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

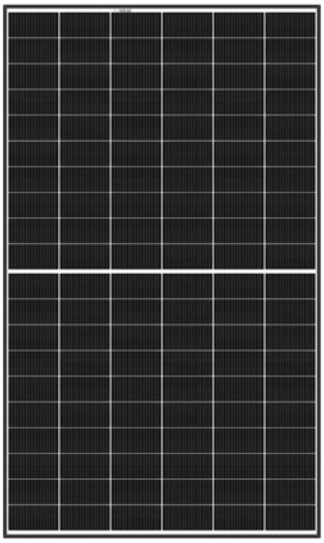
The launch of the REC Alpha Series in May 2019, rocked the solar panel manufacturing industry with the world's most powerful 60-cell panel. With over 20% more power coming from the same installation area, the REC Alpha Series opens a big power gap beyond the commercially available power levels of Tier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

What is the REC Alpha Series?

Born of a development partnership between REC and the Swiss production equipment manufacturer Meyer Burger, the REC Alpha Series builds on REC's experience with n-type monocrystalline cells and half-cut technology as well as Meyer Burger's in depth process knowledge in heterojunction cell technology (HJT). The two companies have been working partners for many years, but the Alpha marks the first time a development project has seen such game-changing results.

The REC Alpha Series (fig. 1) uses heterojunction cells and an advanced low temperature cell connection technology on REC's innovative Twin panel design where cells are cut into equally sized rectangles through REC's half-cut technology and connected in parallel.

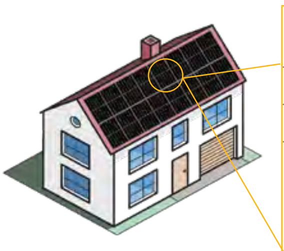
Fig 1: The REC Alpha Series with HJT cells and advanced cell connection technology



What makes the REC Alpha Series different?

Based on REC's unique cell technology and innovative panel design, the leading status of the Alpha has already been acknowledged by the granting of a design patent. 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:



P-type multi	P-type mono	REC Alpha Series
16x290 Wp	16x310 Wp	16x380 Wp
4.6 kW	**4.9 kW**	**6.1 kW**
-28% less power than the REC Alpha Series	-22% less power than the REC Alpha Series	over 20% more power in the same area

What is heterojunction technology?

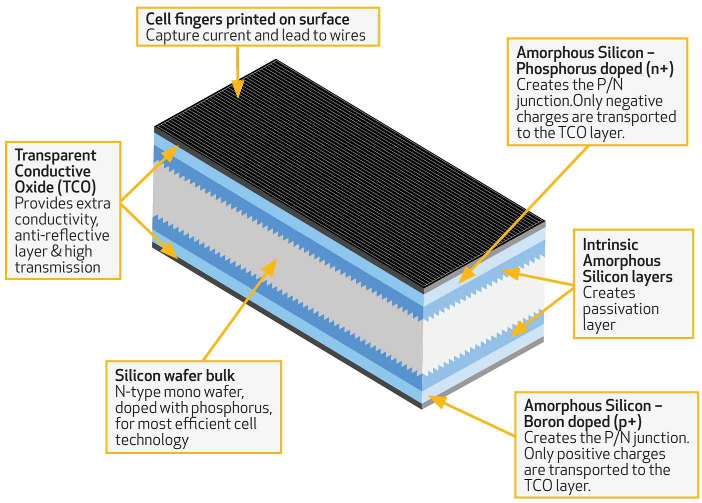
Heterojunction cell technology combines the advantages of crystalline silicon cells and thin film technology within a single cell structure. This means efficiency levels of over 25% are now within reach.

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. Using two different materials results in huge band gaps leading to the best available passivation technology. 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 does 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 cell technologies, where a solar panel irrecoverably loses power capacity during its initial phase of exposure to sunlight. This is caused by the combination of boron and oxygen in the cell. Through the use of n-type monocrystalline cells as a base, the REC Alpha Series avoids this as these elements are kept separate in the cell and not given a chance to combine. This means the REC Alpha shows no sign of permanent loss of power immediately after installation and the customer will receive the power levels paid for.

High resistance against microcracks through HJT

A panel has to endure a lot of different weather conditions during its lifetime. Heavy loads on the front side through snow, dynamic stress from wind and daily temperature variations all put the panel under high 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, reducing the efficiency of the solar 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 the ohmic losses seen in a conventional cell can be reduced.

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.

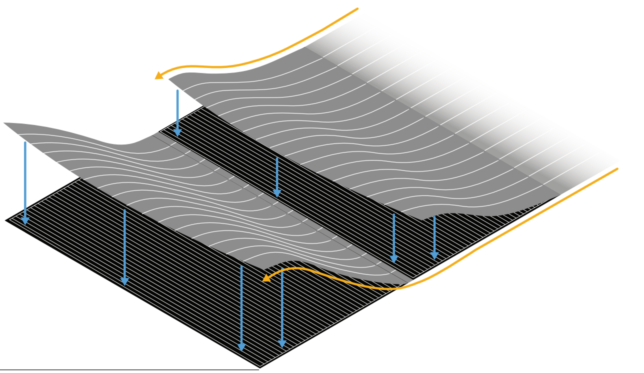
Fig 4: Temperature ratings of standard panels compared to REC Alpha panels

Temperature ratings of panels:	*Standard*	*Alpha*
Temperature coefficient of P_{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?

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 while reducing the overall lead content of the panel by 81%.

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



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

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 occuring. and the lower temperatures used greatly reduce the risk of damage caused by the difference in thermal coeffcents 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 occuring 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 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 320 soldering points in the entire panel.

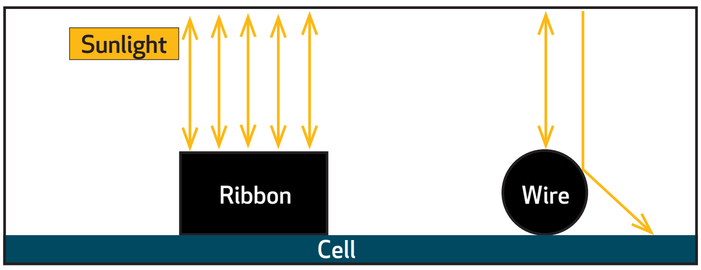
Improved current flow and reduced power loss

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 REC Alpha has over 800 cell to wire connection points per cell resulting in nearly 100.000 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?

As the advanced low temperature connection technology was a proprietary development by REC and Meyer Burger, REC has been fully involved at all development and testing stages.

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 does the REC Alpha improve carbon footprint?

Reducing carbon footprint is often a key mover to invest in solar. The use of advanced low temperature interconnection technology to create a solder-free cell connection uses less energy in production while providing customers with more power density, i.e., more power from the panels fits in a limited space. This means they can generate even more clean energy from their 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, the lead content of a panel is reduced by 81% compared to standard panels. As a result lead now makes up only 0.02% of the total weight compared to 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?

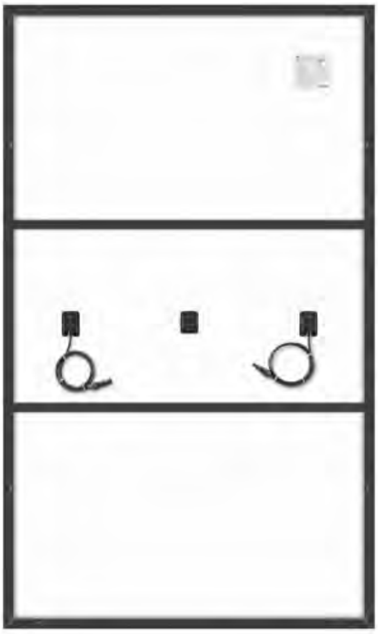
The REC Alpha Series has been tested to withstand 7000 Pa snow load and up to 4000 Pa wind load and features our innovative 2S frame design. This is a 30 mm frame with support bars on the rear to ensure stability and durability. The reinforcement provided from the support bars prevents the glass layer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

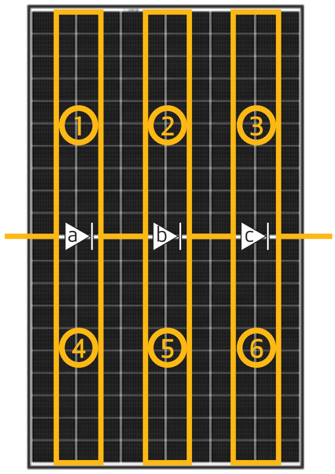


REC's Twin Design on the Alpha

Each half of the panel consists of 60 cells that have been cut into two equally sized pieces to create REC's iconic half-cut cell design. The cells are then connected in series, in three strings of 20 cells. The two are 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 rather than the shading causing a bypass diode to be activated and a cell string the complete length of the panel being circumvented, bringing the string capacity down with it, only half the panel is bypassed, enabling at least 50% to continue contributing to overall energy yield.

Fig 8: 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, ever higher. 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, improving current flow and reducing ohmic losses. Additionally, the solder-free cell connections mean the amount of lead in the panel is lower, for a reduced environmental impact. The result of this is a panel with much higher power density compared to a conventional panel, making the REC Alpha Series the premier product 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.