Performance Analysis/Recommendations for Farm PV System

Prepared

October 31, 2022

Contact information

Leon Kehl, President

519.502.9979

leonkehl@boxbrite.com

Table of Contents

Executive Summary

Boxbrite was asked to investigate what could be done to improve the performance of the 320kW FIT 2 system located at Farm. We have successfully ingested data from the Aurora Vision platform down to the MPPT level from April 2016 to the present day into our Solar Workbench platform to perform this analysis. We used the existing Aurora Vision platform to verify the information. Also we have talked to Ryan Parton from Crescent Ridge about some of the technical aspects of this report.

We are having a site visit on November 10th and anticipate being able to check and perhaps make a quick change that potentially could yield an immediate 3.8% improvement in overall performance or $5,700 annually.

In addition, there are a number of long term problems and ongoing issues that need to be addressed.

This report summarizes the initial finding of our investigation to date:

- The Solar Workbench platform has allowed us to quickly find these types of problems and works much more efficiently than the Aurora Vision and we can easily offer an ongoing monitoring solution going forward.
- The platform allows us to pinpoint individual string faults remotely such as #Y where either soiling or string faults is leading to 31% production levels relative to Inverter #Z and if addressed would be an extra $3,200 annual revenue.
- Our analysis shows ongoing major losses due to 4 inverters' misconfiguration. We have discussed this possibility with Crescent Ridge and can confirm on November 10th. If this analysis is correct this should increase the overall site performance by 3.8% or $5,700 dollars per year on average.
- All 4 of those inverters have never been replaced unlike almost all other inverters. This underperformance may account for their longevity and also why the problem wasn't noticed. However, this also means they are now more likely to fail because of their increased power output.
- All inverters will reach the end of their 10 year warranties in the next few years and a repowering plan and options can be discussed on November 10th.
- 8 of 29 inverters are currently either not communicating or not producing and these problems need to be addressed for effective monitoring and may have additional production problems.

System Description

System Type: 320 kWW with 29 ABB/FIMER PVI 10.0 / 12.0 3 Phase String inverters,
Location: Farm, Ontario
From the image you can see that there are a number of different arrays with differing sizes. Not included are large arrays on the Big Barn because there may be some confusion in terms of orientation and sizing but they represent the bulk of the production.

The four inverters we suspect are misconfigured are all on the Driving Shed. The 3 inverters facing south should be the top producers on the site while #AA on the North side would be the worst of the site.

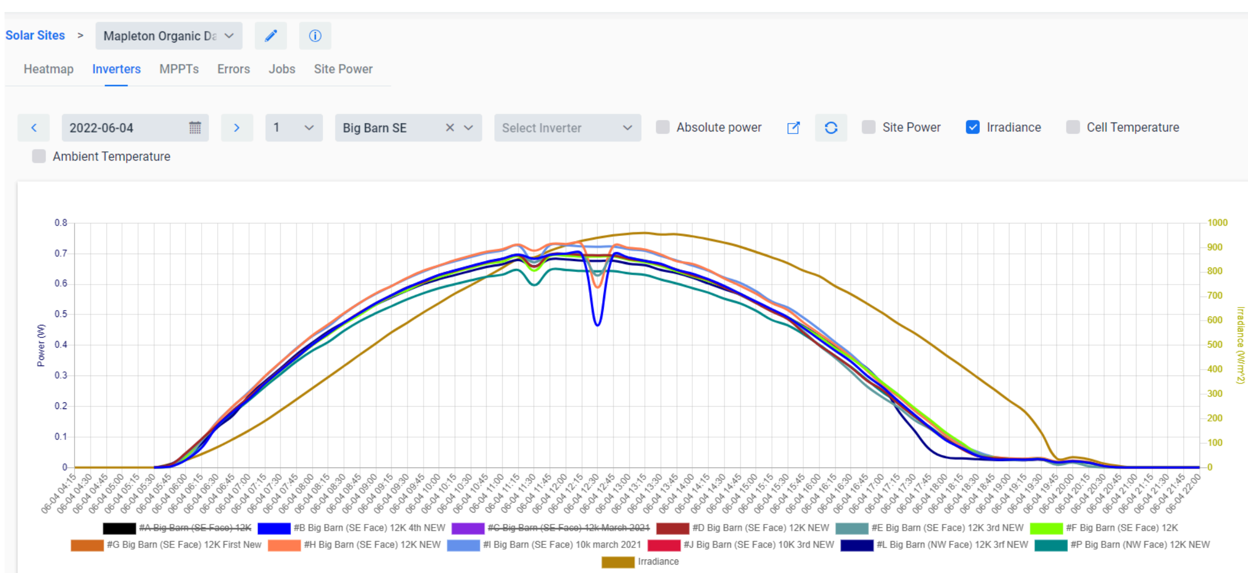
From the image you can see significant soiling present on the #Y,#Z array because of sawdust loading into the barn.
In addition there are significant shading issues from silos both on #Y,#Z but also on some of the Big Barn arrays on the southern end of the barn in the afternoon.

Losses Due to Inverter Misconfiguration

A major loss which appears to be easily addressable involves a likely misconfiguration of inverters #AA, #AB, #AC, #AD all located on the Driving Shed. All inverters with the exception of #S which is a split between two combiners and roof surfaces should be configured for parallel not independent MPPT operation. However, all 4 of these inverters current profiles indicate that they are likely configured as independent. These problems seem to date back to installation. Since none of these inverters have been replaced we think this explains both their longevity and also why the problem was never detected by an electrician.

We have come to this conclusion by analyzing the MPPT profiles of those inverters compared to all other inverters on the site. Based on those profiles and discussions we have high confidence that there is a simple solution to improve performance.

The graphs below are for June 4, 2022 which was a bright sunny day with almost no clouds. The inverter graphs below are for the Big Barn SE inverters which have minimal shade issues and also include data from the irradiance sensor. There appears to be a slight cloud before noon and then the dips you see are due to the tall silo on some inverters.



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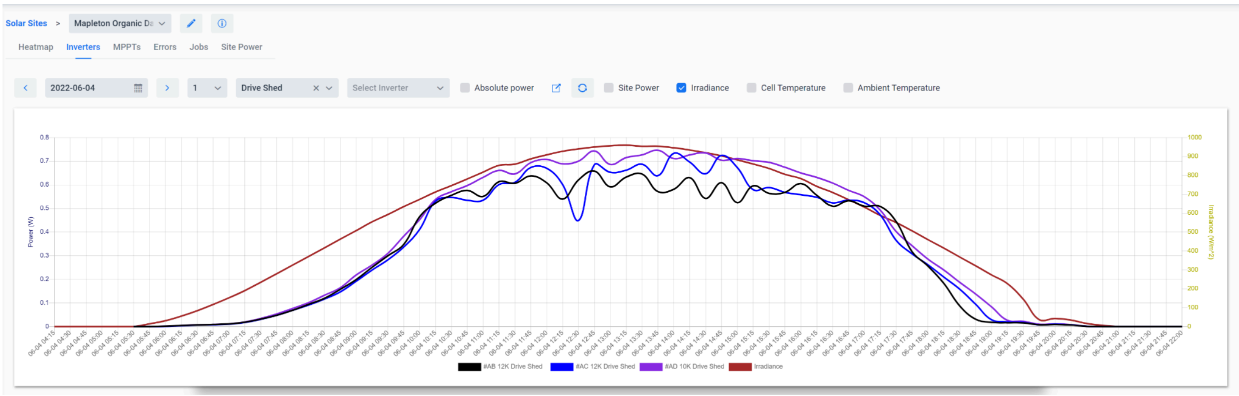
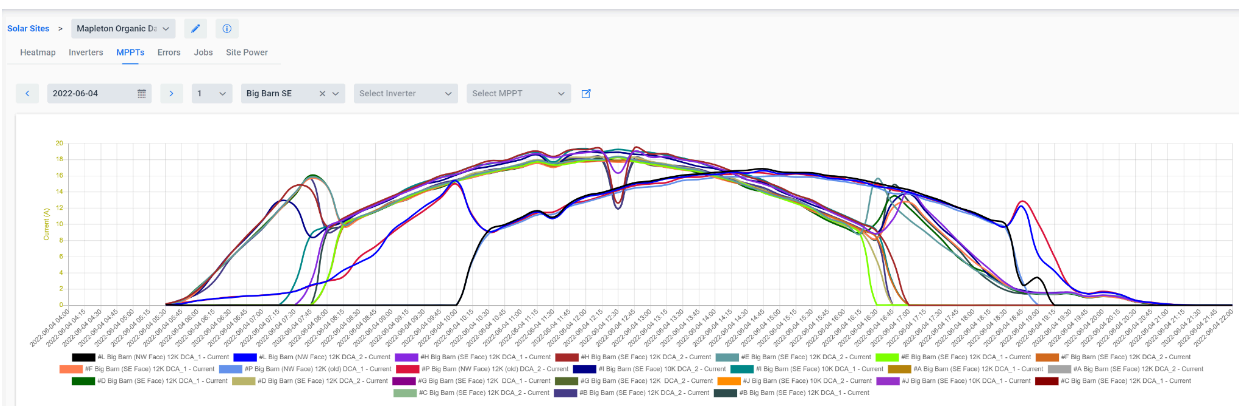
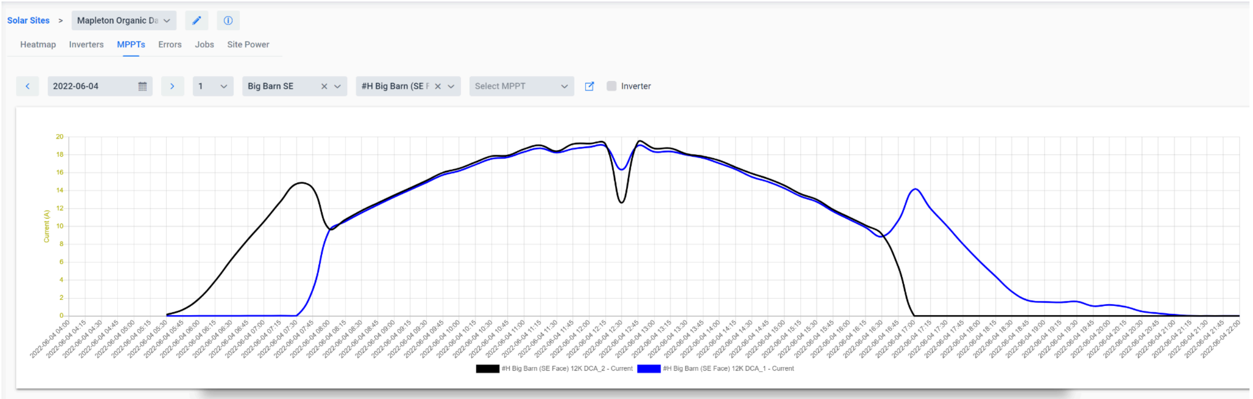
The graph below shows the 3 SW inverters on the Driving Shed. Here you see a very different pattern with all kinds of unexplained drops and also not a clean rounded curve. So the question is why is this happening?



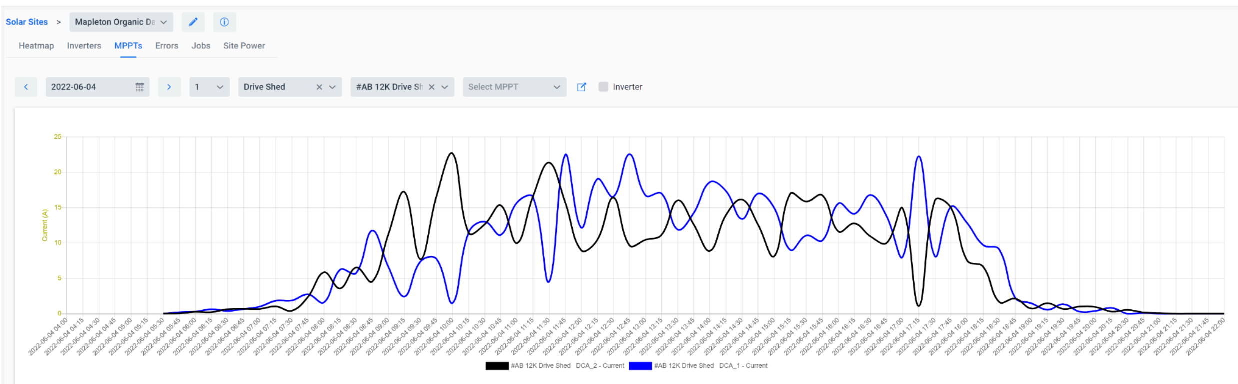
Here for the same day is the MPPT current profiles for the SE Big Barn inverters. The pattern that we see is that when the inverter is set to parallel mode that one or the other MPPT operates until a certain power level is reached. After that the inverter then distributes the current between the two MPPTs. That's why you see increasing current to a point in the morning and then a current drop. The reverse happens in the afternoon. Shading of course and DC sizing impacts when this threshold is reached. This pattern is consistent across all inverters with the exception of #S because it has two roof surfaces and independent MPPTs.

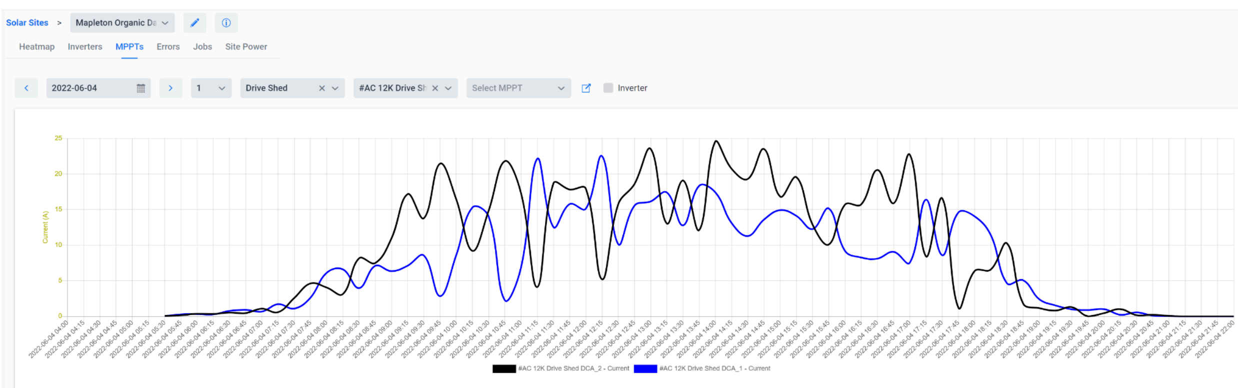


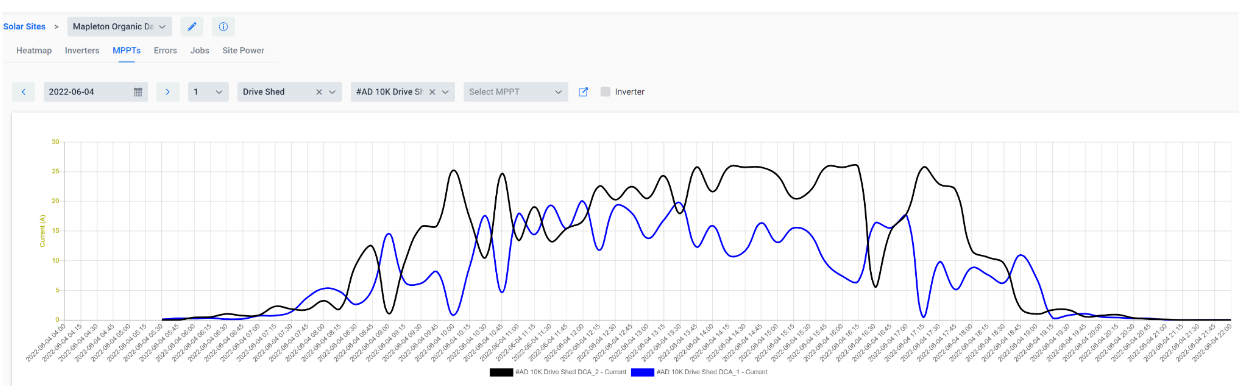
However all the Driving Shed inverters have a very different pattern on that particular day. The first graph shown below is Inverter #H from the Big Barn so you can more clearly see the described pattern and what the curve should look like:

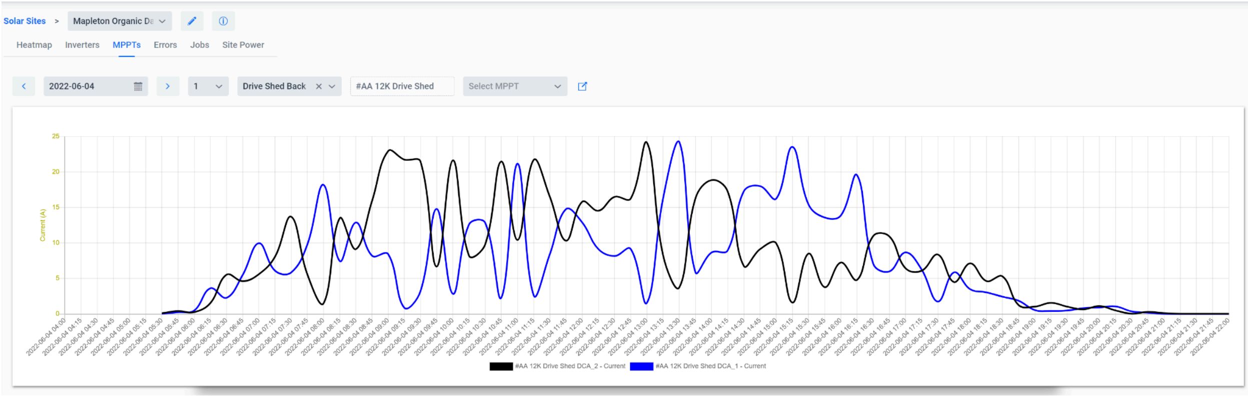


Now shown below are the patterns for the 4 Driving Shed inverters









The graphs seem to show that the MPPTs are “fighting” with each other rather than trying to optimize the production. What isn’t clear is what is potentially misconfigured. Shown on the next page are the instructions for proper configuration of the inverter which we can then validate on November 10th or could be validated in advance if desired.

Independent or parallel configuration of dual inputs

The inverter is configurable with an independent MPPT for each DC input channel or with the two input DC channels connected in parallel with one MPPT.

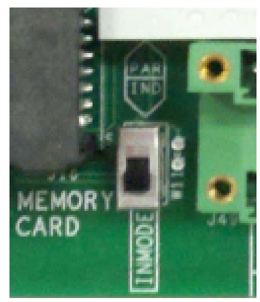
When operated in the dual input mode the inverter can optimize two independent arrays. The inverter can also be operated in a single MPPT mode from a single array by connecting the inputs in parallel using jumpers and proper setting of the INMODE switch (discussed below).

If the inverter is configured with two independent MPPTs, the maximum current for each channel must not exceed 24 Adc (10kW)/ 25Adc (12kW) and the power input for the single channel must not exceed 6.8 kW.

The inverter is configured in independent mode by default. The following section describes how to connect the inverter in parallel mode using jumper cables and the INMODE S1 switch.

Inmode switch S1

INMODE switch S1 (item T on the inverter connection board) is used to select parallel or independent configuration of the inverter. The default position of the switch is in the IND position (DOWN).



Parallel mode PVI-10/12-I-OUTD

- Place INMODE S1 switch UP in the PAR position.
- On the inverter connection board, parallel the two MPPT inputs by means of terminal [–IN1 and –IN2] and [+IN1 and +IN2] using two 10 AWG jumper wires (1 black and 1 red cable) to connect the input as shown below.

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Estimating Drive Shed Improvement

We felt the best way to estimate how much the Drive Shed inverters should produce would be to compare them to the Big Barn SE inverters. The Big Barn inverters will have some shading issues in the afternoon unlike the Drive Shed but would be the best point of reference to compare with.

The Drive Shed also has more favorable southern orientation. We felt the best way to account for this was to use PvWatt to provide a high level relative comparison between the different roof surfaces. That analysis showed that the Drive Shed should have about 3% higher performance than Big Barn SE.

We then used 2021 data to compare those two surfaces and based on that would predict a 33.5% improvement in performance by making this change. That should then lead to an overall system performance of 3.8% or $5,751. All calculations are included in the attached spreadsheet.

Hay Barn #Y Problems

The following inverter graphs are for the Hay Barn on that same day. These graphs are normalized for DC sizing of the inverters. On this particular day Inverter #Y is performing at 31% of Inverter #Z. This could be due to either string(s) failure or significant soiling or a combination of both.

To estimate the current losses on #Y we looked at the total annual output in 2018 for those 2 inverters which was a year with full production because Inverter #Z has been replaced several times. We then contrasted it with the production in 2022.

Assuming the production of #Y can be restored whether through fixing strings or better soiling management the result would represent $3,200 in 2022.

	Inverter #Y	**Inverter #Y**
2022 Production MWh	3.68	11.26
Current Ratio	32.68%	
2018 Production	10.12	12.16
2018 Ratio	83.22%	
Possible YTD Improvement	5.69	
Full Year Improvement	**$3,263**	