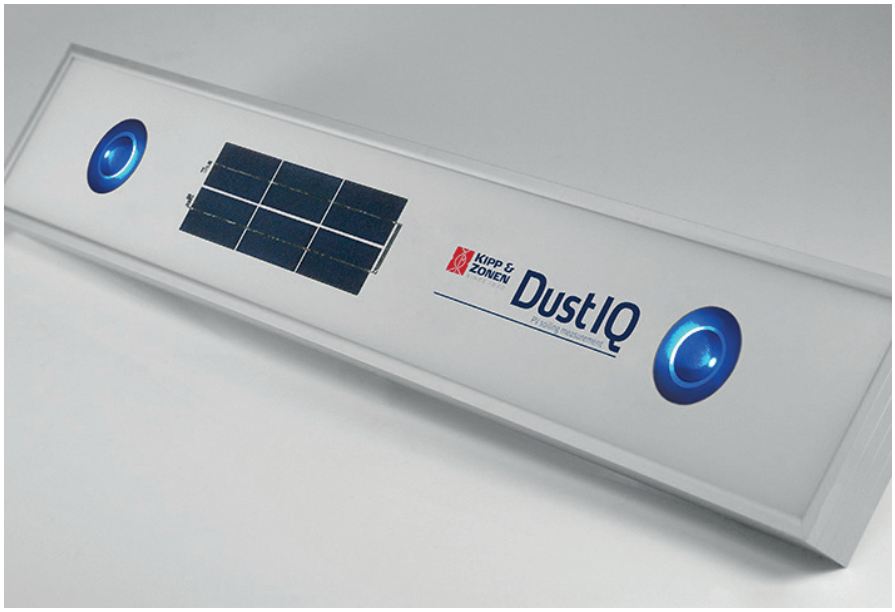
Monitoring the effects of soiling on photovoltaic cells

Kipp & Zonen continue with their quest to improve the DustIQ, which can now be locally calibrated for the exact dust composition on site. This means the PV panels can be monitored 24/7 and cleaned whenever necessary. PES delves deeper to bring you the latest on this affordable and compact, cost saving, optical measuring tool.

The maximum efficiency exhibited by solar cells has been incrementally improved over 150 years of scientific endeavour. But while photovoltaic technology continues to improve, the amount of power we can generate from solar cells is ultimately dictated by environmental factors. Primarily these are solar irradiance, temperature, and soiling. While the effects of solar irradiance and temperature are well-understood, the detrimental effects of soiling on solar panel performance often go overlooked. However, new technologies are making it easier than ever before to measure the effects of panel soiling on photovoltaic performance.

Advances in increasing solar cell efficiency

The world's first photovoltaic device was created by Edmond Becquerel at the ripe old age of 19, while conducting experiments in his father's laboratory.[1] Edmond, the son of prolific electro-/bio-chemist Antoine Becquerel, found that a platinum electric I think they mean conductor coated with a thin layer of silver chloride could be coaxed into exhibiting a phenomenon previously unknown to science: When placed in an electrolytic solution with another electrode and illuminated, a current started to flow.[2]



His experiments were meticulous. Having ruled out thermoelectric effects and even managing to obtain a rough spectral response curve by shadowing the electrode with a series of coloured filters, he correctly deduced the nature of the chemical reaction that occurred at the photosensitive electrode. Becquerel had created a liquid-phase photoelectric cell, the precursor to the familiar (and much more convenient) silicon cell which would go on to become the fastest-growing renewable energy source in the early 21st century.[3]

Photovoltaic cells have come a long way since Becquerel's experiment in 1839. In 1876, scientist William Grylls Adams showed that photovoltaic current could be generated without heat transfer or moving parts, laying the foundation for modern photovoltaic cells.[4] Over the next 50 or so years, the photovoltaic effect (or 'Becquerel effect') was demonstrated in a number of different materials, but efficiency did not budge from around 1% until the 1950's when the power of silicon was discovered. In 1954, Bell Labs made headlines with the first 'practical' silicon solar cell, with an efficiency of 6%.[5]

The front page of the New York Times the next day proudly proclaimed that the 'Vast Power of the Sun is Tapped', these cells heralded the arrival of compact, efficient and commercially viable solar cells.[6] Since then, the sustained efforts of generations of scientists and engineers have multiplied the efficiency of solar cells several times. As of December 2014, the world record for photovoltaic efficiency, the ratio of incident solar radiative energy to usable electrical output, stands at an impressive 46%.

Environmental factors are the most important

However, while the theoretical efficiency of photovoltaic cells is painstakingly pushed upward by scientific advances, their true performance in situ is at the mercy of environmental factors.

Variations in solar irradiance are obviously a primary concern. Slightly less obvious is the effect of temperature on photovoltaic efficiency: increasing the temperature increases charge-carrier recombination rates, effectively taking electrons out of action in the cell, which reduces the generated voltage.[7] Unfortunately, both of these factors are difficult to control. But there is one significant threat to photovoltaic efficiency which we're not powerless to prevent: soiling.

Measuring photovoltaic soiling in real-time

With causes including but not limited to dust, plant products, soot, salt, and even bird droppings; soiling can be a serious threat to the power production of photovoltaic cells. Soiling due to dust is particularly prevalent in the dry areas which receive high sunshine levels – areas which are otherwise most attractive for photovoltaic installations – enough to make investors think twice before setting up a solar cell arrays in desert climates.

The effects of soiling are not to be underestimated. Soiling can lead to losses in energy production of over 10% per week. Accumulated dust and grime negates a sizable chunk of each solar cell's hard-earned capacity.[8] For photovoltaic facility owners, balancing the cost of cleaning cells with losses due to soiling is critical. But unlike relatively well-understood factors such as solar irradiance and temperature, the effects of soiling are difficult to predict. So, a question arises: How can we accurately gauge the effect of soiling on a given photovoltaic system?

Instrument manufacturer Kipp & Zonen, have answered this question by developing DustIQ: a novel way to optically measure photovoltaic soiling. While other soiling-measurement systems work by comparing the signals from a clean cell and one that is allowed to accumulate dirt, requiring both sunlight and perpetual cleaning to work, DustIQ measures soiling directly without the need for fortuitous weather conditions or maintenance. [9 10]

The compact system is designed to be mounted in between or to the side of an existing photovoltaic array. Using an internal LED and photodetector, DustIQ analyses the light reflected by the soiling. Greater soiling results in a higher proportion of reflected light.

The recently added small PV cell allows the DustIQ to be locally calibrated for the exact dust composition on site. Using the local calibration the DustIQ calculates the exact soiling ratio, which can be translated into power losses in real time. The local dust calibration and PV cell only only need to be done once.

The DustIQ's affordability and maintenance free concept enables multiple units to be integrated into a single system measuring local variations in soiling across larger photovoltaic plants.[11] Thus offering redundancy in measurements and insight into the dust distribution over the plant.

Armed with up-to-the-minute information on soiling even in the dark, photovoltaic plant operators can schedule cleaning of panels in direct response to actual soiling rates, allowing them efficiently to prevent significant energy loss and wasting unnecessary expenditure on cleaning resources. DustIQ is accurate, simple-to-use and cost-effective; providing the information needed to keep photovoltaic installations working at their best.

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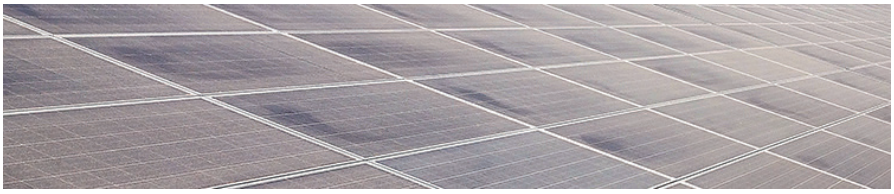

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