DenoWatts™

Advanced Solar Benchmark Management

How Denowatts delivers better performance benchmark data for Business Intelligence processes

By Dan Leary, Founder of Denowatts Solar, LLC

Introduction

Solar asset management and ownership rely on quality data to make informed decisions and optimize profitability. Traditional methods of benchmarking have inherent uncertainty that leads some asset managers to question the results. Denowatts is a data service that developed technology to address this uncertainty and deliver accurate and reliable performance benchmarking, reporting, and testing services.

The Problem

Does solar performance management seem disjointed, confusing, and sometimes unreliable?

The industry is maturing. Investors and stakeholders are demanding better insight into asset performance. Portfolios are growing larger and more diverse. Asset managers and owner's engineers may struggle to answer simple performance questions because they don't trust the data. A lack of data-driven decisions means profits are not fully realized.

The problem with performance benchmarking isn't a lack of precision sensors, capable monitoring services, or detailed standards. These have existed for decades.

The problem is common errors in the execution of performance benchmarking:

1. Varying quality control and management of meteorological instrumentation
2. Confusing and complex performance management standards
3. Lack of high-resolution benchmarking, capacity testing, and energy accounting
4. Disjointed feedback loop for Business Intelligence (BI) processes and data-driven decisions

BI processes are only as good as the data feeding them.

Figure 1: Traditional weather station

The Solution

Denowatts has developed a streamlined technology and service to address these problems. The mission of Denowatts is to produce accurate and reliable performance benchmarking data. We deliver this as a plugin to monitoring services and enterprise platforms in addition to downloadable reports for testing and accounting.

The Deno sensor is designed to deliver high-resolution benchmarking and weather data conforming to IEC 61724-1 standards that is compatible with new and retrofit solar assets.

Figure 2: The Deno sensor and antenna mounted in the plane of array between solar modules.

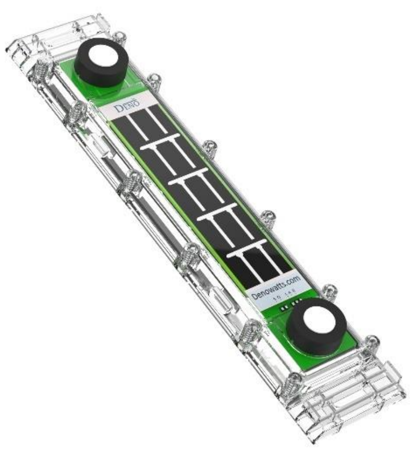

Figure 3: The Deno sensor, about the size of a TV remote control.

The Deno sensor is leased as part of the service which eliminates warranty and recalibration headaches. Remote management functionality simplifies integration and enables data quality controls.

Denowatts developed the Deno sensor specifically for the solar industry to surpass and replace traditional weather stations. The Deno sensor is self-powered and wireless (¼ mi range) which allows it to be installed in just minutes onto the sunniest part of your array without the cost of wiring. Dual pyranometers and temperature sensor collect meteorological data while an onboard processor computes both modeled and comparative benchmarks every 5 seconds.

The Result

With accurate and reliable benchmark data, solar professionals can confidently embrace BI processes to better understand their equipment and expectations, optimize operations, and become more profitable.

It all starts with accurate measurements. The Deno sensor and managed service deployment model lowers the overall system uncertainty by addressing a host of details that would otherwise lead to common errors:

Traditional Sources of Error	Denowatts Solution
Pyranometer orientation doesn't match the array	Deno sensor is mounted in the plane of the array
Sensor location is shaded (inter-row or near shading)	Deno is mounted high in the sunniest part of the array, not limited by wires
Pyranometer drift, damage, or soiling	Deno has two pyranometers to reduce uncertainty and identify differential quality issues
Data lost if no grid power	Self-powered unit records cumulative readings so solar resources are not lost
Sensor/logger configuration errors upon assembly; Multiple manufacturers, human error	Fully integrated sensor, processor, and logger with full remote configuration capability
Temperature Sensor falls off module	The Deno has an integrated temperature sensor for cell temperature simulation; Back of module temperature sensor is optional

With accurate measurements two benchmarks are produced right on the Deno sensor:

1. Expected Energy (IEC 61724): Expected Energy is calculated using the system parameters detailed on an asset's energy model. This is used to benchmark the asset relative to the energy model.
2. Comparative Energy: Also known as the "Denowatt", this is a common reference model that is used on every site. This benchmark is a common denominator for comparing the relative performance of technologies, designs, and site models.

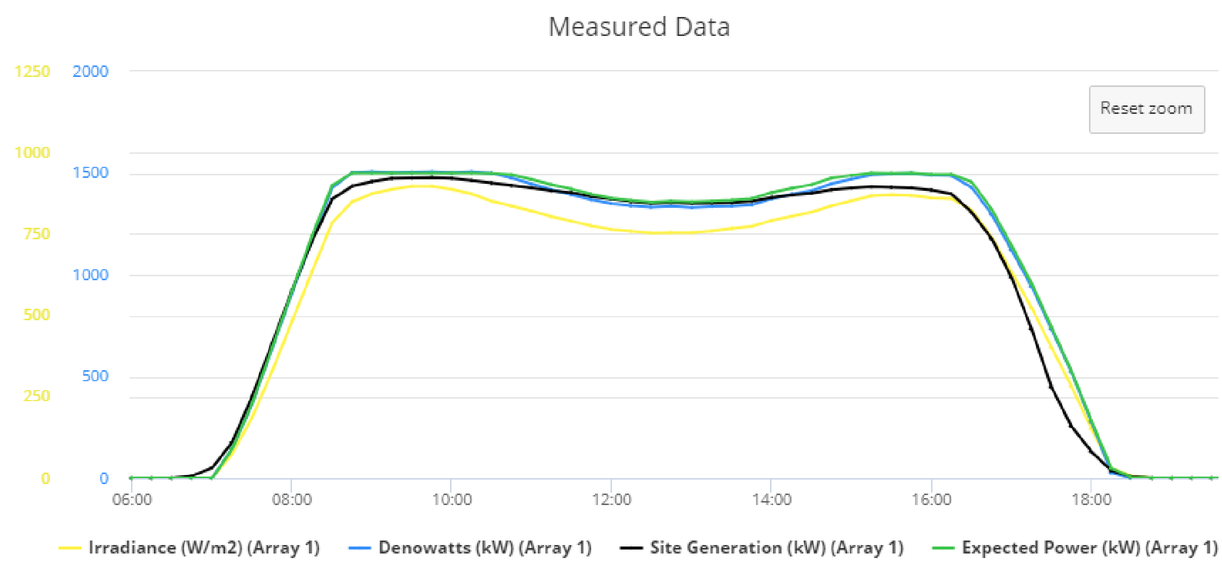

Figure 4: Chart of Expected, Compared, and Generated Power and Irradiance for a Single-Axis Tracker Asset

During daylight conditions these two benchmarks are computed with weather data samples every 5 seconds on the device. This approach to benchmarking delivers a near continuous simulation rather than an interval calculation and addresses sources of error found with traditional approaches:

Traditional Sources of Error	Denowatts Solution
Cloud computing limits resolution of benchmarks due to network bandwidth constraints	Inverter clipping, inverter efficiency, and temperature calculations are made on every 5-second sample and compiled to 1-minute records (IEC 61724-1).
Power/communications outages mean lost benchmark information	Expected and Comparative Energy benchmarks are cumulated on the self-powered sensor and can be accounted for during array outage periods
Age derating adjustments are absent or added later in the data curation	Age derating is part of the benchmark calculation. Annual DC capacity derating is remotely updated into the Deno sensor.

These two critical benchmarks deliver the most important Key Perform Indicators (KPIs) necessary to characterize the performance of a solar asset:

Benchmarks and Key Performance Indicators (KPIs)	Summary
Predicted Energy	Energy that is modelled using P50 weather data (IEC 61724)
Baseline Energy Performance Index (BEPI)	Ratio of measured Generation to Predicted Energy (IEC 61724)
Expected Energy	Energy that is derived using the performance model adjusted for measured weather data (IEC 61724)
Energy Performance Index (EPI), In Service	Performance ratio of actual generation to Expected Energy while the asset is fully Available (IEC 61724)
Energy Performance Index (EPI)	Ratio of measured Generation to Expected Energy (IEC 61724)
Comparative Energy	Energy that is derived from the Denowatts standard model
Comparative Percentile	Energy performance percentile of an asset compared to other assets using Denowatts
Commissioned Index	Ratio of measured Generation to the normalized Comparative Energy established by Denowatts following a start-up commission or recommission
Availability	Energy throughput capability of the asset (IEC 61724)

The Baseline Index is perhaps one of the most important KPIs to asset managers. This KPI, unique to Denowatts, is used to compare the relative performance of the asset to itself. Following a start-up or recommissioning period when the asset is performing at its peak the Denowatts benchmark is normalized (recorded as “100%”) and used thereafter to report the changing performance of the asset over time. The Baseline Index is basis for outage flagging for Availability and All In EPI.

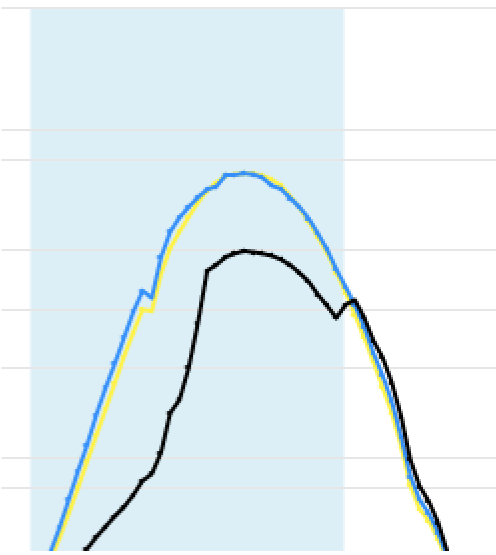

Figure 5: Chart of Measured Generation (black), Compared Energy (blue) and Irradiance (yellow) of a Flagged Outage Period

Denowatts utilizes algorithms to flag and account for periods of underperformance using the Commissioned Index to deliver Availability and All In EPI. These algorithms account for periods of underperformance for each 15-minute time interval thanks to the high-resolution accuracy of the benchmarks. In addition to outages caused by equipment non-availability, Denowatts also detects snow events that commonly impact performance.

Once underperformance periods are flagged Denowatts verifies the outage and allows asset managers to simply confirm the reason for the outage. The result is integrated into the KPIs and reported in a downloadable Energy Test Report (IEC 61724-3). This report lists time periods by asset availability, KPIs based on expected energy, and energy lost to outages and snow events.

Users may additionally download a Capacity Test Report (IEC 61724-2). The Capacity Test Report is typically used during start-up testing and pre/post-recommissioning. The IEC 61724-2 standard states that this may be used in place of ASTM E2848-13 to determine photovoltaic system performance.

Conclusion

Solar asset performance management begins with having accurate and reliable benchmark data. However, common errors in delivering performance benchmarks may create uncertainty in the results. Denowatts recognized the need for streamlined performance management to address this uncertainty and has developed the Deno sensor to deliver accurate and reliable benchmark data, including algorithms to detect and track periods of underperformance. The Denowatts service reports IEC 61724 standardized KPIs, capacity testing, and energy accounting. The result is data that asset managers and owners can confidently use to power BI processes, make data-driven decisions, and increase the profitability of solar assets.