Glare Report
RE: Town of Madbury Safety Complex 102.600 kW DC / 75kW AC Ground Mount Photovoltaic System

Glare occurs when sunlight is reflected off of a flat, shiny surface. Solar panels are flat and somewhat shiny, but they are designed to capture light — not reflect it.

Photovoltaic panels actually cause less glare than standard home window glass. And research has shown that they reflect less light than snow, white concrete and energy-efficient white rooftops.

REC solar panels are coated with anti-reflective material that maximize light absorption.

Page 2 shows how the solar panels are designed and absorb sunlight.

REC Twin Design:
Innovative design to raise the power of solar panels even higher!

First introduced in 2014 and now employed across a whole range of products, REC's pioneering Twin Design combines new and ground-breaking developments for high solar panel efficiency and high power and ensures REC's product range competes strongly on power with competitive products on the market.

What is REC's Twin Design?

The technology behind the patented REC Twin Design is a revolutionary advancement in solar panel technology that delivers a power boost of up to 20 Wp per panel.

The most noticeable difference in REC TwinPeak products is the cell layout design. Due to the implementation of new wafer production techniques back in 2014, REC was able to industrialize cells with a larger surface area to capture more sunlight. In an industry-first, these cells were then cut into two equally-sized pieces, known as 'half-cut cells. Cutting cells in this way reduces internal resistance and increases overall power.

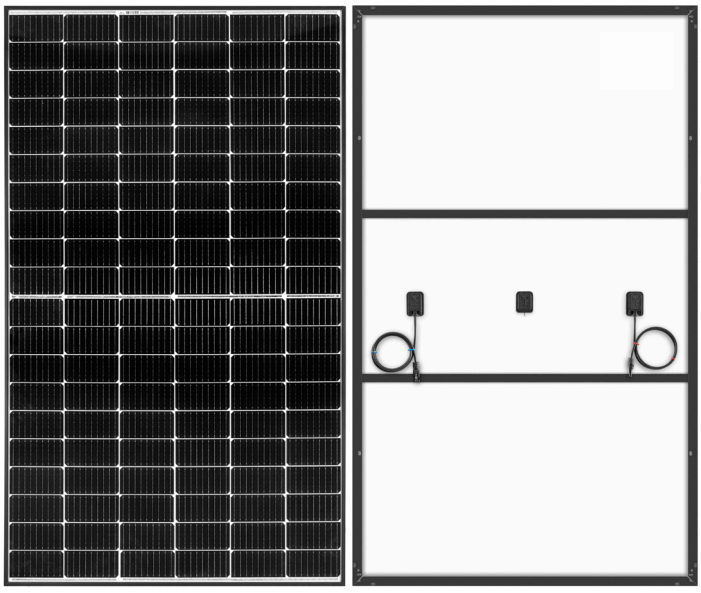
At module level, the half-cut cells are then connected in strings and, the panel is laid out in two 'twin' sections with equal numbers of cells connected in series - appearing as a top and a bottom half (fig. 1). This innovative cell layout is supplemented by a number of other enablers:

- Increased number of bus bars
- Split junction box design
- Cell passivation technology

For which markets is the new panel suitable?

The higher power and efficiency provided by REC's Twin Design technology means customers can boost their energy yield by generating the same amount of power with fewer modules, or through generating higher system yields from the same surface area. This makes REC modules a cost-effective and ideal choice where space is limited, for example on residential, commercial, and industrial rooftops.

Fig 1: Front and rear view of the REC TwinPeak4 Series solar panel, showing the twin section design enabled by the half-cut cell layout, 9 bus bar cells and split junction box on the rear



What advantage do half-cut cells deliver?

A half-cut cell is a standard square cell that has been split into two smaller cells (fig. 2) to become rectangular. Splitting the cells like this reduces internal current by 50% and therefore also reduces the power loss. As power loss is proportional to the square of the current, the power loss in a half-cut cell is actually reduced by a factor of four: ($Ploss = R \cdot I^2$, where R is the resistance and I is the current).

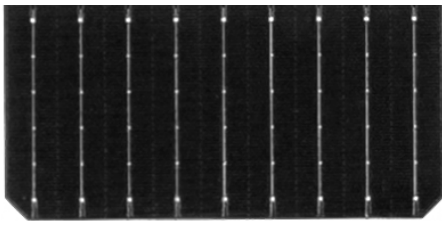
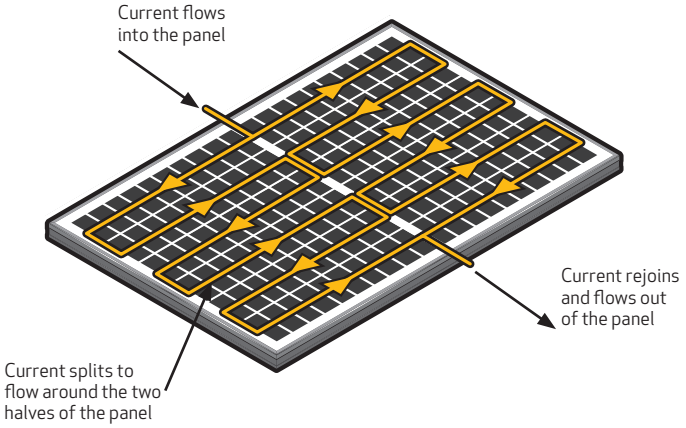


Fig 2: A half-cut cell showing the 9 bus bar design of the REC TwinPeak 4 Series

By reducing losses in this way, the fill factor, an indicator of cell quality, is increased which gives higher light conversion efficiency. This means that the cell can capture more sunlight and produce greater energy yields, especially at times of high irradiance. Such enhancements to the cell quality and the reduction of resistance adds over 6 Wp of extra power output to a panel, dependent on technology and cell size.

Additionally, the new cell layout improves the performance of the modules with the Twin Design in reduced irradiance conditions, e.g., when shaded. For example, if a standard panel is installed in portrait orientation and a single row of cells is shaded, the output of the complete panel is zero, due to the bypass diodes closing the internal strings. The innovative layouot of the REC Twin Design with its twin sections ensures that in the same conditions the power output is at least 50% (fig. 3).

Fig 3: Flow of electricity in a panel with REC's Twin Design. The two twin sections reduce internal resistance and ensure continued production of energy when partially shaded.



What advantage do more bus bars deliver?

The bus bars on a cell are used to capture current from the cell and connect cells together The more bus bars there are on a cell, the less distance electrons have to travel to reach the ribbon, vastly improving the flow of current and the reliability of the panel. The reduction in distance again lowers the internal resistance in the cell, which increases current and allows the width of the bus bars to be reduced, exposing more cell area to light for increased current generation. The reduction in cell resistance through adding bus bars can improve cell efficiency by over 0.2% per cell, adding upwards of 2 Wp more to the panel output.

Panels with five or more bus bars have also shown major improvements in durability during the stringent qualification testing performed by REC, especially in the thermal cycling and mechanical load tests. This is attributed to the lower cross section of the ribbon permitted by the smaller size, easing the amount of stress on the cell. This effect is increased even more in the REC Alpha range of panels where a special foil and wire combination is used to connect the cells, eliminating the need for the printing of bus bars on the cell and the need for soldering the bus bar to the cell surface.

What advantage does a split junction box deliver?

A junction box is generally a single plastic housing which contains bypass diodes and connection options to link the panel to the rest of the system. The term 'split junction box' describes a set up where these functions are split into three smaller boxes, one per internal string, with one bypass diode each (fig. 1).

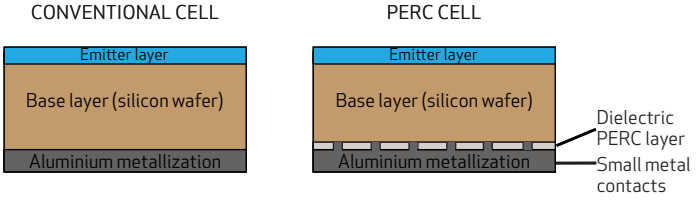
It is this innovative design change that is key to the distinctive cell layout seen in REC TwinPeak products. Use of a split junction box uses less metallization than a standard panel, which reduces internal resistance and saves space. This extra space then allows larger spacing between individual cells, which subsequently increases the internal reflection of light from the backsheet onto the cell surface for higher power.

Tests have also shown a reduction of between 15°C and 20°C in heat build up behind a split junction box compared to a single box on a standard panel. The cooler temperature increases panel reliability and can produce a power gain of over 2 Wp per panel.

What advantage does cell passivation deliver?

Cell passivation is an umbrella term given to the process by which a design change in the rear of the cell sees a special dielectric layer coated on the backside of the cell above the aluminum metallization layer. REC was the first module manufacturer in the world to introduce such a development into the mass production of multicrystalline cells and has since brought variants of this technology to p-type and n-type monocrystalline cells.

Fig. 4: The simplified structure of a conventional solar cell (l) compared to a cell with PERC technology (r)

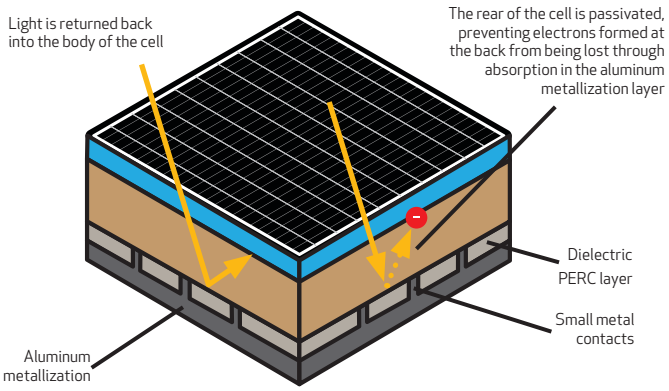


Although the passivation layer cannot be seen in the cells and makes no difference to the visual appearance of the panel, it boosts overall module power in two distinct ways.

Firstly, any wavelengths of light that pass through the cell without generating electrons can be reflected back into the body of the cell giving a further chance to be absorbed. This enables the cell to absorb more light at the infra-red end of the spectrum (wavelengths between 1000 and 1180 nm) increasing production in low light conditions, e.g., dawn and dusk, and improving cell efficiency as well as overall energy yield (fig. 5).

Secondly, passivation acts like a shield at the rear of the cell minimizing the recombination of atoms which keeps the cell cooler and allows it to work more efficiently. This means that any electrons generated near the bottom of the cell are less likely to be attracted to the aluminum metallization pole and lost to recombination. Unattracted by the mettalization polarity, the electrons are free to rise back through the cell structure and be captured by the interface between the base and emitter and contribute to higher cell current (fig. 5).

Fig 5: A cross-section of a cell showing the 'reflective' properties of the PERC cell passivation technology



How do customers benefit from REC's TwinPeak Technology?

Advancing the ability of the cell platform to higher levels of power than with conventional 'square' cell technology, REC's Twin Design provides customers with high power products at very competitive prices, helping to reduce balance of system costs and lower the levelized cost of energy for investors in solar.

The application of the advancements in REC's Twin Design has been shown to increase module power by up to 20 Wp per panel! This is achieved through reducing resistance through the module, exposing more cell area to sunlight and increasing the amount of light absorbed. Together, these enablers ensure that REC solar modules provide a higher energy yield throughout the day when compared to standard technology, and a higher overall energy yield means a higher rate of return on a solar installation.

Such an increase in power per m² is of particular importance to the residential, commercial, and industrial markets as it allows customers to generate more energy from their installation area than was previously possible with the polysilicon platform. These benefits are of course in addition to REC's industry-leading product quality, the fact that REC's panel production is 100% PID free, and the reliability of a strong and established European brand.

NE-18-14 - Rev D 04.2021