Solar Plant Performance Report - Plant S

Daily Performance Ratio Analysis

The analysis of Plant S for May 28-29, 2025, reveals critical anomalies primarily related to reported soiling losses. On both days, the 'plant_soiling_loss_percent' is alarmingly high (134.37% on May 28 and 232.42% on May 29), which is physically impossible for energy loss and strongly indicates a data quality issue or a severe miscalculation within the monitoring system. If these figures were accurate, the plant would be operating at a significant deficit, suggesting a major underlying problem.

Aside from the soiling loss data, the 'daily_pr_percent' for May 28 was 78.07%, falling into the 'warning' range (70-80%) during good radiation conditions. On May 29, the PR was 80.33%, just above the warning threshold. The difference between standard PR and temperature-corrected PR (7.2% and 6.19% respectively) suggests that higher cell temperatures contribute to the uncorrected PR being lower, but not to a critical degree. Plant availability was 100% and there was no curtailment reported on either day, ruling out these factors as direct causes of PR deviations. The consistently lower-than-optimal PR, coupled with the erroneous yet indicative soiling loss data, suggests that actual soiling may be a significant underlying factor affecting the plant's true performance.

Daily PR Metrics

Date	Plant Name	Daily PR (%)	Temp Corrected PR (%)	Soiling Loss (%)	Daily Yield (kWh)	Est. Yield Loss (kWh)	Severity
2025-05-28	Plant S	78.07	85.27	134.37	3385.15	350.73	high
2025-05-29	Plant S	80.33	86.52	232.42	2507.14	142.83	high

PR Performance Summary

- **Average Daily PR:** 79.2%
- **Average Temp Corrected PR:** 85.895%
- **Lowest Daily PR:** 78.07%
- **Highest Daily PR:** 80.33%
- **PR Trend:** stable
- **Temperature Correction Impact:** The temperature correction consistently provides a higher PR, indicating that temperature is a factor affecting raw PR, but the difference does not exceed the critical

threshold of 10%.

- **PR Standard Deviation:** N/A - Insufficient data

Anomaly Breakdown (Daily)

- **Total Anomalies Found:** 2
- **Critical Issues:** 0
- **High Priority:** 2
- **Medium Priority:** 0
- **Low Priority:** 0

Root Cause Analysis (Daily)

- **Primary Causes:** Soiling accumulation (based on highly anomalous reported values), Potential data quality issues with soiling loss calculation
- **Soiling Impact Days:** 2
- **Curtailment Affected Days:** 0
- **Low Availability Days:** 0
- **High Temperature Impact Days:** 0

Performance Trends (Daily)

- **Daily PR Trend:** Stable over the two-day period, but below the ideal 80-90% range.

- **Seasonal Patterns:** N/A - Insufficient data for seasonal analysis.

- **Degradation Rate Estimate:** N/A - Insufficient data for degradation analysis.

- **Temperature Correlation:** Observed inverse correlation between temperature and uncorrected PR, as expected.

Recommendations (Daily)

- **Immediate Investigation of Soiling Loss Data:** Prioritize verifying the accuracy of 'plant_soiling_loss_percent' values (134.37% and 232.42%). These figures are unrealistic and suggest a sensor malfunction, calculation error, or severe data corruption. This is the most pressing issue.

- **Physical Inspection for Soiling:** If data validates the possibility of extreme soiling, a physical inspection of the panels should be conducted immediately to assess dirt accumulation.

- **Implement Aggressive Cleaning Schedule:** If significant soiling is confirmed, implement a panel cleaning schedule to restore PR to optimal levels.

- **Continue PR Monitoring:** Closely monitor daily PR to establish a 7-day rolling average for more robust anomaly detection.

- **Optimize for Target PR:** Aim to consistently achieve PR values within the 85-90% range by addressing identified performance inhibitors.

Estimated Financial Impact (Daily)

- **Total Yield Loss (kWh):** 493.56

- **Estimated Revenue Loss:** Quantification requires electricity price per kWh, but the estimated yield loss of 493.56 kWh over two days represents a measurable financial impact.

- **Performance Improvement Potential:** Significant performance improvement potential exists, primarily by resolving the root cause of the reported high soiling losses and optimizing PR to consistently reach the 85-90% range. This could lead to substantial increases in energy generation and revenue.

5-Minute Performance Ratio Analysis

The 5-minute PR data for Plant S on May 28th and 29th, 2025, reveals consistent underperformance and several critical anomalies. On both days, there are numerous instances of 'low_pr_performance' and 'environmental_mismatch', where PR values are below optimal, especially during periods of moderate to high irradiance. This suggests a systemic issue affecting the plant's efficiency.

Specifically, on May 29th, an 'unrealistic_high_values' anomaly (101.93% PR) points to a potential sensor or data acquisition issue. More critically, there were significant 'dramatic_pr_drop' events on both days, particularly at the end of the day (17:55Z on May 28th and 17:55Z on May 29th), and during high irradiance on May 29th (12:50Z and 12:55Z). The prolonged period of null active power and 0% PR between 13:15Z and 15:10Z on May 29th indicates a complete outage or data loss, which is a critical operational issue.

The 'dawn/dusk_anomaly' instances, while potentially normal for low light conditions, warrant further investigation if they deviate from expected patterns. The overall pattern suggests a plant struggling to maintain optimal performance, with intermittent severe drops and a concerning data gap.

5-Minute PR Data

Datetime	5-min PR (%)	Irradiance (W/m²)	Module Temp (°C)	Active Power (kW)	Anomaly Type	Severity	Context
2025-05-28 09:20:00	75.78	473.50	49.50	355.63	low_pr_performance	low	PR slightly below optimal for the given irradiance.
2025-05-28 09:50:00	83.28	650.00	48.45	536.54	normal_performance	low_flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.

2025-05-28 10:00:00	72.33	673.50	48.65	432.85	environmental_mismatch	medium	PR is low (72.33%) despite moderate to high irradiance (673.5 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 10:40:00	76.99	467.50	49.55	356.75	low_pr_performance	low	PR slightly below optimal for the given irradiance.
2025-05-28 10:45:00	75.31	492.00	46.85	367.26	low_pr_performance	low	PR slightly below optimal for the given irradiance.
2025-05-28 10:50:00	79.66	914.00	46.45	721.66	normal_performance	low_flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.

2025-05-28 11:05:00	77.05	876.50	56.85	669.37	environmental_mismatch	medium	PR is low (77.05%) when irradiance is high (876.5 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 11:10:00	76.85	901.50	59.05	636.70	environmental_mismatch	medium	PR is low (76.85%) when irradiance is high (901.5 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 11:15:00	76.07	924.50	56.90	697.05	environmental_mismatch	medium	PR is low (76.07%) when irradiance is high (924.5 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 11:20:00	72.04	315.50	59.05	225.26	low_pr_performance	medium	PR is low (72.04%) for the given irradiance (315.5 W/m²).

2025-05-28 11:25:00	77.78	755.00	56.90	532.06	environmental_mismatch	medium	PR is low (77.78%) when irradiance is high (755.0 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 11:30:00	77.32	819.00	54.10	627.67	environmental_mismatch	medium	PR is low (77.32%) when irradiance is high (819.0 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 11:35:00	77.39	825.00	53.75	632.85	environmental_mismatch	medium	PR is low (77.39%) when irradiance is high (825.0 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 11:40:00	75.51	402.50	53.25	301.23	low_pr_performance	medium	PR is low (75.51%) for the given irradiance (402.5 W/m²).

2025-05-28 11:45:00	81.55	402.00	51.25	324.93	normal_performance	low_flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.
2025-05-28 11:50:00	86.91	775.00	49.30	667.62	normal_performance	low_flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.
2025-05-28 11:55:00	73.89	773.00	50.05	566.09	environmental_mismatch	medium	PR is low (73.89%) when irradiance is high (773.0 W/m²), indicating potential environmental factors or performance issues.

2025-05-28 12:20:00	75.87	922.00	58.00	693.36	environmental_mismatch	medium	PR is low (75.87%) when irradiance is high (922.0 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 12:25:00	75.02	907.50	59.20	674.76	environmental_mismatch	medium	PR is low (75.02%) when irradiance is high (907.5 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 12:30:00	75.25	872.50	58.10	650.74	environmental_mismatch	medium	PR is low (75.25%) when irradiance is high (872.5 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 12:35:00	75.83	316.00	56.25	237.50	low_pr_performance	medium	PR is low (75.83%) for the given irradiance (316.0 W/m²).

2025-05-28 12:40:00	78.41	305.00	50.10	237.03	low_pr_performance	medium	PR is low (78.41%) for the given irradiance (305.0 W/m²).
2025-05-28 12:45:00	79.33	339.50	48.15	266.95	low_pr_performance	medium	PR is low (79.33%) for the given irradiance (339.5 W/m²).
2025-05-28 13:00:00	76.66	964.00	51.40	732.51	environmental_mismatch	medium	PR is low (76.66%) when irradiance is high (964.0 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 13:05:00	74.16	597.00	53.00	438.82	low_pr_performance	medium	PR is low (74.16%) for the given irradiance (597.0 W/m²).
2025-05-28 13:20:00	76.97	267.00	51.10	203.70	low_pr_performance	medium	PR is low (76.97%) for the given irradiance (267.0 W/m²).
2025-05-28 13:25:00	78.24	380.50	48.00	295.08	low_pr_performance	medium	PR is low (78.24%) for the given irradiance (380.5 W/m²).

2025-05-28 14:20:00	77.70	455.00	352.40	350.43	low_pr_performance	medium	PR is low (77.7%) for the given irradiance (455.0 W/m²).
2025-05-28 15:00:00	76.95	750.50	548.25	572.40	environmental_mismatch	medium	PR is low (76.95%) when irradiance is high (750.5 W/m²), indicating potential environmental factors or performance issues.
2025-05-28 15:10:00	77.77	341.50	249.95	263.24	low_pr_performance	medium	PR is low (77.77%) for the given irradiance (341.5 W/m²).
2025-05-28 17:00:00	74.80	30.50	32.70	22.61	dawn/dusk_anomaly	low	PR is relatively low during low light conditions at dusk, which can be normal but is flagged by the filter.

2025-05-28 17:50:00	70.59	3.00	28.05	2.10	dawn/dusk_anomaly	low	PR is low during very low light conditions at dusk, which is expected but flagged by the filter.
2025-05-28 17:55:00	38.54	2.00	28.00	0.76	dramatic_pr_drop	high	Significant drop in PR to 38.54% during very low irradiance conditions at the end of the day. While irradiance is low, such a low PR could indicate an issue or sensor inaccuracy.
2025-05-29 09:20:00	84.23	305.00	40.20	254.64	normal_performance	low_flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.

2025-05-29 10:25:00	80.66	435.00	47.80	337.75	normal_performance	low_flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.
2025-05-29 10:30:00	84.32	832.50	49.45	737.58	normal_performance	low_flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.
2025-05-29 10:35:00	73.02	1183.50	56.60	856.60	environmental_mismatch	investigate	PR is low (73.02%) when irradiance is very high (1183.5 W/m²), indicating potential environmental factors or performance issues.

2025-05-29 10:40:00	83.58	730.00	61.20	646.16	normal_performance	low	flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.
2025-05-29 10:45:00	76.52	434.50	56.90	367.47	low_pr_performance	medium		PR is low (76.52%) for the given irradiance (484.5 W/m²).
2025-05-29 10:55:00	101.93	565.50	47.60	571.29	unrealistic_high_values	high		PR is unrealistically high (101.93%), indicating a potential sensor error or data anomaly.
2025-05-29 11:00:00	78.05	299.00	44.10	231.31	low_pr_performance	medium		PR is low (78.05%) for the given irradiance (299.0 W/m²).

2025-05-29 11:05:00	81.23	244.50	42.30	196.85	normal_performance	low_flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.
2025-05-29 11:10:00	82.81	211.00	41.80	173.18	normal_performance	low_flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.
2025-05-29 11:15:00	79.86	238.50	39.60	138.78	normal_performance	low_flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.

2025-05-29 11:20:00	91.88	617.50	40.40	562.35	normal_performance	low	flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.
2025-05-29 11:25:00	72.67	562.50	44.65	405.16	low_pr_performance	medium		PR is low (72.67%) for the given irradiance (562.5 W/m²).
2025-05-29 12:00:00	81.35	560.50	45.95	451.92	normal_performance	low	flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.
2025-05-29 12:05:00	76.40	1148.50	47.85	869.64	environmental_mismatch	medium		PR is low (76.4%) when irradiance is very high (1148.5 W/m²), indicating potential environmental factors or performance issues.

2025-05-29 12:10:00	76.17	1122.00	54.50	847.06	environmental_mismatch	medium	PR is low (76.17%) when irradiance is very high (1122.0 W/m²), indicating potential environmental factors or performance issues.
2025-05-29 12:15:00	71.48	1109.00	58.65	785.74	environmental_mismatch	medium	PR is low (71.48%) when irradiance is very high (1109.0 W/m²), indicating potential environmental factors or performance issues.
2025-05-29 12:20:00	72.79	719.50	58.50	519.08	low_pr_performance	medium	PR is low (72.79%) for the given irradiance (719.5 W/m²).
2025-05-29 12:25:00	78.38	559.50	53.60	434.68	low_pr_performance	medium	PR is low (78.38%) for the given irradiance (559.5 W/m²).

2025-05-29 12:35:00	75.78	1068.00	55.25	802.16	environmental_mismatch	medium		PR is low (75.78%) when irradiance is very high (1068.0 W/m²), indicating potential environmental factors or performance issues.
2025-05-29 12:40:00	91.90	619.00	58.50	563.81	normal_performance	low	flagged_by_filter	PR is within expected range for the given irradiance. Flagged by filter, but not a clear anomaly based on defined criteria.
2025-05-29 12:45:00	73.33	1185.00	58.95	861.27	environmental_mismatch	medium		PR is low (73.33%) when irradiance is very high (1185.0 W/m²), indicating potential environmental factors or performance issues.

2025-05-29 12:50:00	52.87	899.50	59.30	471.37	dramatic_pr_drop	high	PR is critically low (52.87%) when irradiance is high (899.5 W/m²), indicating a significant performance issue.
2025-05-29 12:55:00	55.71	704.50	58.70	338.97	dramatic_pr_drop	high	PR is critically low (55.71%) when irradiance is high (704.5 W/m²), indicating a significant performance issue.
2025-05-29 13:00:00	75.59	339.50	60.10	254.37	low_pr_performance	medium	PR is low (75.59%) for the given irradiance (339.5 W/m²).
2025-05-29 13:05:00	71.44	100.00	47.90	70.81	dawn/dusk_anomaly	low	PR is relatively low during low light conditions, which can be normal but is flagged by the filter.

2025-05-29 13:10:00	73.95	71.50	37.70	52.41	dawn/dusk_anomaly	low	PR is relatively low during low light conditions, which can be normal but is flagged by the filter.
2025-05-29 17:50:00	47.54	6.00	26.75	2.83	dawn/dusk_anomaly	low	PR is critically low during very low light conditions at dusk, which is expected but flagged by the filter.
2025-05-29 17:55:00	29.81	3.50	27.00	1.03	dramatic_pr_drop	high	Significant drop in PR to 29.81% during very low irradiance conditions at the end of the day. While irradiance is low, such a low PR could indicate an issue or sensor inaccuracy.

Anomaly Breakdown (5-Minute)

- **Total Anomalies Found:** 62

- **Dramatic PR Drops:** 4
- **Environmental Mismatches:** 19
- **Power Generation Anomalies:** 1
- **Erratic Behavior Instances:** 0
- **Complete Outages:** 1
- **Low PR Performance:** 19
- **Normal Performance Flagged by Filter:** 14
- **Dawn/Dusk Anomaly:** 5

Severity Distribution (5-Minute)

- **Critical:** 1
- **High:** 3
- **Medium:** 38
- **Low:** 20

Environmental Analysis (5-Minute)

- **Irradiance Range Analyzed:** 2.0 W/m² to 1185.0 W/m²
- **Temperature Range Analyzed:** 26.75 °C to 61.2 °C

- **Power Range Analyzed:** 0.76 kW to 869.64 kW

- **Most Problematic Conditions:** Low PR during high irradiance, indicating environmental mismatches or systemic underperformance. Critical PR drops observed during both high and very low irradiance conditions.

Patterns Identified (5-Minute)

- Consistent low PR performance during daylight hours, especially under medium to high irradiance.

- Multiple instances of environmental mismatch, suggesting factors like soiling or module degradation.

- Recurring dramatic PR drops, particularly at the end of the day, and one significant drop during high irradiance.

- A complete data outage/zero power period on May 29th, indicating a severe operational interruption.

Recommendations (5-Minute)

- **Immediate Action for Outage:** Investigate the cause of the complete power outage/data loss between 13:15Z and 15:10Z on May 29th. This is a critical issue that needs urgent attention.

- **Sensor Calibration/Verification:** Address the unrealistic PR value of 101.93% on May 29th. This suggests a sensor malfunction or data acquisition error that needs to be calibrated or replaced.

- **Detailed Performance Review:** Conduct a thorough review of the plant's overall performance, focusing on the periods of low PR during high irradiance. This may involve checking for soiling, module degradation, or inverter issues.

- **Review Dusk/Dawn Performance:** While some PR drops at dawn/dusk are normal, review these instances to ensure they are within expected operational parameters and not indicative of other issues.

- **Preventive Maintenance:** Implement a preventive maintenance schedule to address potential underlying causes of consistent low PR and dramatic drops, such as cleaning, module inspection, and inverter health checks.

Inverter Performance Analysis

The inverters at Plant S exhibited significant underperformance on both May 28th and 29th, 2025. All eight inverters showed high to critical severity anomalies, primarily due to low energy yield and capacity underperformance. Despite generally good availability and operation times, their daily energy production was consistently well below expected levels, leading to substantial yield deviations ranging from -52.22% to -71.88%.

Summary of Anomalies (Inverters)

- **Total Anomalies Found:** 16 (8 inverters x 2 days)
- **Critical Issues:** 3 (all for May 29th)
- **High Priority Issues:** 13 (all for May 28th, and 5 for May 29th)
- **Problematic Devices:** All 8 inverters were problematic on both days.

Detailed Breakdown of Issues (Inverters)

- **Low Yield & Capacity Underperformance:** All inverters on both days experienced significantly lower daily yields compared to their expected production based on capacity. This was the predominant issue, indicating a systemic problem affecting the plant's overall energy generation efficiency.
- **Specific Yield Issues:** On May 29th, several inverters showed specific yields below 3 kWh/kWp, further highlighting severe underperformance relative to their installed capacity.

Impact (Inverters)

- **Estimated Total Yield Loss:** 9453.92 kWh
- **Average Capacity Utilization (problematic records):** 10.09% to 16.92%

Inverter Performance Data

Date	Inverter	Anomaly Type	Severity	Daily Yield (kWh)	Specific Yield (kWh/kWp)	Yield Deviation (%)	Operation Time (hours)	Availability (%)
2025-05-28	Plant S-I01	low_yield|capacity_underperformance	high	517.80	3.97	-53.32	12.90	100.00
2025-05-28	Plant S-I06	low_yield|capacity_underperformance	high	458.00	3.72	-58.60	12.67	100.00
2025-05-28	Plant S-I08	low_yield|capacity_underperformance	high	472.00	3.88	-54.31	12.58	100.00
2025-05-28	Plant S-I04	low_yield|capacity_underperformance	high	494.60	4.06	-52.22	12.77	100.00
2025-05-28	Plant S-I03	low_yield|capacity_underperformance	high	487.30	4.00	-55.57	12.58	100.00
2025-05-28	Plant S-I07	low_yield|capacity_underperformance	high	457.20	3.73	-56.08	12.82	100.00
2025-05-28	Plant S-I05	low_yield|capacity_underperformance	high	457.20	3.75	-58.29	12.72	100.00
2025-05-28	Plant S-I02	low_yield|capacity_underperformance	high	487.70	4.00	-55.46	12.42	100.00
2025-05-29	Plant S-I01	low_yield|capacity_underperformance|specific_yield_issue	high	385.50	2.57	-70.47	10.73	100.00
2025-05-29	Plant S-I06	low_yield|capacity_underperformance|specific_yield_issue	critical	317.70	2.56	-71.55	10.65	100.00
2025-05-29	Plant S-I08	low_yield|capacity_underperformance|specific_yield_issue	critical	317.30	2.61	-71.08	10.38	100.00

Worst Performing Devices (Inverters)

- **Plant S-I06 (6ca3bcb0-e815-11ec-9d0d-5faa5f7f8fb1):** Critical underperformance on May 29th, producing less than 30% of expected energy.
- **Plant S-I08 (6c889390-e815-11ec-9d0d-5faa5f7f8fb1):** Critical underperformance on May 29th, producing less than 30% of expected energy.
- **Plant S-I05 (6c661770-e815-11ec-9d0d-5faa5f7f8fb1):** Critical underperformance on May 29th, producing less than 30% of expected energy.

Potential Root Causes (Inverters)

- Solar panel degradation or damage: Widespread issues could lead to consistent low yield across multiple inverters.

- MPPT issues: Problems with Maximum Power Point Tracking could limit energy harvesting.

- Partial shading: Consistent shading affecting multiple inverter areas.

- Severe soiling on panels: Accumulation of dust or dirt reducing sunlight absorption. The previous plant-level analysis also indicated potentially severe soiling.

- Inverter internal faults: While availability was high, internal component degradation could lead to reduced power output.

Recommendations (Inverters)

1. **Immediate On-Site Inspection:** Conduct a thorough physical inspection of all solar panels for shading, soiling, and any visible damage (e.g., cracks, delamination). Pay particular attention to the modules connected to inverters S-I05, S-I06, and S-I08.

2. **Verify Soiling Levels:** Confirm the extent of soiling, as highlighted in the plant-level analysis. Implement a comprehensive cleaning schedule if significant soiling is present.

3. **Inverter Diagnostics:** Perform detailed diagnostics on all inverters to check for internal faults, MPPT issues, or any abnormal operating parameters.

4. **Performance Trend Analysis:** Continue to monitor the daily and specific yield of these inverters over a longer period (e.g., weekly) to identify any recurring patterns or further degradation.

5. **Comparative Analysis:** Compare the performance of these inverters with other similar plants under similar environmental conditions to identify if this is a localized issue or indicative of a broader problem.

6. **Data Quality Check:** Investigate the data quality, especially concerning soiling loss, as indicated by the plant-level analysis.