



Counting the cost of solar inverters

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There are many factors to consider when choosing the right inverter for a solar project, including ease of installation, performance, reliability and the levelized cost of energy (LCoE). As the renewable energy industry matures, there are more elements to think about too, such as compatibility with batteries, electric vehicles and their ability to keep key loads on the DC side of the inverter.



Excluding soft costs, such as permitting, engineering, customer acquisition, overhead, etc., the two largest components in any residential PV system cost are modules and inverters. The good news is that module costs are projected to decline significantly in 2024, due to an oversupply and will likely continue to fall in price over the next several years. Inverters may also come down in price, but not as significantly as modules. With that in mind, it is important to understand the types of inverters and how they differ in price.

Types of inverters

Today, there are three primary types of residential inverters. Microinverters are low-capacity inverters that connect to one or more modules at the array on the roof. They are also the most expensive, often carrying price tags double that of string inverters.

String inverters are larger capacity inverters located at ground level that convert power from multiple PV modules connected in series, or a string, to one or more

independent inputs tend to be the least expensive option and are the most popular products globally for residential and commercial projects.

The third category of residential inverters are string inverters that utilize DC to DC converters, often referred to as optimizers to always boost or buck module voltage to maintain a constant string voltage going to the simple ground level string inverter.

Advantages of string inverters

Hybrid-compatible

One of the biggest advantages of string inverters is that they can be built as hybrid inverters, capable of connecting to batteries. These batteries require a DC power supply to charge, which can be directly connected to a hybrid string inverter to store excess solar PV energy. This stored energy then only requires one conversion when later used to power AC home loads.

While this is also possible with string inverters utilizing DC to DC optimizers,

it is not as easily accomplished with microinverters, which convert DC power to AC at the module level before being sent to home loads. When using microinverters to charge and discharge a battery, the stored energy in a battery is converted three times with small efficiency losses each time before being sent to home loads.

The DC architecture benefit

Economics will not be the only driving factor for boosting string inverters in the coming years. The industry is also seeing a convergence of technologies. Gone are the days where simple PV-only systems with retail rate net metering dominate the national marketplace.

Today, there is a strong demand for solar coupled with battery storage and advanced energy management capabilities. This is another area where string inverters have an inherent advantage due to performance and ease of installation.

The second big advantage for string inverters also relates to their ability to keep key loads on the DC side of the inverter. When utilizing a DC coupled hybrid string inverter, fewer electrical connections are required at the home's distribution panel. This is due to the hybrid inverter's ability to provide a single output for all DC loads or generation sources including solar PV, battery, and/or electric vehicle supply equipment.

With the strong push for US electrification of homes and vehicles, it is estimated that more than 50% of US homes may require an electrical upgrade if adding significant electrical load such as that of a Level 2 AC charging station or an AC coupled battery.

Having the ability to keep these two loads behind the string inverter may go a long way in lowering the additional amperage being added to a home's electrical panel and thus lowering the potential for costly panel or service upgrades. Fortunately, there are alternative solutions to address this issue such as smart panels, inverter embedded power control systems, and other load shifting management systems, however, these too often come at an extra cost.

How leveled cost of energy impacts inverter choice

While upfront cost is important, any well-established solar installation company will be quick to point out that both the total operational cost and the leveled cost of energy (LCoE), or the total cost of producing energy over a system's life, are perhaps even more important.

These metrics come down to two very important factors; performance and reliability. With these two metrics in mind, string inverters also excel due to their high performance, fewer points of failure, and lower upfront cost.

Inverter performance: outperforming in shade

Historically, one of the central claims to justify the additional expense of microinverters and DC optimizers is that they outperform string inverters without optimizers when shading is present on the PV panels.

Some companies have gone as far as falsely stating that without microinverters or optimizers, the PV system will operate like a string of Christmas lights where one burnt-out bulb will prevent the entire string of bulbs from functioning.

Another misconception is if one PV module is too shaded to produce power, none of the other modules in that string will produce power. This assertion is both misleading and incorrect as modern PV systems have several features for dealing with shading that do not require module level optimization.

First, there are bypass diodes that are intentionally built into common silicon PV modules to allow current traveling through a module to, as the name suggests, bypass areas where current may be blocked, such as a section of shaded cells on a module. Second, modern string inverters also include multiple Maximum Power Point Trackers (MPPTs), generally 3-4, to allow for increased flexibility of system design.

These MPPTs, especially those that include high speed global tracking, can effectively set operating voltage points to best make use of bypass diodes (by activating or not activating them) to generate the highest amount of power possible for each string of modules.

The result of these technologies combined is an efficient PV system that does not require module level power electronics (MLPE) to mitigate the negative effects of shading. In fact, in many situations string inverters perform better with moderate to no shading when compared to systems using module level DC optimizers.

Inverter reliability: a simpler system is a more reliable system

After performance, the next factor to consider is reliability. It is generally understood that there is an inverse relationship between system complexity or number of components and system reliability. In other words, increasing the number of components in a PV system's design is likely to increase its risk of failure.

With this concept in mind, string inverters without additional MLPE have an inherent



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advantage in increasing system reliability and thus lowering costly corrective measures in the event of failures. It is also important to note that, even in markets with NEC required Rapid Shutdown (RSD) requirements, traditional RSD devices that do not perform power conversion will include significantly fewer internal components compared to optimizers or microinverters which also perform power conversion.

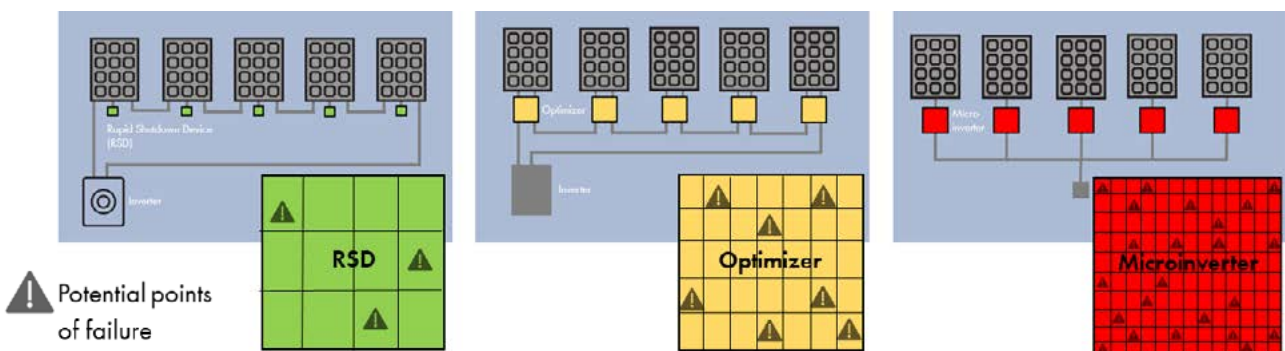
Due to lower upfront costs, strong performance without MLPE, and the advantages for system reliability, in many cases string inverters will have lower LCoE versus those requiring MLPE.

String inverters for a strong fit

To sum up, string inverters represent an optimal selection for numerous solar panel setups, particularly when integrated with battery storage systems and in scenarios where dependability is paramount.

Additionally, they are highly suitable for conditions prone to shading, projects that can gain from hybrid compatibility, and for those project managers who prefer essential loads to remain on the DC side of the inverter.

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System reliability increases with simplicity; fewer components in a device typically leads to fewer points of potential failure, enhancing overall dependability