OTT HydroMet

KIPP & ZONEN
an OTT HydroMet brand

DustIQ Soiling Monitoring Solution

Accurate measurement of PV module soiling

Reports Soiling Ratio, Transmission Loss and PV module

24/7 temperature measurement

No moving parts

Maintenance free

Easy system integration

Know when and where to clean

The final yield of AC power generated is eaily measured with high accuracy at the grid connection. The reference yield is the theoretical power produced by irradiance on the PV panels; the solar energy received by the panels multiplied by the efficiency of the conversion to electrical energy.

100% is rarely achievable (even when the plant is new) due to installation, operational and environmental variables; typical performance ratio's (PR's) are in the 75% to 90% range.

An important factor in the PR is the amount of electrical energy production lost because of deposits on the surface of the PV panels that reduce the transmission of light through to the solar cells.

This can be due to dust, sand, pollen, soot, ash, sea salt, or even bird droppings; generically called 'soiling'.

Soiling Ratio

This effect is expressed as the Soiling Ratio (SR) and runs frrom 1 which means completely clean to 0 which means completely obscured. However, like PR, this is often given as a percentage of 'cleanliness' from 100% all the way down to 0%.

Until now, measuring the loss of light transmission due to soiling has relied on systems where a reference PV panel is kept clean whilst a similar panel is getting dirty.

The cleaning regime may be manual or (more expensively) automatic, and rely on water, brushes, machinery, power, and regular scheduling.

These systems are expensive and are often only installed at one location in a solar park, whereas the panel soiling varies across the site, due to varying wind directions and the shielding effect of leading panel rows on those further back.

Breakthrough Solution

That is why the Innovation & Technology department at Kipp & Zonen, an OTT HydroMet brand, spent a lot of time and effort in researching alternative and novel solutions.

This is how they came up with the unique Optical Soiling Measurement (OSM) technology. This uses an internal light source to measure the loss of transmission of a transparent material caused by soiling of its surface, it does not rely on sunlight and can operate day and night.

The first product that featured the OSM technology was showcased at Intersolar Munich, which we called the DustIQ PV Soiling Monitor. DustIQ does not rely on a clean reference surface, it should be cleaned at the same time as the PV arrays that it is monitoring. This allows for the reduction of the operating costs of the soiling measurement system substantially.

The DustIQ has two spatially seperated sensors to cover a representative area.

Multiple Locations

Due to the DustIQ's compact size, simple installation, and cost-effectiveness, the DustIQ is easy to integrate into PV arrays to form a network of monitors at multiple locations and heights.

This provides Operations and Maintenance teams with a 'soiling map' of the solar park.

This allows panel cleaning schedules to be optimised across the site, reducing costs. These features mean that it is also possible to attach DustIQ to tracking PV panels or CPV systems.

The DustIQ is a revolutionary way to monitor the soiling ratio of PV panels and to access cleaning and maintenance across utility-scale PV sites.

The DustIq instrument is a unique, high quality instrument designed for measuring the light loss resulting frrom the soiling of the panel. The measured light loss is an indication for the losses introduced by the soiling of the nearby PV panels as well.

The DustIQ instrument features internal digital signal processing and interfaces optimised for industrial data acquisition and control systems.

Kipp & Zonen, an OTT HydroMet brand, has developed a smart interface that features RS-485 Modbus® data communication for connection to programmable logic contrrollers (PLC's), inverters, digital control equipment and digital data loggers.

To achieve the required accuracy, the amount of reflected light is precisely measured and combined with the local dust calibration that has to be performed to ensure the right light loss is calculated.

Intended Use

The DustIQ instrument is meant to measure and report transmission loss (TL) and soiling ratio (SR) caused by light being blocked and reflected and subsequently not getting through the glass of the panel due to soiling of the panel.

The DustIQ is meant to be mounted next to and in the same plane as the PV panels in the solar park. The instrument is fully waterproof (IP65) and can be cleaned in the same way as the PV panels, both wet and dry.

Communication with the DustIQ is possible via Modbus® RTU using a RS485 2-wire connection and the power supply needed is 12 to 30 V and max 300 mA.

The DustIQ was developed as a technology to measure and determine the transmission loss due to soiling and is meant to be used to inform cleaning schedules. among other things.

Features

Continuous Optical Measurement

The DustIQ uses our unique Optical Soiling Measurement (OSM) technology to measure the transmission loss of nearby PV modules due to soiling.

Since the DustIQ works independently from the fluctuating sun, this means that it does not need sunlight to make measurements and updates every minute, night and day.

Maintenance Free

DustIQ has no external or moving parts and, after a simple initial calibration to match the local dust characteristics, no seperate maintenance is required.

All you have to do is clean it at the same time as the surrounding PV modules, whether that is with robots or done manually.

Easy Integration

The DustIQ is made frrom the same material (and has similar dimensions) to industry standard silicon PV modules. It installs easily in-between, on the side, or on the top of an array.

This permits and allows reliable measurements than general stand-alone solutions because it faces exactly the same conditions and collects the same amount of dust and dirt as modules around it.

The DustIQ has Modbus® RTU RS-485 serial communication for easy connection to plant SCADA systems.

Multiple Measurement Points

Soiling rates can vary across a PV plant depending on wind direction and module location. The cost-effectiveness of the DustIQ encourages the installation of multiple units to provide a soiling map of a plant that can inform decisions on when and where to clean.

Environmental factors such as wind, rain, and module temperature all affect photovoltaic plant performance but in many environments, PV module soiling has the greatest impact on performance.

Soiling results in a reduced level of energy production, often up to 20% over a year, due to the accumulation of sand, dust, and other particles that obscure the glass surface of a PV module and consequently prevents solar radiation frrom reaching the cells.

About Soiling

Soiling is a complex solar industry problem that increases plant monitoring and performance uncertainty and drives up LCOE through lost energy production, increased O&M costs, and higher financial rates, according to analysis by the U.S. National Renewable Energy Laboratory.

Soiling is a thin layer of dust that covers the surface of a solar module, typically with particles that are less than 25 µm in diameter and depending upon the specific location and its environment.

Dust that is on the ground becomes airborne by many means; such as wind, people, animals, vehicular movements, agriculture, and volcanic eruptions.

Over time, particularly with humid conditions or dew, the dust can form a hard layer like cement that is opaque and hard to remove. The amount of dust on the surface of a PV module that affects the overall energy delivered can be measured on an hourly, daily, monthly, seasonal and annual basis.

Soiling is generally associated with dust, however there are many environmental and natural factors that can result in reduced energy yield; sand and soil, salt deposits near the coast, bird droppings, pollen, snow or frost, and other materials falling on the module surface.

Studies have shown that the following six dust variants have the most significant effect on PV panels across utility-scale solar farms. These six types are:

- ash
- calcium
- limestone
- soil
- sand
- silica

These materials can be present in the air and on the module in different combinations and forms; such that the type of shading that occurs can be considered either 'soft' or 'hard' shading.

Soft Shading

Soft shading takes place when haze particles such as smog or light dust on the module reduces the overall intensity of the solar irradiance which reaches the solar cells. Soft shading affects the current generated by the PV module, while the voltage remains the same.

Hard Shading

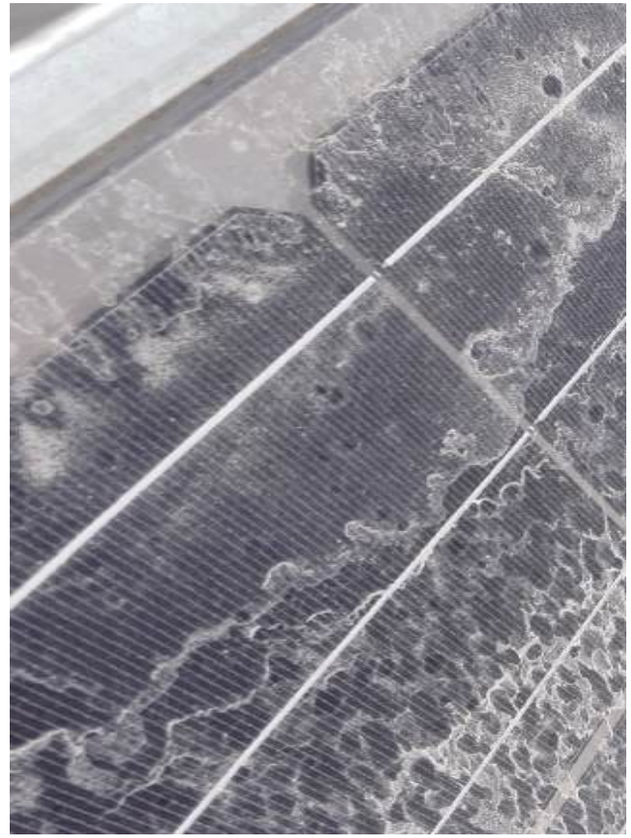
Hard shading occurs when a more solid type of dust or material blocks the sunlight in a clear and definable shape. With hard shading the performance of the module depends on how many cells are shaded, and where they are in the module, and can affect both current and voltage produced.

Soiling Color

Since soiling can be caused by a wide range of material buildup, the color of the soiling can also vary by location. This has different effects on the transmission loss caused.

This means that soiling monitoring equipment needs to be sensitive to the local dust characteristics, including color, of their PV plant.

The factory calibration for the Kipp & Zonen DustIQ is for standard Arizona test dust. The DustIQ can be recalibrated in the field to suit any of the varying site dust color.



Knowing when it is most cost effective to clean solar modules is a function of the detailed monitoring of the soiling state and has a number of benefits.

This information can be used by an O&M company to come to an agreement with stakeholders on an optical cleaning schedule, and to trigger action after an event ranging from a micro-event to a sand storm.

Soiling & Cleaning

Information about the soiling across a PV plant can inform on when and where to clean the modules, rather than having a fixed schedule leading to unnecessary cleaning costs of your PV plant.

Kipp & Zonen's DustIQ uses Optical Soiling Measurement (OSM) technology to determine the Transmission Loss, which can be reported as the Soiling Ratio. It employs two sensors in which a pulsed blue LED and a photodiode measure the light scattered back by soiling on the top of the DustIQ glass cover.

The most common method employed to clean large-scale PV installations involves water being trucked to the site for a manual rinse and dry treatment.

However, a 100 MW desert-sited solar plant could require more than 50 million gallons of water over its lifetime; according to one estimate. The associated long-term costs could be up to $70 million in the U.S. Southwest, considering both the cleaning costs and production losses due to soiling between cleanings.

Cleaning modules daily in an environment like Abu Dhabi, where the local climatic conditions are very dry and with dust storms, might make economic sense.

In semi-arid conditions, cleaning once a week may be required; whereas in much of the U.S. market a bi-weekly or monthly schedule is often times sufficient.

Placement

Many customers often ask about the placement of their DustIQ in the field. Since measuring dust and soiling ratio is a new field of science, there are many opinions about it.

Although the spot measurement of DustIQ is very precise, it is wise to do interpretation and use common sense when extrapolating the measurement value to the whole PV plant (or part of it) for decision making.

For giving a good representation of soiling across your PV plant, placing multiple DustIQs across the solar farm is recommended. In fact, the IEC61724-1:2017 Standard related to PV system performance monitoring prescribes that one should have as many dust sensors as irradiance sensors.

Intuitively, this makes sense as it follows the same logic as irradiance that also is not constant acoss a solar plant, and one has to have sufficiant measurements to make a valid interpretation.

For the number of DustIQs, one can thus follow the IEC61724-1:2017 Standard. For example, in a 1 MW plants, 1 DustIQ placed in the middle could do, whereas for larger plants, say 25 MW - one could imagine the one in the middle, and one near each corner could be a logical choice to understand the soiling pattern across the plant.

Soiling is a different phenomenon than irradiance, and very site specific. Consider, where you normally would expect the same average irradiation value for all pyranometers at a solar plant, this is not necessarily true for DustIQs.

For example, if wind always blows from the east, one could expect more soiling (and thus another cleaning interval policy) only on the east side of that solar plant.

But, if wind directions change, then cleaning patterns change.

DustIQs can be placed at the side, and at the top of PV modules. They can also be placed in the middle of an array or at the sides. Horizontal is not advised as soiling is uneven in the vertical direction.

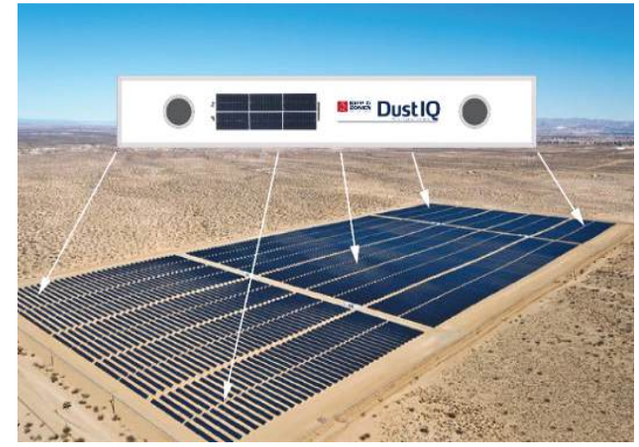
Data Collection

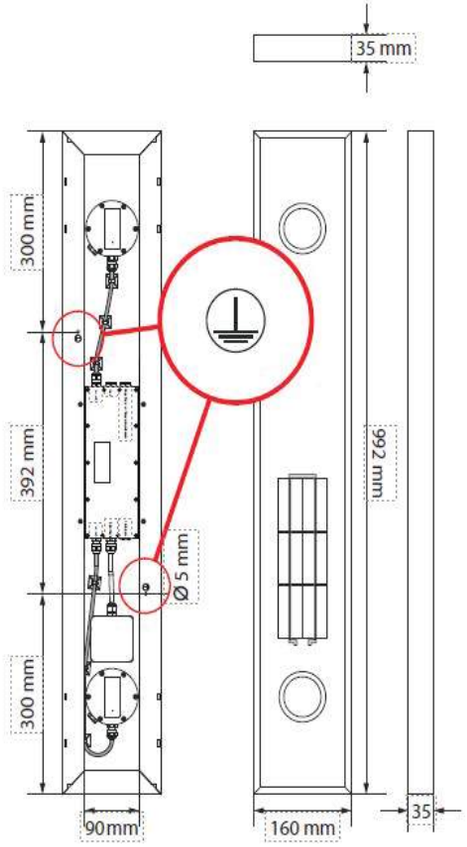
The DustIQ data collection (when optimally set) samples every 1 - 15 minutes and later to post-process the data and remove data points influenced by e.g. rain or dew.

The DustIQ takes a measurement once per minute. It operates throughout the whole day. The measurements are reliable as long as the device is dry.

Storing 24x7 measurements of every minute does not really make sense as soiling grows very slowly. A few measurement points per day are enough.

The DustIQ uses Modbus® RTU over RS-485 wired connection that also supplies the 12-24 V power. However, the solution can be made wireless by using an integrator or customer supplied RS-485 to Wi-Fi converter and Modbus® over TCP/IP.





Benefits Summary

What if you could measure soiling of PV modules with a solution that does not require any maintenance? The new DustIQ is a sensor without moving parts, does not need regular cleaning and uses a breakthrough development to accurately measure soiling.

This fundamental new Optical Soiling Measurement (OSM) technology provides you with insights into the power loss due to light transmission loss. With a network of DustIQs you will know exactly when it is time to clean, and where on the plant.

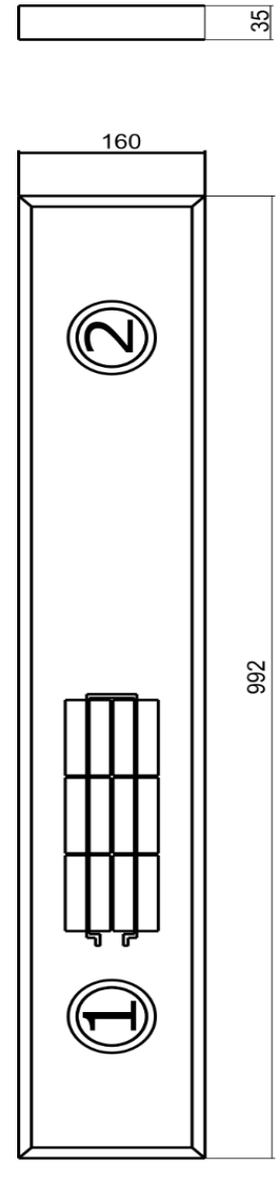
For the DustIQ, additional benefits of this technology and solution include:

1. Patented Optical Soiling Measurement technology
2. Compact and rugged, no moving parts and no water
3. Mount to top, side, or between PV panels
4. No maintenance, clean it with the panels
5. Dual-sensors for statistically sound soiling measurement
6. Very low power consumption
7. Self-calibrating
8. Optional back-of-panel temperature sensor
9. Modbus® RS-485 digital communication
10. Cost-effective

Better Than Alternatives

- Completely passive: no need for daily cleaning as it follows the plant's cleaning schedules
- 24/7 day and night measurements, 1 minute measurement interval
- Multiple sensors are better than existing spot-measurement solutions
- Integration in solar array provides more reliable measurements than existing solutions
- Easy to mount and install

In 2019, the DustIQ from Kipp & Zonen, an OTT HydroMet brand, won the Megawatt Jadeite Award during SNEC. The Optical Soiling Measurement (OSM) technology became a focal point during SNEC as it's innovative technology offered a critical amount of benefits and support for the operators of utility-scale PV plants across the globe that go beyond simply monitoring optical transmission losses caused by soiling buildup on PV panels.



Our team has rounded up the top **frequently asked questions** we get from customers related to soiling and the DustIQ solution.

We hope this better provides you the necessary details and information you will need as you consider implementing the DustIQ Soiling Monitoring Solution into your current and future PV plant projects and designs.

Does the DustIQ Follow IEC 61724?

IEC 61724 specifies two methods to measure soiling that were available at that time:

Method 1: max power and temperature of the soiled device

Method 2: short-circuit current and temperature measurement

The optical measurement that has been introduced with the release of the DustIQ is equivalent to the short-circuit current method.

Obviously it does not measure short-circuit current but the reflected light, that then is translated into transmission loss. The local dust calibration is done based on the step change of the short-circuit current of the built-in silicon panel.

How is the DustIq Different?

Compared to other soiling stations on the market, the DustIQ has a few differences.

Firstly, normal 2-panel systems require daily cleaning of the clean reference cell or panel. Also, they do not fit in between the real PV modules and they only work well on sunny, cloudless days around solar noon.

The DustIQ works 24/7 as long as the DustIQ is free from rain or dew. It even works up-side-down for bifacial PV plants.

What are the Calibration Needs?

With the DustIQ you only need to calibrate once. The calibration is valid for the whole lifetime of the device.

In addition, the DustIQ does not need recalibration for at least 5-10 years as it has extra internal sensors and compensation for any potential wear or drift.

How Does it Compare with a 2-Panel System?

A 2-panel system with PV modules identical to the ones used in the PV plant and cleaned every day is the most accurate but also most expensive solution.

It is also very unlikely that a 2-panel system can be installed right in between the real PV modules and thus the soiling will be different. The DustIQ is the optimum balance between accuracy and being maintenance-free with a low TCO.

What is the Purpose of the Temp. Option?

The PV module temperature sensor (standard since 2019) can be connected to the second port on the DustIQ to measure the rear temperature of a nearby PV module.

The IEC advises to take many temperature measurements to be able to take the PV module temperature into account in the Performance Ratio calculations.

What Exactly Does the DustIQ Measure?

The DustIQ measures the amount of scattered light from soiling. This is converted into Transmission Loss and Soiling Ratio.

The DustIQ reports 2 independent transmission losses and soiling ratios of its 2 sensors. (Transmission loss = 100% - soiling ratio)

What is the Accuracy of Measurement?

Transmission loss measurement accuracy: ± 10% of reading after local dust calibration (not including zero offset). Zero offset: < ± 1% when clean.

What Can I do with Zero Offset?

The zero offset can be subtracted from the measurements to reach zero again. E.g. a transmission loss of 0.3% for a completely clean DustIQ is within specification and can be compensated by TLcorrected = TL - 0.3 or Soiling Ratio corrected = Soiling Ratio + 0.3.

How Many DustIQs Do I Need?

The standard IEC61724-01 on monitoring gives recommendations. Due to copyright we cannot share the document. Table 1 in the document advises as follows:

- 5MW 1 instrument
- 40MW 2 instruments
- 100MW 3 instruments
- 200MW 4 instruments
- 300MW 5 instruments
- 500MW 6 instruments

How is the DustIQ Cleaned?

The DustIQ is made of PV module material like the glass and aluminium. Thus, the same procedures as for cleaning the PV modules can be used.

The DustIQ is never cleaned on its own.

It is only cleaned when the actual PV modules are cleaned. Then it remains "in sync" with the real PV modules.

Scan the QR code to download this DustIQ brochure

Specifications DustIQ

Transmission Loss (TL) range Percentage of sunlight that is blocked or scattered in such a way that it does not reach the actual solar cells	0 to 50 %
Soiling Ratio (SR) range	100 to 50 % (SR = 100 –TL)
Transmission loss measurement accuracy	± 0.1 of reading ± 1% (after local dust calibration)
Ambient working temperature	-20 to +60 °C
PV panel temperature sensor	-20 to +100 °C, ± 1 °C
Tilt X and Y	-180 to 180 degrees ± 1 degree
Communication	Modbus® RTU over 2-wire RS-485
Daisy-chain capability	Up to 3 devices in one chain
Power	12-30 VDC, 200-70 mA at 24 V, 500 mA power supply is advised
Power consumption	< 2.5 Watt
In rush current	10 A for 50 µs
Glass type	Glass with anti-reflection coating as used for silicon PV modules
IP Class	IP65
Dimensions unpacked	990 x 160 x 35 mm
Weight packed with 10 m cable	6 kg
Weight unpacked	DustIQ unit: 4 kg; Mounting clamps: 600 g; 10 m cable: 400 g

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