PERFORMANCE REPORT · UTILITY-SCALE SOLAR O&M

Helios: operating a 100 MW solar plant against its *contract*.

A 100 MWdc single-axis-tracker plant, modeled and operated the way a performance engineer does it: an expected-energy model, the Performance Ratio and yield metrics owners and lenders track, a loss waterfall that accounts for every megawatt-hour, a capacity test that isolates excusable losses, and a fleet view that flags plants drifting below guarantee.

Author S. Ize-Iyamu **Audience** Asset owner · O&M performance team **Length** 3 pages **Status** Performance report

The Plant

A 100 MWdc plant inverter-loaded to 76.9 MWac (1.30 ILR), single-axis tracking in the US Southwest. Against a representative resource of 2475 kWh/m^2 of plane-of-array irradiance, the P50 model delivers **199 GWh** in year one, a specific yield of **1995 kWh/kWp** and a **80.6%** Performance Ratio. That model is the number the asset is judged against: the energy estimate the financing was sized on, and the baseline every month of production is measured back to.

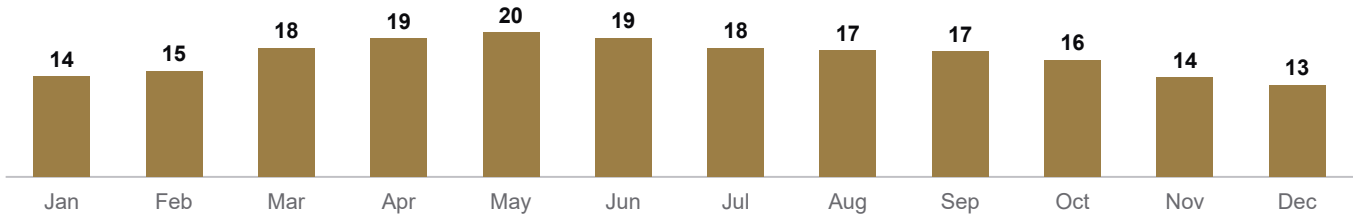
Performance engineering is the discipline of holding the plant to that model. The owner is paid for delivered energy, not sunlight; the gap between the two, temperature, soiling, clipping, inverter losses, and downtime, is the engineer's domain to measure, attribute to a cause, and act on where it is widening.

DC CAPACITY	SPECIFIC YIELD	PERFORMANCE RATIO	CAPACITY FACTOR	ANNUAL ENERGY
100 MW	1995	80.6%	29.6%	199 GWh

How Performance Is Measured

Four metrics carry the contract. **Performance Ratio** (IEC 61724-1) is delivered energy over what the irradiance and nameplate should have produced, the climate-neutral measure of conversion; this plant runs **80.6%**, the shortfall dominated by desert cell temperature. **Specific yield** (1995 kWh/kWp) normalizes energy to nameplate. **Capacity factor** (29.6% AC) measures against a 24/7 run at AC nameplate. **Availability** is the share of generating hours the plant could produce, the metric most inside the operator's control.

FIGURE 1 · MONTHLY DELIVERED ENERGY (GWH, AC)



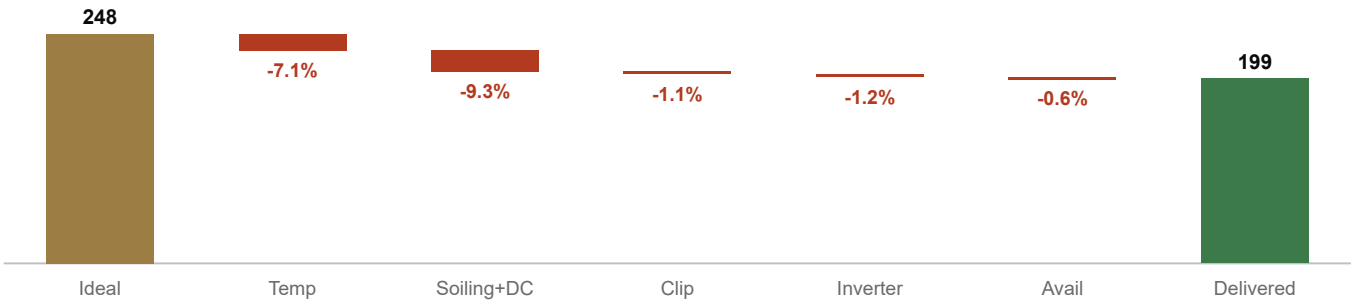
Production tracks the tracker-boosted irradiance and is pulled down in mid-summer by cell-temperature losses despite peak sun.

> THE NUMBER THAT MATTERS
>
> The 80.6% Performance Ratio is the one figure an owner, a lender, and the O&M contractor all watch: it strips out weather and plant size to ask whether the asset is converting the sun it receives as well as it should. Everything downstream, the loss waterfall, the capacity test, and the fleet ranking, exists to defend or explain that single number.

Energy Loss Accounting

The waterfall is the core of the work: from the ideal energy the irradiance and nameplate imply, it steps down through each loss to the energy delivered. From **248 GWh**, cell **temperature** takes 7.1% (the largest, a desert signature), **soiling and DC losses** 9.3%, **clipping** 1.1% at the 1.30 loading ratio, **inverter** 1.2%, and **availability** 0.6%, leaving **199 GWh**. Attribution turns a weak month into a work order: temperature is physics, soiling is a wash decision, availability is a tracker or inverter fix.

FIGURE 2 · ENERGY-LOSS WATERFALL, IDEAL TO DELIVERED (GWH)



Each red step is energy lost to a named mechanism; green is energy delivered. Temperature and soiling/DC together account for the bulk of the 19% gap from ideal.

STAGE	CUMULATIVE ENERGY	LOSS (% OF IDEAL)
Ideal (STC x POA)	247.5 GWh	0.0%
Temperature	229.8 GWh	7.1%
Soiling + DC	206.8 GWh	9.3%
Clipping	204.1 GWh	1.1%
Inverter	201.1 GWh	1.2%
Availability	199.5 GWh	0.6%

Acceptance / Capacity Test

At commissioning and each anniversary, the plant is tested against guarantee: measured energy versus model, excusable losses added back. Year-one energy came in **1.8%** below P50, a measured PR of **0.791**. Of that gap, **1.4%** is excusable, grid curtailment (1.1%) and a force-majeure outage (0.3%) the O&M agreement does not charge the operator. Adding it back lifts the adjusted PR to **0.803**, clearing the **0.78** guarantee.

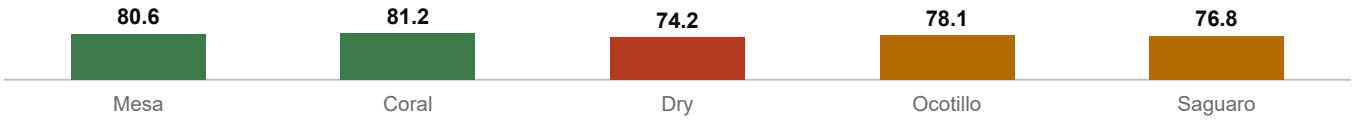
CAPACITY TEST	VALUE	RESULT
P50 modeled energy	199.5 GWh	baseline
Measured energy	195.9 GWh	-1.8% vs model
Measured PR	0.791	below guarantee
Excusable losses (curtailment + force majeure)	1.4%	added back
Adjusted PR vs 0.78 guarantee	0.803	**PASS**
Availability vs 98% guarantee	98.5%	**PASS**

> **WHY IT PASSES**
> The plant misses its raw PR but clears the guarantee once excusable curtailment and force majeure are isolated. Separating operator-controllable losses from contractually-excused ones is the difference between a liquidated-damages claim and a clean anniversary.

Fleet Performance & Anomaly Detection

One plant is a report; a fleet is triage. Ranking siblings on PR and availability shows where to send the next truck roll. **Dry Lake** is the outlier, 0.742 PR and 97.6% availability flag it **INVESTIGATE**, consistent with a tracker fault or missed wash dragging a block. **Ocotillo** and **Saguaro Flat** sit on **WATCH**; the rest, including Mesa Verde at 0.806, hold guarantee.

FIGURE 3 · FLEET PERFORMANCE RATIO BY SITE (FLAGGED)



Green holds guarantee, amber is on watch, red is flagged for investigation. Bar height is PR; the flag also weighs availability.

SITE	SIZE	PR	AVAILABILITY	STATUS
Mesa Verde	100 MW	0.806	99.2%	OK
Coral Wash	80 MW	0.812	99.4%	OK
Dry Lake	120 MW	0.742	97.6%	INVESTIGATE
Ocotillo	60 MW	0.781	98.9%	WATCH
Saguaro Flat	150 MW	0.768	99.0%	WATCH

Key Risks

HIGH **Soiling and tracker faults**

The largest controllable losses; addressed by a soiling-driven wash schedule and tracker monitoring, with Dry Lake's flag triggering an inspection.

MED **Degradation drift**

Modules degrade ~0.5%/yr; annual capacity tests confirm the plant tracks the curve, not a step-change fault.

MED **Curtailment misattribution**

Excusable curtailment must be metered at interconnection, or it is wrongly charged to availability; the capacity test isolates it.

Recommendation

> ACTION
> Dispatch a Dry Lake inspection (tracker and soiling), hold the wash schedule on the watch-list plants, and report the fleet at a 0.782 average PR. The portfolio clears its contractual energy once excusable losses are isolated; residual risk is concentrated and actionable.

Method & Sources

Energy is modeled with the NREL **PVWatts** method (POA irradiance, a cell-temperature derate, a DC-loss stack, clipping at the loading ratio, conversion and availability); Performance Ratio and yield follow **IEC 61724-1**, and the capacity test follows **ASTM E2848**. The plant is illustrative but calibrated to empirical US-Southwest fleet data: its capacity factor, specific yield, and 1.30 loading ratio sit within the ranges Berkeley Lab and the NREL ATB report for trackers in the sunniest regions. Model open at github.com/sophia-ize-iyamu/helios-pv-performance.

References, fact-checked (Jun 2026): Dobos, A., *PVWatts Version 5 Manual*, NREL/TP-6A20-62641 (2014); IEC 61724-1:2021, *PV system performance, Part 1: Monitoring*; ASTM E2848-13(2023), *Reporting PV Non-Concentrator System Performance*; Holmgren, Hansen & Mikofski, *pvlib python*, J. Open Source Software 3(29):884 (2018); Lawrence Berkeley National Laboratory, *Utility-Scale Solar, 2024 Edition* (fleet capacity factors, tracker adoption); NREL *Annual Technology Baseline 2024, Utility-Scale PV* (100 MWdc, 1.30 ILR reference system); US EIA, *utility-scale solar capacity factors by state* (2024); Jordan & Kurtz, *Photovoltaic Degradation Rates*, Progress in Photovoltaics (2013).