
ReNew
POWER
CONDITION-BASED
MODULE CLEANING
ReD
DIGITIZE . OPTIMIZE . MONETIZE
Use Case Diary
Vol 3

Introduction

Module cleaning is one of the major operational activities in PV plants. Cleaning is normally required for the removal of soiling over PV panels to mitigate any inefficiency in the performance of the PV module due to soiling loss. Soiling loss refers to the loss in power resulting from the deposition of dirt, dust and other particles over the surface of the PV module. The amount of accumulated dust on the surface of the PV module affects the overall energy delivered from the PV module on a daily, monthly, seasonal and annual basis, making cleaning a very critical activity.

Besides being a key factor in determining the performance efficiency of a PV module, module cleaning also contributes significantly to O&M cost. Typically, about 15-20% of total O&M cost is attributed to module cleaning. Time based module cleaning that is commonly followed in the industry is not effective in optimally mitigating soiling loss. This method does not consider the soiling condition of modules at the time of cleaning nor does it take into account the costs involved. Modules may be over-cleaned or under-cleaned while incurring cleaning cost without any real improvement in overall generation.

As a result, the idea of condition-based cleaning came into existence. This method of cleaning entails creating an optimum cleaning schedule based on generation loss of modules while taking cleaning costs into account.

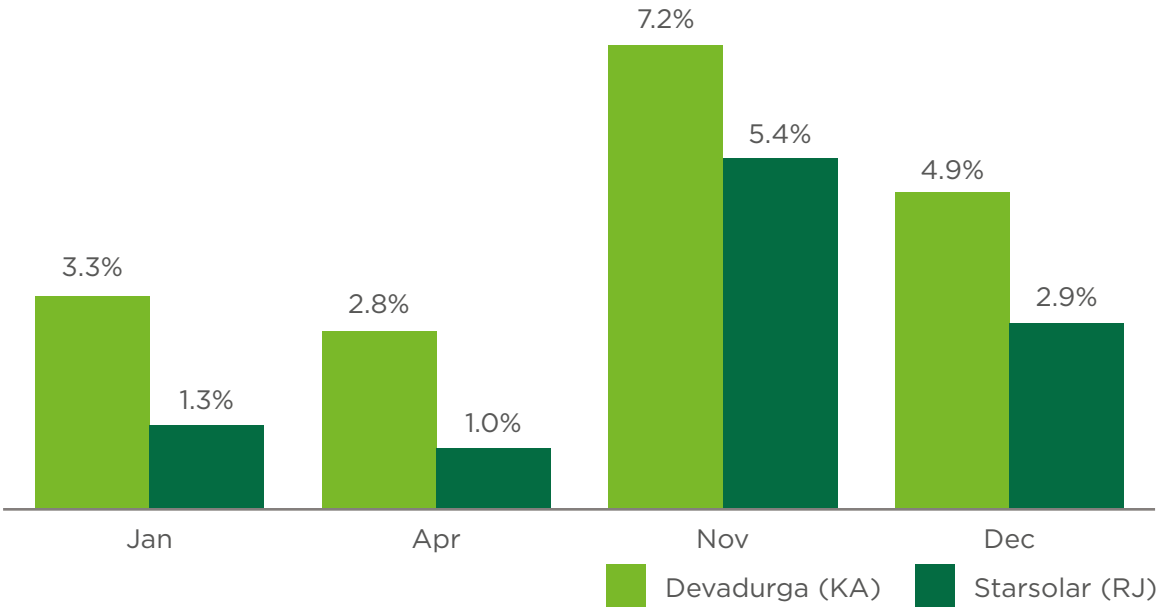
Key Persons Involved:

To devise an analytical methodology that would determine the appropriate conditions for cleaning, a team of experts drawn from various departments was involved in this use case:

- **Birendra Pandey**, a seasoned electronics engineer with about 15+ years of experience, was the Idea and Use Case owner & **Suresh Kannan** was the Co- Idea owner.
- **Madhur Modi** (Data Scientist with 4 years of experience) from ReD. Data Science team helped in creating the data model & **Rohit Deshmukh** from the Data Engineering team helped in building the data pipeline to get the required data for all the sites. A team from IT helped in building intuitive dashboards on PowerBI for easy interfacing of cleaning schedules while the SCADA Team helped with data availability.
- **Gagan Arora** from Implementation & Site Operations Team helped in implementing the use case at the sites, ensuring cleaning adherence and providing closed-loop feedback for continual improvement in the model.
- **Ganesh Kamble** was the Project Manager.

The Use Case

Before this use case, ReNew followed the industry practice of time-based cleaning of modules in PV plants which essentially means cleaning once every specified number of days. Time-based cleaning entails approximately 18-20 cycles of cleaning in a year. Cleaning of modules is done without any regard to dirt deposition levels of individual modules which may vary depending on several different factors like soil type, location of plant, wind speed, MMS design, weather condition, humidity, rainfall etc. This approach is quite ineffective and often leads to unnecessary wear and tear of modules.



Actual Soiling Loss % at 2 ReNew Sites across 4 months

The above graph shows actual data on soiling loss across different months at 2 different Renew sites. As one can observe, soiling loss differs widely in both sites for the same month. Similarly, soiling rate within a site can also differ during the same time period as illustrated by the images below taken at different locations in the same PV plant on the same day. The first image shows modules located near the boundary of a plant and the second shows modules located around the centre of the same PV plant. As one can see, there is visible difference in the amount of soiling at the two sampled locations.

Modules at the boundary of the site

Modules at the centre of the site

In such a scenario cleaning of panels based on dirt deposition conditions ensures greater reliability, sustainability and optimal performance of plant. On this premise, "Condition based module cleaning" is now implemented across all Renew sites.

How does it work?

Minute level data on radiation, environmental conditions, DC/ AC output is gathered for all sites and fed into a proprietary model developed by ReNew's data science team for soiling loss calculation. The model gets the data feed through fully automated data pipelines daily without any manual intervention. It calculates the soiling loss each day and triggers cleaning as soon as soiling loss exceeds the cleaning cost. The model output is published daily on a dashboard available to the site teams. They check the status and accordingly perform cleaning only on the flagged inverters thereby taking timely corrective action on soiled modules and optimizing resource utilisation.

Use case impact

With the practice of traditional time-based cleaning of PV panels teams were not sure whether the modules were being over-cleaned or under-cleaned. By switching to condition-based cleaning, the panels are cleaned at the right time and an optimal cost. At some sites, gains are as high as 1.7 times than before due to reduction of O&M costs.

Moreover, the whole activity i.e. scheduling the cleaning, deployment of resources, monitoring the quality of cleaning, resource utilization, increase/decrease in the number of cleaning cycles in a particular block of plant etc. was driven by the local site personnel i.e. it was person dependent. However, now the whole process has shifted to a structured, centralized, effective and more transparent system based on data driven decision making. This has strengthened the operational process of PV plants.

Some of the benefits we achieved along the way:

- Decrease in annual soiling loss of portfolio
- Increase in yield across the portfolio
- Increase in site employee efficiency in regular cleaning activities
- Reduction in time for identification of actual soiling on modules
- Optimization of cleaning cost
- More transparency in the overall cleaning process at site including the quality of cleaning
- Built-in unique signals to integrate events like dust-storms, rains, cloud-cover etc. in the model to optimize cleaning schedules
- Avoidance of 'over' cleaning
- Use of actual soiling loss rather than assumed value based on industry perception in PVSYST report for designing of upcoming projects

Team Engagement

Team engagement was another area extensively focused on at various stages of this use case. Central and site teams came together to discuss the methods and approaches to develop a state-of-the-art prescriptive advanced analytics model for determining the right cleaning schedule. Teams were also enthusiastic to align with this new process. They were regularly sharing their feedback, and engaging with the core team on resource requirement/planning/deployment, etc. To boost engagement, the following steps were taken:

- Training given to Asset Manager/State Leads.
- Engaging with ReD. SPOCs of each state on regular basis for their feedback to further refine the model.
- Execution of work at the site and ensuring cleaning adherence.
- Resolving resource constraints if any to achieve 100% adherence.
- Providing data input required for the model on daily basis on or before scheduled time and visualization of model output on the dashboard for scheduling cleaning activity.
- Engaging with Asset Manager in deciding Test -Control Block for value measurement.

Site visit of use case owners to understand soiling and factors which trigger it

Challenges Overcome

Change in mindset

The journey was not easy! Among several challenges faced, the biggest was to change the mind-set of the operations teams which had gotten used to the conventional operational practices for maintenance of plants.

Ensuring data quality

Another notable issue includes the requirement of a variety of data from several sites every day. Ensuring that the data is received in a consistent format from 54 sites is a mammoth task. This task was initially overcome through extensive training and continuous engagements with the site operations team. Data checks had to be and still are implemented at different checkpoints to maintain the quality of data.

Leading the transition

While transitioning from time-based to condition-based cleaning, the team received feedback of difficulties related to cleaning schedules especially when a large number of inverters got flagged on a particular day. To mitigate this issue, the central team engaged with the site teams to understand the problem, and modified the model accordingly. Aspects such as abrupt changes in weather, manpower planning, and water requirement were also strengthened.

Next Steps

- The use case to be extended to sites that have robotic cleaning solutions.
- Continual feedback to be shared with Engineering, Procurement, and Construction team so that MCS design in future projects is more suited to condition-based module cleaning.
- Feedback from site members, continual refinement of the model, and making the dashboard more user and business-friendly.
- Monitoring of additional revenue gain vs actual cost for each site through Test & Control block at each site.

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