

SOLAR'S MOST TRUSTED



# THE REC ALPHA PURE SERIES

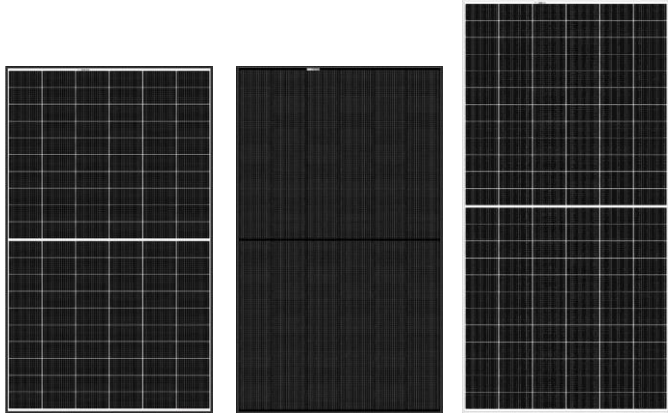
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Leading the green energy revolution to ever more sustainability

Neil Edwards & George McClellan  
June 28, 2021

Munich, Germany  
REC Alpha Black Series

# REC manufactures and sells high quality solar panels for use in various applications worldwide



## Residential



## Commercial



## Utility



## Floating





## OUR VISION

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We want every person to benefit from electricity directly from the sun.



# REC at a glimpse – 25 years of commitment to solar REC



**>40M SOLAR PANELS**  
produced and sold



**>17M PEOPLE**  
Powered at home




**~1,600**  
employees globally



**NORWAY & SINGAPORE**  
Manufacturing facilities



**~1.5 GW**  
2021 solar panel  
production capacity



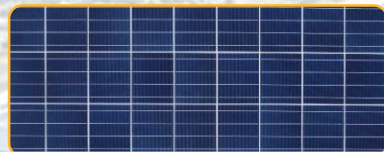
**CONSISTENT HIGH QUALITY**  
4 million panels manufactured each year;  
<400 from return from the field (PPM: <100)




# REC Alpha Pure Series: A product of strength and experience throughout the value chain



REC founded in Norway



REC introduces cells with 4 bus bars  
REC PE cells:  
18% CE



REC applies half-cut cell technology to mono n-type for the first time



**LEAD-FREE**  
ROHS COMPLIANT

REC starts lead-free, RoHS compliant panel production with REC Alpha Pure Series

1996

2010

2012

2015

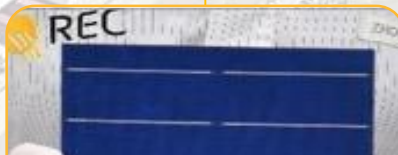
2018

2019

2021




REC starts operations in Singapore  
REC first to use 3 bus bars:  
<16.4% CE



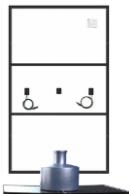
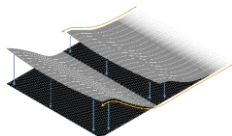
REC first to apply half-cut technology to multi cells: 18% CE  
REC first manufacturer to apply PERC to mass production multi-Si cells

REC introduces half-cut technology on HJT cells  
REC is first with advanced cell connection technology



N-type mono wafer

# The REC Alpha Pure Series: What makes it so different?



- Lead-free construction
  - RoHS compliant
- Gapless cell layout technology
  - Hybrid, bifacial, half-cut heterojunction cells
  - Makes optimum use of panel surface
- Advanced cell connections
  - Low temperature, solder-free
- Super-strong frame design
  - Withstands exceptionally high snow & wind loads
  - Flexible clamping zones
- Premium warranty package
  - **92%** guaranteed after 25 years
  - Up to **25 years** product & labor coverage



# REC Alpha Pure Series is a powerful hybrid combination of cell technology



## High power structure through technology hybrid

N-type mono crystalline silicon wafer for:

- Performance
- Reliability
- Abundance

Amorphous silicon for:

- Great absorption
- Superior passivation
- Low temperature deposition

## N-type technology

- Highest crystalline cell structure efficiency
- No LID

## Better for the environment

- Lead-free silver paste
- No bus bars for more cell exposure

Transparent Conductive Oxide  
Amorphous silicon  
N-type mono wafer  
Intrinsic amorphous silicon

## Best passivation

- Leading temperature coefficient
- More power when sun is strongest
- More energy in hot climates

## Highest bifaciality

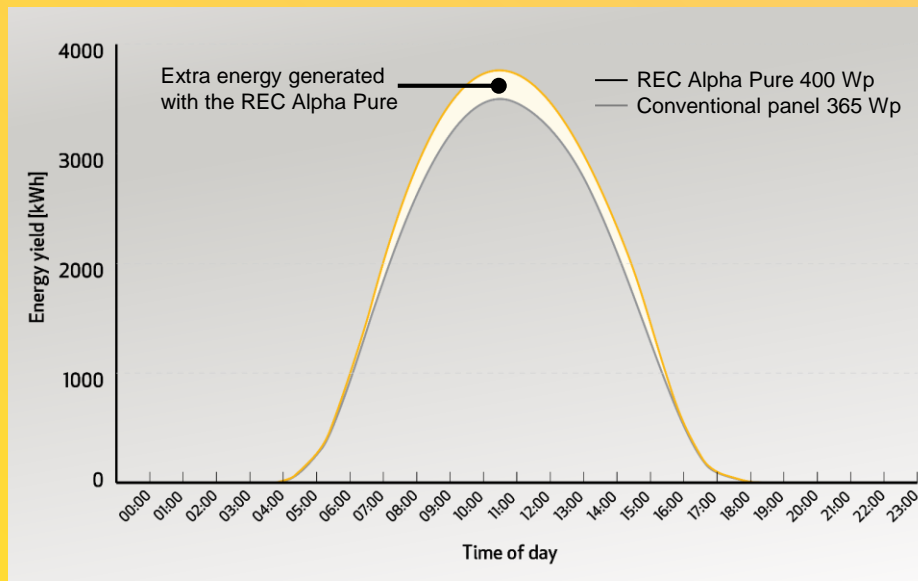
- Captures more light
- Higher power

# Heterojunction cells produce more energy when the sun is strongest



- The REC Alpha Pure packs in even more energy generation
  - Super efficient cell structure
  - No LID
  - Lowest temperature coefficient
  - Leading power density
- Ideal for making the most of available rooftop space
- Greater annual yields for more savings on electricity bills

**Average Daily Energy Production Comparison Over 1 Year shows 6 % more production when the sun is strongest**



Simulation results for full calendar year, based on an 8 kWp system in Palm Springs, CA, USA.  
Peak REC Alpha Pure Series energy yield difference at midday: +6%. Performance may vary dependent on location



# Advanced Cell Connections: Environmentally-friendly, solder-free cells for high efficiency



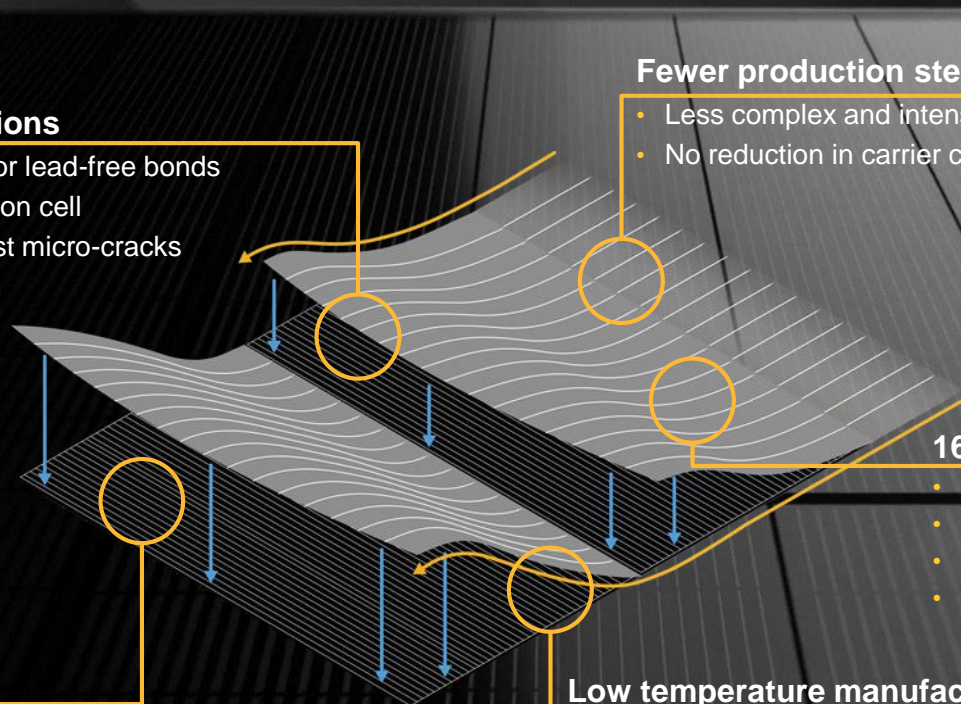
## Solder-free connections

- No soldering on cell, for lead-free bonds
- Lead-free silver paste on cell
- High resistance against micro-cracks



## Fewer production steps than competitive processes

- Less complex and intensive production
- No reduction in carrier collection efficiency



## 16 wires

- Shorter current path
- More contacts reduce resistance
- Only 390 solder points in entire panel
- Round shape to improve internal reflection and reduce shading

## No busbars

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

## Low temperature manufacturing

- Greatly reduces thermal stress for fewer defects
- Energy-efficient process for fewer emissions and lower CO<sub>2</sub> footprint

# Going lead-free for an even more environmentally benign option?



- Lead is a toxic substance
  - Can cause neurological disorders e.g., brain damage and/or behavioral problems
- Wider electronics industry moved to lead-free, RoHS compliant production
- But lead is **still used** in solar cells and panels
- RoHS Directive first adopted in Feb 2002 by the EU
  - All electrical goods in the EU must comply
  - Components must contain less than 0.1% lead to be compliant



- RoHS Directive controls the use of hazardous substances in electrical products
  - Limits use of 10 toxic substances in individual components (<0.1% of weight)
  - Any remaining traces are incidental and unintentional
  - No toxic leakage into ecosystem
- Current exemption for solar panels
  - Lead and cadmium continue to be used
  - Mostly in soldering of cells, cross-connectors, and junction box
- With the REC Alpha Pure, REC is committing to a lead-free and toxin-safe future
  - REC has an external certification of RoHS compliant showing no detection of lead
  - Customers choosing the REC Alpha Pure are doing even more for the environment than just producing clean energy



# How has REC achieved RoHS compliancy?



- REC has experience with lead-free production since 2012
- Source lead-free components, incl:
  - Cell connections
  - ICB
  - Flux
  - Junction Box
- REC's cell connection technology on 60-cell Alpha is already lead free
- Develop correct soldering mix and best temperature for lead-free components



Component	RoHS compliant
HJT cell	✓
Glass	✓
Encapsulant	✓
Foil + wire	✓
Cover strip	✓
Backsheet	✓
ICB	PbSn → lead free
Solder Wire	PbSn → lead free
JB ICB to baseplate solder	PbSn → lead free alloys
JB cable to baseplate solder	PbSn → lead free alloys
Sealant	✓
Potting	✓
Frame	✓



# Clear marking ensures lead-free production



## Color coding of tools/components

- Prevent accidental mix
- Clear equipment divisions in lines ensure no mix of solder


## Tool Identification

### Standard solder wire



### Lead free solder wire



An aerial photograph of a two-story brick house with a dark blue tiled roof. The roof is covered with solar panels. The house is surrounded by green fields and trees. In the background, a wind turbine is visible. The sky is blue with some clouds.

REC is a driven facilitator of energy  
autonomy

Going gapless

Oterleek, Netherlands  
REC Alpha Black Series

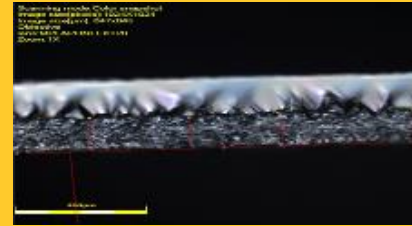


# Non-destructive laser cutting for better quality and more durable cells



- Conventional cell cutting:
  - High temperature laser cuts into cell structure
  - Cell split by mechanical separation
  - Leaves rough surface
  - Prone to development of defects
- REC's Advanced Laser Cutting lowers risk of cell damage
  - Full laser cut, no mechanical split
  - Reduces microcrack defects
  - Great improvement in cell durability under load

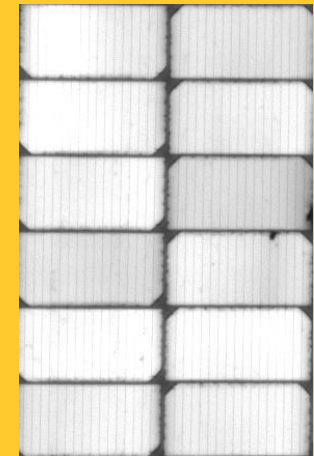
## Conventional cutting



## REC Advanced Splitting Technology



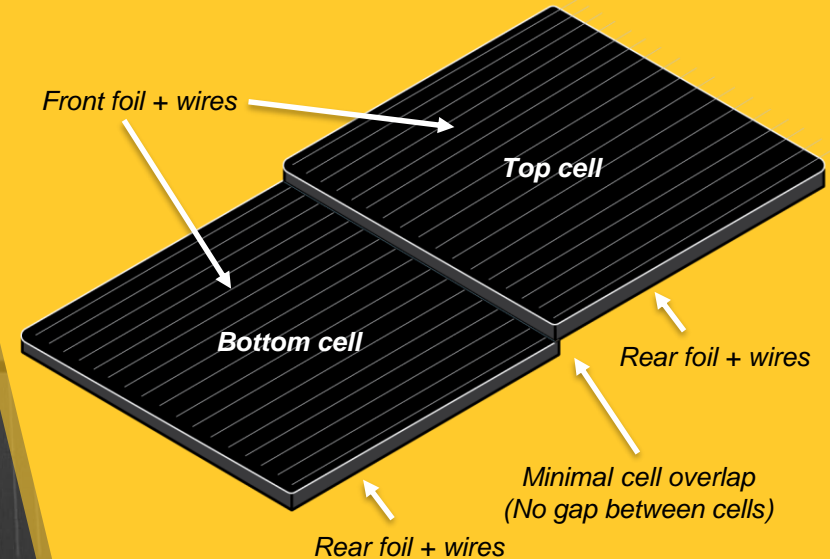
Cracks propagate post MLT



0 cracks post MLT

# Gapless cell layout makes optimum use of the entire panel surface to generate energy

- Innovative gapless cell sees cell edges overlap slightly
  - Separated by wire and foil connections
  - Give seamless appearance of string
- Increases power density
  - Gapless design creates space for additional cells rows
  - Keeps panel as compact as possible.

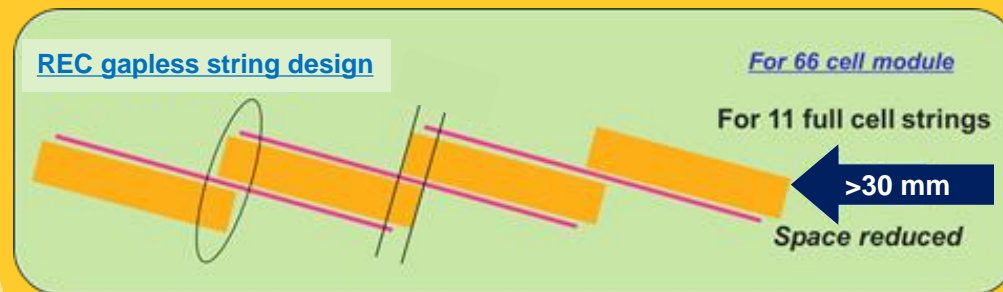
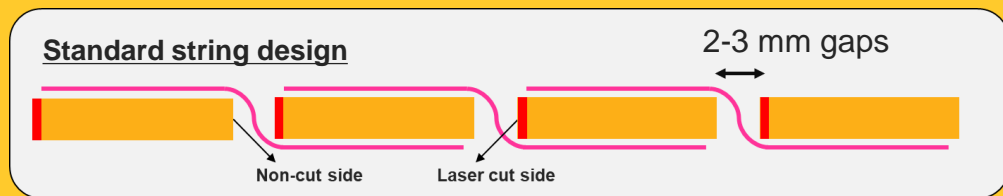


# REC gapless technology compared to standard string design



- Lower panel area: 1.92 m<sup>2</sup> to 1.85 m<sup>2</sup>
- Efficiency increase of +0.8%
  - High cell density high power density
- Lower material consumption and lighter module weight (less glass)
- Compatible with REC patented Twin Design

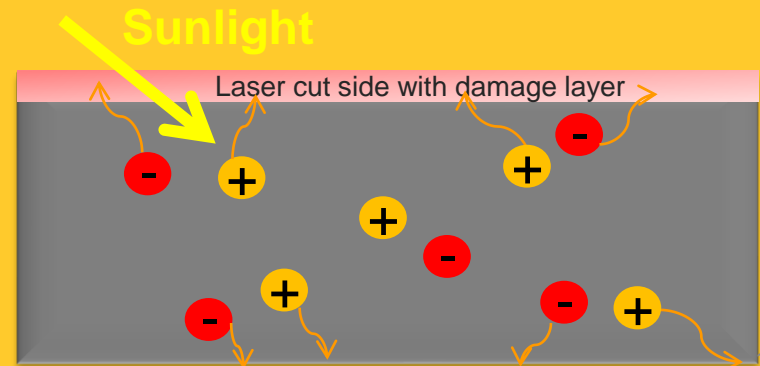
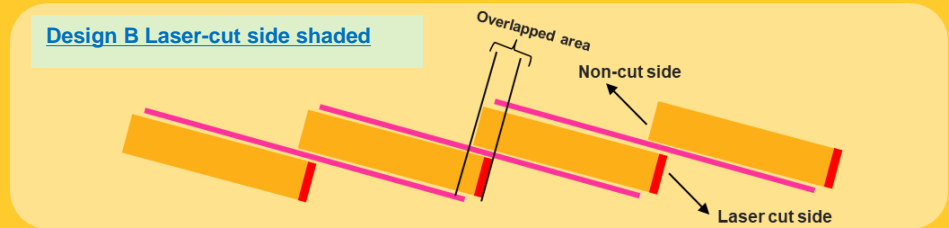
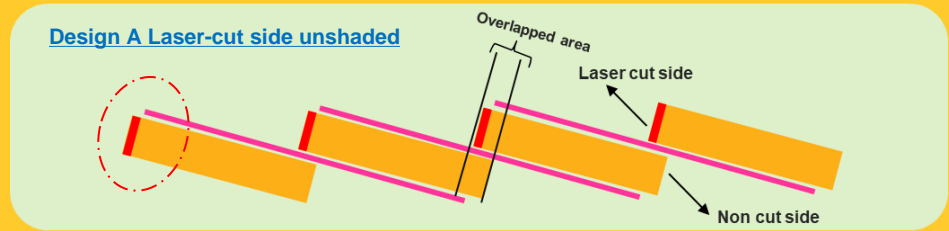
	Example module with: 66, HJT M4+, cells (Standard BBS module design)	REC Alpha Pure
<b>Module Size</b>	1888 x 1016mm	<b>1821 x 1016mm</b>
<b>Module Area</b>	1.92 m <sup>2</sup>	<b>1.85 m<sup>2</sup></b>
<b>Module Power</b>	405W	405W
<b>Module Efficiency</b>	21.1%	<b>21.9%</b>
<b>Module Weight</b>	21.4kg	<b>20.5kg</b>





# Laser-cut side design

- With design A, the cut side is unshaded
  - Sunlight generates excess carriers in entire HJT cell
  - Carriers generated from sunlight will have a recombination center at the cut side
  - Micro-defects at laser cut edge trap excess carriers and prevent them from contributing to the current
- With design B, the laser-cut side is shaded
  - Helps prevent carrier recombination and generates more power, higher Voc and FF.



Condition	Delta Value			
	Power (W)	Voc (V)	Isc (A)	FF
Design A	-1.15%	0.11%	-2.43%	1.18%
<b>Design B</b>	-0.89%	0.38%	-2.24%	1.7%

\* Compared to production baseline

# REC Alpha Pure compares favorably vs. competitors in key 66 cell format metrics




Specification	Competitor 1	Competitor 2	Competitor 3	REC
Cell technology	P-PERC	P-PERC	P-PERC	N-HJT
Max power (W)	365	385	410	405
Wafer size	166 mm (M6)	162 mm (M4+)	164 mm	162 mm (M4+)
Cell count	60	66	66	66
Dimensions (mm)	1755 x 1038 x 35	1840 x 1030 x 32	1855 x 1029 x 30	1821 x 1016 x 30
Area (m <sup>2</sup> )	1.82	1.89	1.91	1.85
Weight (kg)	19.5	19.5	20.8	20.5
Efficiency (%)	20.0	20.3	21.4	21.9
Mech. load (Pa)	+5400 / -2400	+6000 / -4000	+5400 / -2400	+7000 / -4000
Gapless/overlap	No	Yes	Yes	Yes
RoHS compliant	No	No	No	Yes

## Why REC Alpha Pure ?

- High efficiency n-type HJT
- Shorter module length
- Smaller module area
- Higher module efficiency
- Higher power density
- Higher loads
- Gapless technology
- ROHS compliant

# High power density:

The REC Alpha Pure generates more energy from the same area  REC



Roof size

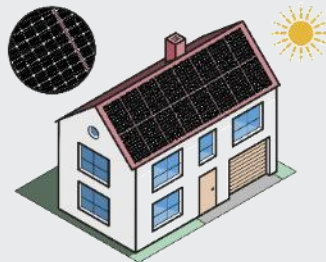
Panel size

Panels on roof

Module power

System power

Residential system with  
Standard mono-PERC



40 m<sup>2</sup>

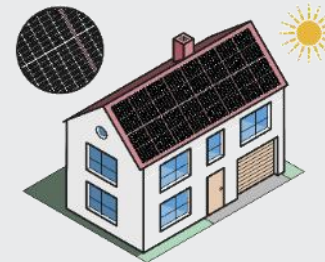
1.82 m<sup>2</sup>

16

365 Wp

5.8 kW

Residential system with  
REC Alpha Pure



40 m<sup>2</sup>

1.85 m<sup>2</sup>

16

400 Wp

6.4 kW

**+ 10% MORE POWER**

## **+10% MORE CAPACITY**

installed in the same area and same number of panels by using the REC Alpha Pure Series

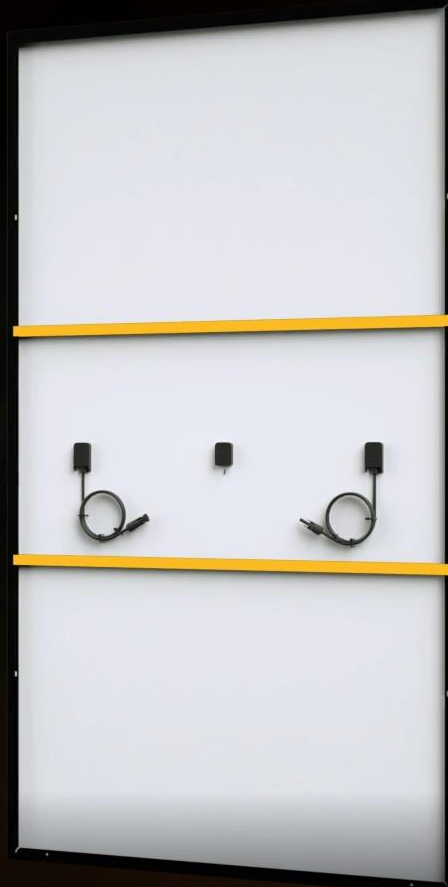


# Super-strong frame design increases protection and durability adds real advantages



## 2 additional support bars across the rear of panel

- Increases cell protection
- Support laminate from below
- Increases load-bearing capability
- Extra durability means cells retain high power over a longer period
- Improved clamping zones help overcome all on-roof obstacles



## Reduced 30 mm frame height

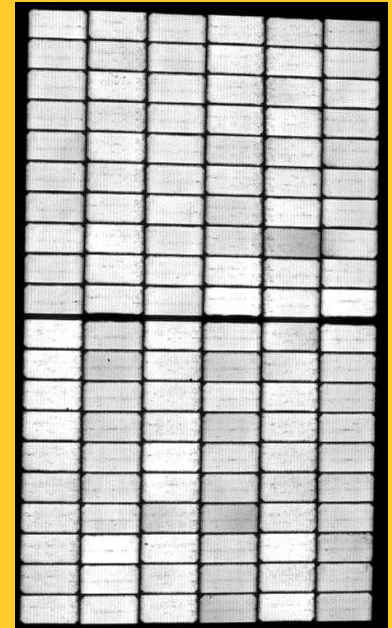
- Easier panel handling on site
- Allows optimized transportation
  - 33 panels per pallet
  - Packs more power density into a container or onto a truck
  - Helps reduce delivery costs

# REC's frame design better protects cells for reliable high power output over time



- P-type mono PERC shows notable damage even at only 5400 Pa
  - 5 cracked cells with developing dark spots
  - Still passes IEC certification
- REC Alpha panels show impressive performance under heavy loads
  - 0 cell cracks, even with front side load up to 7000 Pa

	P-type mono PERC panel	REC Alpha panel
Load tested	+5400 / -2400 Pa	+7000 / -4000 Pa
Power loss	-1.3%, 5 cracked cells	-0.45%, 0 cracked cells





# High quality, industry 4.0 manufacturing: Made in REC's integrated production facility in Singapore



REC Wafer Plant

REC Cell Plant

N-type Cell Plant

REC Module Plant



**MODULE  
PRODUCTION  
CAPACITY**

**1.8 GW**

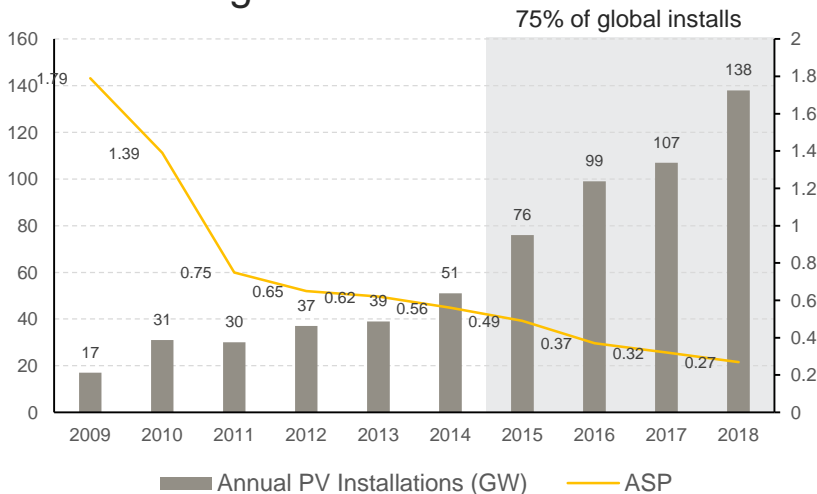
151,000 m<sup>2</sup> of production space



# REC's long history of the best quality is shown by consistent performance in third party tests



- 75% of global installed solar capacity has operated for less than 5 years
- In only 10 years, the average price of solar panels dropped by over 80 %
- Manufacturers needed to make drastic cost savings



- REC performs consistently high in DNV-GL / PVEL long-term reliability tests
- 6 years in a row, REC has been named a Top Performer



# Low claims, strong warranty



- A very low warranty claims rate justifies favorable warranty terms
- REC's warranties reflect this, further supporting REC's premium quality

Product Series	Product warranty		Performance warranty		
	Product warranty	Extension eligibility*	Minimum power in year 1	Year 2-25 maximum annual degradation	Guaranteed % of name-plate power in year 25
REC Alpha Pure	20 years	+5 years	98.0%	0.25%	92.0%
REC N-Peak				0.5%	86.0%
REC TwinPeak			97.5%	0.7%	80.7%

\* Product warranty extension eligibility is exclusive to REC Certified Solar Professional installer as part of the REC ProTrust Warranty; visit [www.recgroup.com/warranty](http://www.recgroup.com/warranty) for details

(Except REC TwinPeak 4, other REC TwinPeak products not available in Germany)

# REC Alpha Pure Series: Exceptional levels of power from Solar's Most Trusted!



**405 Wp**

Outstanding power maximizes energy generation from limited spaces

**100 %**

Of lead content removed from all panel components, RoHS compliant

**219 W/m<sup>2</sup>**

High power density helps maximize power on a rooftop space

**-0.26 %/°C**

Leading temperature coefficient for more energy in the heat of peak times

**7000 Pa**

REC's Twin Design with super-strong frame for years of durable high power

**92 %**

Warranted power after 25 years for a secure investment





A group of seven children are silhouetted against a bright, golden sunset sky. They are captured in various dynamic poses, jumping and playing together in a field. The children are holding hands in a loose circle, and their hair and clothing are blowing in the wind, conveying a sense of joy and movement.

# Thank you!

