MULTIPLE MPPT VS SINGLE MPPT INVERTERS

INTRODUCTION

Monitoring and maximising the energy yield of any PV system is critical to the stakeholder that will be benefitting from the production. It might be the home owner, or the PPA owner that will be concerned about the Operations and Maintenance cost as well as the yield of the system. It might be the bank that is financing the system. Achieving the best possible return on investment is what will matter.

Understanding what the possible issues are and how to overcome it will make a difference when designing a system and choosing a solution.

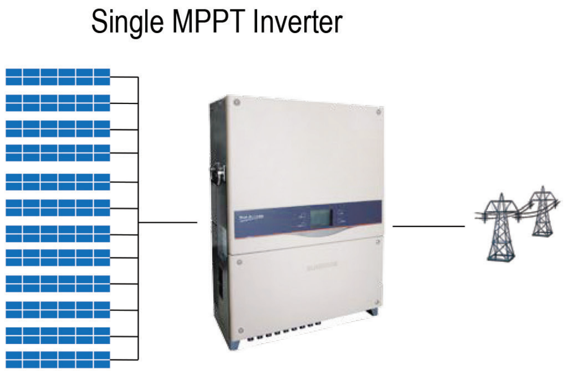
A key consideration is to decide what level of flexibility and control is needed over an array for the given project. This can be achieved by determining how many MPPTs (Maximum Power Point Tracker) are required.

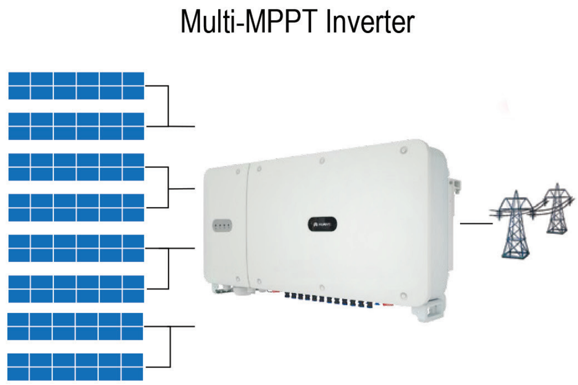
MPPTS: MAXIMIZE YOUR MODULES

The function of an MPPT is to maximize the energy available from the connected solar module arrays at any time during its operation. PV modules all produce slightly different levels of voltage and current, but a series circuit can only have one value of current (which is based on the worst performing module), and it is the job the MPPT to extract the best possible amount of power from the circuit. It does this by varying the resistance in the circuit to adjust the voltage and current.

MORE MPPTS: BETTER YIELD

PV inverters were originally designed to have a single MPPT, which means the inverter is capable of maximizing the output for one value of DC current. This limits the inverter to getting the best out of one roof face only, or one type of PV module. For small and simple PV arrays, that might be perfectly adequate. For larger and more complex designs, having the PV array managed by more MPPTs will help to improve the energy yield.





HERE ARE SOME WAYS IN WHICH INCREASING THE NUMBER OF MPPTS IMPROVES THE SYSTEM PERFORMANCE:

- Only one string length is possible per MPPT, so having more MPPTs means greater design flexibility. E.g. with a multiple-MPPT inverter a design can have different string lengths depending on the roof requirements, some 20 panels, others 21 panels. With a single-MPPT inverter all strings into one inverter must be the same length.

- Only one module type is possible per MPPT, so having more MPPTs allows module types or ratings to be mixed on a roof. E.g. one area of the roof could use 320W modules, another 275W if they are better suited for the available roof space. With a single-MPPT inverter all modules connected into one inverter must be the same type.

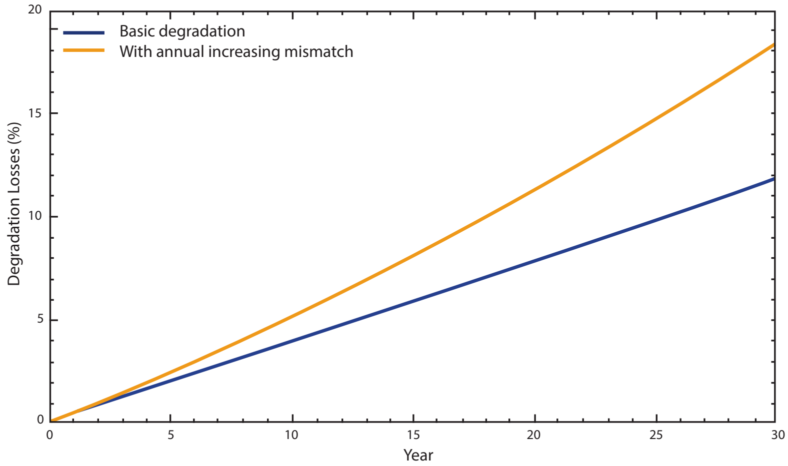
- Making installations possible on multi-facetted roofs with different pitch angles. Modules mounted on an east facing roof will produce much lower current than those mounted on the west roof face. A single MPPT inverter would output power based on the lower current value, whereas a multi-MPPT inverter could use both current values and therefore fully utilize the modules with higher current. Designs with an east-west orientation can generate 2% - 3% extra yield with a multi-MPPT inverter compared to a single-MPPT one.

	1 MPPT	4/6 MPPT	YIELD GAIN
String Length Flexibility	No	Yes	
Module Type Flexibility	No	Yes	
Selective Optimisation	No	Yes	
Different Orientations	Very Poor	Good	0.0% - 2%
Mismatch Losses	Poor	Good	0.5% - 1%
Shading Losses	Very Poor	Good	0.0% - 2%
Degradation Losses	Poor	Good	0.5% - 1%
Temperature Losses	Poor	Good	0.5% - 1%
Soiling Losses	Poor	Good	0.5% - 1%
Low Voltage Start-up	Poor	Good	0.5% - 1%
TOTAL			**2.5% - 9%**

- PV modules of the same rating from the same production line do not possess identical current–voltage characteristics, this is called module mismatch. A series circuit works at the lowest current in the string, so the more MPPTs the inverter has, the smaller the number of affected modules by the lowest current. Ideally,modules flash data should be consulted prior to installation to determine how to allocate the modules in the system. Modules could be put in the same strings as those with very similar currents. With a multi-MPPT inverter an increased in yield of 0.5% can easily be achieved by sorting modules prior to installation. The mismatch loss will increase when more strings are combined. On multi-MPPT string inverters the goal is to only combine 2stings ensuring the lowest losses and on single-MPPT string inverters the mismatch losses can be more than double.

- A shaded module produces drastically lower current, and the current of the whole string will drop down to the value of the affected module. On a multi-MPPT inverter, where there are only two strings per MPPT, that shaded module will cause the current from two strings to drop. On a single MPPT inverter, the entire array current will drop even if only a single module is shaded.

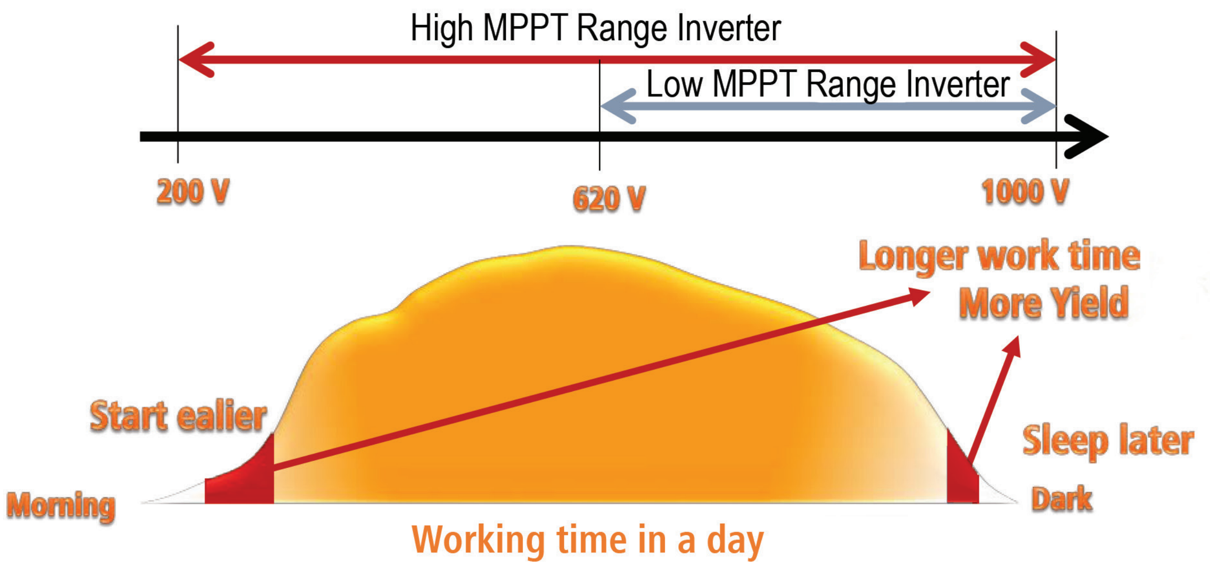
- Panels degrade at different rates over time and the output will always be limited by the poorest performing module in a string. The impact of this is difficult to predict, and impossible to measure on day one, but having fewer strings per MPPT means poor performing modules affect others less. With a single-MPPT inverter there is a significant risk that excess degradation in a small number of modules will impact the viability of the project over the long term.



- Soiling can drastically affect the performance of individual modules and more so in low rain fall areas. On average there is a daily efficiency reduction of 0.2% in days without rainfall in dry weather. Annual losses caused by this trend due to soiling ranges from 1.5% to 6.2% depending on the location of the PV plant. For larger ground mounted systems, the bottom row of the modules can be separated from the rest of the sub-array when using an inverter with multiple MPPTs to ensure the overall performance is not affected.

- Modules produce less energy the hotter they are, typically they reduce in output by about 4% for every 10 degrees increase in temperature. Modules on different sections of roof will reach different temperatures due to the amount of ventilation and expose to even light winds. With a multi-MPPT inverter each area of roof will perform to its maximum based on the actual module temperature and not be affected by higher temperature modules elsewhere on the roof.

- Every MPPT will have a minimum voltage needed before it starts up and so in the early morning whilst there may be some sunlight on the modules it may not be sufficient to enable the MPPT to operate. To maximize the energy yield it is therefore essential to have a lower a MPPT start-up voltage as possible. E.g. an MPPT with a start-up voltage of 200V will generate energy earlier in the morning and later in the evening than one with a start-up voltage of 600V. With a multi-MPPT inverter each MPPT will individually start up as soon as it can, independent of the others, whereas a single MPPT inverter will only start up when the entire module array produces sufficient voltage.



OPTIMISERS: MPPTS FOR EVERY MODULE

For extremely granular control over an array, DC optimizers can be added to effectively provide an MPPT for individual modules or pairs of modules. This allows the inverter to make the most of every module, even if the modules are producing radically differing amounts of DC current (for example due to shading or soiling). Mitigating the effects of shading can potentially make a project financially viable when it previously wasn't.

Especially important is the concept of 'Selective Deployment' which allows only a portion of a system to be optimised. This might apply where one segment of the roof has different orientations, partial shading, higher soling, higher temperatures or other factors which impact performance. A commercial scale system with only modules on a small number of the MPPTs optimised will perform significantly better than a non-optimised system, but be a lot more cost effective than a 100% optimizer solution. E.g. you might have a 100kW system with 300 X 330 modules but only need to optimise 1 MPPT out of 8 with 38 panels, just 19 dual optimisers. This is not possible with a single-MPPT inverter where all the modules would have to be optimized, even if some did not need to be and so increasing the cost.

BALANCING THE BENEFITS OF MORE MPPTS WITH THE COSTS

However, all that increased control and design flexibility adds to the project cost, so it's important to consider whether the project viability really depends on having MPPTs on every module.

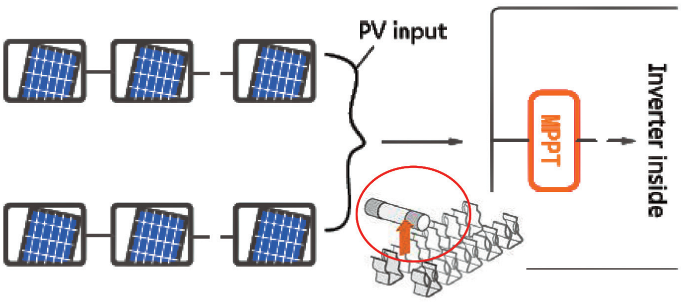
In commercial plant design, where the roof spaces are typically very large and unshaded, tracking each module is often not necessary and tracking individual string performance is sufficient. It's less likely that modules will experience very different light conditions to their neighbours, so having MPPTs managing a number of modules within the array is sensible.

Similarly, if there is no reason to think modules will behave differently from each other, there is little benefit in having module-level monitoring. For the majority of commercial installs, monitoring each module string is sufficiently accurate, and it avoids the cost of full optimisation. Some more detail on the benefits of string level monitoring is included later.

COMMERCIAL DESIGNS: THE 'TWO STRINGS PER MPPT' RULE

Another important design consideration is the number of DC strings per MPPT. Domestic arrays will always have a single DC string per MPPT, but large commercial strings will usually produce very similar DC currents, so could be managed by a single MPPT. Aside from the arguments above that say more MPPTs is better for yield, the number of strings per MPPT should not be greater than two. This is because of module reverse current ratings.

Most PV modules have a maximum permissible reverse current value of 15A and a short circuit current value of about 9.5A. Adding DC fuse protection is obligatory if the number of strings per MPPT is ≤ 1+ (reverse current rating / short circuit current). This would suggest most modules can cope with approximately 2.5 strings worth of reverse current. Hence, keep the number of strings per MPPT below 3.



Adding DC fusing to each string is a costly and time-consuming addition to a design that can be avoided by limiting the number of strings per MPPT to two.

Apart from the added cost to the design, DC fuses are usually one of the first parts of the system to develop faults. Even though they are very simple to replace, they are a trip back to site easily avoided by not including them in the first place through better design.

MULTIPLE MPPTS VS DC COMBINER BOXES

Some large commercial inverters have a single MPPT, and rely on DC combiner boxes (multiple DC strings connected in parallel to increase the DC current). This enables a lower cost inverter that can focus on simply performing its core job of DC to AC. The quantity of strings that can be connected in parallel to the combiner box is determined by the maximum input current of the inverter.

A major drawback of using combiner boxes is that all the strings need to be same length, which reduces design flexibility. The inverter only has one MPPT, so the whole system can only produce power based on the lowest string current. On a large commercial system, it’s very likely that the current between two strings at opposite ends of the roof will vary a lot, which means the most productive strings will get dragged down by the least, and system yield will suffer.

STRING LEVEL MONITORING

Another important factor in the financial viability of a system, apart from using multiple MPPTs to extract the highest yields, is the capability to monitor the system closely and to react quickly if things go wrong. A system with more MPPTs will allow more accurate monitoring of each section of the system enabling better targeting of issues.

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