String inverter capacity

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The utility-scale PV market is maturing. Last year, 22.5 GW of utility-scale PV was installed in the US, a 77% jump from 2022. Solar PV accounted for over half (53%) of all new electricity-generating capacity additions for the first time ever. That fact bears repeating: the majority of the new power sources on the grid last year were large-scale solar plants.

As renewables gobble up grid capacity, utility-scale developers are pressured to deliver high volumes of reliable, cost-effective installations. This is a massive opportunity and a considerable challenge. On one hand, the list of viable utility-scale technologies is longer than ever and continues growing. On the other, PV systems are being asked to do more and more. Energy storage attachment rates are on the rise, utilities are demanding advanced grid services, and the availability of "ideal" plots of land is dwindling.

Choosing the right technology for each project is hard. This article will overview perhaps the most essential components in a PV system, inverters, and compare the two main options dominating today’s utility-scale market: central and string inverters.

There are three primary tiers of PV inverters: microinverters, string inverters, and central inverters. Since microinverters are not rated for utility-scale voltages, we will largely ignore them in this article.

String inverters convert DC power from "strings" of PV modules to AC and are designed to be modular and scalable. Smaller string inverters may have as few as one input, with one PV string per input. Larger string inverters can handle many string inputs. In both cases, string inverters will likely have integrated maximum power point trackers (MPPTs) on their input (dc) side to boost array performance at the string level. Newer string inverter models have upwards of 12-15 MPPTs and can handle dozens of PV string inputs.

Note: A "string" is any series combination of 2 or more PV modules. For utility-scale systems, strings often consist of 20-30 modules installed in series.

String inverters have historically been more common at the residential and commercial scales, where string-based designs with MPPTs are effective at maximizing energy harvest from arrays with partial shading, multiple orientations, or undulating terrain. However, recent technology improvements have boosted string inverter power densities, making them more competitive with…

The likelihood of encountering a central inverter on a project increases with project size and age. Utility-scale projects above ~10 MW are the most common application today. Large C& I and smaller utility-scale projects from just a few years ago are likely to have central inverters as well, for reasons we"ll touch on in the next section.

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The first PV inverters were developed in the 1980s as a spinoff of drive system technologies. At the time, all models could be considered central inverters rated to handle no more than a few kilowatts. As with any new technology, early iterations were far from perfect. Ironically enough, the drawbacks of early central inverters (mismatch losses, inflexible system design) led to the development of module-level microinverters.

The PV inverter market of this era had two bookends: microinverters for residential and small commercial projects and increasingly large central inverters for everything else. The first generation of string inverters was developed in the mid-1990s to support projects that were not especially large or small. Initially designed for a single string input, early string inverters were viable for residential and commercial applications but struggled to scale up.

With the groundwork laid for a three-tiered inverter market, the ensuing decades were spent refining each technology. Sometimes, innovation was driven by codes, standards, and AHJs (rapid shutdown and UL 3741), and other times by manufacturers themselves (anti-islanding and grid-forming capabilities).

That brings us to today, where the lines of the three-tiered market have blurred. Microinverters and other module-level power electronics can be found on residential rooftops as well as commercial systems. Central inverters are installed in large commercial and utility-scale systems. String inverters are designed for all system sizes.