Buying Guide

Grid-Tied Solar

What does it mean to be grid tied?

A grid-tied solar system is connected to the utility grid. This is the most common system type for those who already have commercial electricity at their home. Grid-tied systems offer a simple and cost-effective way to offset electric bills with solar energy. At their core, simple grid-tied systems consist of two main components: solar panels and an inverter. The solar panels collect light from the sun, and a chemical reaction inside the panel converts the light energy into DC electricity. This DC power is then sent to the inverter, which converts it to usable AC power before sending that power to the loads in your home. If the loads in the home are satisfied, and the solar panel array is producing excess power, a typical grid-tied system will send the extra power back to the grid. Most customers will get some kind of credit or reduction in their electric bill for selling excess solar production to their utility company. Any energy used by the home (such as at night, when it's cloudy or if there are extra power needs) is purchased from the utility company like normal.

What are the limitations of grid-tied systems?

A common characteristic of most grid-tied inverters is that they sync to the same voltage and frequency of the grid in order to output power. This means that irregularities or outages with the grid will affect inverter operation. The biggest impact with this involves anti-islanding requirements. Anti-islanding ensures that there is no power from residential solar systems on the "grid" during an outage in order to prevent injury to line workers who may fixing the issue. As a result, grid-tied inverters are not allowed to back feed the grid during an outage and the system will shut down, even if the outage occurs during the middle of a sunny day.

How can I avoid anti-islanding shutdowns?

Grid-tied systems with battery backup provide a flexible and sophisticated solution. Also known as a hybrid system or ESS (Energy Storage System), grid-tie with battery backup utilizes the best of both the grid-tied and off-grid worlds. Hybrid systems with batteries typically have similar operation to grid-tied inverters described above during times when the grid is active. However, instead of shutting down during a grid outage, an ESS will continue to operate. It can do that because the batteries provide power to loads and will also keep the solar array working in the midst of a blackout. In most cases, a separate breaker panel is installed in the home to contain the critical loads which must be powered during a grid outage. Incorporating battery backup in a grid-tied system also opens the door for things like increased self-consumption, time of use, peak load shaving, etc.

What's involved in installing grid-tied systems?

Roof-mounted solar panels are most common for these types of systems, but ground mounted arrays can be used as well. Most roof-mounted grid-tied systems will need to meet rapid shutdown requirements, which protect first responders in emergency situations and entail some additional components. Typically, grid-tied systems will require a bit more paperwork than off-grid systems. A full plan set including a site map, electrical single line drawing, product spec sheets, and more have to be submitted as part of the permitting process with the local AHJ (authority having jurisdiction). In addition to the permit process with the AHJ, a separate interconnection agreement or similar contract is made with the utility company.

Grid-tied and hybrid systems can be configured with various types of inverters, from a single centralized string inverter to individual microinverters on each solar panel to a string inverter with DC optimizers. See our inverter buying guide for more details on selecting the best type of grid-tied or hybrid inverter for your applications.

How do you size a grid-tied system?

Offsetting energy consumption with solar and reducing electric bill totals are usually the main motivators for going with a grid-tied system. That being said, the average energy consumption at the site is one of the most important factors when sizing a grid-tied system. Since the home or property is already connected to the grid, a copy of the electric bill can be very helpful in this phase. It will have some sort of average (daily, monthly, yearly) consumption of energy listed in kWh (kilowatt hours). This kWh consumption combined with other factors such as geographical location, panel mounting method, shading issues, etc. is used to determine the size of the solar array needed for a grid-tied system. Ideally, reviewing an entire year's worth of energy usage (if available) is best so that variances in usage patterns between different seasons can be considered.

- **Characteristics/parameters needed to size and design GT System:**
  - Electric bill, % offset
  - Grid stability location
  - Time of use, peak load shaving, etc.
  - Tax incentives
  - Utility interconnection/buy back agreement

Should I go with a standard grid-tied or hybrid system?

For most, offsetting 100% of the site's energy usage is the primary goal for grid-tied solar, however a smaller offset percentage can also still be effective. Even offsetting 75% of one's energy usage still puts a big dent in the electric bill and will also further reduce the initial upfront equipment cost. This would shorten the payback period and increase return on investment.

With the addition of battery backup, energy offset can be further tailored to meet the specific needs of an individual or application. Batteries maximize self-consumption by storing the energy produced by the solar array to use it in the home when it's needed, rather than selling that excess back to the grid. This can be cost-effective when the local utility company may not offer great incentives for selling back excess solar production. Batteries can store energy that is produced by the solar panels during the day to be used at night or during times of insufficient solar production. This can reduce—or even eliminate— power purchased from the utility company.

Utility customers with time-of-use billing structure, or higher electric costs during periods of peak demand, can benefit from battery storage. Stored battery energy can be used to cover the loads during these peak rate periods to avoid buying kWh from the utility company at a higher price than normal. Periods of peak demand or higher price per kWh, usually occur toward the end of the solar day when the power output from the panels is minimal. Therefore, batteries can be used to make up for the lack of solar output during on-peak rate periods.

The stability of the local electric grid at the site of installation is big factor in selecting the proper equipment. A stable grid with good quality power and infrequent and/or short-lasting outages makes a solid candidate for a traditional grid-tied system. On the other hand, if the local electric grid is unstable or sees frequent outages which may be long lasting, a hybrid type system with batteries may be a better option.

Incentives offered by the utility provider for excess solar power sold back to them should also be considered for grid-tied systems. There are very few true net-metering (1:1 ratio) interconnection agreements in existence nowadays, so most of the time the utility will pay the customer a wholesale price for the kWh sold back to them, but still charge retail price for kWh purchased from them. In other words, you may only get credit for 75% of every 1 kWh of excess solar production sold back to the utility company. If the utility does not offer great incentives or is not accommodating to solar, a grid-tied system designed to maximize self-consumption may be a more viable option.

Furthermore, there are also tax incentives available for grid-tied solar, for both residential and commercial type systems. A 26% federal tax credit is currently available for both residential and commercial solar systems, and this was recently extended through the end of 2022. Similarly, there may be additional incentives available on a state, county or municipal level. At times, even the utility company itself may have other financial incentives for installing a solar system.

What are the types of grid-tied systems?

The traditional grid-tied system consists of a group of solar panels and an appropriately sized string inverter. This inverter is named as such due to having a relatively high input voltage, which requires that the solar panel array is connected in relatively large panel strings (groups of panels in series). Each string input (typically 1-3 in total) has its own MPPT (maximum power-point tracking) charge controller. (See our section on charge controllers for more information on this topic.) Because multiple charge controllers are present, it's possible to have different panels on each MPPT (in terms of model & wattage). Additionally, the output wattage of a string inverter directly correlates to the number of PV modules it has connected to it. In most cases this can be overloaded slightly, but always keep the recommendations of the inverter manufacturer in mind when doing this. The correlation between inverter size and MPPT wattage input is not so common in systems with batteries present. This characteristic is a result of the inverter and the MPPT's being integrated as one device.

Newer grid-tied system designs have module-level devices known as micro inverters—named because instead of passing DC power to a string inverter, they invert DC power produced by every module and act as a small grid-following inverter (or an inverter that syncs up its power output to match that of the grid, and responds to powerline commands from the grid, a process known as frequency shifting). Power sent out of each micro inverter is already 120/240VAC split-phase power. Micro inverters typically have one or more control panels for real-time organized communications and monitoring capabilities.

What are the strengths and weaknesses of the different types of inverters?

Factors should be taken into consideration when choosing the right grid-tied inverter for your system—there are advantages to both. String inverters are typically more cost-effective and efficient than their micro inverter counterparts, but must be treated as MPPT's when designing the solar arrays connected to them. All solar panels connected to one MPPT charge controller must have similar levels of PV exposure at the same time so that losses are avoided, i.e., the solar panels must be facing the same direction on each MPPT. In many cases this can be designed around, but sometimes it cannot—one doesn't simply change their home's roofing. In this case, micro inverters are a great solution and provide a much more flexible solar panel array design.

The exact grid-tied inverter solution also depends heavily on which version of the National Electric Code (NEC) that your AHJ is using. Rapid shutdown requirements in NEC 2014 and NEC 2017 differ greatly. In the NEC 2014 version, array-level rapid shutdown is required, whereas in the NEC 2017 version, PV module-level rapid shutdown is required. Rapid shutdown requirements dictate that PV modules must have a rapid shutdown feature built into any system that has them—whether that is module level or array level. For both versions a rapid shutdown initiator switch must be located near the main panel so that in an emergency situation power lines from the solar array can be de-energized for firefighters or other emergency personnel. However, if your AHJ's rapid shutdown requirement is module level, this means you must have a device at every panel that can facilitate rapid shutdown. If you are to get a string inverter in this case, you still need a rapid shutdown device at each module. This usually makes a micro inverter solution more cost-effective and simpler to design around. In order to use a string inverter under this circumstance, one must use an extra module-level rapid shutdown device or a DC optimizer (this device is similar to a module-level MPPT charge controller) to meet the module level rapid shutdown requirement.

Another consideration for grid-tied systems is the possibility of battery backup. In most cases it is simpler and more cost-effective to select a hybrid inverter that can have batteries added later. (One that operates with or without batteries is commonly called a "battery agnostic" inverter.) Adding batteries to a pre-existing grid-tied system often requires the use of a process known AC coupling. AC coupling is an inefficient and complex solution to use and should be generally avoided when possible. If you are adding a grid-tied system with battery backup in mind, it is highly recommended that you choose an inverter solution that doesn't need to resort to the AC coupling method. Most string inverter and micro inverter manufacturers have products that integrate with or are battery backup options that do not use this process. Keep this in mind when choosing your grid-tied inverter solution.