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Why array oversizing makes financial sense

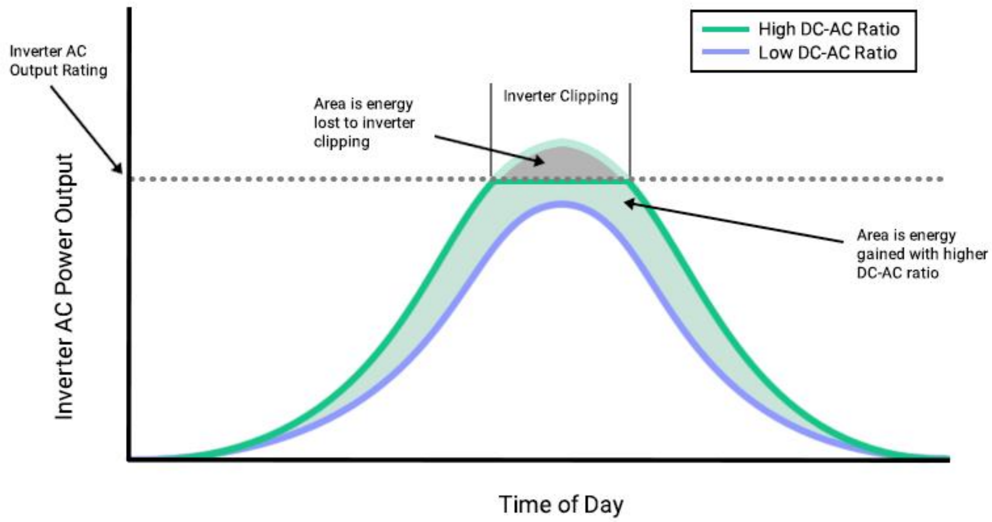
By Kathie Zipp | February 12, 2018

With cheaper panels and new time-of-use rates, higher DC-to-AC ratios are becoming more economic

Going back to solar basics for a moment, inverters must convert the DC electricity the solar cells produce into AC electricity homes and businesses can use. So when designing a solar installation and selecting an inverter, it's important to consider how much DC power the array will produce and how much AC power the inverter can output (also known as its power rating).

The ratio of how much DC capacity (the quantity and wattage of solar panels) is installed to the inverter's AC power rating is called the DC-to-AC ratio, or DC load ratio, oversizing ratio or overloading ratio, etc. For example, a 120-kWdc array with a 100-kWac inverter has a DC-to-AC ratio of 1.2.

"It often makes sense to oversize a solar array, such that the DC-to-AC ratio is greater than 1," said David Bromberg, senior scientist at Aurora Solar, on Aurora's blog (blog.aurorasolar.com). In other words, one would adjust the number of solar panels so the DC capacity divided by the AC output is greater than one. "This allows for a greater energy harvest when production is below the inverter's rating, which it typically is for most of the day."



Consider the graph of energy production as a function of time of day. The purple line shows a typical bell curve of AC output power peaking at noon, just below the rating of the inverter indicated by the dashed line. Adding more panels to increase the size of the solar array increases the DC-to-AC ratio of the system (as illustrated by the green curve), allowing greater energy harvest throughout the day. The area between the green and purple curves is the energy that is gained by increasing the DC-to-AC ratio. Credit: Aurora Solar

Considering clipping losses

However, oversizing a solar array isn't without consequences or costs. When the array is producing the most solar energy (the DC maximum power point) at a level higher than the inverter's power rating, the extra power is "clipped" by the inverter. This inverter clipping, or power limiting, ensures the inverter is operating within its capabilities but results in lost energy production during peak production hours. All UL 1741-certified inverters should have power-limiting capabilities.

"The inverter effectively prevents the system from reaching its [maximum power point], capping the power at the inverter's nameplate power rating," Bromberg said.

Therefore, the inverter's clipping must be carefully modeled when designing a system, especially in areas with high levels of irradiance that can lead to higher power output. Otherwise, the system could underperform. Sometimes the solution is to add another inverter. Solar design software that automatically considers inverter clipping, like Aurora's, can make accurate performance simulations easier.

"Knowing how much energy is clipped allows a designer to understand how effective the oversizing scheme is at increasing energy harvest and determine what system configuration is the most cost-effective, in order to make an informed decision about how much DC power to connect to the inverter," Bromberg said.

DC-to-AC Ratio	Annual AC Energy Production	Energy Lost to Clipping
1.0	163.06 MWh	0.0 MWh
1.3	193.86 MWh	1.8 MWh (0.9%)
1.5	217.24 MWh	11.0 MWh (4.8%)

Annual energy production out of a 100-kW inverter as a function of DC-to-AC ratio. As the DC-to-AC ratio increases, so does the AC output and clipped energy. Credit: Aurora Solar

However, Marco Trova, technical sales support manager at ABB, worries that software doesn't consider the effects of oversizing when analyzing inverter life.

"DC-to-AC ratio can impact the inverter's useful lifetime differently in various locations. Software cannot account for all the different conditions of every manufacturer's products," he said.

Oversizing exposes the inverter to more power, more short circuit current and more full-power input voltage during clipping. The inverter has to work harder for longer hours, even in hot summer months. Most inverters operate less efficiently above their maximum power point voltage, which also increases internal component temperature.

ABB did a series of studies to find a safe limit for DC-to-AC ratios using its inverters specifically. It looked at temperature—which significantly contributes to component aging—and other factors.

"Defining a one-fits-all DC-to-AC limit is a tricky task," Trova said. "You not only have to consider the variability of the environmental conditions, but also different mounting orientations."

While ABB was able to find a maximum DC-to-AC ratio for its Trio-50.0-TL OUTD inverter in fixed-tilt and solar tracking installations, Trova said it's not possible to find a convenient "one-size-fits-all" value across all inverter brands.

The maximum oversizing ratio of an inverter depends on string count, string size, inverter efficiency and factors that affect the inverter's operating temperature and ability to cool, such as shading, mounting and elevation. Proper maintenance is also important.

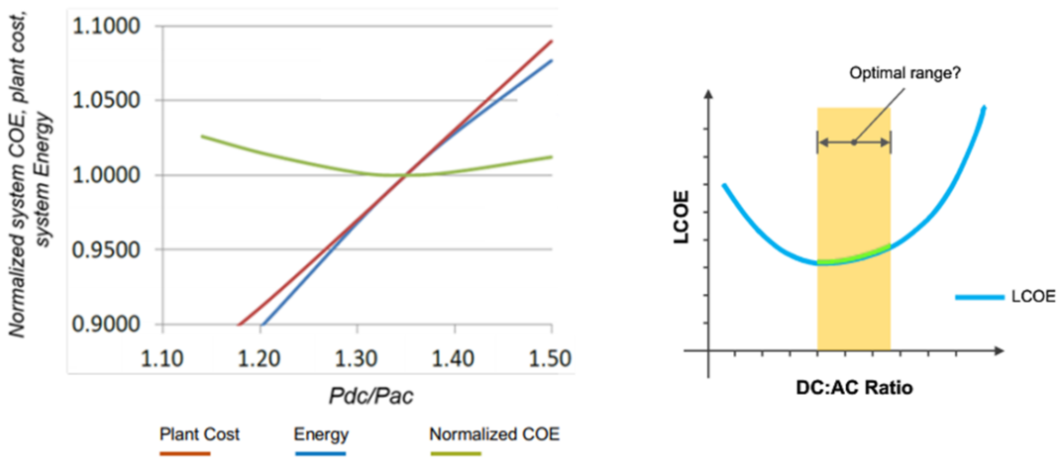
"The choice to oversize a solar array should be made responsibly," Trova said.

Designing for financial efficiency

Though oversizing PV systems is not a new practice, falling panel prices and new time-of-use rates are further improving economics. Maximum energy yield traditionally governed system design, so developers focused on positioning models to avoid shading and sizing the array so the inverter spent little or no time clipping. But now developers are driven to maximize financial returns. Cheaper panels make it cost-effective to add more modules to the array and benefit from the gains in energy production during peak hours, even with clipping losses. Also, new time-of-use rates mean it makes sense to increase DC-to-AC ratios when the value of solar energy is high. While designers traditionally may have used a DC-to-AC ratio of 1.1 or 1.2, these aspects are pushing ratios as high as 1.6.

"The idea is for the inverter to run at full power when energy is the most valuable," said Trova. "However, oversizing only improves project economics up to a certain point at which energy losses and costs outweigh the economic benefit from the additional panels."

The levelized cost of energy (LCOE) can be used to determine a system's sensitivity to DC-to-AC ratios. ABB did a study in which it looked at solar arrays in three locations (cities in Washington, Virginia and New Mexico) with different irradiance levels and temperatures using DC-to-AC ratios between 1 and 1.6. It simulated the effects of oversizing in NREL's system advisor model (SAM), calculating LCOE and comparing results with specific yield (the system's annual energy harvest per kW of installed DC capacity) calculated in PVsyst.



The economical limit of oversizing a system can vary, but most projects have the same goal of optimizing the levelized cost of energy. Credit: ABB

ABB found that the optimal DC-to-AC ratio in these areas depended on the design goal. For example, regardless of site conditions, sizing a system to maximize specific yield allows for an ideal DC-to-AC ratio at or slightly below 1.2. However, sizing a system to target the best financial output could lead to higher DC-to-AC ratios, between 1.3 and 1.6.

ABB concluded that an inverter that could manage a DC-to-AC ratio up to 1.6 would be the most ideal because then the project could achieve the best economic benefit of increasing the DC capacity, without adding to the fixed cost of the system.

Developers are oversizing in projects from large utility installations in the desert, to space-constrained commercial roofs. Though, with changing time-of-use rates, Trova said oversizing may make sense on the residential level as well.

“Having a larger array on a fixed-size inverter results in greater annual system production, while fixed system, permitting, interconnection and other costs stay the same, shifting financials in favor of a higher DC-to-AC ratio,” he said.

With decreasing module prices, utilities adopting time-of-use rates and new inverter technology and grid-support functions, oversizing is a trend that isn’t going away anytime soon.