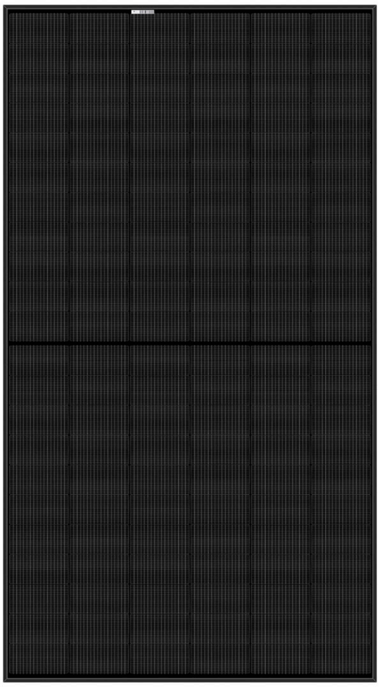
REC Alpha Technology:
Delivering ground-breaking new levels of power and creating a legacy of sustainable energy

The launch of the REC Alpha Series in May 2019, rocked the solar panel manufacturing industry with one of the world's most powerful 60-cell panels at the time. With over more power coming from the same installation area, it initially opened a big power gap beyond the commercially available power levels of Tier 1 competitors, but power is only one of the major advantages offered - there are many more:

What is the REC Alpha Series?

Building on the foundations of REC's long experience with with half-cut cell technology and n-type monocrystalline cells, and applying these to cells with heterojunction cell technology (HJT), REC Alpha solar panels have proven to be a ground-breaking development in high efficiency photovoltaic technology (fig. 1), and this has now been taken to the next generation by the REC Alpha Pure Series.

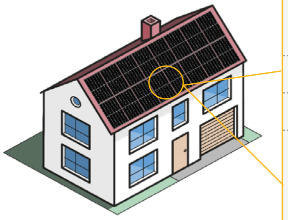
Fig 1: The REC Alpha Pure Series with HJT cells and advanced cell connections



What makes REC Alpha panels different?

Using heterojunction cells and an advanced low temperature cell connection technology on REC's innovative Twin panel design, the REC Alpha has received numerous design patents including in the EU and Singapore, affirming its status as a leading and unique panel design. It was the first solar panel to ever combine the advantages of highly-efficient heterojunction cells, an advanced, solder-free cell connection technology, the power benefits of half-cut cells and the performance-boosting Twin panel design. All this meant that REC was able to deliver the world's highest power density for a 60-cell panel at the time, with up to 219 W/m², a key consideration where space is limited, such as on residential and small commercial rooftops.

Fig 2: Power of the REC Alpha Pure versus conventional panels on a home roof:



P-type multi	P-type mono	REC Alpha Pure
16x290 Wp	16x365 Wp	16x400 Wp
4.6 kW	**5.8 kW**	**6.4 kW**
-28% less power than the REC Alpha Series	-10% less power than the REC Alpha Series	over 10% more power in the same area

What is heterojunction cell technology?

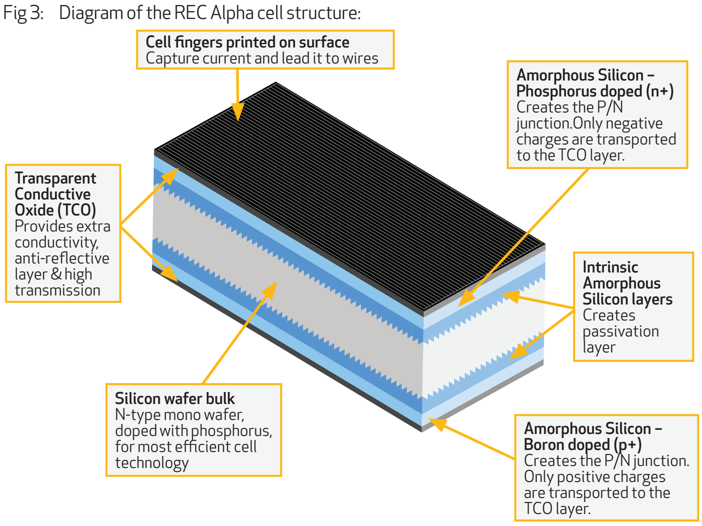
Heterojunction cell technology combines the advantages of crystalline silicon cells and thin film technology within a single cell structure. This means efficiency levels of over 25% are now within reach.

Where a conventional crystalline solar cell uses a single material, silicon, in an HJT cell, the junction is formed between two different materials: crystalline and amorphous silicon, with the junction therefore referred to as a heterojunction. This creates numerous performance benefits compared to conventional cells.

What are the benefits of HJT technology?

The structure of an HJT cell plays an important role in improving panel power and efficiency. The intrinsic amorphous silicon layers provide the best passivation of the silicon wafer thus increasing the cell voltage significantly. The amorphous silicon layers make the contact layers 'carrier selective', allowing only one kind of carrier to pass through and reach the contacts - either electrons (negative charge) or holes (positive charge) - ensuring a major reduction in recombination for better cell efficiency and higher power.

Fig 3: Diagram of the REC Alpha cell structure:



Due to the symmetrical structure of an HJT cell, it is in fact a bifacial cell and offers the highest bifaciality among all cell structure types. Other structures have lower bifaciality due to absorption in one of the layers or due to resistance losses. The bifacial structure means that HJT cell technology is ideal for bifacial panel applications, but equally, even in mono-facial panels, the bifacial aspect can be used to improve energy yield through light capture at the rear of the cell.

Low temperature production

Conventional solar cells use a process called diffusion to create thin doped layers in the wafer which form the p-n junction. While this process is widely used and well-established, it needs high temperatures consuming a lot of energy as well as requiring an additional wet chemical process to clean the wafer. In an REC HJT cell, layers of intrinsic and doped amorphous silicon are deposited on the crystalline silicon substrate at low temperatures and do not require any subsequent process steps, reducing the impact of the manufacturing process on the cell for an improved build quality.

No LID

Light Induced Degradation (LID) is a phenomenon seen in many crystalline cells, where a panel loses power during initial exposure to sunlight. This is caused by a combination of boron and oxygen in the wafer. REC Alpha cells use n-type monocrystalline wafers which do not contain boron and are not affected by LID. This means there is no drop in power immediately following installation and the customer receives the power they expect.

High resistance against microcracks through HJT

A panel endures different weather conditions during its lifetime. Heavy loads and stress through snow, wind and temperature variations test the panel to its limits. Under such conditions, the fragile cells in conventional panels can develop microcracks, potentially reducing overall performance. Independent testing by the University of Central Florida (UCF) has shown that reduced thermal and mechanical stress on the cell during production leads to better build quality and a high resistance to such defects.[1]

No direct contact with metallization

In conventional cells, the cell metallization is in direct contact with the silicon. This contact acts as a recombination trap for electrons and holes, reducing the cell efficiency. By contrast, an HJT cell employs a transparent conductive oxide layer (TCO) deposited on top of the doped amorphous silicon, which prevents direct contact to the silicon.

As the TCO layer is conductive, the high amounts of silver paste found in conventional cells are not needed. This frees up more cell surface area for more light capture. In addition the low temperature paste used in HJT cells is lead-free further improving the environmental footprint of the panel.

Leading temperature coefficient

Through the HJT cells, the temperature ratings of REC Alpha panels are greatly improved and external testing has shown this technology offers a market-leading temperature coefficient - the percentage loss in power for every 1°C rise above 25°C - and means continued high efficiency performance even at higher operating temperatures (fig. 4).

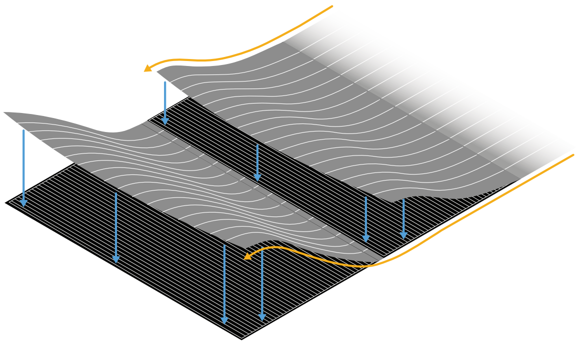
Fig 4: Temperature ratings of standard panels compared to REC Alpha panels

Temperature ratings of panels:	*Standard*	*REC Alpha*
Temperature coefficient of P_{MAX}:	-0.37 %/°C	-0.26 %/°C
Temperature coefficient of V_{OC}:	-0.31 %/°C	-0.24 %/°C
Temperature coefficient of I_{SC}:	0.05 %/°C	0.04 %/°C

What is REC's advanced cell connection technology?

REC Alpha panels use a specially-developed foil and wire combination to create the contacts between cells. This is a less invasive process than the high temperature soldering used on standard cells, and protects the HJT cell's integrity for better quality. The wires have a low temperature, lead-free, alloy coating, supporting the lead-free status of the REC Alpha Pure.

Fig 5: Advanced low temperature connection joining two half-cut cells



To create the bond between wires and cell, the wires are first placed on the foil, before the foil is placed on the cell (fig. 5). The foil acts as an extra protective layer against leakage and mechanical stress. The foil is then lightly heated to ensure it stays in position during further manufacturing stages. Once the panel reaches lamination, the outer layer of the wires melts to form a fully mature bond to the cell. This results in improved aesthetics as the wires are only 1/4 of the width of the ribbons used on conventional cell connections.

1 Eric Schneller et al, PV Magazine Webinar, 09.2019, Fewer microcracks thanks to HIT technology?, www.pv-magazine.com/webinars/fewer-microcracks-thanks-to-hit-technology

What are the benefits of REC's advanced connection technology?

One key advantage of the the advanced cell connection technology used in REC Alpha panels is that the number of manufacturing process steps is far fewer than used to make conventional cells. Reducing the number of process steps, reduces the opportunity for introducing defects into the panel. In addition to this, the cell production stage of the REC Alpha requires relatively low temperatures of ~200°C compared to conventional cells where temperatures up to 800°C or more are required.

Improved build quality

In conventional panels, the ribbons connecting the cells need to be soldered to the busbars with very high temperatures. This creates pockets of high thermal stress between the different materials. REC's advanced cell connections are solder-free, so cells do not need heating as intensely. The lower temperatures used by REC greatly reduce the risk of damage caused by different thermal coefficents of materials, e.g., solder mix, paste, and silicon. Not heating the cell in the same invasive way reduces the chance of defects occuring in the cell which would otherwise create internal resistance and reduce power.

Looked at practically, a conventional half-cut cell with 5 ribbons and 5 solder points per ribbon, is soldered ~50 times per cell with >6000 cell solder points in a full panel - even more with multi busbar technology! So much soldering increases how susceptible a cell is to micro-cracks through the application of localized heat and pressure. The advanced connections of REC Alpha panels uses wires directly applied to the cell surface, meaning that no bus bars are printed on the cell, reducing coverage of the surface and completely eliminating soldering on the cell, i.e., there are zero (0) solder points on REC Alpha cells and only 320 in the entire panel.

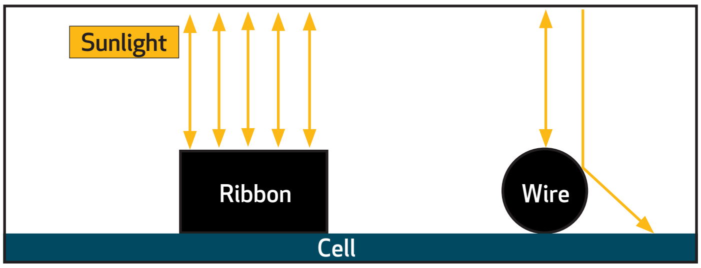
Improved current flow and reduced power loss

REC's advanced low temperature connection technology is also about reducing resistance losses in the panel for more power and higher energy yields. Testing has shown that an increase in the number of wires to 16 (from five busbars) provides the best balance between reducing internal resistance and cell coverage to achieve the most power. As a result REC Alpha panels have over 5000 connection points per cell resulting in over 331.000 connections in a full REC Alpha Pure Series panel. This reduces the distance for current to travel and vastly improves current flow (less 'congestion') for reduced power loss.

Increased efficiency through round wires

A further advantage of wires compared to conventional bus bars is that their round shape increases reflection of sunlight onto the cell (fig. 6). As a result the cell can produce more energy resulting in a higher efficiency.

Fig 6: Illustration showing the increased light reflection of round wires



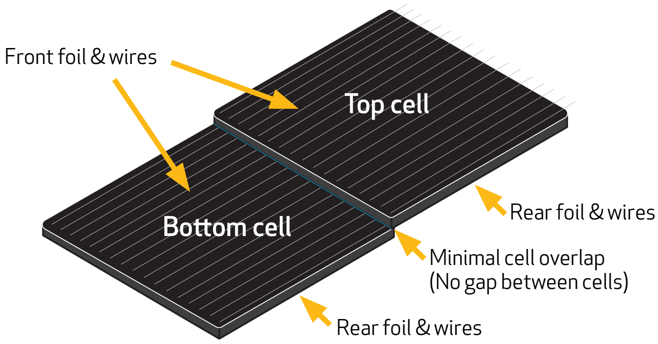
Gapless cell connections

Furthermore, the REC Alpha Pure employs gapless technology which eliminates the space between cells in a string. Having the cells overlap slightly raises the power density of panels and helps achieve higher efficiency. The innovative gapless cell layout helps the REC Alpha Pure break the 400 Wp threshold while keeping the panel compact.

With a gapless layout, the edge of a cell overlaps the next one so it sits on top of the other, separated only by the foil and wires. Overlapping the cells has two benefits: first it creates space for additional cells while reducing the 'empty' space between cells which keeps the panel size compact. Additional cells increase panel power and power density helping homeowners and businesses benefit from optimum use of space and even higher savings on energy bills.

Secondly, the cell overlaps the split edge of each half-cell. Split edges are active areas where light-generated carriers can be trapped. By shading these areas, this process is prevented and the panel gains in efficiency.

Fig 7: Illustation of the gapless cell overlap



Removing the gaps between cells also creates an more uniform and elegant aesthetic making the REC Alpha Pure a compelling choice of panel for both residential and commercial rooftops.

How does REC guarantee the quality of cell connections?

REC Alpha Series panels are subject to external certifications e.g., IEC 61215/61730 & UL 61730, which include accelerated testing under humidity-freeze, thermal cycle and damp heat conditions. Furthermore, REC tests panels through rigorous internal qualification up to three times more the IEC test criteria to ensure the panels meet our stringent quality standards and that the panels have a long lifetime.

How environmentally-friendly is the REC Alpha?

Carbon Footprint

Reducing carbon footprint is often a key mover to invest in solar. REC Alpha panels use low temperature processes in both cell and panel production to reduce energy consumption, while providing customers with more power density, so that more power fits in a limited space. This means they can generate even more clean energy from their installation, to further reduce their own carbon footprint.

Lead-free construction

REC further demonstrates its commitment to sustainability and the environment with the REC Alpha Pure Series, which is now lead-free according to the European regulations on the 'Restriction of Hazardous Substances in electrical and electronic equipment' (RoHS)[2]. This regulation restricts the maximum allowable levels of a number of harmful substances such as lead and cadmium in a product. However, as lead plays an important role in panel manufacturing, especially in the soldering and cell interconnections, solar panels are currently exempt from these regulations. This means lead-containing components continue to be used in conventional panels, with around 25 grams of lead used per panel, upwards of 0.13 % of the total panel weight - something that leaves a black mark against the industry's claims to be truly ecological.

With the REC Alpha Pure, REC has successfully removed lead and all other restricted substances from all components in the REC the panel to make it fully RoHS comliant and lead-free. The result of this is that it is much less harmful to the environment and easier to dispose of at the end of its working life with no danger to the surrounding ecosystem or human health. Customers choosing the REC Alpha Pure are therefore doing even more for the environment than just producing clean energy

What advantages does a split junction box offer?

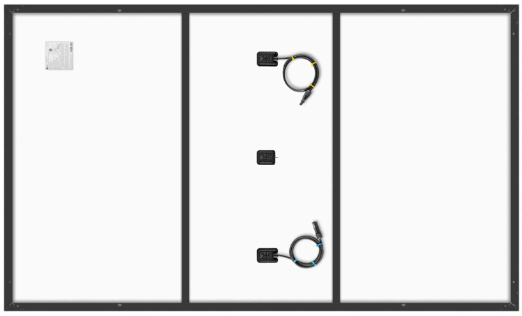
Splitting the junction box uses less metallization, reducing resistance in the panel (fig. 7). It also enables the panel to be split into two 'twin cell sections' connected in parallel, forming REC's iconic Twin panel design.

With three smaller boxes, heat build up in the cells behind the junction box is reduced by 15 - 20°C compared to a standard panel with a single box. The cells are therefore cooler, increasing absorption efficiency, reducing resistance, reliability and overall output.

What advantages does REC's frame design offer?

REC Alpha panels are tested to withstand 7000 Pa snow load and up to 4000 Pa wind load and feature an innovative 30 mm frame design. With support bars on the rear to ensure stability and durability, this reinforcement provided from underneath prevents the glass layer from bending as far under heavy load, protecting the cells from any extreme deflection. As there is less risk of cell damage, and/or frame and glass breakage, the panels retain their ability to deliver high power over a longer period giving customers higher overall long-term energy yields.

Fig 8: Rear view of the REC Alpha panel with support bars and split junction box

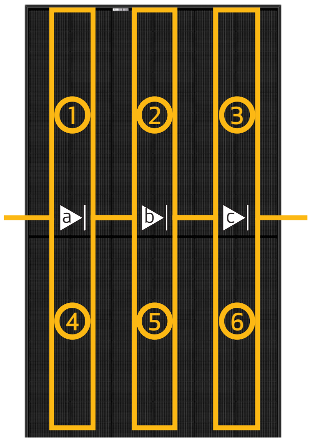


REC's Twin Design on the Alpha

First introduced to the market by REC in 2015, the iconic appearance of the REC Twin Design sees half-cut cells in an innovative cell layout. The half-cut, rectangular cells are cut into two equal pieces reduceing the current in a cell by half. As power loss in a cell is proportional to the square of the current ($P_{loss} = R \times I^2$, where R is the resistance and I is the current), power loss in the cells is reduced by a factor of four compared to full size cells.

On top of this, the Twin Design approach splits a panel into top and bottom halves. These 'twin' halves are connected in parallel before current exits the panel (fig. 8). The advantage here is that energy can still be produced when under partially shaded conditions, e.g., if part of the bottom half is shaded, the top half will still produce power!

Fig 9: REC Alpha Series Panel with six internal strings of cells



Conclusion:

REC Alpha panels push power, efficiency, and reliability to a whole new level. The combination of crystalline and amorphous silicon in an HJT cell provides excellent passivation due to the difference in band gaps. Added to this, REC's advanced low temperature cell connection technology achieves even higher efficiency through increased contact points, improved current flow and reduced losses. The result of this is a panel with much higher power density, making the REC Alpha Pure the premier product for installations where space is limited.

However, the nameplate power of a solar panel is not the only critical feature, but also it's performance over its entire lifetime. It is here that REC Alpha panels excel. With the removal of cell soldering there are fewer weak points caused by thermal stress, making them less susceptible to micro-cracks, hotspots and other defects. Meanwhile the super-strong frame design provides additional robustness, affording increased protection over a longer period of time and even at the end of its serviceable lifetime, being lead-free makes disposal and recycling of the panel easier and more environmentally-friendly.

Coupled with the full-black and seamless appearance of the REC Alpha Pure with its gapless cell connections, the new technology enables increased energy generation over decades. Backed by a industry leading warranty with a maximum of 2% degradation in year one and 0.25% degradation in years 2-25, leading to a final value of 92% after 25 years is guaranteed, making it the ideal panel for high energy generation over its entire working lifetime.

[2] Regulation of Hazardous Substances EU/2015/86. Panels contain no intentional use of lead