Webinar
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Maxeon Solar Technologies

pv magazine webinars

The bigger the module, the bigger the ROI? Let's crunch the numbers!

15 October 2020

9 am – 10 am	| CEST, Berlin
12.30 pm – 1.30 pm	| IST, Delhi
3 pm – 4 pm	| CST, Beijing
4 pm – 5 pm	| AWDT, Perth

Marian Willuhn
Editor | pv magazine

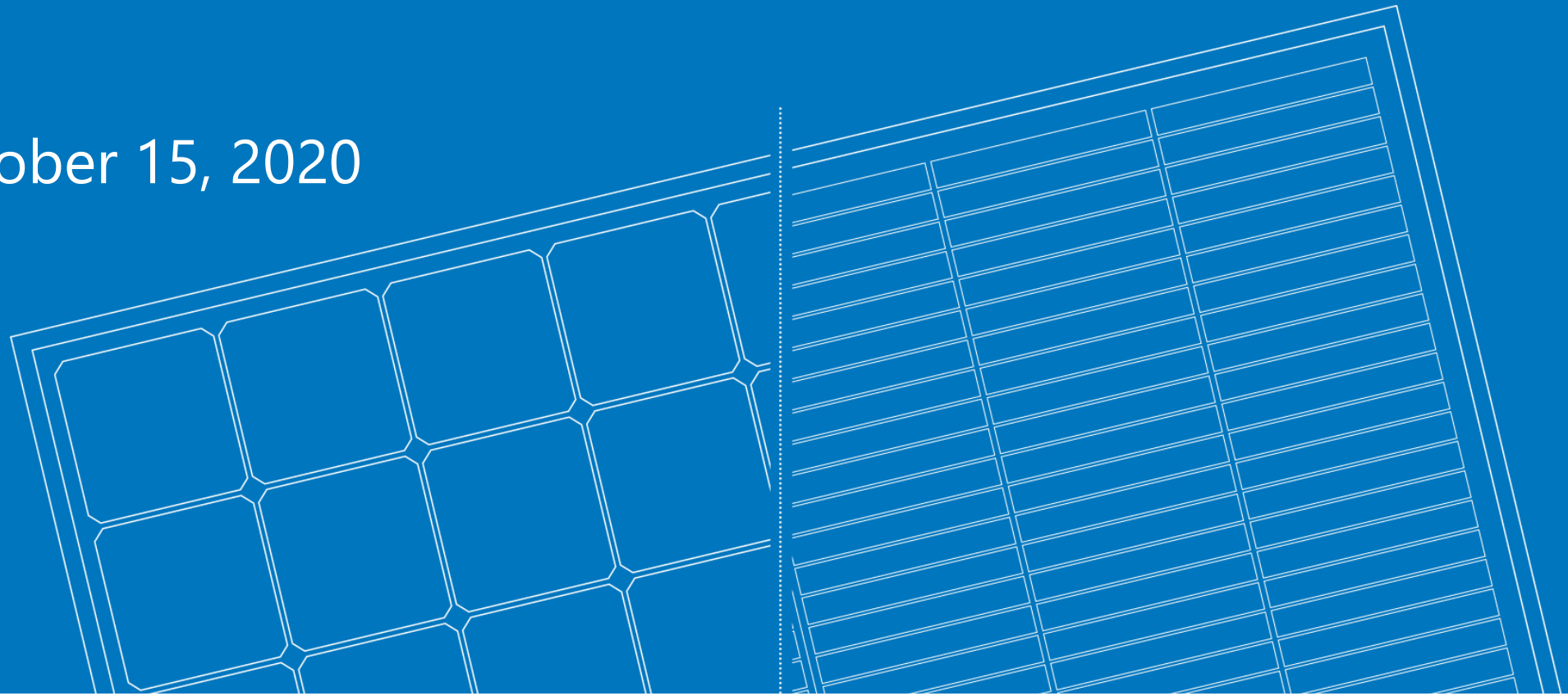
Robert Chew
Maxeon Solar Technologies

Sevi Gultes
Maxeon Solar Technologies

Pierre Gousseland
Terabase Energy

MAXIMISING RETURNS OF LARGE-SCALE SOLAR INSTALLATIONS

October 15, 2020



SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

AGENDA

- Introduction: Maxeon Solar Technologies
- Impacts of reliability and quality
- Impacts of larger, more powerful solar panels
- Let’s crunch the numbers
- Conclusion

Sevi Gultes
Application Engineer - Maxeon Solar Technologies

MAXEON SOLAR TECHNOLOGIES

SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

COMPANY OVERVIEW

HQ in Singapore
NASDAQ (MAXN)

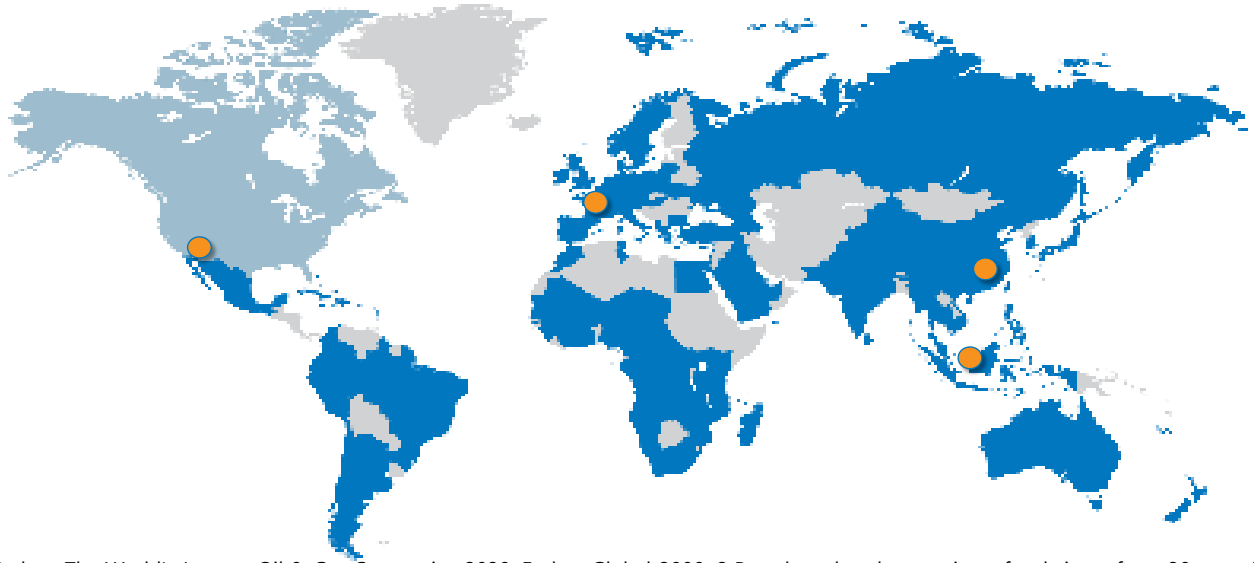
5,000 Employees
In 14 Countries

$1.2 Billion
Net Revenue (2019)

2.75 GW Manuf. Capacity
France, Mexico, China, Malaysia, Philippines

SunPower brand
Outside of the USA

#1 Shareholder is Total S.A.,
a $150 Billion energy company.[1]




Residential Solar


Commercial Solar


Solar Power Plants

1 Source: Forbes, The World's Largest Oil & Gas Companies 2020. Forbes Global 2000. 2 Based on datasheet review of websites of top 20 manufacturers per IHS, as of Jan, 2020.

MAXEON BENEFITS FROM STRONG STRATEGIC PARTNERSHIPS

SUNPOWER® Corporation

maxeon

Industry-Leading Solar Manufacturer
with Global Customer Base

- Capital to accelerate scale-up of Maxeon 5
- Strong access to low-cost Asia-based solar supply chain
- Strategic supply relationships - New SunPower, TZS
- **Differentiated product platforms with compelling future roadmap**
- Strong global channels and brand

TOTAL

- Strong support for SPWR since 2011
- Deep commitment to renewable energy
- Growing downstream global presence

Nasdaq

Public investors

TZS ZHONGHUAN SEMICONDUCTOR

- Leading global wafer supplier – 40GW
- Innovation leader - larger wafers (G12)
- China supply chain and market access

MAXEON HAS A DEEP GLOBAL POWER PLANT LEGACY

- Maxeon has extensive large-scale solar system domain experience
- More than 5GW of SunPower panels installed across 6 continents
- Deep understanding of value chain drivers — from EPCs and developers, to financiers, IPPs and investors
- Legacy downstream experience informs Maxeon product development & design

Bavaria Solar One, 2004

One of the industry's first power plants

10 MW, 1-axis tracking arrays

Solar Star, 2015

Largest solar project in the USA at 747 MW

1.7 million SunPower Maxeon panels installed

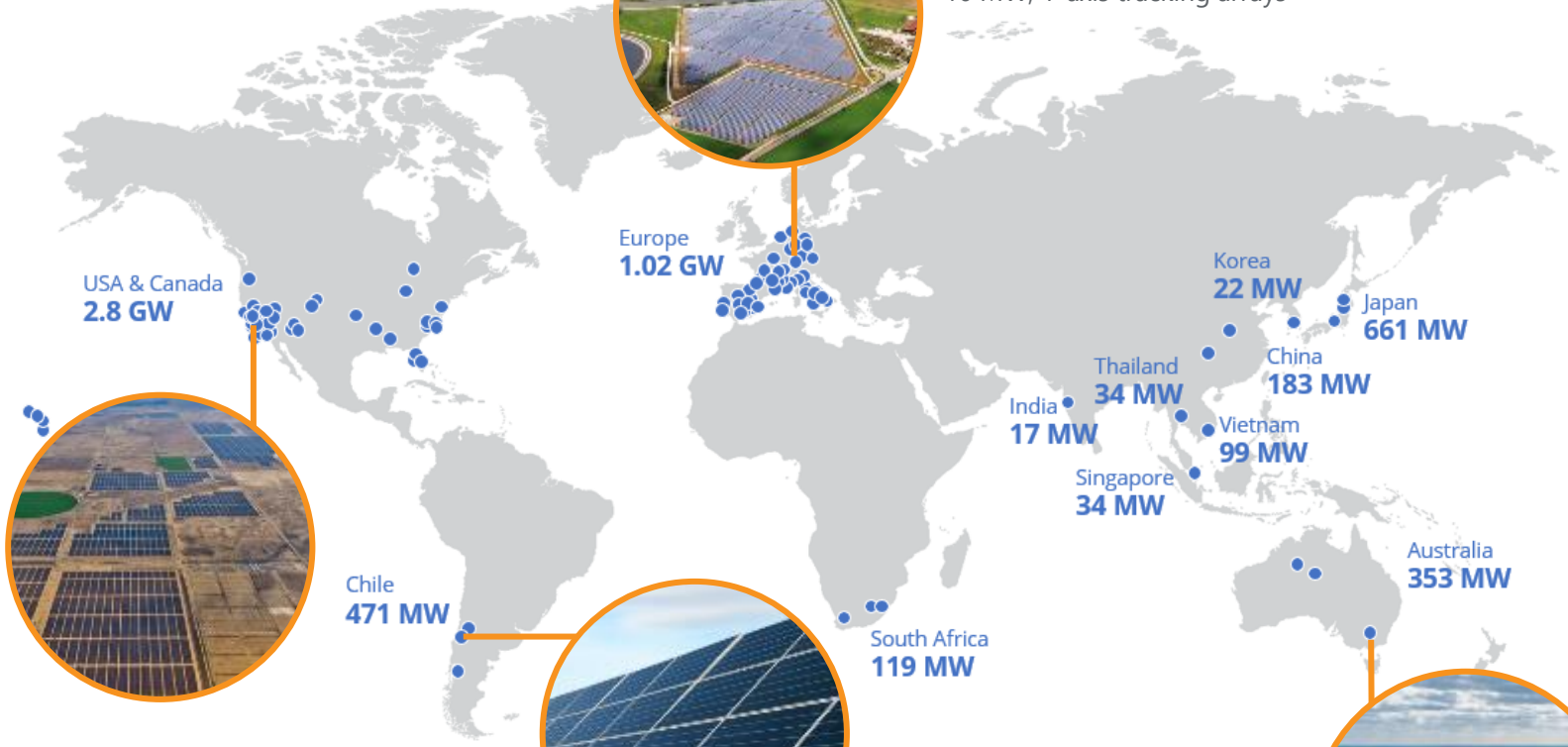
Santa Isabel, 2020

190 MW SunPower Performance panel project owned by Total

Limondale, 2020

Largest solar power plant in Australia at 349 MW

872,000 SunPower Performance panels installed



Note: Not an exhaustive illustration of SunPower PP projects

SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

SUNPOWER PERFORMANCE PANELS

Proven in the field

2015
PERFORMANCE P17

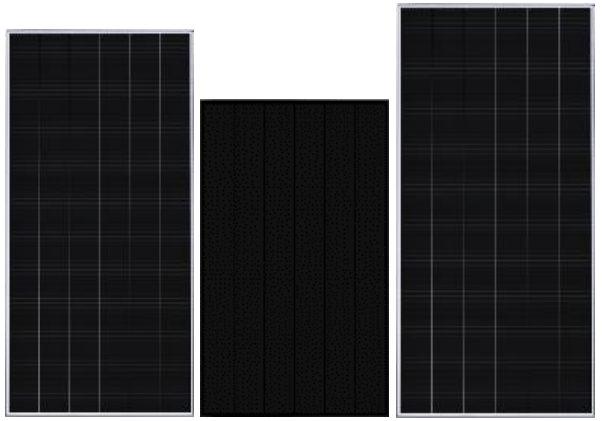
P17 COM
340-360 W

2018
PERFORMANCE P19

P19 COM
390-410 W

P19 BLK
315-330 W

2020
PERFORMANCE 3

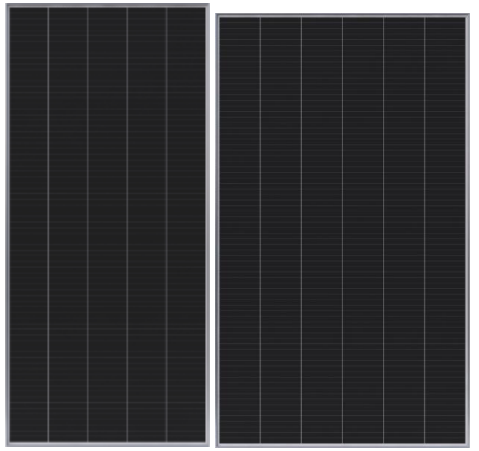


P3 COM
405-420 W

P3 BLK
320-335 W

P3 UPP
460-500 W

2021
PERFORMANCE 5



P5 UPP
520-545 W

P5 UPP
600 - 635 W

September 2015	November 2015	December 2016	July 2017	November 2017	June 2018	October 2018	January 2019	February 2020	July 2020
Cogenra Acquisition	1st P17 panels on 25 MW pilot line in USA	Mexico manufacturing (400MW)	1st P19 panel manufacturing in China (750MW)	NextEra completes 125MW Performance panel project	Additional P19 manufacturing in China (1.25 GW)	349 MW supply agreement (Innogy, Belectric; Australia)	Additional P19 manufacturing in USA (220 MW)	Launch of Performance 3 panel	Performance 5 UPP panel for power plant systems is launched

SUNPOWER | PERFORMANCE

PANEL RELIABILITY IMPORTANCE IN LARGE SCALE SOLAR

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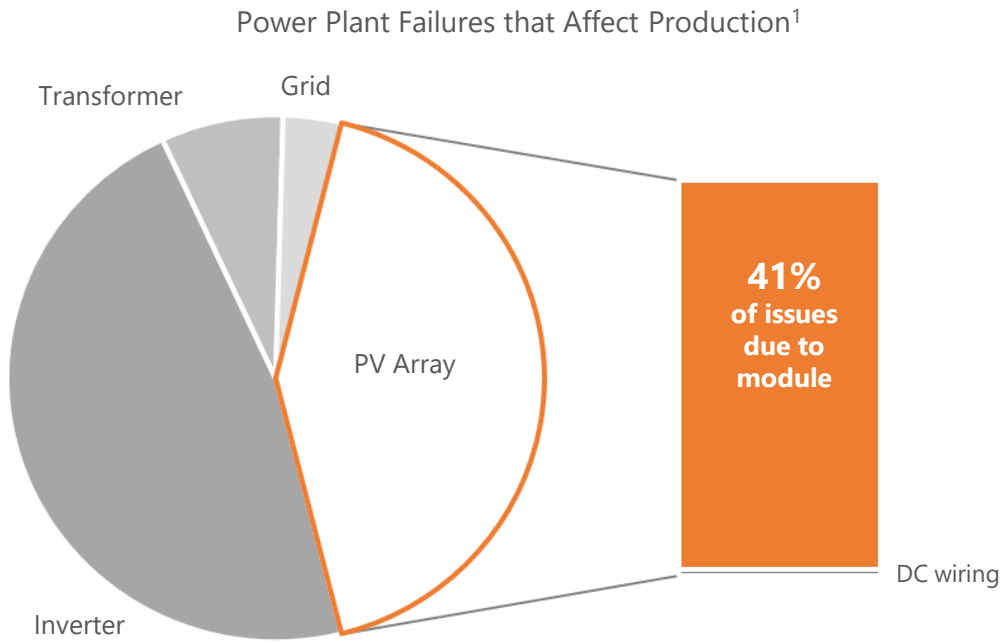
RELIABILITY OF SOLAR POWER PLANTS

Panel reliability is an ongoing issue in the field

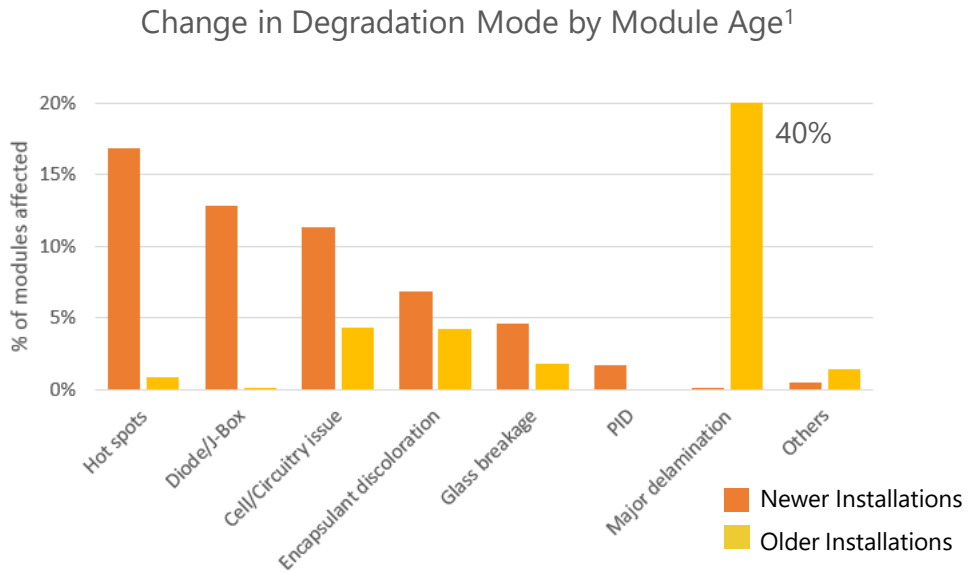
A recent study of EU powerplants found 41% of issues were caused by panels.[1]



Newer panels show a higher occurrence of major panel issues like hotspots and diode failure.

The youngest group of panels, built during a period of intense cost pressure, shows:

- Increased hotspots
- Increased diode and J-box issues
- Increased cell circuitry issues
- Increased encapsulant issues
- Increased PID



[1] Lillo-Bravo, et. al. "Impact of Energy Losses Due to Failures on Photovoltaic Plant Energy Balance." *Energies.* 2018.

[1] Jordan, et. al. "Photovoltaic Failure and Degradation Modes." PiP, 2017.

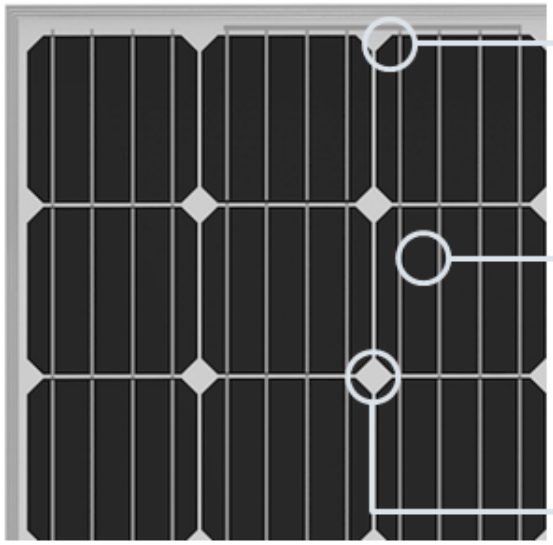
MAKING THE CONVENTIONAL, EXCEPTIONAL

Innovative shingled cell design uniquely engineered for the reliability and durability needs of power plant installations

Conventional

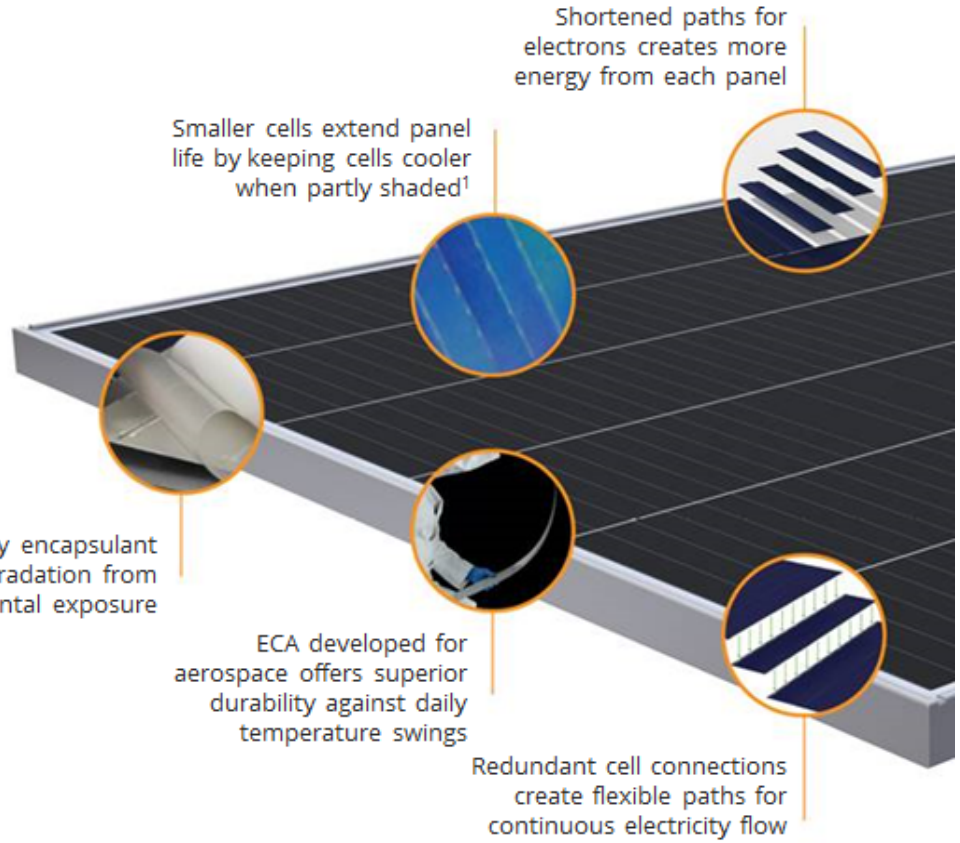
Vulnerable to Breakage & Corrosion

2x the connections in half cell panels



VS.

SUNPOWER® | PERFORMANCE

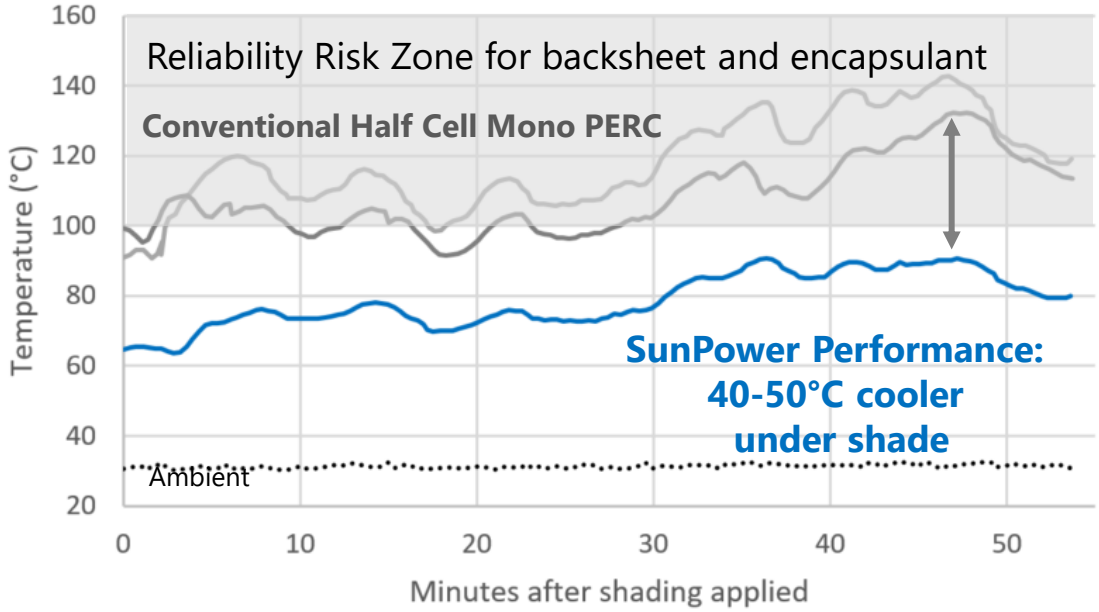


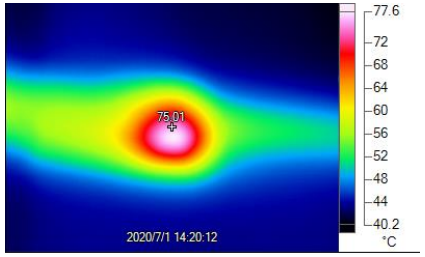
1 SunPower Performance Series – Thermal Performance, Z.Campeau 2016.

HOTSPOT PROTECTION THROUGH BETTER DESIGN

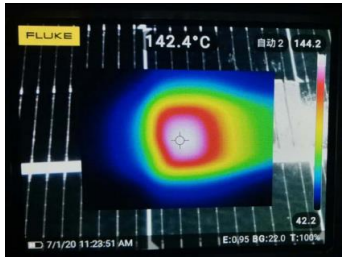
Performance panels reduce the risk of temperature-related failures through crack mitigation and unique circuitry

Under severe cell cracking or worst-case shading conditions, Performance panels operate at **40-50°C lower temperature.**[1]

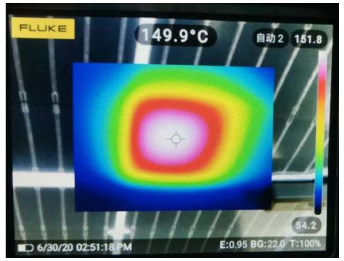




75.01°C



142.4°C



149.9°C

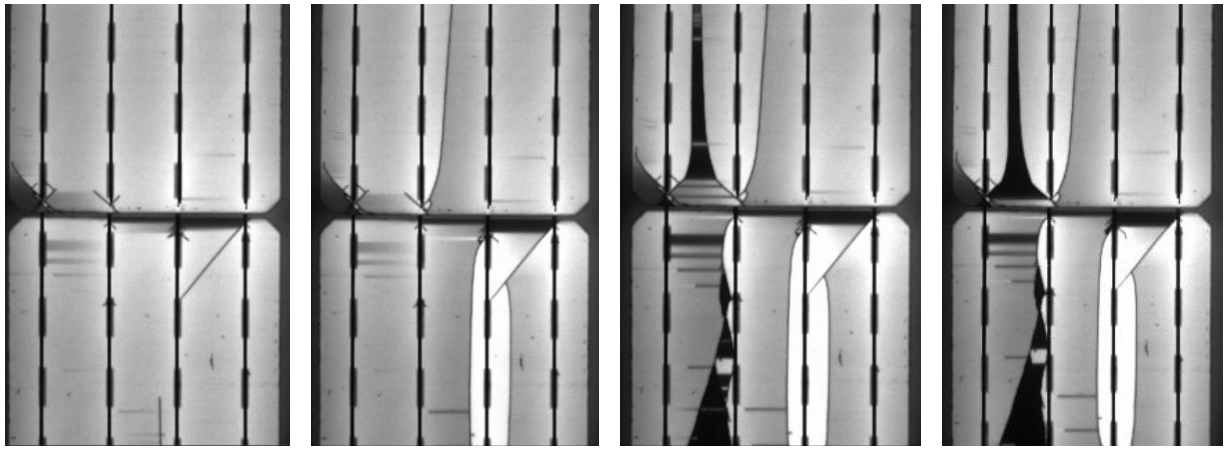
[1] SunPower internal study, 2020.

[1] SunPower internal study, 2020.

ENGINEERED TO STAND UP TO THE ELEMENTS

Minimising power loss from cell damage

Conventional front-contact mono PERC



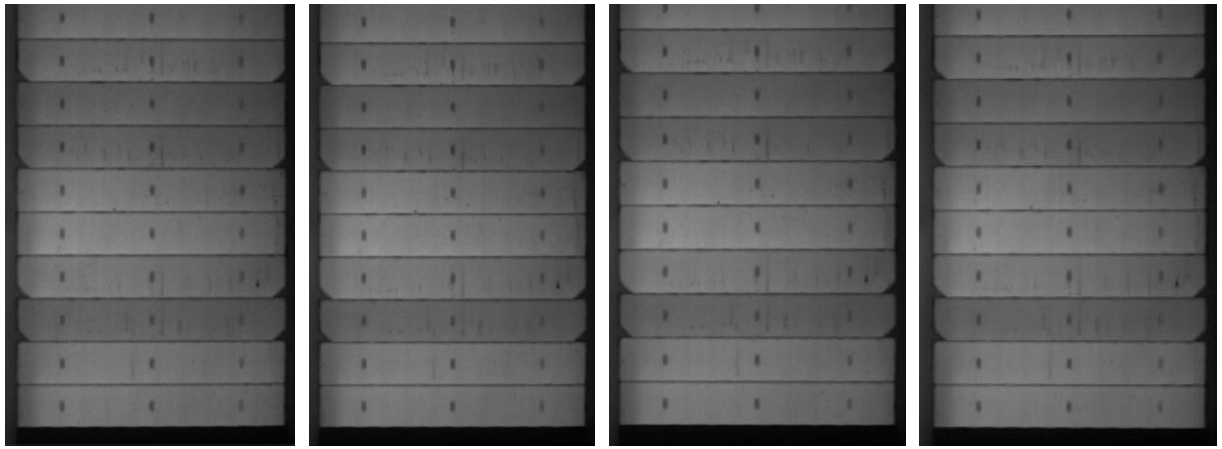
0 N | 150 N | 300 N | 390 N

FORCE APPLIED IN NEWTONS

Demonstration shows brittleness of typical conventional cells

VS.

SUNPOWER | PERFORMANCE



0 N | 150 N | 300 N | 390 N

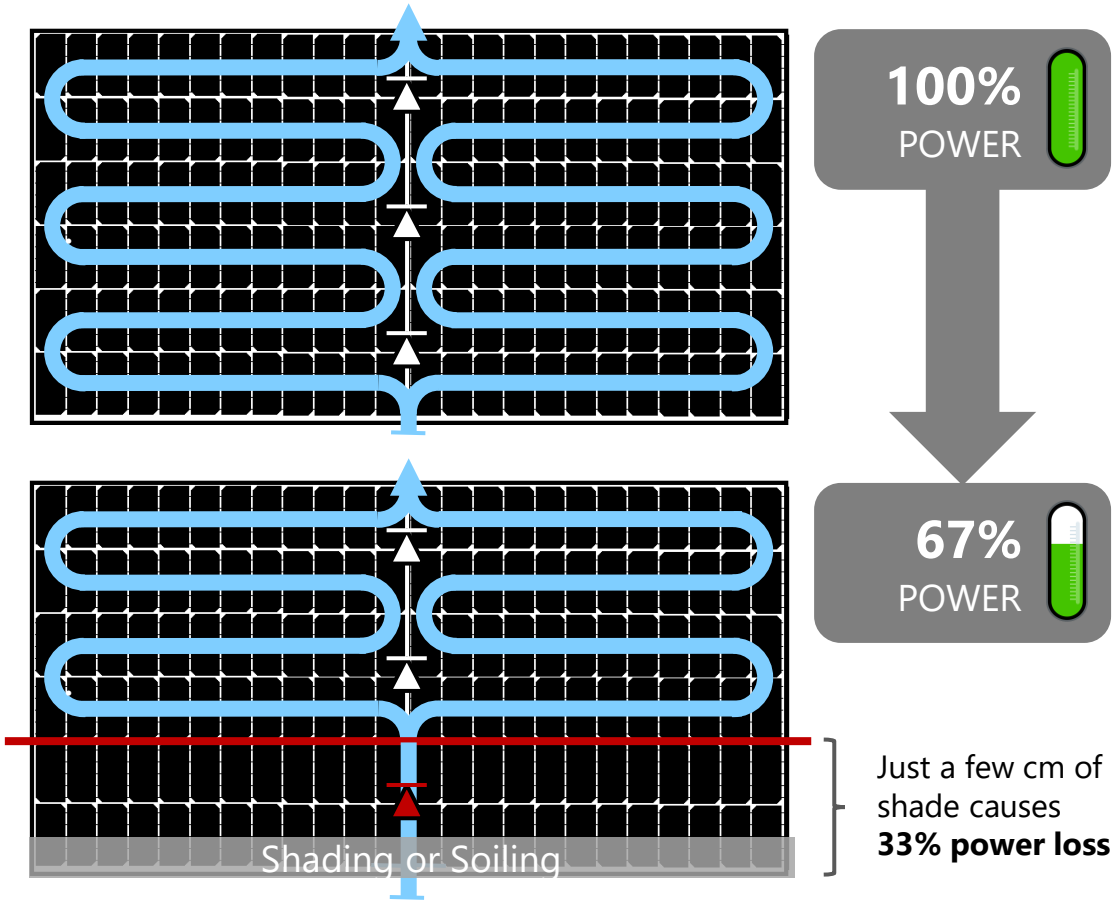
FORCE APPLIED IN NEWTONS

Smaller cells are less susceptible to breakage

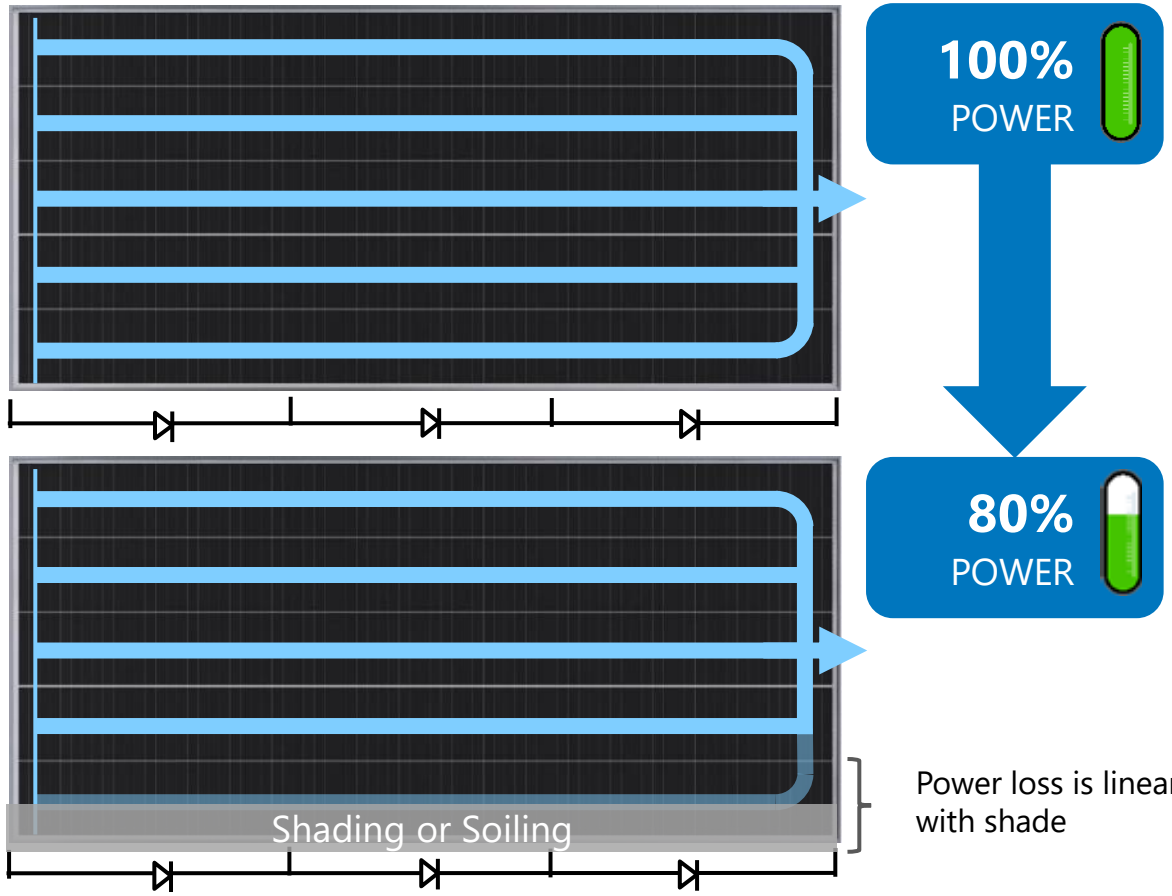
Confines cracks to a smaller portion of the panel

UNIQUE DESIGN MITIGATES INTER-ROW SHADING (LANDSCAPE)

Conventional Panel



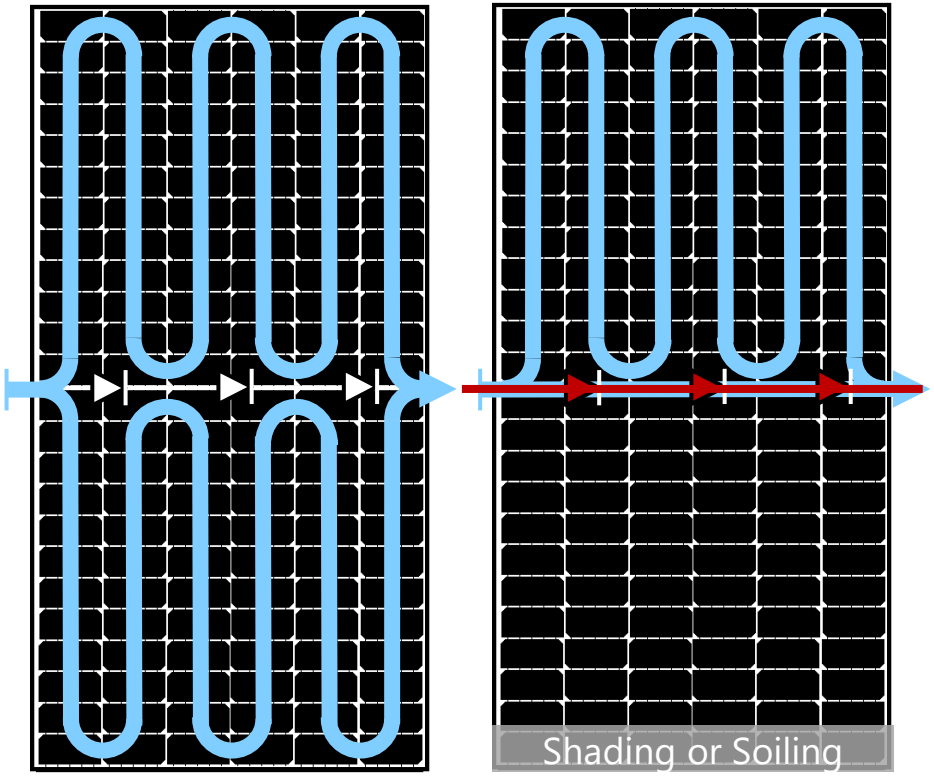
SUNPOWER | PERFORMANCE



UNIQUE DESIGN MINIMISES SHADING LOSS (PORTRAIT)

Conventional Panel

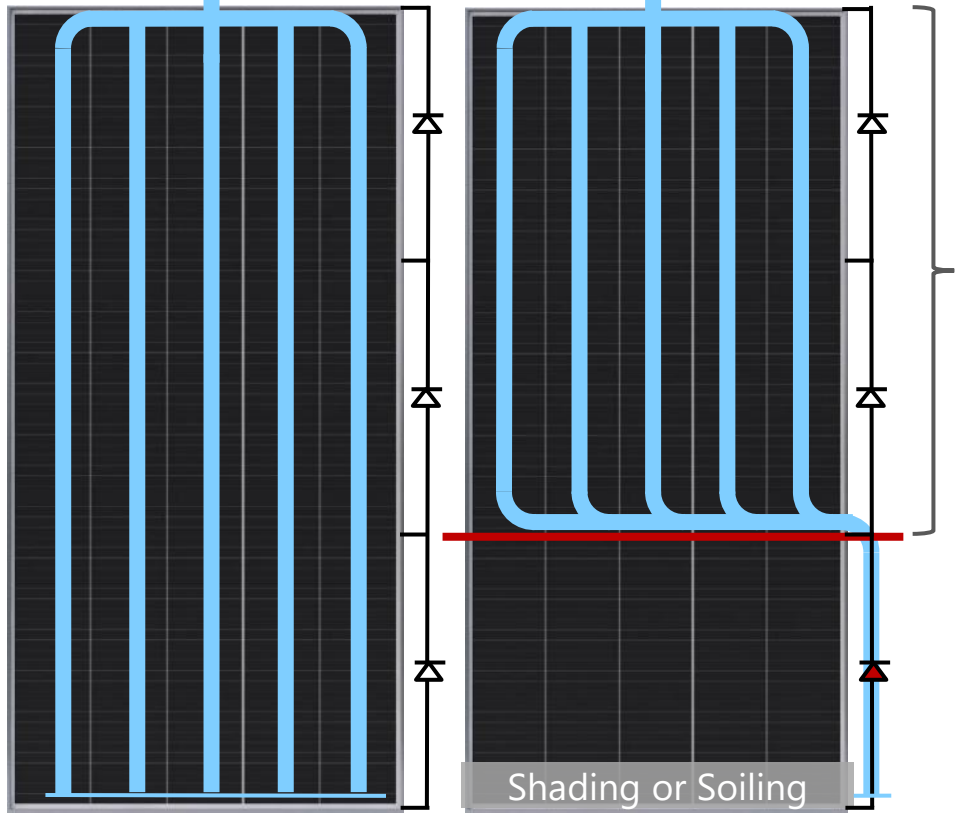
100% POWER → 50% POWER



50% power due to shade along the bottom

SUNPOWER | PERFORMANCE

100% POWER → 67% POWER



Retains 67% power with shade along the bottom

SUNPOWER PERFORMANCE PANEL LINE FEATURES

Performance 5 UPP (Utility and Power Plant)

SUNPOWER | PERFORMANCE 5

NEW Larger, full square G12 cells

NEW Bifacial power generation

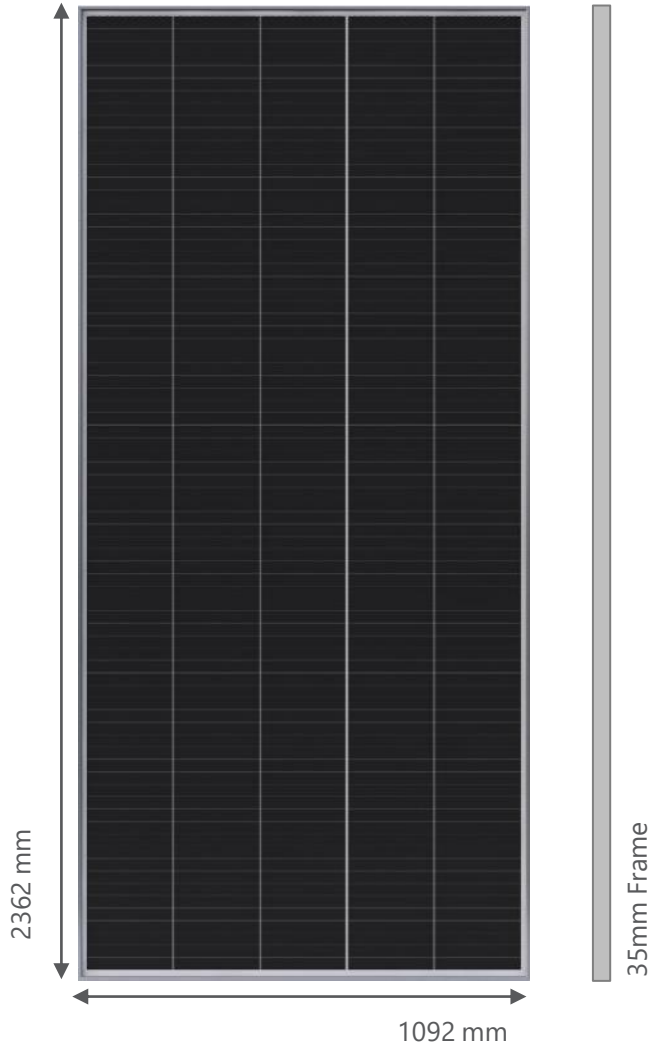
NEW Framed glass/glass construction

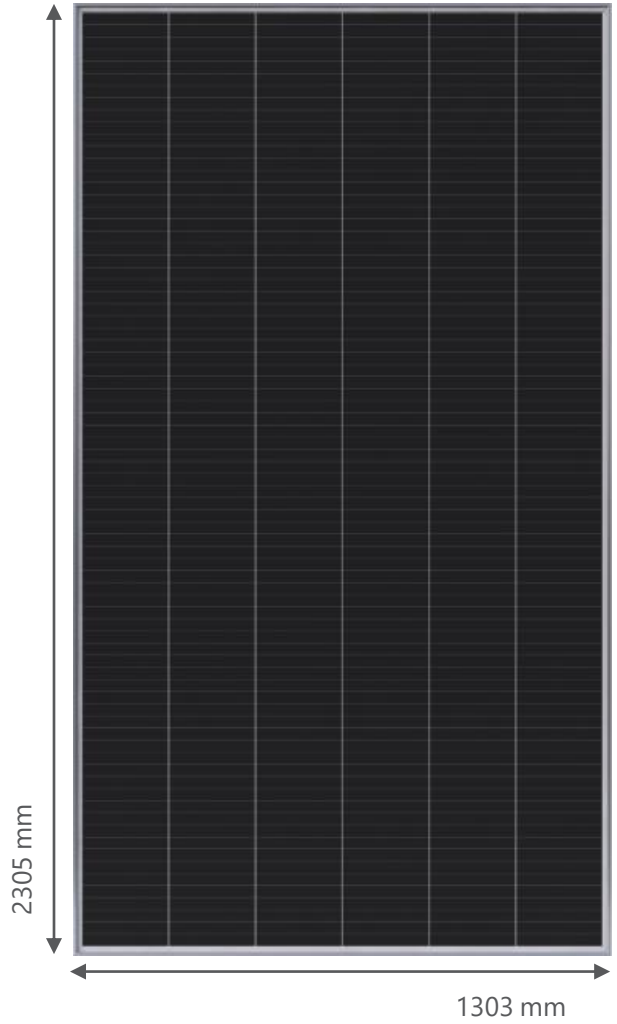
3 Junction boxes, 3 Diodes (1 each)

Warranty	P5 UPP
Power (years)	30
Start	98.0%
Deg rate	0.45%

Power
Up to 545 W

Efficiency
Up to 21.1%





Power
Up to 635 W

Efficiency
Up to 21.2%

terabase

Impacts of larger, more powerful solar panels

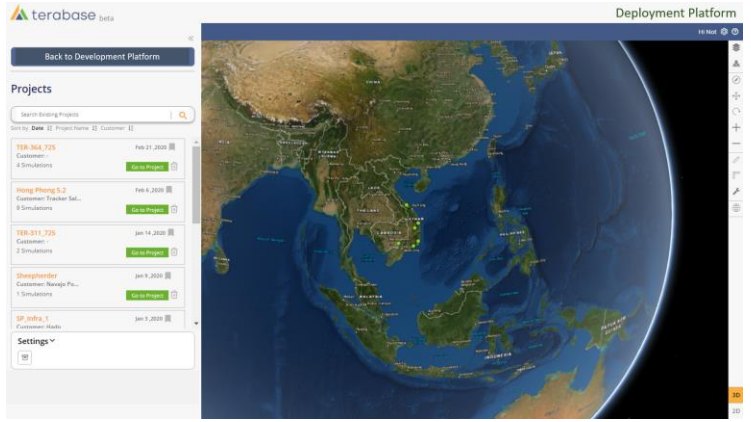
Pierre Gousseland
Co-Founder and VP for
Business Development & Partnerships
Terabase Energy

Terabase Energy

Terabase Energy is developing the digital & automated development and installation platform to achieve $0.01/kWh solar power by 2025

Significant momentum & milestones since launch early 2019:

1. IP and team spin-out of a major public solar company
2. Seasoned team with deep solar industry experience
3. $8M raised from leading cleantech investors
4. Platform Phase 1 released; 200+ companies registered in 25 countries
5. US DOE R&D grant awarded for construction automation
6. Headquartered in California with teams in EMEA and APAC



What we do:

1. **Development platform** – GIS & AI based design platform to assess technology/project fit and optimize projects
2. **Development phase services** – evaluation of complex engineering, technology, and financial parameters with the full project lifecycle in mind
3. **Engineering Services** – from conceptual to IFC drawings
4. **Procurement Services** – from supplier qualification to EPC tenders
5. **Deployment platform** – Logistics, fulfillment, QC & automated installation

Contact Info:
Pierre Gousseland
VP, Business Development & Partnerships, Co-Founder
pgousseland@terabase.energy

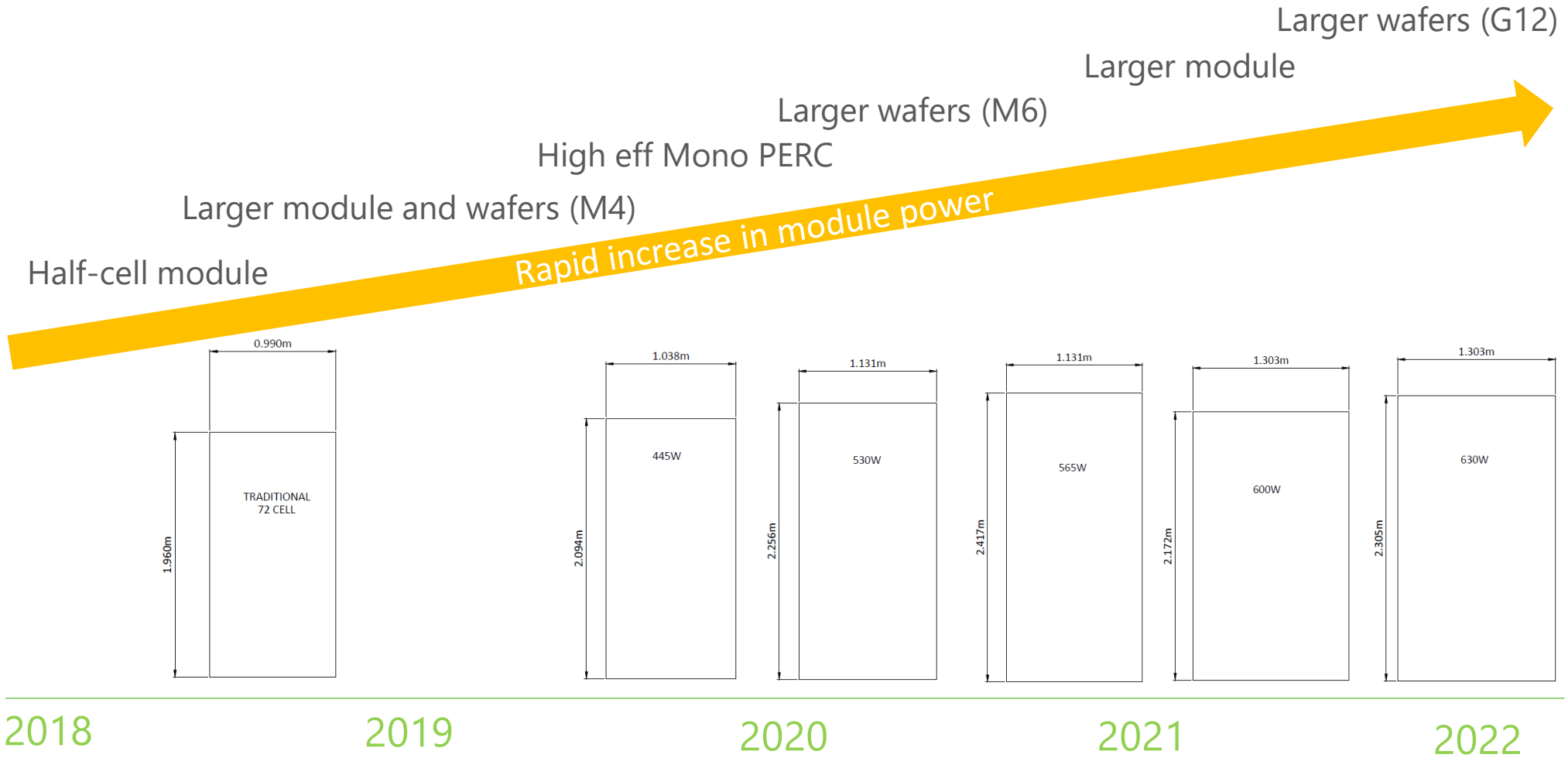
The 72-cell form factor

- Utility solar dominated by the 72-cell form factor for ~10 years
- Mounting and electrical systems optimized around this form factor
- Commoditization of utility solar panels facilitated by standard 72-cell design since:
  - Entire ecosystem from development to BOS to construction has been designed around it
  - Modules have been largely plug-compatible
- 72-cell module very rapidly becoming obsolete being replaced by half-cell or shingled bifacial panels in different form factors and increasing in size

72-cell panel

23kg

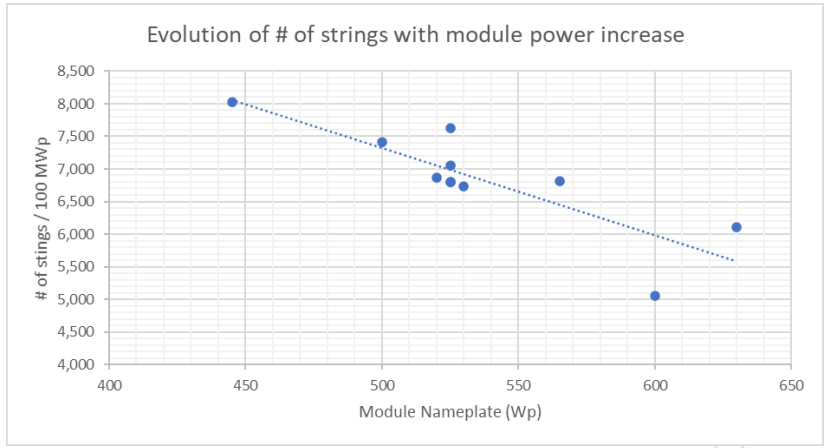
Utility Module Competitive Trends



System Levels Benefits and Trade-Offs

- Module Installation
  - **Installation unit cost increased** (by 0% to 20% depending on size, weight and installer) due to productivity loss from bigger/heavier modules; BUT
  - **Overall net positive due to lower module count**

- Electrical BOS Impacts
  - Cost of DC hardware is subject to the length (m) of the string; BUT
  - Higher string power resulting in **savings due to lower string count**
  - Potentially some hardware optimization required by string inverter manufacturers for higher current

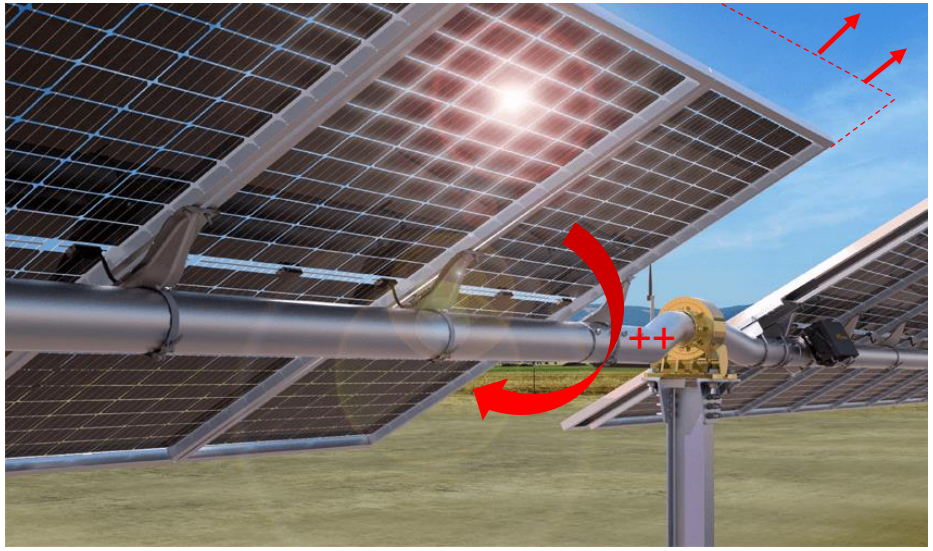


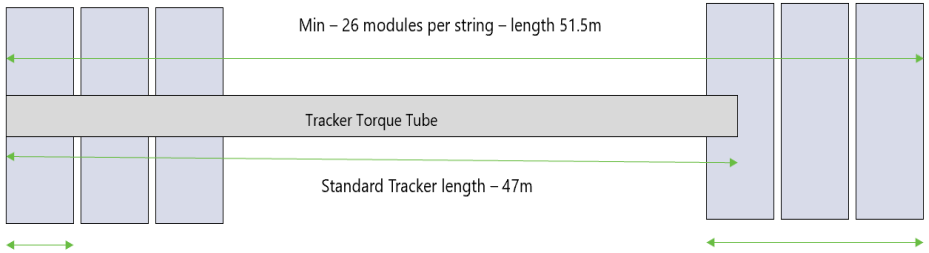
- Shipping Benefits
  - **Higher shipping density** in most cases but might vary based on form factor

Note: String lengths calculated based on a Min Site Temp of -20C

Mechanical Impacts to be Considered

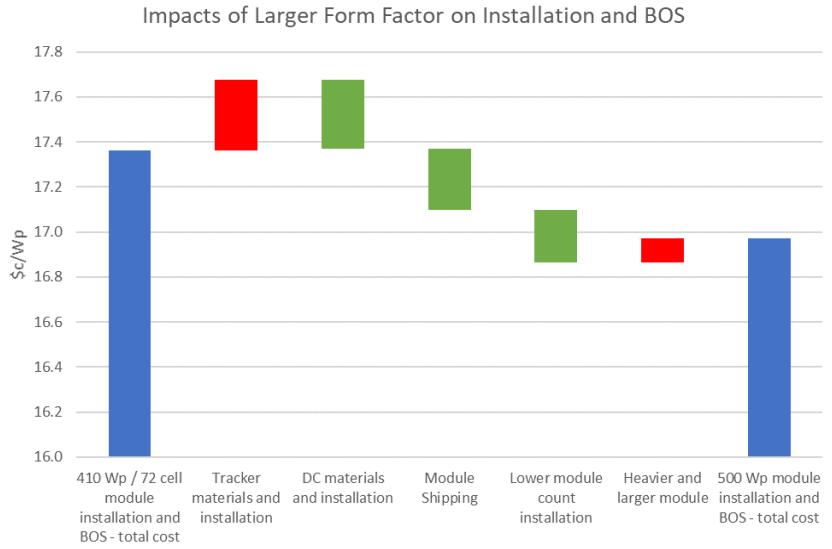
- Increased wind loads on racking due to bigger “sail area” and heavier modules:
  - May require more steel, increasing racking costs
  - May need to shorten tracker or reduce number of rows, decreasing total tracker power
  - For most trackers, increasing module width preferable as opposed to module length to reduce force on torque tube components
- Increased pile loading -> increase in pile length -> increase in material and potentially installation costs
- Published max tracker wind speed on datasheets based on traditional 72-cell modules. May be inadequate for larger form factors
- Optimal string length for wider modules may not exceed max allowable tracker length
- **Strong coordination with racking vendors** is needed and will address most of the above challenges



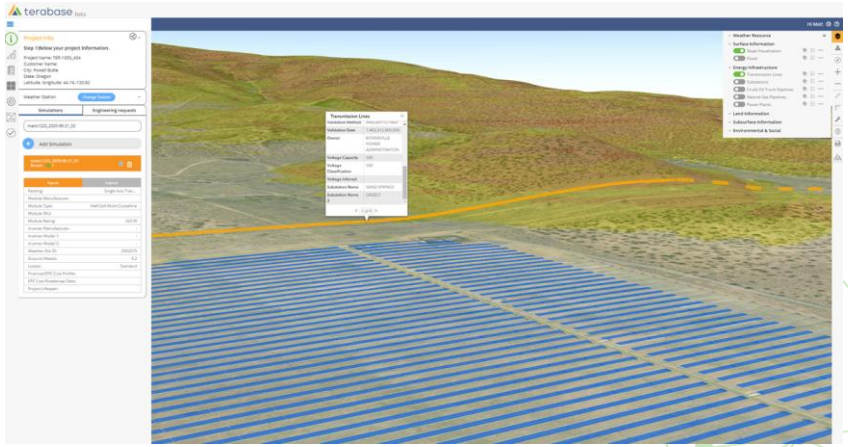


Impacts Summary

- Overall a **net positive impact on project LCOE**
- Benefit varying project by project. Need to **carefully assess the impact** on mechanical/electrical BOS and installation on a project specific basis
- Impacts to be further assessed and mitigated with racking suppliers and installers
- Some impacts to be further studied:
  - Do larger modules endure more stress during shipping, installation, operation causing PV modules reliability concerns? (e.g. microcracks)
  - Tracker wind tunnel test carried out with traditional 72-cell modules. Using larger form factor modules might lead to change in tracker natural frequency
- As the industry moves towards larger form factor modules, the careful qualification and selection of **compatible, high performance, high reliability PV modules** become **more critical than ever**.



Note: same efficiency for 410 and 500 Wp modules, based on project in Spain, based on 1P unganged tracker



Robert Chew
Application Engineer - Maxeon Solar Technologies

IS BIGGER ALWAYS BETTER? LET'S CRUNCH THE NUMBERS

SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

EXAMPLE CASE STUDIES

Project: 50MWp 1P & 2P Tracker

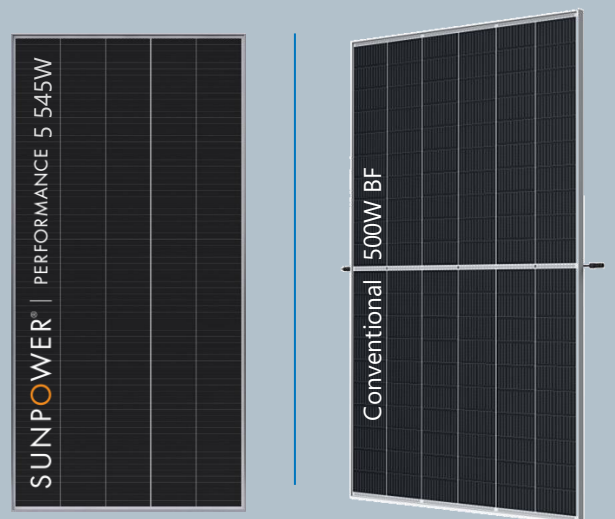
Site Albedo: 0.2 avg
GCR: 0.4

Inverter: SMA SC 4600 UP
PPA: Country Dependent
Discount Rate: Region Dependent
O & M Cost: $2.4-8k/MWp/Yr

Yield Simulation: PVSyst Ver7.XX

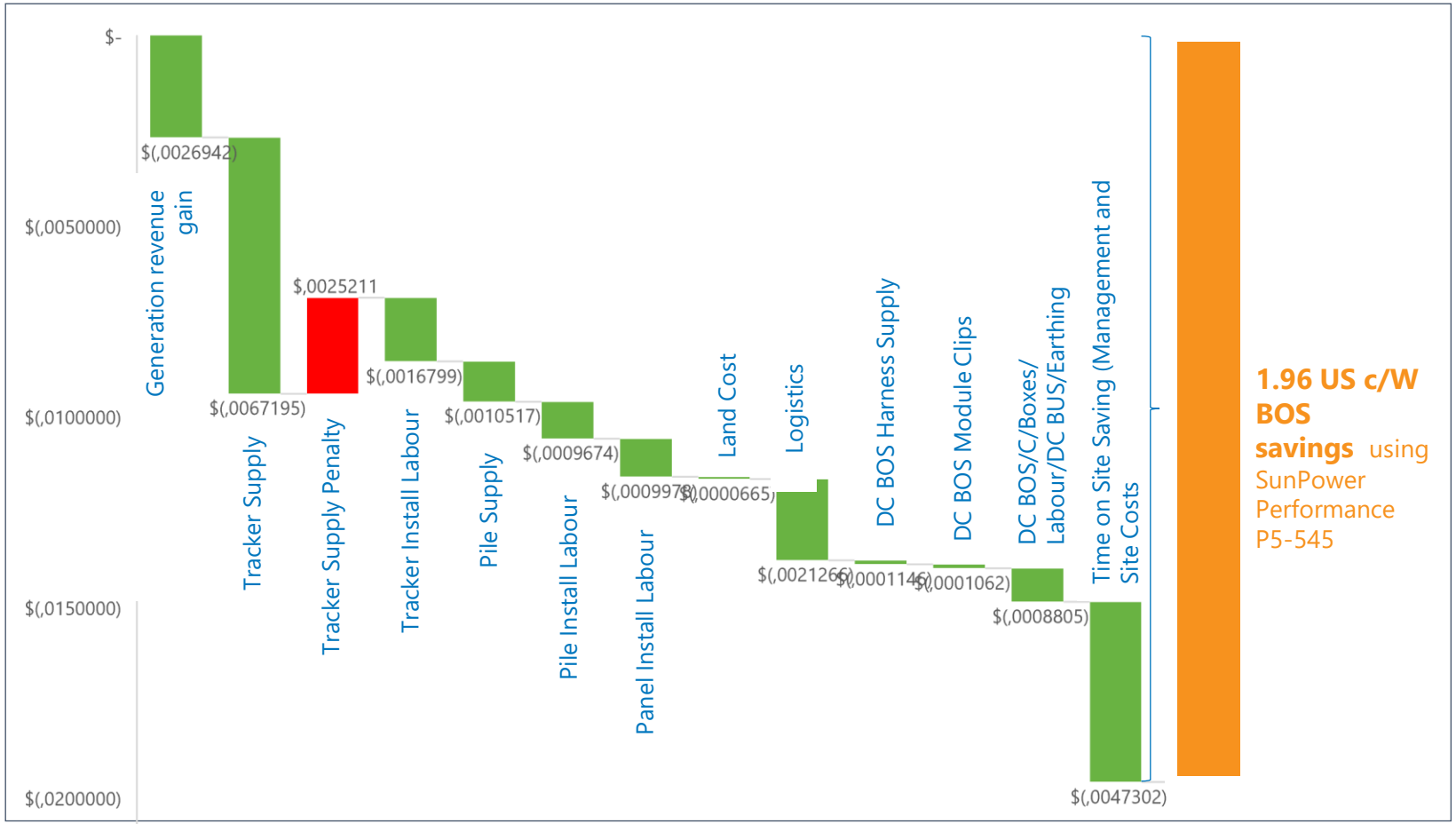
Inflation: Region Dependent

CASE STUDY 1: 50MW 2P TRACKER | VIETNAM

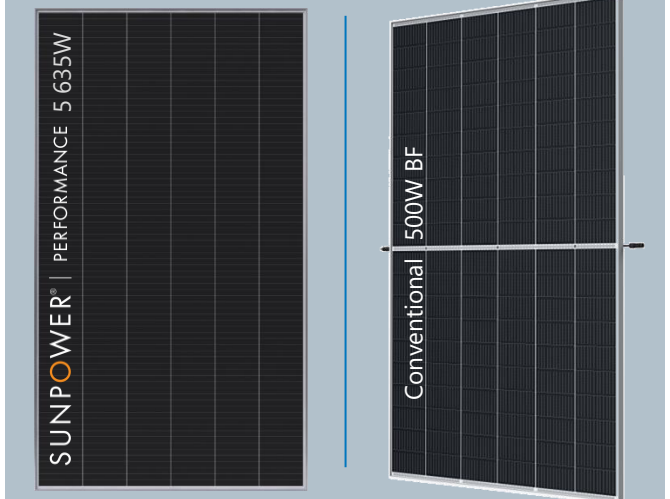


545W	Power (Front Side)	500W
26	Modules/String	28
3529	No. of Strings	3572
14.17	Power/string (kW)	14.00
91,754	No. of Modules	100,016
2042	Specific Yield (kWh/kWp)	2010
998	Tracker Power Density (W/m)	907

Understanding the balance of system reductions

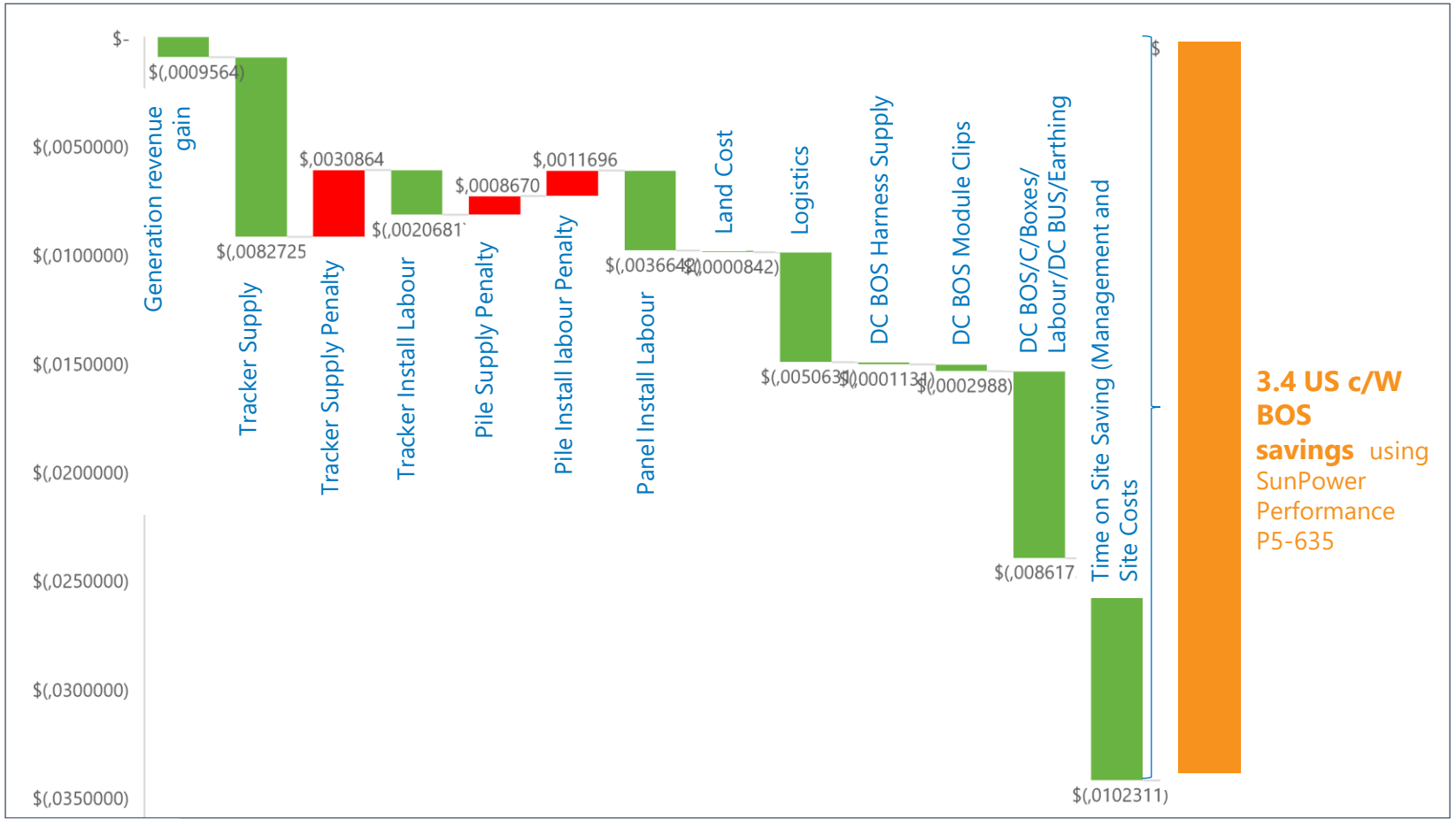


CASE STUDY 2: 50MW 1P TRACKER | AUSTRALIA

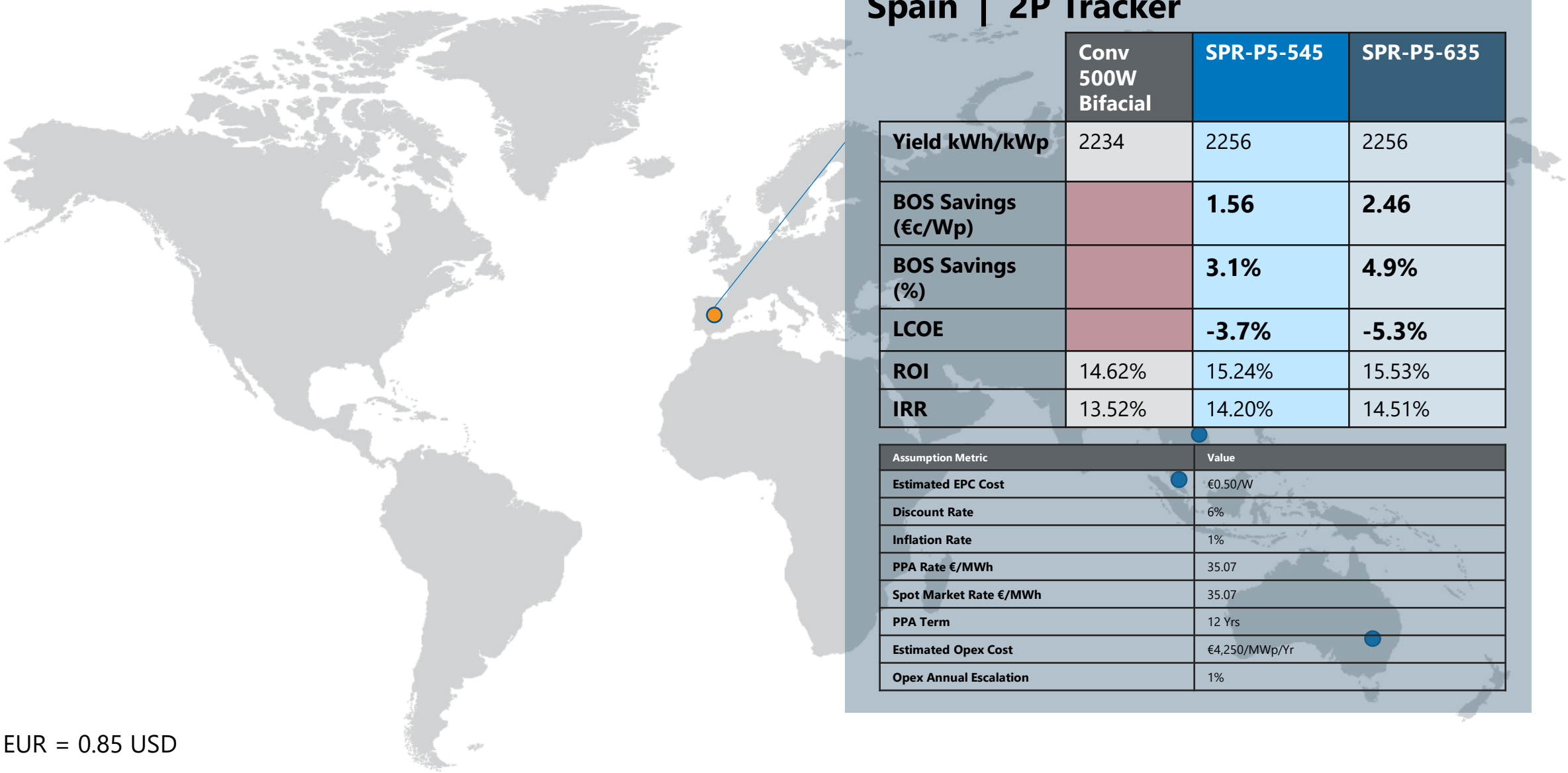


635W	Power (Front Side)	500W
27	Mod/String	28
2917	No. of Strings	3572
17.15	Power/string (kW)	14.00
78,759	No. of Modules	100,016
2042	Specific Yield (kWh/kWp)	2010
487	Tracker Power Density (W/m)	453

Understanding the balance of system reductions



CASE STUDY: 50MW SUMMARIES



Spain | 2P Tracker

	Conv 500W Bifacial	SPR-P5-545	SPR-P5-635
Yield kWh/kWp	2234	2256	2256
BOS Savings (€c/Wp)		**1.56**	**2.46**
BOS Savings (%)		**3.1%**	**4.9%**
LCOE		**-3.7%**	**-5.3%**
ROI	14.62%	15.24%	15.53%
IRR	13.52%	14.20%	14.51%

Assumption Metric	Value
Estimated EPC Cost	€0.50/W
Discount Rate	6%
Inflation Rate	1%
PPA Rate €/MWh	35.07
Spot Market Rate €/MWh	35.07
PPA Term	12 Yrs
Estimated Opex Cost	€4,250/MWp/Yr
Opex Annual Escalation	1%

* 1 EUR = 0.85 USD

CASE STUDY: 50MW SUMMARIES

Vietnam | 2P Tracker

	Conv 500W Bifacial	SPR-P5-545	SPR-P5-635
Yield kWh/kWp	2010	2048	2048
BOS Savings ($USc/Wp)		**1.96**	**2.98**
BOS Savings (%)		**3.4%**	**5.2%**
LCOE		**-4.8%**	**-6.4%**
ROI	23.64%	24.97%	25.44%
IRR	22.81%	24.19%	24.68%

Assumption Metric	Value
Estimated EPC Cost	$0.57/W
Discount Rate	10%
Inflation Rate	1.5%
PPA Rate $/MWh	70.90
Spot Market Rate $/MWh	25.00
PPA Term	20 Yrs
Estimated Opex Cost	$7,000/MWp/Yr
Opex Annual Escalation	1%

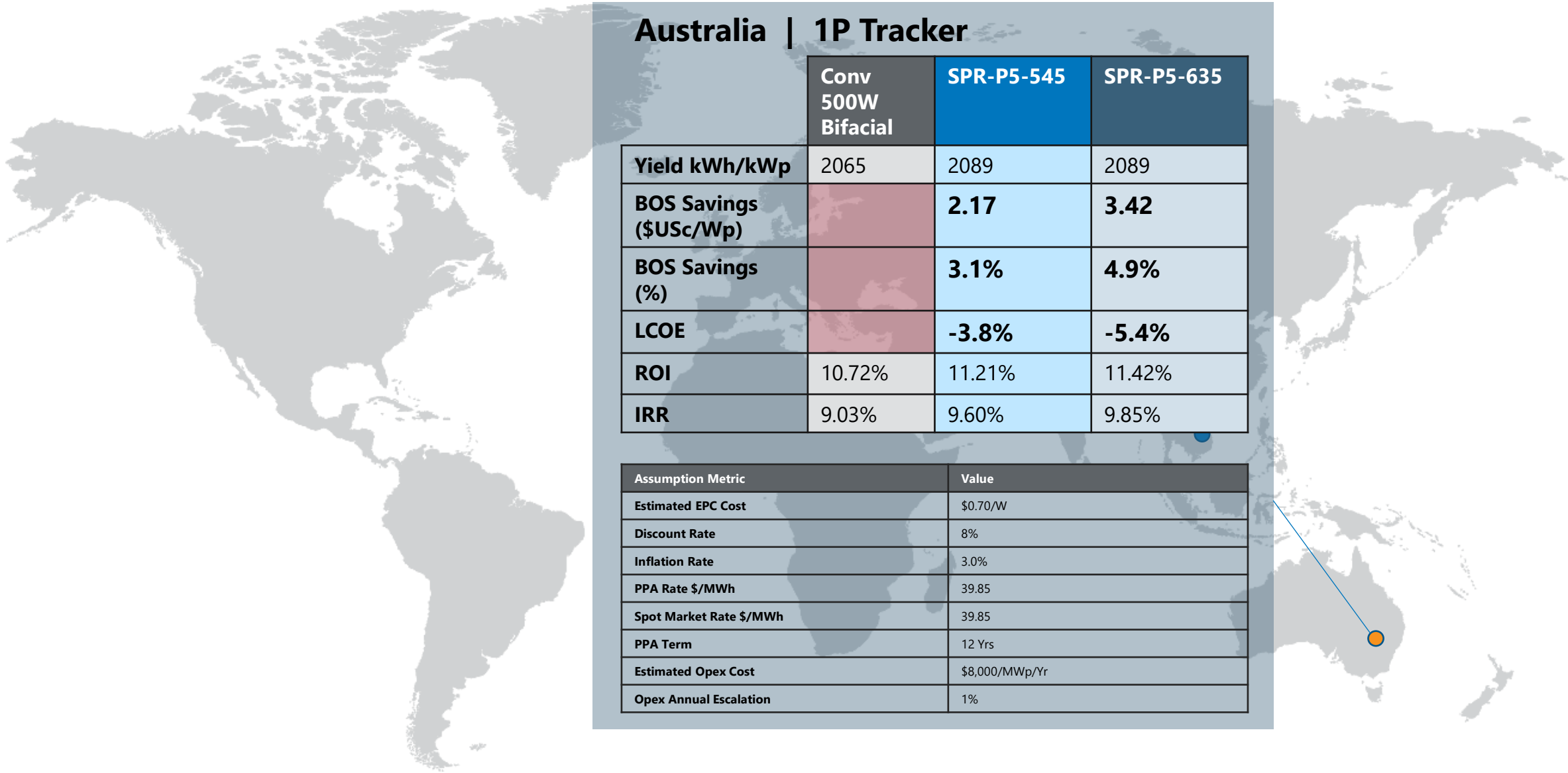
CASE STUDY: 50MW SUMMARIES

Malaysia | 2P Fixed Tilt

	Conv 500W Bifacial	SPR-P5-545	SPR-P5-635
Yield kWh/kWp	1537	1559	1559
BOS Savings ($USc/Wp)		**1.71**	**2.70**
BOS Savings (%)		**3.1%**	**4.9%**
LCOE		**-4.3%**	**-6.0%**
ROI	9.76%	10.22%	10.41%
IRR	7.96%	8.52%	8.76%

Assumption Metric	Value
Estimated EPC Cost	$0.55/W
Discount Rate	7%
Inflation Rate	3.0%
PPA Rate $/MWh	36.14
Spot Market Rate $/MWh	36.14
PPA Term	21 Yrs
Estimated Opex Cost	$2,400/MWp/Yr
Opex Annual Escalation	1%

CASE STUDY: 50MW SUMMARIES



Australia | 1P Tracker

	Conv 500W Bifacial	SPR-P5-545	SPR-P5-635
Yield kWh/kWp	2065	2089	2089
BOS Savings ($USc/Wp)		**2.17**	**3.42**
BOS Savings (%)		**3.1%**	**4.9%**
LCOE		**-3.8%**	**-5.4%**
ROI	10.72%	11.21%	11.42%
IRR	9.03%	9.60%	9.85%

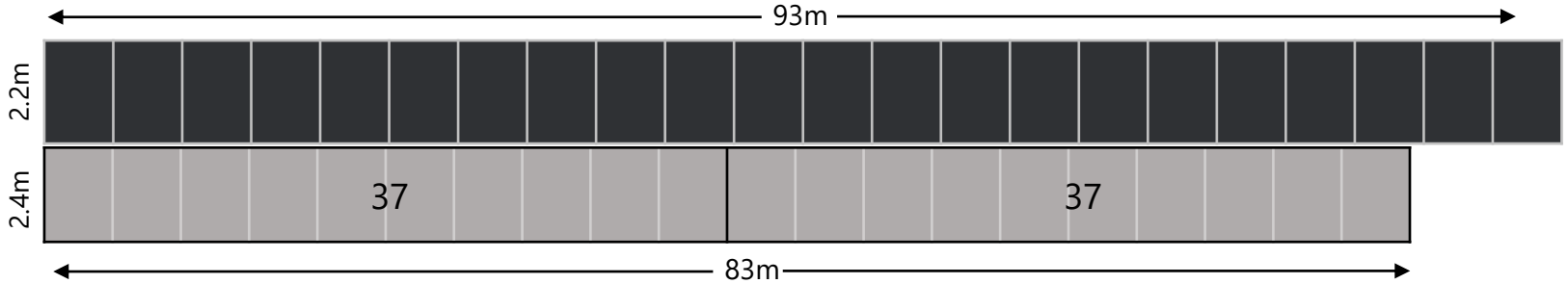
Assumption Metric	Value
Estimated EPC Cost	$0.70/W
Discount Rate	8%
Inflation Rate	3.0%
PPA Rate $/MWh	39.85
Spot Market Rate $/MWh	39.85
PPA Term	12 Yrs
Estimated Opex Cost	$8,000/MWp/Yr
Opex Annual Escalation	1%

TRACKER COMPATIBILITY

The keys to ensuring a high installed capacity per tracker

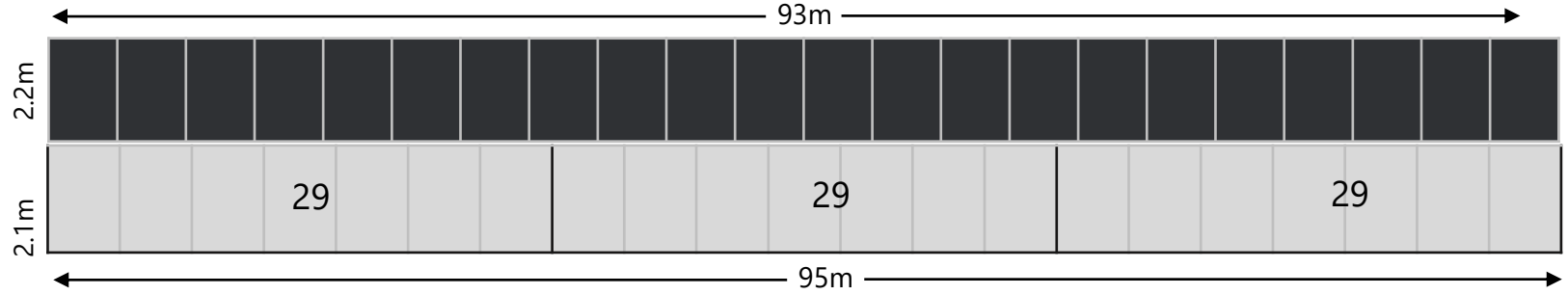
Optimal
1P Module Area: 215-220m2

G12 Cell: 540W typ



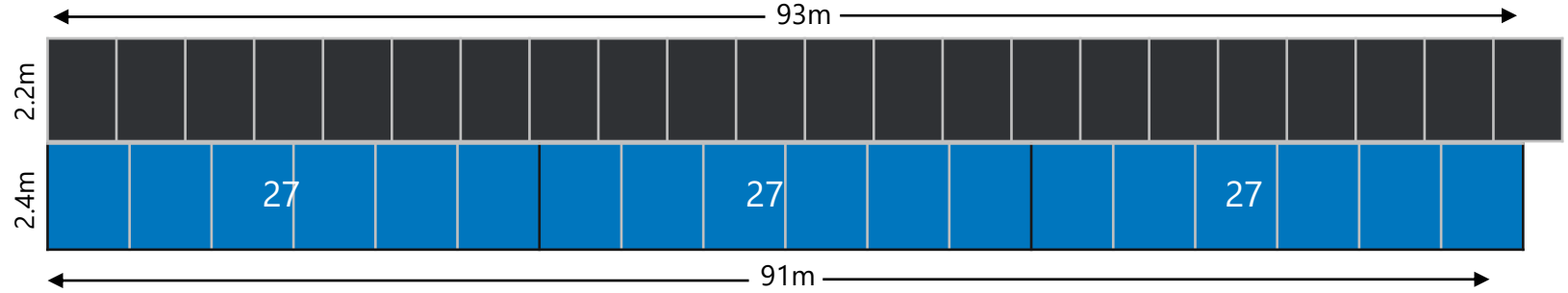
Module Area: 193m2
Power: 39.9kW
Imp: 17.2A
Ploss: 366W

G1 Cell: 445W typ



Module Area: 190m2
Power: 38.8kW
Imp: 10.8A
PLoss: 213W

SUNPOWER
P5-540W



Module Area: 209m2
Power: 42.1kW
Imp: 11.5A
PLoss: 229W

SUNPOWER | PERFORMANCE

CONCLUSION

THE BIGGER THE BETTER, DEPENDS ON DETAILED ASSESSMENT

Conclusion

Large form factor modules drive the balance of system costs down by:

- ☑ More power per module (We physically install modules not watts) - Less overall DC Strings.
- ☑ Reduced Tracker quantities and piles in most cases
- ☑ Reduced Logistical movements
- ☑ Reduced time on site (Less modules & trackers to install)

However, the level of BOS savings depends on:

- Individual assessment of each project site
- Tracker, BOS & Inverter full compatibility check
- Assessment of electrical losses
- OH&S

Reliability & Durability is Key:

- Large modules mean more force and movement. Maxeon Solar Technologies has engineered durability and reliability into their modules designs.

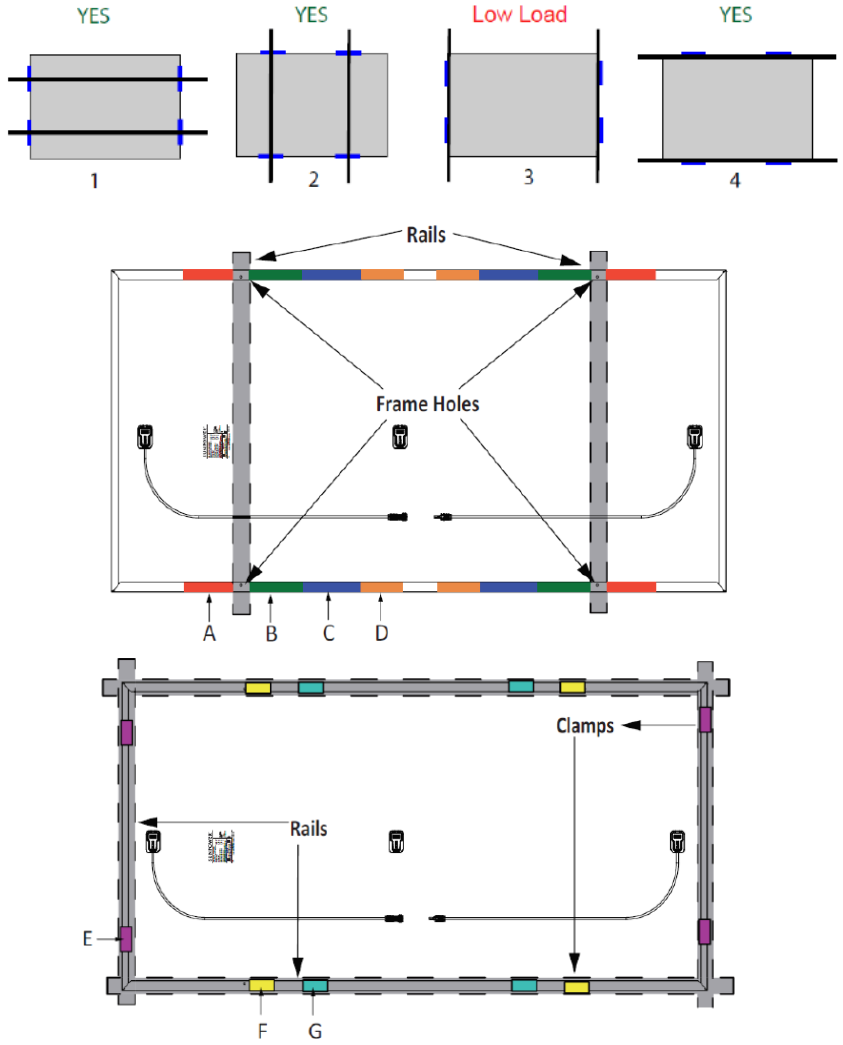
SUNPOWER

FROM MAXEON SOLAR TECHNOLOGIES

Thank You

MODULE LOADING & CLAMPING INFORMATION

Flexible mounting configurations



Allowable mounting configurations

Applicable Products	Mounting Zone	Distance from corner (mm)	Wind (up & down) / Snow(down) (units in Pa)[3]	Mounting Method
P3 UPP (2066 x 1160 x 35mm)	A	183-283	1600/2400	Clamp
	B	466-566	1600/3600[4]	
	D	783- 833	1600/1600	
	E	300-400	1600/1600	
	F	465-565	1600/2400	
	Frame Holes[2]	303	1600/3600	Bolt
		504		
		603		
		803		
P5 UPP (2362 x 1092 x 35mm)	C	540-640	1600/3600	Clamp
	G			

The table represents design loads at 1.5 Factor of Safety

SUNPOWER® | IBC Panels

Fundamentally different, and better.

#1 Solar Panel Efficiency[1]
in the market, fitting more energy in less space

#1 Lowest Degradation Rate
in the solar industry[2]

Leading Durability[2]
with a 40-year useful life[3]

Ultra-pure silicon on a patented copper foundation

1. Based on search of datasheet values from websites of top 20 manufacturers per IHS, as of January 2019
2. As of 2018, Jordan, et al, "Robust PV Degradation Methodology Application" PVSC 2018 and "Compendium of Photovoltaic Degradation Rates" PiP 2016
3. Performance panels expected useful life of 35 years. Source: "SunPower P-Series Technology Technical Review," Leidos Independent Engineer Report. 2016. SunPower Maxeon panels expected useful life of 40 years. Source: "SunPower Module 40-Year Useful Life," Useful life is 99 out of 100 panels operating at more than 70% of rated power
4. SunPower Performance P19 panels identified as top performers in the 2018 DNV GL PV Module Reliability Scorecard: https://www.dnvgl.com/publications/2018-pv-modulereliability-scorecard-117982.

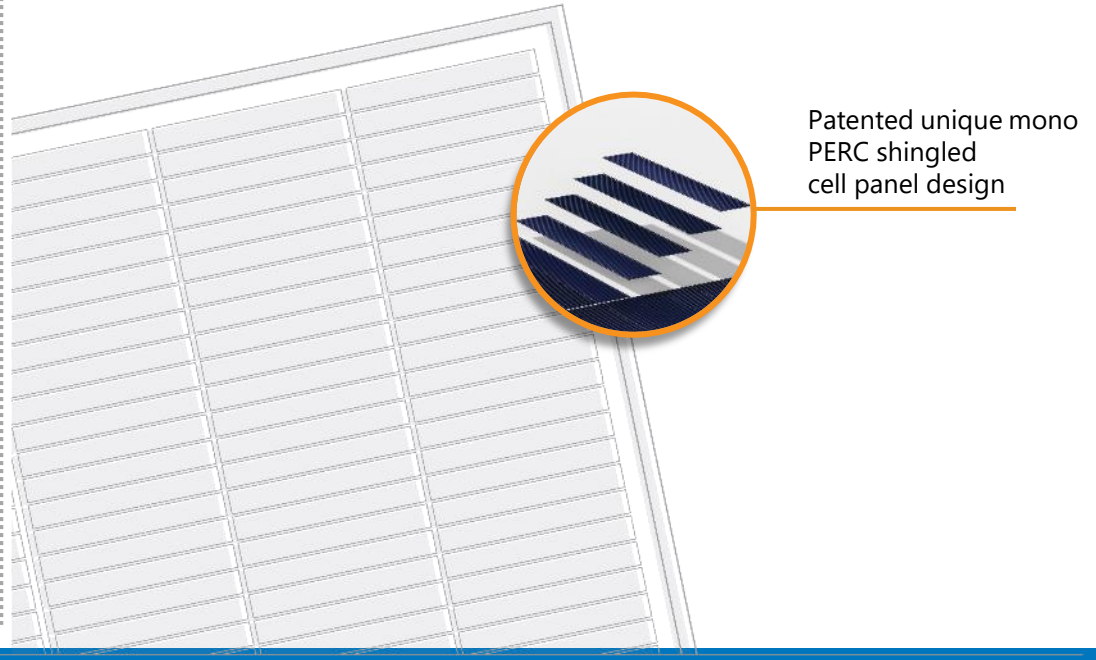
SUNPOWER® | Shingled Panels

Making the conventional, exceptional

Higher Efficiency at a Competitive Price
Patented technology, G12 wafers, China JV

Enhanced Energy Yield
Less soiling/shading loss (row spacing), bifacial, greater power density

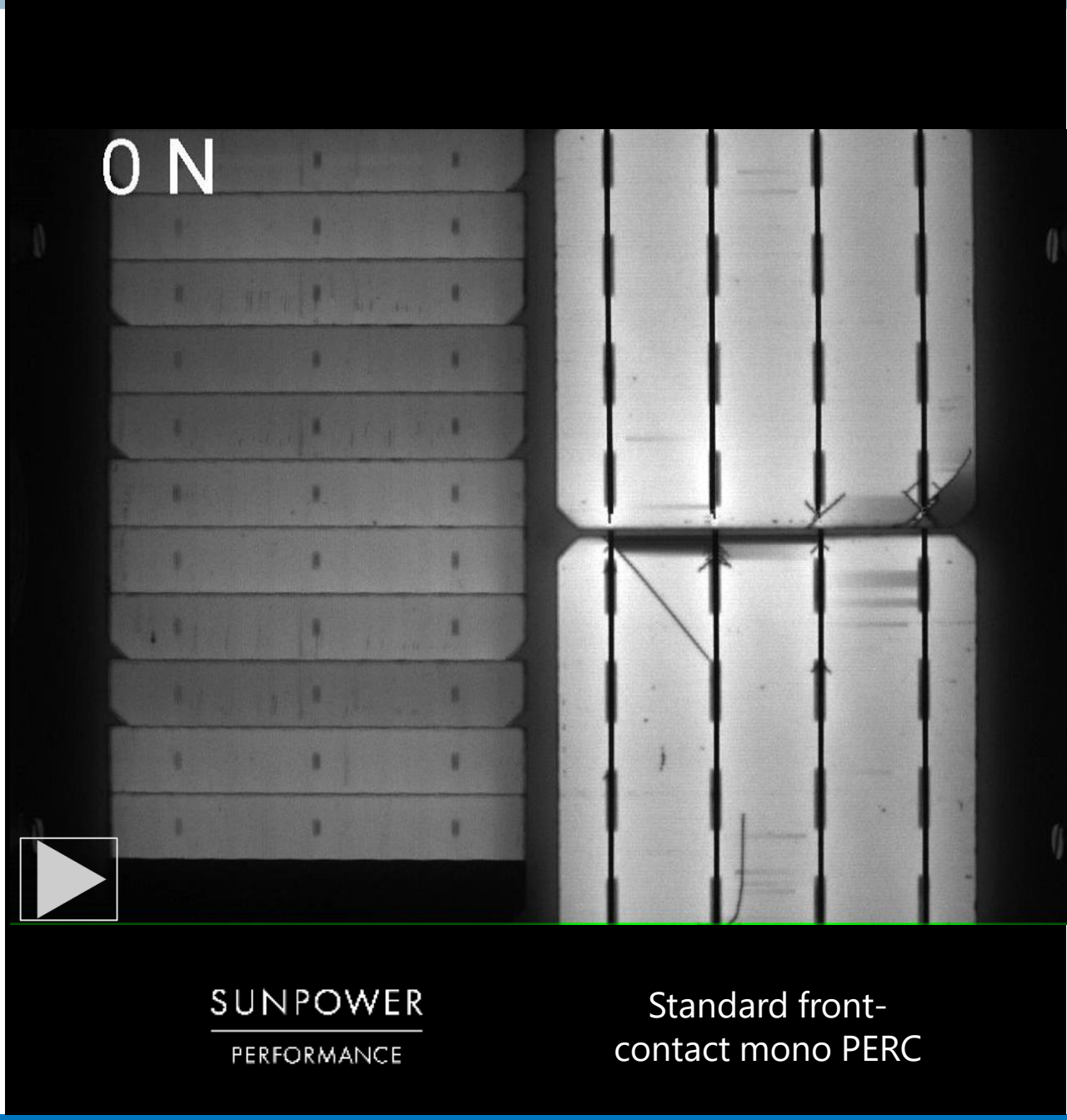
Reliability Advantages in Harsh Environments
Comprehensive warranty, top module reliability performer



Patented unique mono PERC shingled cell panel design

MINIMISING POWER LOSS FROM CELL DAMAGE

- Smaller cells are less susceptible to breakage and confine cell cracks to a smaller portion of the panel, maximizing energy generation
- These EL scans from a 4-point bend test at a mechanical load of nearly 400 N show no cracking in the Performance hypercell



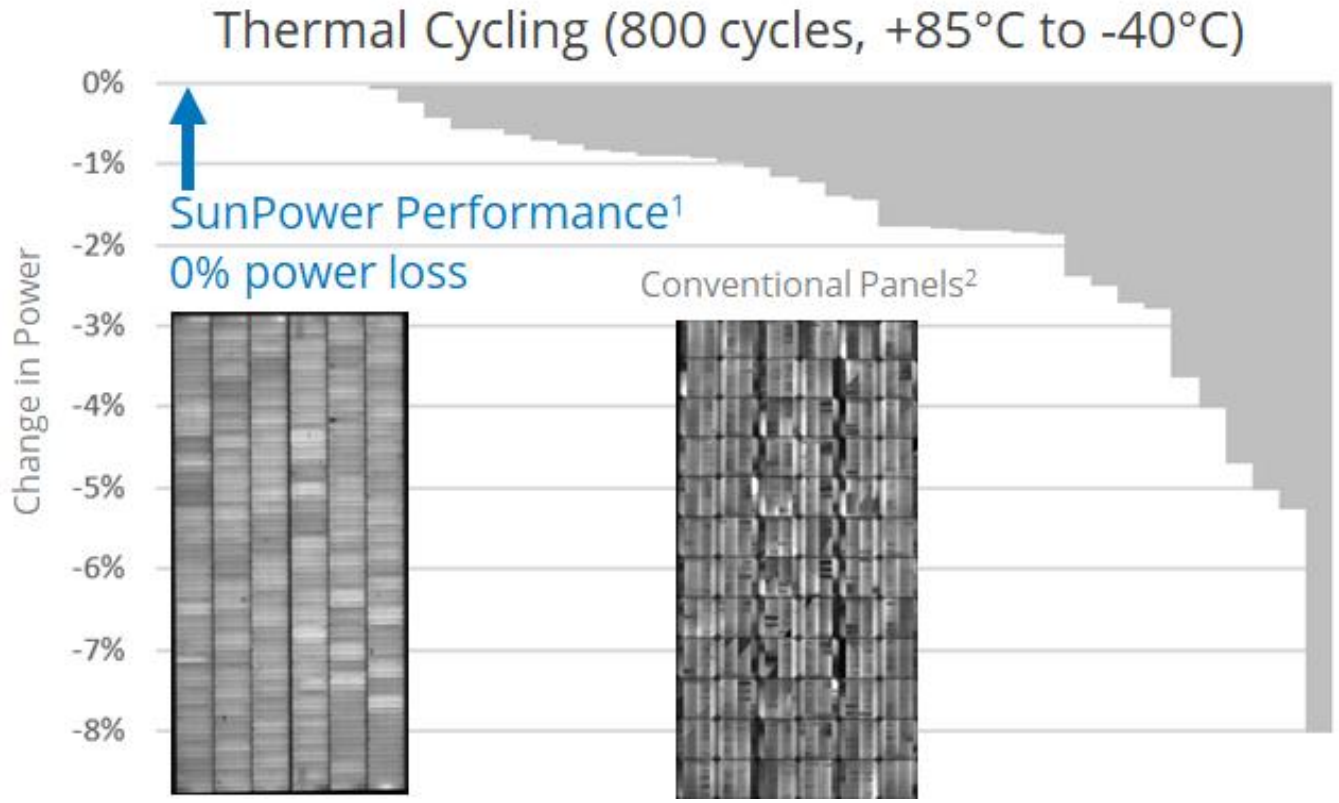
EL scans collected from internal SunPower laboratory testing of conventional front contact mono PERC cell stringing vs SunPower Performance panels; September, 2017.

STABLE CELL INTERCONNECTIONS UNDER THERMAL CYCLING

Third party validation

•Ribbon failure due to regular thermal cycles is a leading failure mode for Conventional Panels

•Performance Series uses a robust non-ribbon cell-to-cell connection to design this weak link out of the panel

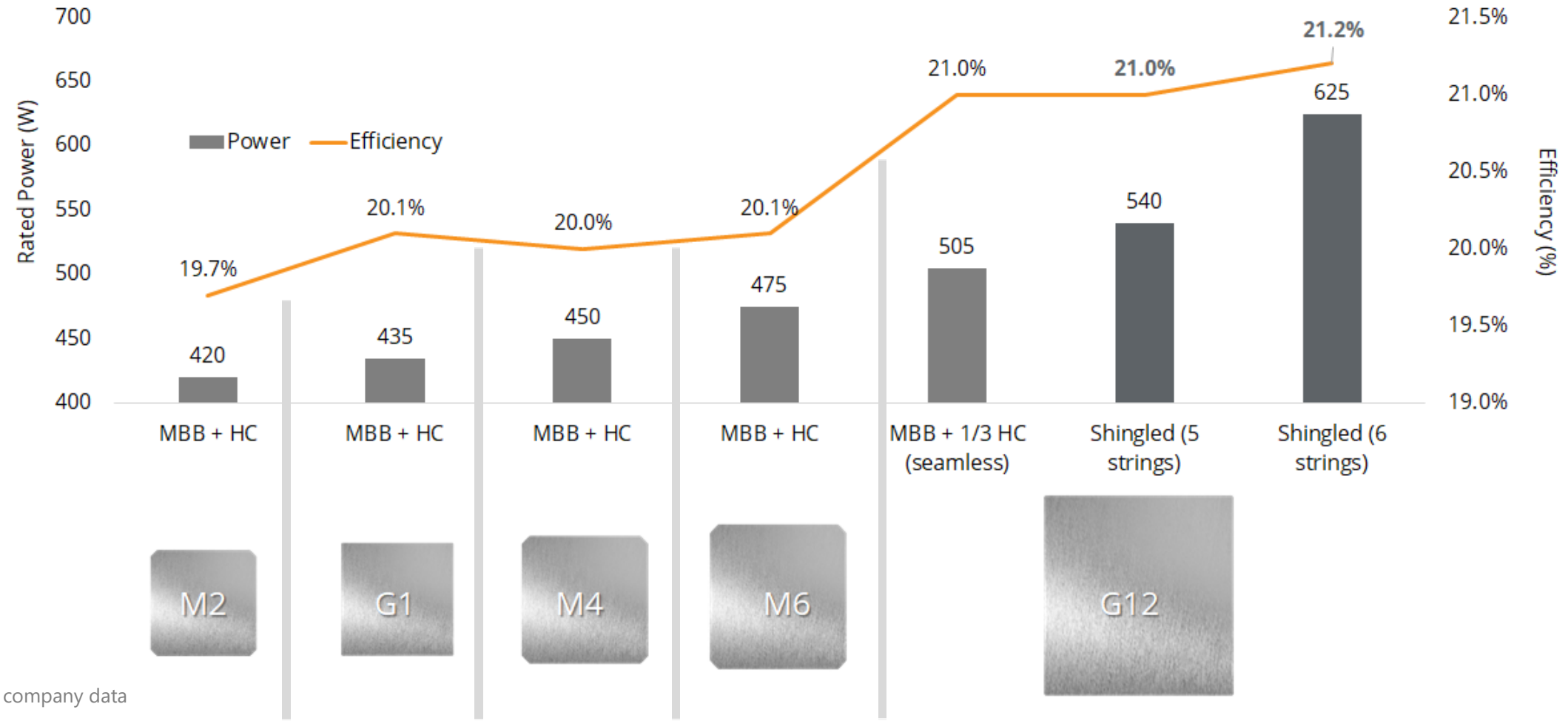


TOP PERFORMER 2018
DNV·GL
PV MODULE RELIABILITY SCORECARD

[1] DNV report R10051033J-2.
[2] PVEL Module Reliability Scorecard, 2019

G12 SHINGLED PANELS ENABLE HIGHER EFFICIENCY AND LOWER LCOE

G12 Shingled Panels vs Multi-Busbar (MBB) Cut Cell Panels (assuming equivalent efficiency mono-PERC cells)

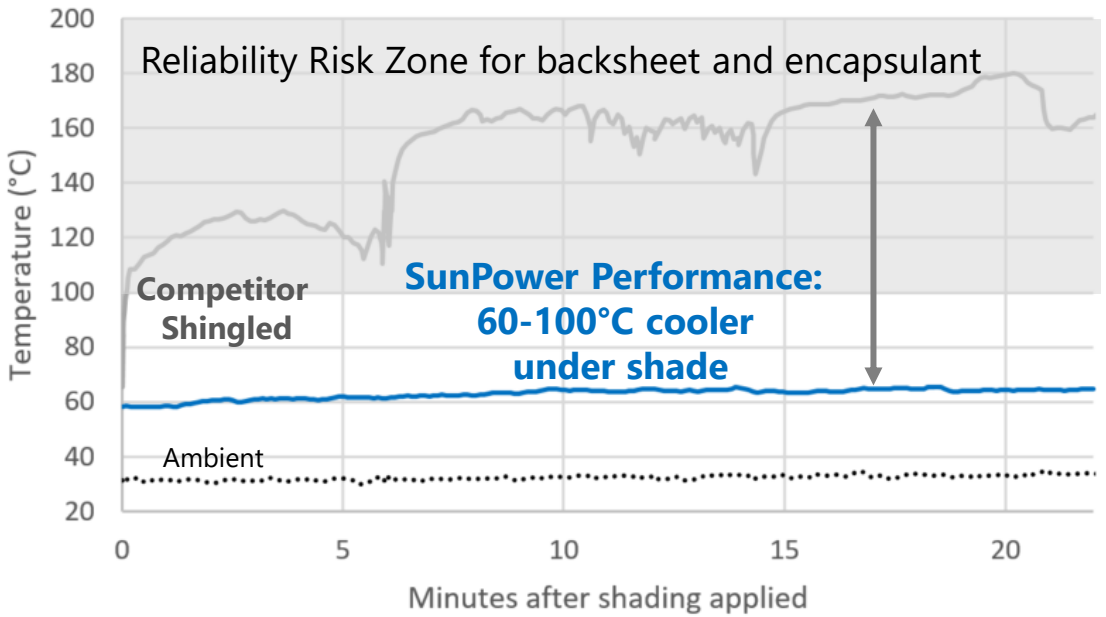


Source: Internal company data

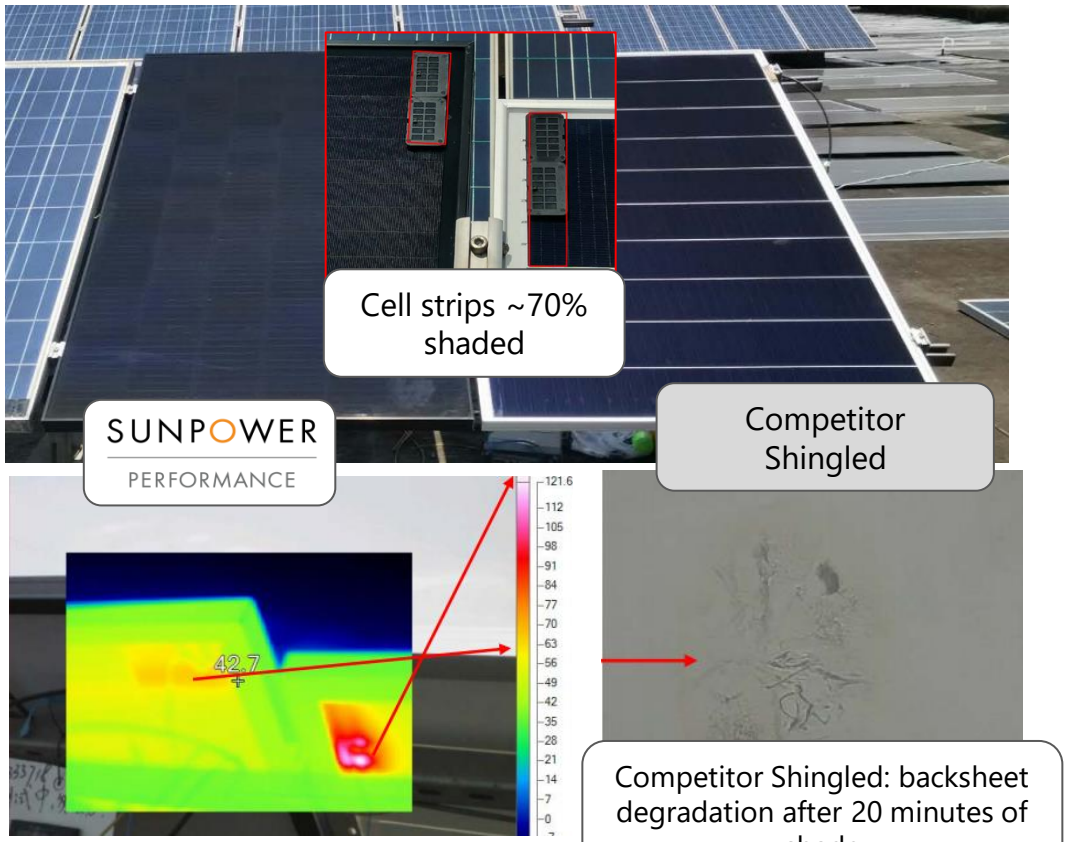
HOTSPOT PROTECTION THROUGH BETTER DESIGN

Performance panels reduce the risk of temperature-related failures through crack mitigation and unique circuitry.

Under severe cell cracking or worst-case shading conditions, Performance panels operate at **60-100°C lower temperature.**[1]



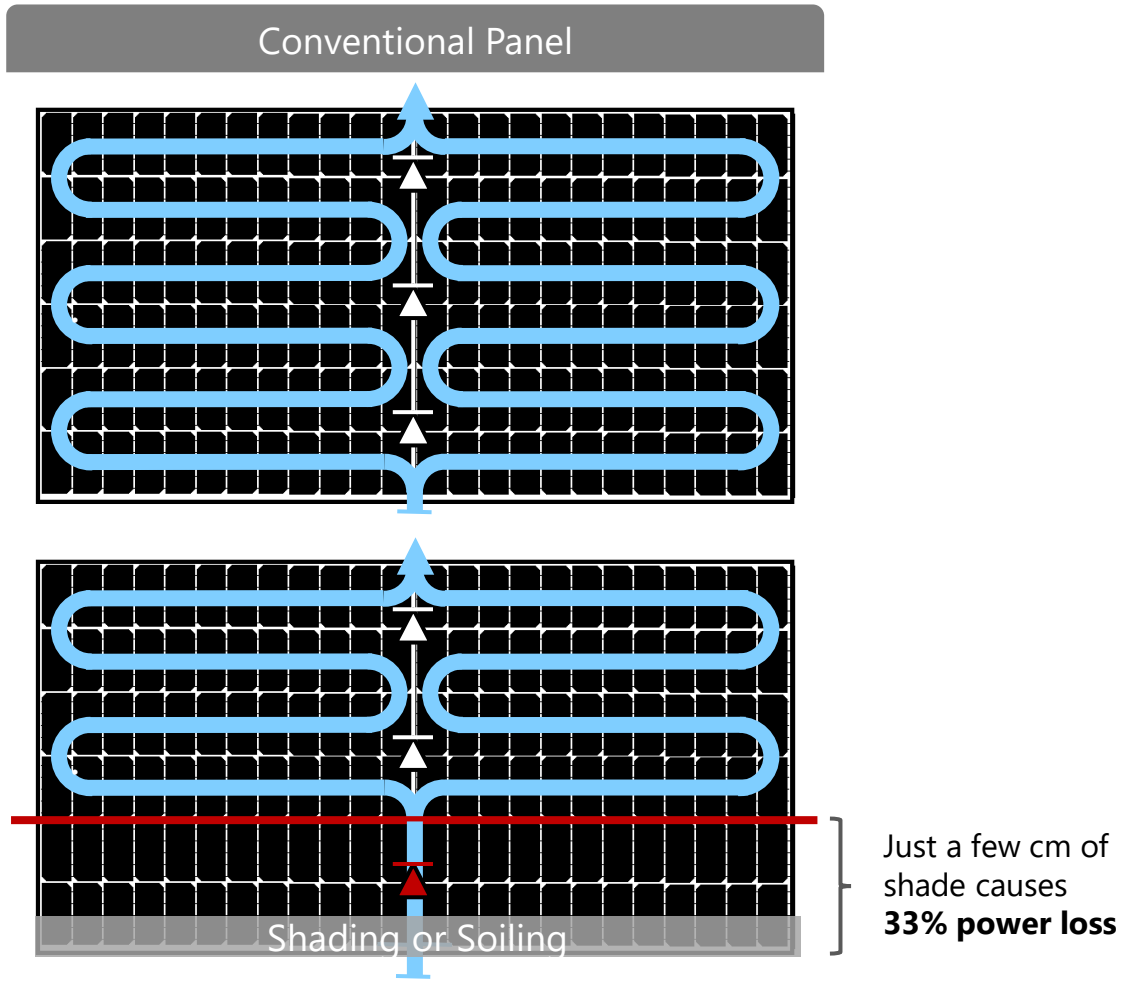
Test #2

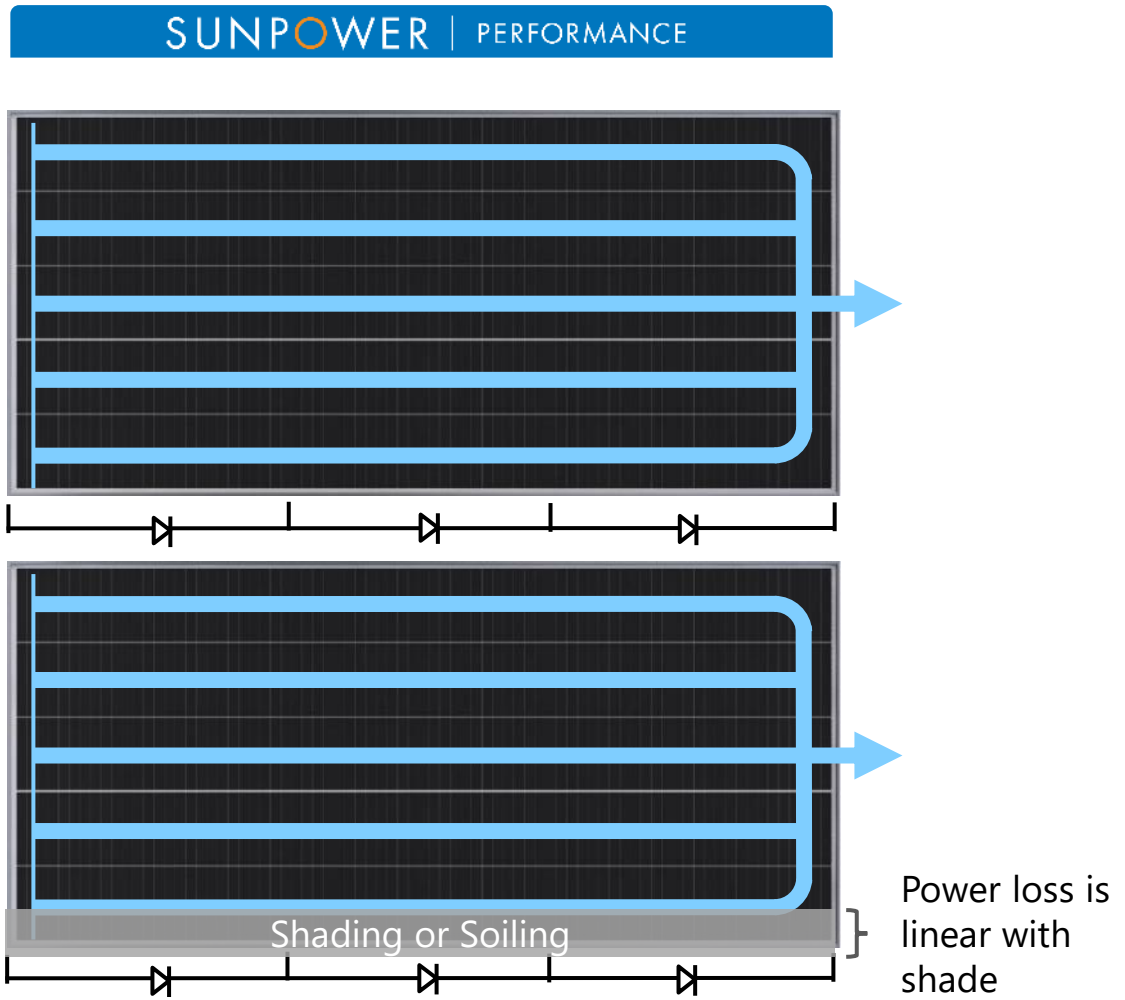


Competitor Shingled: backsheet degradation after 20 minutes of shade

[1] SunPower internal study, 2020..

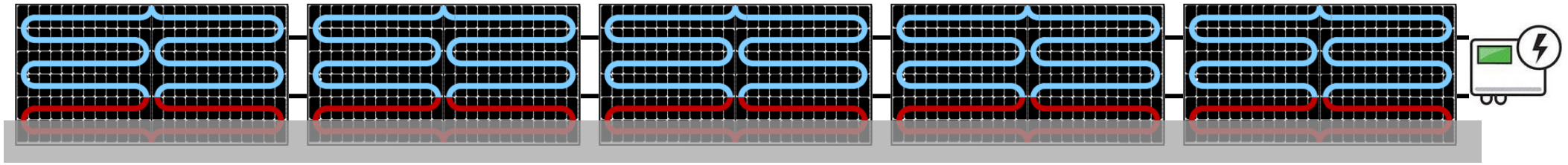
UNIQUE DESIGN MITIGATES INTER-ROW SHADING





SHADING IMPACT ON SYSTEM VOLTAGE (IN LANDSCAPE)

Conventional Panels



100% POWER

String voltage = 2/3

67% POWER

SUNPOWER | PERFORMANCE

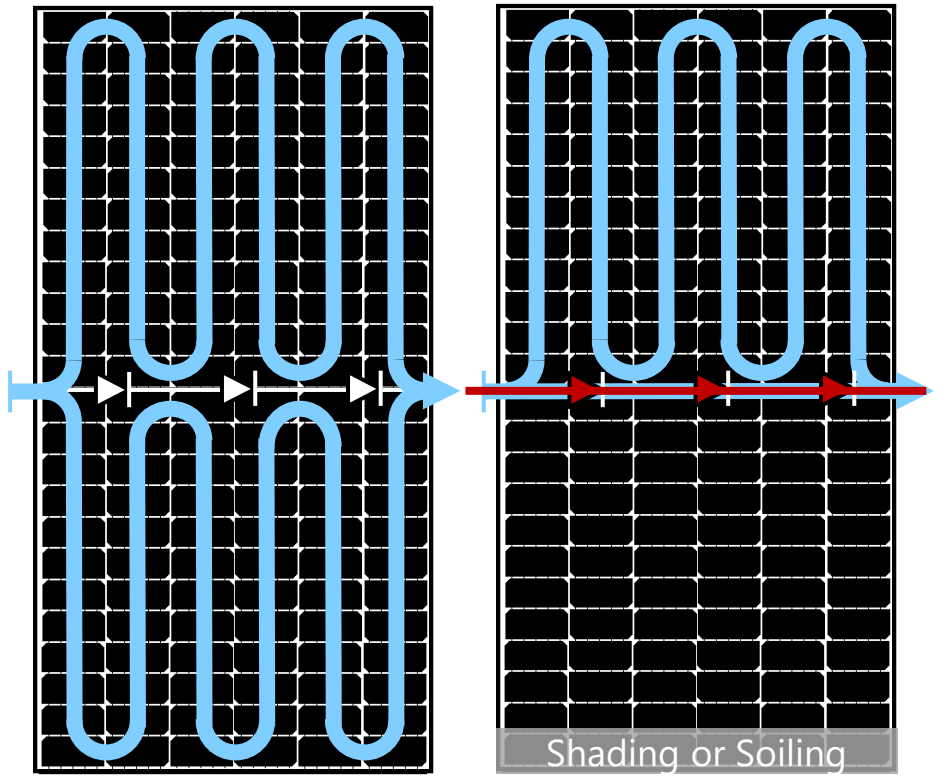
100% POWER

Voltage is unaffected

80% POWER

INTER-ROW SHADING IN PORTRAIT ORIENTATION

Conventional Panel



50% power due to shade along the bottom

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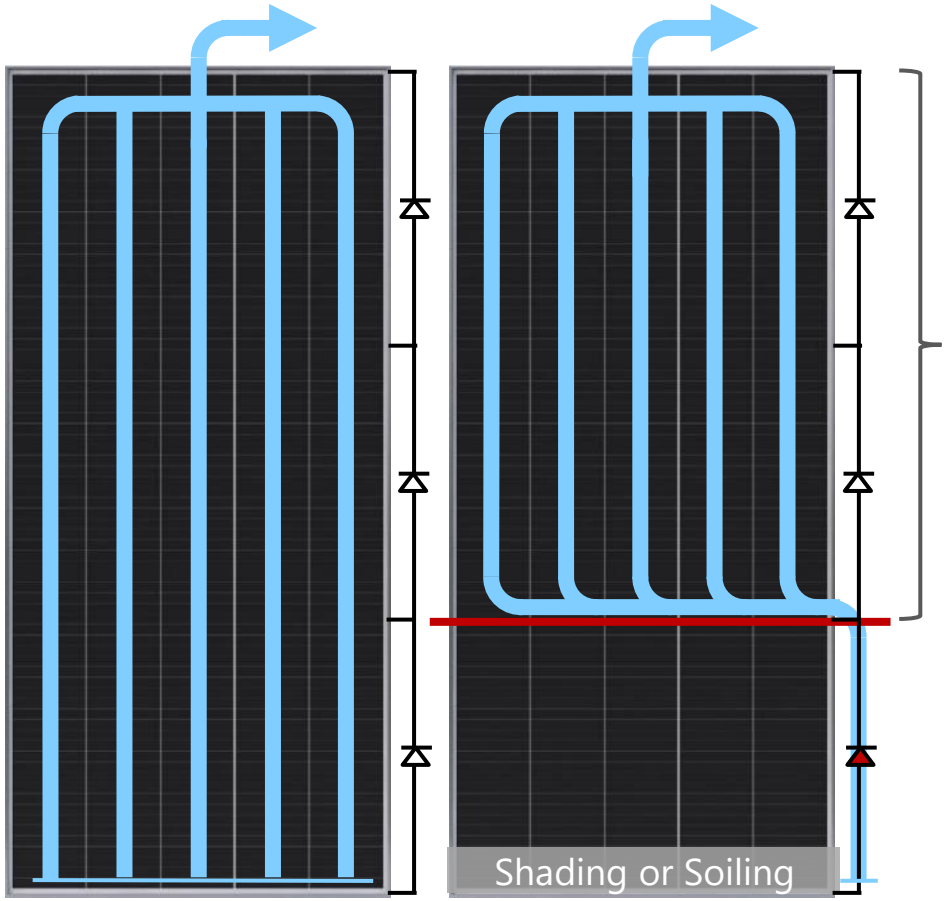
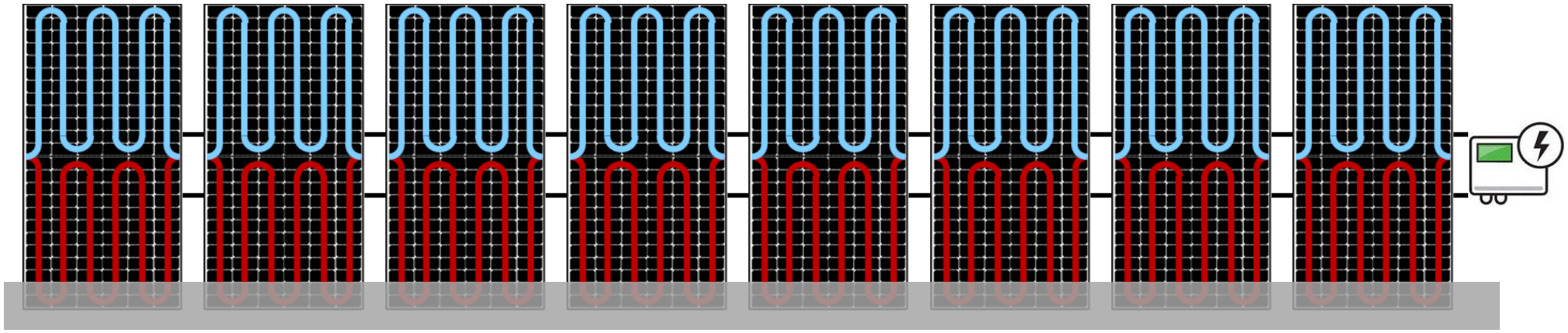


Retains 66% power with shade along the bottom

SHADING IMPACT ON SYSTEM VOLTAGE (IN PORTRAIT)

Conventional Panels

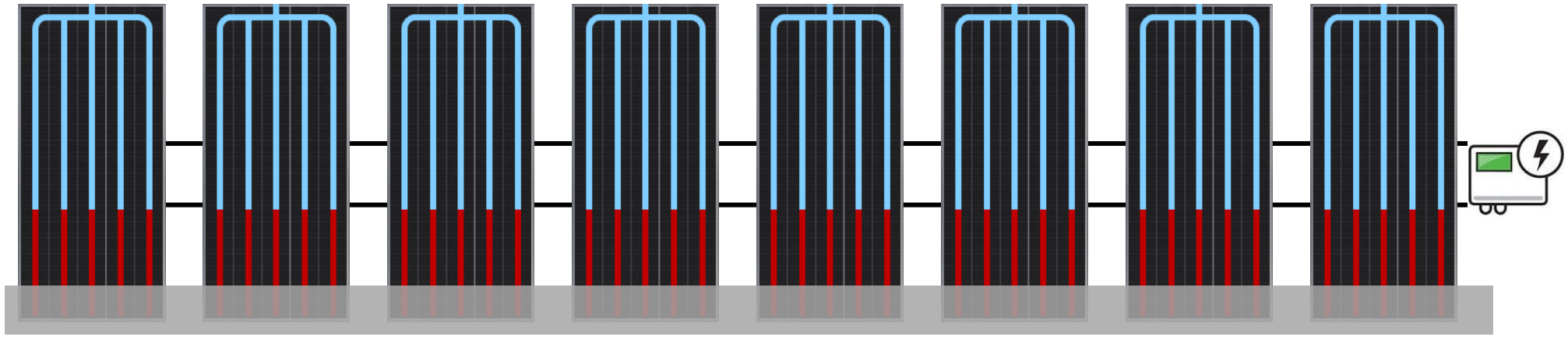


100% POWER

String voltage = 1/2

50% POWER

SUNPOWER | PERFORMANCE

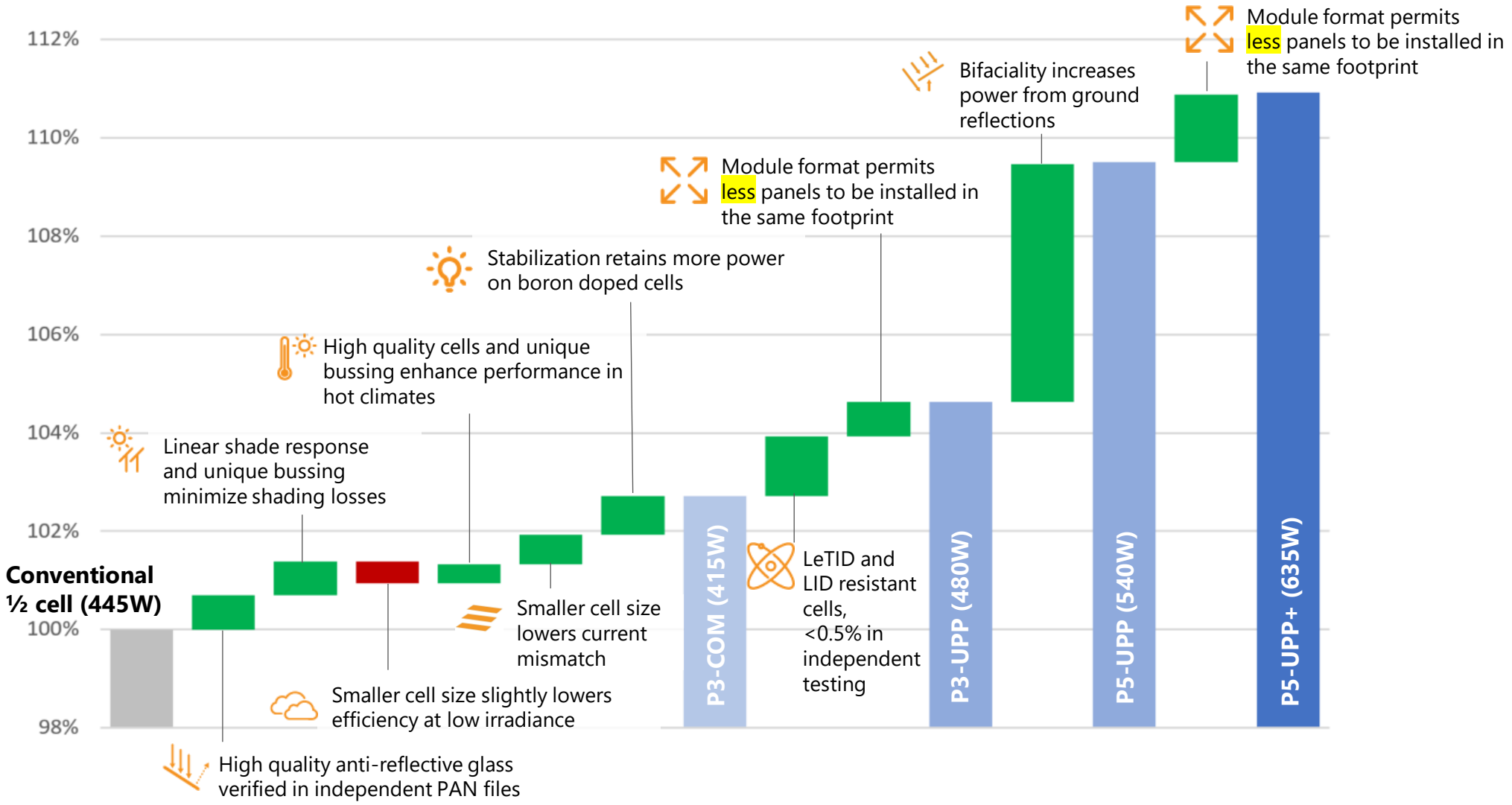


100% POWER

String voltage = 2/3

67% POWER

DESIGNED WITH ENERGY YIELD IN MIND



[1] Compared to a Conventional ½ cell mono-PERC 445 panel using PVSyst model of a 50MW 2P tracker site with 0.4 GCR and 0.2 albedo in Vietnam. Other locations, including EMEA and APAC indicate a range of 2-12%.

DESIGN INFORMATION

Tracker compatibility

Tracker	P3-UPP	P5-UPP
Arctech 1P	✓	✓
Arctech 2P	✓	✓
ATI 1P	✓	✓
FTC Solar Voyager	✓	✓
Gamechange 1P	✓	✓
Gamechange 2P	✓	✓
Ideematec H4	✓	✓
NXT Gemini 2P	✓	✓
PV Hardware 1P	✓	✓
PV Hardware 2P	✓	✓
Soltec SF7 2P	✓	✓

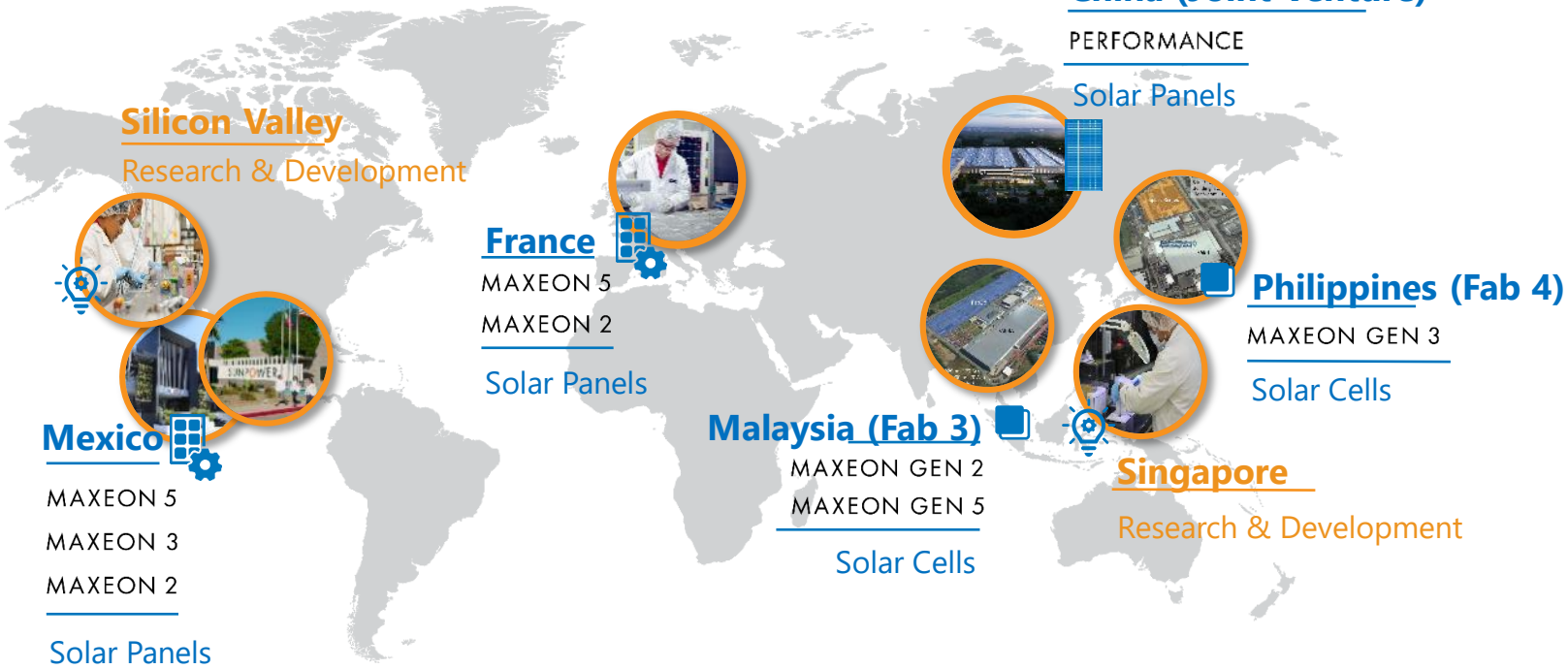
Compatibility subject to final review by EPC/tracker OEM.

SunPower is actively engaged with suppliers to provide compatibility for P5-UPP+ (600W+).

OUR GLOBAL FOOTPRINT
A Leader in Global Solar Innovation

We design and build industry-leading[1] **SunPower solar cells and panels.**

Global Development & Manufacturing Locations
Maxeon Solar Technologies, Ltd.



[1] SunPower Maxeon line solar panels have the #1 efficiency among commercialized solar panels. Based on datasheet review of websites of top 20 manufacturers per IHS, as of Jan. 2020.