8 Ways Power Optimizers are Better by Design

Microinverters & Power Optimizers - a Technical Comparison

solaredge

HOW BOTH APPROACHES ARE SIMILAR

Module-level electronics, namely microinverters and power optimizers, address the shortcomings of traditional PV systems by managing the system at the module-level and not at the string level. Both microinverters and power optimizers achieve higher energy harvest than traditional string or central inverters, through module-level Maximum Power Point Tracking (MPPT). Additionally, module-level electronics offer enhanced maintenance and greater system performance visibility via module-level monitoring, enhanced safety through automatic voltage shutdown and design flexibility.

WHY THE POWER OPTIMIZER APPROACH IS BETTER

Microinverters achieve module-level functionality by placing a full DC/AC inverter at each module, making the DC/AC inversion the center of their concept. While power optimizers also allocate power electronics to the module, but conversely keep the DC/AC inversion at the inverter-level. There is no need to add an inverter to every module since DC/DC power optimizers achieve all the module-level benefits at a lower cost, a higher efficiency and with much greater reliability.

BENEFITS COMMON TO MICROINVERTERS AND POWER OPTIMIZERS OVER TRADITIONAL INVERTERS

1. **Higher energy harvest**
2. **Safety**
3. **Module-level monitoring**
4. **Design flexibility**

BENEFITS OF POWER OPTIMIZERS OVER MICROINVERTERS

1. **Greater module compatibility and no power clipping**
2. **Higher energy yield through wider MPPT range**
3. **Higher reliability**
4. **Higher efficiency**
5. **Superior communication technology (DC Power Line Communication)**
6. **Compliance with advanced grid codes**
7. **Lower system cost, faster ROI**
8. **System scalability**

1. MODULE COMPATIBILITY AND POWER CLIPPING

In order to ensure broad module compatibility, manufacturers of module-level electronics need to keep pace with the constantly increasing module power ratings. Currently, SolarEdge power optimizers allow for the connection of modules with up to 420WDC and 125VDC, supporting the vast majority of modules on the market today. This includes high-wattage modules preferred for commercial installations. At present, microinverters allow for the connection of modules with power ratings of up to merely 260WDC (and only 60 cells), not supporting many of the module capacities available on the market.

Furthermore, it is not the connected DC capacity but the AC output limit of the microinverter which determines how much energy can be harvested from a module. The current maximum output limit of the Enphase M215 microinverter, for example, is 215WAC, while the average wattage for modules today is above 230W and rising every day. While some oversizing can be recommended also with central or string inverters, connecting a 260W module, for example to a 215W AC microinverter results in 17% oversizing which can result in power clipping and limits installers in their choice of modules.

2. WIDER MPPT RANGE FOR MORE HARVEST IN SHADED SITUATIONS

Module voltage decreases when partial shading occurs. When a module is partially shaded, its substrings are usually bypassed, resulting in less cells available for production. This causes a drop in the module's voltage. If one or two substrings are partially shaded, that module can potentially lose one or two thirds of its voltage. Take for example a common 60-cell module with an MPP voltage of 27VMPP. In this scenario, 27VMPP would decrease to 18VMPP or 9VMPP, respectively.

To effectively harvest energy from a partially-shaded module, low voltage tracking capabilities are crucial. However, microinverters need relatively high voltages to be able to track a module's MPP. For example, the datasheet for the Enphase M215 microinverter states a minimum MPPT voltage of 22V. This means that if a module's voltage decreases below 22V, this microinverter would not be able to track its MPP. Rather, it would de-MPP the module to maintain a high enough voltage to continue to operate in an un-optimized working point.

In the example above (60-cell module with shaded substrings), this means that the M215 microinverter would not be able to track that module's MPP in neither of the two scenarios (18V or 9V). (Figure 1).

Conversely, SolarEdge power optimizers start MPP tracking from as low as 5V meaning they track a module's MPP even under severe partial shading. Power optimizers therefore perform better than microinverters in partially-shaded areas. (Figure 2).

Given that partial-shading loss mitigation is one of the most valuable benefits of module-level MPPT, the MPP operating window of module-level electronics is a critical criteria.

Figure 1:

The lower the minimum MPP voltage of a module-level MPP tracker, the higher its tolerance to shading and the more power can be recouped before bypass diodes are activated[1].

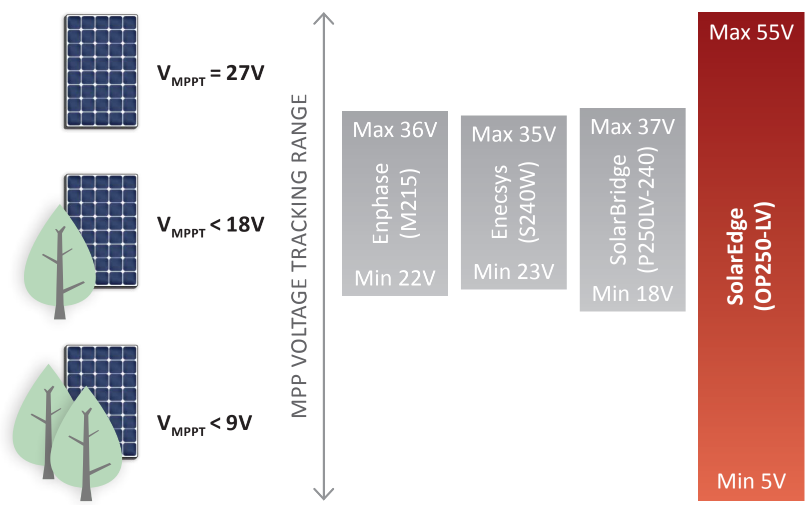


Figure 2:

SolarEdge allows for full roof utilization despite shading elements (here: chimney). Full roof utilization can only work if the MPPT range of the module-level device goes low enough to prevent module bypass diodes from being activated.

3. RELIABILITY

Reliability is paramount when it comes to module-level technology. Long-life module warranties, for example, reflect the industry standard that PV equipment is a one-time purchase. Designed to work alongside PV modules, both microinverters and power optimizers are judged by this standard. Therefore, both technologies offer a standard 25 year warranty.

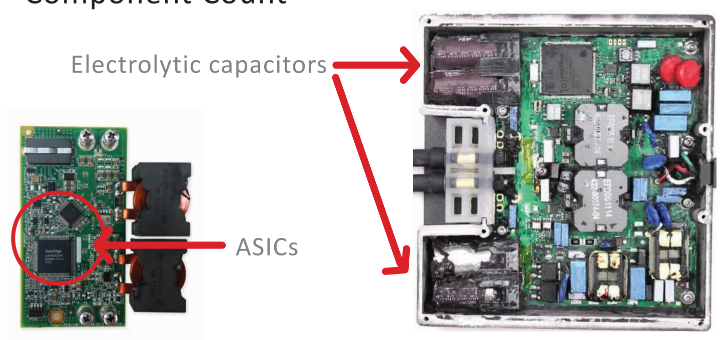
However, compared to PV modules and mounting brackets, electronic devices pose a challenge in maintaining a long lifetime. Microinverters require large input capacitance due to the low grid frequency. In many cases, this is implemented with electrolytic capacitors. As evidenced by the comparably short standard warranties provided for traditional inverters, electrolytic capacitors are specifically challenging as they contain fluids which evaporate under operating conditions, a factor which can significantly shorten the lifetime of microinverters compared to that of power optimizers

Not constrained by the requirement of DC/AC capacitance, power optimizers can guarantee long product lifetime by relying on two inherently reliable components: ceramic capacitors and Application Specific Integrated Circuits (ASICs). First, power optimizers have a high switching frequency, which allows them to use ceramic capacitors which have a low, fixed rate of aging. Second, ASICs allow for embedding many of the required electronics into the chip. This reduces the number of discrete components, and with that, the potential points of failure (figures 3 & 4). The design of power optimizers is therefore more reliable.

Figure 3:

The PCB of the SolarEdge power optimizer compared to a leading microinverter. (Images to scale)

Component Count



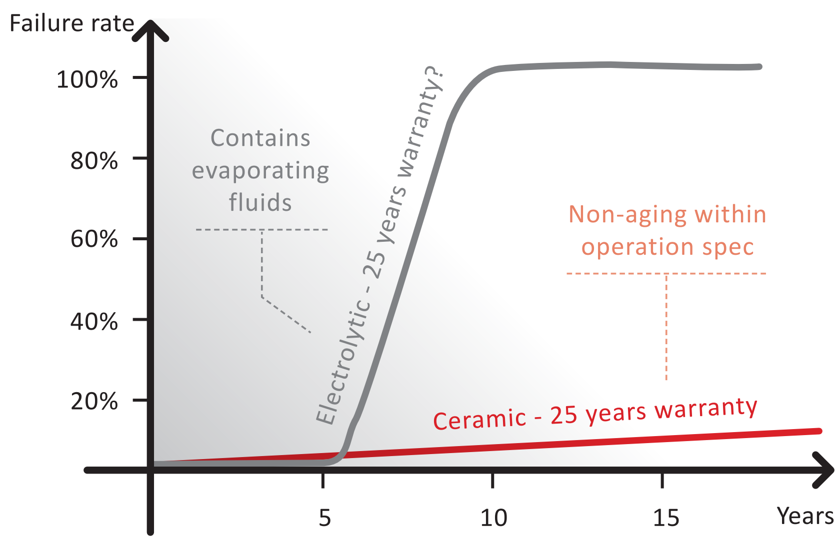
PCB SolarEdge power optimizer: 186 components including two ASIC chips

PCB of a leading microinverter: 466 components

Figure 4:

Ceramic capacitors have a significantly longer lifetime than electrolytic capacitors.

Cumulative Failures per Capacitor



[1]: http://www.solaredge.com/files/pdfs/se_technical_bypass_diode_effect_in_shading.pdf

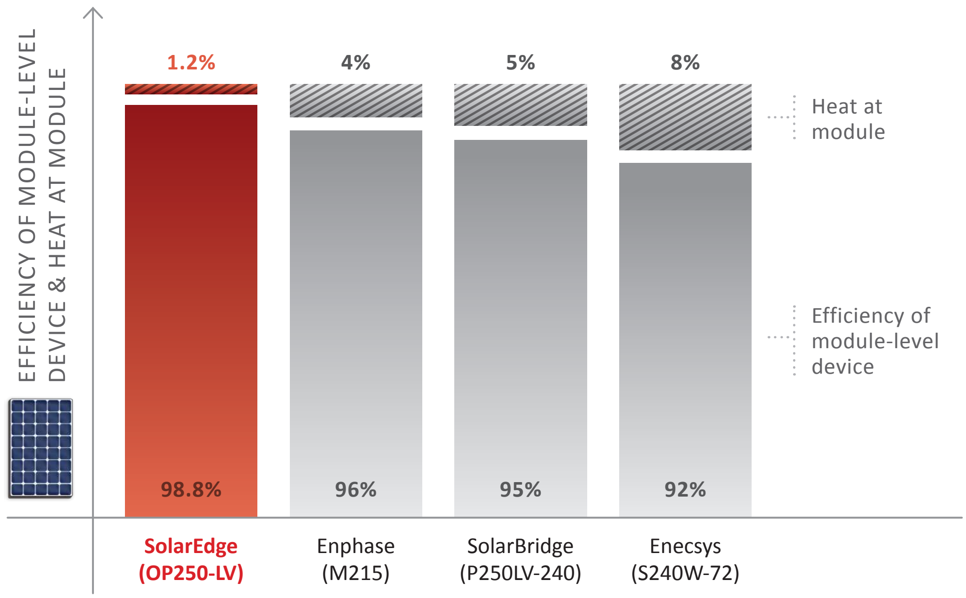
4. LOWER HEAT AND HIGHER EFFICIENCY

a. Influence on heat dissipation:

Power optimizers dissipate less heat. Power optimizers are more efficient than microinverters since the heat generation associated with inversion is done in the inverter and not in the optimizer. SolarEdge power optimizers, for example, operate at 98.8% weighted efficiency. As a result, less heat is dissipated to the module (1.2%). Microinverters have lower efficiencies than power optimizers. The highest known efficiency of microinverter brands is 96%, meaning 4% heat dissipation to the module (figure 5). Higher efficiencies therefore improve both product and module lifetime and reliability.

Figure 5:

Lower conversion efficiencies mean higher temperatures at the module and can impair module functionality. Power optimizers have a peak efficiency of 98.8% CEC. Therefore, the heat dissipated to the module is negligible compared to that of microinverters.

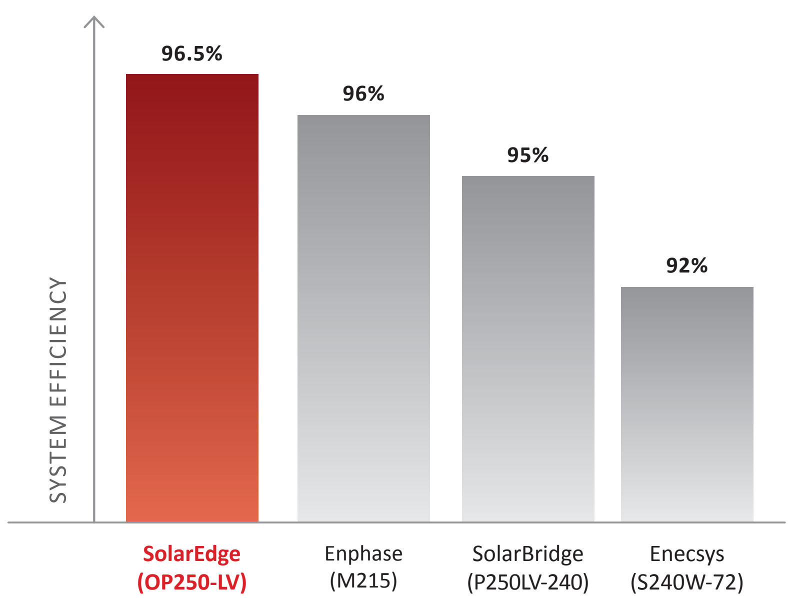


b. Influence on yield:

Currently, the weighted conversion efficiency of microinverters ranges between 92% – 96%. The weighted efficiency of the SolarEdge system is 96.5% (98.8% power optimizer efficiency multiplied by 97.6% inverter efficiency) . Thus, the overall system efficiency still remains higher than that of any microinverter: 96.5% (figure 6).

Figure 6:

The figure shows how the combined weighted efficiencies of SolarEdge power optimizers and inverters are superior to the weighted efficiency of microinverters.



5. COMMUNICATION

Communication between module electronics and the data monitoring service must be robust. Some microinverter companies use wireless communication between each module and a gateway, a working environment which is not robust enough to guarantee uninterrupted communication. Using wireless communication in an urban environment appears specifically problematic.

The desired choice of communication technology for module-level electronics would be power line communication (PLC), meaning the communication of data across cables. Within the realm of PLC, microinverters use AC PLC, as they are connected through AC cables. The problem with AC PLC is that it can easily be interrupted by every home appliance connected to an AC plug on the property. Power optimizers apply DC PLC connected to the modules via DC cables. In addition to being robust, DC PLC is also a completely separate (and hence completely uninterrupted) working environment; the proper functionality of module-level monitoring is therefore assured.

6. GRID CODE COMPLIANCE

With the number of PV installations rapidly increasing, some European countries have adopted a new set of grid codes to preserve the stability of the electric grid such as active power correction, low voltage ride through (LVRT), etc. The SolarEdge system complies with these grid codes while microinverters currently do not.

7. SYSTEM COST AND RETURN ON INVESTMENT

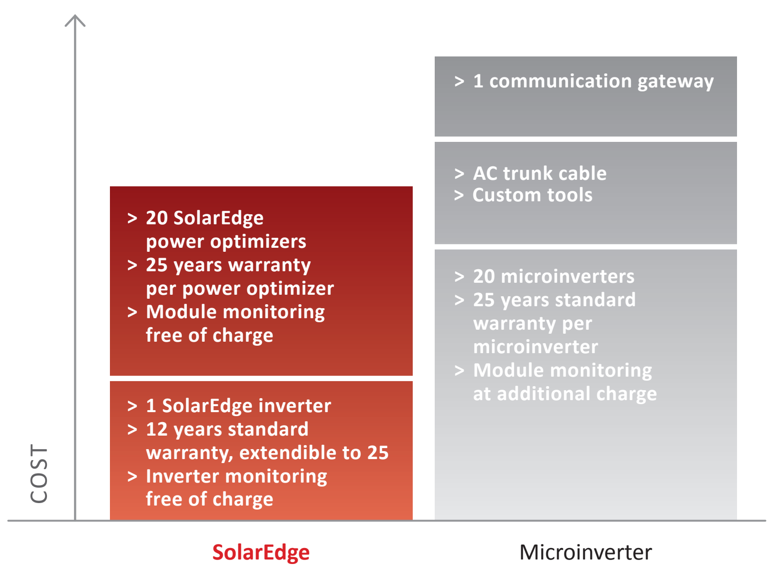
a. Lower upfront cost:

A microinverter system typically consists of one microinverter per module, communication gateways and costly AC trunk cables requiring custom tools. The limited current of the AC trunk cables further limits the amount of microinverters that can be connected to the same cable trunk. Thus installers still need to design AC strings and separate them with AC breakers. Furthermore, as there is no standard maintained for truck cable connectors, backward compatibility is not necessarily guaranteed.

The up-front cost of a SolarEdge system is 20%- 35% lower than that of a system installed with microinverters (figure 7). To begin with, the cost per unit for one SolarEdge power optimizer is lower than that of a single microinverter. As described in section 3 of this paper, SolarEdge power optimizers consist of fewer components than microinverters. In addition, the SolarEdge system includes a highly cost-effective DC/AC inverter, with communication hardware already built-in. Further, a maximum string length of 25 modules allows installers to reduce the wiring costs in a system. SolarEdge power optimizers are compatible with standard PV connectors used for the connected of PV modules and are therefore easy to replace.

Figure 7:

Upfront cost of a SolarEdge system compared to a microinverter system for a 5kW installation, with breakdown into required system components. The cost of a SolarEdge system is typically 20%-35% lower.



b. Faster return on investment:

Given a lower upfront cost, higher efficiency and more effective mismatch mitigation, the SolarEdge solution offers a better cost performance ratio against a microinverter system. The return on investment of an installation with a SolarEdge system will therefore be faster than for a system installed with microinverters.

8. ECONOMY OF SCALE:

It is an established fact that an inverter's cost per Watt decreases with increasing inverter capacity. In contrast, the principle of scaling does not apply to balance of system components allocated to the module-level; their cost is linear to the number of modules in the system. While microinverters duplicate the entire grid interface for each module, power optimizers still allow for the DC/AC conversion stage to occur only once at the inverter. A central DC/AC inversion stage means less components and therefore means a significant part of the cost remains scalable. Power optimizers are conclusively the more economical solution.

BETTER BY DESIGN

While microinverters are initially appealing for their simple concept, no advantages exist for the "all-AC" solution. In fact, microinverters or "AC modules" introduce many limitations. First, microinverters have limited AC output capacities and hence lack compatibility with many modules on the market. Microinverters have limited output rating than modules on the market today leading to the clipping of module power. Furthermore, microinverters have a narrow MPPT range restricting their effectiveness in partially shaded areas and system uptime. In addition, data communication in the AC environment suffers from interferences in the communication of data. Finally, the choice to use electrolytic capacitors and a high part count challenges the microinverter system's reliability and adds cost.

In contrast, power optimizers work efficiently in the DC environment of PV systems while providing all the features required at the module-level. Installers who use power optimizers benefit from full module compatibility, high product reliability, higher efficiency, a broad MPP tracking range with low MPPT voltage and uninterrupted DC power line communication. In addition, power optimizers and the SolarEdge system in particular, offer a more cost-effective solution as the DC/AC conversion remains centralized at the inverter. This keeps system cost low and scalable, as compared to that of microinverters. Power optimizers are simply better by design.