Reflecting on ways to boost module output

Module coating | Anti-reflective coatings have been a standard technology on solar modules for some time, but several companies are now targeting the market for older solar farms. Sara Verbruggen reports on the promising early results from trials of these performance-boosting technologies

Credit: Pellucere

Anti-reflective coatings retrofitted to untreated PV modules are offering a new option for boosting performance

While the majority of installed solar capacity globally comprises modules with anti-reflective (AR) properties, applied during production, coatings producers are working with the solar industry to target the aftermarket opportunity.

Many photovoltaic (PV) installations built before 2012 would have used panels without any AR coating applied during production. While the share of installed PV capacity comprising modules with pre-applied AR properties is much greater than the share of panels without any such coating, there is still a substantial capacity of uncoated modules – tens of gigawatts, some estimate – concentrated mainly in Europe's mature solar markets, such as Germany, Italy, Spain and Greece.

As these established markets host substantial amounts of solar capacity receiving high feed-in tariff (FiT) payments, the pre-2012 solar market in Europe is a lucrative opportunity for AR coatings since even incremental output improvements can result in significant additional value for owners and operators of solar asset portfolios.

AR coatings and how they work

According to trade body SolarPower Europe, reflection losses are one of the first loss factors that occur in the energy flow when PV plants convert sunlight to electricity.

AR coatings, usually based on a silica gel solution applied to the glass face of the module, work by creating a gradual transition from air to glass for incoming photons. The result is a reduction in the amount of light that is reflected off the glass, allowing more light to reach the PV cells in the module, which is converted into energy.

AR coatings do this by varying the porosity of the material from very high at the coating-to-air interface through to very low at the coating-to-glass interface.

AR coatings are very thin, 150 nanometres in thickness, or less. They are applied to the module surface via techniques such as spraying. A process that can be highly controlled achieves a more uniform thickness, which can optimise the amount applied.

The coatings that are being developed for the solar aftermarket are based on the same technology platforms as the AR coatings applied in production technology for new modules, according to SolarPower Europe. However some companies are developing advanced coatings based on nanomaterials and are targeting solar with their technology.

Pellucere's MoreSun

AR coatings designed for retrospective application on installed PV modules are close to commercialisation as producers of these coatings collaborate with solar companies providing operations and maintenance (O&M) services for asset owners.

One product is Pellucere's MoreSun coating, which combines AR and anti-soiling properties, using what the company describes as a 'silica shield' technology. The coating, which is available on the market, is designed for solar modules that have not been supplied with a factory-applied AR coating. Pellucere is also working on a product for application during production by module manufacturers.

Pellucere's senior vice president, business development for Europe/MENA Peter Fuss says: "AR coating applied to new modules in production became established between 2012 and 2013. We

estimate there is an eligible installed base of 45-70GW worldwide, comprising crystalline silicon modules without an AR coating, which were installed mainly prior to 2011 and 2012 and almost all First Solar series 2 to 4 modules, except the series A modules."

According to Pellucere, MoreSun achieves higher gains in the evening when sunlight is falling on the module at an angle and also when the sunlight is more diffused, such as on cloudy days, when light is hitting the panel from multiple angles. Solar plants installed in coastal areas with more mist and in cloudy regions can achieve higher performance gains, compared with plants in very dry regions, with little cloud and lots of direct sun.

Pellucere has been working with Alectris, a European third-party O&M service provider, which has exclusive rights to install MoreSun in Italy and Greece.

To date Alectris has applied MoreSun on over 6MW of test arrays at 16 different locations across a variety of module technologies. Field-testing of modules has occurred in countries that include the US, China, Taiwan, Italy, Greece, UK and Germany. Most of the trials have been running since 2015 with results gathered so far validated with accelerated lifecycle laboratory testing.

MoreSun helps the solar module capture more light, increasing energy output from direct axis light by 3.4% to 3.8% and total energy output, modelled in PVSyst software, by up to 4.7%. These energy gain estimates are based on laboratory-certified energy gains applied to a specific solar farm using PVSyst, according to Pellucere.

According to Alectris, real-world field trials demonstrate energy gains of 3.4% to as much as 4.9%.

For example, results from trials where the coating was applied on modules in central Germany in May 2018 achieved power gains of 4.1% (AC) (Figure 1).

The cost of applying MoreSun depends on several factors, such as plant and module layout, with an expected payback period of between 1.5 and 3.5 years, depending on factors such as plant yield, which can depend on location, performance and the subsidy support mechanism in place.

According to Pellucere and Alectris, MoreSun's application can complement solar farm upgrades, such as replacing inverters and other repowering options.

"MoreSun can either be applied as a retrofit product on older PV plants. In such cases the boosted output would increase the plant performance therefore compensating for the natural degradation of the mature asset. Or it can be applied as an 'added value' product, providing a performance gain as additional revenue," says Fuss.

Depending on plant location, the cleaning cycles and environmental conditions, the coating is expected to last over 10 years. If and when it does begin to degrade, it can be reapplied, explains Fuss.

MoreSun's anti-soiling properties can lengthen cleaning cycles, reducing O&M costs associated with cleaning. The MoreSun coating incorporates Pellucere's proprietary Talus Dirt Rejection Technology (DRT). Talus DRT prevents build-up of dirt and other particulates. Unlike hydrophobic anti-soiling technologies, the Talus DRT's properties allow the coating to reject dirt without requiring rainfall.

Fuss says the primary function of MoreSun is to provide anti-reflective properties. "The anti-soiling is an added value. However, our technology roadmap includes developing an anti-soiling coating for modules that is highly effective in regions where water is scarce and which can make panel cleaning challenging, as part of O&M activity," says Fuss.

Pellucere has developed the MoreSun package to be a comprehensive offering for both independent solar O&M service providers as well as solar asset owners that manage their own O&M activity, and is in discussions with companies in various European markets as well as in the US, according to Fuss.

"We see lots of potential in markets such as Italy, Greece, France, Spain and Germany as well as the US, where in certain regions there are some very large solar parks, built pre-2011. Coating season runs from May to October, so we are hoping to announce some customers in the next few months," says Fuss.

The package includes the coating as well as two types of application tools. For smaller solar parks, the backpack tool (pictured, main image), which workers wears on their back and apply to each panel, is suitable. For larger solar parks, the company provides an application system that a human operator sets up to apply the coating to several panels in a row.

Fuss says Pellucere is continuing to focus on application tool development to enable more efficient application of the coating. "The MoreSun package also includes insurance, quality control and measurement devices. The aim is to provide a standardised product across the industry that is very simple and straightforward to apply," he says.

Alectris is promoting the AR coating to PV plant owners that the company already provides O&M services to and has begun marketing it to the wider industry, offering the coating as an added value product and a point of differentiation to other O&M service providers.

In Italy and Greece, where the company has been testing the coating among solar asset owners, it expects to capture the largest share of the potential market for retrospectively applied solar AR coatings.

In addition to its discussions and customer trials with existing and potential new clients Alectris says it is working on optimising operations and reducing the labour costs associated with applying the coating in situ by training dedicated teams and project managers.

Fuss says one of the benefits of working with Alectris is the feedback Pellucere has been able to gain from the practical application of MoreSun on PV modules within solar farms. "The cooperation has helped us to refine the offering," he says.

MoreSun Field Trial Energy Gains		
Location	**Date applied**	**Power gain**
Germany		
Central	May 2018	4.1% AC
Southern	Nov 2017	4.0% AC
Central	Jul 2018	3.7% AC
United Kingdom		
Central	Nov 2017	3.6% DC
Italy		
Central	Sep 2018	3.8% DC

Source: Pellucere

Figure 1. Power gains in trial modules treated with MoreSun AR coating

DSM

DSM has spent over two years testing its AR solar module coating in the lab and, more recently, in the field to optimise the product ahead of its commercialisation, working in cooperation with German solar EPC company Enerparc.

According to Moritz Glossat, a senior systems engineer at Enerparc, the company sees greatest potential for the coating in Europe, which has the highest proportion of older solar parks, installed before 2011, and also with the highest FiT rates.

The retrofit AR coating has no other functions, though DSM does produce a coating combining anti-soiling properties with anti-reflective properties, which is applied by the glass producer. However future solar coatings for retrofit applications may comprise AR and anti-soiling properties or contain anti-soiling properties only, according to Paolo Tusa, commercial director at DSM.

The retrofit AR coating is based on DSM's existing technology, which is applied during solar panel production. The company estimates the technology has been used within the production process of over 70GW-worth of modules since 2011/12.

The retrofit AR coating is produced in DSM's coating plant and production can be scaled rapidly to meet demand, according to Tusa.

The retrofit AR coating will be launched in the first half of 2019 and the company expects it to be used in a significant amount of PV plant repowering projects this year, starting in Europe and then rolling out into other, undisclosed markets, from 2020.

DSM has conducted 10 trials of the coating in Italy and in Germany since 2017, while Enerparc is testing the coating on a subfield of panels within a 27MW solar park.

Enerparc's first trial began in September 2017, followed by further trials in 2018. Results in field trials show a 2-3% increase in output. The coating can achieve a payback in under three years, according to DSM.

Enerparc has been interested in the potential for retrofit AR coatings for a number of years, according to Glossat, however, since there were no references of performance that Enerparc could rely on the company and DSM cooperated on pilots. Glossat says this was so that Enerparc could establish trust in the product and the team that developed it. The partnership is not exclusive, however.

Following on from the field trials, the next stage is to scale up the coatings application on several megawatts of capacity, within Enerparc's portfolio.

For the retrofit market the only pre-requisite is that the coating is applied to PV modules where the glass does not have an existing AR coating and the sooner it is applied the sooner the solar farm can achieve increased output.

DSM is also working to enhance the commercial coating offering with a tool that can apply the coating in a highly controlled manner and at high speed, which will help reduce cost and enable more efficient application and is targeting commercialisation of the tool by the end of 2019.

Opus Materials

UK-based start-up Opus Materials has developed a coating, called Solar Sharc, which combines anti-reflective and anti-soiling properties.

The core technology is based on nanostructured particles, functionalised to provide different attributes within a base matrix, to create a coating with different properties, such as anti-soiling and anti-reflective properties.

Target markets for the coating include the Middle East, Sub-Saharan Africa and India.

"In these markets, particularly, we see great potential for the coating because of water scarcity, so a coating that combines these various functions, not just AR, but also anti-soiling, will reduce O&M costs by minimising water consumption needed to keep PV modules and solar thermal tubes clean from dust, while also optimising output," says company co-founder Russell Banks.

In India, Opus Materials is working with a UK company called Solar Polar, to trial the coating on solar thermal panels. Opus Materials has been trialling the coating in several other countries, including the UK, Denmark and, most recently, locations across Saudi Arabia.

According to Banks: "The field trials are important because they will enable us to finesse the coating formulation as we prepare for commercial launch in late 2019/early 2020," adding: "The ultimate objective is to develop a 'tuneable' coating, where we take the base matrix and adapt the formulation for different regions, as environmental conditions change."

Solar Sharc trials around the world

Opus Materials is working with an undisclosed solar research and development (R&D) facility in Saudi Arabia, which began trialling the Solar Sharc coating two to three months ago on installed solar panels in eight locations throughout the country.

Co-founder Russell Banks says: "The trials will last for about a year so we can gather results on how the coating performs in different seasonal weather conditions, as well as in different locations throughout the country."

The company also has field trials ongoing in the UK, including London and Ipswich, which both started in late 2018. In Ipswich the coating is being trialled on panels equivalent to multiple kilowatts within an operational PV farm. Even from early results the coating has initially increased output by 3.8%, due to the easy cleaning and anti-reflective properties.

Through its academic partner Crest, Opus Materials is also trialling its coating and is awaiting results from an initial weathering period.

The field trials are a critical step as they will enable us to finesse the coating formulation in preparation for commercialising it in the solar industry.

Ultimately Opus Materials wants to produce the coating adapted for different regions, to optimise performance, particularly in terms of its anti-soiling properties, according to Banks.

"For example, for solar farms nearer the coast, salt and sand is a problem whereas in other regions sand and humidity is more of an issue," he says.

According to Opus Materials, the coating's production process deploys a "materials by design" approach, so that the composition can be fine-tuned according to geographical location or climatic conditions.

The coating can be applied by spraying, dip coating or it can also be wiped on. Under accelerated testing, based on the IEC 61215 standard for outdoor testing PV modules, Solar Sharc has proven its performance so far.

Banks says the company is also investigating a prototype able to apply the coating via an automated application tool, for large multi-megawatt solar farms.

To raise funds to commercialise its technology, Opus Materials is in talks with potential investors.

Over the next 12-18 months owners of solar PV assets and O&M contractors should benefit from an array of AR coatings for retrofit application designed to improve returns from existing PV farms. The development potentially paves the way for advanced coatings that combine AR properties and the latest in anti-soiling functionality, opening up new opportunities for slashing O&M costs whilst enhancing the performance of assets across global markets. ■