Perspectives on soiling

O&M | Keeping on top of the impacts of dust and sand on power output is crucial to making solar a viable option in desert regions such as the Middle East. A fierce debate is currently raging over which methods are the most effective. Ben Willis listens to some of the arguments

Credit: PI Berlin

The strong, plentiful sunshine in the Middle East and North Africa makes the region particularly well suited to solar power. But the flipside to that coin is that the dusty and often humid conditions found in this part of the world can create all kinds of headaches for plant owners and operators who must contend with the significant and unpredictable effects that the soiling of PV modules can have on a project's performance.

When PV was first suggested as a solution to meeting the Middle East's spiralling appetite for power, critics said that soiling – the collection of dust, sand and other particulates on a module's surface – would make it unviable. But as the rush of large-scale, price-beating solar development currently underway the region clearly demonstrates, the predicted problems have so far failed to materialise.

"There's been a lot of emphasis on soiling – to the extent that it will kill PV in the Middle East. And that's proven to be not true – it's not the deal breaker or destroyer of performance that it was portrayed by some experts to be," says Raed Bkayrat, head of business development in the Middle East for US integrated PV firm First Solar.

The reason for this is not that soiling is not an issue – far from it. According to Bkayrat, First Solar's experiences in building and operating some of the first large-scale PV plants in the Middle East demonstrate that soiling, if not managed properly, can have a significant impact on the performance of a plant. What's more, it's unpredictable, varying from season to season, site to site and even within individual sites.

"With DEWA 13 we've seen soiling as low as half a percent per day, which if it accumulates then it's 15% per month," says Bkayrat, referring to the 13MW project First Solar completed in Dubai in 2013. "And we've seen soiling as low as 0.1% per day, which is less than 5% per month. So we've seen those two extremes. And it varies over the year: in winter we see very low soiling – less than 5% per month, for sure. In summer it could be 10, 12% easy. If you have a sandstorm you could have soiling of 20%."

All of which highlights just how difficult a problem soiling is to manage. The fact that soiling has so far not developed into the problem some feared it would be is testament to the ingenuity of plant operators such as First Solar in understanding the nature of the soiling problem and finding ways of keeping on top of it.

Unless managed properly, dust and sand on modules located in desert regions can significantly reduce a project's output

But with the size of projects about to get very much larger in the Middle East, and with new parts of the region with varying soiling characteristics opening up, so too is the scale of the soiling issue. Below we present four different perspectives on the different technologies and strategies emerging for contending with the soiling issue.

Understand the problem

For Bkayrat, the key to managing the impact of soiling on PV performance is first to understand it in order to be able to predict it and thus put in place the most cost-effective management regime. That will become particularly crucial given the increasingly cut-throat nature of the prices being tendered for projects in the Middle East, where the difference between a successful or unsuccessful bid can come down to as little as US$0.001.

He says First Solar's experience in the Middle East, in the UAE and other countries such as Saudi Arabia, has taught the firm that the level and type of soiling found in different areas can vary hugely and require different responses. "Humid deserts would require a different frequency and method of cleaning compared to, for example, dry deserts," Bkayrat explains. "The composi-

tion of the dust itself varies, the size of the particles varies, as does the adhesive capability for the dust: if you're in a coastal area you get the sticky kind of dust that falls on the panel, there's some kind of organic content, compared to dry deserts where it's very loose, you can just wipe it with your fingers and feel how loose it is."

He cites the example of DEWA 13 in Dubai, where the comparatively humid conditions and more regular rain in the winter months help minimise the impact of soiling by naturally cleaning modules. "If we took the approach that we would not do anything [with DEWA 13] we would have a soiling loss on average of about 6% – which is interesting; you might think it should be 20, 30% but actually it's only 6%. And people ask me would that be the case in Riyadh, no, it's probably going to be higher in Riyadh."

First Solar has so far relied on manual, waterless cleaning for its projects in the Middle East – waterless because of the scarcity of this resource in this arid region, manual because First Solar's calculations have shown this to be the most cost-effective method, for now at least.

"I think you can do manual cleaning up to 30-40MW roughly. But if you have 100, 200MW large-scale projects then you have to automate, because managing the labourers will go up and it becomes logistically difficult. So you have to introduce automated or semi-automated cleaning solutions – be it robotics or cleaning machines," Bkayrat says.

In anticipation of the larger projects that are set to emerge in the Middle East from next year, Bkayrat says First Solar is working on developing an in-house automated solution. He doesn't reveal further detail of this, but says this is a response to the company's view that none of the automated cleaning solutions currently on the market are yet fully bankable. The main issues he has with products currently on the market are their cost and the fact they often require modifications to modules to make them compatible. "That ties you to that specific solution; if that company disappears, then you're sitting on thousands of robots you have to dump or fix, or change your frame to put another company's robot on there. We continue to evaluate them but we haven't seen anything yet that ticks all the boxes, in my book at least."

Nevertheless he is confident that new cleaning products will appear that give the peace of mind First Solar is looking for. Another promising solution he believes could emerge is an 'anti-soiling' coating for modules, which use nano-technology to prevent the build-up of particulates. Bkayrat highlights the work being done by the likes of Fraunhofer in Germany to develop solutions that combine anti-reflective and anti-soiling properties. "This is the 'super coating' if you will – a coating that has optical properties that improve light transmission, but which also prevents the accumulation of dust. And I think we're close probably to seeing a commercial coating whereby it minimises your frequency of cleaning."

Through technological developments such as this, and through continued good practices in monitoring soiling and proper cleaning, Bkayrat's main message is that although soiling certainly is an issue in the Middle East, it should not be seen as a terminal one as far as PV is concerned: "We want others to believe soiling is not a big deal – a few years back there were people fighting PV saying it's not going to work with the soiling in the ME. And it's proven to be a point of consideration, but it's manageable."

The future is automated

As chief executive of Ecoppia, the Israel-based supplier of waterless, robotic cleaning solutions, Eran Meller unsurprisingly is of the view that the future of anti-soiling efforts is automated. As plants get bigger, Meller's belief is that manual cleaning will become unviable.

"Maintaining 2, 3, 4, 5MW sites is one thing; maintaining those large utility-scale solar plants is almost impossible to do manually," he says. "The quantities of water are quite significant, and with the gigawatts the Middle East, India and other places are talking about, it's really unsustainable."

Another factor militating against the future use of manual cleaning is the consistency of results that can be achieved. "Unlike robotics, human beings one day can clean one way, the other day they can clean another way," says Meller.

Some of the manual techniques, he argues, also damage the anti-reflective coating (ARC) found on modules today, undermining their performance. "Currently the anti-reflective coating provides an additional 3% uplift per year [in output] and according to many studies that were conducted, some with us but also by the major movers and shakers, they have found out that with six manual cleanings the anti-reflective coating will be destroyed."

Meller claims the Ecoppia solution gets around this problem by employ-

Credit First Solar

First Solar's DEWA 13 project in the UAE has been a test-bed for its approach to managing soiling

Credit Ecoppia

ing a specially designed soft brush that minimises the abrasion visited on the module. Another advantage of automated cleaning he says is its responsiveness to sudden soiling events such as sand or dust storms. Ecoppia's solution is operated via the cloud, with sensors at the site keeping a constant check on particulate levels, and issuing instructions to clean if they pass a certain threshold. That means cleaning can be underway in next to no time.

"Once a dust storm arrives within less than two hours your site will be crystal clean; with manual technology it takes in many cases two days even to detect the problem and then another two weeks to clean it – so you're talking 16 days of sub-optimal production. And in many areas this could be negative 30-40%."

Like First Solar's, Ecoppia's solution is waterless, a factor that Meller believes must define the industry's approach to controlling the impact of soiling in water-stressed parts of the world. "Once you use water, even a little bit of water, you need water infrastructure, you need high-quality of water, you need reverse osmosis, you need storage for water," he says. "We strongly believe that our mission is to make green energy even greener and by not using water we're doing that."

Simplicity is key

Another automated cleaning solution making its way to market is the NOMADD (NO-water Mechanical Automated Dusting Device). Developed over the past three years by engineers at King Abdullah University for Science and Technology near Jeddah, Saudi Arabia, the NOMADD solution is shortly expected to see its first applications in commercial installs in the Middle East.

NOMADD's chief technology officer, Georg Eitelhuber, explains how the NOMADD solution came into being. "Lego was my prototyping tool! I was playing around with Lego for about 12 months to get a mechanism for waterless automatic cleaning. And I discovered this quite funky mechanism by accident that seemed to make a huge difference to the effectiveness of the cleaning. I took the model to the tech transfer department here and they said 'we're going to back this, here's some development money'. And it all went from there."

The NOMADD machine is now in its seventh version and has been extensively trialled in the harsh desert conditions found in Saudi Arabia. With the kingdom now finally looking to embrace solar after several years of stop-start interest in the technology, Eitelhuber is excited that his technology's time may soon be about to come. "It's getting to be a big deal now," he says.

Ecoppia believes waterless, fully automated cleaning is the future for desert solar

The effect of dust on PV in Saudi Arabia can be particularly acute; "background soiling" can cause a loss of output of between 0.4 and 1.1%, Eitelhuber says. If there's a dust storm, the problem can be much worse. Eitelhuber cites one recent storm that lasted two hours and caused a 60% loss of power from a test site. "The problem with that is that they will stay at [40%] output until you clean them. And if you're relying on a scheduled, manual-based cleaning method, where you've got an army of fellas out there and they start at one end and take days to get to the other end, you're only producing at 40% output for a long time."

As others have, Eitelhuber and his team concluded that automatic, waterless cleaning was the only way to go in the Middle East. Aside from the consistency issue highlighted by Meller where manual cleaning is concerned, another drawback of this method noticed by the NOMADD team was that the bottom rows of panels in arrays were getting mysteriously damaged. "We couldn't work out why at first," Eitelhuber says. "But it turned out the fellas cleaning the panels got exhausted and were sitting on the panels on the bottom row and they were breaking."

The development of the NOMADD system he says was based on the two principles of cost-effectiveness and reliability "It's got to be cost effective – and we are: we've got a payback period of a couple of years compared to traditional cleaning methods. And we can also provide assurance that the array will be performing optimally at the touch of a button."

Credit NOMADD

The NOMADD cleaning system has been designed to withstand the rigours of the desert environment

Credit: SunPower

The NOMADD system works by running a cleaning unit along individual rows of modules. Each unit contains a long brush powered by a direct-drive motor that runs diagonally across the modules. The essence of the design is simplicity, says Eitelhuber: "Anything that's complex will not survive in the desert. And the art of the engineering around NOMADD has been about how we get this as absolutely simple as possible. When we talk about robotic cleaning, people think of something highly complex and futuristic. NOMADD is not like that, it's more a power tool than a robot. We see machines out there now; some of them have up to five separate electric motors on them, doing complex mechanical processes. That's a recipe for disaster – there are so many failure modes you're introducing to your machine."

The NOMADD team is now in discussions with developers of projects in the Middle East, Latin America and Australia about commercial deployment of the technology. He is particularly hopeful that the first wave of projects in Saudi Arabia will deploy the system.

Indeed, Eitelhuber believes manual cleaning will soon – and quite rapidly – become a thing of the past as the industry recognised the advantages of technologies such as NOMADD. "I think it'll be almost overnight," he says. "The majority of projects going through the tendering process in the next six months in dusty regions will all have automated waterless cleaning on them – this is going to be industry standard, pretty much instantaneously. The economics add up, the value proposition adds up. The future of cleaning is waterless, automatic systems."

Know your costs

One company that still advocates water in cleaning is SunPower, via its Greenbotics automated cleaning system. SunPower acquired Greenbotics as a start-up in 2013 and now uses the system in its Oasis utility-scale power plants.

At a presentation at Intersolar Europe in June, Kyle Cobb, co-founder of Greenbotics and now a senior product manager at SunPower, described the considerations in deciding on the best cleaning strategy for PV plants – whether manual, semi-automated, fully automated, with water or waterless. With each of these decisions there are trade-offs, Cobb said.

Taking water, for example, he said not using it could result in poor cleaning of panels. "[If] you use no water, you put yourself at risk of coming across a soil type that doesn't respond well to dry cleaning, not fully restoring a module to 100% cleanliness," he said. "So I'd argue that there's a sweet spot, and it took us a long time to figure out that there's a semi-automated cleaning method that uses low water and low labour to reach the maximum return on investment for your cleaning activities at a power plant." The Greenbotics solution uses a small amount of water per panel to achieve what he said was the optimum cleaning result.

SunPower advocates small quantities of water in module cleaning to achieve optimal results

In deciding whether to go for manual or automated cleaning methods, Cobb said again there were trade-offs, with the generally lower cost but greater inefficiency of manual set against the greater efficiency but also much higher cost of full automation. "The important questions to ask yourself are: what is the true benefit of the cleaning technology you're exploring; make sure you look into the details about the efficacy of the cleaning. The second is what is the true cost? You could go down the route of paying the higher initial installation cost and perhaps lower O&M down the road on those fixed robots, or you could also make the trade-off to do a semi-automated cleaning method which gives you more flexibility and has lower up-front cost. Spending a lot of money up front on a robot might not be the right decision – you might decide that it's better to use a semi-automated, lower-water, low-labour cleaning solution that requires a lower upfront investment and around the same operational cost."

For now, no clear winner in the cleaning debate has emerged. But as more and more solar is installed in areas where managing the soiling problem is vital, no doubt the best solution will eventually become clear. ■