance 7 uses one-third cut cells, which reduce cell-level current to a third of the full-size cell.

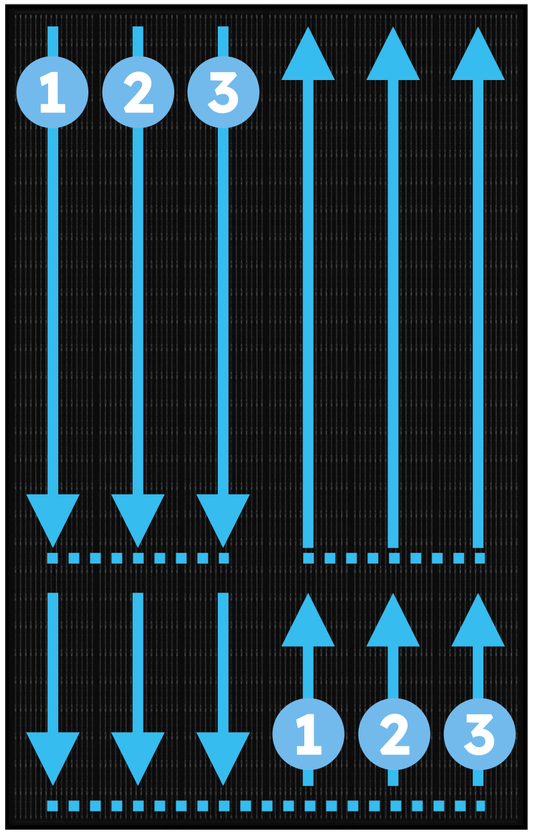
Standard panels typically use half-cut cells.

Performance 7 shade resilience stems from its design

Smaller Cell Size



Circuit Design



More electrical circuits allow more current to flow through the panel, while lowering resistive losses.

Additionally, when one circuit becomes shaded, a higher current can be routed through unshaded circuits.

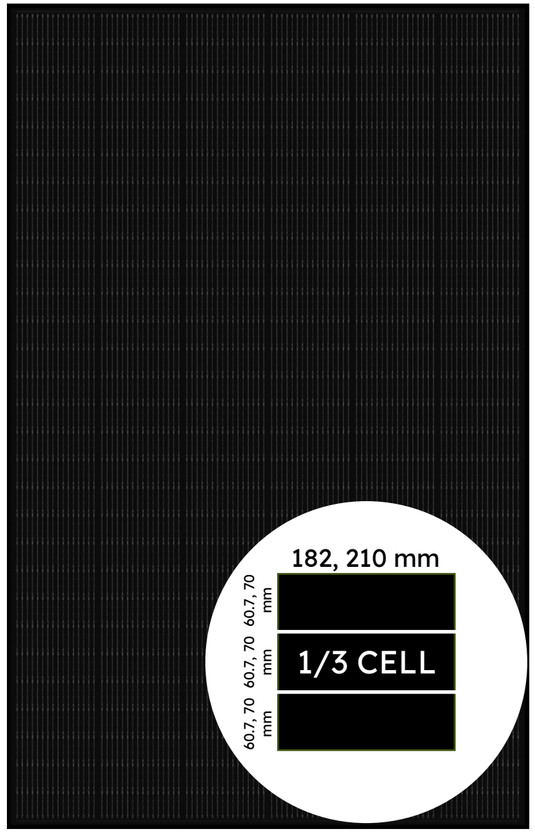
Performance 7 has three parallel substring circuits with cells connected in series, while standard half-cell panels typically only have two circuits.

Strategic busbar placement further redistributes current to optimize performance.

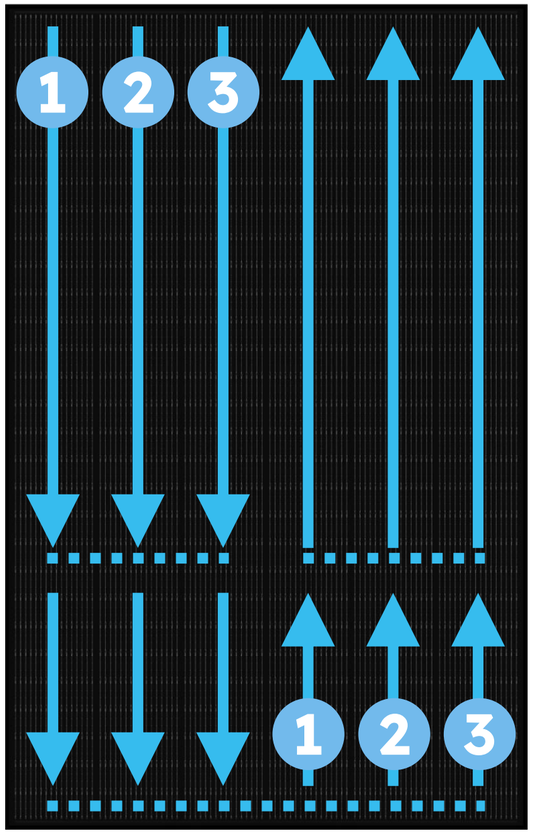
Energy flow / Circuits Busbar

Performance 7 shade resilience stems from its design

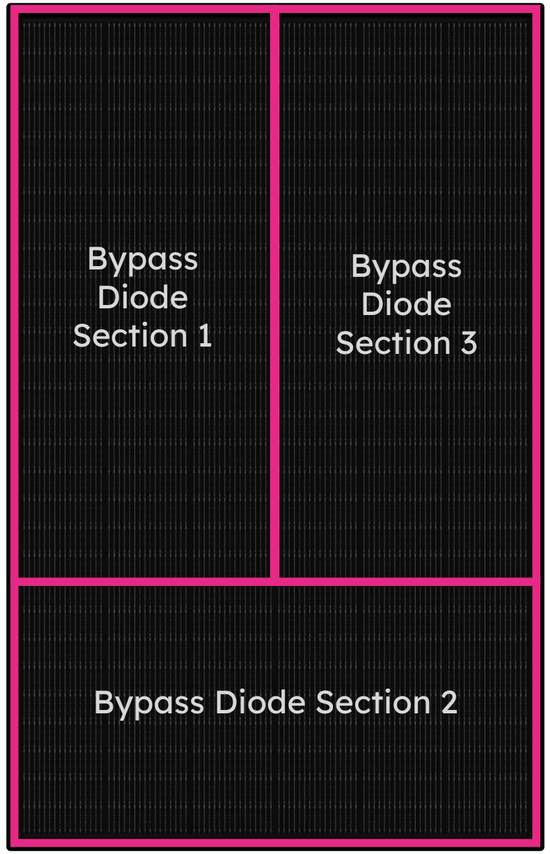
Smaller Cell Size



Circuit Design



Bypass Diode Layout



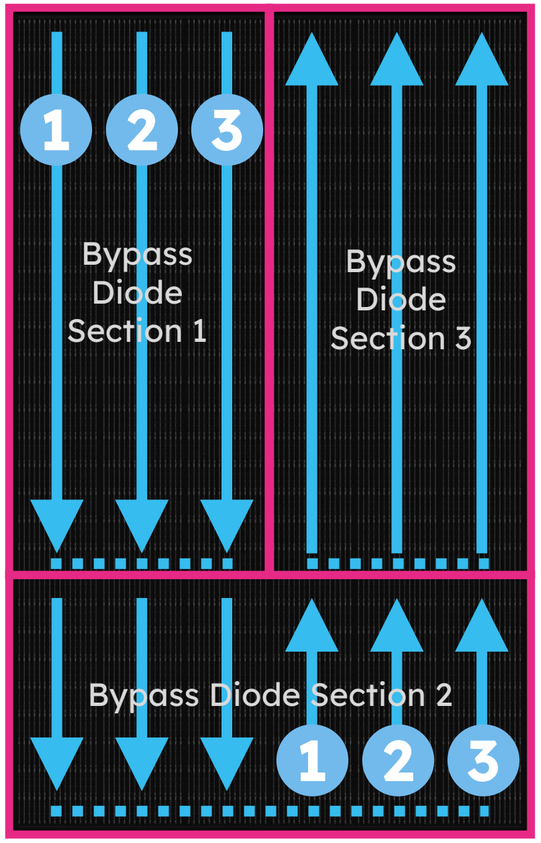
Voltage is the amount of force pushing the current through the panel—a higher voltage means more current is flowing. Shade limits current, which has a direct impact on voltage.

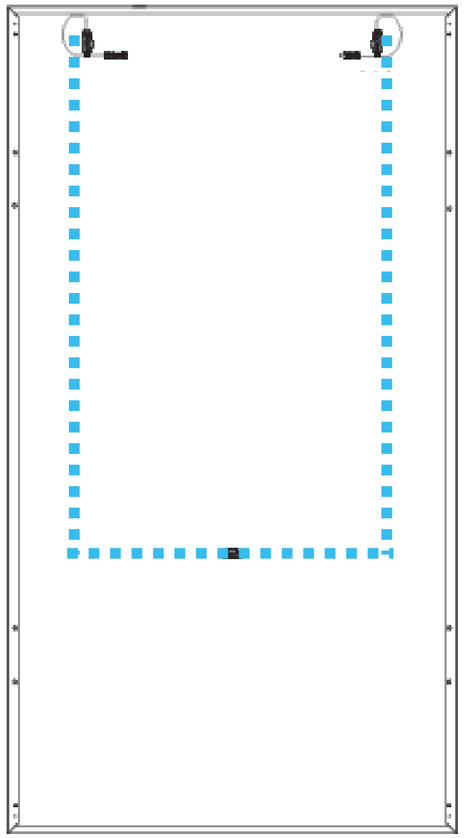
As voltage drops in a string, bypass diodes activate to route current around shaded cells to maintain a consistent voltage within the system, maximizing panel output.

Like standard panels, Performance 7 has three electrical sections, each governed by one bypass diode that reduces power by one-third when active.

Energy flow / Circuits Busbar Bypass diode section

Energy flow within the Performance 7 panel





Performance 7 panels consist of **three distinct electrical sections**, each **governed by a single bypass diode**.

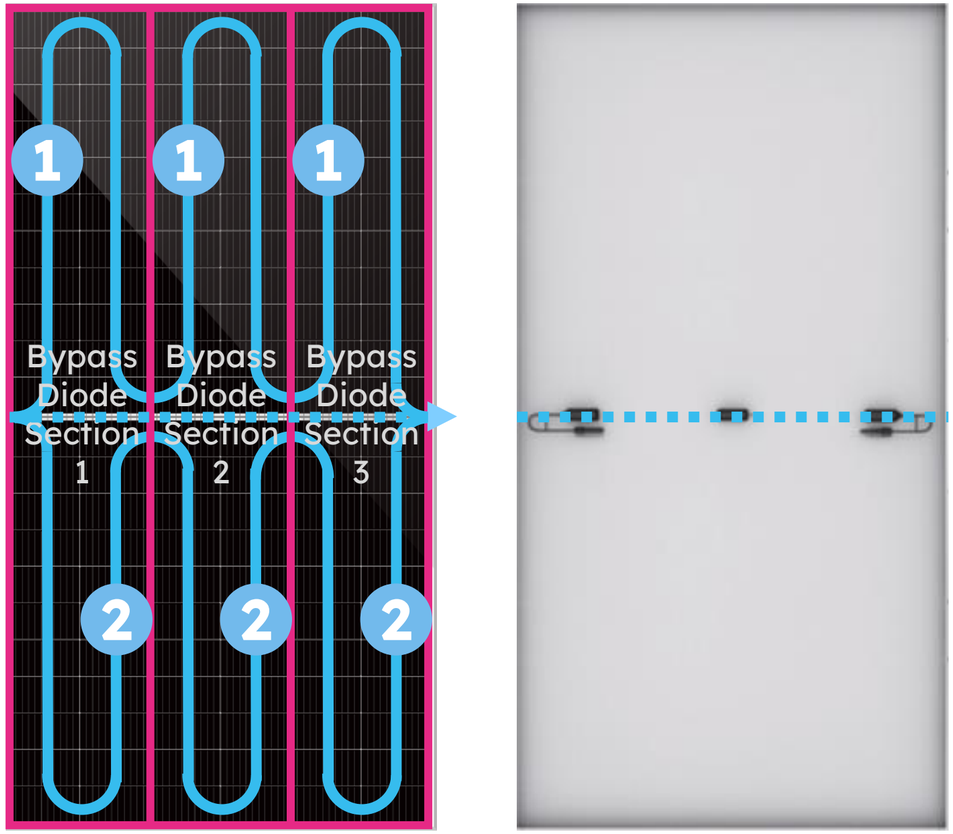
One-third-cut cells are connected in **three parallel substring circuits, with cells connected in series**.

Two busbars positioned horizontally on the panel redistribute current to optimize panel performance, with the upper busbars only active if the lower portion of the panel is bypassed.

Independent busbars connect the three junction boxes to ensure continued energy flow in the event a section of the panel is bypassed.

Energy flow / Circuits Busbar Bypass diode section

Energy flow within standard half-cell panels



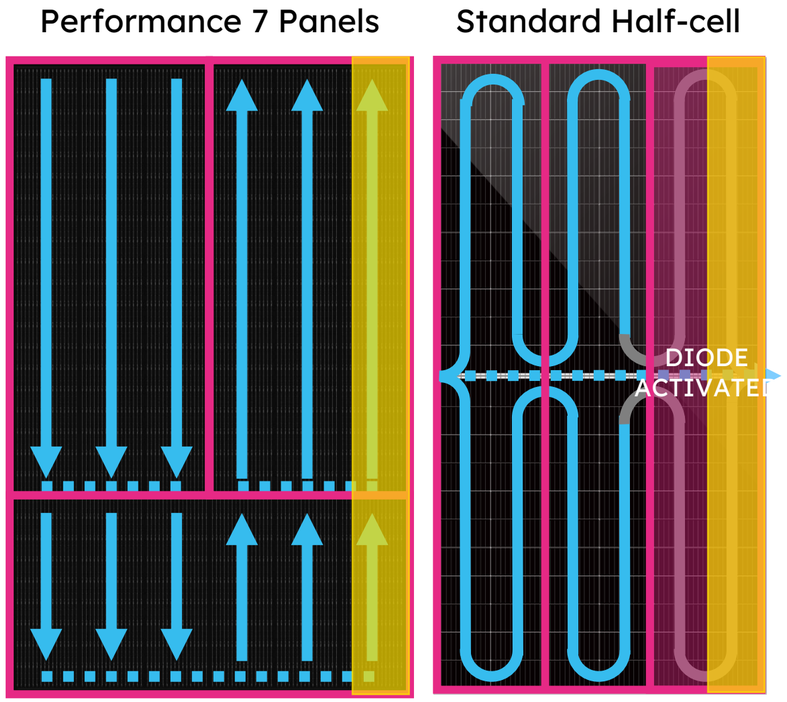
Standard half-cell solar panels (e.g. xBC, TOPCon, HJT, mono PERC) consist of **three distinct electrical sections**, each **governed by a single bypass diode**.

Cells (typically half-cut) are connected in **two parallel substring circuits** (panel top and bottom), with energy flowing through each substring in a circuitous pattern.

Independent busbars connect the three junction boxes to ensure continued energy flow in the event a section of the panel is bypassed.

Energy flow / Circuits Busbar Bypass diode section

Impact of shade falling on the front face of the panel



Once a cell or cells becomes shaded, the shaded area of the panel effectively becomes a bottleneck to the flow of electric current across the entire panel.

The energy-generating capacity of the panel (W) is reduced as a result, which in turn decreases the energy output of the panel (kWh).

Changes to panel current and voltage may require bypass diodes to activate to protect the panel from overheating.

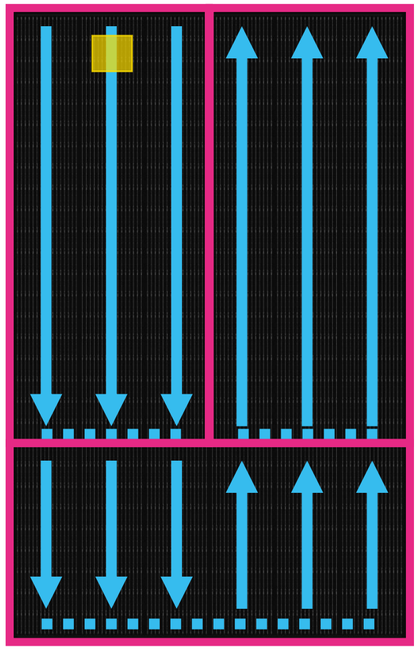
Resulting voltage and current changes are dictated by cell size, the number of circuits, and diode arrangement in particular—factors that change from panel to panel.

Energy flow / Circuits Busbar Bypass diode section Shade (80% Opacity)

Assessing power loss from shade: 120x120 mm spot shadow

Performance 7 Panel

Instant Power Loss | **-16%**



Shade Profile
120x120 mm spot shadow

Diode Sections Impacted
1 of 3

Circuits Impacted
1 of 3

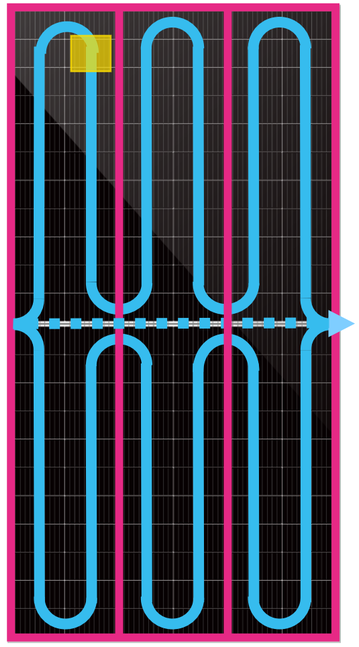
Cell Size
One-third-cut

Reverse Bias Voltage
>30 V

Diode Activation
None

Standard Half-cell Panel

Instant Power Loss | **-23%**



Shade Profile
120x120 mm spot shadow

Diode Sections Impacted
1 of 3

Circuits Impacted
1 of 2

Cell Size
Half-cut

Reverse Bias Voltage
>30 V

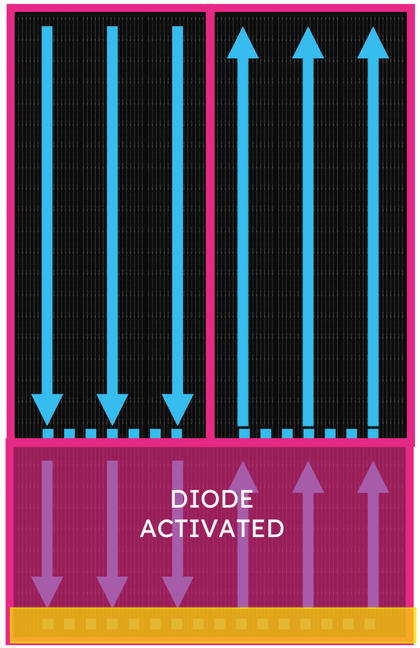
Diode Activation
None

Energy flow / Circuits Busbar Bypass diode section Shade (99% Opacity)

Assessing power loss from shade: Short edge shade profile

Performance 7 Panel

Instant Power Loss | **-32%**



Shade Profile
Short edge (100 mm)

Diode Sections Impacted
1 of 3

Circuits Impacted
3 of 3

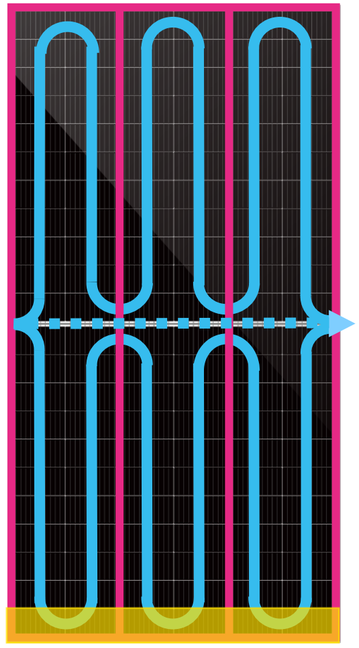
Cell Size
One-third-cut

Reverse Bias Voltage
>30 V

Diode Activation
1 of 3

Standard Half-cell Panel

Instant Power Loss | **-36%**



Shade Profile
Short edge (100 mm)

Diode Sections Impacted
3 of 3

Circuits Impacted
1 of 2

Cell Size
Half-cut

Reverse Bias Voltage
>30 V

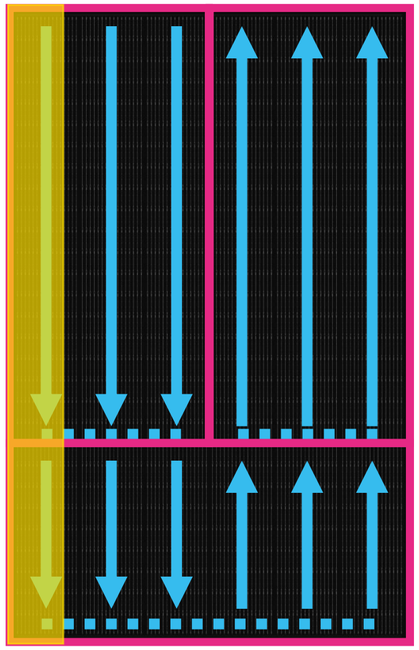
Diode Activation
None

Energy flow / Circuits | Busbar | Bypass diode section | Shade (80% Opacity)

Assessing power loss from shade: Long edge shade profile

Performance 7 Panel

Instant Power Loss | **-23%**



Shade Profile
Long edge (200mm)

Diode Sections Impacted
2 of 3

Circuits Impacted
1 of 3

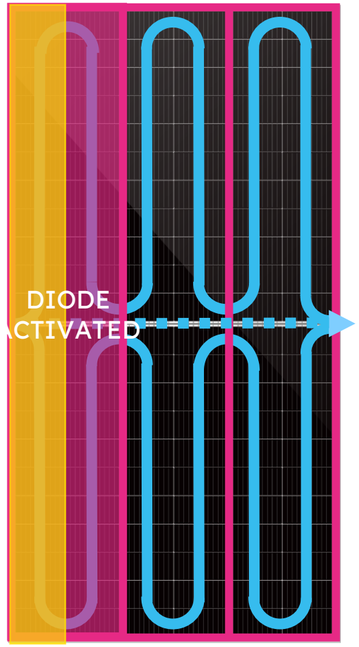
Cell Size
One-third-cut

Reverse Bias Voltage
>30 V

Diode Activation
None

Standard Half-cell Panel

Instant Power Loss | **-35%**



Shade Profile
Long edge (200mm)

Diode Sections Impacted
1 of 3

Circuits Impacted
2 of 2

Cell Sze
Half-cut

Reverse Bias Voltage
>30 V

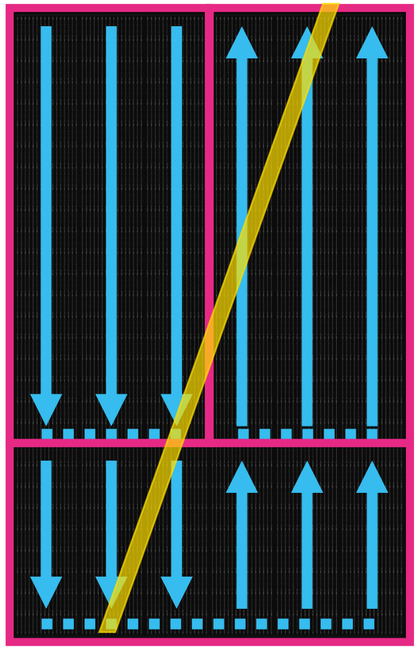
Diode Activation
1 of 3

Energy flow / Circuits Busbar Bypass diode section Shade (80% Opacity)

Assessing power loss from shade: Diagonal pole

Performance 7 Panel

Instant Power Loss | **-28%**



Shade Profile
Diagonal pole (25mm)

Diode Sections Impacted
3 of 3

Circuits Impacted
3 of 3

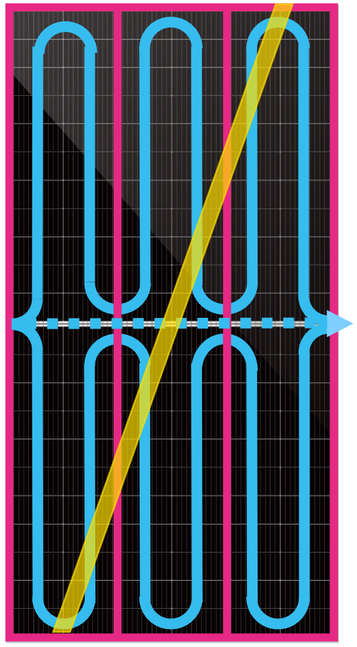
Cell Size
One-third-cut

Reverse Bias Voltage
>30 V

Diode Activation
None

Standard Half-cell Panel

Instant Power Loss | **-40%**



Shade Profile
Diagonal pole (25mm)

Diode Sections Impacted
3 of 3

Circuits Impacted
2 of 2

Cell Sze
Half-cut

Reverse Bias Voltage
>30 V

Diode Activation
None

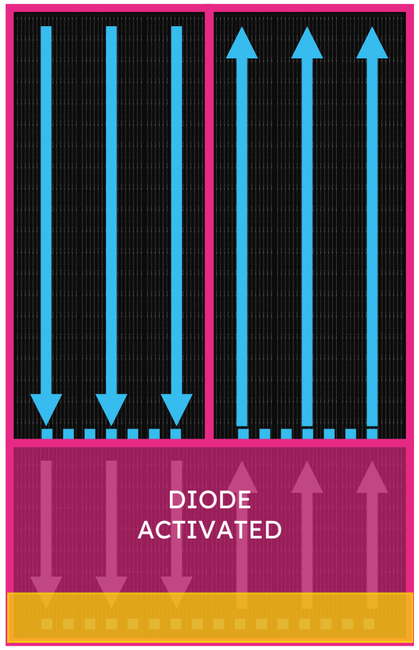
Energy flow / Circuits | Busbar | Bypass diode section | Shade (80% Opacity)

Miscellaneous—Portrait Orientation of Performance 7

Performance 7 Panel

Two-diode end of panel at top

Instant Power Loss | **-37%**



Shade Profile
Short edge shade

Diode Sections Impacted
1 of 3

Circuits Impacted
1 of 3

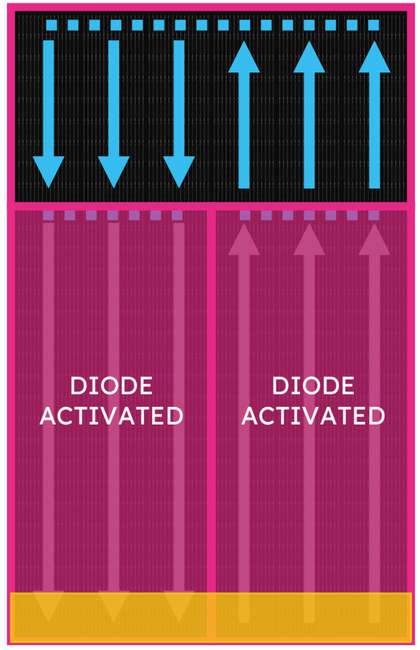
Cell Size
One-third-cut

Diode Activation
1 of 3

Performance 7 Panel

Two-diode end of panel at bottom

Instant Power Loss | **-71%**



Shade Profile
Short edge shade

Diode Sections Impacted
2 of 3

Circuits Impacted
2 of 3

Cell Size
One-third-cut

Diode Activation
2 of 3

Energy flow / Circuits Busbar Bypass diode section Shade (80% Opacity)

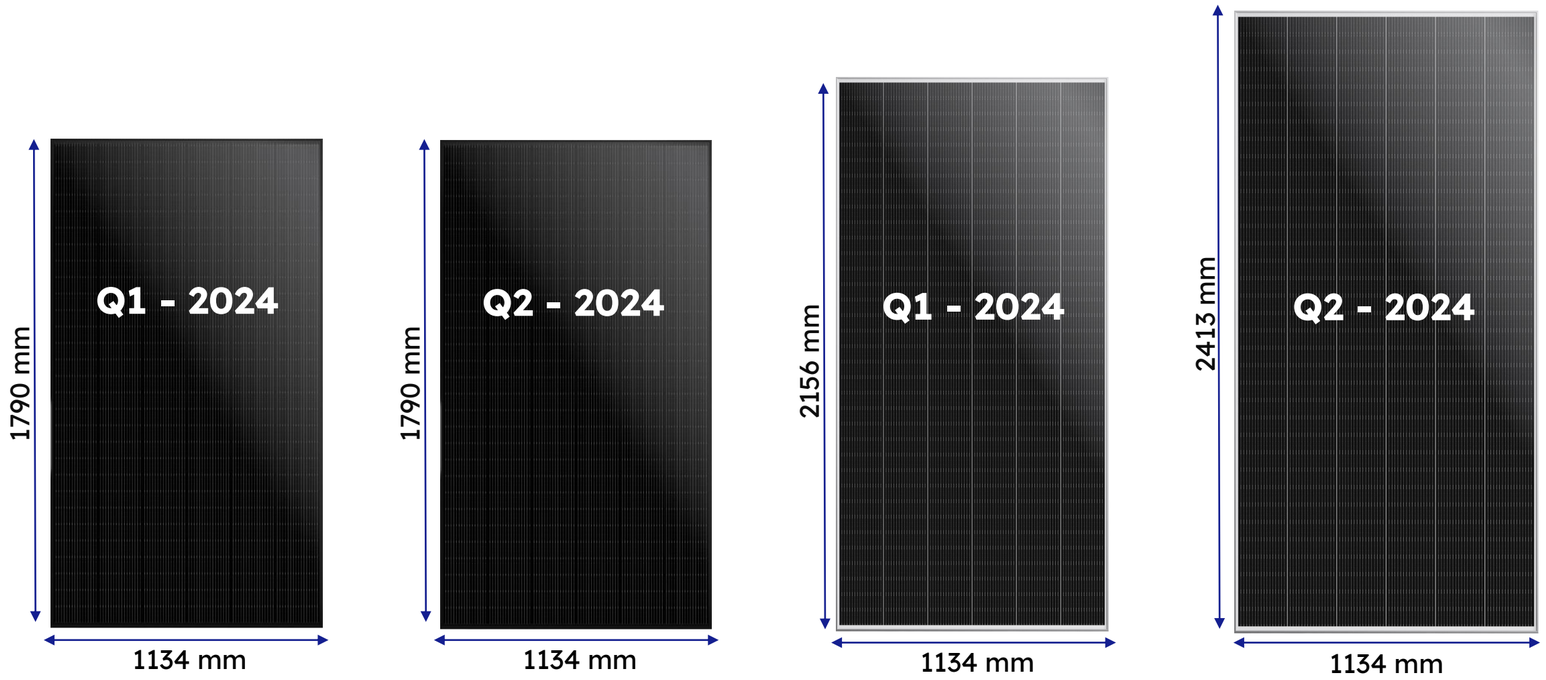
SunPower Performance 7 panel portfolio

PERFORMANCE PANEL PORTFOLIO

Roadmap for panel launches

BIFACIAL

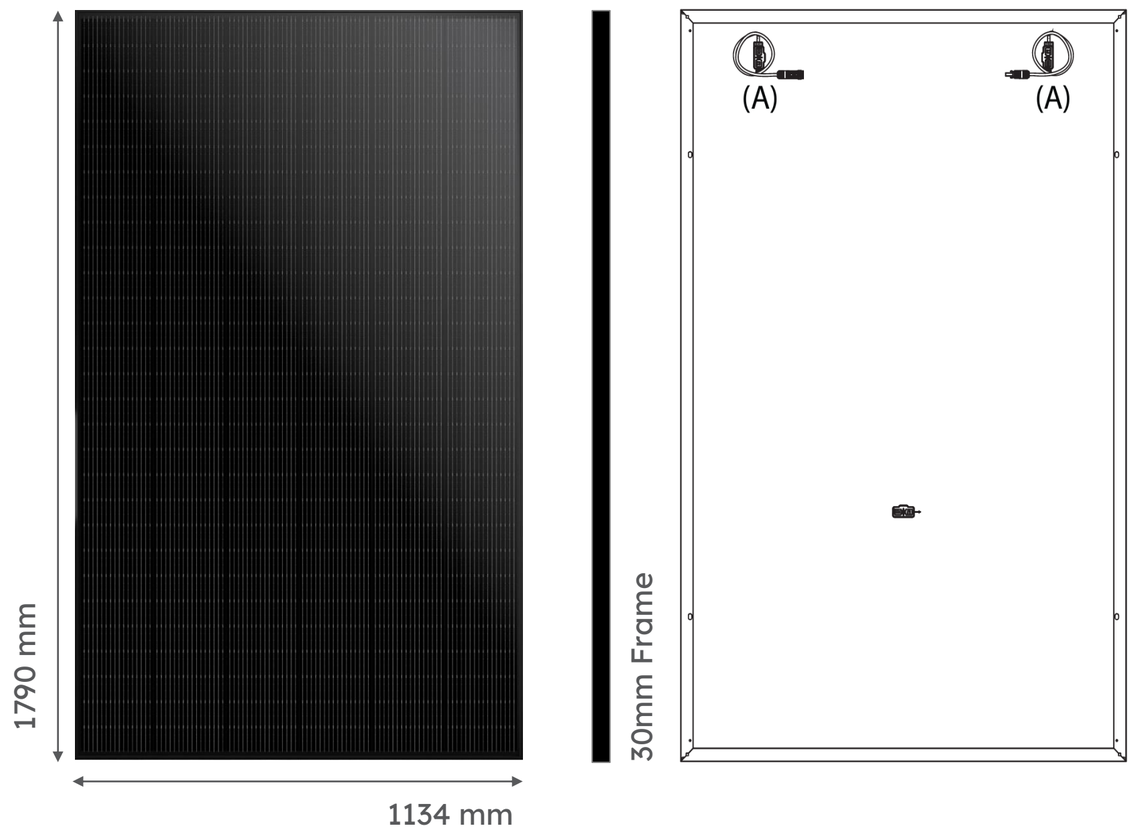
TOPCon



P7-BLK	P7-BLK-AC	P7 COM-S	P7 COM-L
440-455 W Up to 22.4% Eff.	445-450 W Up to 22.2% Eff.	535-555 W Up to 22.7% Eff.	595-620 W Up to 22.6% Eff.

PERFORMANCE PANEL PORTFOLIO

SunPower Performance 7 BLK



30 YEAR WARRANTY
Power | Product | Service

SPR-P7-xxx-BLK

Up to 455W | Up to 22.4% Efficient

Ideal for residential applications

Bifacial Generation

FEATURES

- Bifacial power generation
- Glass-Glass construction, black frame
- Full square 182mm (G10) solar cells
- 30 mm frame
- 3 Junction boxes, 3 Diodes (1 each)
- Cables: (-) 1200 mm / (+) 1200 mm
- MC4 Connectors

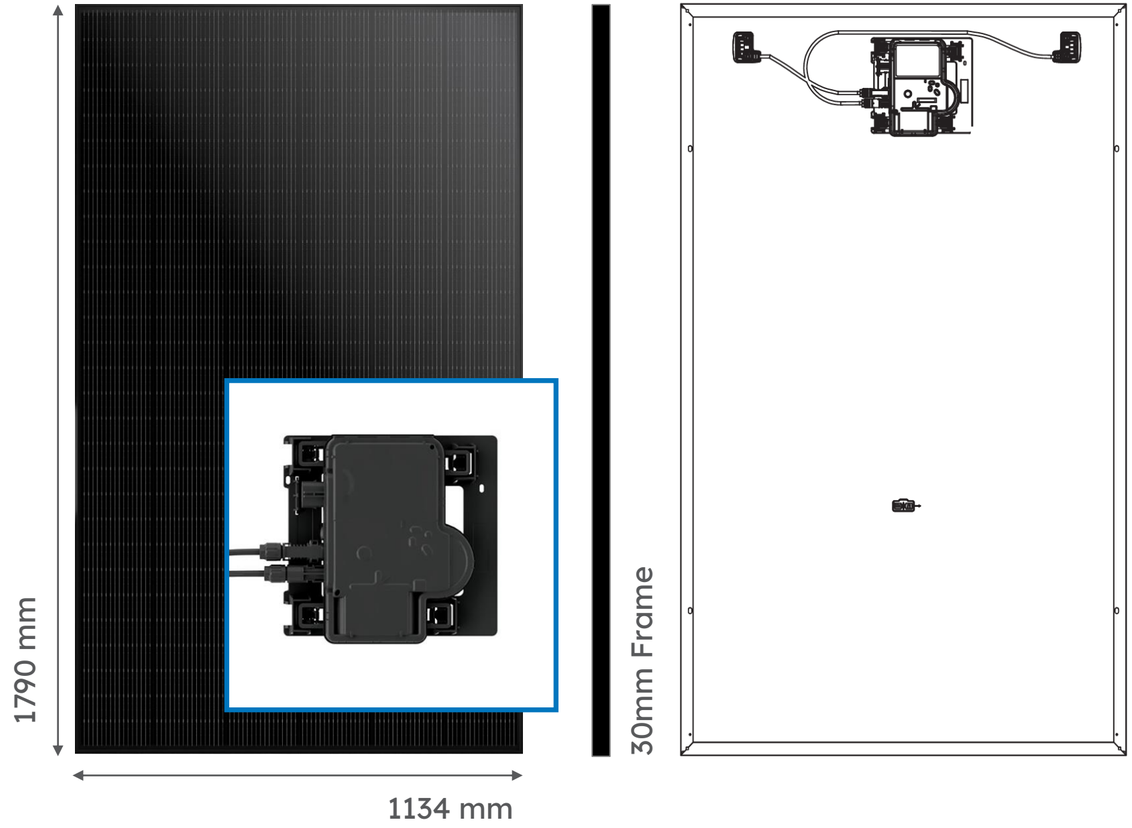
WARRANTY

Power, Product, Service	30/30/30
Year 1 min warranted output	99.0%
Maximum annual degradation	0.40%

SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

PERFORMANCE PANEL PORTFOLIO

SunPower Performance 7 BLK AC (preliminary)



30 YEAR WARRANTY
Power | Product | Service

SPR-P7-xxx-BLK-XX-AC

Up to 450W | Up to 22.2% Efficient

Ideal for residential applications

AC Factory-integrated microinverter

FEATURES

Bifacial power generation
Glass-Glass construction, black frame
Full square 182mm (G10) solar cells
30 mm frame
Enphase factory-integrated microinverter
Cables: (-) 800 mm / (+) 400 mm
MC4 Connectors

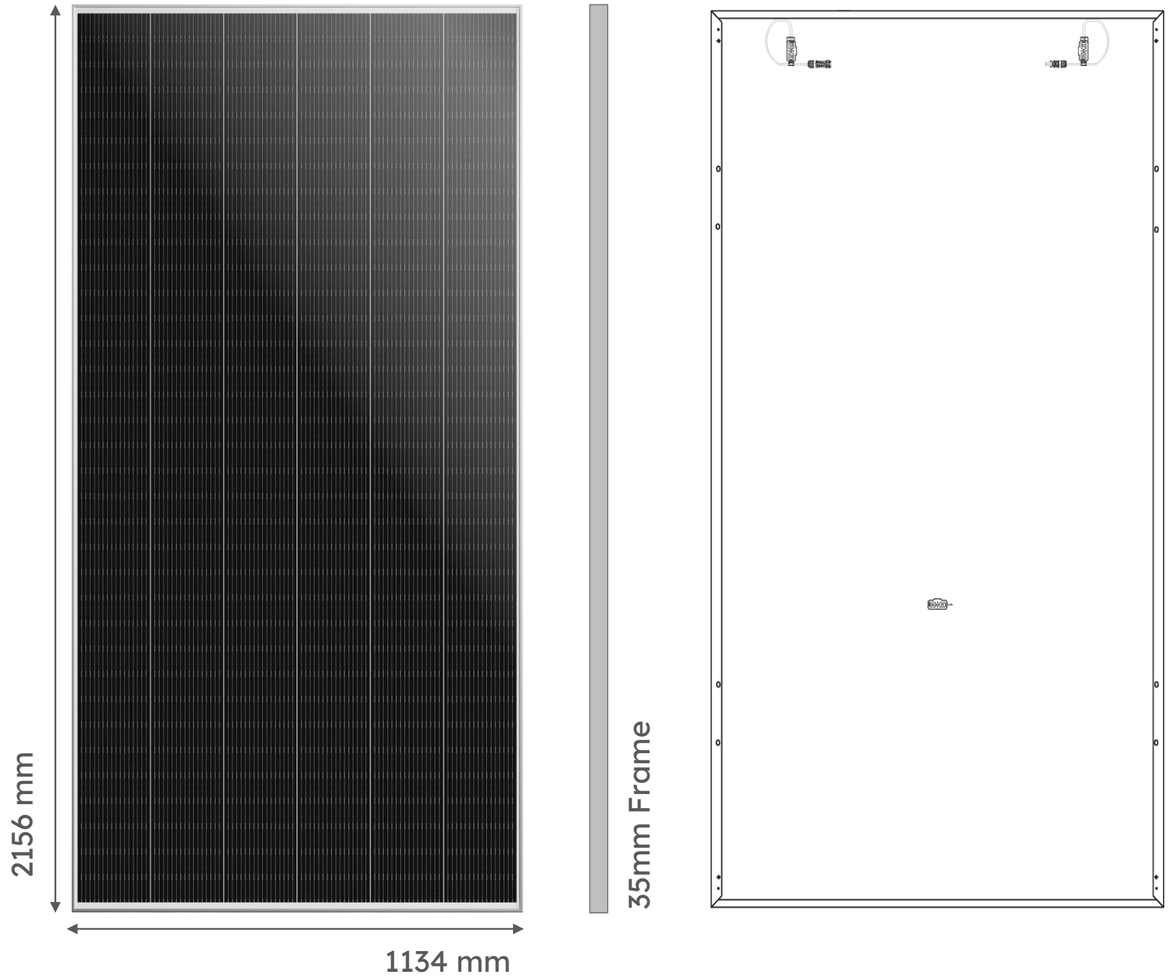
WARRANTY

Power, Product, Service	30/30/30
Year 1 min warranted output	99.0%
Maximum annual degradation	0.40%
EU microinverter warranty	25 years
AU microinverter warranty	15 years

SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

PERFORMANCE PANEL PORTFOLIO

SunPower Performance 7 COM-S



30 YEAR WARRANTY
Power | Product | Service

SPR-P7-xxx-COM-S

Up to 555W | Up to 22.7% Efficient

Ideal for Commercial Applications

Bifacial Generation

FEATURES

- Bifacial power generation
- Framed glass-glass construction
- Full square 182mm (G10) solar cells
- 35 mm frame
- 3 Junction boxes, 3 Diodes (1 each)
- Cables: (-) 1500 mm / (+) 1500 mm
- Connectors: EVO2

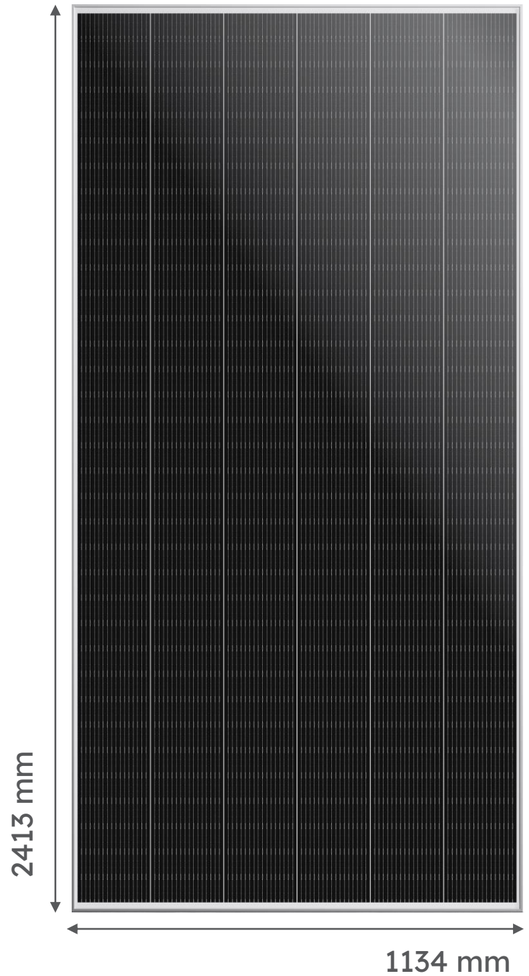
WARRANTY

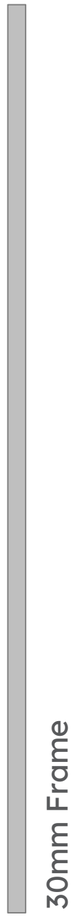
Power, Product, Service	30/30/30
Year 1 min warranted output	99.0%
Maximum annual degradation	0.40%

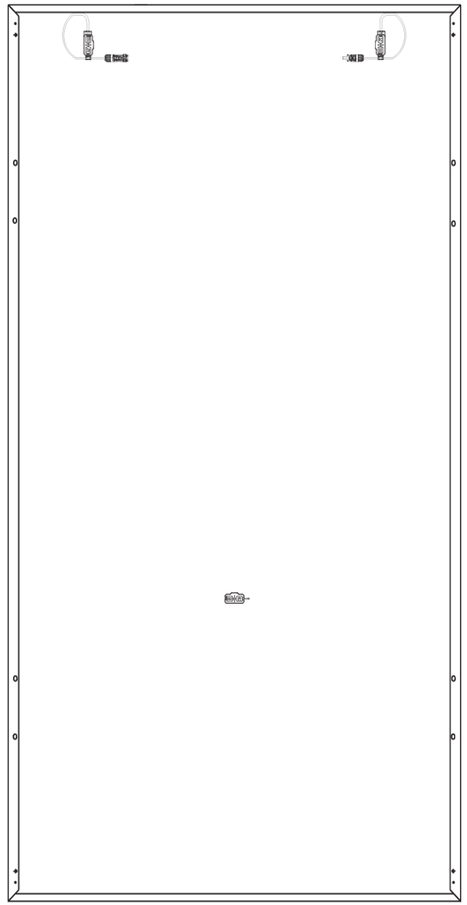
SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

PERFORMANCE PANEL PORTFOLIO

SunPower Performance 7 COM-L (preliminary)







30 YEAR WARRANTY
Power | Product | Service

SPR-P7-xxx-COM-L

Up to 620W | Up to 22.6% Efficient

Ideal for Commercial Applications

Bifacial Generation

FEATURES

- Bifacial power generation
- Framed glass-glass construction
- Rectangular 210*182mm (G12R) solar cells[1]
- 30 mm frame
- 3 Junction boxes, 3 Diodes (1 each)
- Cables: (-) 1500 mm / (+) 1500 mm
- Connectors: EVO2

WARRANTY

Power, Product, Service[2]	30/30/30
Year 1 min warranted output	99.0%
Maximum annual degradation	0.40%

SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

[1] G12R solar cells have chamfered corners.

[2] 30-year product/30-year power warranty only applicable to DG market. For COM/UPP markets 15-year product/30-year power applies.