When Do You Need a Charge Controller?

Morningstar's TriStar MPPT charge controller (45 or 60 amp) is one option for a whole-house RE system.

Whenever you have a charging source (solar-electric system, or hydro, wind, or engine generator) connected to the batteries, controlling the rate of charge is vital.

Charge controllers protect RE system batteries by managing the amount of energy the battery receives. Overdischarging and undercharging can lead to decreased capacity, early failure, and replacement of an expensive component. Controllers adjust their behavior based on battery voltage. Besides managing the current to the batteries, some controllers can act as load controllers, disconnecting DC loads if battery voltage gets too low. For wind and hydro systems, with outputs that should not be turned off, some charge controllers can be used as diversion controllers, sending excess power to a DC heating element instead of overcharging the batteries.

For smaller systems—such as a battery-powered DC light charged by a single PV module—a basic shunt or series controller may be sufficient. Shunt controllers release excess energy as heat, while series devices act like on/off switches. When battery voltage drops below a preset level, the controller switches on the circuit that allows current to move to the batteries. Pulse-width-modulating (PWM) controllers use rapid electronic switching of input, regulating the energy flow by decreasing the amount of their "on" state as batteries become fully charged.

For residential systems, maximum power point tracking (MPPT) controllers allow the PV array to operate at optimal conditions for optimal production. MPPT controllers turn excess array voltage into usable current for battery charging, offering the most energy increase in cooler temperatures and times of lower battery charge—often the case for off-grid PV systems during the short days of winter.

Sizing a charge controller for a PV array depends on the controller type selected (MPPT vs. non-MPPT). Controllers should be sized by the operating voltage and the current of the charging source and, if it is also a load controller, of the load. To size a PWM, series, or shunt charge controller with load control, the array short-circuit current (Isc), nominal voltage, and the DC load current and voltage are used. For example, a system consisting of a single 80 W module (12 V nominal; Isc = 4.8 A) that charges a 12 V battery and operates a 60 W, 12 VDC light could safely use a 6 A (or higher), 12 V controller with a load control that disconnects the light when battery voltage is too low:

Charge controller: 4.8 A × 1 module in parallel × 1.25 (safety factor to account for high irradiance conditions) = 6 A

Load control: 60 W ÷ 12 V = 5 A

PWM, series, and shunt controllers are typically available in 12, 24, or 48 V nominal, with amperage capacity from 6 to 60 A.

MPPT charge controllers usually do not offer DC load control, since primary loads in residential systems are AC and controlled (and protected from under-voltage) by an inverter. Manufacturers provide maximum PV array voltage and wattage (STC) values on their specification sheets (or offer array string-sizing tools on their Web sites) for MPPT charge controller sizing. Let's say a 60 A MPPT controller's spec sheet shows a maximum array voltage of 150 VDC. The array power the controller can handle depends on the nominal battery bank voltage: at 12 V, the maximum array size the controller can deal with is 800 W; at 24 V, it's 1,600 W; at 48 V, it's 3,200 W. If the array's power capability is higher, look for a higher amperage charge controller, or split the array into subarrays and use multiple charge controllers. MPPT controllers are commonly available in 60 and 80 A.

While a charge controller can help protect batteries, thoughtful system design should account for proper battery sizing. If your loads consistently discharge your batteries, then revisiting the load analysis, battery capacity, and charging requirements might be in order.

—Erika Weliczko