Design and Indoor Validation of DUSST: A Novel Low-Maintenance Soiling Station

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DUSST: Detector Unit for Spectral Soiling Transmittance

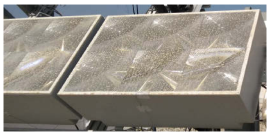
A low-maintenance soiling station, not requiring water to operate and with no movable components, that measures monochromatic light emitted by a known collimated source and transmitted through a naturally-soiled glass to quantify the soiling ratio of a PV array.

Provisional Patents:
USPTO 62/652,955, 2018
USPTO 62/690,086, 2018

BACKGROUND

SOILING

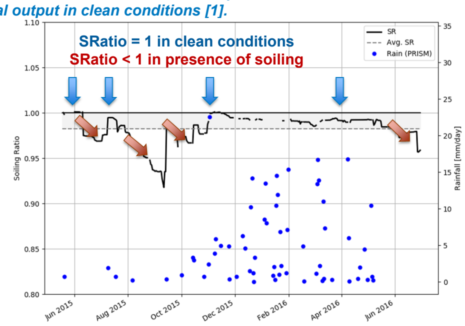
Soiling causes non-negligible losses to PV systems worldwide, and has to be carefully monitored.



In the EU, annual soiling losses range between 2 and 6%.

SOILING RATIO

Daily ratio between the electrical output of the soiled PV device and its electrical output in clean conditions [1].



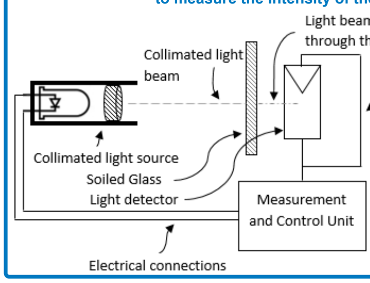
Soiling stations, the common solution to quantify soiling, use the electrical outputs of a regularly-cleaned PV device and of a naturally-soiled one.

FEATURES

- DUSST eliminates the need to clean the reference cell thanks to the use of stable monochromatic light of known intensity,
- The lack of movable parts and the use of standard components make it reliable, durable, and low-cost.
- Re-calibration, automatically conducted after each cleaning, reduces the effects of component aging and degradation.

DESIGN

DUSST uses a collimated monochromatic light source through a glass surface and on to a detector to measure the intensity of the transmitted light.



As the glass surface naturally soils, the losses are quantified by comparing the soiled reading with a calibrated reading in the baseline clean condition.

MEASUREMENT PROCEDURE

DAILY OPERATION

CONDUCTED AT DIFFERENT MOMENTS EACH NIGHT (MINIMUM EXTERNAL LIGHT NOISE)

ZERO MEASUREMENT
The detector reading is recorded while the collimated source is OFF to identify external light sources.

SOILING MEASUREMENT
The collimated source is ON. Once the signal is stable, the intensity of the light measured by the detector is recorded.

MEASUREMENT CORRECTION
The soiling measurement is corrected by subtracting the zero-measurement to remove part of the light signal due to external sources.

LIGHT INTENSITY RATIO
The ratio of the intensity of the light transmitted through the soiled glass to its baseline (intensity of the light transmitted through the clean glass) is determined.

SOILING RATIO
The soiling ratio is calculated by correcting the light intensity ratio according to the type of modules under investigation.

CALIBRATION

CONDUCTED AT THE MOMENT THE DEVICE IS INSTALLED AND AFTER EACH CLEANING

CALCULATION OF THE BASELINE

ZERO MEASUREMENT → **BASELINE MEASUREMENT** → **BASELINE MEASUREMENT CORRECTION**

INPUT PARAMETER: TYPE OF MODULES

INDOOR VALIDATION

PROTOTYPE

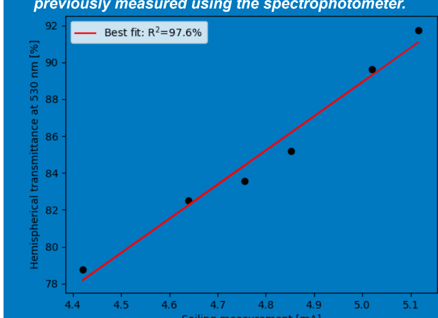
- *A monochromatic diode emitting light at 530 nm (green).*
- *An optical structure to collimate the light.*
- *An encapsulated solar cell as detector.*
- *A Fluke 289 multimeter to measure the current generated by the detector.*

ARTIFICIALLY-SOILED COUPONS

Five 4 cm × 4 cm sized and 3 mm thick coupons have been artificially soiled with different amounts of Kaolinite. Their hemispherical transmittances were measured between 250-1300 nm, at 1 nm steps, by using a Cary 5000 dual-beam spectrophotometer equipped with a DRA-2500 integrating sphere.

SOILING MEASUREMENT

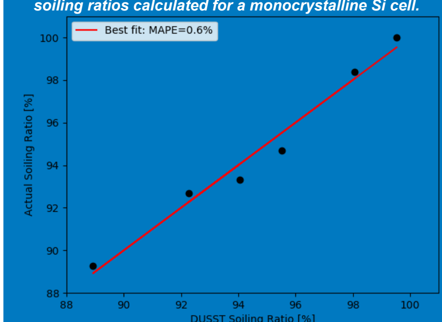
- *The intensities of the light transmitted through each glass were measured, and corrected using the zero-measurement.*
- *The readings of the multimeter were compared to the hemispherical transmittance of the same glass at 530 nm, previously measured using the spectrophotometer.*



The results show that the two measurements have a R^2 of 97.6%, a strong linear correlation between the measurement of DUSST and the actual transmittance of the glasses at the same wavelength as the diode used in the prototype.

FROM SOILING MEASUREMENT TO SOILING RATIO

- *The soiling measurements are converted into soiling ratios by dividing each measurement by the baseline measurement, and by applying a correction factor that considers the spectral response of the PV modules [2].*
- *The DUSST Soiling Ratios are compared with the actual soiling ratios calculated for a monocrystalline Si cell.*



A Mean Absolute Percentage Error (MAPE) of 0.6% is found between the actual soiling ratios and the values of the best fit line calculated at the DUSST soiling ratios.

FUTURE WORKS

The indoor validation will be continued, using different types of dusts and comparing the DUSST measurements with the soiling losses of actual cells. In addition, more prototypes are now being deployed in outdoor conditions, to validate the reliability of DUSST in natural soiling conditions and to test the durability of its components.

REFERENCES

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2. Micheli L, Fernandez EF, Caballero JA, Smestad GP, Nofuentes G, Mallick TK, *et al. Waveband investigation on the impact of soiling on various photovoltaic technologies.* Submitted.

This work was authored in part by Alliance for Sustainable Energy, LLC, the manager and operator of the National Renewable Energy Laboratory for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under Solar Energy Technologies Office (SETO) Agreement Number 30311. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes. Part of this work has been funded through the 2018 NREL Accelerating Inventions to Market Award, duly acknowledged.
This study is partially based upon work from COST Action PEARL PV (CA16235), supported by COST (European Cooperation in Science and Technology). COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation, see www.cost.eu.

35th EU PVSEC 2018
Brussels, Belgium
September 24 to 28, 2018
NREL/PO-5K00-72428