



Weathering the future with precision meteorological monitoring



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As the global solar industry matures, its challenges are evolving. No longer driven purely by expansion and installation rates, solar operators are turning their attention toward efficiency, reliability and long-term profitability. At the heart of this shift lies a fundamental and often underappreciated variable: weather.

This data-informed approach enables operators to strike a balance, minimizing cleaning costs while preserving output.

Weather is both a driver and disruptor in solar energy production. From irradiance and temperature to wind and soiling events, the environmental conditions at a photovoltaic (PV) site determine the success or struggle of solar operations. In the face of intensifying climate variability, accurate, site-specific environmental monitoring is becoming more than just a best practice, it's a necessity.

The maturation of solar and the rise of O&M

Global forecasts predict that solar PV will account for an increasingly significant portion of energy generation in the coming decades. But as installed capacity scales, so too does the complexity of maintaining and optimizing these assets. Industry reports indicate that the solar O&M market is poised for rapid growth, reflecting a growing realization: the long-term viability of solar depends not just on installation, but on how well systems perform over time.

A modest drop in annual efficiency, due to environmental wear or suboptimal management, can significantly affect performance and profitability for utility-scale operations. In this operational landscape, real-time, granular meteorological data is becoming as valuable as the solar modules themselves.

Beyond irradiance: a new generation of weather data

Historically, the solar industry focused on a single metric, solar irradiance, to estimate and optimize energy output. But that's no longer enough. While irradiance remains the cornerstone of PV performance analysis, other variables have emerged as critical contributors to both short-term forecasting and long-term asset health.

Temperature, for instance, has a known inverse relationship with solar cell efficiency. High ambient or panel temperatures reduce voltage and energy conversion rates. Panel efficiency can drop by 0.3% to 0.5% for every degree Celsius above the standard testing temperature of 25°C, a factor that cannot be overlooked.

Wind speed and direction influence operations, not only through cooling effects but by posing mechanical stress risks. Wind can exacerbate dust accumulation or cause damage during extreme events. And precipitation, while helpful in cleaning panels, can also contribute to soiling when followed by high humidity or dust-laden winds.

Modern PV monitoring systems are designed to track a complete suite of environmental variables, including solar irradiance, both global horizontal irradiance and plane of array; ambient and panel temperature; wind speed

and direction; relative humidity; barometric pressure; rainfall; and soiling index.

By integrating these measurements, operators can shift from reactive to predictive maintenance, enhancing system uptime and reducing unforeseen costs.

Localized monitoring in a changing climate

While the solar industry plays a crucial role in combating climate change, it is not immune to its effects. As weather patterns become more unpredictable, long-term assumptions based on historical data can no longer be considered reliable. This new reality reinforces the value of localized, real-time monitoring over regional models or estimates.

Recent studies have shown that relying on generalized weather data for PV forecasting can result in significant energy yield estimation errors, especially in areas with microclimate variability. In contrast, systems equipped with dedicated onsite sensors demonstrated more accurate forecasting and improved O&M responsiveness.

'One of the most impactful ways to improve solar project economics is by improving the accuracy of the data going into performance models,' notes Dr Jamie McClellan, an environmental engineer specializing in renewable systems. 'You can't control the weather, but you can control how well you understand it.'

Integrating weather data into smart operations

The future of solar site management lies in data-driven automation. Many utility and commercial scale PV plants are increasingly integrating weather data into their operational control systems. Real-time meteorological input can inform automated tracker positioning, inverter responses and battery dispatch timing.

For instance, smart inverters can adjust their behavior based on irradiance or temperature thresholds, preventing potential clipping or overvoltage. Maintenance schedules can be optimized using weather-triggered alerts, while forecasted rain events can influence decisions about panel cleaning frequency.

All of these capabilities depend on accurate, real-time environmental data collected from onsite weather monitoring systems. Seamless communication protocols allow weather stations to connect with energy management platforms, empowering intelligent, responsive operations.

Soiling detection: protecting long-term performance

Among the most impactful contributors to efficiency loss is soiling, accumulated dust,

pollen, pollution or organic debris that reduces a panel's ability to capture sunlight. In some climates, soiling can reduce energy output by 20% or more, especially if not properly managed.

Rather than relying on set schedules or visual inspections for cleaning, many operators are now using soiling detection methods that compare data from clean and soiled irradiance sensors. When the soiling ratio exceeds a predefined threshold, alerts are triggered for targeted maintenance.

This data-informed approach enables operators to strike a balance, minimizing cleaning costs while preserving output. It also reduces unnecessary labor and water use, a consideration increasingly relevant in arid or resource constrained regions.

From measurement to management

High quality environmental data enables much more than just performance monitoring, it becomes a critical part of decision making and risk management. Throughout the lifecycle of a PV project, from feasibility and design to operation and asset repowering, weather insights guide energy yield forecasting and modeling; financial performance assessments; component selection and system layout; preventative and corrective maintenance planning; and grid compliance and load forecasting.

As regulatory scrutiny increases and margins for inefficiency tighten, the ability to generate and act on site-specific environmental intelligence will separate high performing operations from the rest.

Looking ahead: long-term resilience

As the solar sector evolves from its early growth phase into a more established and competitive energy source, priorities are shifting. No longer measured solely by the number of megawatts installed, success will be defined by reliability, predictability and resilience.

Environmental monitoring tools like the PVmet line are designed to meet this moment. By capturing high-resolution meteorological data, they empower asset owners and operators to respond dynamically to weather conditions, extend equipment life and maximize return on investment.

The road to long-term solar profitability is paved with information. Weather stations are no longer peripheral, they are central infrastructure. They don't just tell you what the weather is, they help you decide what to do next.

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