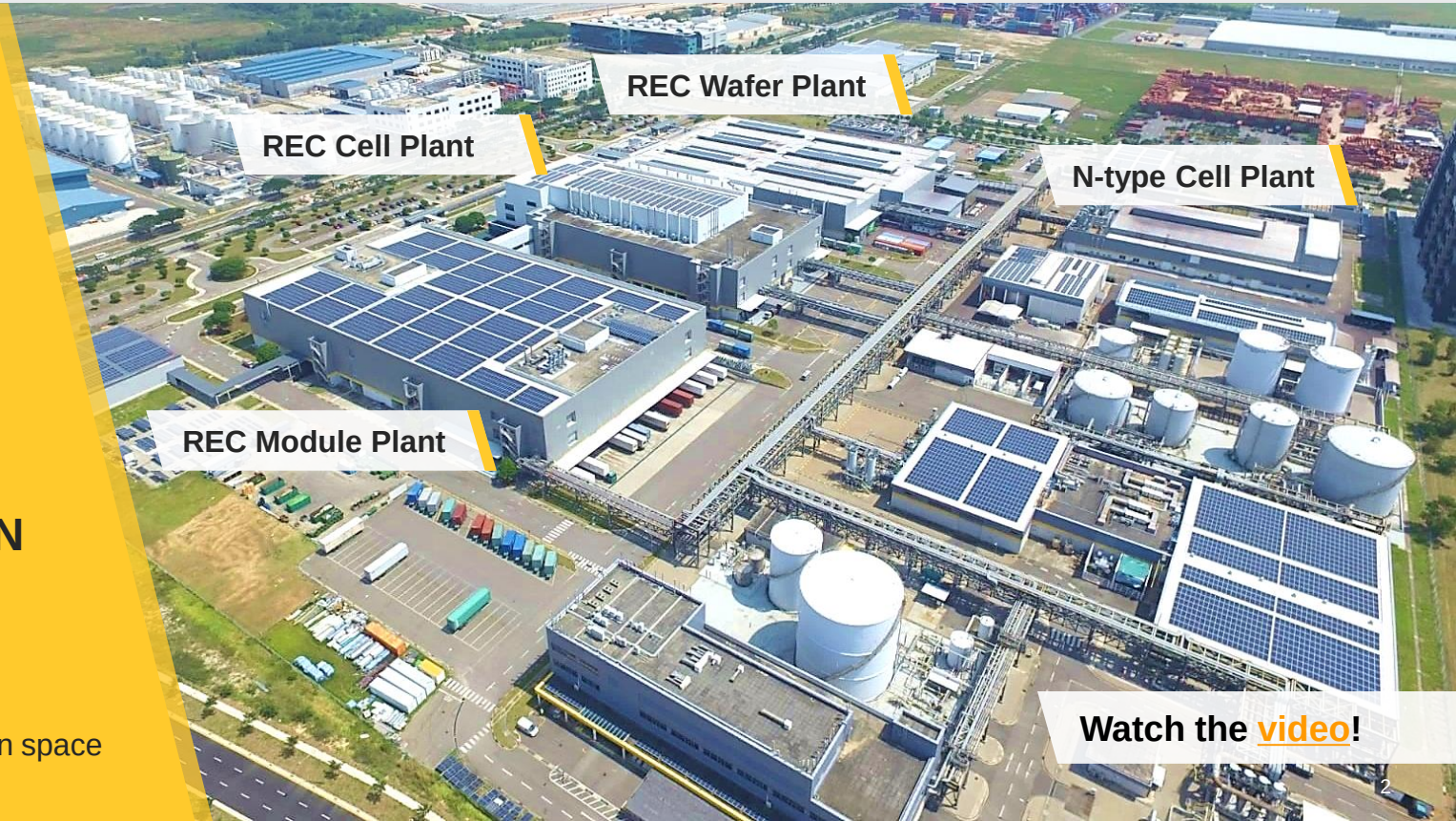
REC PRODUCTS

Giving you best results through high power and high quality

REC Integrated Production Facility
Tuas, Singapore
REC TwinPeak 72 Series

REC’s integrated production facility in Singapore

Outstanding quality, industry 4.0 manufacturing



MODULE PRODUCTION CAPACITY

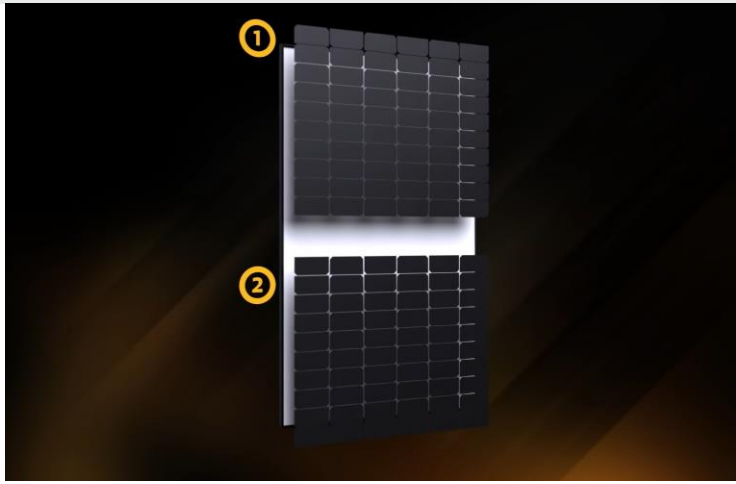
1.8 GW

146k m^2 of production space

A Frontrunning Innovator

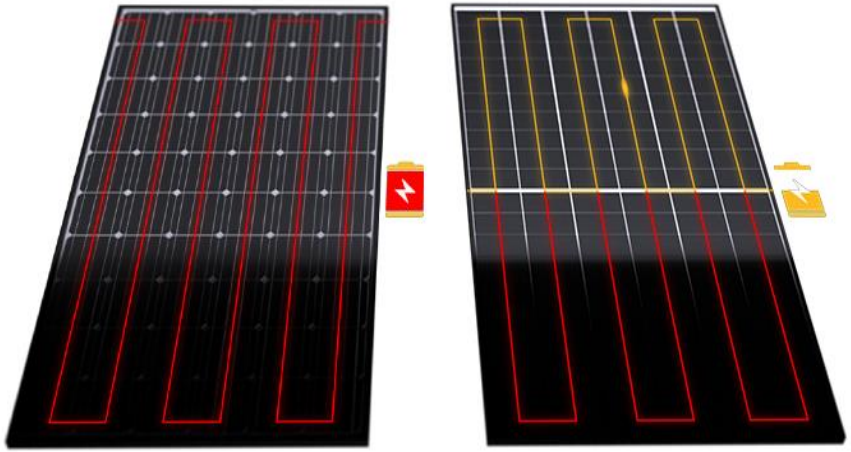
REC is one of the major innovators in solar technology

- **Innovation is in REC's DNA** − constantly setting the pace when it comes to high efficiencies, novel and here-to-stay products
- **REC TwinPeak** − First to bring multicrystalline half-cut cell modules to mass production
- **REC TwinPeak 2 Mono** – Up to 320Wp (60-cell), 380Wp (72-cell)
- **N-Peak** − First n-type mono solar panel with half-cut cells and a twin design
- **Floating** − First to push half-cut cell solar panels on water
- **Alpha revolution** – Pushing 60-cell power up to 380Wp
- **4 x Top Performer status** in DNV GL tests
- **Multiple award-winning** Twin Design concept technology



REC Twin-Peak technology

Improved performance when shaded



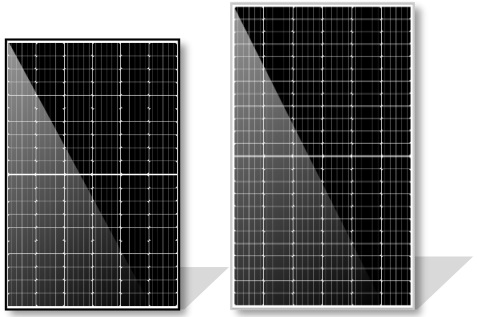
Standard module **REC module**

- **Award-winning** design, pioneered by REC
- Panel split into two ‘**Twin**’ sections
- Reduces internal resistance for **more power** and reliability
- Continued **energy production in shaded** conditions for **higher energy yields**

REC product portfolio

Wide portfolio for all areas of application

60 & 72 cell p-type PERC

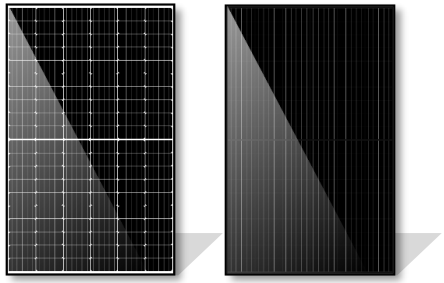


TwinPeak 2 Mono
300-330 W

TwinPeak
2S Mono 72 XV
370-400 W

- REC module for commercial and industrial systems
- 72 cells: 1500V system voltage

60 cell n-type PERT

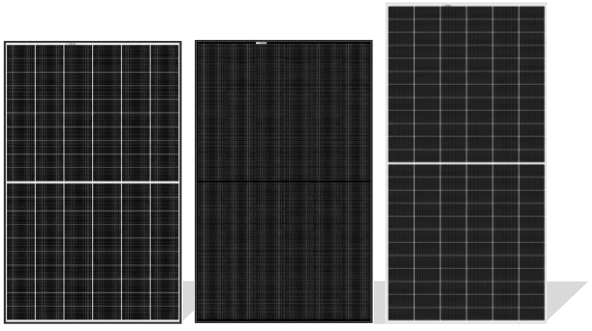


N-Peak
310-330 W

N-Peak Black
305-325 W

- World's first n-type mono module with Twin design
- Ideal for C&I and residential applications

60 & 72 cell HJT



Alpha
360-380 W

Alpha Black
355-375 W

Alpha 72
430-455 W

- Aesthetically attractive HJT high-performance module
- Ideal for C&I and residential applications

More performance through award-winning technology

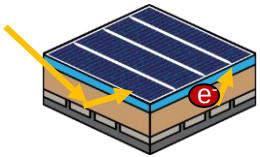
TwinPeak 2 Mono

	TP2 M
Cell	Half-cut
Passivation type	PERC
No.of busbars:	5 busbars
Junction box type	Split JB

Half cut cells

- Laser cut before stringing
- Reduced internal loss
- Reduced cell current by 50%
- Reduced power loss by 75%

PERC

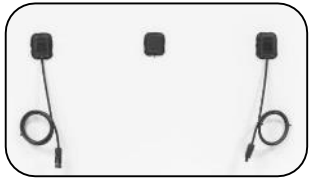


- Passivated cell backside
- Reduces recombination of electrons
- Higher Voc
- Lower operating temperature
- Higher efficiency

5 busbars

- Reduces travel path of electrons
- Improved flow of electrons
- Reduced the internal resistance
- Improves reliability

Split junction box



- Accelerated heat dissipation
- Reduces cell temperature for higher efficiency
- Central position gives advantages when under shading conditions

More performance through award-winning technology

TwinPeak 2 Mono ⇨ N-Peak

	TP2 M	N-Peak
Cell	Half-cut	→
Passivation type	PERC	PERT
No.of busbars:	5 Busbars	→
Junction box type	Splitted JB	→

Half cut cells

- Laser cut before stringing
- Reduced internal loss
- Reduced cell current by 50%
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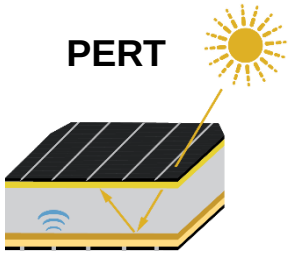
PERT



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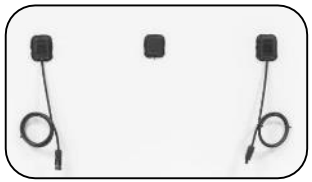
Split junction box



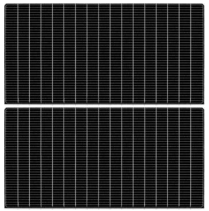
- Accelerated heat dissipation
- Reduces cell temperature for higher efficiency
- Central position gives advantages when under shading conditions

More performance through award-winning technology

TwinPeak 2 Mono → N-Peak → Alpha

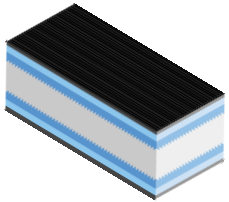
	TP2 M	N-Peak	Alpha
Cell	Half-cut	→	→
Passivation type	PERC	PERT	HJT
No.of busbars:	5 Busbars	→	16 thin wires
Junction box type	Splitted JB	→	→

Half cut cells



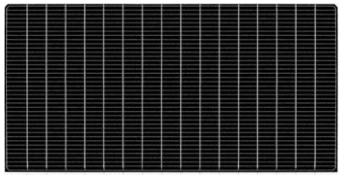
- Laser cut before stringing
- Reduced internal loss
- Reduced cell current by 50%
- Reduced power loss by 75%

HJT



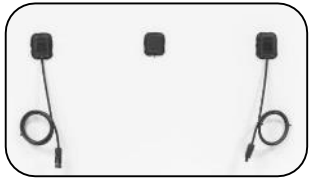
- Hybrid cell made of crystalline and amorphous silicon
- Leading temperature coefficient
- Higher Voc
- Higher efficiency

Advanced cell connections



- Low temperature manufacturing
- Solder-free production
- Near-invisible wires
- Shorter electron travel path
- Reduces the internal resistance

Split junction box



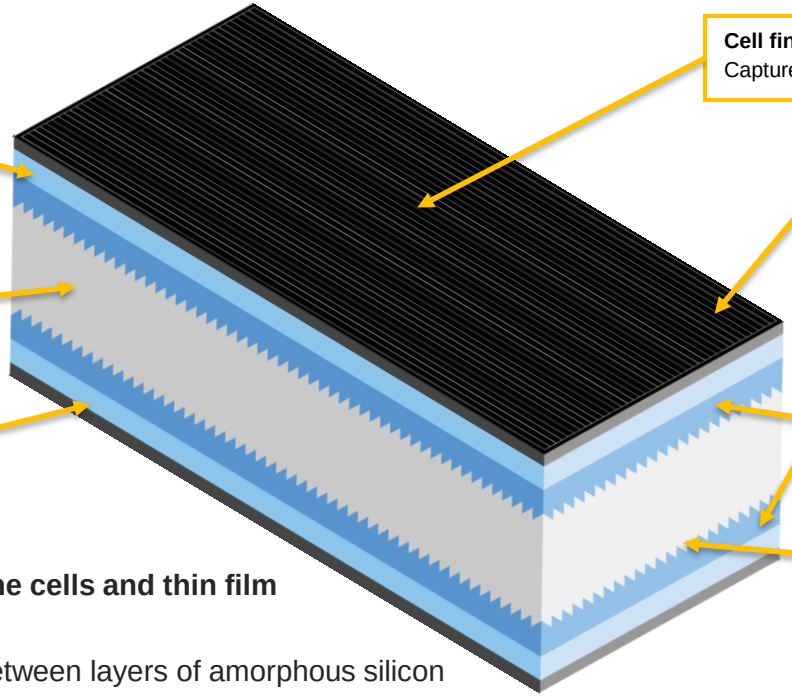
- Accelerated heat dissipation
- Reduces cell temperature for higher efficiency
- Central position gives advantages when under shading conditions

Intersolar 2019 Day 1

Alphα announcement

REC Alpha-Series

Heterojunction cell technology for high efficiency



Amorphous Silicon:
Phosphorus doped (n+)
Transports only negative charges to the TCO layer.
Ensures no positive charges are transported.

N-type mono wafer
doped with phosphorus

Amorphous silicon
Boron doped (p+)

Cell fingers printed on surface
Capture current and lead to wire

Transparent Conductive Oxide(TCO)
Provides extra conductivity, anti-reflective layer & high transmission

Intrinsic Amorphous Silicon layers
Creates passivation layer

Wafer texturing
Creates pyramids which minimize the reflection of light

- **Combines advantages of crystalline cells and thin film for high efficiency & power**
- High efficiency n-type mono wafer between layers of amorphous silicon
- High efficiency cell produces more energy at higher temperatures
- Amorphous layers are doped with phosphorus and boron to create cell structure
  - Intrinsic amorphous silicon acts as a passivation layer

Advanced cell connections

Solder-free, low temperature bonding for high efficiency

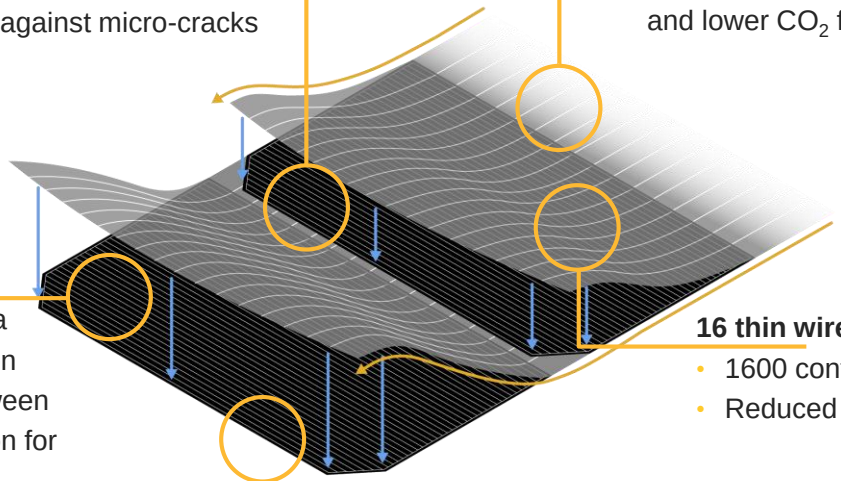
81 % LEAD REDUCTION

Solder-free connections

- Lead-free as no solder is used on cell
- Lead-free silver paste
- Low temperature, non-invasive process
- High resistance against micro-cracks

Low temperature process

- Greatly reduces thermal stress for fewer defects
- Energy-efficient production for fewer emissions and lower CO_2 footprint



No busbars

- Exposes more cell area for more light absorption
- Increased contact between fingers and metallization for higher power

16 thin wires

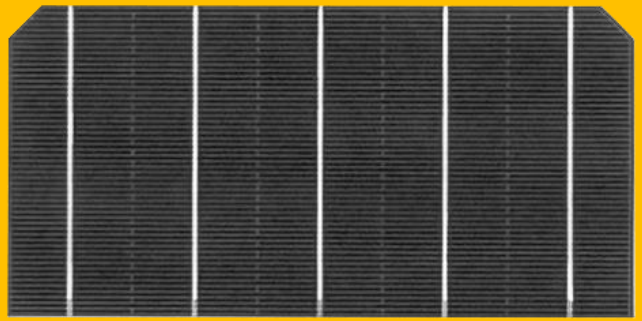
- 1600 contact points per cell
- Reduced internal resistance

Industry-leading quality

Highly automated production improves efficiency and reliability

More contacts points to the cell
Improved electron flow and power

Standard 5 busbar cell

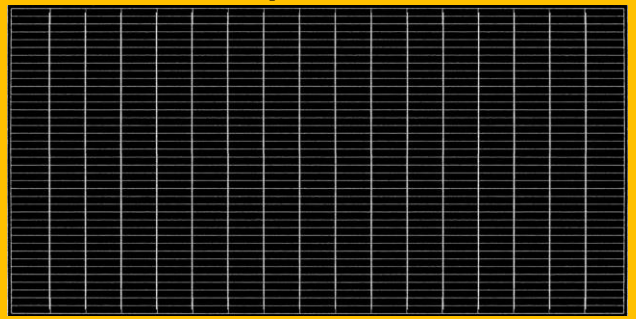


- 5 wide busbars and ribbons
- High temperature curing process
- Requires soldering process in production

250 contact points per cell

30,000 cell connections per panel

REC Alpha Series cell



- 16 thin round wires
- No busbars
- No soldering

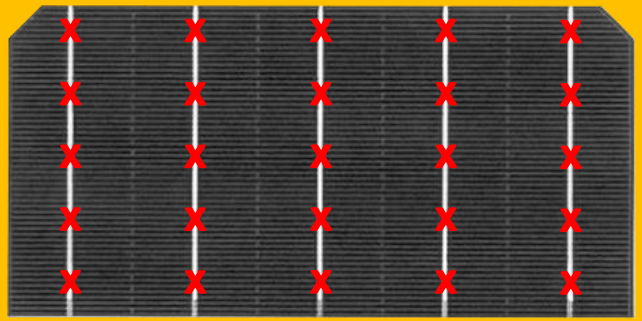
1600 contact points per cell

192,000 connections per panel

Eliminates invasive soldering

Solder-free process for improved quality

Standard 5 busbar cell

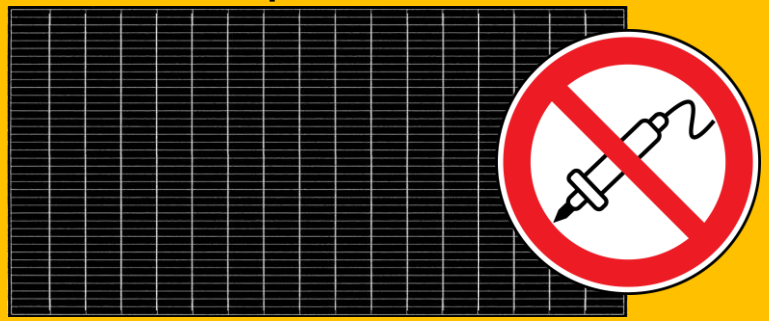


- ~25 x solder per cell side
- High paste requirement covers cell surface
- Ribbons need soldering to busbars

>50 soldering points per cell

>6000 cell connections per panel

REC Alpha Series cell



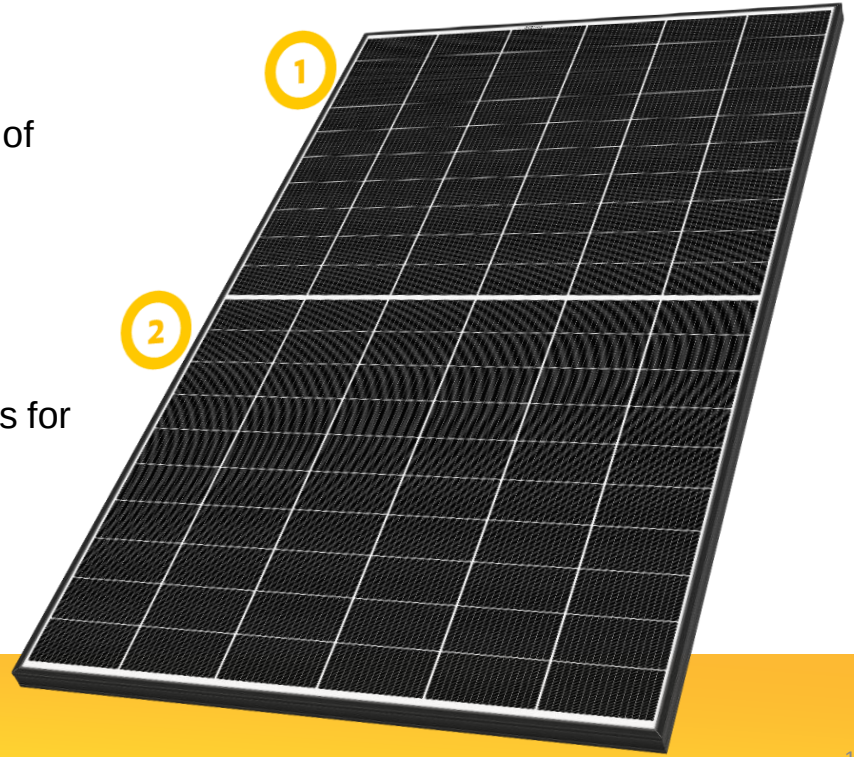
- Direct bonding of wires to cell surface
- Exposes more cell surface area to light
- 81% reduction in lead content

Zero soldering on the cell

390 soldering points in full panel

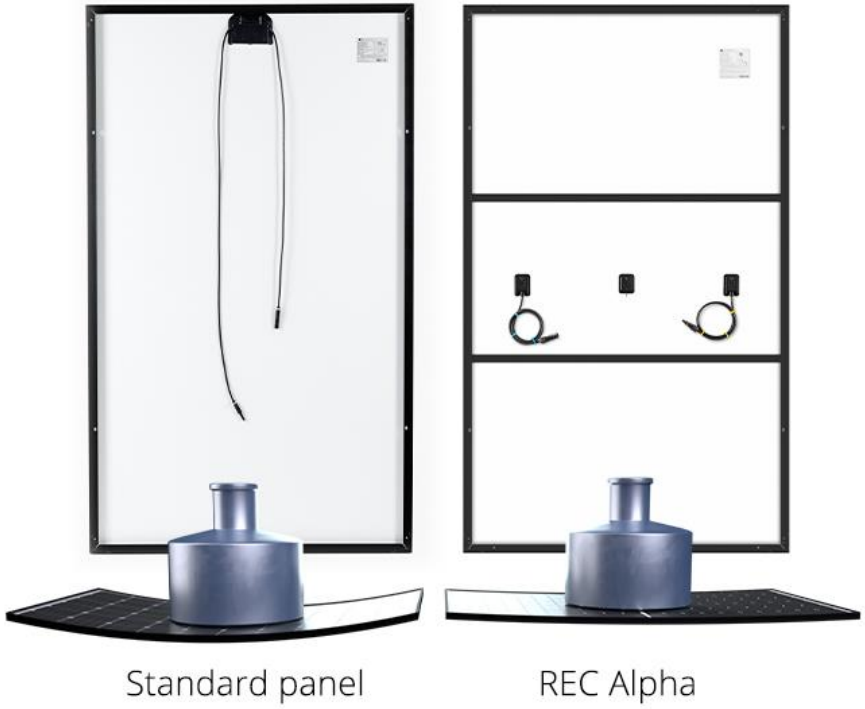
Award-winning Twin Design concept for higher power

- Award-winning Twin panel design concept
  - Introduced to market in 2015
  - Panel split into 6 separate strings in two sections of 60 half-cut cells
  - 50% reduction in current per cell
  - Power loss in panel reduced by factor of 4
    - $P_{loss} = R \times I^2$
  - Continued energy production in shaded conditions for higher energy yield
- Additional larger cell area for higher power
  - Increases surface area to capture light



REC Alpha Series: Performance Advantages

Giving you better durability

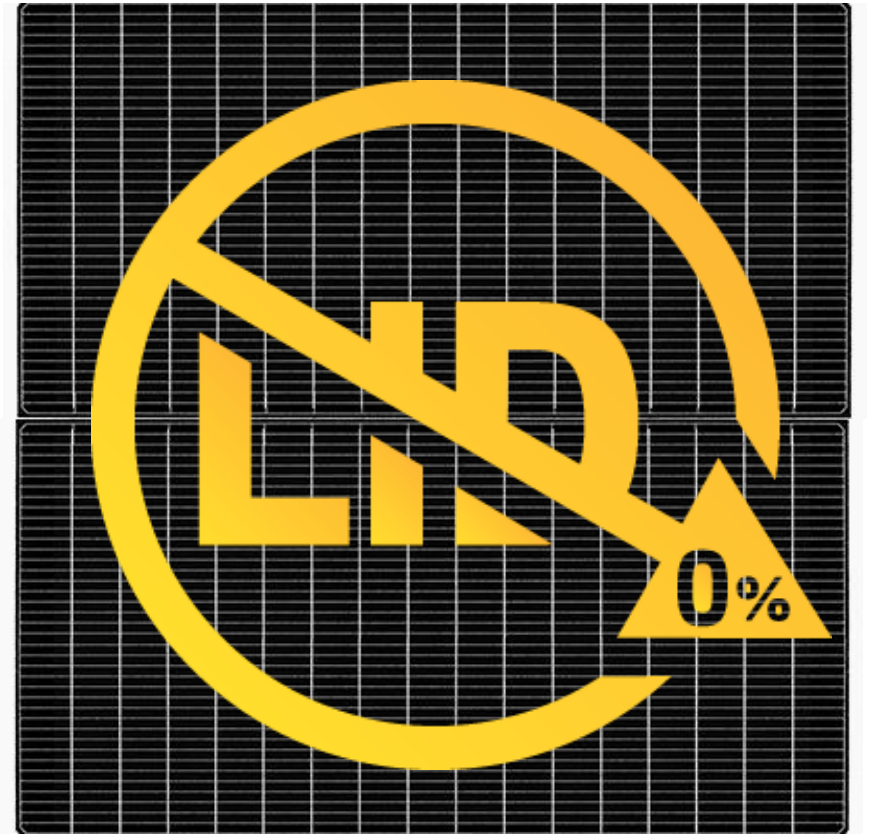


- **Support bars protect** cells and glass from excess bending under load
- Allows extreme loads up to **7000 Pa** snow load, **4000Pa** wind load
- Panels **maintain high performance levels** over the installation lifetime
- 30 mm frame height makes panel **easier to handle**
- 30 mm frame design allows **optimized transportation**: more panels/pallet = more panels/container = fewer trucks on the road = **more savings**

REC Alpha Series: Performance Advantages

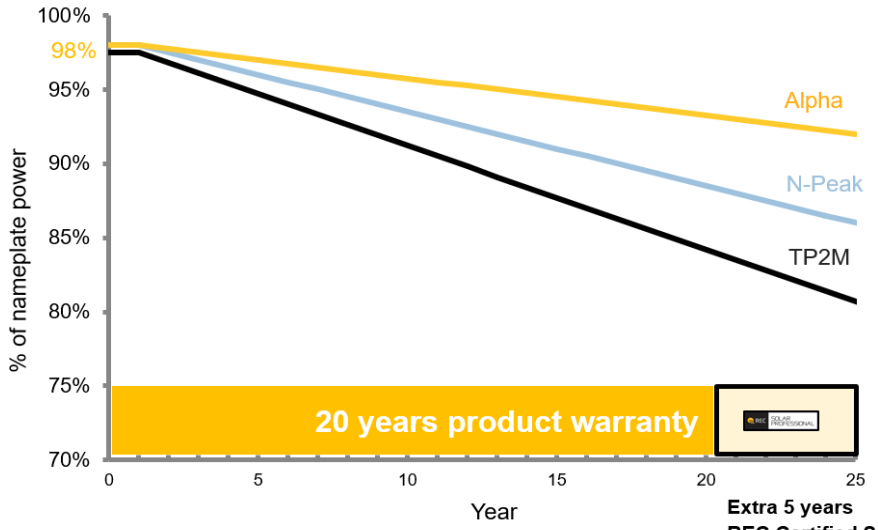
No LID – so no drop in performance immediately after installation

- Light Induced Degradation affects most crystalline solar cells on the market
  - Immediate drop in power over initial exposure to sunlight, i.e., after installation
  - Some panels see losses of up to 3% before stabilizing
  - Caused by interaction of boron and oxygen in the cell
- REC Alpha Module uses n-type doping which prevents the interaction of boron in the cell
  - So no drop-off in power after installation
  - The power purchased is the power customers receive on their installation



REC Alpha Series: Performance Advantages

Leading warranty for greater customer security



2% 1. year **0.25%** years 2-25

2% 1. year **0.5%** years 2-25

2.5% 1. year **0.7%** years 2-25

REC's industry-leading warranty

20-year product guarantee

+ 5 years additional if installed by a REC Certified Solar Professional (25 years in total)

25 years power output warranty

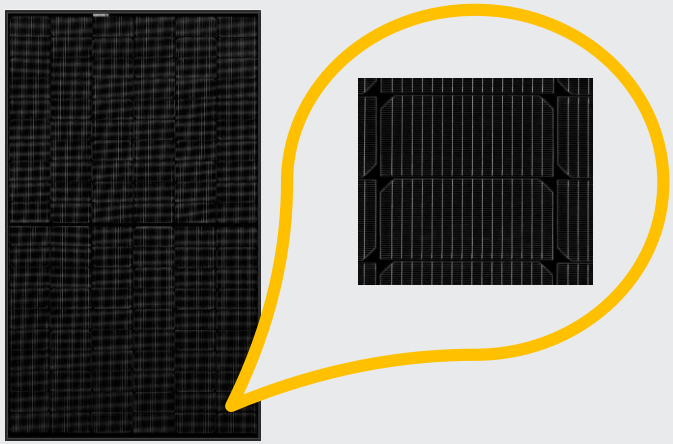
Starting at only 98% after one year with a guaranteed minimum output of 92% after 25 years of operation

REC Alpha Series: Performance Advantages

Highest aesthetics on the roof

REC Alpha Series: Performance Advantages

Advanced cell connections give great aesthetics on the roof

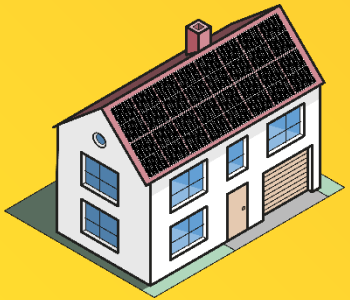


Black cells with a black frame for the best look
The metallization of the solar cells is less visible

- The wires are invisible from a short distance
- The module connections are covered

"Full Black" variant for an elegant and uniform appearance on the roof

REC Alpha maximizes your system power for maximum savings



Example of a typical residential installation			
Conventional panels	P-multi	16 x 300 Wp	4.8 kW
	P-mono	16 x 320 Wp	5.1 kW
REC Alpha	HJT	16 x 380 Wp	**6.1 kW**

More power with the REC Alpha

+20% **more power** than p-type mono

+27% **more power** than p-type multi

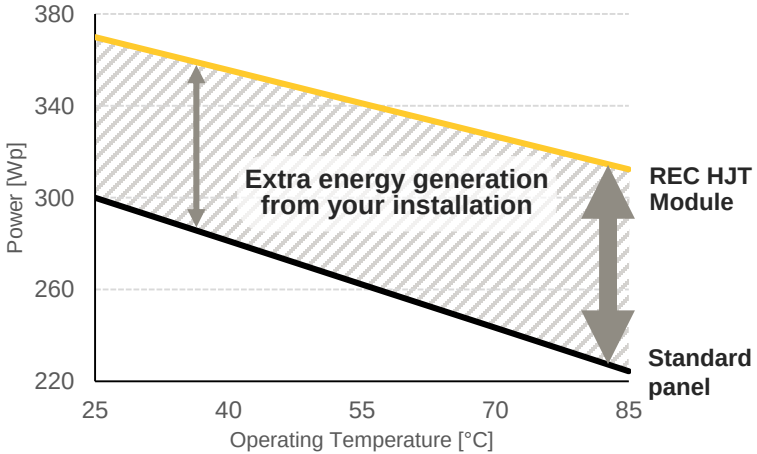
REC Alpha Series: Performance Advantages

More energy production when temperatures rise

Alpha performs better than conventional technology

- As cell temperature rises, solar modules lose a certain % of their efficiency
- **Temperature coefficient: - 0,26% /ºC**
- The REC Alpha module has a much lower power loss as cell temperature rises

Up to 5% more power at higher temperatures with the REC Alpha Module!

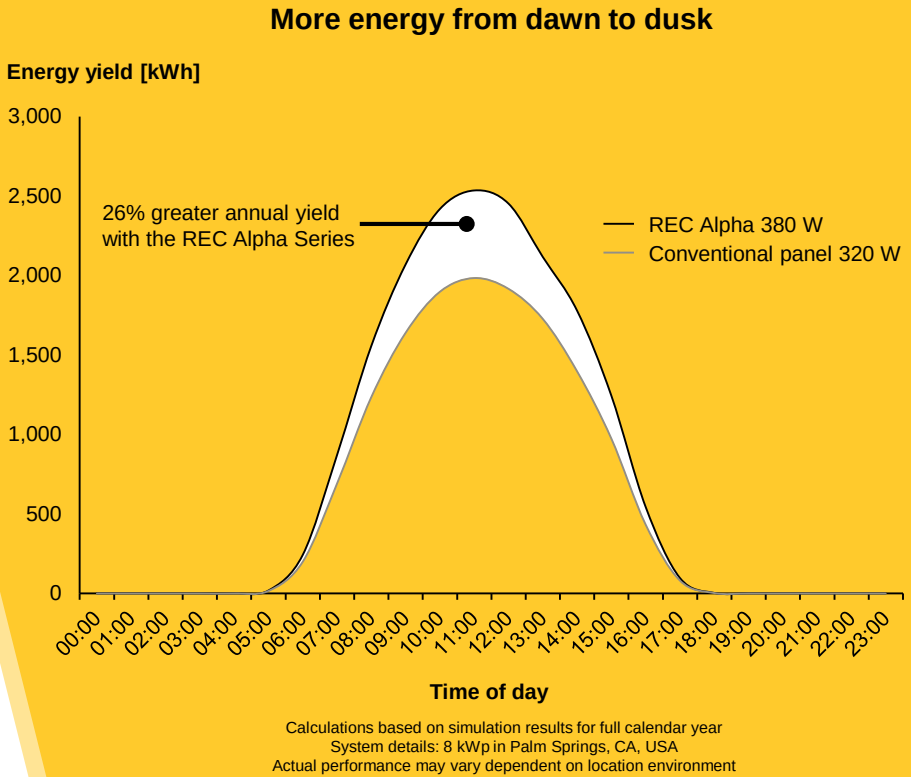


Temp.	Conventional 300 Wp mono		REC Alpha Module		Power loss diff.
Tcoeff	-0.42%/°C		-0.26%/°C		
	% Loss	Power [Wp]	% Loss	Power [Wp]	
25°C	**0**	300	**0**	370	
40°C	**6.3**	281.1	**3.9**	355.6	**2,4%**
55°C	**12.6**	262.2	**7.8**	341.1	**4,8%**
70°C	**18.9**	243.3	**11.7**	326.7	**7,2%**
85°C	**25.2**	224.4	**15.6**	312.3	**9,8%**

REC Alpha

Leading temperature coefficient produces more energy when the sun is strongest

- The REC Alpha Series packs in even more energy generation
  - Most efficient cell technology
  - No LID
  - Leading temperature coefficient
  - Highest 60-cell power density
- Ideal for making the most of available rooftop space
- Greater annual yields for more savings on electricity bills



Calculations based on simulation results for full calendar year
System details: 8 kWp in Palm Springs, CA, USA
Actual performance may vary dependent on location environment

REC Alpha Series: Environmentally-friendly

Reduce your environmental impact

	Standard panel	REC Alpha Module
Module weight (kg)	18.5 kg	19.5 kg
Lead content (g)	23.7 g	4.7 g
% lead content	0.13 %	0.02 %
% reduction lead of content		**81 % reduction**

- Solder-less cell connections eliminate majority of lead
- 81% reduction in lead content
  - Lead-free silver paste
  - No soldering on cells

The REC Alpha Series

So many advantages for maximum use of installation space

20% more power on your roof*

- The most advanced cell structure for high efficiency performance
- High power density maximizes the energy from limited spaces

More reliability with advanced connections

- Eliminates invasive soldering process
- Reduced thermal stress for long-lasting high performance

REC's iconic Twin Design

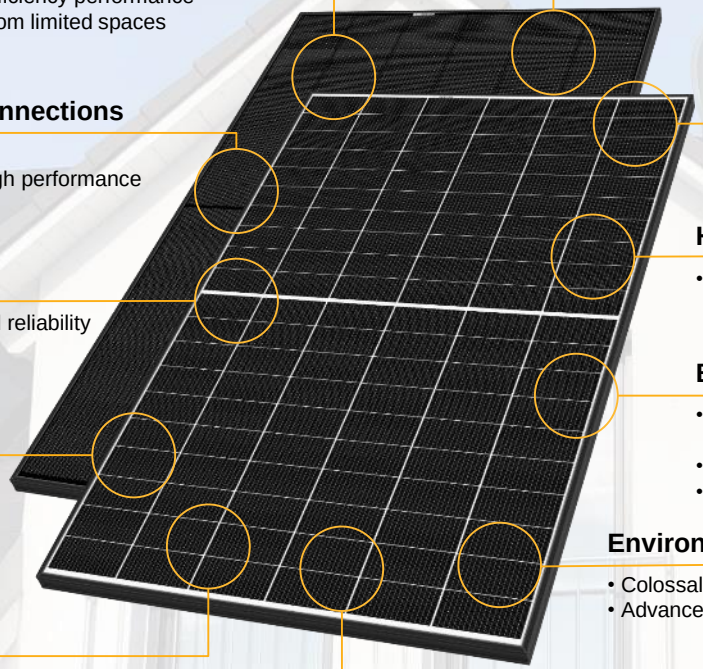
- Reduces internal resistance for more power and reliability
- Improved output when shaded

Outstanding quality

- State of the art, automated production in Singapore
- Renowned for consistently low warranty claims rate

Takes the heat

- Lowest temperature coefficient for best performance in hot climates
- Means more energy produced at the hottest times of the day



Stylish looks

- Seamless appearance on your roof
- Full-black option: an elegant feature for your home

Maximize power to maximize savings

- Get a greater reduction on your energy bills
- Outstanding warranty protection for a secure investment

Higher light transmission

- Special anti-reflective glass increases light transmission for higher power

Better durability

- Super-strong frame for better protection against bad weather conditions
- Long-lasting high power through improved durability
- Warranted 92% power after 25 years

Environmentally-friendly

- Colossal 81% reduction in lead content
- Advanced manufacturing technology greatly reduces carbon footprint

N-type cell technology = No LID

- No initial drop in installed power, so you get the power you pay for

* Compared to a 320 Wp conventional technology module