Inspired by Mars

Atonometrics was founded in Austin, Texas, in 2007, with the mission to provide high-quality test and measurement equipment to the small but growing photovoltaics industry. The company founders came from a long background in test and measurement equipment for the semiconductor industry. The experience of the management team included over 30 years of R&D, product development, sales, marketing, and manufacturing.

The company's first products included light soaking systems and IV measurement systems for PV module manufacturers and test labs. These products have been installed in factories and labs worldwide.

This experience in the PV industry led the company to develop products for operational PV plants. The company's first soiling measurement system was introduced in 2010 and that product was followed by calibrated reference cells for cost-effective irradiance measurements.

Soiling: the accumulation of dust and other contaminants is a significant concern for photovoltaic (PV) solar power plants.

Soiling affects solar power generation by blocking sunlight from getting to the solar panels. It causes worldwide solar industry power losses of 4 to 7%, with corresponding revenue loss in the multibillion-dollar range. And some locations, such as the Middle East, can experience soiling losses of 50% or more during dust storms.

Soiling occurs primarily because airborne particulate matter settles onto the surfaces of solar panels and sticks to them. The rate of soiling accumulation, usually discussed in terms of the daily increase in power loss in between cleanings, varies between 0.1 to 1.0 percent per day, depending on the amount and type of dust in the air, wind speeds, humidity, and other conditions. The total soiling loss continues to grow until a cleaning or rainfall event occurs.

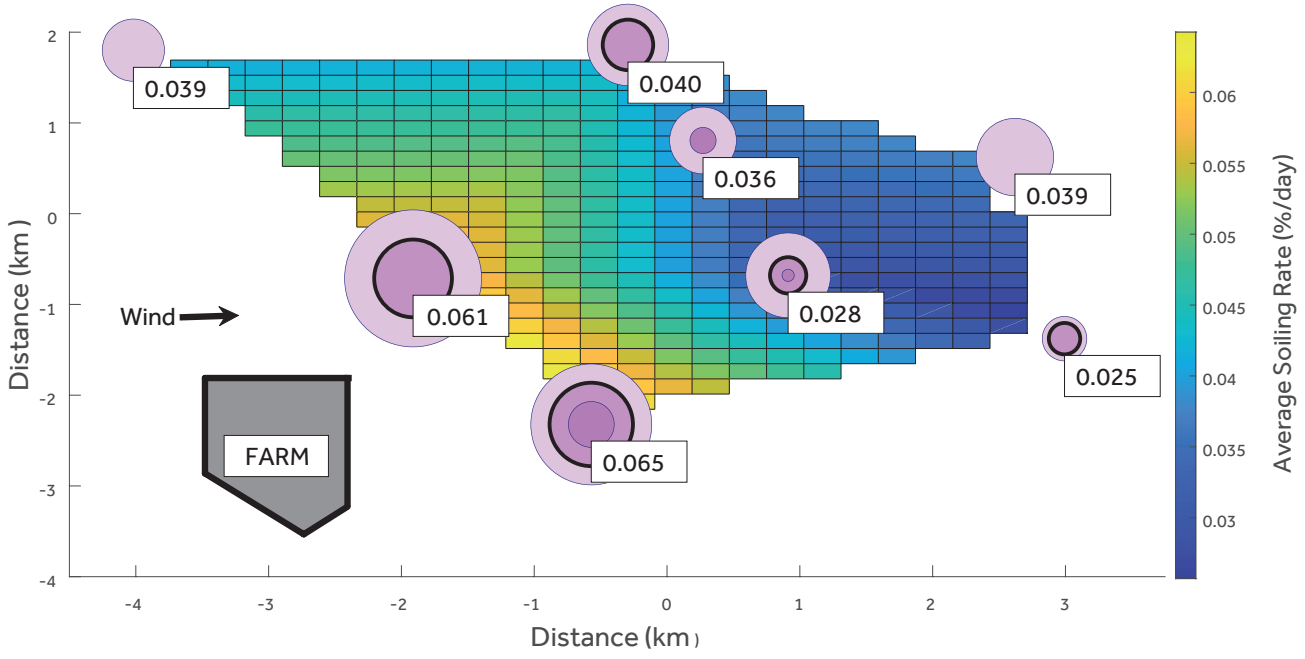
Soiling is a location-specific phenomenon. Not only are there are clear differences in soiling rates between geographic regions, but even on the local scale there can be significant differences in soiling rates depending on local surroundings. Soiling rates can even vary significantly across a single PV power plant, perhaps due to a road, farm, or factory on one side of the plant or due to prevailing winds. Studies have reported up to 3% performance variations across a single plant due to location-specific soiling rates.

For PV power plant sites without regular rain, cleaning strategies need to be developed, keeping in mind the costs of cleaning which vary significantly by cleaning method and plant location. The decision of how often and when to clean is an economic one, increases in revenue due to cleaner solar panels should exceed losses due to soiling.

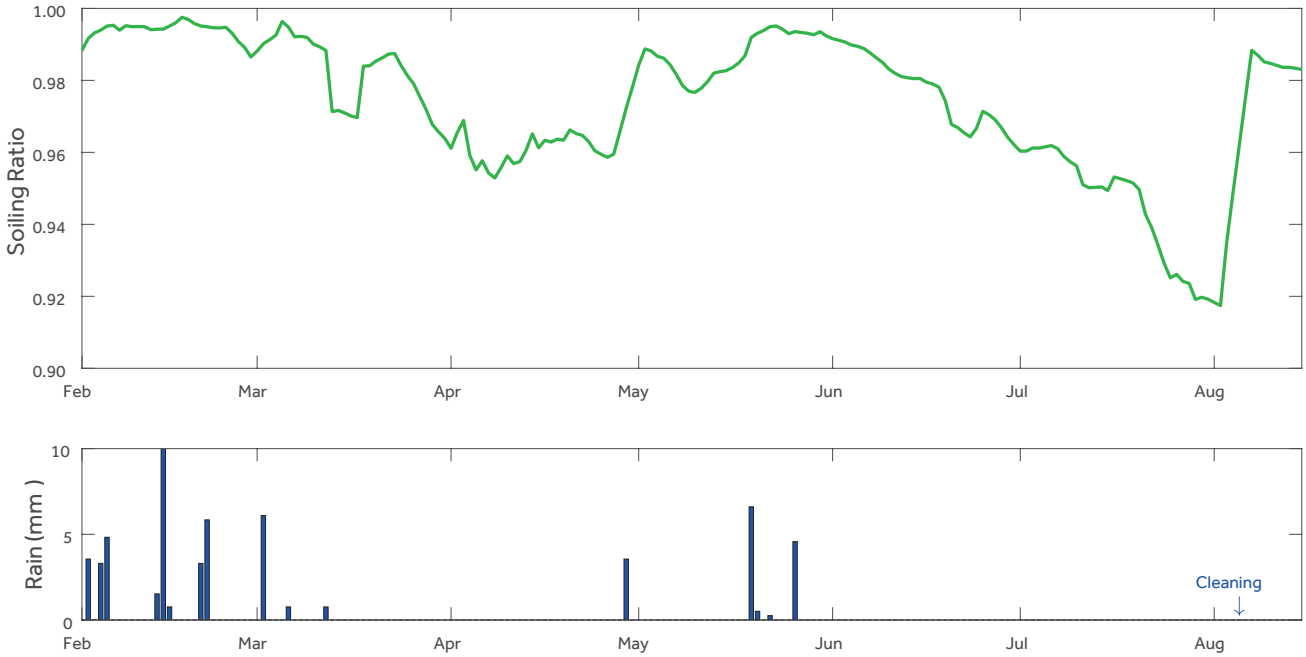
Since soiling losses are highly variable and have plant-specific impacts, instrumentation is needed to measure soiling losses on site. At operational power plants, ongoing measurement of soiling loss is an important component of performance monitoring. At pre-construction sites, soiling loss measurement is an important part of resource assessment for future power plant performance prediction.

There are several methods for measuring soiling losses at PV plants. Atonometrics, is a leader in the field and has been providing PV irradiance and soiling measurement systems for over 10 years and has over 1,000 systems installed in over 30 countries worldwide. The most common PV soiling measurement method is based on the comparison of two PV devices such as solar panels, reference cells, or a combination.

One device is regularly cleaned, either automatically or manually, and the other device is allowed to soil naturally like the solar panels at the site. Comparing the soiled device to the clean one yields the impact of soiling loss. These methods require some labor and maintenance costs, either in manually washing a clean reference



Variation of soiling rates measured by 8 soiling sensors, distributed within a utility-scale solar power plant. Multi-year average daily soiling rates in %/day, shown in text and by circle radius in figure, are highest near the edge of the plant immediately down-wind of a farm. Soiling rates could be up to 2x the averages, as shown by the outer circles at each sensor location.



Top: soiling ratio the fraction of actual system power to expected clean-state power, measured by a soiling sensor at a site in California, showing varying soiling losses over time with rain and cleaning and heavy build-up in summer months.
Bottom: Rain and cleaning events at the site.

device or in periodic refilling of a water tank for automated cleaning.

All-optical low-maintenance techniques are a recent development in soiling measurement technology. Atonometrics has developed a compact, easy-to-use measurement device called Mars™. This is a camera-based technology that requires no maintenance and no calibration procedures. It is a completely hands-free operation when installed.

The name for Mars came from a conversation with technologists at The National Aeronautics and Space Administration (NASA), inspired by the idea of serving remote locations for which any maintenance, or calibration procedures would be difficult. Any sensors eventually deployed to Mars would have to be fully autonomous since maintenance technicians are difficult to find on Mars. So, the Atonometrics' optical soiling sensor's name was conceived with future Mars missions in mind.

Mars™ was introduced to the market in 2018 and has since been installed in many PV plants worldwide.

The low-cost, maintenance-free, and calibration-free aspect of good optical technologies has expanded the market for soiling measurement systems to smaller installations including commercial rooftops.

Previously, these installations did not have the budget or on-site personnel to install soiling measurement technologies, but that is changing with the introduction of new techniques.

Soiling measurement is becoming increasingly important to optimize PV power plant performance and revenue. The conclusion is that soiling measurement technologies are very cost-effective and newer optical technologies, such as Mars™, enable soiling measurements on a wide scale worldwide.

Along the way, Atonometrics has become the recognized technical experts in PV test and measurement technologies. This is evidenced by over 30 published technical papers at the industry's leading conferences, workshops, and magazines. In addition, the company has over 20 issued and filed patents.

To date, Atonometrics has installed several thousand products in over 30 countries and 6 continents worldwide.

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