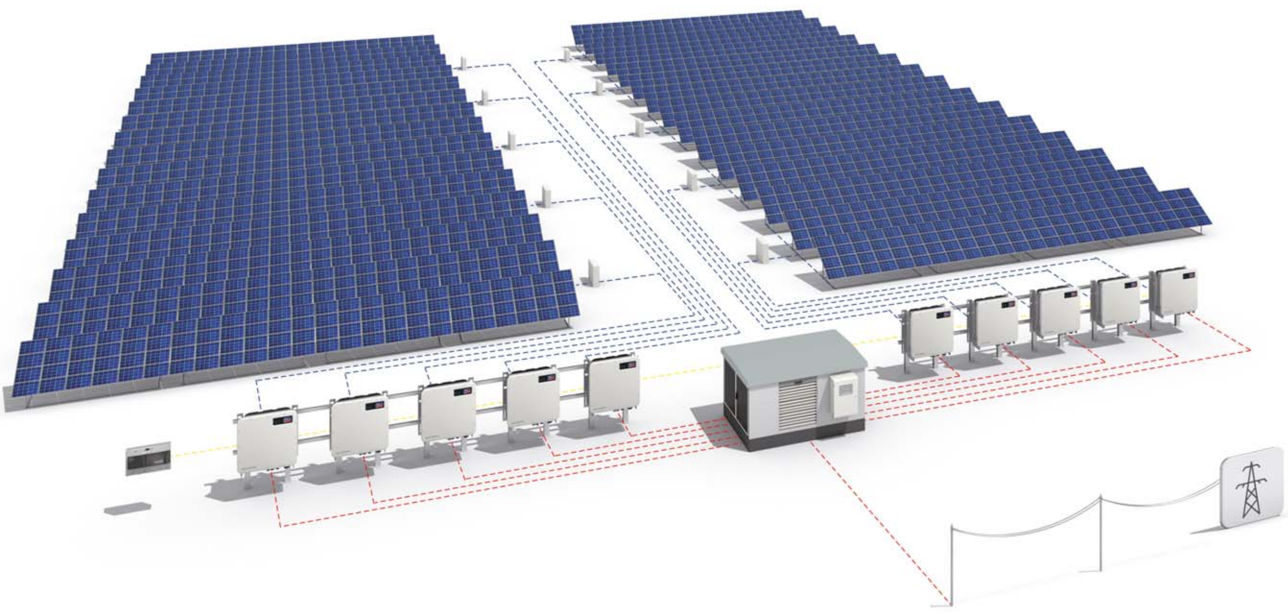
WHITEPAPER

CENTRALIZED SYSTEM LAYOUT – DECENTRALIZED INVERTER CONCEPT

The Sunny Highpower PEAK3 String Inverter Combines the Advantages of Two Worlds



Centralized or decentralized. Which is the best layout for a large-scale PV power plant? In today's solar power plants, reliability matters most.

Every component, every feature and every redundant component needs to be evaluated before being added to the product. This is where a centralized system layout has the edge over a decentralized system layout using traditional string inverters.

The main factors influencing the selection of a centralized or decentralized system layout are described in detail in the following sections.

MORE MPPTs OR MORE FAILURES?

A widespread myth in the market today is that it is better to use more MPPTs. The fact is that it is extremely difficult to attribute losses to MPPTs in projects. The theory behind this is quite straightforward.

Irradiation affects only current and temperature affects only voltage. That means in a typical plant, the voltage of one section cannot vary too widely from other sections since a temperature delta of more than a few degrees is impossible. All other factors such as module mismatch, shading, clouds, etc., are random in nature. The mathematics of random behavior clearly indicates that when one moves from one module to a string, most of the voltage deviations would be eliminated, simply because a PV string adds voltage.

"With every 1,000 extra components, the annual failure rate of a PV inverter is increased by 1%," said Daniel Clemens, an SMA Reliability Engineer involved in SMA inverter development.

This becomes even less prominent as one moves from 600V DC to 1,000V and from 1,000V to 1,500V DC, simply because the number of modules in the series is higher. That means if you have 0.x% gains with module level power electronics (1 MPPT per module) and you move to string level MPPT (30 modules in series per MPPT), most of the gains are wiped out. When you move from string level to central level, there is effectively no gain left.

Another point to remember is that voltage and current measurement sensors are not designed for highly accurate measurements. This means the typical deviations with string measurement can also mislead MPP tracking behavior.

Finally, it's important to note that using more MPPTs comes at a high cost. First, the losses of having more MPPTs can go up to 0.5% in most cases. Second, extra components (like sensors) within the inverter would again bring down the reliability of the entire inverter. Remember that every extra component has to last for 20 years. A single failure within a MPPT-related component would mean the complete inverter fails.

Multiple studies, including internal studies by SMA, support the above findings. Therefore, a general principle is: the lower the MPPT count the better off the customer is, and not the other way around.

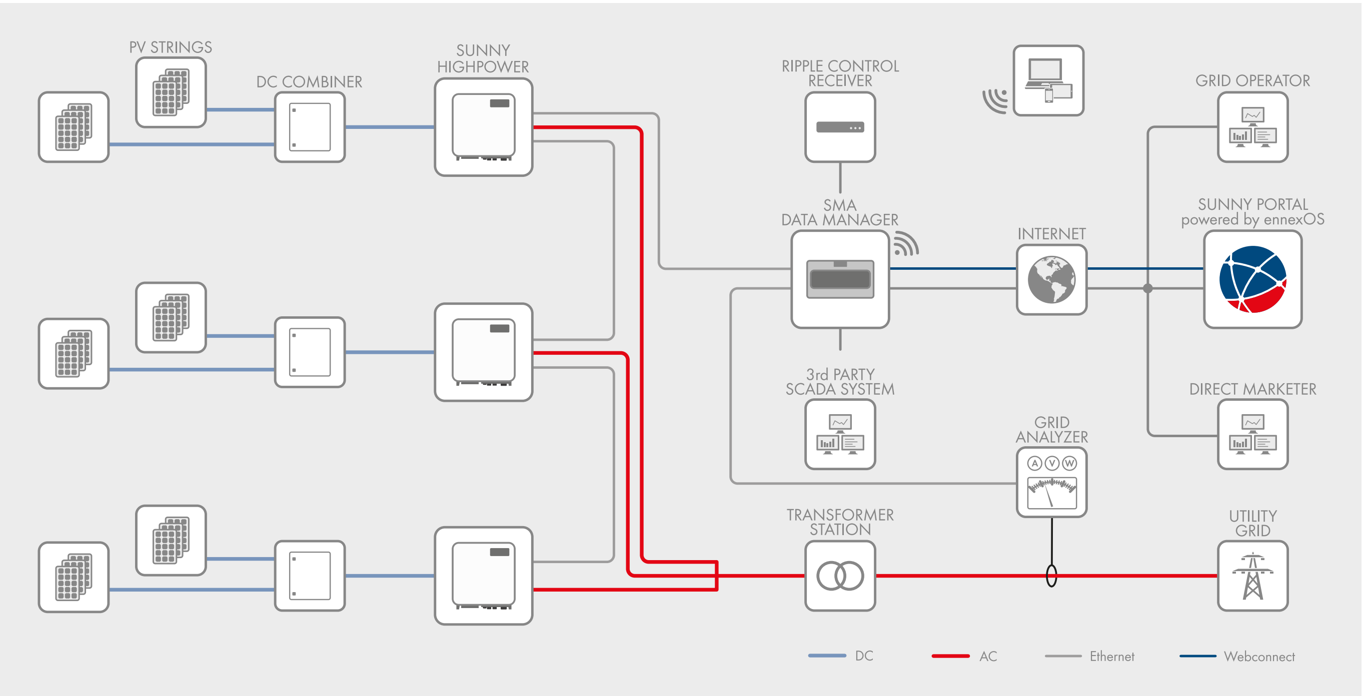
Avoid Cabling Losses

A typical decentralized string inverter design works best with for 600V DC technology, which was the norm about 10 years ago. Let's take a hypothetical inverter, for example, with 600V DC and 600V AC. In this case the DC components between the inverter and PV modules would not matter. But as new DC module technology has evolved from 600V DC to 1500V DC, today's scenario is much more favorable on the DC side because the DC current is typically reduced by 2.5 times. That means it is much more effective to transfer power on the DC side when compared to the AC side. Additional downsides for EPCs include needing four AC cables rather than two as well as the difficult installation of AC cables.

Centralized layout also allows working at Low Voltage (LV) level (690V) on the AC side due to short cabling between the inverter and transformer. Staying on LV has many practical and valuable advantages. The commercial attractiveness (like pricing, lead time, vendors availability) of all components between inverter and MV connection is much better compared to the same components certified for >690V.

In a high DC overloading scenario, the benefits of centralized architecture are enormous. Consider a case of 150% DC overloading (1.5MW PV and 1MW inverter). A typical string inverter would first clip and then transmit the available AC power for the long distance to the transformer (approximately 1% loss). That means 1.5MW would be limited to 1 MW and when it reaches the MV transformer it would become 0.99MW, whereas a centralized architecture would transmit first and then clip. This results in a 1% loss on the DC side before it reaches the inverter during transmission. When it does reach the MV transformer, it is still 1MW. This additional 1% gain happens during the most effective hours of sunshine. When the effect is observed in kWh terms, it can result in significant gains for the plant owner. It is also important to remember here that during clipping, MPPT functionality in the inverter is disabled and hence of no use!

Communication cabling is yet another factor that adds cost to a decentralized plant layout. One has to run Ethernet cabling all around the plant. The cost of cabling, installation difficulties in the field and possible maintenance issues with communication make the centralized layout financially attractive. Power line communication for utility applications has many disadvantages. Even for small data packets, the speed is prohibitively slow and cannot be relied upon for a time-critical application such as grid management functionality.



Optimum system layout recommendation

THE OPTICOOL™ ADVANTAGE

In every inverter, cooling technology is definitely one of the most important aspects after power electronics. SMA has mastered this with a simple, reliable technology design only for PV applications. We have seen many different approaches that have been tried and have failed. However, nothing beats the simple, speed-controlled fan design of OptiCool™.

The key to the longevity of a PV inverter is having the lowest thermal cycling possible. It is not the absolute temperature but rather the fluctuations that matter most SMA has done various studies on this topic, and in a few cases, even observed that heating the inverter overnight (like in desert climates) increases the life of the components.

PV inverters are extremely compact. Even at highest efficiency, there is massive heat dissipation required. For example, the Sunny Highpower PEAK3 has an efficiency of 99.1%. But even when under full power, it has to dissipate around 1.5 kW power. This is comparable to twice the power used by a home microwave or electrical space heater.

In other words, if we collect the spare heat from one Sunny Highpower PEAK3 inverter, it could power a typical household. That much energy has to be dissipated by the Sunny Highpower PEAK3 in a volume which is smaller than a typical refrigerator. This much heat dissipation cannot rely on fan-less cooling. Typical PV applications also mean that natural cooling due to wind gusts or rain can easily bring the life of the components down significantly. The inverter will simply not last for 20 years. OptiCool™ maintains uniform temperatures across the day as the fans are speed controlled. Thermal cycling and heat dissipation are minimized to vastly extend the life of the inverter.

Servicing the Inverter

This point clearly favors the modular central inverter design in the sense that there is almost no dependency for on-site support from inverter manufacturers. This could be a real deciding factor for plant operators but it is more a mindset than a financial consideration. Purely from a failure and energy loss perspective, central inverters are still the better option despite their dependency on on-site support. In the end, it's up to the plant owners to decide how best to cope with such a scenario.

CONCLUSION

A centralized system layout is a clear winner when it comes to ground-mount, large-scale PV projects. Outside the extremely narrow set of applications, a decentralized system concept makes no sense from a financial, cost-benefit perspective. The real question for plant owners is whether to chose a single, large central inverter or multiple, smaller inverters, and the decision is heavily driven by the service concept suitable for a given project and the dynamics around the project.

The design of the Sunny Highpower PEAK3 solution is perfect for providing benefits from both worlds. For PV plant designers, it is simply a Sunny Central UP broken down to 25 to 30 "manageable pieces." It is much closer to the centralized approach preferred by most PV designers.

ENERGY
THAT
CHANGES

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