White Paper

Tackling uncertainty on utility-scale solar performance and yield assessment

Why Asset Owners Need to Prioritize Accurate Weather Data

Accurate meteorological data is essential for the lifespan and success of a solar farm. Uncertainty in weather data leads to unpredictable energy yields and performance calculations, affecting both the development and operational phases of projects. This uncertainty can only be mitigated by using precise weather data.

Development Stage

During the development stage, the performance of photovoltaic (PV) systems is analysed using data from a typical meteorological year (TMY). TMY provides comprehensive meteorological data for a specific area, including:

- Global Horizontal Irradiance (GHI)
- Diffuse Horizontal Irradiance (DHI)
- Beam Normal Irradiance (BNI)
- Ambient Air Temperature
- Wind Speed

This annual data helps understand weather patterns crucial for designing a solar farm. For instance, in areas with low solar irradiance, rainy climates, or extreme temperatures, the DC/AC ratio can be adjusted to optimize performance without overloading inverters.

However, TMY databases often lack critical factors such as soiling, albedo and module temperatures:

- **Albedo:** Albedo is not a constant; it varies with the spectral and angular distribution of sunlight, ground surface variations, changing sun positions due to time of day, season, and latitude, and weather conditions. Measuring albedo variability is necessary to evaluate uncertainty properly, as required by IEC standards.

- **Soiling:** The accumulation of dust or dirt on solar modules and sensors affects productivity and measurement accuracy.

Figure 1 - Heavily soiled pyranometer, accumulated during 7 days without cleaning.

- **Back-of-Module Temperature:** Unlike ambient or surface temperature sensors, back-of-module temperature sensors provide a more accurate reflection of the operating conditions that solar panels experience. This distinction is critical because the temperature at the back of the module can significantly influence the electrical output and efficiency of a solar panel.

If TMY data does not account for these variables, collected weather values will be incomplete, and expected yields will be inaccurate. Complete measurements and data accuracy are essential for financing solar energy projects. **Reliable ground-based solar monitoring reduces the inherent uncertainty in satellite data and performance models.**

Operational Stage

During the operational stage, precise weather data continues to be vital. The project's revenue depends on the solar facility's

performance in terms of output, efficiency, and reliability. EPC contracts contain performance guarantees backed by Performance Liquidated Damages (PLDs), which are payable by the contractor if performance guarantees are not met. Performance is typically measured using the Performance Ratio (PR), calculated as follows:

$$PR = \frac{Y_f}{Y_r} = \frac{(\frac{E_{out}}{P_0})}{(\frac{H_i}{G_{i.ref}})}$$

Where:

- G_i (POA): Plane-of-array irradiance, the sum of direct, diffuse, and ground-reflected irradiance incident upon an inclined surface parallel to the plane of the modules.
- H_i: In-plane irradiation.
- E_{out}: Energy output from the PV system (AC), after the inverter.
- P_0: Array power rating (DC), the total DC power output of all installed PV modules at the power rating reference condition (STC: 1000 W/m² irradiance, 25°C cell temperature).

Improper maintenance of pyranometers (e.g., shading by bird droppings, dust) can falsely reduce the measured irradiance (H_i), artificially increasing the PR figure and giving a misleading indication of better performance. This discrepancy can cause:

- **Inconsistent KPIs**: The PR ratio may indicate overperformance while actual generation is below budget, complicating rebudgeting exercises.
- **Reduced Liquidated Damages**: During the performance guarantee period, the value of liquidated damages will be reduced if the project's measured PR falsely indicates overperformance.

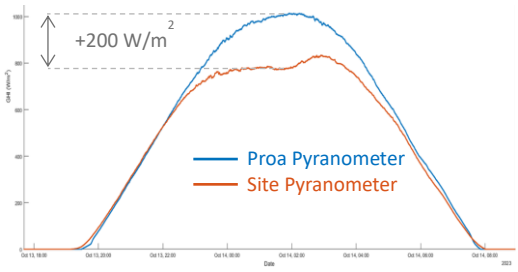

Figure 2 - Benchmarking of Proa daily cleaned Pyranometer with other on a same site

Given the critical importance of accurate weather data across all project stages (Figure 2), it is clear that reliable data improves financing accuracy, reduces risks to equity and loans during operations, and ensures informed decision-making.

Accurate weather data enables:

- **Improved financing through precise yield calculations.**
- **Reduced risk during the operational phase by ensuring reliable performance metrics.**

Prioritizing accurate meteorological data is, therefore, essential for optimizing the design, expected yield, and actual performance of solar energy assets, ultimately safeguarding the investment and operational success of solar projects.

MetCube: Revolutionising Weather Data Protection

Figure 3 - MetCube representation

MetCube — Proa Energy's cutting-edge weather station — ushers in a new era of data accuracy and reliability for solar projects. Engineered to integrate seamlessly with any sensor required throughout a project's lifecycle, MetCube eliminates data accuracy uncertainties with its cleaning technology.

Key Features:

- **Self-Sufficient Operation:** MetCube is designed for continuous operation with minimal O&M intervention, drastically reducing maintenance costs, risks and effort.

- **Intelligent Self-Cleaning:** The station features an advanced self-cleaning mechanism that ensures sensors remain free from obstructions like dust and bird droppings.

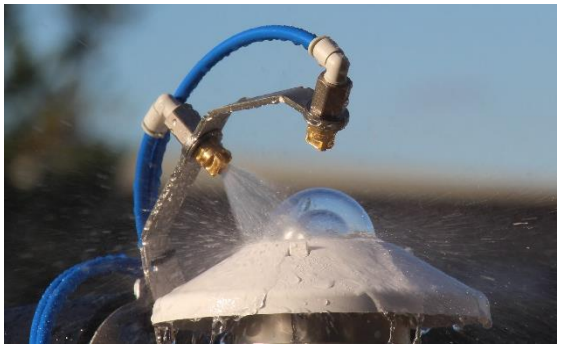

Figure 4 - Proa automatic self-cleaning system for Pyranometers and Skycams - The MetProtect

- **Bird Detection System:** Integrated bird detection prevents sensor shading, maintaining uninterrupted data collection.

- **Built-In Soiling Station:** Equipped with a self-cleaning "clean" solar panel, MetCube continuously monitors and compensates for soiling, ensuring precise irradiance measurements.

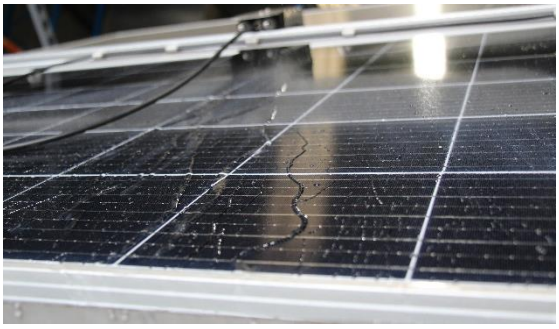

Figure 5 - Automatic cleaning system of MetCube´s built-in Soiling Station

- **Water Capture & Recycling:** MetCube uses filtrated and demineralised water to avoid traces on the sensors. It has a rainwater catchment system, filtration and demineralisation, all built-it.

Proa Energy's proprietary ongoing monitoring service and comprehensive data storage guarantee full data reliability, providing project equity with peace of mind and the assurance of unerring performance metrics.