Prescinto Actionable Intelligence

Hindcasting Report

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY **2**
2. INTRODUCTION **4**
2.1. Purpose 4
2.2. Plant details 4
2.3. Progress of the PoC 4
3. INPUT DATA SUMMARY **6**
3.1. Data Availability 6
3.2. Data Quality 7
4. MONITORING **9**
4.1. Custom KPIs and Dashboard 9
4.2. Custom Report 10
5. TAHOE ANALYTICS **11**
5.1. About Tahoe Analytics 11
5.2. Generation vs Irradiation 14
5.3. Loss Analysis 16
5.3.1. Loss Analysis for June and July 18
5.3.2. Loss Analysis for August 21
5.3.3. Loss Analysis for September 27
5.3.4. Loss Analysis for October 29
6. STRING ANALYTICS **31**
6.1. About String Analytics 31
6.2. Observations 31
6.3. Recommendation 37
7. GENERATION IMPACT OF LOSSES **38**

Annexure-1: Company Profile **41**

1. EXECUTIVE SUMMARY

We are grateful to one of the largest asset owners in the renewables industry for providing Prescinto Technologies with the chance to demonstrate our superior renewable energy data analytics software capabilities.

Problem statement

1. Ingest the historical data from June 2022 till October 2022 and identify the performance opportunities leveraging various analytical capabilities of Prescinto
2. Identify controllable losses and strategies to correct them.
3. Demonstrate monitoring and analytics capabilities of Prescinto using historical data.

Outcome and Results Achieved

1. Plant performance levels: This is a well operated plant where for majority of the months the PR value has been on or above the target, except for August 2022. The plant has an "Optimal PR" of 5% above the Target (PVSyst) PR. The loss and performance improvements were hence calculated based on the Optimal PR.

Month	Target PR (%)	Actual PR (%)	Difference in PR (%)
June	78.33%	84.37%	6.04%
July	77.83%	77.11%	-0.72%
August	76.83%	67.66%	-9.17%
September	75.06%	76.91%	1.85%
October	74.41%	79.84%	5.43%

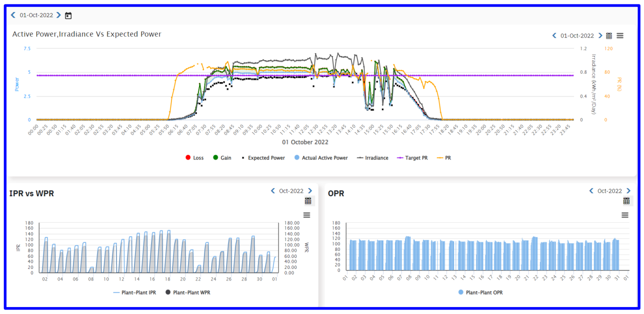
2. The month of August 2022 specifically showed a lower PR resulting in a loss of approximately 211.83 MWh.
3. Overall controllable opportunity during the entire period was identified as 325.1 MWh which is 7.42% of the total production during this period.

a. By leveraging the insights from String analytics and Tahoe we believe 2.39% can be improved leading to 19.92 MWh additional generation.

4. During this POC we were able to demonstrate

a. **Monitoring**

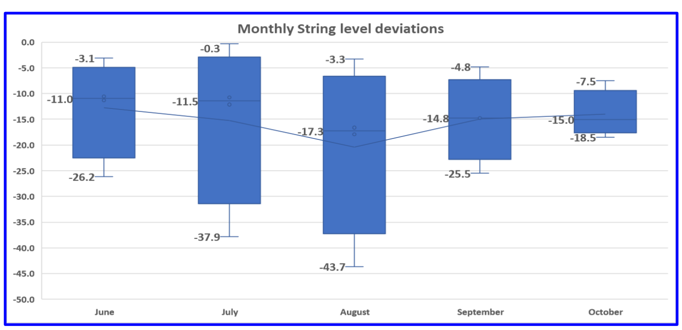
i. Specially computed KPIs and Custom dashboard (based on various KPIs recommended by IEC61724.



b. **Analytics**

i. **Data governance and Quality**: The data quality of the plant has been exceptionally good, reflects strongly about the maintenance practices and robust design of the plant.

ii. **String Analytics**: String analytics show very high level of variation between high and low performing strings and present an opportunity to drive generation gain by 2% to 3% at plant level even in October, the best month in terms of performance in the entire duration.



iii. **Loss Waterfall Analytics**: Shows the loss categories comparison and helps identify high level issues across plant and at inverter level.

2. INTRODUCTION

2.1. Purpose

The main objective of this engagement is to exhibit Prescinto's capability to identify underperformance events and to give data-driven insights on plant and device-level performance to help arrive at precise actions aimed at optimizing the plant's energy output.

2.2. Plant details

Client Name	A Large Renewable Asset Owner
Project Name	Solar Project 1
Project AC Capacity (MW)	5000 kW
Project DC Capacity (MWp)	6030 kWp
Project Location	Brazil
Project Coordinates	
Site SPoC Name	
Site SPoC Mail ID	

2.3. Progress of the PoC

Prescinto started working on the PoC in the first week of February 2023. We received the historical data dump of the mentioned solar plant during the third week of February 2023. The historical data was given for the months of June to October 2022. Inverter files at 5-minute granularity and weather station files at 1-minute granularity were shared. The Weather station files at 1-minute interval were aggregated to 5-minute level to maintain uniformity and make the analytics work seamlessly. As Prescinto didn't receive any other device data, including the plant's data, it was decided to compute Plant level parameters and KPIs from the inverter and weather station data alone.

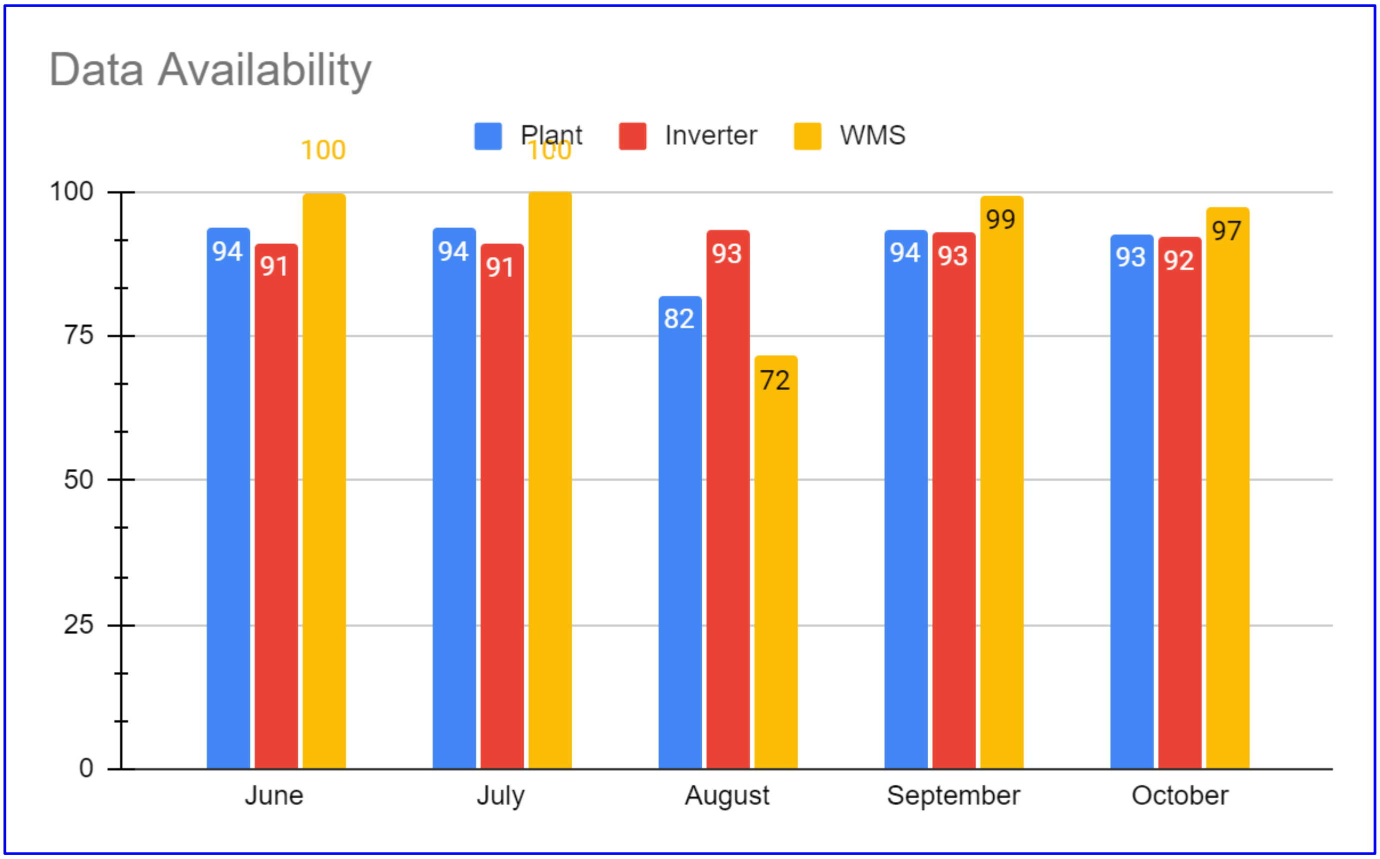
The data ingestion for the months of June to October was completed during the first week of March 2023. With the help of Data Governance tool, It was observed that the Weather station files had significant gaps in the months of June & July, and this feedback was immediately shared with the client. Multiple KPIs (as recommended by IEC61724) were requested by the client, with some KPIs requiring forecasting and predictive models' creation and training. Historical data at 5-minute granularity for Inverter data and 15-minute granularity for weather station data for 2021 and the remaining months of 2022 were shared by the client for the same. Upon mutual understanding, the KPIs which did not require Forecasting and Predictive model building and training were calculated and made available on the platform, for the purpose of this entire PoC. The missing weather station data in the months of June and July for the data on the platform was made available by using the newly shared weather station data, however at 15-minute granularity. Since the remaining data was ingested at a granularity of 5 minutes earlier, the new dataset was also interpolated to the same granularity of 5 minutes to maintain uniformity and derive effective insights from the analytics.

3. INPUT DATA SUMMARY

"This section provides an overview of the data provided by the solar asset owner for the purposes of this hindcasting exercise. Further, the section provides information on the quality of data, pre-processing details and filtering carried out on the ingested data".

3.1. Data Availability

The summary of Data Availability for the months from June to October 2022 is shown below.

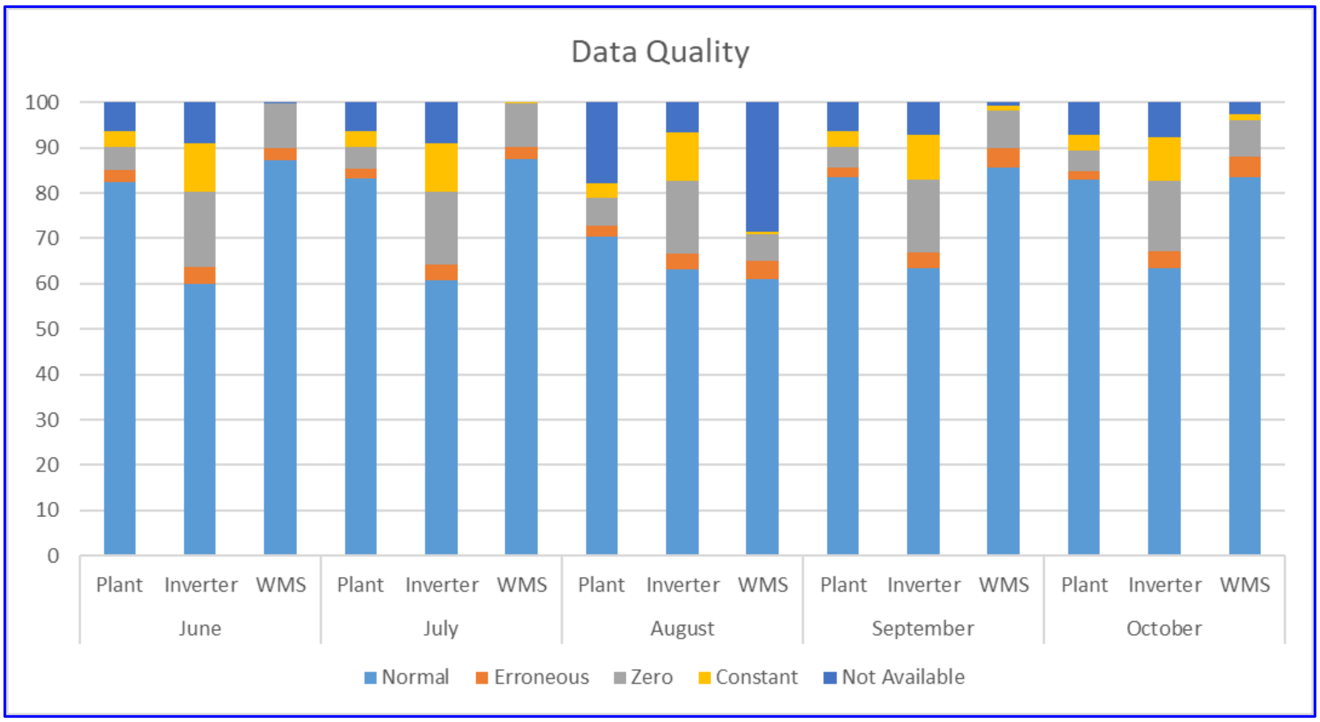


The Plant level data was computed from the Inverter and the weather station data. The data availability at different devices is above 90% for the months of September and October. For the month of August on the other hand, the weather data availability is below 80% due to the fact that, for the days of August 1 - 8th, and August 11-12th, there was blank data in the 1-minute granularity files shared. The data from the

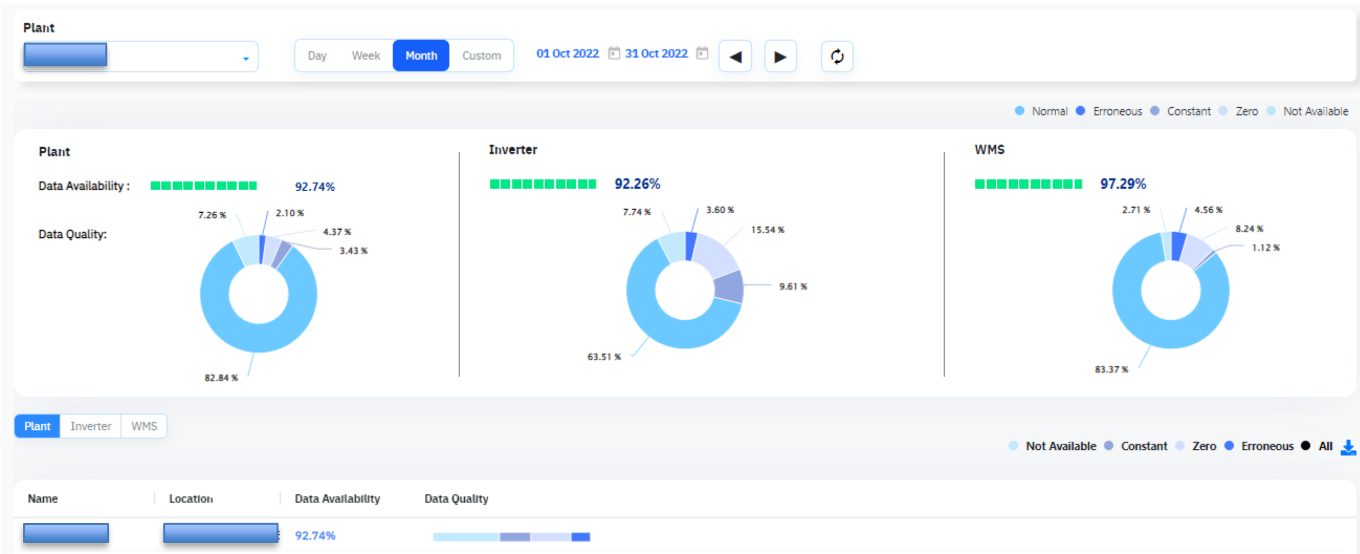
15-minute granularity files is not ingested into the platform for the month of August, as having weather data from two different granularities might have impacted the quality of the analysis for the month. On the other hand, the Weather data for the months of June and July were ingested from the 15-minute granularity files shared as there was almost negligible data present in the 1-minute weather data files shared for this month.

3.2. Data Quality

All the data available for Inverters and WMS was found suitable for the analysis. The summary of data quality at various levels for the months of June to October is shown below. The data governance tool on the platform categorizes the entire dataset based on some pre-defined domain based rules into a few categories – Normal, Erroneous, Zero & Constant. This quality label is assigned only to the period when data was available.



Data Governance considers values for parameters such as frequency, power factor etc. to be communicated throughout the day. As for this plant, these parameters are zero valued in the non-generational hours, data governance is categorizing the data for these parameters as zero valued data. At the Plant level, the zero valued category is due to the zero values present in the “temperature corrected PR” parameter, which was computed by Prescinto at day end and therefore had just one data point for the entire day.

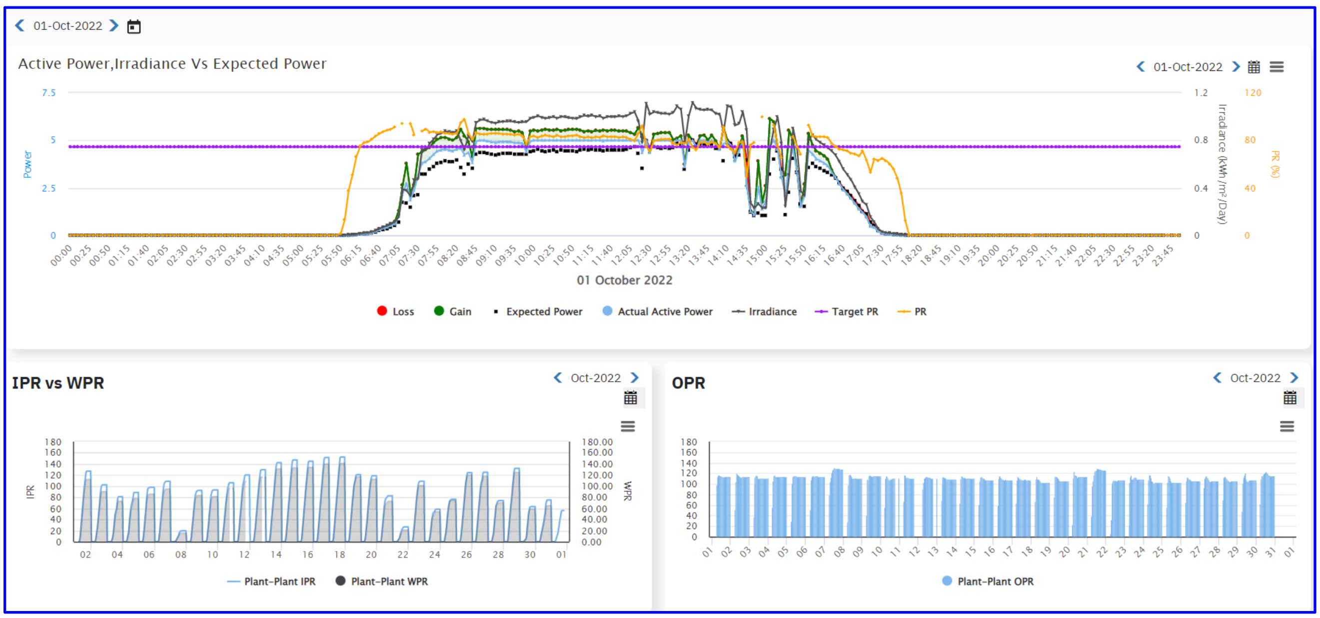


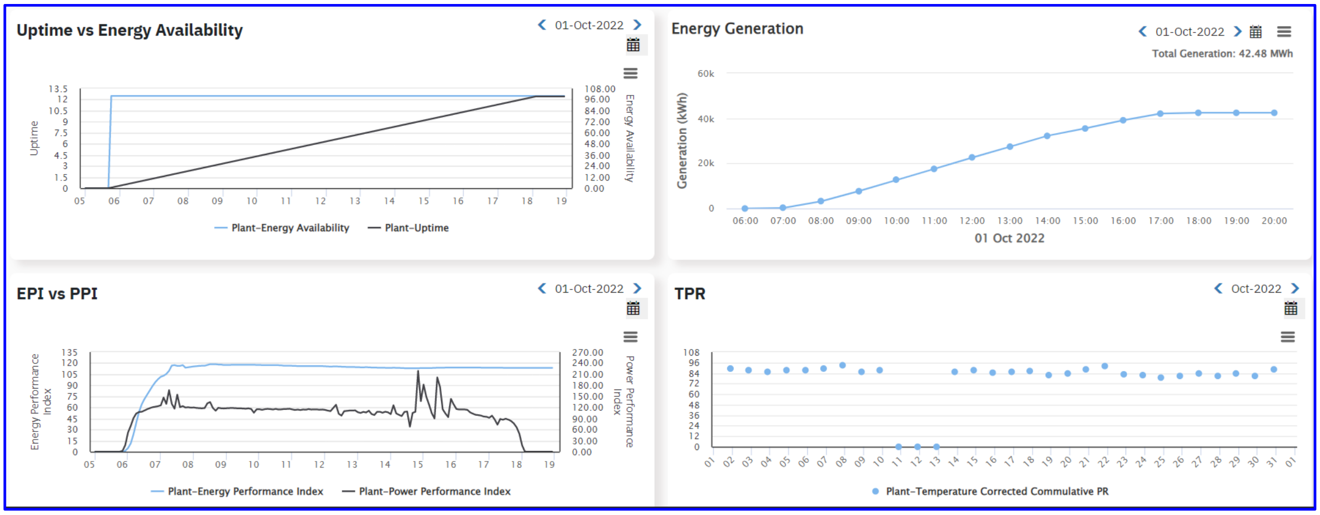
4. MONITORING

“Several Monitoring tools were deployed for the project to give a glimpse of all the possible features that can be seen in a live environment. The details of each of these will be mentioned in the sections that follow”.

4.1. Custom KPIs and Dashboard

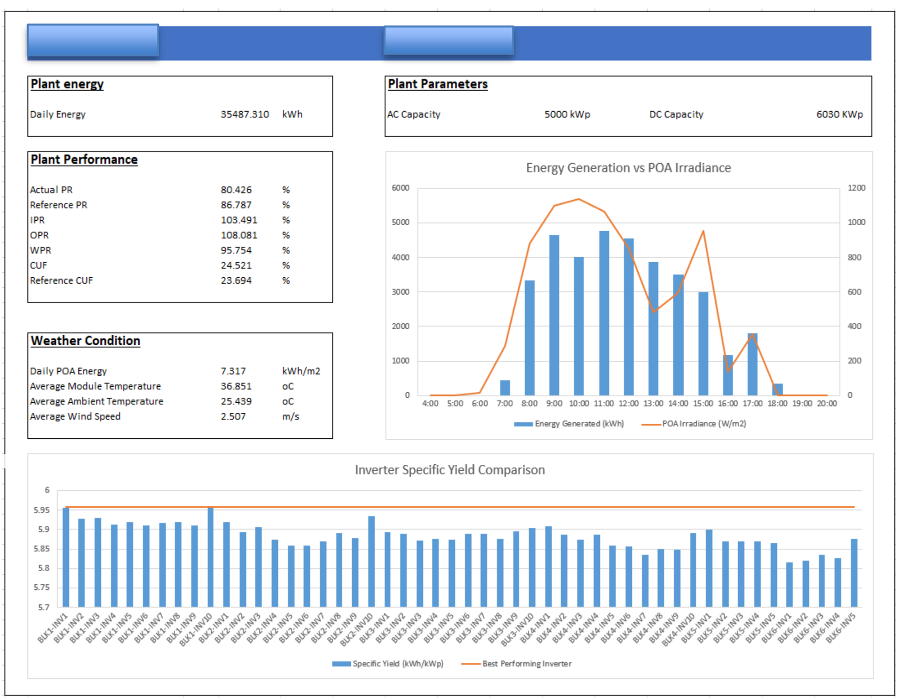
Multiple KPIs based on Prescinto’s best practices, and the ones requested by the asset owner (as per IEC61724) were deployed. A dashboard was designed with all the KPIs deployed. It was named “KPI_Dashboard”, which can be accessed from the Dashboard section.





4.2. Custom Report

A report consisting of the previous day's plant performance, weather condition, inverter comparison was designed to demonstrate the reporting capabilities of the platform. It can be accessed from the Report Viewer page under the Reports section of the Prescinto portal. In a live setup, the same report can be scheduled to be sent in either excel or pdf format to associated recipients on a periodic basis (day, month, quarter etc.)



5. TAHOE ANALYTICS

5.1. About Tahoe Analytics

"This section describes how Prescinto's software can identify underperformance due to various system issues such as soiling, clipping, and curtailment losses. It includes a brief note on how the analytics works to find out areas of improvement and create actionable insights".

In IIOT implementations, it's commonly observed that the signals go out of range. Hence it is imperative that we perform a basic sanity check before the data is consumed for performance analysis.

As was explained earlier, each data point is checked for data sanity before any or all of it is consumed for all downstream analytics. This is where our AI-based algorithm comes into play that creates a correlation between different plant parameters and runs a data quality check before utilizing the same to run further analytics.

Loss buckets refer to the different kinds of losses incurred during production in a solar plant. These loss buckets are set at each device/plant level. i.e., the loss buckets arrived at for each plant/equipment will be different unless we receive a standard exhaustive set of data to capture all different kinds of losses.

The Tahoe Analytics offered by Prescinto can categorize plant production losses into twelve different categories. The same is briefly explained below:

- **Irradiation Loss**: Inadequate sun irradiation can put solar farm operators under tremendous strain. The increasing popularity of renewable energy generation is accompanied by the inherent unpredictability of renewable energy sources, as well as the related financial risk. This risk impacts renewable energy producers as well as an ever-increasing number of stakeholders along the value chain. This bucket categorizes the loss in generation due to shortfall in irradiation received w.r.t. the P50 goals.

- **Temperature Loss**: Thermal loss is induced by rising module temperatures and is a significant performance loss factor, particularly in mono-c-Si and multi-c-Si technologies. The power output of the solar modules is rated at the module temperature, under the standard test conditions of 25oC. The losses incurred in the energy generation of the solar plant due to temperature conditions beyond STC module temperature is categorized as Temperature Loss.

- **Downtime Loss:** This is nothing, but the energy lost due to unforeseen downtimes due to inverters. Since Prescinto directly monitors all the inverter level tags and parameters, it can automatically classify downtime and the associated generation loss in this bucket.

- **Systemic & Cleaning Loss:** Systemic and cleaning losses are arrived at using a proprietary machine-learning algorithm that uses regression-based performance measurement metrics to measure the performance of individual Inverters on a single day, after filtering the Active Power and Irradiance data which is not suitable for analysis. The swing or variation in the performance of the inverters throughout the period of analysis is used to arrive at soiling / cleaning loss. The deviation of the maximum performance of a particular inverter, to the best performance recorded of all the Inverters, throughout the analysis period is used to arrive at the net systemic losses that indicate an underperformance of systemic nature like inverter internal issues, module degradation, permanent or long-term downtimes in the DC array, SCB underperformance, etc. These are the losses which are "fixed" in nature for an Inverter over the analysis duration. The daily deviation of the performance of an Inverter with respect to its best performing day is the basis for arriving at Cleaning or Variable Losses.

- **Curtailment Loss:** Curtailment is the purposeful reduction in the output below what might have been achieved to balance energy supply and demand or owing to transmission restrictions in electric grid power plants. The term is not rigid, and there are various sorts of curtailments. The most prevalent is "economic dispatch" (low market price). Curtailment is a loss of potentially usable energy that may have an influence on Power Purchase Agreements.

- **Clipping Loss:** Clipping loss is the energy wasted in a solar photovoltaic (PV) system because of the inverter reducing its output to meet either its maximum power rating or the maximum permitted power at the grid connection. An optimized PV solar farm must have a DC/AC ratio greater than one so that some clipping losses occur, especially at the start of the project, or else the inverters would be underutilized, resulting in a higher energy cost. Clipping losses are generally a few percent at the start of a project and decrease during the project owing to PV module and other equipment deterioration.

- **Shadow Losses:** Photovoltaic (PV) systems create energy by harnessing the photovoltaic effect, which occurs when sunlight knocks electrons loose in the materials that comprise solar cells. As a result, anytime a cell or panel does not get sunlight because of a shaded blockage, the quantity of power generated by that solar section is reduced. This is referred to as PV system shadow loss.

  Such impediments might originate from a variety of sources, including.

  - Trees, antennae, and poles are examples of nearby things.
  - Other PV panel rows "self-shade"
  - The landscape around the installation location provides horizontal shade.
  - Other considerations include panel orientation, soiling, and differential aging.

- **AC Loss:** AC loss is the energy lost in pushing power from the inverter end to the plant-end Point of Interconnection with the Grid (DISCOM/Client)

- **Inverter Efficiency Loss:** No inverter functions at 100% efficiency, which means that the energy at the output (AC) side is never the same as the energy at the input (DC). The efficiency of most inverters ranges between 96 and 98 percent, however, this figure fluctuates depending on the input DC power and voltage. Instead of taking the inverter efficiency tag directly, Prescinto takes both the DC side and the AC side power tags and calculates the energy lost in converting from DC to AC.

Prescinto calculated and classified days of clipping, curtailment, and shadow using an AI-based pattern recognition technique and quantified the generation loss.

5.2. Generation vs Irradiation

"In this section, the plant's performance based on generation and irradiation levels will be detailed. The plant's highest performance levels appear to be around 5% higher than the PVSyst targets. The lowest performance level with ~9% lesser than the PVsyst targets was recorded in the month of August."

The Plant's performance was analyzed and evaluated based on the data from August to October's data owing to the delayed availability of the weather data for the months of June and July. The target and actual generation vs irradiation for the months is presented below *(The Target, Expected and Actual numbers were taken from the "Target vs Actual" page of Tahoe)*.

Month	Radiation (kWh/m2)		Production (MWh)			Target PR (%)	Actual PR (%)	Difference in PR (%)
	Target	Actual	Target	Expected	Actual			
June	194.7	178.43	919.58	842.75	907.75	78.33%	84.37%	6.04%
July	210.8	215.54	989.35	1011.6	1002.24	77.83%	77.11%	-0.72%
August	246.4	167.93	1141.48	777.98	685.09	76.83%	67.66%	-9.17%
September	233.8	205.21	1058.15	928.75	951.7	75.06%	76.91%	1.85%
October	236.9	173.23	1062.99	777.3	833.99	74.41%	79.84%	5.43%

The target values are derived from the month's PVSyst numbers adjusted for yearly average module degradation. Expected production for the month is the pro-rated generation with respect to the actual irradiation numbers. The Actual PR is greater than Target PR for June and October by approximately **5%**. For the months of July and September, the actual PR is almost equal to the Target PR. The least Actual PR is recorded in the month of August, which is **9%** less than the Target PR. There seems to be a huge performance differences between the months of June to October. Hence, in the analysis for plant performance for the months of August to October, each of these months have been analyzed separately.

5.3. Loss Analysis

"In this section, the details of the monthly losses incurred, their acceptable limits, the possible reason(s) for the losses will be detailed. The Plant's performance is optimal in the months of June and October, followed by September, July, and August."

The loss distribution for the months of June to October, taken from Loss Waterfall section of Tahoe Analytics, is as follows. This table also has the information on the acceptable limits of each of the losses for comparison. We can see that June and October months have the best generation w.r.t. target and minimal losses. The details of individual losses will be dealt with in the sections that follow.

	June	July	August	September	October	Acceptable Limits
Days considered	30	31	21	30	26	>15
Actual Production	98.71%	101.30%	88.60%	89.94%	93.54%	
Downtime Loss	0.00%	0.00%	0.19%	0.02%	0.13%	<1%
Efficiency Loss	0.07%	0.07%	0.06%	0.07%	0.07%	<1%
AC Loss	0.00%	0.00%	0.00%	0.00%	0.00%	<2%
Systemic Loss	0.31%	0.58%	18.69%	2.22%	1.51%	<=3%
Cleaning Loss	0.09%	0.00%	2.19%	8.04%	0.98%	<=3%
Snow Loss	0.00%	0.00%	0.00%	0.00%	0.00%	0%
Shadow Loss	0.76%	1.90%	1.39%	0.65%	0.01%	<1%
Clipping Loss	0.00%	0.00%	0.10%	0.68%	3.52%	
Curtailment Loss	0.70%	1.15%	0.57%	0.13%	0.00%	<1%
Grid Out Loss	0.00%	0.00%	0.00%	0.00%	0.00%	0%
Temperature Loss	2.22%	3.08%	4.54%	4.92%	5.19%	<6%
Radiation Loss	8.35%	-2.25%	-0.61%	12.23%	12.81%	
Unidentified	-11.21%	-5.82%	-15.72%	-18.89%	-17.77%	
Target Generation	100.00%	100.00%	100.00%	100.00%	100.00%	

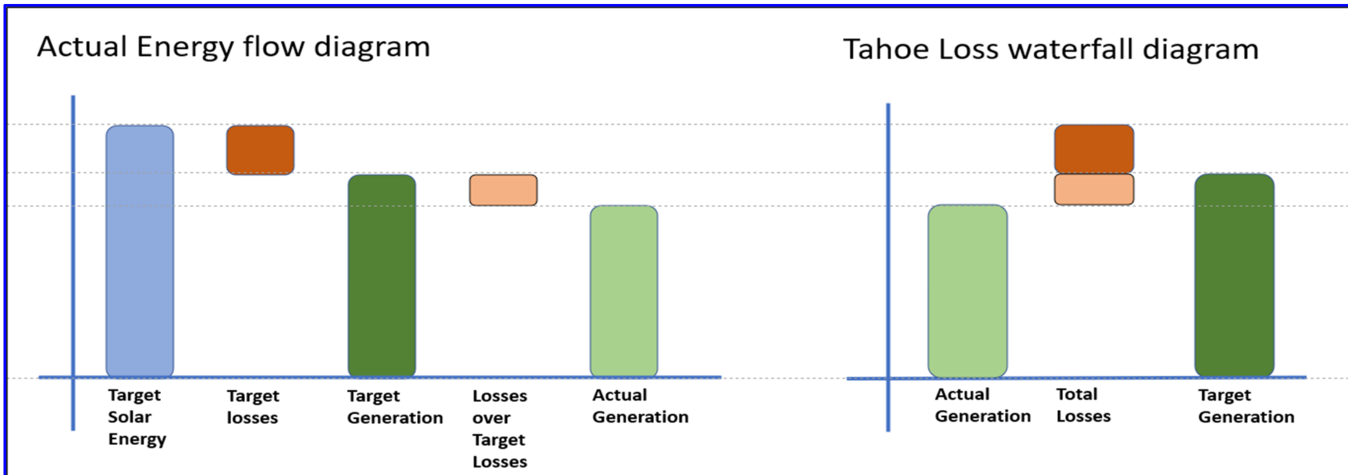
A sample calculation for the losses incurred in the month of September is attached here. As the losses such as Clipping, Shadow, and Curtailment are based on pattern recognition algorithm, the calculation for these losses cannot be provided. Additionally, the systemic and cleaning loss calculations require a significant amount of computation, which is too strenuous to be calculated in excel. Hence, the way these losses are calculated is presented for representation purposes.

Tahoe_Loss_numbers_calculations.xlsx

Note: The calculation for the cells highlighted in purple is inaccurate due to the 15min to 5min interpolated data considered for the two months of June & July 2022. This is also because Tahoe works on the fundamental concept of the correlation behavior between individual inverter active power and weather station recorded irradiance.

It is evident from the above table that the Actual production + Losses is exceeding the Target Generation by a significant amount. It can happen because of the following reasons:

a) Selection of Target Generation and Irradiation numbers: The Loss waterfall page compares the Actual Generation with Target Generation. It may happen in many cases that the set targets are lower than the actual generation capacity of the plant. But, in this plant, the selected targets are PVSyst Targets, which are adjusted for Plant average module degradation of (2.5 + 0.6) % compared to the base year, 2020. Though there is module degradation of 3.1%, the generation achieved due to the DC overloading in this plant, which is 1.206 times of the total Inverter AC Capacity, more than compensates for the 3.1% decrease in performance of the plant.
b) Tahoe's calculation of total Losses: Tahoe calculates the total absolute losses present in the plant. These total losses arrived by summing up the target losses considered by PVSyst and additional Losses. Ideally, the difference between the Actual and Target Generation is due to additional Losses and not total Losses. Considering additional losses alone requires the information on Target Losses considered by PVSyst. As not all clients can provide the PVSyst consideration of these target losses, Tahoe is designed in a way to calculate total absolute losses alone. The picture shown below explains this.

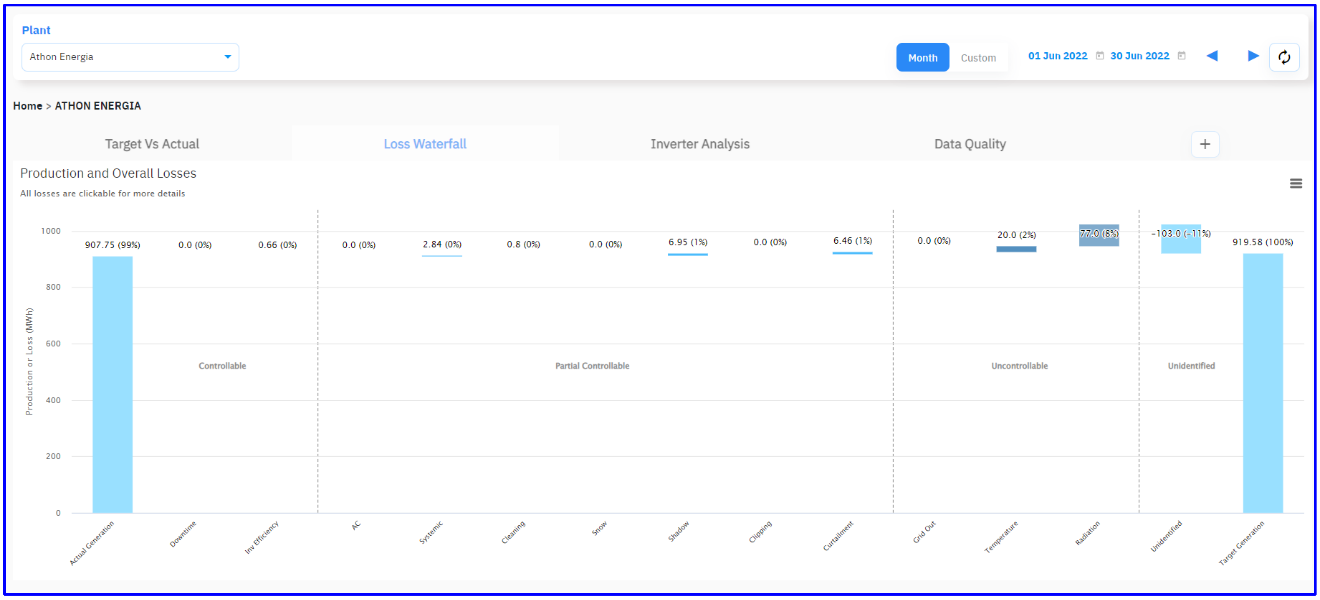


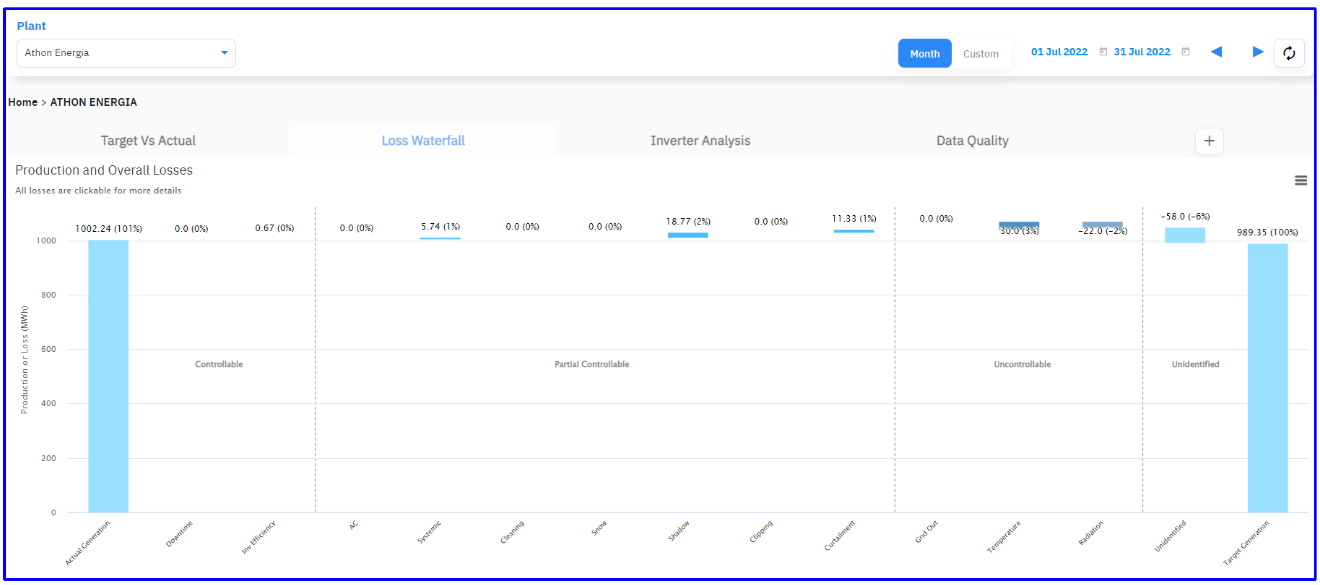
Target Solar Energy:	*The target solar energy incident on the solar panels in the plant (Wh).*
Target Losses:	*Target Fixed Losses* **+** *Target Variable Losses*
Losses over Target Losses:	*Radiation losses* **+** *Fixed Losses over Target Losses* **+** *Variable losses over Target Losses*
Total Losses:	*Target Losses* **+** *Losses over Target Losses*

Note: Tahoe doesn't differentiate between "*Target losses*" and "*Losses over Target losses*" as it would require the information on Target / PVSyst losses which not all the clients can provide. Also note that "*Target Solar Energy (Wh)*" is not the same as "*Target Insolation (Wh/m2)*".

5.3.1. Loss Analysis for June and July

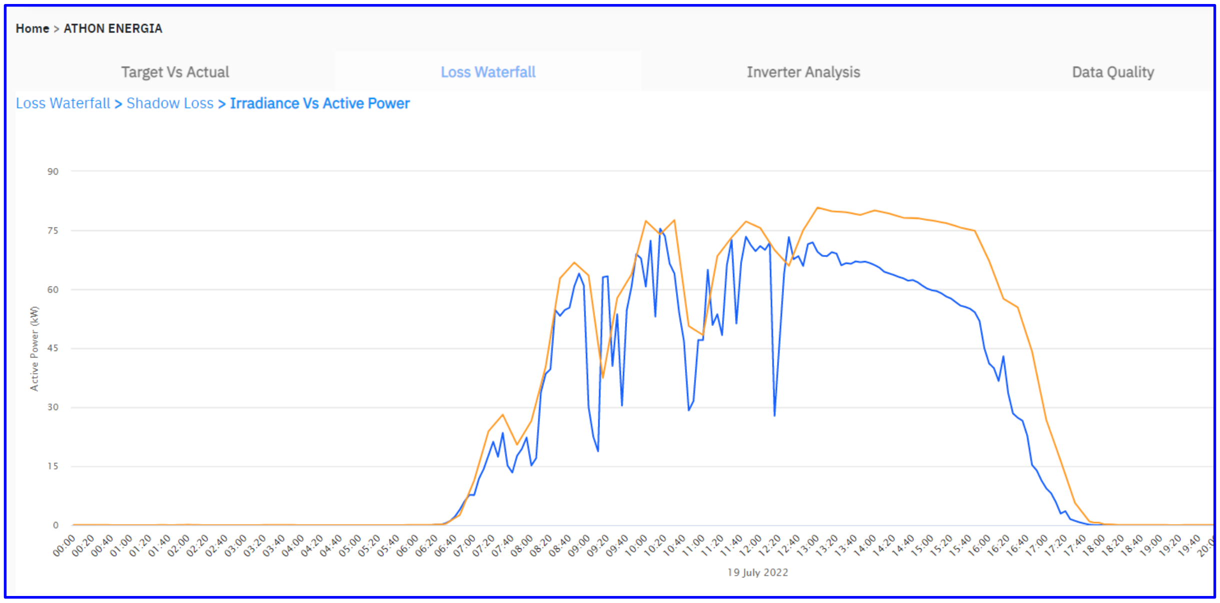
"In this section, the details of individual losses that were incurred in the months of June and July are presented. For these months, leaving cleaning and systemic losses aside, there are considerable shadow and curtailment losses."



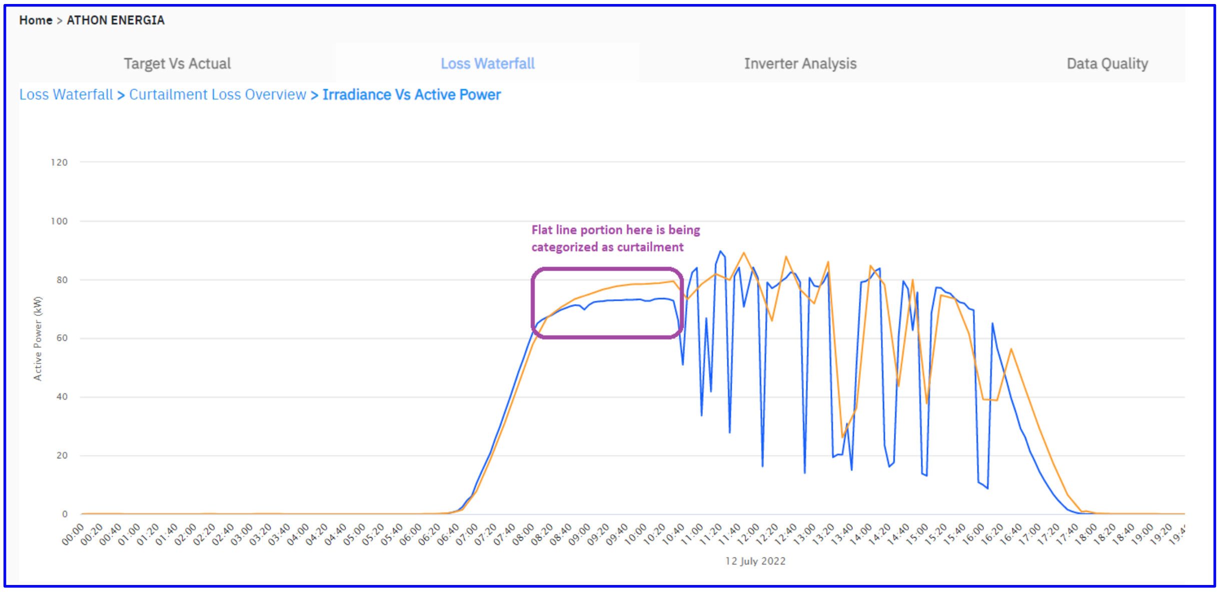


For the months of June and July, the weather station data considered is a 5 min interpolated data from the 15 min data shared by the client. As the systemic and cleaning losses are highly dependent on the correlation between individual Inverter Active Power and POA Irradiance, the values obtained for these two losses are comparatively less accurate for the months of June and July due to poor correlation coefficient.

There are shadow losses of 0.76% and 1.9% in June and July respectively. An example for the loss can be clearly visualized in the following trend of Active Power and Irradiance for June 19 for BLK3-INV3, taken from Shadow Loss chart of Tahoe. We can see a significantly less power output in the second half of the day.

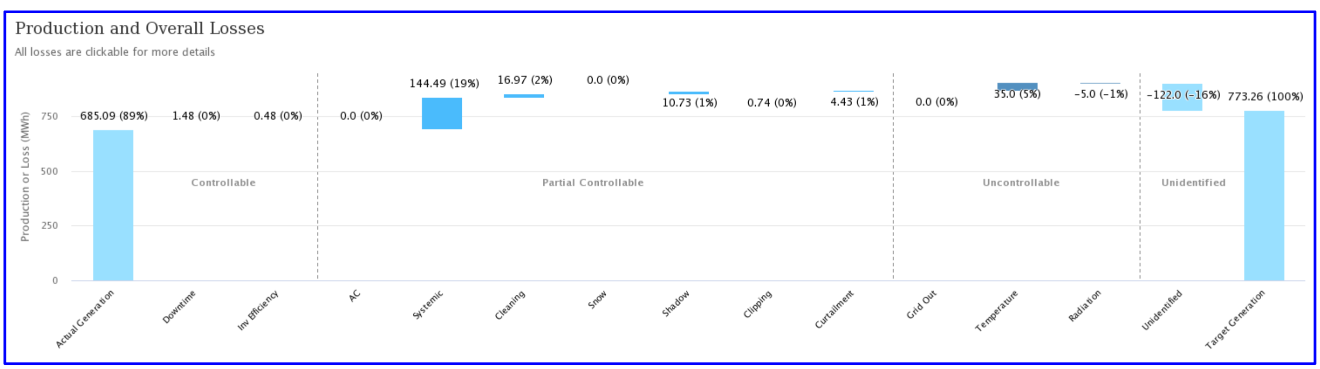


There is about 0.7% and 1.15% Curtailment loss in the months of June and July respectively. An active power pattern is classified as curtailment when the value of active power follows a constant pattern over a period when irradiance is changing. This can be clearly seen from the plot of Irradiance vs Active Power under Curtailment Loss section of Tahoe for BLK1-INV2 inverter on 12th July. There is a constant Active Power region between 8AM to 10AM for the inverter on 12th July, which is classified as curtailment.



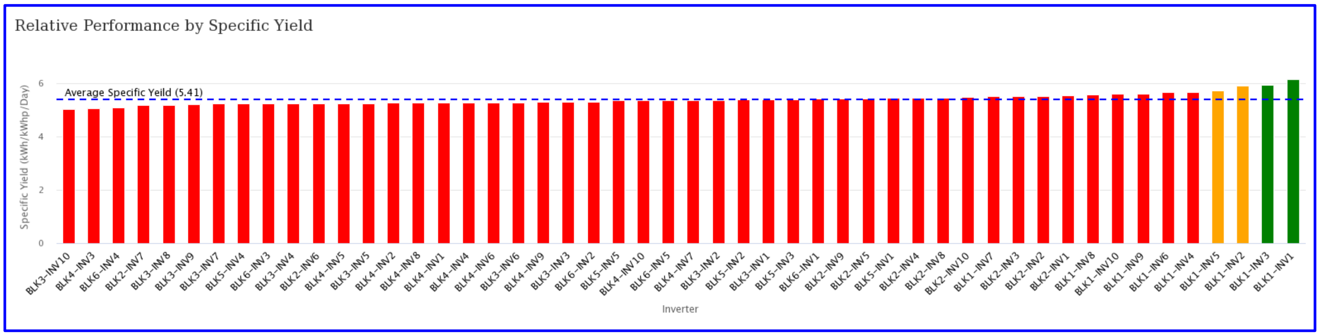
5.3.2. Loss Analysis for August

"In this section, the details of individual losses that happened in the month of August are presented. A top-bottom analysis for root cause identification for this month is presented. It was found that the performance of a few Inverters started increasing to their optimal levels by the end of this month. The lower performance levels were possibly due to issues at MPPT section or trackers installed in the inverters."



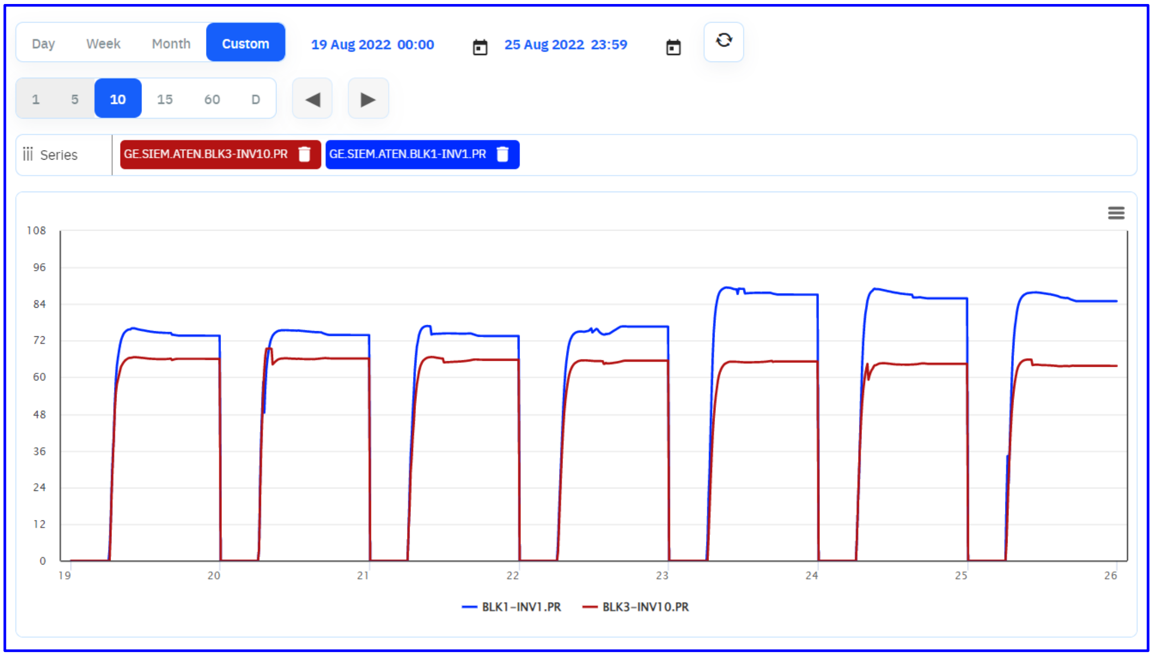
From the above Loss distribution table for August month, we can see that August has abnormally high Systemic Loss (~18.69%), a slightly higher shadow Loss (~1.39%), a slightly higher cleaning loss (~2.19%), and a slightly higher Curtailment Loss (~0.57%) as compared with the month of October. Each of these losses will be dealt in detail in the following sections.

Systemic and Cleaning Loss: Systemic Loss for individual Inverters is calculated by taking its best recorded performance and comparing it with the best performance recorded among all the Inverters. An abnormally high systemic loss indicates that one or many Inverter(s) have recorded significantly higher performance in at least one day during the analysis period, compared to the rest of the Inverters.



From the specific yield chart in the Inverter Analysis page of Tahoe, we can see that the best performing inverter, has a specific yield of 6.16 kWh/kWp which is 13.86% higher than the average inverters' specific yield of 5.41 kWh/kWp. The lowest performing inverter, BLK3-INV10 has a specific yield of 5.04 kWh/kWp, which is 6.8% lower than the average inverters' specific yield. This shows that there is at least one Inverter with a significantly higher performance than the rest of the inverters, causing high systemic loss as noted by the loss waterfall diagram.

This behavior can also be seen using the trends page under the Analytics section in Prescinto platform. Plotting the PRs of BLK1-INV1 and BLK3-INV10 which are the best and the worst performing inverters with respect to their Specific yields, we can clearly see that the PR of BLK1-INV1 has improved from around 70% to 85% between August 19 to 26, while BLK3-INV10's PR was around 65% throughout the week.



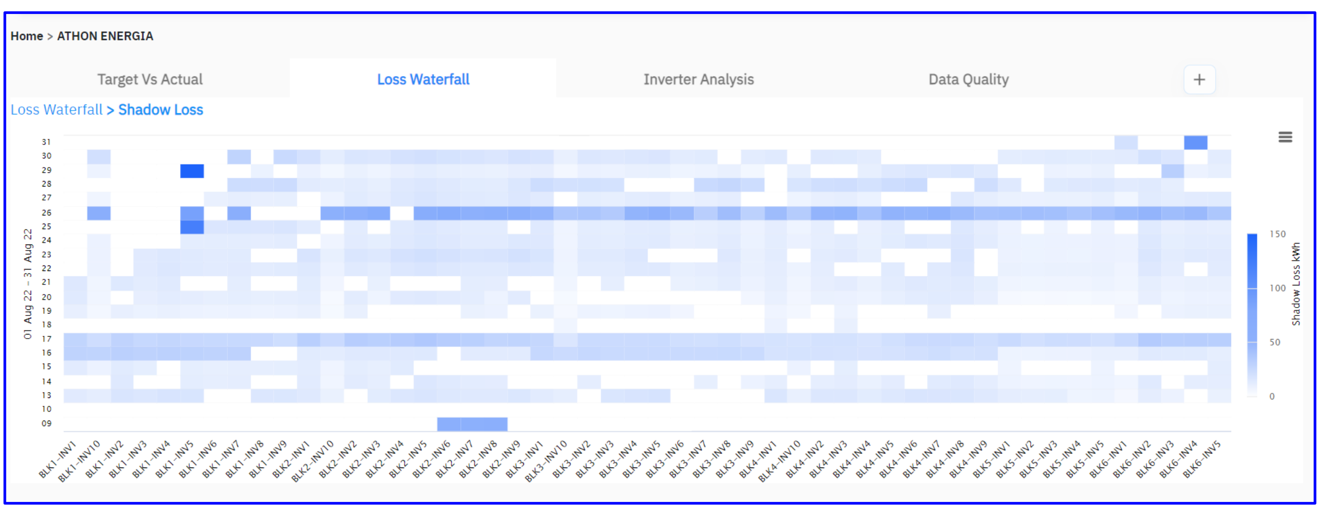
Digging deeper into the PRs of other Inverters shows the same pattern of Increasing PR. The following plot has been generated from the *Profiling* page under the Analytics section of the Prescinto platform. We can also see the variation in PR in various Inverters. This variation in performance is being categorized as Cleaning Loss.

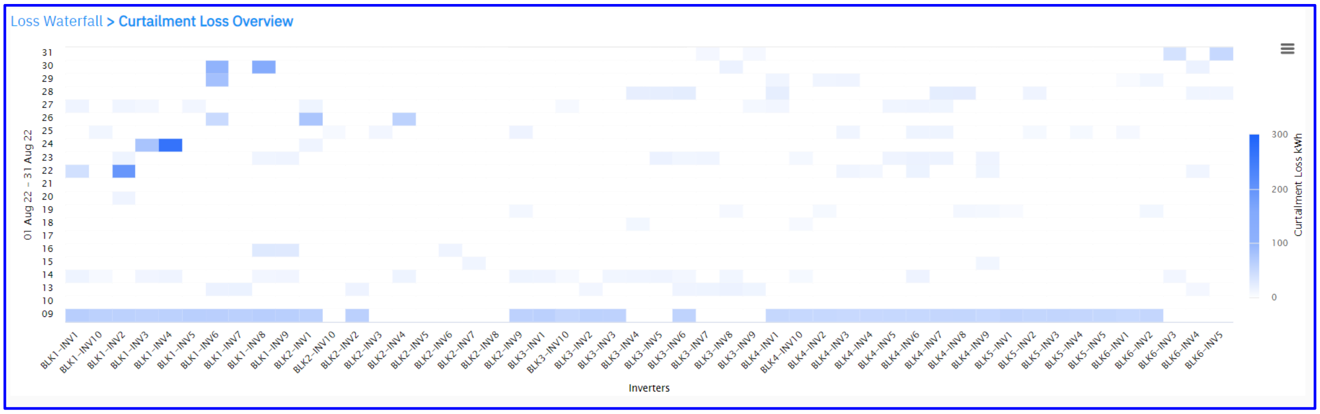
This pattern of increasing performance started happening only after August 21 and continued through September 15. Noting that the Inverter Efficiency loss is 0.06% during this month, it seems that the loss in generation before August 22 is **not due to the Inverter action, but at or before the DC conversion section of the Inverter, i.e. in the MPPTs or in the trackers.**

Plotting the Individual strings currents of BLK1-INV1 for the days of August 21 to 23 (shown in the chart below), the days during which the Inverter performance increased significantly, we see that there is a significant increase in the string current output. However there are no changes in the shape of the Current curve with respect to the POA Irradiance, before and after the performance jump. **This tells us that it is not a tracker issue.**

Plotting the String Voltages and AC Voltages show that there are negligible changes in the voltage levels pre and post the performance jump. **This strengthens the idea that the issue might be in the MPPT section of the Inverters and not on the AC output section.** This plant level issue in the MPPT section can happen in the case when there is manual curtailment, or faulty PPC, etc.

Curtailment and Shadow Loss: During the period in which the performance jump occurred (after August 21), few Inverters' Active Power was erratic. This erratic Active Power during the morning (before 10AM) and evening (after 3PM), has been classified as Shadow Loss. The rest of the period's Active Power has been classified as Curtailment.



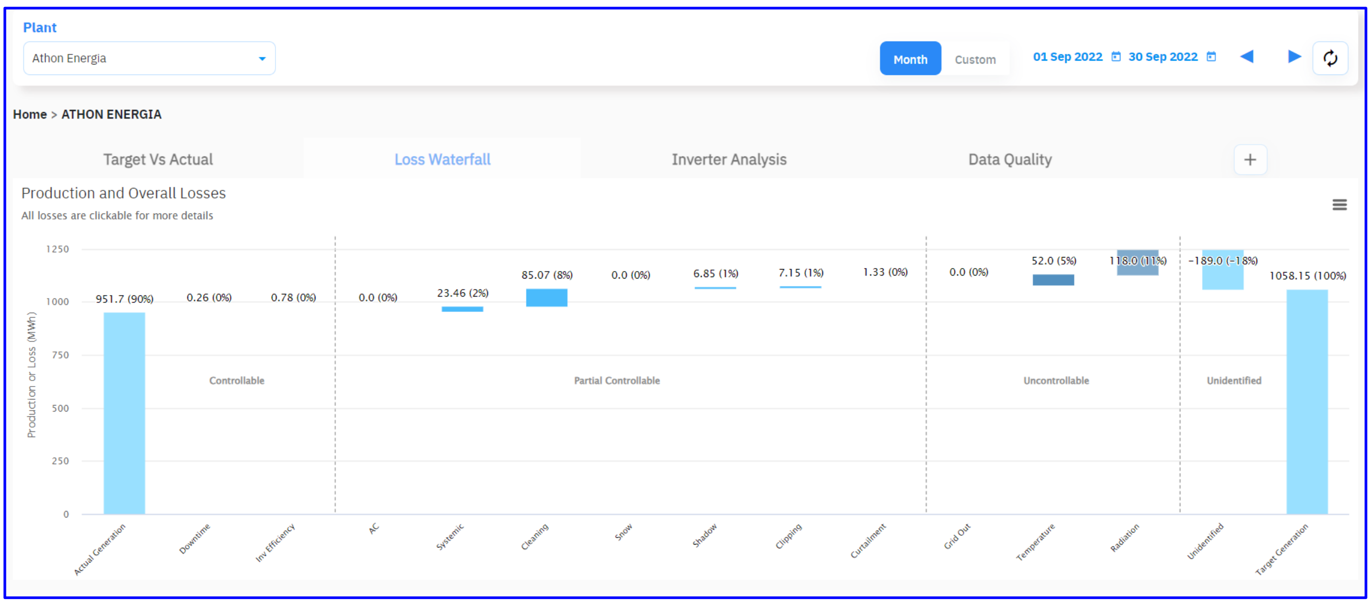


We can see this in the shadow and curtailment loss distribution chart, which can be visualized after clicking on individual losses in the Loss Waterfall chart. These loss distribution charts show a higher concentration of losses during the transition period. This performance drop and raise pattern within a day is representative of tracker related issues.

An important conclusion can be drawn from the above graph, which is that the POA irradiance data is a good quality data. This can be inferred from the fact that, at similar irradiance levels in August 21 to 23 (as noted in the previous charts), the individual Inverter performance started increasing one after the other and not all at once, showing that there are good and bad performing inverters on the same day, with the performance of the best inverter not crossing any upper limits of possible performance levels. This shows that the issue is localized in nature, and there is no global effect of any factors. Hence, the readings of POA Irradiance (which is a global factor) are trustworthy.

5.3.3. Loss Analysis for September

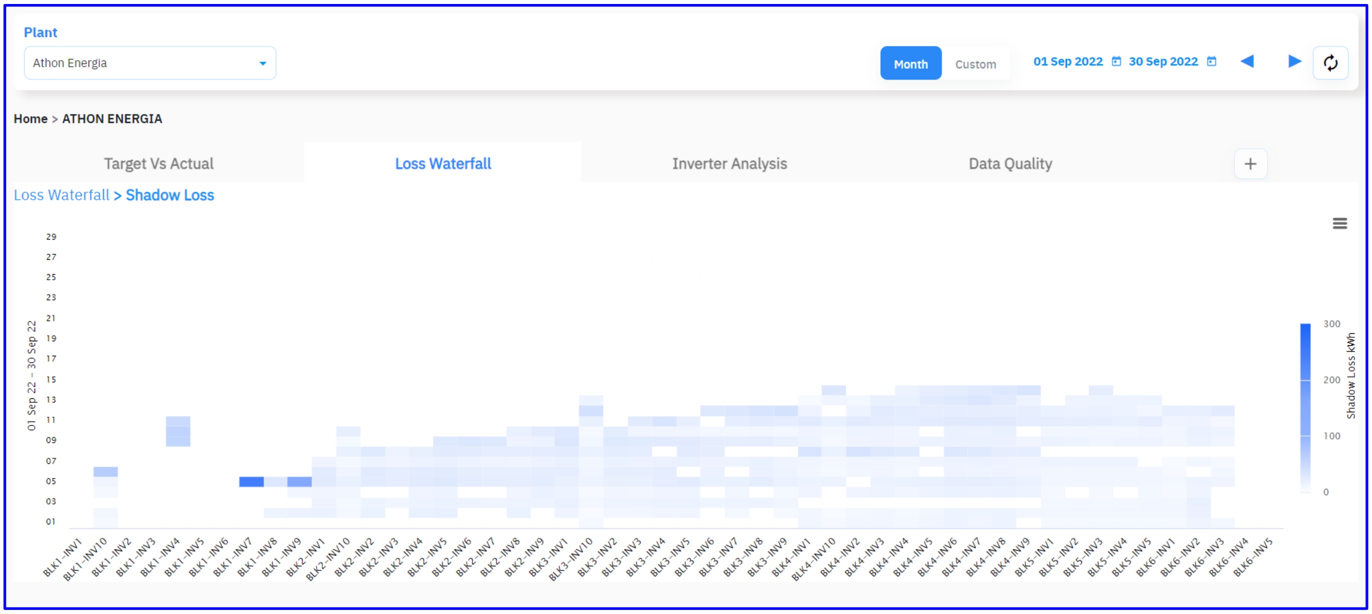
“In this section, the details of individual losses that were incurred in the month of September are. It was observed that in this month, the performance of all the inverters started improving to their optimal levels. These changes were being classified as high cleaning and low systemic losses”.

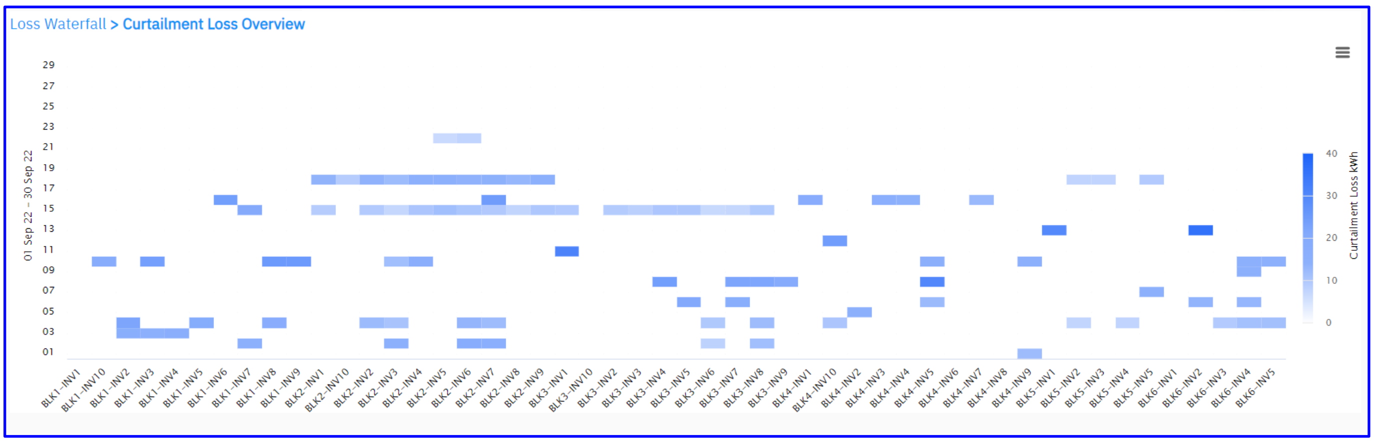


For the month of September, the Cleaning Loss is abnormally high (~8.04%) and the Systemic Loss is at a similar level to October (2.22% vs 1.51%), slightly higher Shadow Loss (0.65%) and a slightly higher Curtailment Loss (0.13%).

This behaviour can be explained by the same process followed for analysis for the month of August. As noted in the Loss analysis of August, there is a performance jump that occurred in all the Inverters starting from BLK1-INV1, between the periods of August 21 and September 15. The Systemic Loss is lower as all the Inverters transitioned from a lower performance range (PR of 65% - 75% before August 21) to a higher performance range (75% to 85% after September 17). This swing in PR can be seen clearly in the chart below. As there is a significant performance variation, the Cleaning Loss is huge.

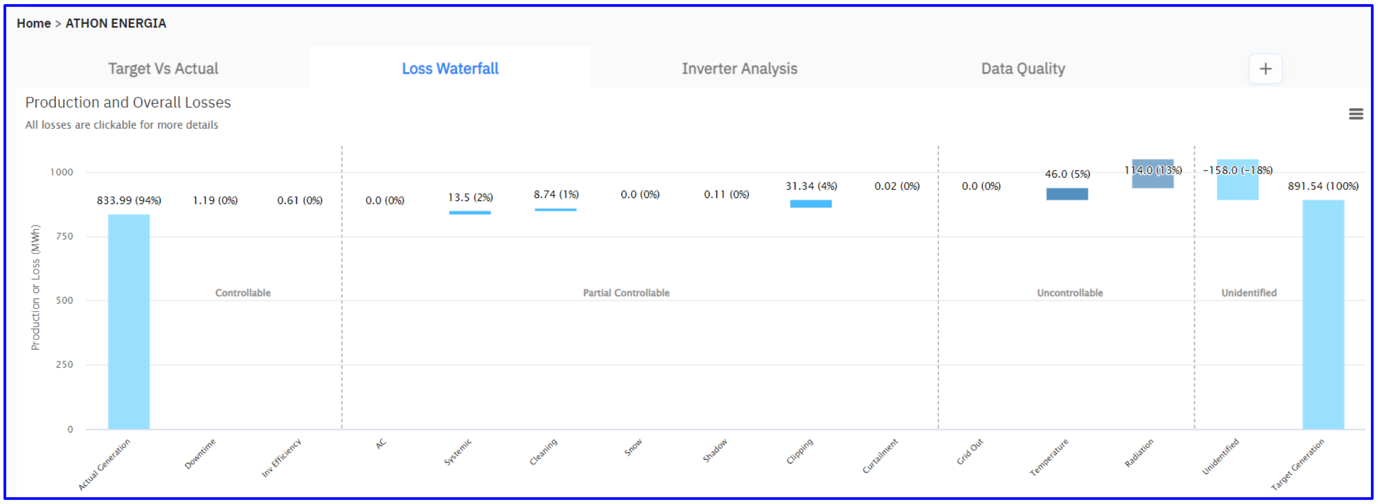
The Curtailment and Shadow loss mostly exist before September 15, as evident from the Inverter level curtailment and shadow loss charts attached below, which were obtained by clicking on the losses from the Tahoe's Loss waterfall diagram. This behaviour is as expected from the observations made in the previous sections.


Plant
Athon Energia
Month
Custom
01 Sep 2022
30 Sep 2022
Home > ATHON ENERGIA
Target Vs Actual
Loss Waterfall
Inverter Analysis
Data Quality
Loss Waterfall > Shadow Loss
01 Sep 22 - 30 Sep 22
Shadow Loss kWh


Loss Waterfall > Curtailment Loss Overview
01 Sep 22 - 30 Sep 22
Curtailment Loss kWh

5.3.4. Loss Analysis for October

"In this section, it is shown that the losses incurred in the month of October were minimal, with the plant's performance again reaching back to its optimal levels".



The plant is at an optimal performance level with no loss value exceeding the acceptable limits. There is a systemic loss of 1.51% of the target generation. The Cleaning Loss is minimal owing to no drastic changes in Inverters' performance across the days. There is also negligible curtailment loss and a very negligible shadow loss.

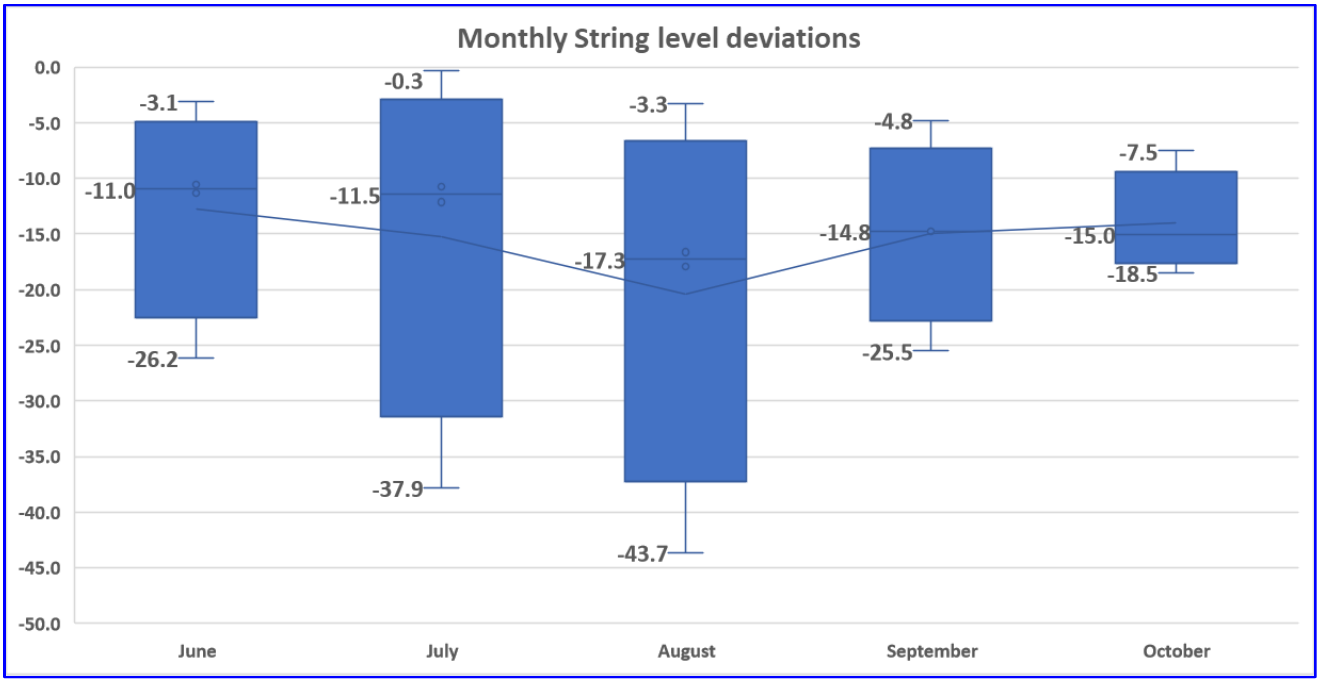
6. STRING ANALYTICS

6.1. About String Analytics

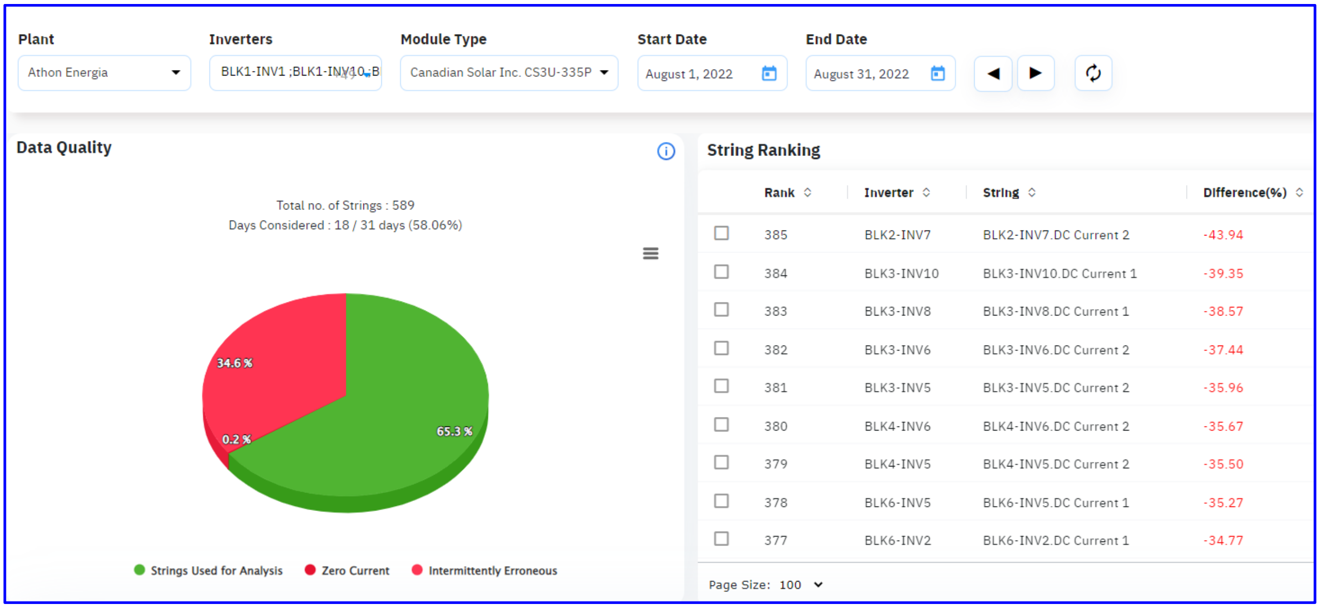
String analytics (SA) is a novel string level underperformance analysis tool created by Prescinto. For identifying the underperforming strings, the SA tool analyzes the current output of all the strings in the plant on a given day after normalizing them for DC capacity, POA Irradiance, and module temperature values. The normalized currents of each string are compared with the best performing string, and the deviation percentage from the best performing string for each day is calculated. These deviations are calculated for a given period and the average deviation w.r.t. best-performing string within each module group is calculated. The strings are ranked in performance based on their average deviation figures. This analysis is usually carried out using two weeks' data, to minimize the effect of arbitrary noise, and to arrive at a deviation number which is the best indicator of the string's actual health. The strings which have breakdowns, strings with zero and constant current values, and strings with intermittently erroneous current values are identified, categorized separately and excluded from the analysis.

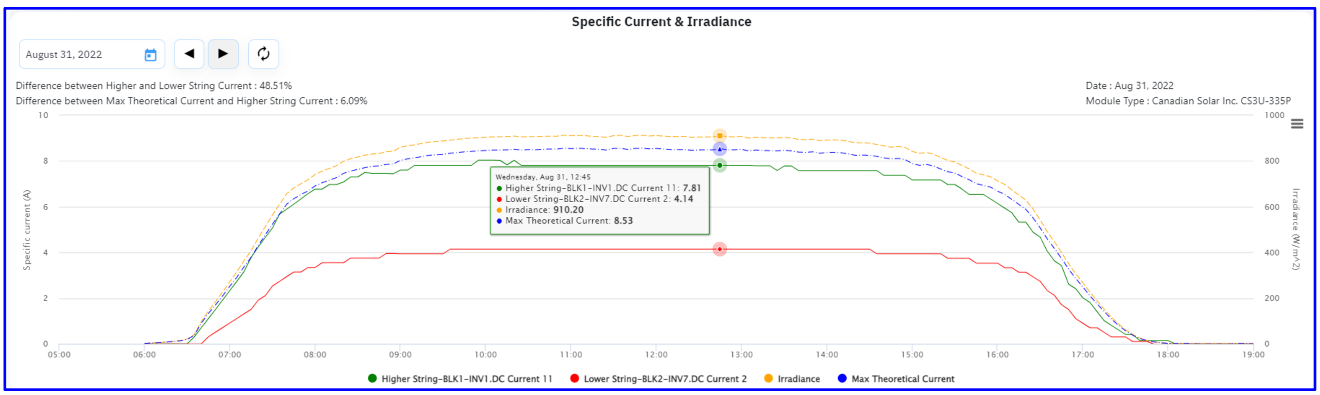
6.2. Observations

"At a string level, the deviations in performance between strings of all the inverters in the plant were around highest in the month of August, followed by July and September. The median deviation of strings in the month of June is the lowest and the string deviation range in the month of October is the least of all the months"

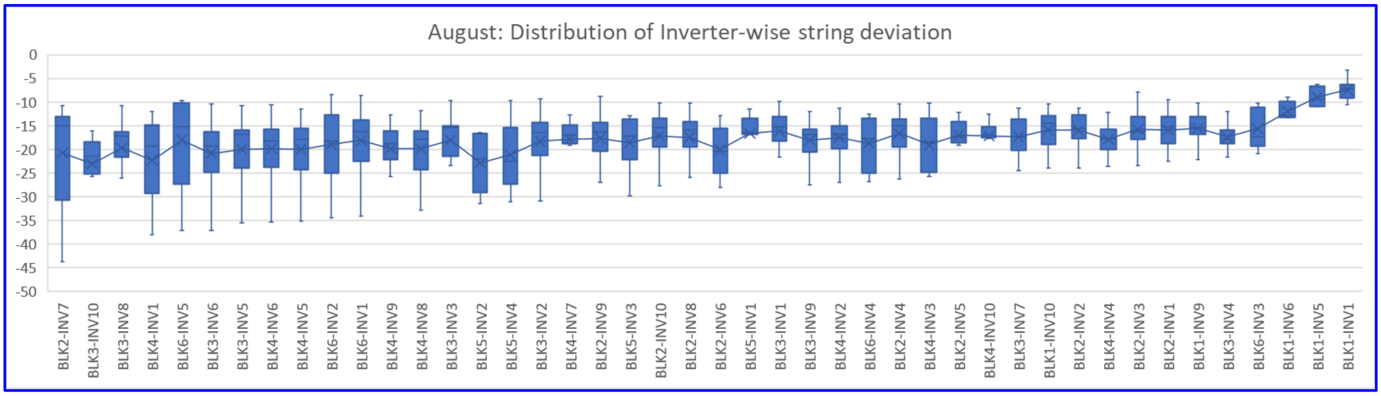


For this project, we have seen rapidly changing performance levels for the five months from the previous sections. A similar observation can be seen from the string analysis tool. For each of these months, the string deviation list is downloaded and the minimum, maximum, and median values of deviations were calculated for individual Inverters. The resultant chart is shown above. We can clearly see that the month of August has the highest variation in string level deviations, followed by July and September. Even though the deviation range in June is higher than in September, the median deviation of strings in June is lower than that of September. The month of October has the lowest spread in the deviation levels of strings, but the minimum deviation is higher than the rest of the months. Thus, there is significant scope for generation improvement at the string level performance as of the 31st of October, even though the Inverter level losses are lower. Snapshots of the strings list and chart of the best and the worst performing strings from the String Analysis tool are attached below.

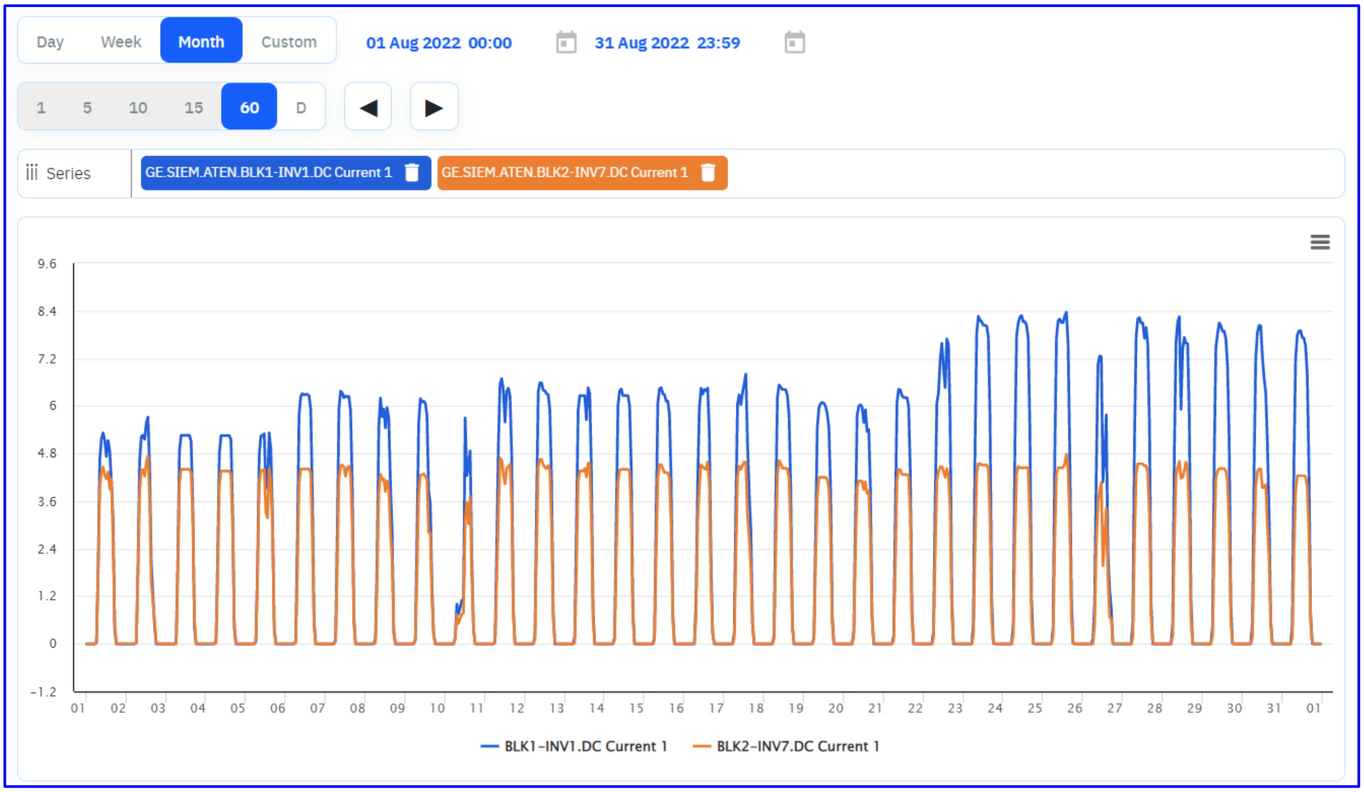




In the month of August, the deviation of strings is in the range of 2.5% to a maximum of ~45%. The strings of Inverters BLK1-INV1 as a whole are the best performing with deviations in the range of 2.5-10%. The worst performing inverter is BLK2-INV7 with string deviations in the range of 10-45%. This huge deviation is due to the fact that BLK1-INV1 performance has drastically improved in the last week of August as noted in the Tahoe analysis for August.

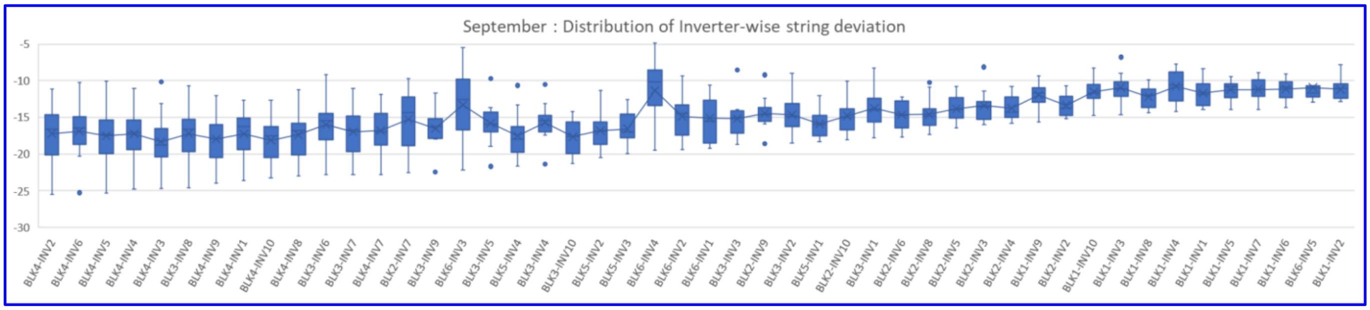


This deviation in performance can be clearly seen from the trends plot for one of the strings of BLK1-INV1 and BLK2-INV7 below.

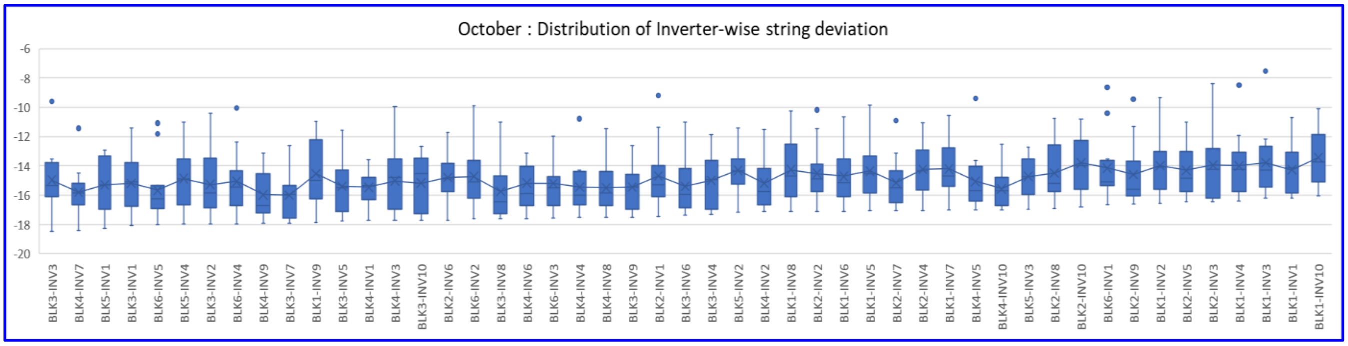


In September, the distribution of string deviations is in a much smaller range of 5-25%. A few inverters have strings with significant variations in performance, for example, the strings of BLK6-INV3, BLK6-INV4. In the case of BLK6-INV3, String 1 was performing much lower than String 10 of the same inverter, until

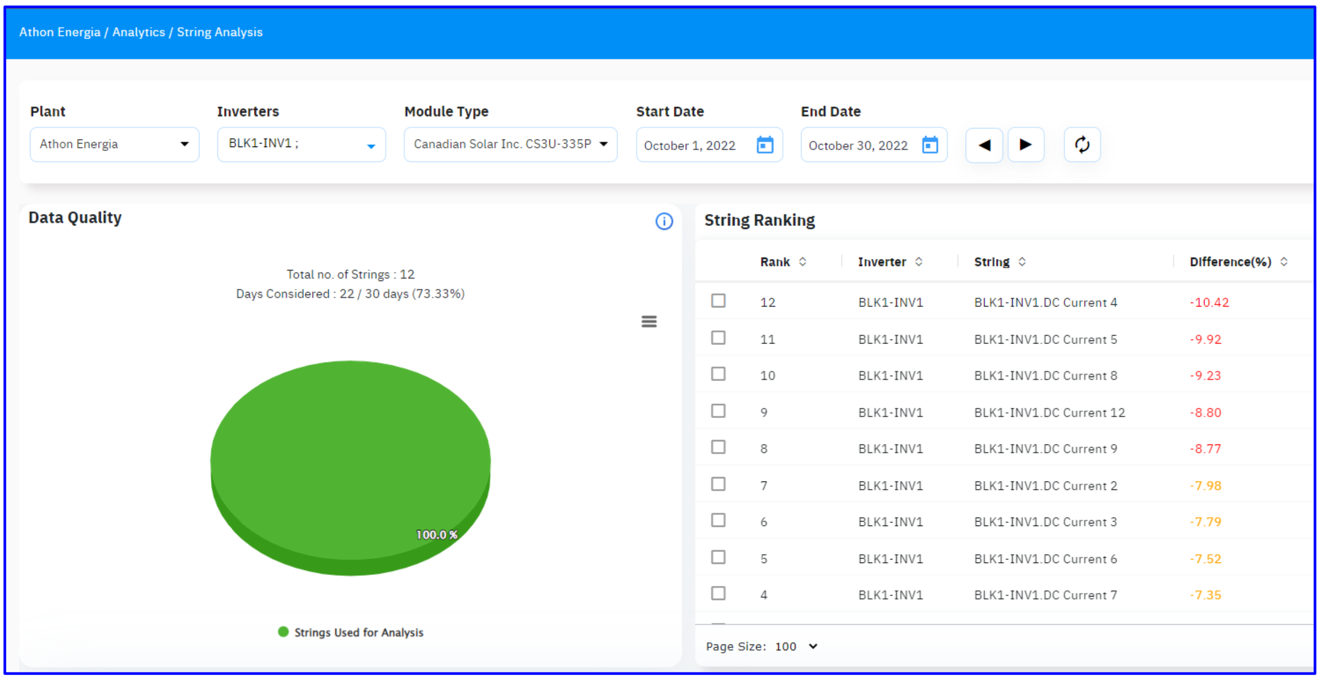
September 13, and on a similar performance level to that of String 10 after September 14. These swings in string current output resulted in variations in performance at Inverter level, which was classified as Variable or Cleaning loss.



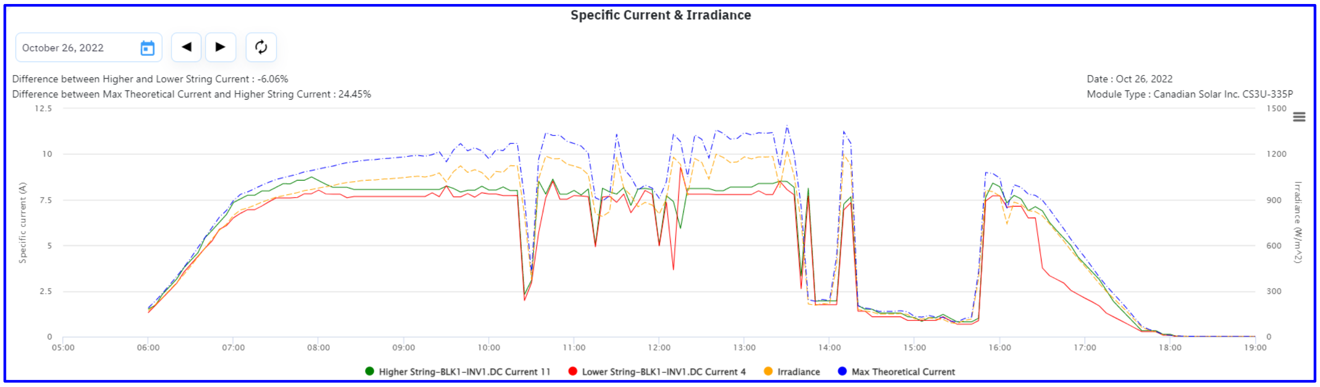
In October the performance range of all the inverters is in the tight band of 12-18%. This behaviour of similar performance range matches with the least cleaning loss in the Tahoe analysis for this month.



On running String Analysis for BLK1-INV1 alone, we find that there is significant deviation in performance among its strings, which can be seen from the below attached string list taken from the String Analysis page.



We can see that string 4 is the worst performing string with deviation of 10% and string 11 is the best performing one in the Inverter, with deviation of 3%. A snapshot of the two strings is presented in the chart below, taken from the "Specific Current and Irradiance" chart of String Analysis.



This behaviour is observed in multiple Inverters. A list of all the strings underperforming by more than 15%, and the best performing string in each Inverter is compiled in the excel sheet below, which can be used for string rectification activity for generation improvement.

Oct_string_dev_15above.xlsx

(Please note that this list is compiled by selecting all the inverters (entire plant), and the start and end dates being Oct-01 and Oct-30. Thus, the deviations observed while selecting a single Inverter and all the Inverters would be different)

6.3. Recommendation

For the month of October, the list of strings that are underperforming by more than 15% are shared in this Excel sheet below.

Oct_string_dev_15above.xlsx

The string-level correction activity, which has shown significantly promising results in improving the generation of plants for many of our clients, involves the following steps:

1. Visual inspection and correction of the strings for soiling and vegetation impact.
2. Visual inspection and module replacement in case of the strings with module related issues such as damaged modules, de-laminated modules, burnt junction diodes, hotspot decolorization.
3. Visual inspection and correction of electrical connectivity issues such as loosened module MC4 interconnects, mismatch in connected modules in series at each channel of the inverter.
4. In case of no visible issues, there can be hidden issues such as hotspots, partial or total module bypass due to the failure of bypass diodes, etc. These issues can be detected by IR thermography and drone

thermography. Post detection, based on the issue detected, a replacement of bypass diodes or replacement of modules can be done.

7. GENERATION IMPACT OF LOSSES

"The maximum generation loss incurred is in the month of August, which is 211.83MWh, followed by 74.34 MWh in July, and 38.93 MWh in the month of September, considering an optimal PR of 5% greater than the target PR. The generation improvement possible in the month of October is 23.67MWh considering string level correction activity."

From the previous sections it is established that October is the better performing month with actual PR being around 5% higher than the target PR. As this similar optimal performance was also observed in the month of June, we can take this PR number which is 5% higher than the targets as the plant's "Optimal PR". The generation loss is thus calculated based on this optimal PR value, rather than the target PR value. The below table shows the calculation of generation losses for June to October with Tahoe calculated generation values.

Month	Days Considered by Tahoe	Actual PR (%)	Target PR (%)	Optimal PR (%)	Production (MWh)		Generation Loss (MWh)	Generation loss for month (MWh)
					Actual	Optimal		
June	30	84.37%	78.33%	84.37%	907.75	907.75	0.00	0.00
July	31	77.11%	77.83%	82.83%	1,002.24	1,076.58	74.34	74.34
August	21	67.66%	76.83%	81.83%	685.09	828.59	143.50	211.83
September	30	76.91%	75.06%	80.06%	951.70	990.63	38.93	38.93
October	26	79.84%	74.41%	79.84%	833.99	833.99	0.00	0.00

We have seen the generation loss in each of the months, according to Optimal PR as reference and noted that in the month of October, there is negligible generation loss in October. But, as noted in the String Analysis section, there is still significant scope for generation improvement in the month of October as well just by identifying and correcting DC array level defects. Thus, a generation improvement scope can be calculated for the month of October. To calculate the generation improvement scope for October from the string analysis results, the list of all the strings analyzed for the month of October is downloaded, and for the strings deviating by more than 10%, it is considered that the performance of these strings can be corrected to a minimum of 10% performance deviation level on an average. The difference between the weighted average of string deviations at the plant level, post and pre string correction is calculated. This consideration of greater than 10% correctable deviation number is based on prior experience with many clients that Prescinto catered to. Typically, the strings deviating by more than 20% are corrected first by on-site inspection, cleaning of modules, replacing broken modules, or making any electrical corrections to the system. Later, strings deviating in the range of 15-20% are corrected, and at last the strings which are deviating in the range of 10-15% are corrected. It was observed that there is not a significant opportunity of improvement in the performance of strings whose deviations are less than 10%. This stems from the measurement uncertainties of the instrumentation installed at string level.

The weighted average string deviation at the plant level for the month of October is 14.48%. The same value after correcting the string deviations greater than 10% is 9.73%. The difference in performance level of strings pre and post-correction is thus 4.75%. Although the theoretical possible generation improvement is 4.75%, the practically possible generation gain post string correction activity is 50-60% of the theoretical value. Thus, the practically possible generation improvement is about 2.39%. This translates to **19.92MWh of possible generation improvement** or a similar level of notional generation loss without having done any string-level correction. The sheet for the calculations is provided in this link Report_calculations

Annexure-1: Company Profile

Having its Headquarters located at Ahmedabad and Development Center in Bangalore, with office presence across Barcelona, Spain, and New York City, US; Prescinto was founded by Mr. Puneet Singh Jaggi who also founded Gensol Engineering Limited (Listed at BSE), one of India's largest Clean Consulting & Technology firms, with exposure of handling more than 30 GWs of Clean Projects. Prescinto has built a cutting-edge technology platform to seamlessly integrate data from different brands of devices, each communicating in their own distinct ways. Prescinto acquires data from remote devices, presents it in neat customizable dashboards, and analyzes it to give actionable insights. While Prescinto is hardware and sector agnostic, it has already made its presence felt in the clean energy industry within 3+ years of its founding, it has integrated data from over 13,000 MW of Solar, Wind, and Battery storage projects across 14 countries.

TEAM:

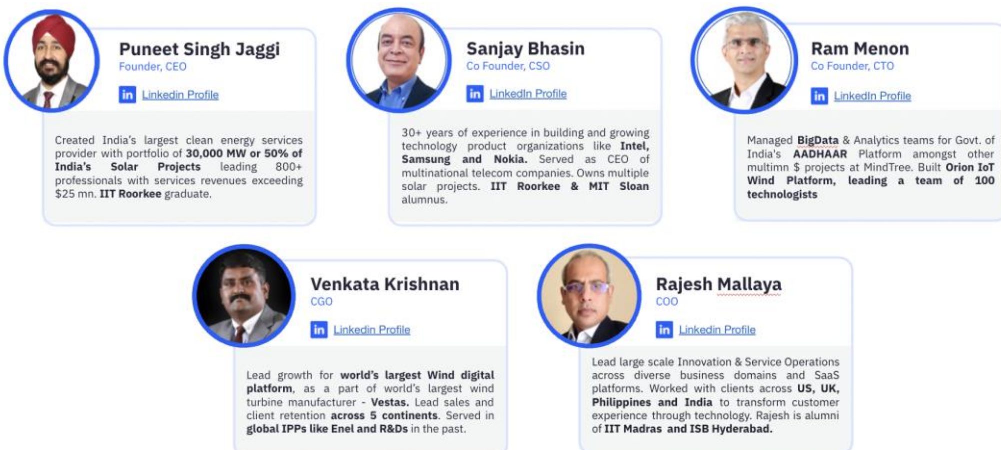


Figure 1.0 Our Leadership Team

What is unique about Prescinto?

Prescinto captures data at a 1-sec granularity and applies its data science model on top to identify causes for underperformance. The analysis extends to Weak Module Identification, Battery performance, Downtime analysis, and performance benchmarking. Equipment Alarms, Underperformance Insights, and Preventive Maintenance Schedule are all converted into work orders which are then executed and verified by the site team with the ability to upload documents and photos for validation. With 250 milliseconds granularity, it is 1000 times more accurate than its industry peers which in turn enables it to capture micro-faults that are ignored but lead to long-term deterioration of plant performance. It is among the first platforms that completely empowers users - from the CEO at his corner office to the technicians on the ground - with customizable dashboards, reports, and analytics in ways that make the most sense for their roles. Further, it is amongst the few platforms that automate Operation & Maintenance activities on site based on assets and teams deployed, thereby eliminating the requirement of having separate ERP systems, paper-based checklists, and often ignored duty rosters.