

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

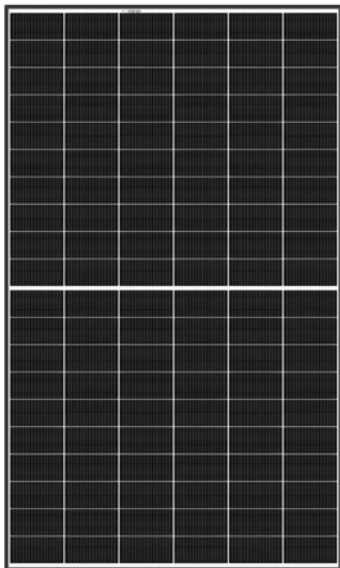
The launch of the REC Alpha Series in May 2019, rocked the solar panel manufacturing industry with the world's most powerful 60-cell panel. With over 20% more power coming from the same installation area, the REC Alpha Series opens a big power gap beyond the commercially available power levels of Tier 1 competitors, but power is only one of the numerous advantages offered by the Alpha:

What is the REC Alpha Series?

Born of a long-term development project, the REC Alpha Series builds on REC's long experience with n-type monocrystalline cells and half-cut technology as well as developing in depth process knowledge in heterojunction cell technology (HJT). Indeed, the REC Alpha Series marks the very first time a new solar panel technology development has seen such a game-changing outcome and extended the boundaries of what customers can achieve by investing in solar power.

The REC Alpha Series (fig. 1) uses heterojunction cells and an advanced low temperature cell connection technology on REC's innovative Twin panel design.

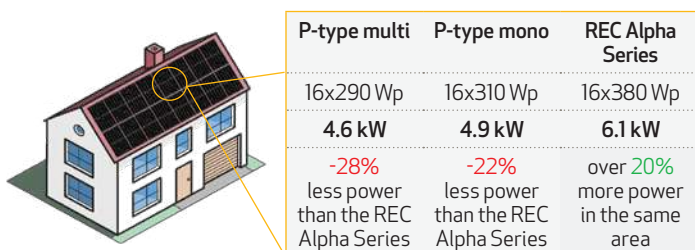
Fig 1: The REC Alpha Series with HJT cells and advanced cell connection technology



What makes the REC Alpha Series different?

The Alpha has already received design patents in the E.U. and in Singapore, which confirms its status as a leading and unique panel design. It is 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 means that REC is able to deliver the world's highest power density on a 60-cell panel, with over 20% more power compared to a conventional panel - up to 217 W/m² - a key consideration where space is limited, such as on residential and small commercial rooftops.

Fig 2: Power of the REC Alpha compared to conventional 60 cell panels on a residential rooftop:



What is heterojunction technology?

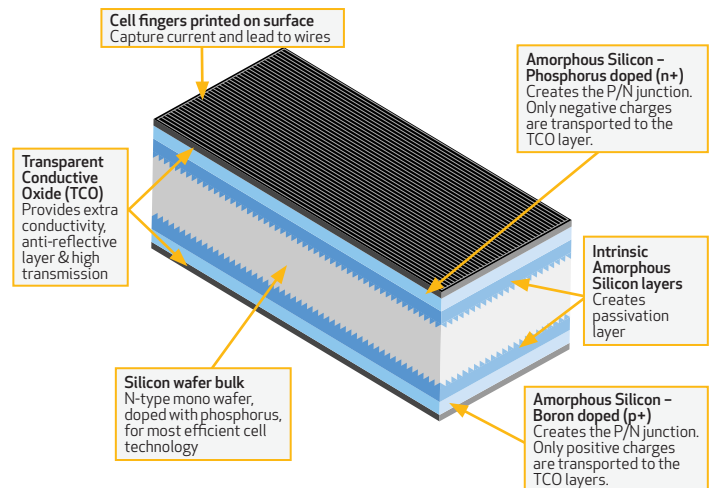
Heterojunction cell technology combines the advantages of crystalline silicon cells and thin film technology within a single cell structure. This means efficiency levels of over 25% are now within reach.

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 significantly increasing the cell voltage. 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 which do not require any subsequent processing, thus reducing the impact on the cell of manufacturing processes for an improved build quality.

No LID

Light Induced Degradation (LID) is a phenomenon seen in many crystalline cell technologies, where a solar panel irreversibly loses power capacity during its initial phase of exposure to sunlight. This is caused by the combination of boron and oxygen in the wafer. Through the use of n-type monocrystalline wafer technology - which does not contain boron - the cells in the REC Alpha Series are not affected by LID. This means the REC Alpha shows no sign of permanent loss of power immediately after installation and the customer will receive the power levels they purchased.

High resistance against microcracks through HJT

A solar panel has to endure many different environmental stresses during its lifetime. Heavy loads, through snow, wind and daily temperature variations, all put the panel under pressure. Under such conditions, the fragile cells in a conventional panel can develop microcracks, potentially leading to a reduction in overall performance. Independent testing by the University of Central Florida (UCF) has shown that the 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 silicon. This metal-silicon contact acts as recombination trap for electrons and holes generated by light, which reduces the efficiency of the cell. However, an HJT cell employs a transparent conductive oxide layer (TCO) deposited on top of the doped amorphous silicon, which prevents direct contact between the contacts and the silicon, meaning a reduction in recombination.

As the TCO layers are conductive, there is less need for the high amounts of silver paste found in conventional cells, which frees up more HJT cell surface area for increased light capture.

Leading temperature coefficient

Through the use of HJT cells, the REC Alpha's temperature ratings are greatly improved. The REC Alpha Series demonstrates a market-leading temperature coefficient - this is an indication of 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: Temperature ratings of standard panels compared to REC Alpha panels

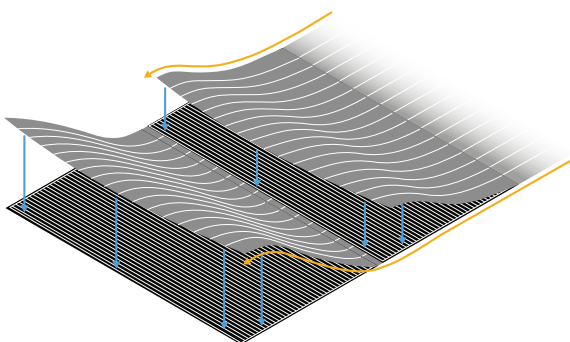
Temperature ratings of panels:	Standard	Alpha
Temperature coefficient of P_{MPP} :	-0.37 %/°C	-0.26 %/°C
Temperature coefficient of V_{OC} :	-0.31 %/°C	-0.24 %/°C
Temperature coefficient of I_{SC} :	0.05 %/°C	0.04 %/°C

What is REC's advanced cell connection technology?

The REC Alpha Series uses a specially-developed foil and wire combination to create the contacts between the cell and the metallization. This is a far less invasive process than the high temperature soldering found on a conventional cell, protecting the integrity of an HJT cell for better quality.

The wires used in the REC Alpha Series have a special low temperature alloy coating on them which are lead-free, helping to reduce the panel's lead content by 81% compared to conventional panels.

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 will act 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.

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

One of the key advantages of the REC Alpha Series's advanced cell connection technology is that the number of manufacturing process steps is far fewer than used to make conventional cells. Additionally, the Alpha's cells require only relatively low temperatures of ~200°C compared to a conventional cell where temperatures of up to 800°C or more are required.

Improved build quality

In a conventional panel, the ribbons need to be soldered to the cell busbars with very high temperatures, creating high thermal stress between the different materials. The advanced cell connection technology is solder-free, so has no need to heat the cells so intensely in production. The elimination of cell soldering produces a cell with far fewer weak points, greatly reducing the chance of hotspots and other defects occurring, and the lower temperatures used greatly reduce the risk of damage caused by the difference in thermal coefficients between materials, e.g., tin/lead solder mix and the silicon. By not heating the cell in the same invasive way, there is a much reduced chance of defects occurring in the cell structure which would otherwise create internal resistance and reduce power.

When looked at practically, a conventional cell, based on halfcut technology with 5 ribbons and only 5 solder points per ribbon has 50 soldering points per cell and well in excess of 6000 cell solder points in total. This makes the cells more susceptible to micro-cracks through the regular appliance of heat and pressure. The REC Alpha's advanced cell connections however, see the wires directly applied to the cell surface, meaning that no bus bars need to be printed on the cell, reducing coverage of the cell surface. It also eliminates the cell soldering process completely, i.e., there are zero (0) solder points on the cell, and only 390 soldering points in the entire panel, protecting the cell from soldering-induced weak points.

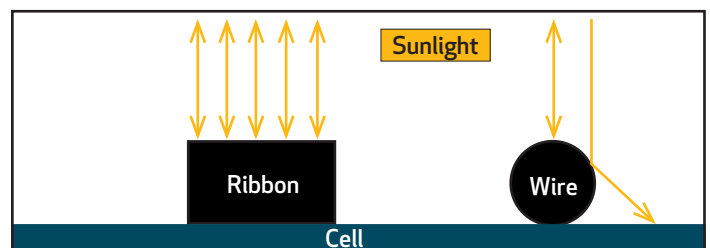
Improved current flow and reduced power loss

REC's advanced low temperature connection technology is also about reducing ohmic (resistance) losses in the panel. Reduced losses mean 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 the Alpha has over 1600 cell paste to wire connections per cell resulting in close to 200,000 connections in a full 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 increased sunlight reflection of round wires compared to ribbons



How does REC guarantee the quality of cell connections?

The REC Alpha Series panel has been developed over a period of more than two years where every aspect of the design and manufacturing variations have been carefully considered and their impact on panel reliability carefully studied.

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

Furthermore, 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. Prior to certification however, REC puts its panels through rigorous internal qualification up to three times more demanding than the IEC test criteria to ensure the panels meet our stringent quality standards and enjoy a long and productive lifetime.

How does the REC Alpha improve carbon footprint?

Reducing carbon footprint is often a key mover to invest in solar. The REC Alpha Series uses low temperature processes in both cell and module production which reduce energy consumption, while providing customers with more power density, i.e., more power from the panels fits in a limited space. This means customers can generate even more clean energy from their solar installation, to further reduce their own carbon footprint.

REC shows its commitment to sustainability with the REC Alpha Series, which, due to the enormous reduction of lead content in the panel, also stands for environmentally-friendly solar. As the advanced cell connections of the Alpha are 100% solder-free (where solder has a high proportion of lead content) and the low temperature silver paste used on HJT cells is lead-free, the overall lead content in an REC Alpha Series panel is reduced by 81% compared to a standard panel. As a result lead now makes up only 0.02% of the total weight compared to upwards of 0.13% in a conventional panel. The Alpha is therefore much less harmful to the environment and easier to dispose of at the end of its working life.



What advantages does REC's new frame design offer?

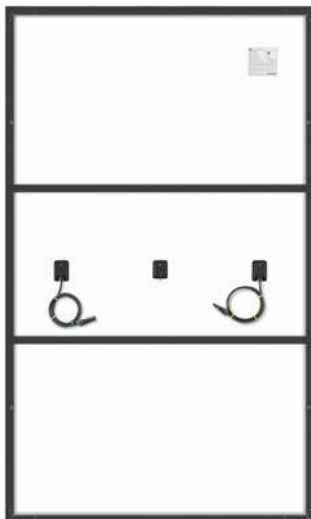
The REC Alpha Series has been tested to withstand 7000 Pa snow load and up to 4000 Pa wind load and features our innovative 2S frame design. This is a 30 mm frame with support bars on the rear to ensure stability and durability. The reinforcement provided from the support bars prevents the glass layer 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.

What advantages does a split junction box offer?

Splitting the junction box into smaller parts uses less metallization, reducing resistance in the panel (fig. 7). It also enables the panel to be split into two 'twin cell sections' of 60 half-cut cells connected in parallel, which forms REC's iconic Twin panel design.

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

Fig 7: Rear view of the REC Alpha panel with support bars and split junction box

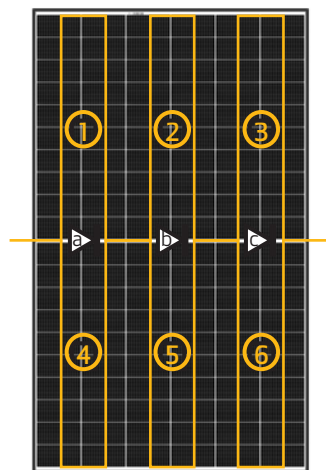


REC's Twin Design on the Alpha

A panel using REC's Twin panel design is visibly divided into two sections - a top and a bottom half. Each half consists of 60 half-cells that have been cut into two equally sized pieces from a larger square cell to create this iconic appearance. The cells are then connected in series, in three strings of 20 cells, and the two sections then connected in parallel to create a panel of six strings with 120 half-cut cells.

With this layout, the panel can continue to produce energy, even when one part is shaded. What this means is that even under shaded conditions if cells in the entire bottom half of the panel are shaded, the top half still produces power!

Fig 8: Current flow around an REC Alpha Series panel with six internal strings of cells



Cutting the cells into two equal pieces reduces the current per cell by half. 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), therefore power loss in the REC Alpha Series is reduced by a factor of four compared to full size cells.

Conclusion:

The REC Alpha Series pushes panel power, efficiency, and reliability, to a whole new level. The combination of crystalline silicon with amorphous silicon in an HJT cell provides excellent passivation properties due to the difference in band gaps. Added to this, REC's advanced low temperature cell connection technology helps achieve even higher efficiency through increased number contact points, improved current flow and reduced ohmic losses. The result of this is a panel with much higher power density compared to a conventional panel, while massively reducing its environmental impact. This makes the REC Alpha Series the premier product for installations where space is limited.

However, the initial power level of a solar panel is not the only critical feature, but also the performance over its entire lifetime. It is here that the REC Alpha Series excels. 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.

With new technology enabling increased energy generation and ensuring that power is generated over decades, the REC Alpha Series is supported by a industry leading warranty. 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 solar panel for high energy generation over its entire working lifetime.

