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SunPower™ Solar Panels

Reliability, Production, Efficiency, Sustainability

July, 2015

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SunPower solar panels are different.

SunPower solar panels are better.

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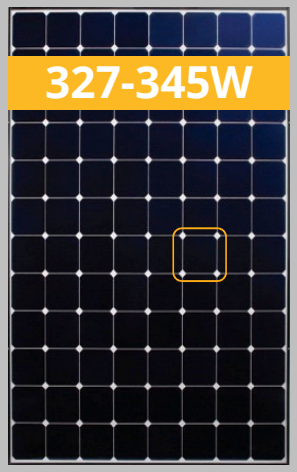
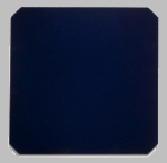
The Heart of the SunPower Panel is the Maxeon™ Solar Cell

- The Maxeon cell has a fundamentally different design from a Conventional Cell: it's built on a solid copper foundation
- Copper plated solar cells cost more to manufacture than Conventional Cells, but the investment pays off with a much more reliable and high-performing solar cell.
- SunPower starts with a tough, durable copper foundation – the Conventional Cells are made by baking a metal paste onto the silicon wafer – just like screen-printing a logo onto a T-shirt.[1]

SunPower Panel with Maxeon

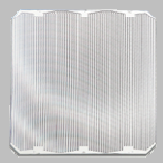


FRONT



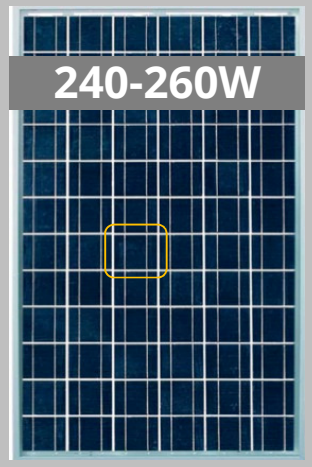
No metal

BACK



Copper-plated

Conventional Panel (same size)



FRONT

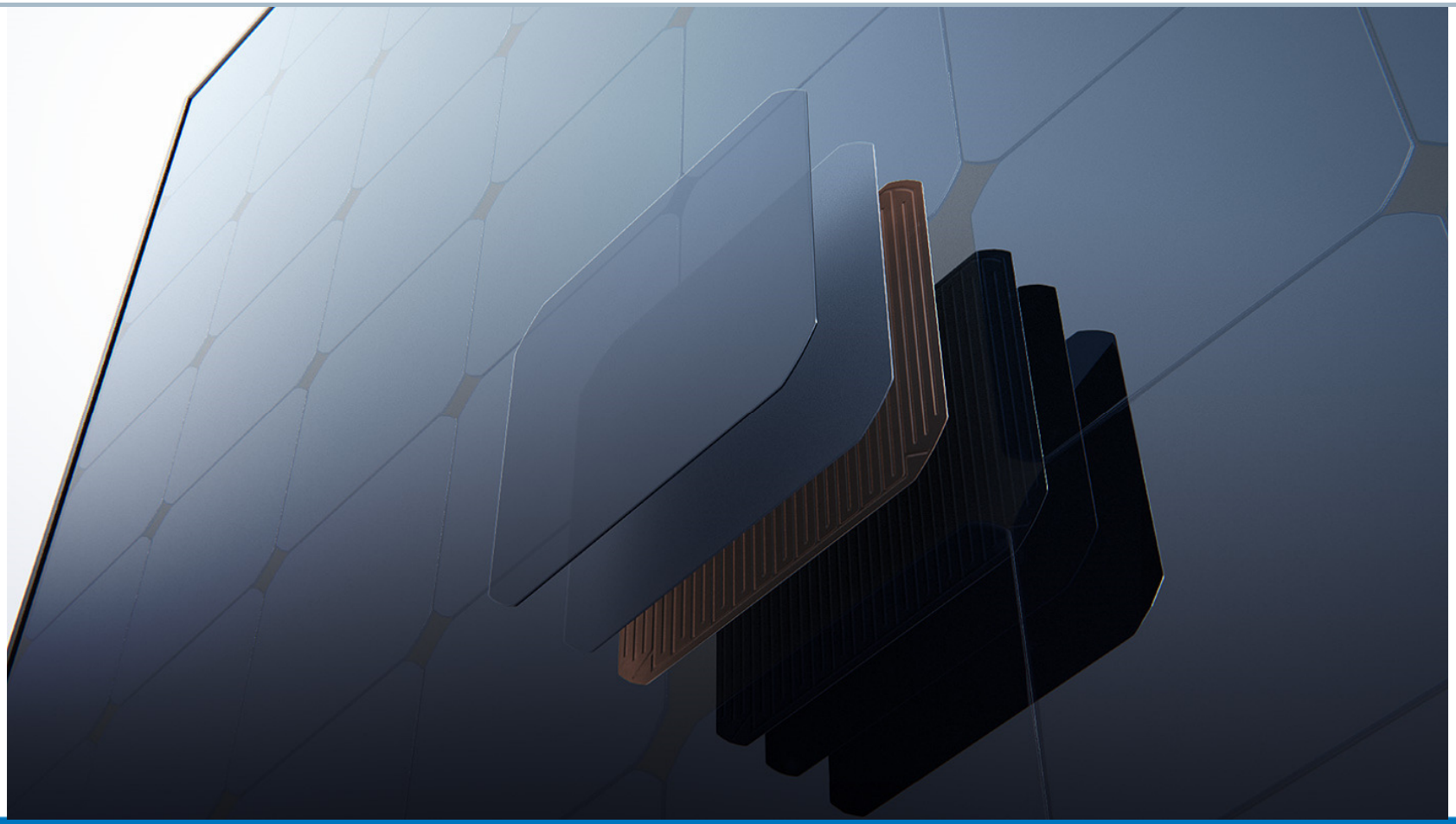
Thin lines of metal paste

BACK

Full-coverage metal paste

[1] Definitions used throughout presentation: "Conventional Panel" is a 250W panel, 15.3% efficient, approx. 1.6 m^2, made with Conventional Cells. "Conventional Cells" are silicon cells that have many thin metal lines on the front and 2 or 3 interconnect ribbons soldered along the front and back.

Maxeon Cells are Different



Reliability

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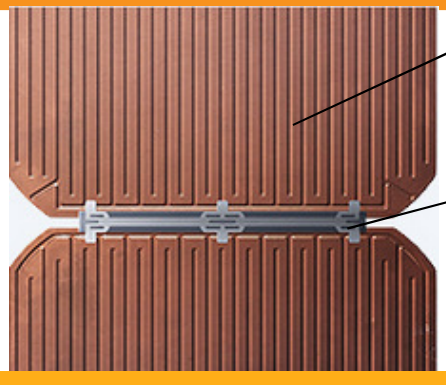
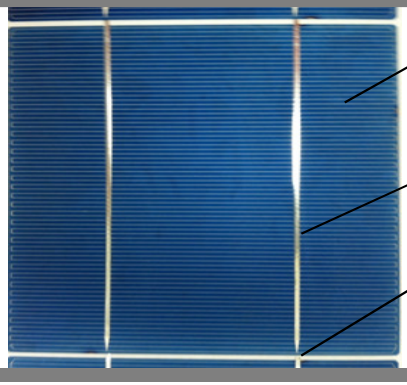
Maxeon Solar Cell Vs. Conventional Cell

Maxeon Solar Cell (Back)



1. Thick copper (tin-plated) is robust against corrosion.
2. No soldering along the length of the cell
3. Copper bar connecting cells has robust copper-to-copper soldering, strain-relief, and double-redundancy.
4. Solid copper foundation maintains the cell energy production even if the silicon cracks.

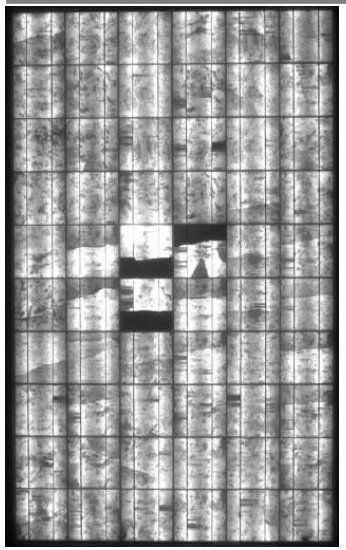
Conventional Cell (Front)



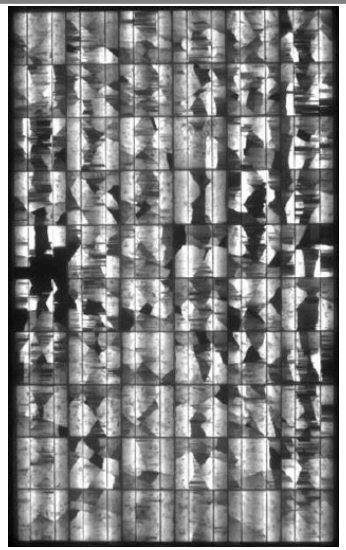
1. Very thin screen-printed metal lines on the front of the cell are susceptible to corrosion over time
2. High-stress solder joints between the long copper ribbons and the crystal solar cell
   - As the panels get hot in the day and cold at night the copper expands but the silicon cell does not.
   - Over time, this repeated stress causes cells to crack and solder bonds to break.
3. Single points of failure on copper ribbons between cells.
4. Screen-printed metal paste has no strength to hold the cell together when the silicon cracks

Cracked Conventional Cells in the Field

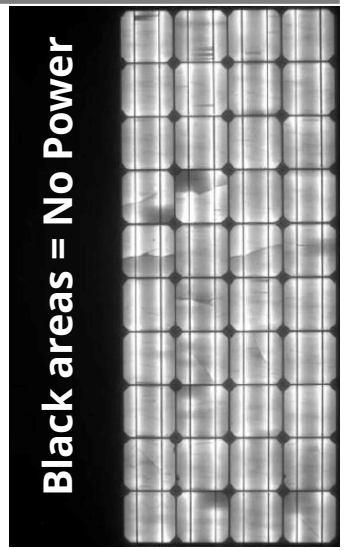
Conventional Panels



Likely damaged in installation or from repeated hot/cold temp cycles

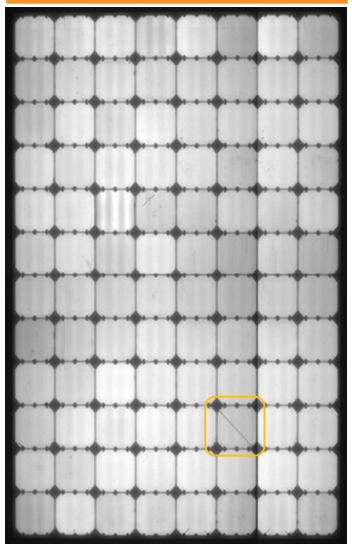


Likely damaged from poor soldering process and hot/cold temp cycles.



Left side has broken copper ribbons between a pair of cells.

SunPower Panel



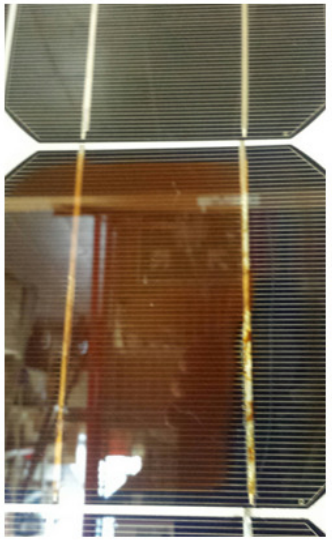
Even with a crack, all parts of the cell are running (no black).

Conventional Panels commonly fail from hot/cold temperature cycles that crack solar cells, solder joints and copper ribbons over time.

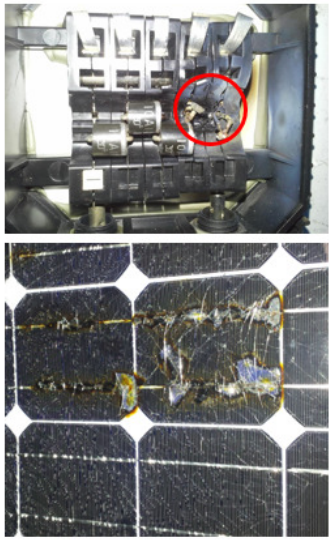
Conventional Panel Reliability Risk

- In a front contact panel, the ribbon and cell are made of different materials which expand and contract at different rates, resulting in a high stress concentration.
- Cycles of temperature change fatigue the ribbon-cell connection, eventually causing failure.
- Kato[1] has documented this three step process:
  1. Solder bond separates on one ribbon.
  2. Other ribbons disconnect from cell due to increased stress. Diode activates, reducing panel power by 33%.
  3. Continuous diode activation leads to diode failure. Power is then forced through defective cells causing hot spots and loss of power in the string until the panel is replaced.

1 Solder bond failure of one cell interconnect



2 Solder bond failure of both cell interconnects

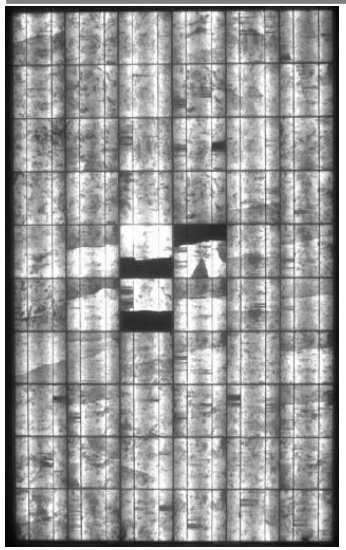


3 Bypass diode wear out and panel failure

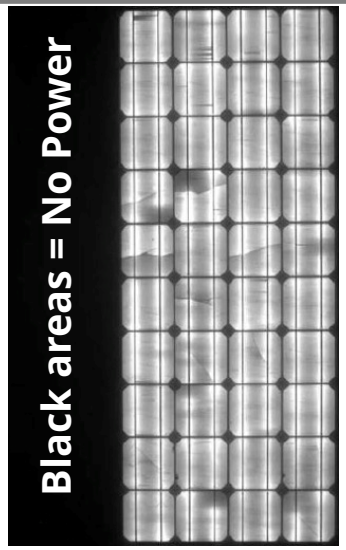
[1] Kato. (2012). PV module failures observed in the field: solder bond and bypass diode failures. In Characterizing and Classifying Failures of PV Modules.

Conventional Panel Reliability Risk

Conventional Panels



1 Solder bond failure of one cell interconnect



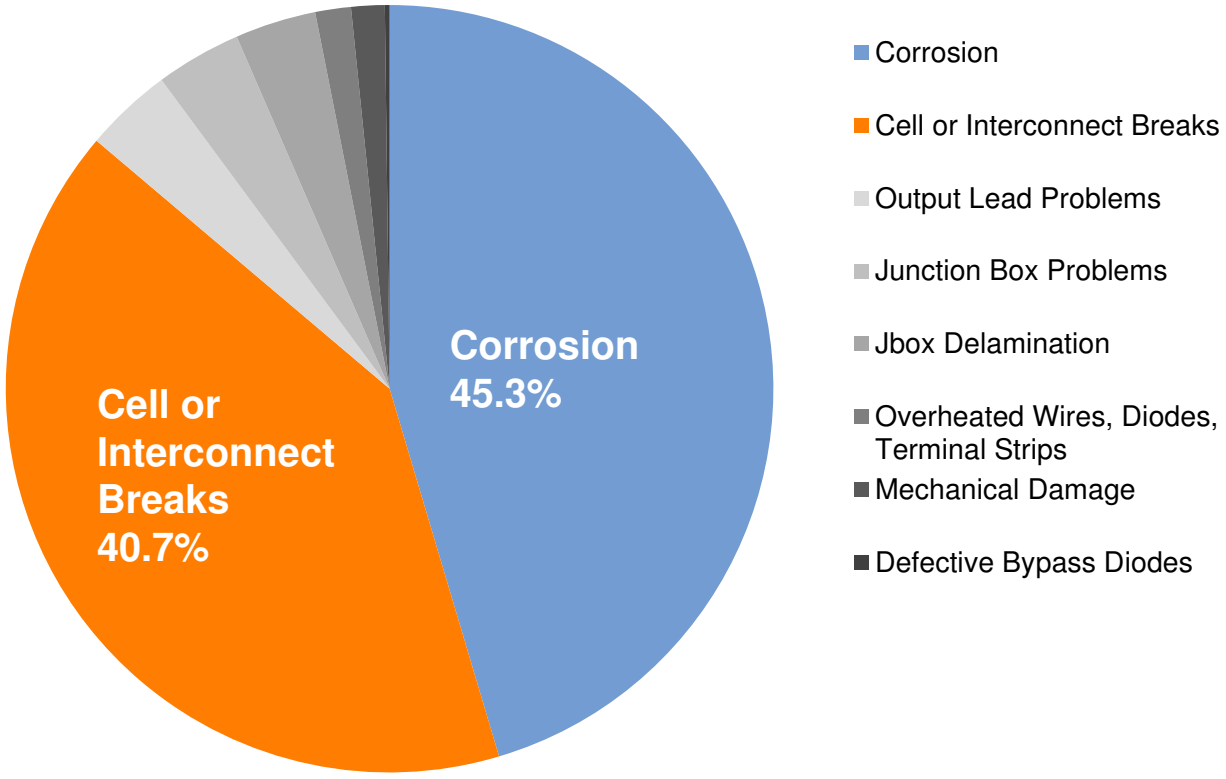
2 Solder bond failure of both cell interconnects

3 Bypass diode wear out and hot spot leading to panel failure

Conventional panels use front ribbon contacts, which fail in a three-stage process.

Image of stage three failure from pvserve.de

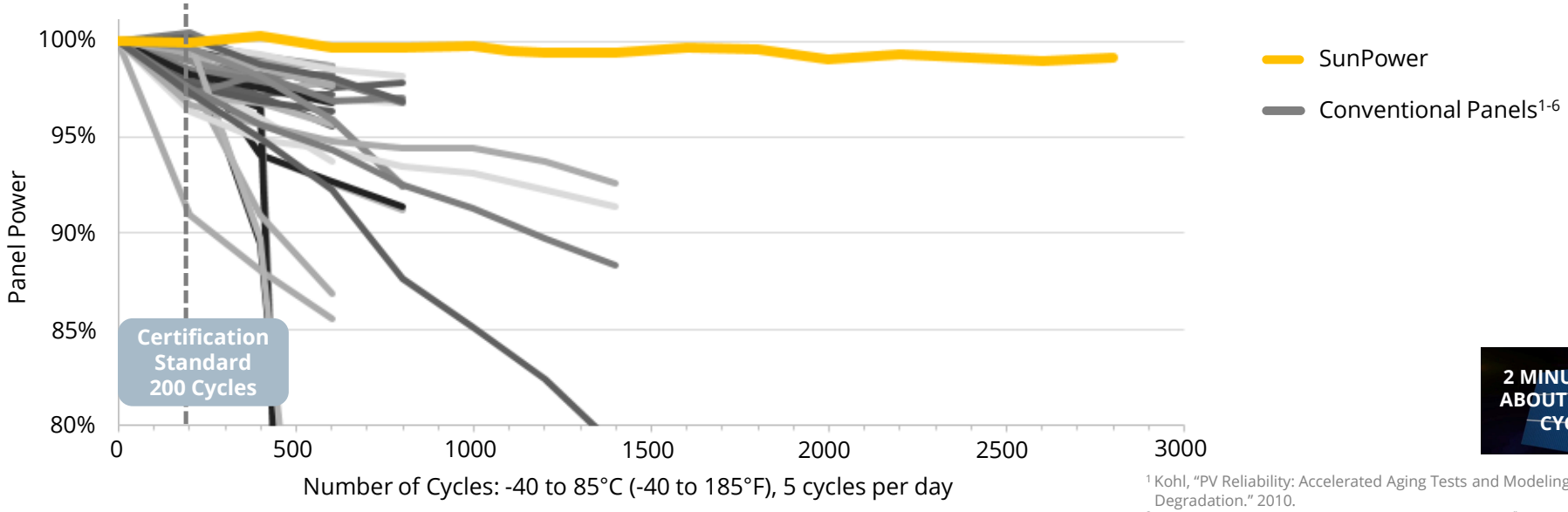
Common Ways Conventional Panels Degrade



Wohlgemuth, J. "Reliability of PV Systems." Proceedings of SPIE, 2008.

Unmatched Reliability: Unique Maxeon Design

- No cell-to-cell interconnect breakage
- Cell cracks have essentially no impact on energy output



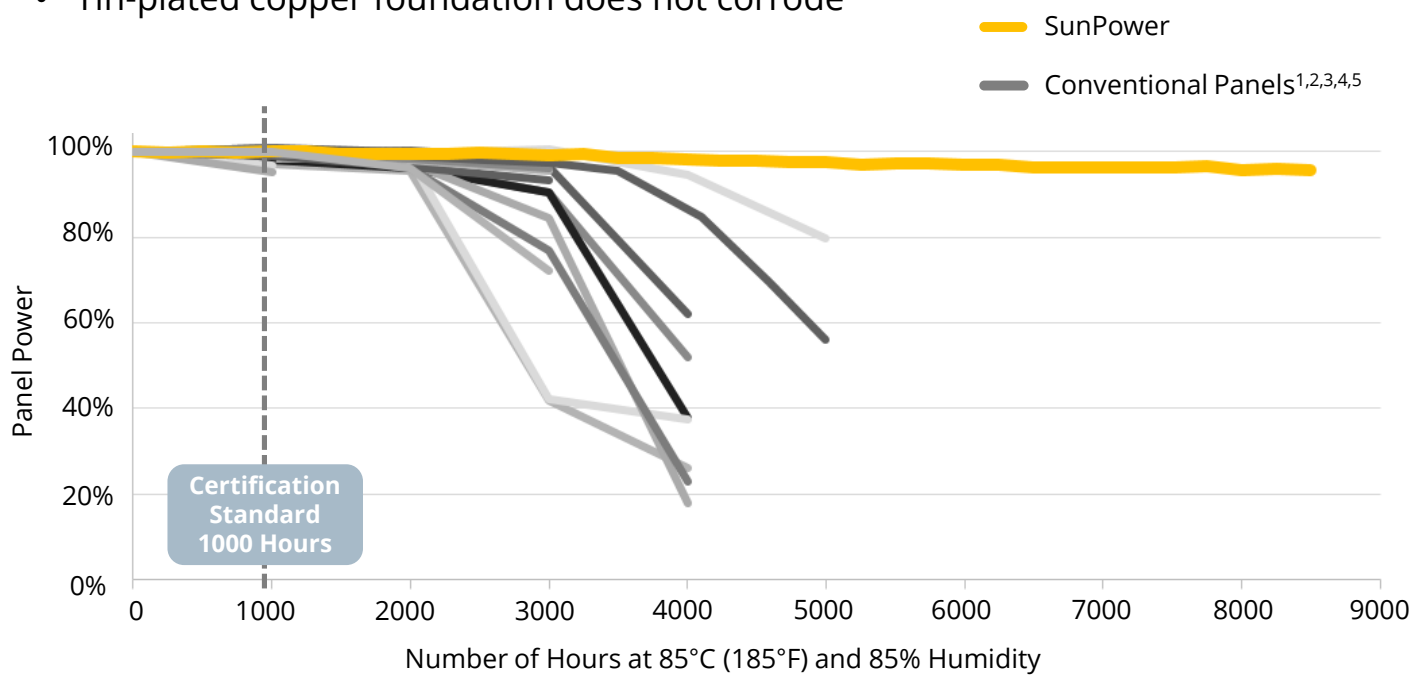
2 MINUTE VIDEO ABOUT THERMAL CYCLING

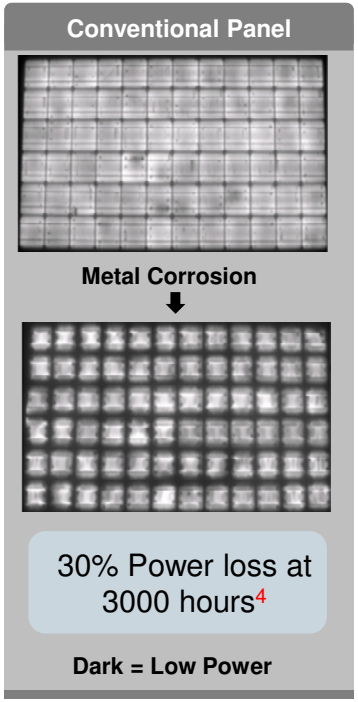
The unique design of the Maxeon cell makes the panels almost impervious to hot/cold temperature cycles.

[1] Kohl, "PV Reliability: Accelerated Aging Tests and Modeling of Degradation." 2010.
[2] Meakin, "PV Durability Initiative for Solar Modules." 2013.
[3] Ferrara, "PV Durability Initiative for Solar Modules: Part 2." 2014.
[4] Herrmann, "Outdoor weathering of PV modules - Effects of various climates and comparison with accelerated laboratory testing" 2011.
[5] Ketola, "Degradation Mechanism Investigation of Extended Damp Heat Aged PV Modules." 2011.
[6] Tsuno, "Effect of corrosion due to damp heat test on the I-V characteristics and analysis based on the equivalent circuit model." 2014.

Unmatched Reliability: Unique Maxeon Design

- Tin-plated copper foundation does not corrode



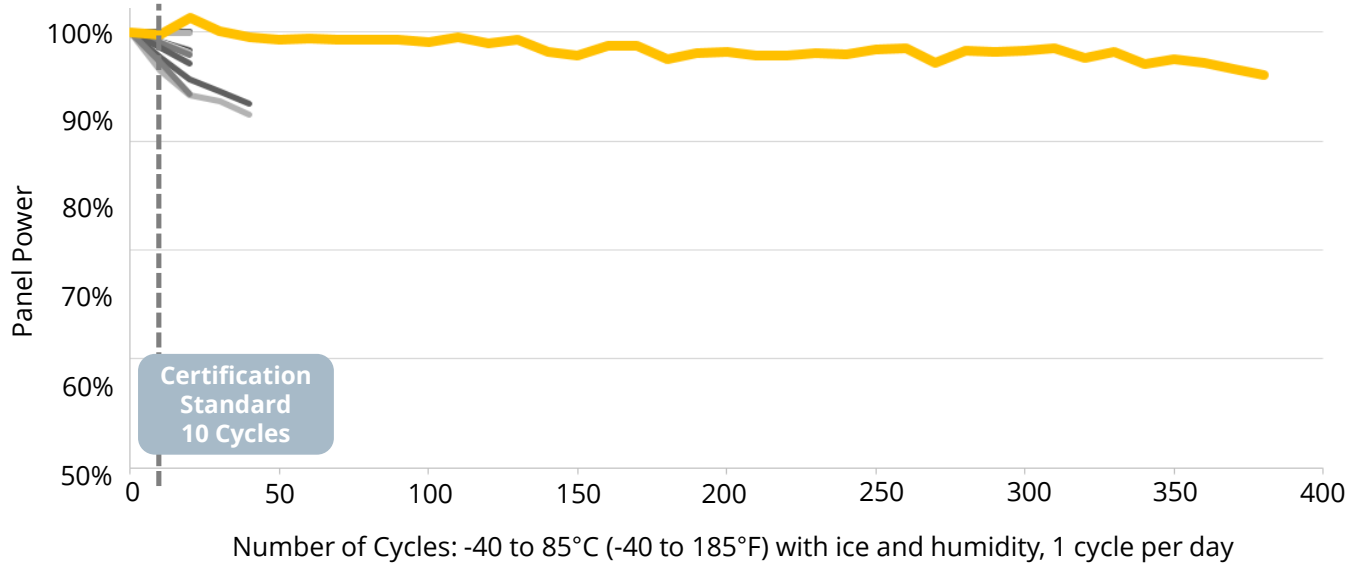


The unique design of the Maxeon cell makes the Panels almost impervious to corrosion.

[1] Kohl, "PV Reliability: Accelerated Aging Tests and Modeling of Degradation." 2010.
[2] Meakin, "PV Durability Initiative for Solar Modules." 2013.
[3] Ferrara, "PV Durability Initiative for Solar Modules: Part 2." 2014.
[4] Ketola, B., & Norris, A. Degradation Mechanism Investigation of Extended Damp Heat Aged PV Modules, EUPVSEC, 26th, Hamburg, Germany, 2011
[5] Jahn, U. PV Module Reliability Issues Including Testing And Certification. 27th EUPVSEC, 2012.

Unmatched Reliability: Unique Maxeon Design

- No "many-cycle" Conventional Panel data is available for comparison for the world's most challenging accelerated test: cycles of hot-and-humid followed by rapid freezing.
- The certification standard of 10 cycles has a failure rate exceeding 10%[2]. SunPower panels are almost unaffected after 310 cycles.

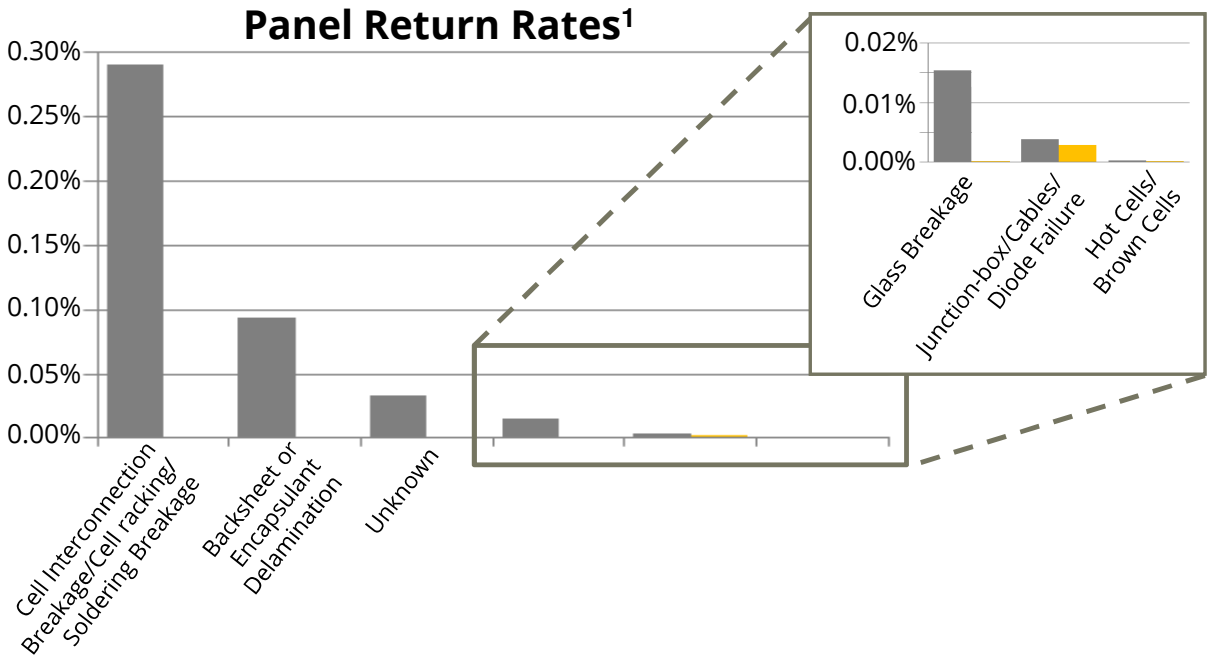


For certification testing: "The top 4 failure rates for c-Si panels were related to damp heat, thermal cycling, humidity freeze and diode tests."[2]

The unique design of the Maxeon cell makes the Panels almost impervious to water-freezing cycles.

[1] GTM Research, "PV Module Reliability Scorecard 2014"
[2] TamizhMani, B. G. "Failure Analysis of Module Design Qualification Testing – III," 36th IEEE PVSC Conf, 2010

Unmatched Reliability: Unique Maxeon Design



SunPower Maxeon II

- 8.45M panels (2.1yr avg. age)
- **0.005% returns**

Conventional Panels

SunPower services 740MW of Conventional Panels from purchasing two other companies

PV System Installer

- 20 Manufacturers
- 850,000 panels (7yr avg. age)
- **0.87% returns**

European Manufacturer

- 2,600,000 panels (4yr avg. age)
- **0.15% returns**

SunPower panels have a very low return rate.

[1] Hasselbrink, E., et al. Validation of the PVLife Model Against 3 Million Module-Years of Live Site Data. 39th IEEE PVSC, Tampa Florida, 2013.

Global Quality Survey

- IHS is a 50 year old company that provides critical information to key decision makers
- Global EPC and system integrators, distributors, and installers were surveyed on buying preferences, brands, and panel suppliers.
- These experts from over 30 countries rated SunPower[1]

  #1 in Panel Quality

  #1 Most Requested Brand

- Module reliability and high quality were ranked as the two most important attributes when selecting a panel

SunPower is globally recognized as a quality leader by industry experts

[1] Gilligan, C., et al. 2014 *PV Module Customer Insight Survey*. IHS Consulting.

Third-Party Reliability Testing

- Atlas, a subsidiary of Ametek, has been the leader in durability testing of materials for more than 90 years, and developed the "Atlas 25+ Comprehensive PV Durability Testing Certificate"
- This testing also qualified for the "SGS Performance Tested" Certificate.
- 3 panels tested per manufacturer: Salt Spray Corrosion, Humidity-Freeze cycling, Solar-Thermal Humidity-Freeze Cycling.

SunPower earned the toughest certificate, with an average power drop of 0% across all panels[1]

[1] Atlas 25+ Certificate, 2013. 0% power drop relative to the non-stress-tested control panel.

Third-Party Reliability Testing

Fraunhofer

- Fraunhofer is one of the world's largest organizations for applied research, with a staff of more than 20,000 people and an annual research budget exceeding $2 billion. It is world-renowned for its expertise in solar power technology.
- Fraunhofer CSE selected 5 of the top 8 silicon PV manufacturers' panels to rank based on their reliability … SunPower and 4 others (anonymous to participants)
- 20 panels per manufacturer were purchased directly by Fraunhofer either from distributors or on the open market
- The PDVI Test Protocol included: PID testing (damp heat exposure with bias), temperature cycling, humidity-freeze cycling, ultra-violet light exposure, static and cyclic mechanical load testing
- In 2013, three more panels were tested - SunPower maintained its leadership with 6 times less power loss[1]

Manufacturer	Average Power Drop	Max Power Drop
SunPower	1.3%	2.3%
Four out of the top eight crystalline silicon panel manufacturers in 2012 (*SunTech, Yingli, Trina, Canadian Solar, Sharp, Hanwha SolarOne, Kyocera*) Three anonymous panels in 2013.	7.8%	94%

SunPower panels came out #1, with an average power drop of 1.3% across all panels[1]

[1] Ferrara, C., et al. (2014). Fraunhofer PV Durability Initiative for solar modules: Part 2. Photovoltaics International, 77–85.

Third-Party Reliability Testing

PV EVOLUTION LABS
ADVANCING SOLAR

- PV Evolution Labs is an independent testing lab specialized in performance and characterization testing on PV panels owned by the independent engineering firm, DNV-GL.
- The Potential Induced Degradation Certification Program tests a panel's susceptibility to voltage stress, which can cause rapid power loss.
- Panels were tested at maximum voltage rating in all grounding configurations.
- SunPower panels degraded negligibly during this test.

Manufacturer	Pass Rate	Average Power Drop
SunPower	100%	0.2%
Conventional Panels	50%	4-5% for panels that passed the test

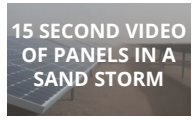
SunPower panels are exceptionally resilient against PID in any grounding configuration.

[1] Based on independent testing and analysis performed by PV Evolution Labs in 2013. To pass, panels must have less than 5% power loss at 100 hours and 10% power loss at 600 hours.

Third-Party Reliability Testing

TÜV Rheinland PTL

- TÜV is a 130 year old organization founded in Germany and is recognized as global leader in validating the safety of products and determining their robustness against environmental hazards.
- Desert conditions present harsh stresses:
  - Intense UV exposure breaks down materials
  - Blowing sand and dust erode surfaces
  - Fine dust infiltrates seals and connectors
- TÜV's Sandstorm Testing is based on military and IEC specifications for desert environments and goes well beyond conventional panel certification programs. For example:
  - UV dosage is 8x IEC requirement
  - Quartz particles are shot at 108 kmh (67 mph) against the panel surfaces
- SunPower is the first and only manufacturer to pass this stringent test[1].

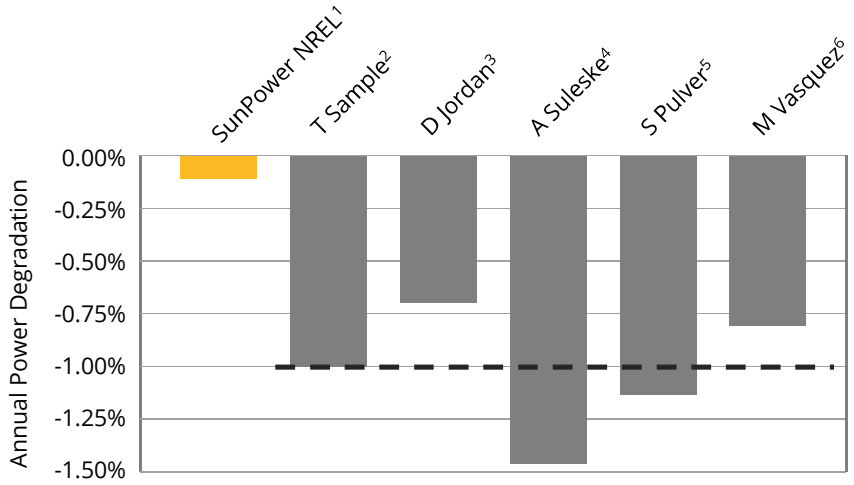


SunPower panels are robust against state of the art desert stress tests

[1] "SunPower Successfully Passes TÜV Rheinland's Rigorous Sand and Dust Testing". TÜV press release. 2014.

Third-Party Studies: Lower Degradation Rate

- National Renewable Energy Lab (NREL) has been measuring SunPower panel degradation in Colorado since May 2007: -0.10%/yr.
- Large research studies of Conventional Panels indicate a degradation rate of approximately -1.0%/yr.



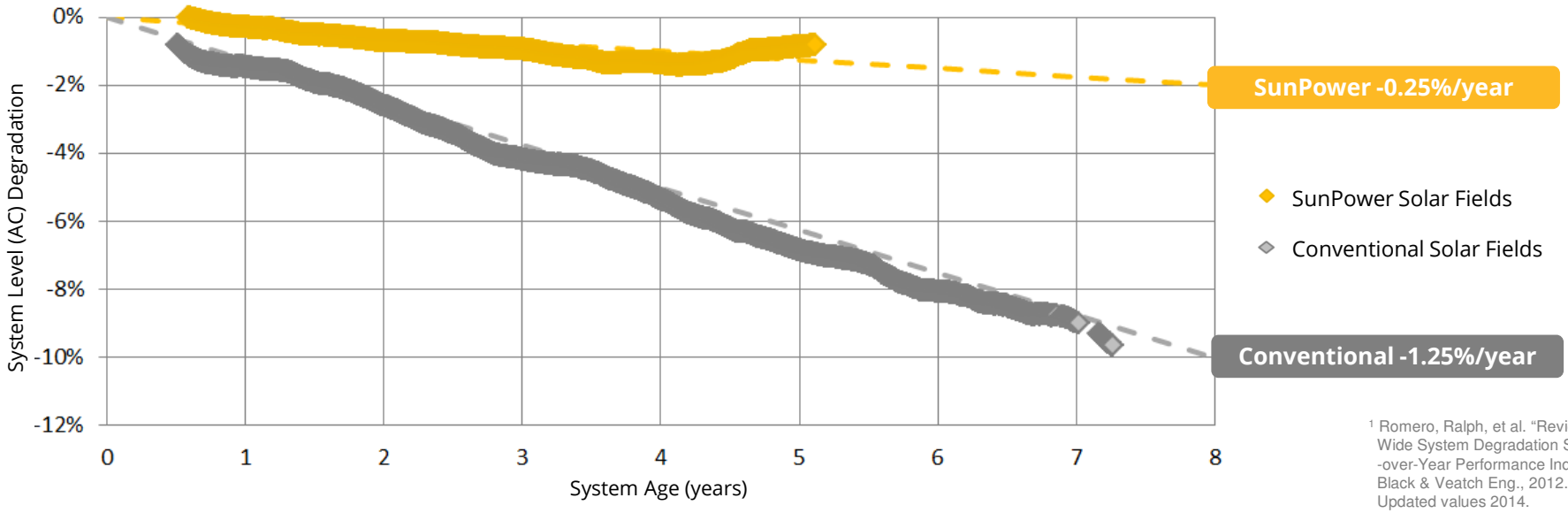
Average Conventional Panel degradation rate = **1.0%/year**

Lower degradation = more energy over the life of the system

[1] Jordan, Dirk "SunPower Test Report," National Renewable Energy Laboratory, Q1 2015
[2] Sample, T. "Failure modes and degradation rates from field-aged crystalline," 2011
[3] Jordan, D., et al. "Photovoltaic Degradation Rates – an Analytical Review," Progress in Photovoltaics. 2013. Vol 21, p 12-29. Average degradation rate show in plot.
[4] Suleske, A. "Performance Degradation of Grid-Tied Photovoltaic Modules in a Desert Climatic Condition," 2010.
[5] Pulver, S. "Measuring Degradation Rates without Irradiance Data," 2010
[6] Vazquez, M. "Photovoltaic Module Reliability" 2008

System-Level Degradation from Field Data

- The most comprehensive degradation study ever done: more than 800,000 panels from over 400 monitored inverters across 144 sites, for time spans averaging 6 years.
  - SunPower systems: 86MW, age 3.5-7.5 years
  - Non-SP systems: 42MW, age 4.5-13.5 years
- SunPower degradation rate affirmed by Black & Veatch[1], one of the most experienced Independent Engineering firms in solar power plants, with over 2,000 MW of utility scale projects

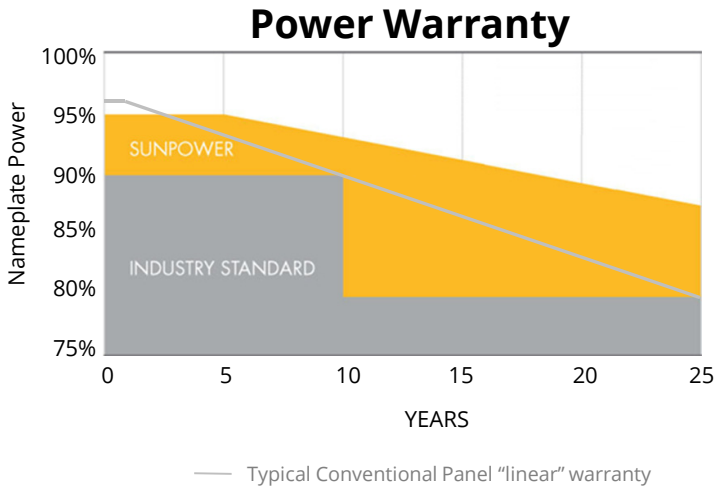


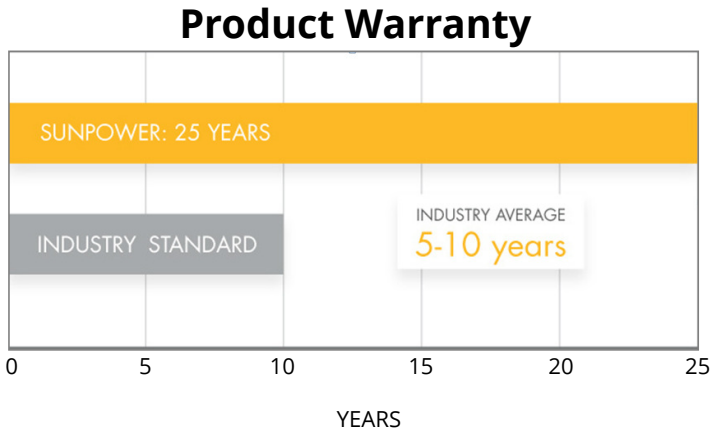
[1] Romero, Ralph, et al. "Review of SunPower Fleet-Wide System Degradation Study using Year -over-Year Performance Index Analysis," Black & Veatch Eng., 2012. Updated values 2014.

Durable Maxeon Cell Design Allows SunPower to Offer the Best Combined Power and Product Warranty

Because of the excellent reliability of the Maxeon cell, SunPower can deliver:

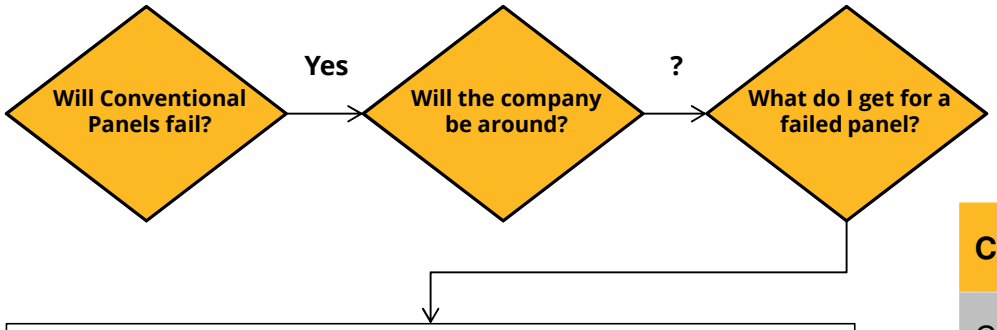
- Best Warranty: 25 year Combined Product and Power Warranty on all panels
- Low Guaranteed degradation rate: -0.4%/yr
- Replacement costs are covered[1]





[1] Some restrictions apply. See warranty for details

Traditional Warranties



- **Traditional Warranty legal remedy (chosen by manufacturer):**
  - ~$1 per Watt below guaranteed power level 1-time payment

    OR
  - A new or used panel of the then-current model

Coverage[1]	Estimated Cost	SunPower Warranty	Traditional Warranty
Covers removal of bad panel?	$200	Yes	No
Covers shipping for panels?	$600	Yes	No
Covers new panel installation?	$200	Yes	No
Product Warranty Term		**25 Years**	**10 Years**

SunPower's remedy pays for replacement and a new panel

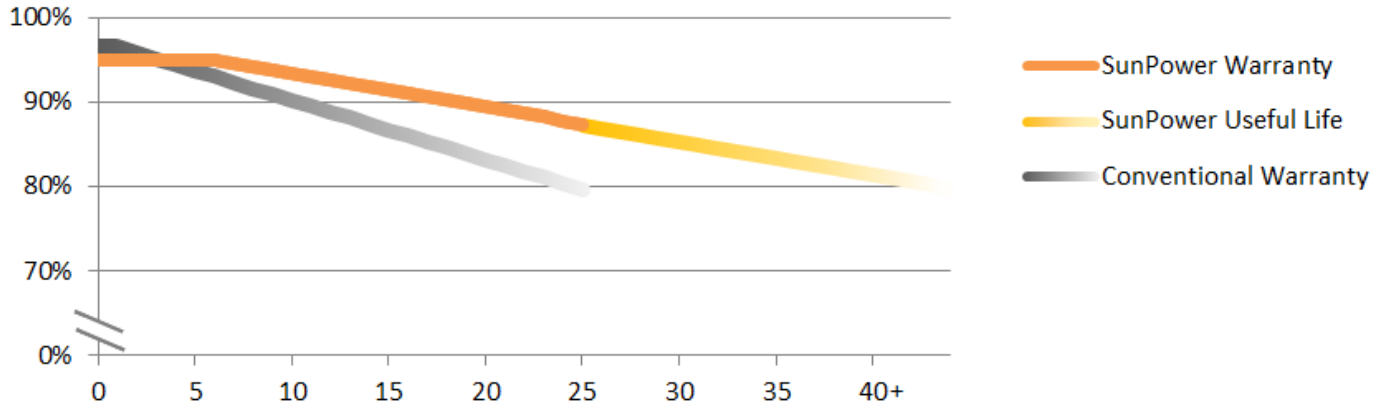
[1] Some restrictions apply. See warranty for details

Useful Life Beyond 25 Years

SunPower panels are designed for at least 40 years of service

Useful Life is defined as 99% of the panels producing at least 70% of their rated power.

- SunPower's robust design and industry leading research on accelerated ageing shows SunPower panels are expected to last well beyond their warranty period – at least 40 years.
- This is the same in other industries: home electronics and automobiles have a useful life well in excess of their warranty



Much more energy for same upfront cost, higher potential resale value.

[1] SunPower Module 40-year Useful Life. SunPower whitepaper. 2013.

Energy Production

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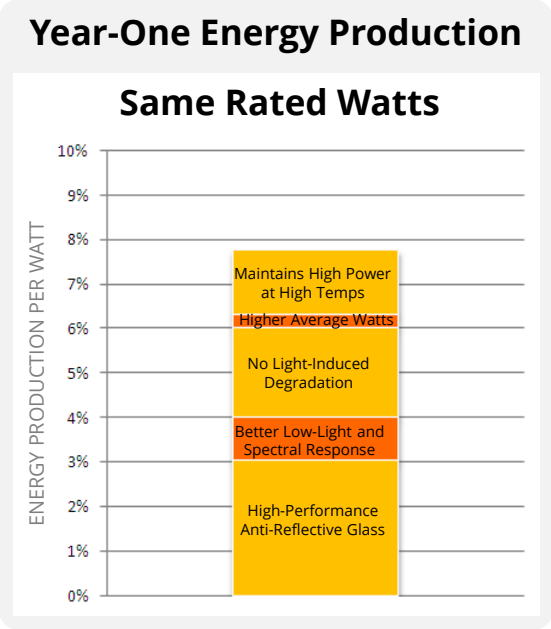
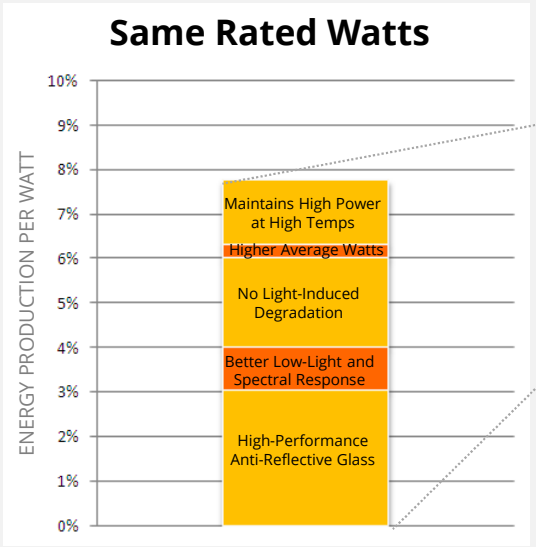
Summary of E-Series Energy Comparisons



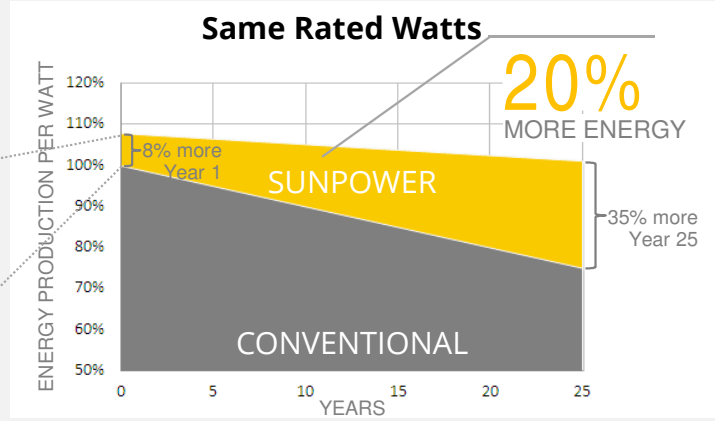
See slide 59 for footnotes.

Summary of E-Series Energy Comparisons

Year-One Energy Production



25-Year Energy Production

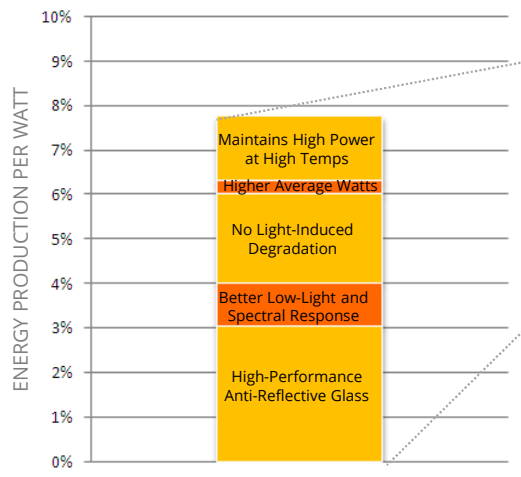


See slide 59 for footnotes.

Summary of E-Series Energy Comparisons

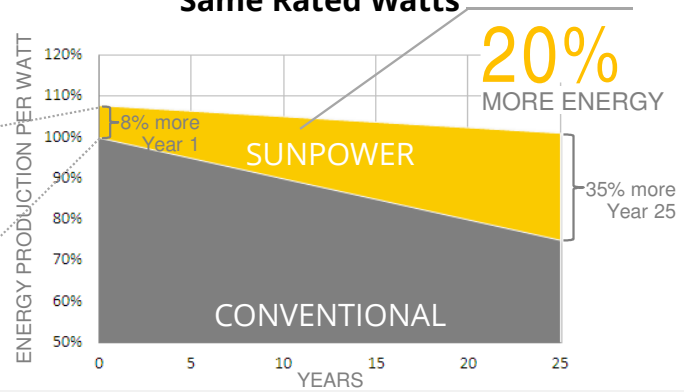
Year-One Energy Production

Same Rated Watts

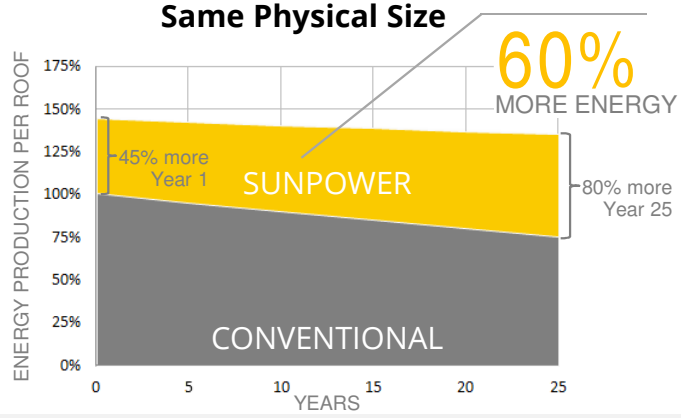


25-Year Energy Production

Same Rated Watts



Same Physical Size

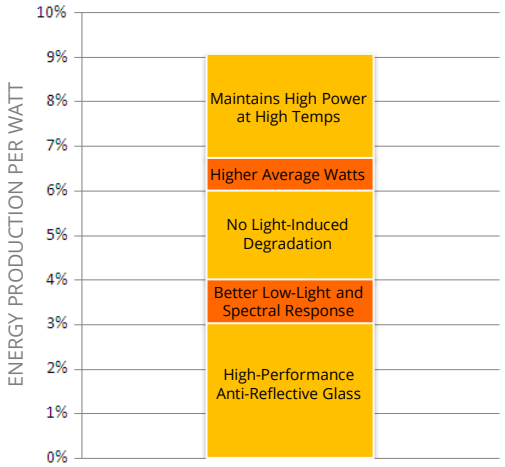


See slide 59 for footnotes.

Summary of X-Series Energy Comparisons

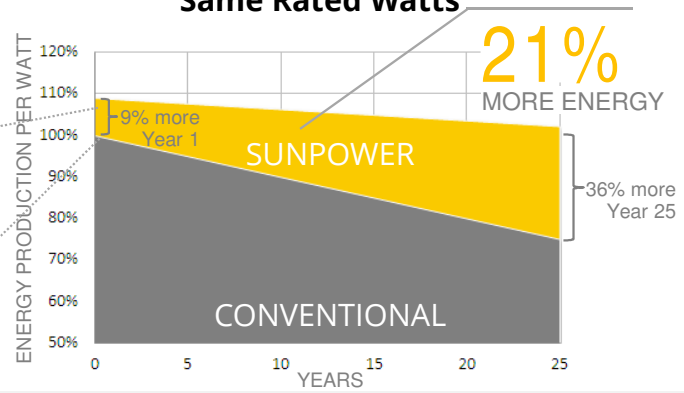
Year-One Energy Production

Same Rated Watts

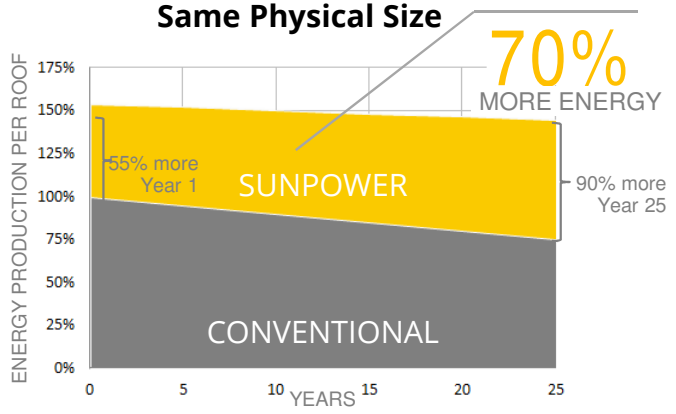


25-Year Energy Production

Same Rated Watts



Same Physical Size



See slide 60 for footnotes.

Are All Rated Watts the Same?

- All panels are rated on Watts output at 25°C (77°F), 1000 W/m2 of sun (noon on a clear summer day)
- But people don't care about Watts, because the electric company charges for energy … kilowatt-hours (kWh)

Example: Light Bulbs

Rating: **60W** **60W** **60W**

But people don't care about Watts, they care about how much light comes out!

If we're comparing only incandescent bulbs, then we know they perform about the same, so we can go by Watts rather than how much light comes out.

But what happens when there's a different technology?

Rating: **7W**

But the same amount of light!

… you can't just use Watts anymore.

Are All Rated Watts the Same? No.

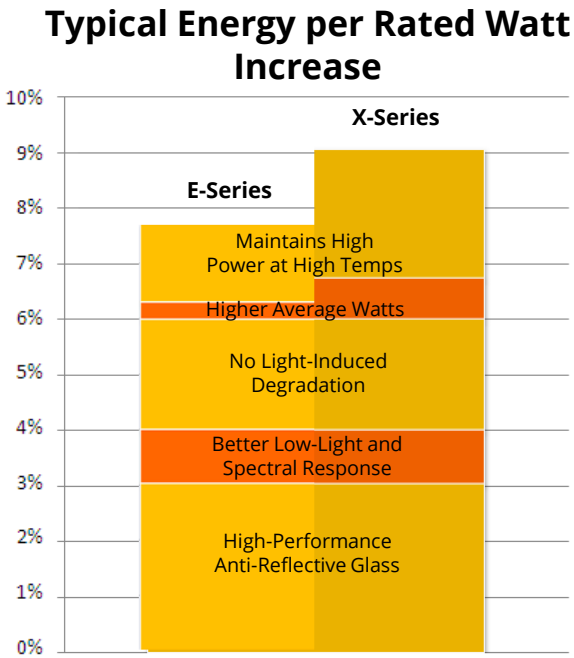
- All panels are rated on Watts **output at 25°C (77°F)**, **1000 W/m2 of sun** (noon on a clear summer day)

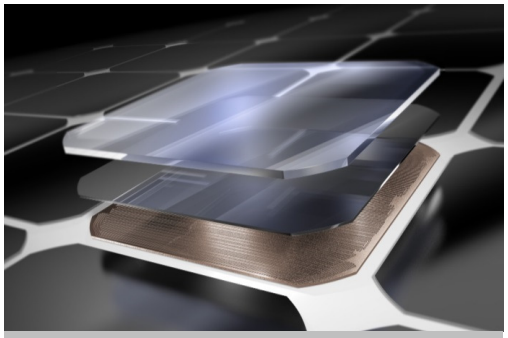
Many days, and morning & afternoon of each day, do not have this much sun light.

Many sunny days are hotter, especially on the roof. High temperatures decrease power.

- SunPower's Maxeon cells deliver more energy (kWh) per Rated Watt because of the unique design, especially in hot or low-light conditions.

Maxeon Cell Design Delivers More Energy Per Rated Watt





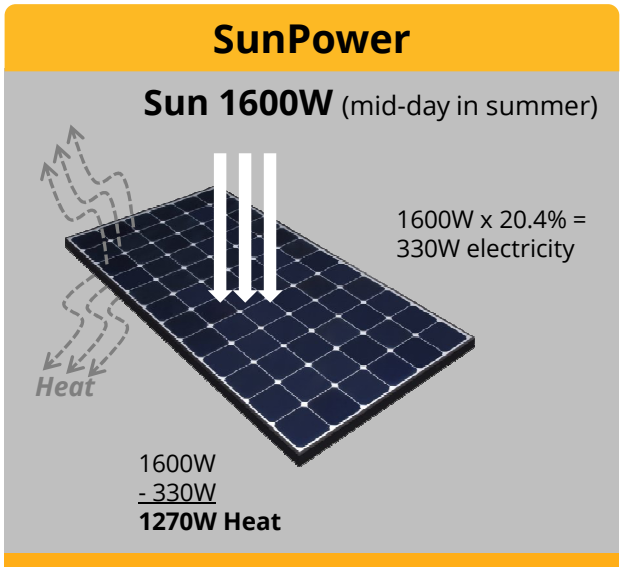
Maxeon Cell Technology

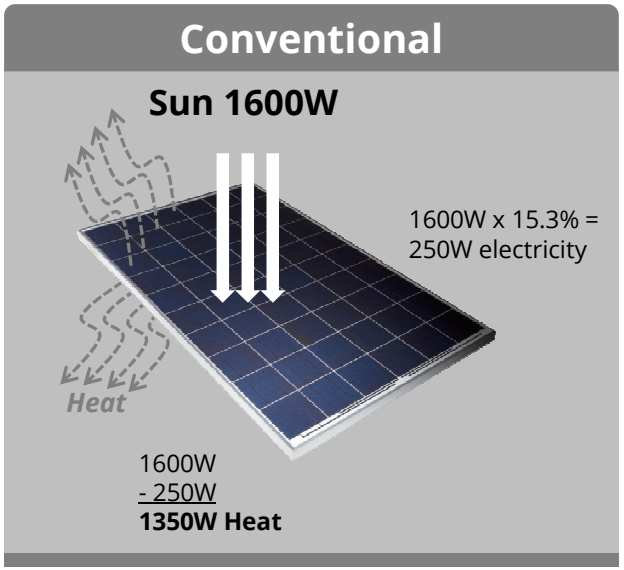
SunPower E-Series Panels deliver 7-9%[1], and X-Series 8-10%[2], more energy per rated watt.

[1] SunPower E-Series Panels deliver 7-9%, and X-Series 8-10%, more energy per rated watt in the first year.
[2] BEW/DNV Engineering "SunPower Yield Report," 2013 with CFV Solar Test Lab Report #12063, 2013 temp. coef. calculation. Compared to a Conventional Panel (250W, 15.3% efficient, approx. 1.6 m^2)

SunPower Panels Stay Cooler

- Because of the additional efficiency, more of the sun's energy is converted to electricity
- So less energy needs to be transferred to the air as heat and the panel stays cooler: typically 2-3°C (4-6°F) cooler on the roof

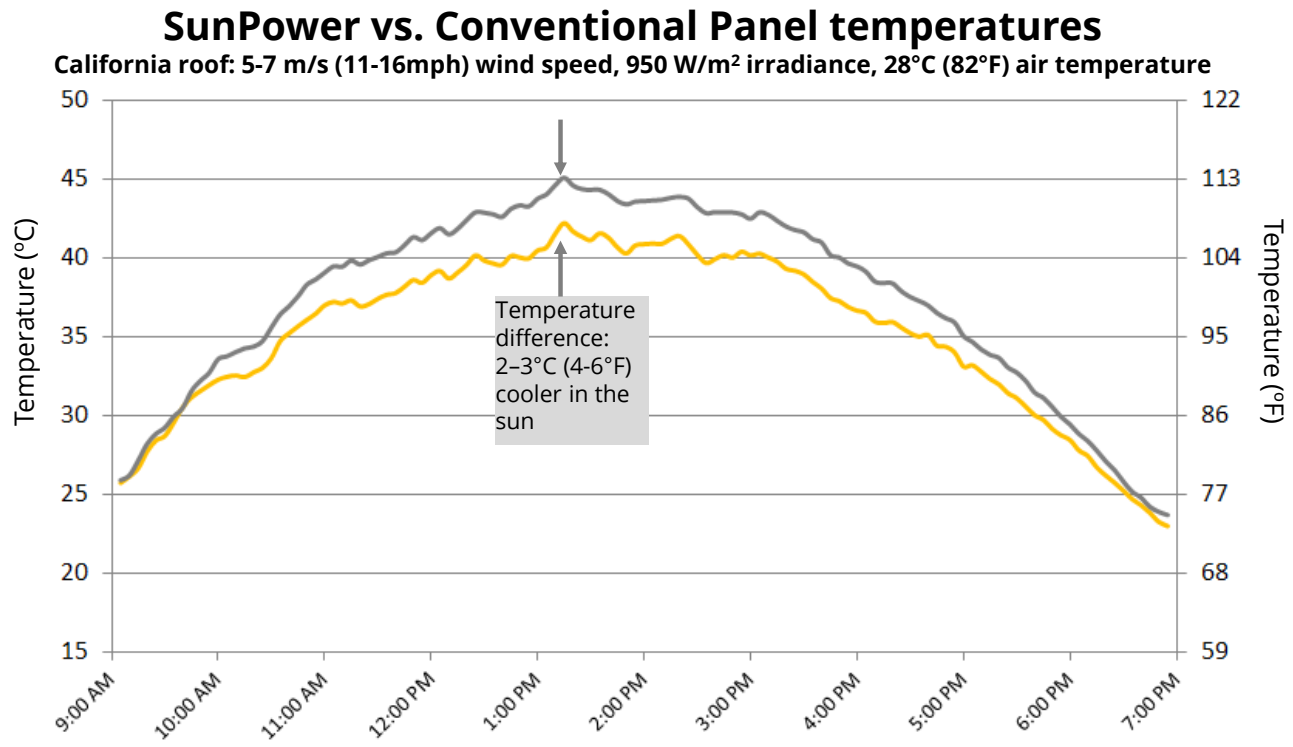




Conventional Panels run hotter because less of the sun's energy is converted to electricity.

Operating Temperatures: SunPower vs. Conventional Panels

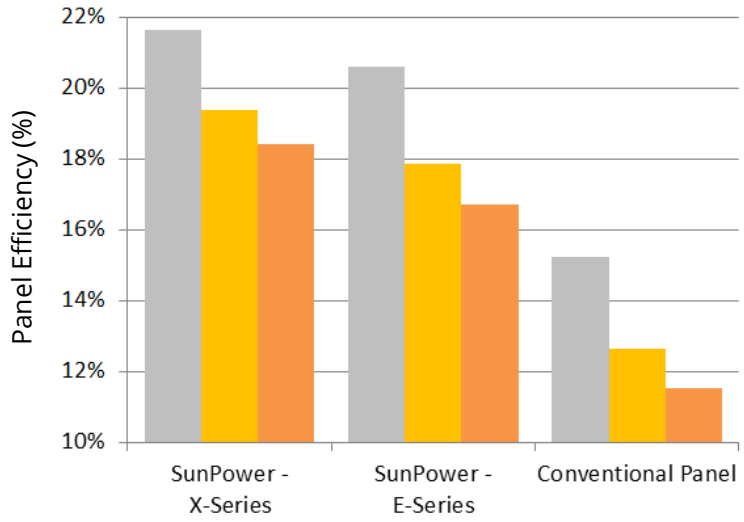
High efficiency panels operate at lower temperatures because they convert more of the sun's energy to electricity[1]



[1] Module temperature measurements, SunPower white paper, 2013.

Higher Energy Production in Real Conditions

- As the temperature increases, all solar technologies perform at lower efficiencies.
- SunPower panels change more slowly than Conventional Panels so they maintain their efficiency advantage even in hot environments.[1]



Panel Temperature

- 25°C (77°F) - STC Power Rating
- 60°C (140°F) - Typical Rooftop
- 75°C (167°F) - Hot Desert

SunPower X-Series panels **have 50% more power than Conventional Panels** at rooftop temperatures. E-Series panels have 40% more power.

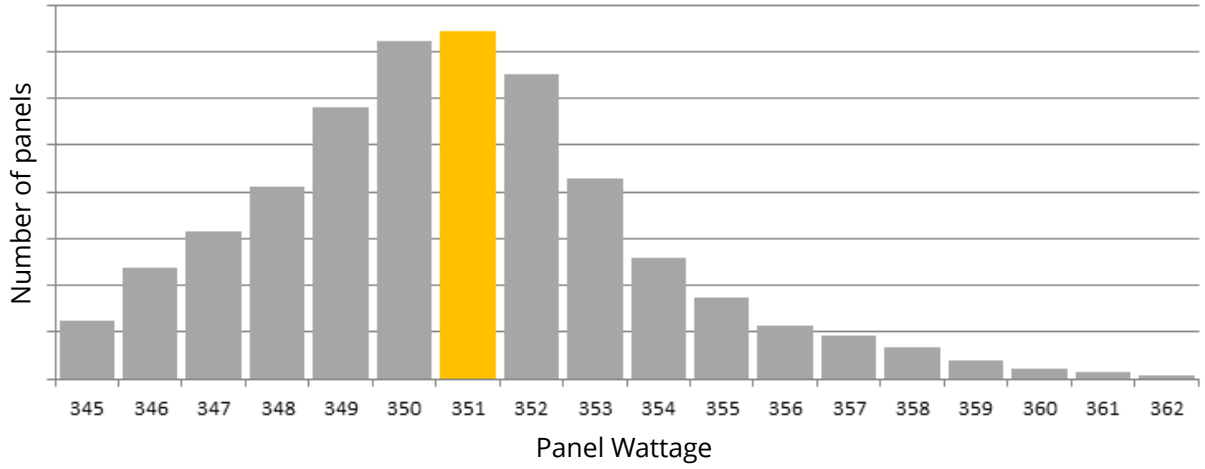
SunPower panels maintain the highest efficiencies, even in hot climates

[1] Based on temperature coefficients provided in manufacturer datasheets

Higher Average Panel Watts

- It takes computer-chip-making accuracy to produce high-efficiency solar cells, resulting in panels which are all very similar in power.
- SunPower sells almost all its panel production under one model, so typically over-delivers by 6 to 7 watts
- Conventional Cell production results in a broad distribution of panel power ratings, which are then binned into 5 watt increments

Production distribution for SPR-X21-345[1]

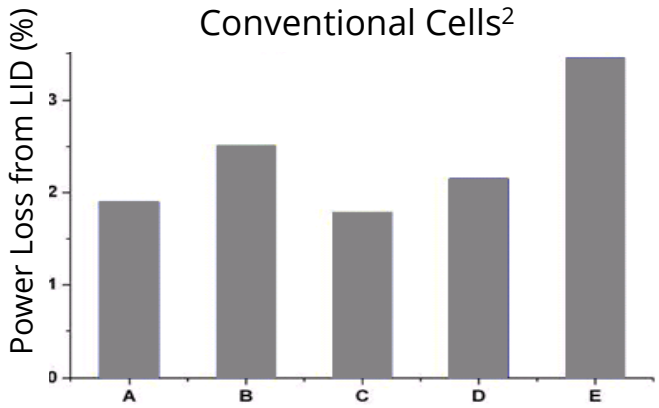


- **Rated Watts: 345W (Nameplate)**
- **Average Watts: 351W**

[1] SunPower data from Q4'13 for SPR-X21-345 To improve accuracy, SunPower calibrates is panels through the National Renewable Energy Laboratory using SOMS current and LACSS voltage and fill factor.

No Light Induced Degradation (LID)

- SunPower n-type solar cells are not subject to LID and do not lose 1-3% of their rated power once exposed to sunlight like Conventional c-Si cells (which are p-type silicon).
- BEW/DNV Engineering report: "Actual LID data from manufacturers is rarely available, but generally accepted to be between 0.5% and 3.5% for polysilicon and between 2% and 5% for monosilicon cells." [1]

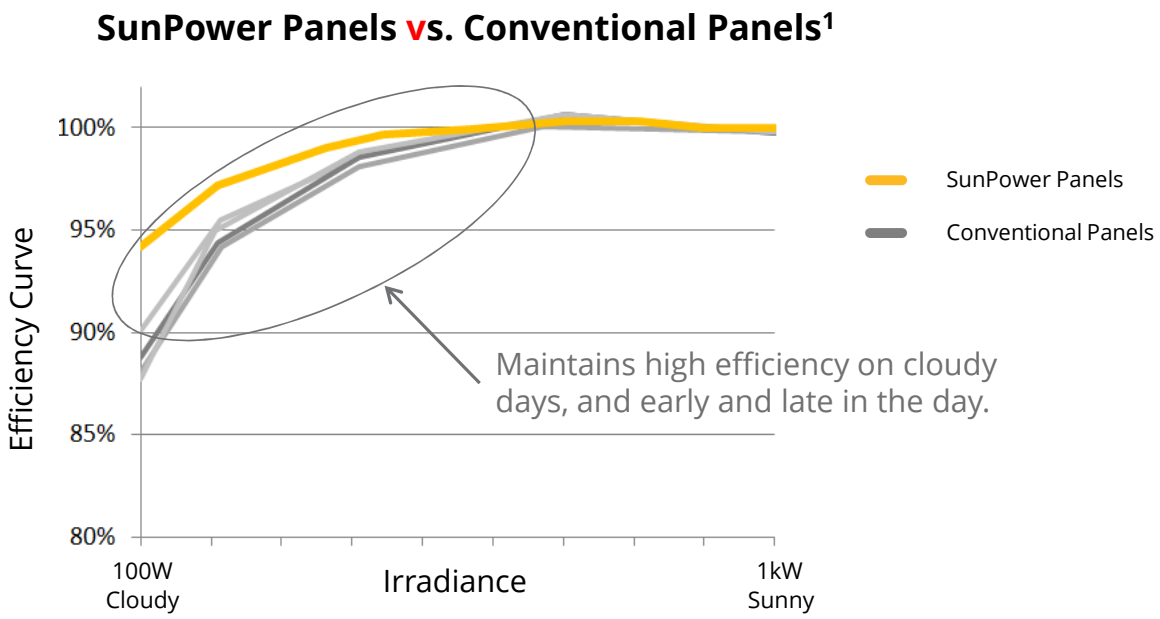


SunPower panels do not have Light Induced Degradation.

[1] BEW Engineering, part of DNV KEMA, SunPower Yield Report, 2013.
[2] Pingel, S., et al., "Initial Degradation of Industrial Silicon Solar Cells in Solar Panels," EU PVSEC, Valencia 2010.

Maintains High Efficiency at Low Light Levels

- Photon measurements: Low-light energy production



Photon: "The device has a nearly straight efficiency curve with almost no change in the medium-to-high irradiance range and only a minimal drop at low irradiance levels. No other module tested thus far has such an efficiency curve."[1]

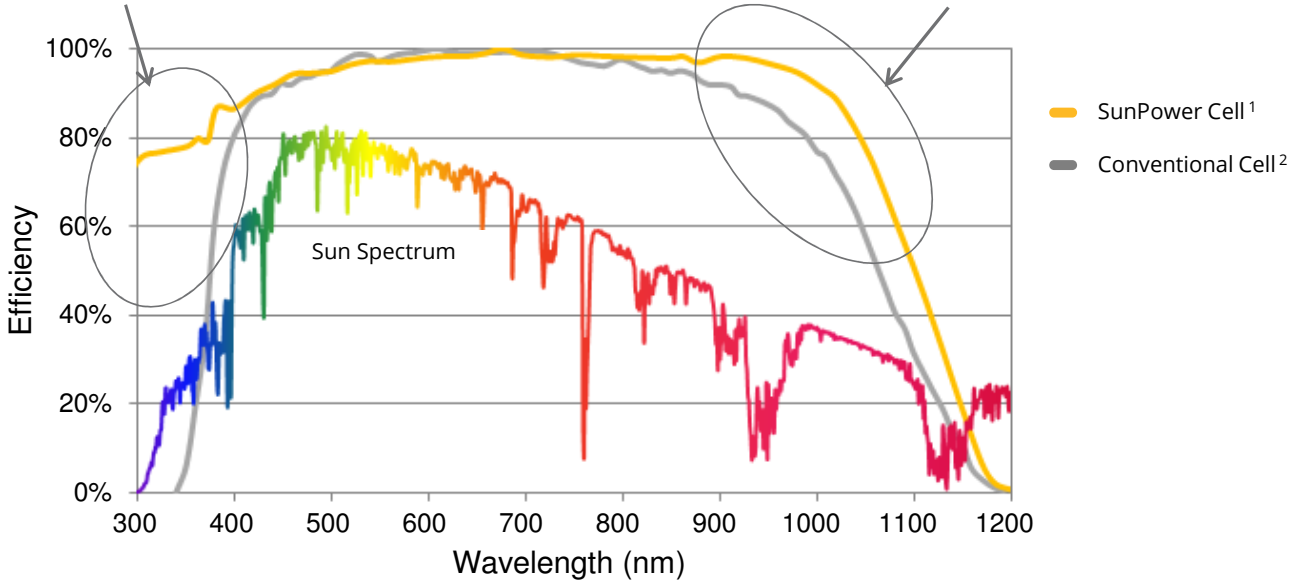
[1] E-Series and Conventional Panels tested by Photon International. Jun 2012.

Broad Spectral Response

- Red-shifted sunlight occurs every morning and evening (the sunset colors), so a SunPower system starts earlier and stays on longer.

More light from the blue parts of the spectrum, enables higher energy production in cloudy conditions

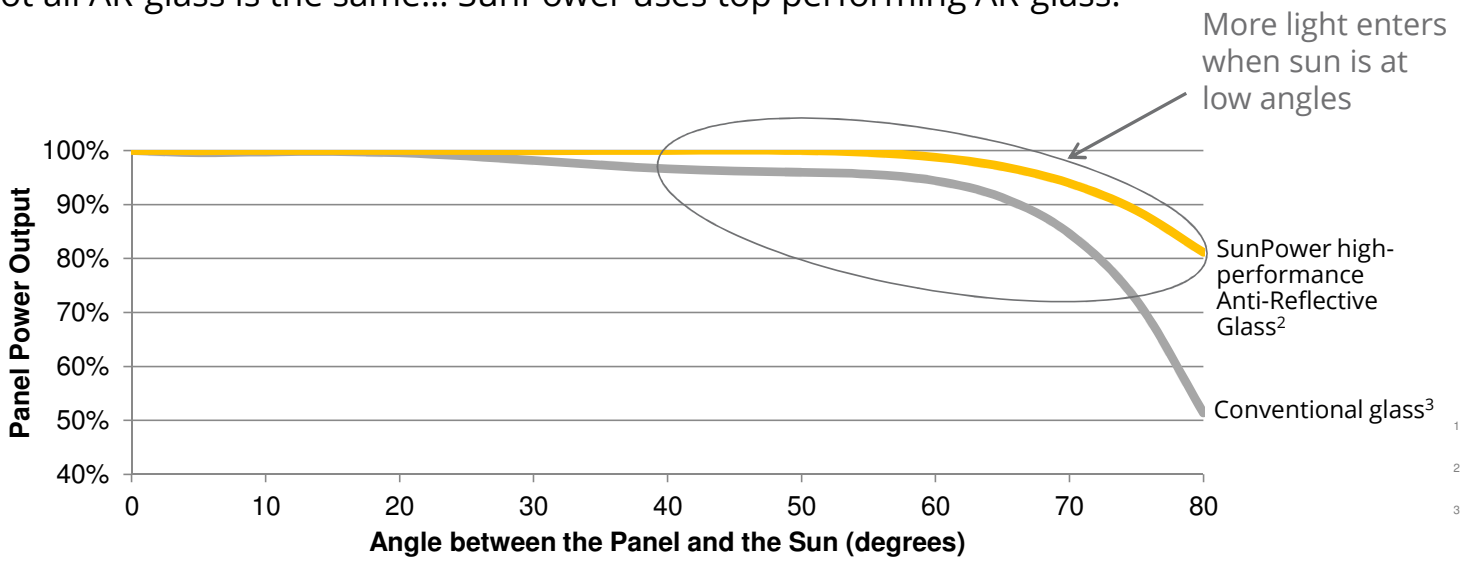
More light from the red parts of the spectrum, enables higher energy production in low-light conditions



[1] National Renewable Energy Lab measurements "Full, Gen C Bin I1," 2007
[2] Green, M. et al., "Solar cell efficiency tables (version 36)" Progress in Photovoltaics, 18(5), 46–352.

Anti-Reflective Glass Comparison

- Panels with anti-reflective glass have 3-5% energy gain vs. panels with non-AR glass from better light capture when the sun is not directly overhead.
- Cloudy periods, Early and Late hours, and the winter season.
- The majority of Conventional Panels do not us AR-glass because it is more expensive, and that cost is harder to justify with lower efficiency Conventional Cells.[1]
- Not all AR-glass is the same… SunPower uses top performing AR-glass.



[1] BEW Engineering , part of DNV KEMA, SunPower Yield Report, 2013.
[2] Sandia National Lab, Outdoor Performance Characterization of Three SunPower Modules, 2013
[3] Fanney, P., et al. "Comparison of Photovoltaic Module Performance Measurements." Journal of Solar Energy Engineering 128.2, 2006, p 152.

Independent Engineer Assessment

BEW Engineering is part of DNV KEMA Energy & Sustainability, with more than 2,300 experts world wide.

- Have provided technical services on over 10GW of commercial and power plant installations
- Specialize in modeling expected system energy production

- Report reviewed the same 5 primary differentiators for SunPower panels.
- BEW/DNV Engineering Conclusion:

"Depending on the climate, the type of fixed or tracking structure that has been deployed, and the exact properties of the competitor's module, the yield advantage can reasonably be expected to range from 7% to 9%."[1] (E-Series Panels)

[1] BEW Engineering, part of DNV KEMA, SunPower Yield Report, 2013. Compared to a Conventional Panel.

Quantifying the $/W Value of More Energy

Depending on the competitor and the mounting and climate conditions:

- E-Series: 7-9% more energy per rated watt[1]
- X-Series: 8-10% more energy per rated watt[2]

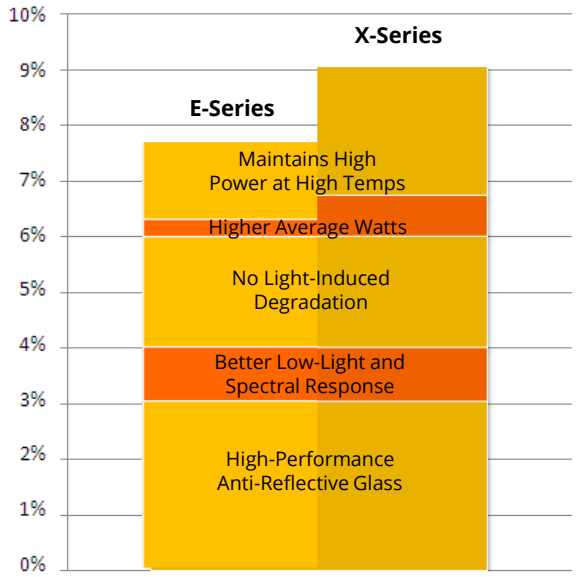
Every 1% of additional energy = 1% of additional system value

- In other words, a system that's twice the cost, and generates twice the energy, delivers the same value on a cost-per-energy basis
- Example: an 8% energy increase for a $4/W system[3] = $0.32/W value

More Energy per rated Watt in real-world conditions:

- Hot roof conditions
- Medium and low sun conditions
- Off-angle sun conditions
- Partially shaded conditions (not included because it does not always apply)

Typical Energy per Rated Watt Increase

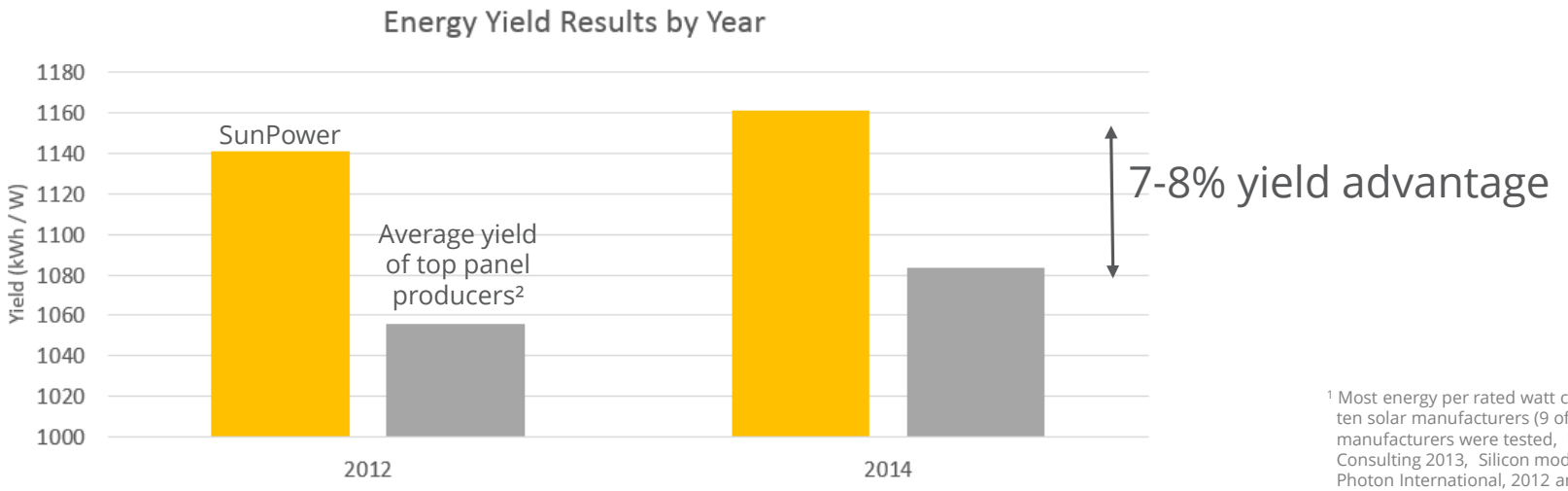


[1] BEW/DNV Engineering "SunPower Yield Report," 2013. Compared to Conventional Panels.
[2] BEW/DNV Engineering "SunPower Yield Report," 2013 with CFV Solar Test Lab Report #12063, 2013 temp. coef. calculation. Compared to a Conventional Panel (250W, 15.3% efficient, approx. 1.6 m²)
[3] Prices are examples for illustration only

Photon International Results (kWh/kW)

3rd party test of 106 PV Manufacturers to measure the additional energy per rated Watt

- In 2012, SunPower E-Series panels produced 7-8% more energy per rated watt than the top 10 manufacturers[1]
- In 2013, Photon encountered equipment malfunctions resulting in incomplete measurements; yet, reported that SunPower was the likely winner[2]
- In 2014 SunPower continues to average 7-8% more energy per rated watt[1]
- X-Series offers an additional 1% more energy-per-watt than E-Series.



[1] Most energy per rated watt compared to the top ten solar manufacturers (9 of the top 10 manufacturers were tested, based on Photon Consulting 2013, Silicon module shipments). Photon International, 2012 and 2014.
[2] Photon International, Feb 2014.

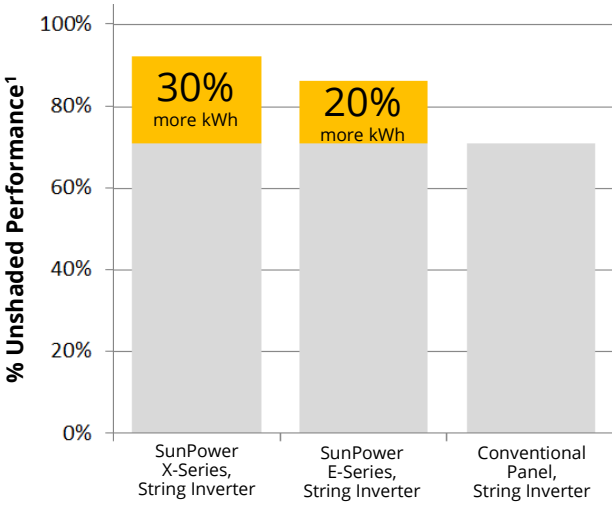
Lower Shading Impact than Conventional Panels

Independent test lab study of the impact of partial shading on SunPower panels vs. Conventional Panels[1]

- Each string identically shaded with real-world partial-shade conditions: 2 vent pipes along south edge, 1 tree on east side, 4 leaves on the panels
- Daily energy output measured, and each string compared with its own un-shaded energy production

SunPower cells have built-in diode protection, so partial-shading has much less impact. Compared to Conventional Panels in these shade conditions:

- E-Series has 20% higher yield
- X-Series has 30% higher yield
- SunPower panels on a string inverter outperform Conventional Panels on micro-inverters



[1] PV Evolution Labs "SunPower Shading Study," 2013. Compared to a Conventional Panel (240W, 15% efficient, approx. 1.6 m2)

SunPower Panels are More Reliable in Shade

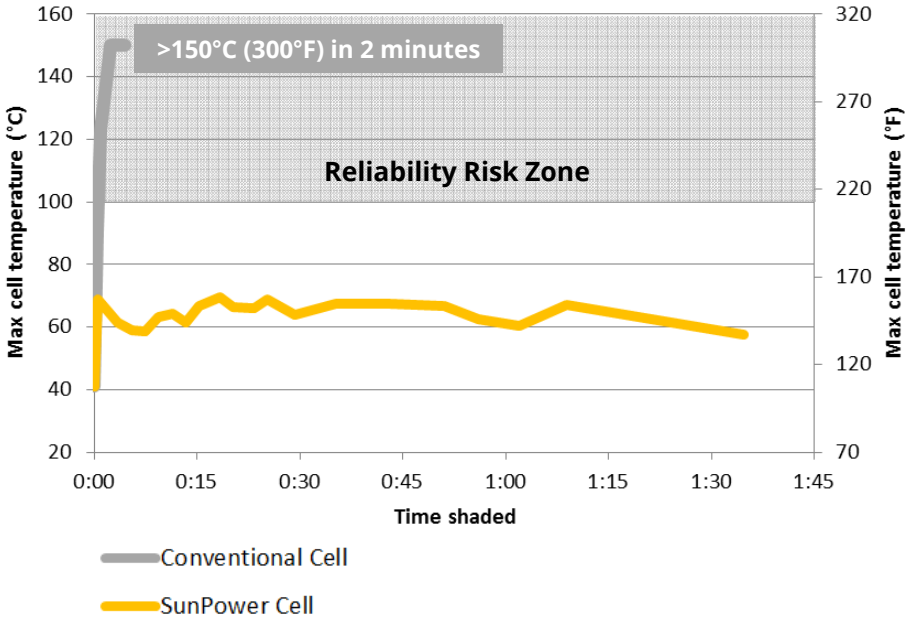
Conventional Cells require diodes for protection:

- Damaging hot spots form when a Conventional cell is shaded[1], so diodes are needed to bypass a shaded cell.
- When diodes are turned on due to shading or cell cracks, they heat up, which ages the diodes faster.
- Once diodes have failed, they do not protect the cells from shading.
- A field study in Japan found 47% of panels had defective bypass diodes after ten years with daily partial shading[2].

SunPower Cells have protection built into each cell:

- Unique cell characteristics mean 90% less heat is generated, and the heat is emitted uniformly across the cell, so the temperature stays low[3].
- Since cells run reliably under shade, SunPower uses diodes only to optimize energy yield.

Shaded Cell Temperature over Time[3]



[1] Breitenstein, et. al. Understanding junction breakdown in multicrystalline solar cells. Journal of Applied Physics, 109(7), 071101.
[2] Kontges, et al. (2014). Performance and Reliability of Photovoltaic Systems, Subtask 3.2: Review of Failures of Photovoltaic Modules.
[3] Campeau, Z. et al. "SunPower Module Degradation Rate," SunPower white paper, 2013

Accurately Predicting the SunPower Energy Advantage: PVSim

PVSim is a state-of-the-art Energy Model

- "PVSim is an accurate simulator for SunPower and non-SunPower PV systems. For SunPower systems, it offers a simple approach with little user adjustment necessary. For non-SunPower systems, it allows for extensive customization of a broad range of input parameters as needed."[1]
- "Uses the Sandia National Labs Photovoltaic Performance Model with module coefficients established through 3rd party Sandia testing."[1]
- Eliminates gaming of the modeling programs by manufacturers through self-reported and unvalidated datasheets.

Audited by BEW/DNV Engineering, an independent engineering firm:

- "BEW using PVSim obtained results closer to measurements than BEW using PVSyst with comparable modeling assumptions."
- "Compared to measured data, PVWATTS is 10-30% low in annual energy, and modeled-to-measured power correlations are poor."
- "PVSim generally uses state-of-the-art algorithms that should yield accurate results."

Use PVSim online for free: https://pvsim.sunpowercorp.com/PVSim/Login.aspx

Nothing is more important than getting the energy production right, since what we are really selling is the promise of future energy!

[1] BEW Eng, part of DNV KEMA, PVSim Evaluation Report, 2013.

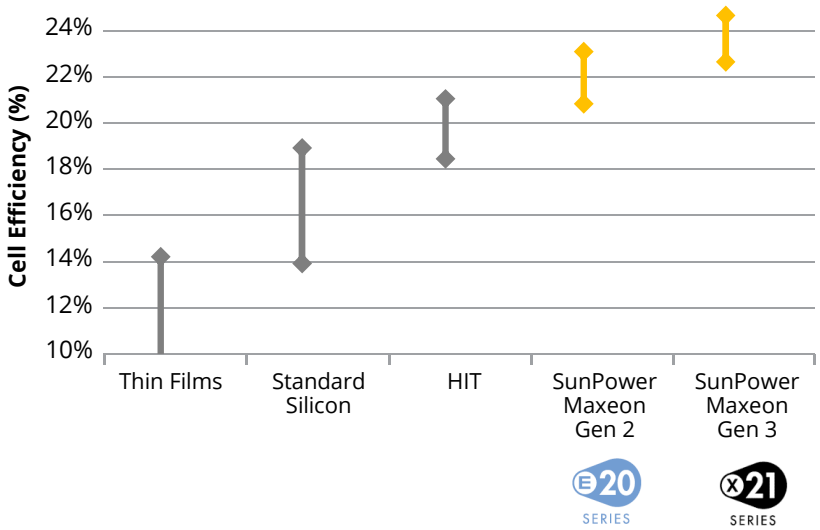
Efficiency

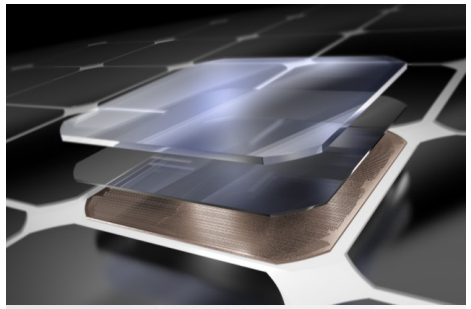
SUNPOWER

The Maxeon Solar Cell is the Core of the SunPower Technology

- Maxeon cells are back-contact silicon cells built on a solid copper foundation
- Up to 24.2% efficient cells in commercial production

SunPower Maxeon Cell Efficiency Advantage[1]





MAXEON CELL TECHNOLOGY

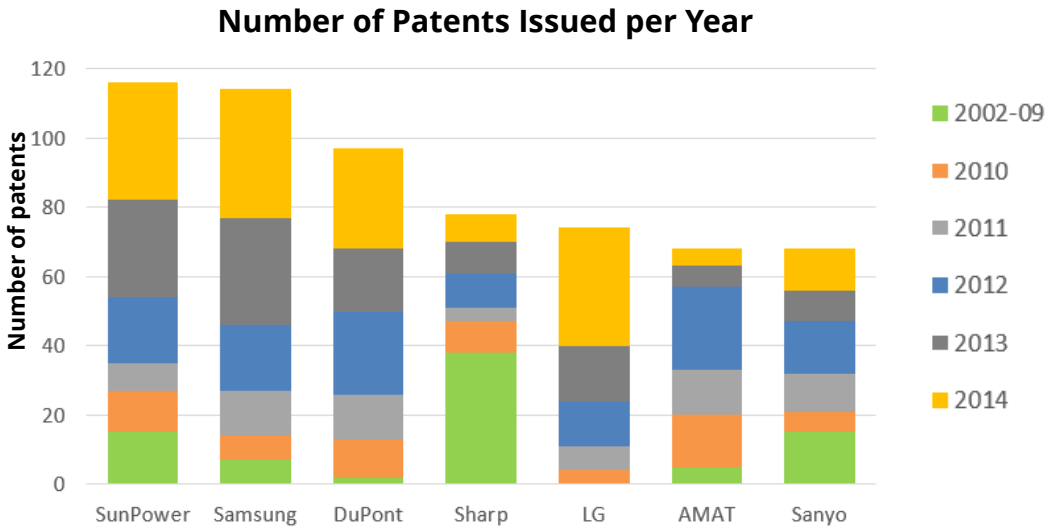
SunPower holds the world-record large Silicon panel efficiency (22.4%).
Green, M. A., et. al. "Solar Cell Efficiency Tables (version 43)," Progress in Photovoltaics, 2014

SunPower continues to out-innovate the competition

[1] Cell efficiencies based on high volume production

SunPower: leading the industry in innovation

- SunPower leads research and innovation in the solar industry:
  - Top three solar company for R&D investment for six years running[1]
  - Track record of innovation and patents[2]



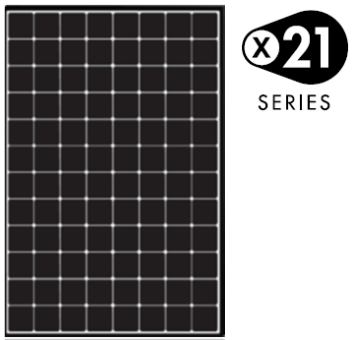
SunPower: #1 solar company for assigned patents

[1] Osborne (2014). R&D spending analysis of top PV module manufacturers in 2013. PVTech.com
[2] Heslin Rothenberg Farley & Mesiti P.C. (2015). Clean Energy Patent Growth Index: 2014 Year in Review. Non-solar companies removed for clarity.

Overview: X21 Solar Panel

Best PV Panel on Every Dimension: Energy Production[1], Reliability[2], Efficiency[3] and Aesthetics

335 Watts
21.0% average efficiency



345 Watts
21.6% average efficiency

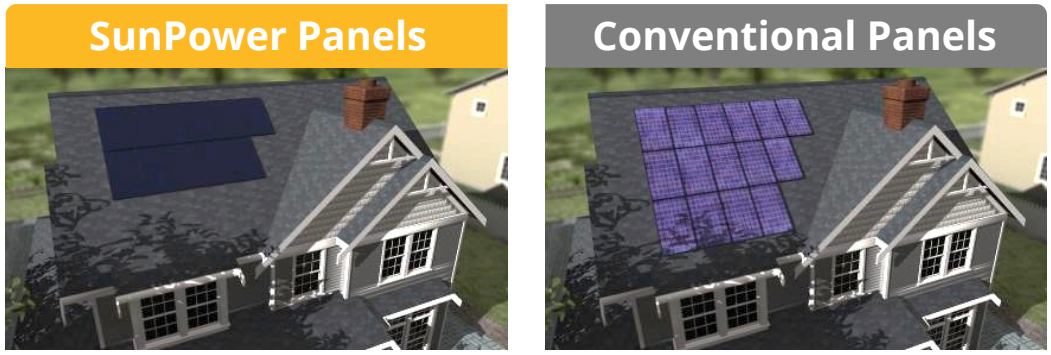
World's highest energy and power solar panel
Delivers the maximum power possible from your roof[1]
More energy output in hot locations and summer months when sunlight is strongest[2]
Unique SunPower™ Signature™ Black look
Delivers the most energy even when located in small shadows like vent pipes, pole or wire shadows, or when partly covered with fallen leaves or dirt[2]
Holds world record 22.4% panel efficiency![3]

[1] Compared with E-Series solar panels..
[2] See Slide 45 for footnotes
[3] Green, M. A., et. al. "Solar Cell Efficiency Tables (version 43)," Progress in Photovoltaics, 2014

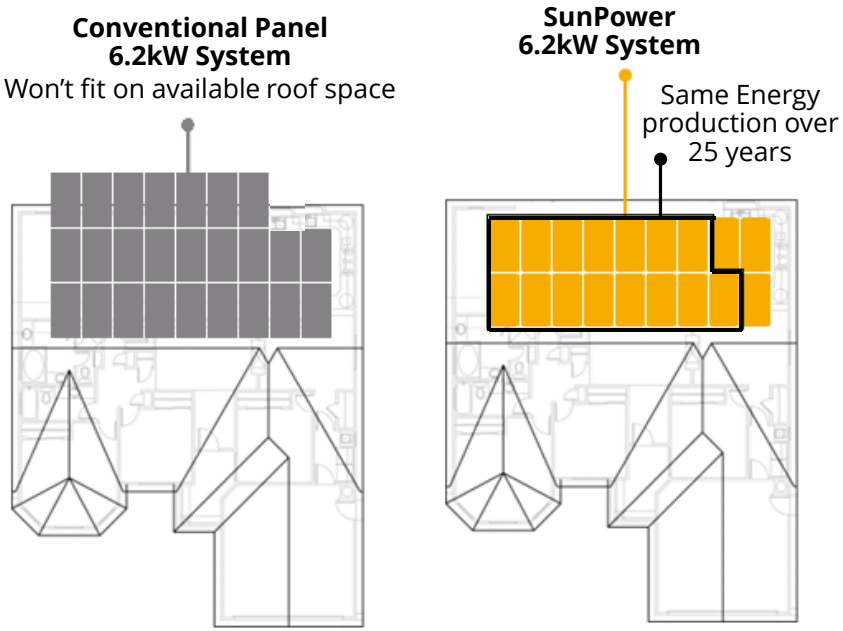
The Value of High Efficiency

- More power from the same space: the SunPower system will deliver 55% more energy in the first year. After 25 years, the difference will grow to almost 90% more energy … for an average of 70% more energy each year[1].
- Most roofs are constrained by south-facing size, and shadows (trees, vents, wires, etc.)
- More expandable later if energy needs increase in the future (e.g. electric car)

Less Shading with SunPower



More Power from a Limited Roof Space



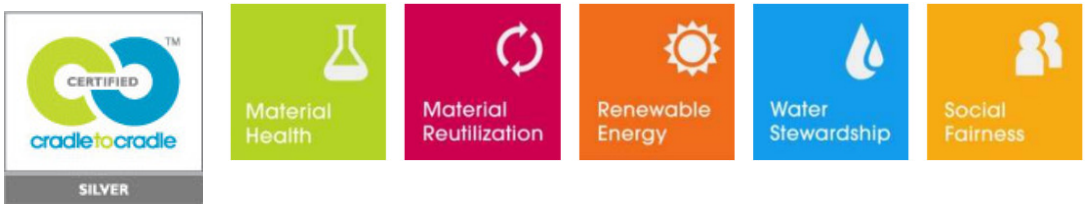
[1] Based on 345W SP panels, 250W Conventional Panels. See footnote on slide 59.

Sustainability

SUNPOWER

SunPower Environmental Advantage

Clean from start to finish… to start



- SunPower panels manufactured in Mexicali and France, representing 75% of SunPower's global volume, are the only *Cradle to Cradle Certified*™ Silver (C2C) solar product. This demonstrates SunPower's leadership in environmental stewardship and sustainable product design.
- Cradle to Cradle Certified™ is a multi-attribute certification program that assesses products and materials for safety to human & environmental health, design for future use cycles, and sustainable manufacturing.
- Cradle to Cradle Certified™ is recognized by the US Green Building Council's LEED v4 Standard and can contribute to additional points towards LEED certification.
- On a typical project[1], a solar system contributes 5 points, and using Cradle to Cradle™ certified products and reducing construction waste can yield an additional 9 points.
- Only 40 points are required to achieve LEED Basic, and on a $20Mn LEED Basic project, 14 points are worth $90,000[2]

[1] A typical project assumes core and shell or major renovation with at least 48% of the energy offset by solar, sufficient products to qualify for Material and Resource categories, and 33% of the hardscape covered with solar, or other heat island reducing coverings.
[2] Syphers, et al, "Managing the Cost of Green Buildings," 2003.
Cradle to Cradle Certified™ is a certification mark licensed by the Cradle to Cradle Products Innovation Institute.

Faster energy payback time

- SunPower conducts lifecycle assessments to identify opportunities to reduce the impact of its products.
- One measure in lifecycle assessment is Energy Payback Time (EPBT), the number of years required for a panel to offset the energy for the entire product lifecycle of the system:
  - Raw material extraction
  - Production
  - Distribution
  - Installation
  - Decommissioning
- SunPower panels have a 1.2 year EPBT[1] **– all of the energy produced after this time is a net gain**.
- Conventional Panels take 60% longer to offset their energy footprint[2].

SunPower panels require just 1.2 years months to pay back the energy needed to build and deploy them

[1] Francke, L, et al. (2015). GHG Emission and Energy Payback Time of AC Electricity Generated by SunPower® Oasis® Photovoltaic Power Plant. 42nd IEEE PVSC

[2] De Wild-Shcolten, M. (2013). Energy payback time and carbon footprint of commercial photovoltaic systems. Solar Energy Materials and Solar Cells, 119, 295–305.

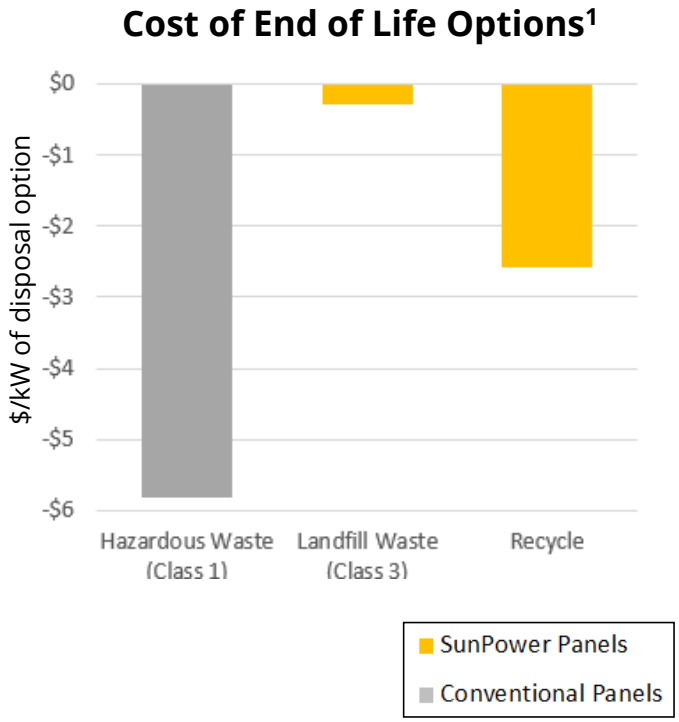
SunPower End of Life Environmental Advantage

Some solar panels have elements which are considered hazardous:

- Silver in front contact paste
- Lead found in solder
- Cadmium found in thin film

SunPower panels have undergone independent third party toxicity testing for heavy metals and show no significant levels of these toxic compounds.

- As a result, removal, reuse, or recycling of SunPower panels does not require hazardous waste handling procedures under both US federal and California regulations.
- SunPower panels also comply with RoHS and REACH guidelines used in the EU.



More end of life options, lower decommissioning costs, lower risk of future legislation

[1] SunPower Panel Environmental Advantages. SunPower whitepaper, 2014.

Sustainability Leadership

- Circular Economy 100
  - SunPower has joining other leaders and innovators in the movement to create a truly regenerative economy including Apple, Ikea, Philips, and Unilever.
- Guardian 2015 Sustainability Award
  - Recognizes SunPower's net positive innovation in sustainable business practices.
- 2015 Patents for Humanity Award
  - Identifies the use of patented technology for social good.
- US Green Building Council Member
  - SunPower has achieved LEED gold at two cell factories and its San Jose headquarters as well as LEED platinum at its central administration building.

ELLEN MACARTHUR FOUNDATION
Rethink the future

PATENTS for HUMANITY
It's not just an invention.
The U.S. Patent and Trademark Office
an agency of the Department of Commerce

U.S. GREEN BUILDING COUNCIL
MEMBER

Summarizing the Value

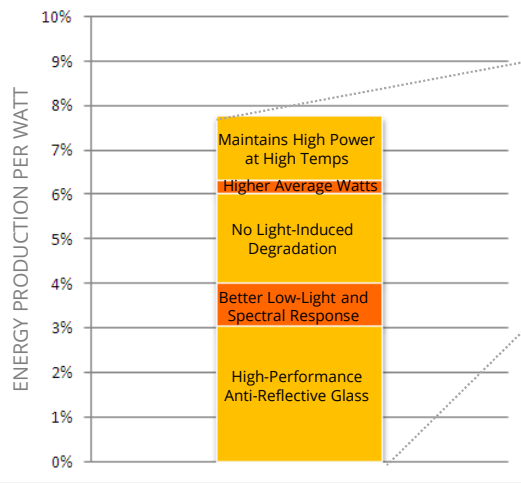
SUNPOWER

Summary of E-Series Energy Comparisons

E20 SERIES

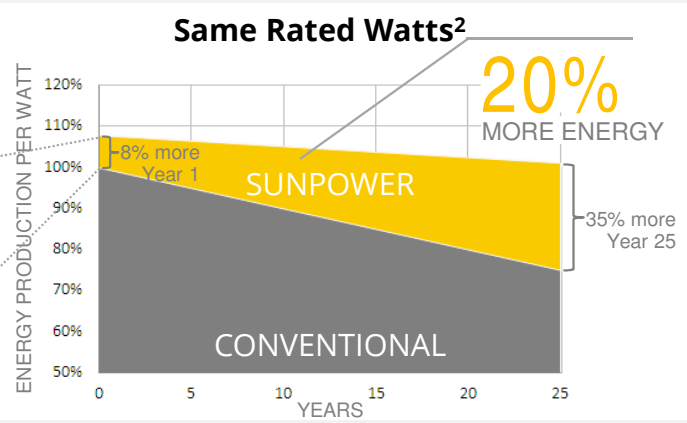
Year-One Energy Production

Same Rated Watts[1]

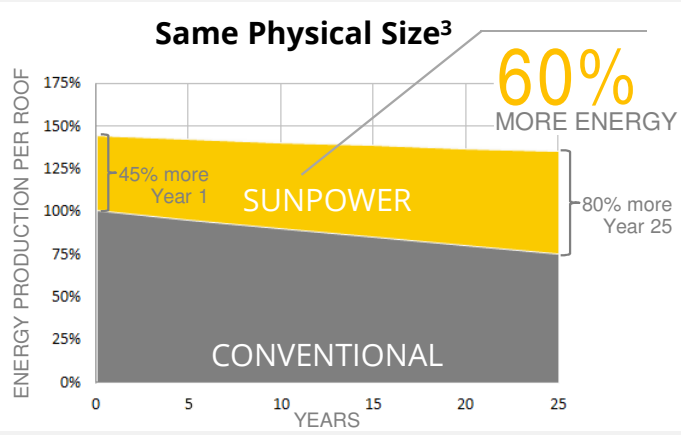


25-Year Energy Production

Same Rated Watts[2]



Same Physical Size[3]



[1] Typically 7-9% more energy per rated Watt compared to a Conventional Panel (250W, 15.3% efficient, approx. 1.6 m²). BEW/DNV Engineering "SunPower Yield Report," 2013.

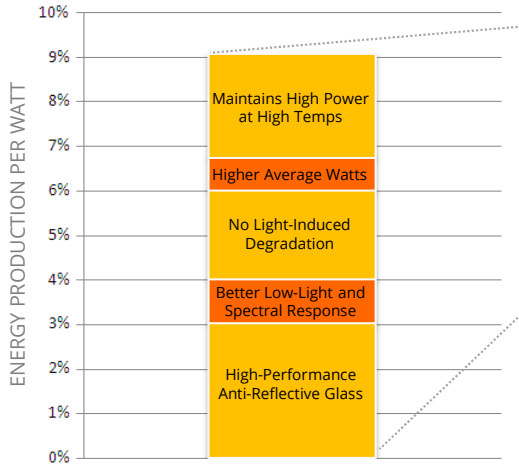
[2] SunPower 327W compared to a Conventional Panel (250W, 15.3% efficient, approx. 1.6 m2), 8% more energy per watt, 0.75%/yr slower degradation. BEW/DNV Eng. "SunPower Yield Report," 2013. Jordan, Dirk "SunPower Test Report," NREL, Apr 2015. Campeau, Z. et al. "SunPower Module Degradation Rate," SunPower white paper, 2013. See www.sunpowercorp.com/facts for details

[3] 327W SunPower vs. 250W Conventional Panel.

Summary of X-Series Energy Comparisons

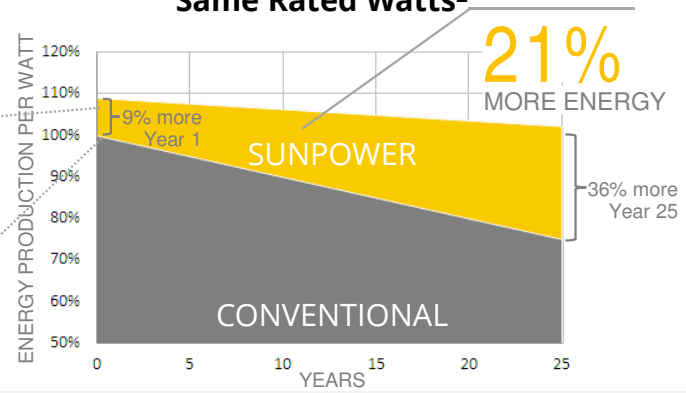
Year-One Energy Production

Same Rated Watts[1]

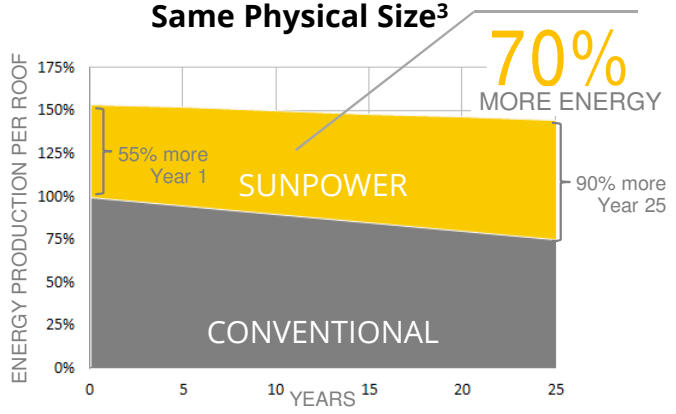


25-Year Energy Production

Same Rated Watts[2]



Same Physical Size[3]



[1] SunPower 345W compared to a Conventional Panel (250W, 15.3% efficient, approx. 1.6 m2), 9% more energy per watt, 0.75%/yr slower degradation. BEW/DNV Engineering "SunPower Yield Report," 2013 with CFV Solar Test Lab Report #12063, temp. coef. calculation. Campeau, Z. et al. "SunPower Module Degradation Rate," SunPower white paper, 2013. See www.sunpowercorp.com/facts for details.[2] Same as E-Series, because the cell architecture is the same (copper foundation), and the panel is the same. Footnote on previous slide.

[3] 345W SunPower vs. 250W Conventional Panel.

What is the total customer value of a SunPower System?

For E-Series, 20% more energy per rated watt means 20% more value at the system level. (For X-Series, 21%)[1]

- For example, a $4.80/W SunPower system[2] generates the same cost-per-kWh as a $4.00/W Conventional system

More energy generated from the same size installation. (For E-Series, 60% over the first 25 years; for X-Series, 70%)[1]

Peace of Mind

- Excellent reliability and quality
- Support from a US-based company with long history and a proven track record
- The best module warranty, with combined 25 year product and power warranties
- Strong balance sheet and financial backing and majority owned by Total, the world's 10th largest company

Excellent Products

- End-to-end solutions, including services
- Better aesthetics
- Leading Technology
- Excellent performance in real-world conditions, even partial shade

Sustainable – low footprint, fast energy payback, not hazardous waste

[1] Footnotes on slides 59 and 60.
[2] System Costs are examples for illustration only.

- SunPower end-mounted panel withstanding 11,000 Pa (230 psf)
- 1,400 kg (3,000 pounds)
- The glass did not break.

Thank You!

SUNPOWER

Appendix A:

Additional Panel Information

SUNPOWER

Examples of Independent Reliability Verification

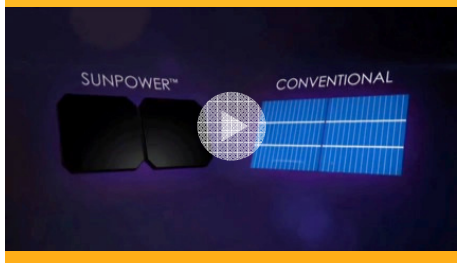
Institution	Program	Results
PV EVOLUTION LABS ADVANCING SOLAR	Potential Induced Degradation (damp heat with bias)	SunPower panels degraded 20x less than the average of Conventional Panels which passed the test[1]
Fraunhofer	Temperature cycling, humidity-freeze cycling, ultra-violet light exposure, static and cyclic mechanical load testing, PID	SunPower panels came out #1, with an average power drop of 1.3% across all panels, 6x lower than the other panels[2]
ATLAS 25+ Comprehensive PV Durability Testing; SGS PERFORMANCE TESTED Long-term durability www.sgs.com/solar	Combined "mini days" – UV light + temperature cycles + humidity + voltage, all at the same time	SunPower earned the toughest certificate, with an average power drop of 0% across all panels[3]
TÜV Rheinland PTL	Extended UV exposure, abrasive particle exposure, package integrity	SunPower is the first manufacturer to pass this test, demonstrating high reliability in extreme climates[4]

[1] Fraunhofer PV Durability Initiative for Solar Modules: Part 2". Photovoltaics International, 2014.
[2] Based on independent testing and analysis performed by PV Evolution Labs in 2013.
To pass, panels must have less than 5% power loss at 100 hours and 10% power loss at 600 hours.
[3] Atlas 25+ Durability test report, 2013. 0% power drop relative to the non-stress-tested control panel.
[4] TUV Rheinland test report on 10.1109/PVSC.2013.6744437. 2014.

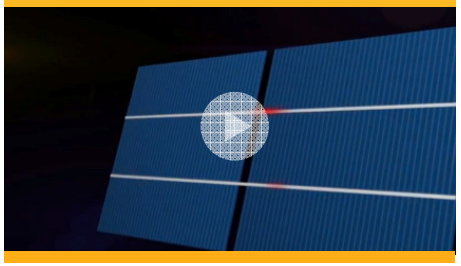
Videos

- These short videos demonstrate how the design of the Maxeon solar cell results in high reliability in various stressful environments.
- Search: “SunPower reliability” or click below:

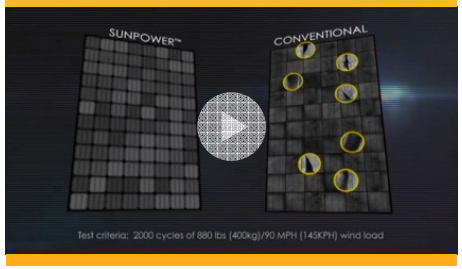
Humidity



Thermal Cycling



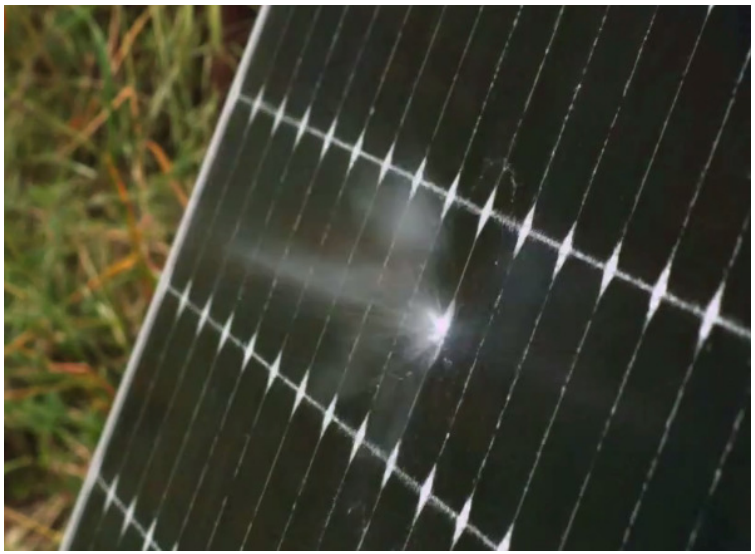
Loading

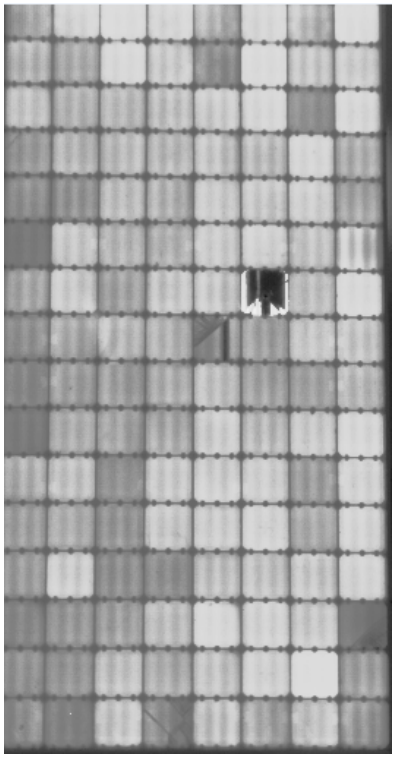


Shading

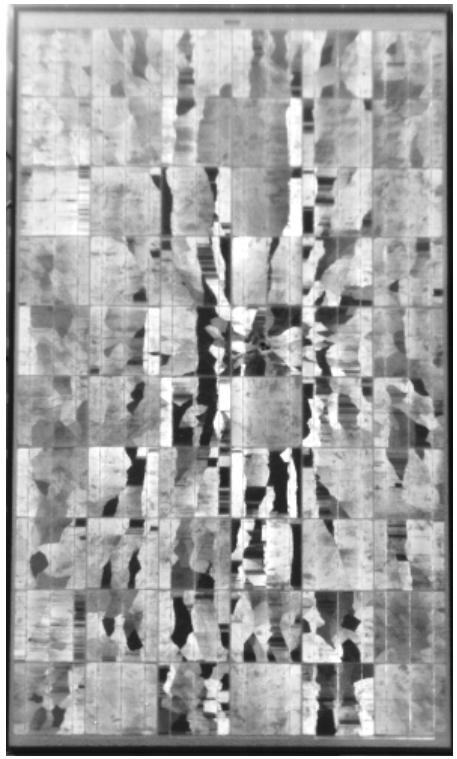
Bullets

- This short video demonstrate the robustness of the Maxeon solar cell under *extreme* conditions.
- Click here for video.





SunPower Panel
Power loss = 9%

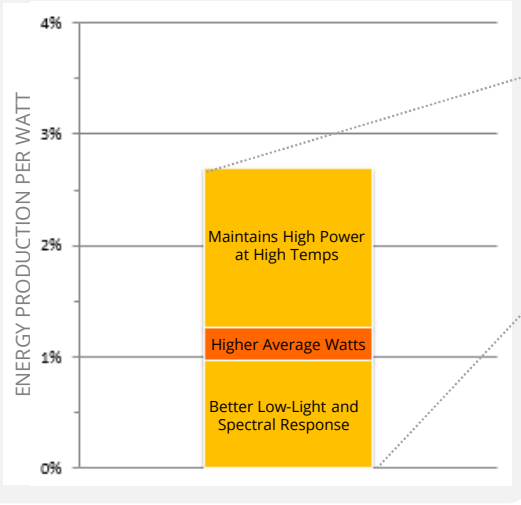


Conventional Panel
Power loss = 26%

Summary of E-Series Energy Comparisons to Medium Efficiency Conventional Panel

Year-One Energy Production

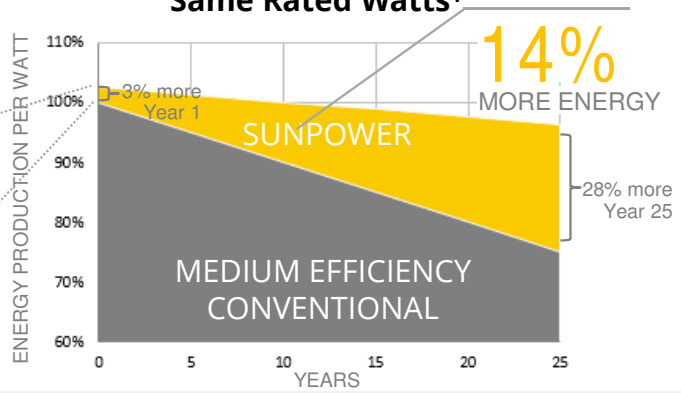
Same Rated Watts[1]



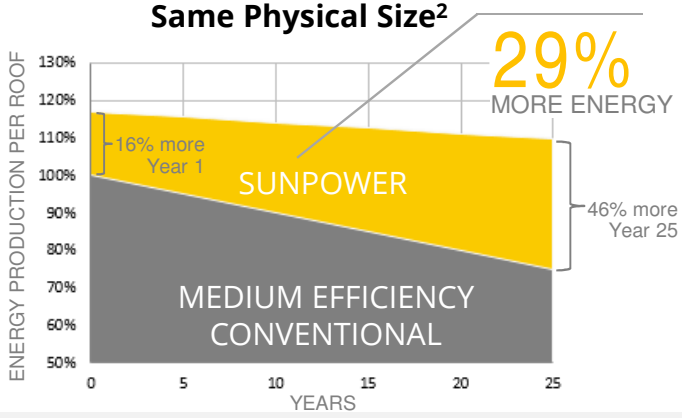
Medium Efficiency Conventional Panels use anti-reflective glass and n-type silicon, so there is a lower yield advantage.

25-Year Energy Production

Same Rated Watts[1]



Same Physical Size[2]



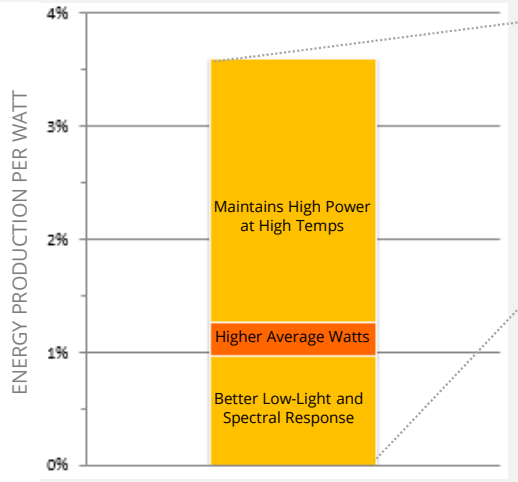
[1] SunPower 327W compared to a Medium Efficiency Conventional Panel (295W, 18% efficient, approx. 1.6 m2), 3% more energy per watt. BEW/DNV Eng. "SunPower Yield Report," 2013.

[2] SunPower 327W compared to a Medium Efficiency Conventional Panel (295W, 18% efficient, approx. 1.6 m2), 3% more energy per watt, 0.75%/yr slower degradation. BEW/DNV Eng. "SunPower Yield Report," 2013. Campeau, Z. et al. "SunPower Module Degradation Rate," SunPower white paper, 2013. See www.sunpowercorp.com/facts for details.

Summary of X-Series Energy Comparisons to Medium Efficiency Conventional Panel

Year-One Energy Production

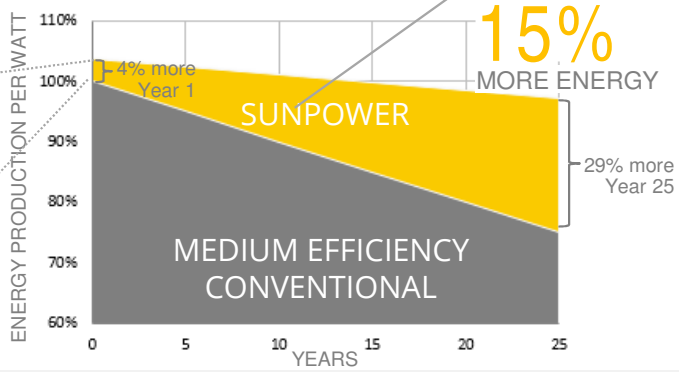
Same Rated Watts[1]



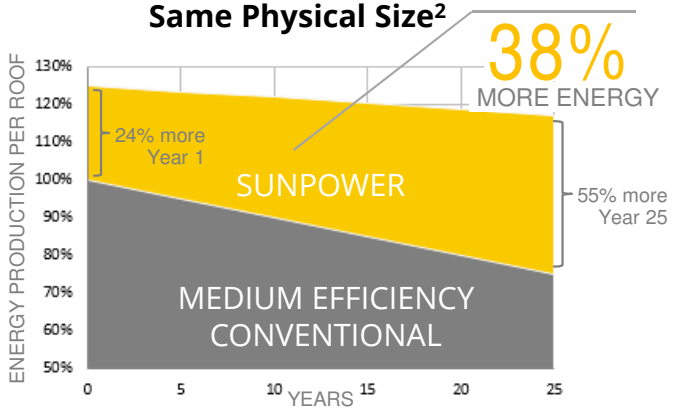
Medium Efficiency Conventional Panels use anti-reflective glass and n-type silicon, so there is a lower yield advantage.

25-Year Energy Production

Same Rated Watts[1]



Same Physical Size[2]



[1] SunPower 345W compared to a Medium Efficiency Conventional Panel (295W, 18% efficient, approx. 1.6 m2), 4% more energy per watt. BEW/DNV Engineering "SunPower Yield Report," 2013 with CFV Solar Test Lab Report #12063, temp. coef. calculation.

[2] SunPower 345W compared to a Medium Efficiency Conventional Panel (295W, 18% efficient, approx. 1.6 m2), 4% more energy per watt, 0.75%/yr slower degradation. BEW/DNV Engineering "SunPower Yield Report," 2013 with CFV Solar Test Lab Report #12063, temp. coef. calculation. Campeau, Z. et al. "SunPower Module Degradation Rate," SunPower white paper, 2013. See www.sunpowercorp.com/facts for details.

[2] Same as E-Series, because the cell architecture is the same (copper foundation), and the panel is the same. Footnote on previous slide.

Appendix B:

Quotes from Independent Engineering firm reports

SUNPOWER

BEW/DNV Report on the Accuracy of PVSim

Quotes from BEW/DNV Engineering Report:

"PVSim generally uses state-of-the-art algorithms that should yield accurate results. For example, PVSim uses the Sandia Performance Model with module coefficients established through 3rd party Sandia testing."

"PVSim is an accurate simulator for SunPower and non-SunPower PV systems. For SunPower systems, it offers a simple approach with little user adjustment necessary. For non-SunPower systems, it allows for extensive customization of a broad range of input parameters as needed. It incorporates advanced algorithms and defaults based on data from a large fleet of installed systems to provide accurate results without the need for extensive knowledge of PV physics by the user."

"BEW agrees that PVSim is able to simulate portfolios of actual installed systems to within 1%+/-2.3%."

"BEW using PVSim obtained results closer to measurements than BEW using PVsyst with comparable modeling assumptions. PVsyst can yield reasonable results if expert care is taken to configure inputs. This is particularly true for modules with higher relative efficiency at low light levels (corresponding to lower annual energy loss), such as SunPower products."

"SAM/PVWatts is a relatively crude simulator, and the observed departure from measured performance is excessive."

Details from BEW/DNV Report on SunPower Energy Production Advantages

	SunPower Yield Advantage - Anti-Reflective Coating (%)		
Climate	Oasis T0	25° Fixed Tilt	5° Roof Mount
Diffuse (Munich)	2.4%	3.1%	
Clear (Daggett)	1.5%	2.7%	
Hot (Phoenix)			3.3%

"Orientations with consistently larger incidence angles offer the largest opportunities for increases in energy production over non-coated glass. Even for the Oasis 1-axis tracker, the gains are significant…leading to meaningful differences in absorbed sunlight."

	SunPower Yield Advantage - Low Temperature Coefficient (%)		
Climate	Oasis T0	25° Fixed Tilt	5° Roof Mount
Diffuse (Munich)	0.6%	0.5%	
Clear (Daggett)	1.8%	1.7%	
Hot (Phoenix)			2.1%

"Depending on the climate, SunPower modules can be expected to exhibit a yield advantage by virtue of (their) reduced sensitivity to temperature (this advantage is magnified…by the fact that SunPower modules operate slightly cooler than slightly less efficient c-Si modules."

	SunPower Yield Advantage - Low-Light Efficiency (%)		
Climate	Oasis T0	25° Fixed Tilt	5° Roof Mount
Diffuse (Munich)	1.3%	1.4%	
Clear (Daggett)	0.4%	0.7%	
Hot (Phoenix)			0.8%

"Sandia's testing showed a consistent relative drop-off of just 3% at the…200 W/m2 and 25 °C cell temperature (vs.) other common c-Si modules, which report comparable drop-offs of 4% to 5% for well-known recent and current brands such as Solon, Suntech, SolarWorld, and Trina."

	SunPower Yield Advantage - Overall (%)		
Climate	Oasis T0	25° Fixed Tilt	5° Roof Mount
Diffuse (Munich)	6.8%	7.7%	
Clear (Daggett)	6.6%	8.0%	
Hot (Phoenix)			9.1%

Summary table of all the energy benefits and how they combine for the 3 weather and 3 mounting configurations.

"The SunPower module will produce energy with a higher baseline power than a module that has light induced degradation. This translates directly to increased relative energy production from SunPower modules of 1.5% to 3%."

Black & Veatch Audit of SunPower Degradation Study

IMPORTANT: The contract with Black & Veatch requires that communications involving this **report either quote the following three paragraphs in their entirety, or share the report in its entirety.** B&V is critically interested in not even having the appearance of endorsing any particular manufacturer, and is only willing to confirm SunPower's analysis given the field data. B&V will not say anything about non-SunPower panels, or about current and future SunPower panel performance.

Usable quote from B&V:

"The data array used by SunPower to calculate the median degradation value of the 70 sites analyzed in the Degradation Report consists of all of the daily year over year degradation rates for each site. The Degradation Report also calculates the uncertainty of the median value using the median of absolute deviations.

The analysis concludes that the median annual system power degradation rate for these sites is 0.32 ±0.05 percent per year. The analysis also indicates that the degradation is linear over the period of time of over three years that was measured.

Black & Veatch reviewed the calculation techniques and the data used to obtain the degradation rates for the systems using SunPower modules and believes that the system power degradation results appear to be derived from the data reviewed, and are based on appropriate statistical analysis."

About Black & Veatch:

- Black & Veatch is one of the most experienced photovoltaic engineering consulting firms in the world.
- Independent engineer for financial institutions on dozens of utility scale projects totaling over 2,000 MW.
- Owner's engineer in developing and building over 2,000 MW of solar facilities.
- Ralph Romero lead author – solar specialist with over 25 years experience in the design and manufacturing of solar photovoltaics. He is a recognized expert in the commercial development of PV technology.

Using other Energy Models

- Models always have two parts:

1. Weather File "Typical year" for each location + **2. Energy Model** = **kWh/yr** = **Energy Bill Savings**

- If two models disagree, it could be the model or the weather file
- PVSyst is pretty close to PVSim
  - if the latest version is being used, the SunPower PAN file will be accurate
  - if the IAM (Angle-Of-Incidence) points are modified in the Losses section to account for the AR-Glass performance (as measured by Sandia National Labs)
- PVWatts is very inaccurate
  - 10-30% actual energy production
  - does not distinguish between different panel types, so cannot show any additional energy from SunPower panels
- PVSol is pretty close to PVSim, but is not a sophisticated model
  - if the latest version is being used
  - if "mismatch loss" is changed from 2% to 1% for SunPower panels

If you must use something other than PVSim, use PVSyst

Appendix C:

Cell Cracking Demonstration

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Cell Breakage Demonstration

Demonstrate that Maxeon cells are fundamentally different: Built on a Solid Copper Foundation.

- **IMPORTANT: broken solar cells are like broken glass**
  - Be cautious to avoid getting cut by shards
  - Keep the solar cells in the plastic bags – these are thick enough to contain shards (especially the Conventional Cell)
  - Before cracking the cells, point out the differences and why they are important

Video directions:

http://tinyurl.com/9grvwx2 (SalesForce login)
or https://sunpowercorp.box.com/s/4kk7hr2p688c6bskgm8y

Cell cracking demonstrating kits (10 SunPower cells, 10 Conventional Cells) are available from SunPower.

1. Hold the cells with the blue side facing out and bring two opposite corners together until the cell cracks.
   - This creates the most realistic cracks (diagonal following the crystal plane)
   - Note that any chips along the edge of the cell will cause it to crack almost immediately when bent (which is still ok for demonstrating the copper foundation)
2. After cracking the SunPower cell, flex it back-and-forth along the cracks to show that the copper plating is keeping the cell together
   - Do not flex the cell in a different direction after it is broken. The silicon is very strong when compressed so this could create unrealistic forces that could even break the copper
3. If you can do so safely, SunPower encourages you to recycle broken solar cells just like you would recycle broken glass

Thank You

Let’s change the way our world is powered.