



EXPERT NOTE

PHOTOVOLTAIC PERFORMANCE

How to Accurately Calculate the Performance Impact of Module Cleaning

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Soiling of solar modules can silently reduce plant output by 2-10% or more, depending on location. Yet many asset owners underestimate its impact or rely on guesswork. This expert note explains how to quantify that impact scientifically with I/V curve testing.

In today's expert note we start with three important statements

1. Regular module cleaning should be planned in to O&M strategy on all solar PV installations to ensure optimal output.
2. Rain doesn't sufficiently clean modules, particularly those with low tilt.
3. It is impossible to accurately quantify soiling losses from visual inspection alone.



No one can go to a site and accurately tell you how much performance impact this soiling is having from a visual inspection alone.

Optimal module cleaning strategy

The decision on when and how often to perform module cleaning varies slightly from site to site and region to region:

- Sites in industrial areas will typically require more cleaning which can be up to monthly or even higher frequency, depending on the exhaust fumes of nearby factories.

- In tropical areas it doesn't make sense to clean during the wet season, it makes sense to clean just before the wet season to remove any grime and then the rain will be sufficiently frequent to clean the modules.
- In dry seasons it is necessary to increase the frequency of cleaning as there will be more dust depositing on the modules.

So we see that a cleaning strategy is not a linear "clean every 3-6 months", it requires some planning into when the seasons are and what the local conditions are like.



It's important to experiment a bit with module cleaning to work out the optimum strategy. For example it is useful to test different (module manufacturer approved) products; many contractors use water but on some sites with rubber dust or even worse, cement, specialised anti-soiling and cleaning solutions such as Chemitek may be required.

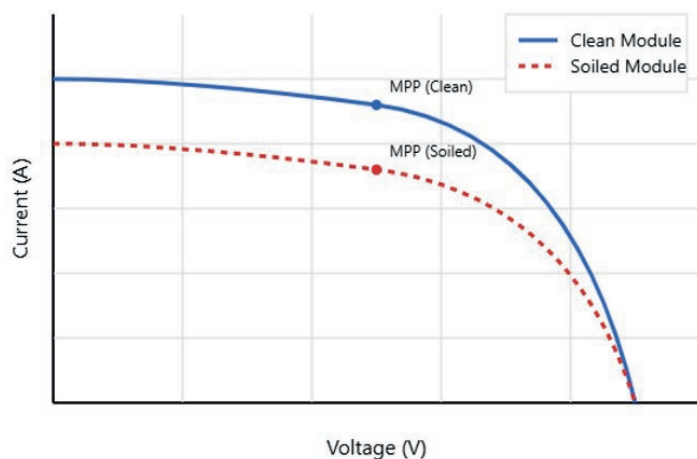
Measuring Soiling Impact with I/V Curves

In order to calculate the performance impact of module cleaning we use I/V curve measurements (Current/Voltage measurements). These I/V curve measurements should be done at the module level and not the string level (unless the whole string is cleaned). This means safely disconnecting the reference module(s) from the string to then connect the I/V tracer to perform the testing.

The general process with I/V curve measurements is to vary resistance to work out the optimum combination of current and voltage where the maximum power point (mpp) is highest. Then we need to compare this actual mpp to the expected module power curve (less any module degradation). We perform this process on a module before and then after cleaning, with the % difference being the performance impact from soiling.

Soiling primarily reduces the short-circuit current (I_{sc}), since less light reaches the cells. Since V_{oc} is largely unchanged, the maximum power point (MPP) decreases, lowering module performance.

This is illustrated on the chart below.



What we want to find out with the I/V curve measurements is:

1. What is the instant % performance gain of module cleaning.
2. How long does that % performance gain last.

Testing conditions

The weather on the day of testing is critical, the irradiance should be as close as possible to $1000\text{W}/\text{m}^2$ and ideally at least over $800\text{W}/\text{m}^2$. This is because the results obtained need to be converted to Standard Test Conditions (STC) of $1000\text{W}/\text{m}^2$, so being far away from $1000\text{W}/\text{m}^2$ leads to extrapolation errors.



Converting obtained results to STC ($1000\text{W}/\text{m}^2$, 25°C cell temperature, 1.5 air mass) is also critical to ensure a normalisation of results from different times of day/conditions.

Plan testing based on weather forecasts, and avoid testing during:

- Passing clouds
- Unstable irradiance conditions (e.g. cloudy, rain)
- Early morning or late afternoon (changing air mass)
- High wind conditions (module temperature fluctuations)

Step-by-Step Testing Process

The test process is relatively simple:

1. Firstly you or a contractor need an I/V curve tester such as a PVPM 1040C (as an example) which also includes an irradiance sensor and a module temperature sensor. This equipment should all be calibrated and the same equipment used for all testing.
2. Choose two modules that will be used for the testing. These modules should be easy to access, free of shading and located next to each other.
3. One module is the reference module; this is left uncleaned.
4. The other module is the test module, this is cleaned .
5. Safely disconnect the reference and test modules from the string using qualified personnel, PPE and isolation procedures.
6. Attach the irradiance sensor in the same tilt and orientation as the modules being tested and attach the module temperature sensor to the back of one of the tested modules.
7. Perform I/V curve measurements on both modules uncleaned, then clean the test module, wait ~30 minutes for the cleaned module's temperature to stabilise to normal operating conditions (cleaning will artificially cool the module leading to artificially better performance), then perform I/V curve measurements on the cleaned module.
8. It's good practice to perform 3 I/V curve tests on each module just in case one or two of the results are affected by external factors.
9. The I/V curve results as well as the weather data, time of testing etc then need to be recorded in a spreadsheet and extrapolated to STC conditions.
10. From there you can work out (1) the impact of the module cleaning on performance and also (2) how the cleaned modules are performing --> this is useful information for site performance analytics.
11. After this, I/V curve testing should be done on both reference and test modules at regular intervals (e.g. every 1-2 weeks) WITHOUT

cleaning any modules. This allows us to determine the 2nd part which is how long the module cleaning performance improvement lasts.

If the testing is performed correctly (based on the guidelines above), from this process you'll know exactly:

- How much module cleaning impacts module performance. In industrial areas, performance can easily improve by 5% after cleaning.
- How well cleaned modules are performing (this data can be very useful if there is a potential module degradation issue or underlying module problem).
- How long the module cleaning impact lasts.

From this data we can then define the module cleaning strategy for any site.

Key takeaways from this expert note are

- Regular module cleaning is critical for yield and revenue.
- Visual inspection isn't enough; quantification requires I/V curve testing.
- The optimal cleaning frequency depends on environment, season, and measured soiling impact.
- With proper testing, asset owners can balance O&M costs against energy yield gains.

Accurately quantifying soiling losses allows asset owners to define cleaning schedules that maximize output while minimizing costs. If you'd like to access our detailed I/V testing procedures or STC conversion templates, reach out to us—we'll be happy to share and discuss.

CONTACT US

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