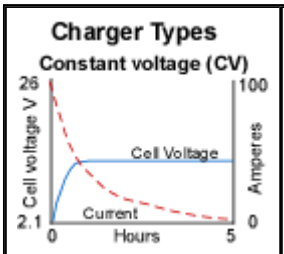
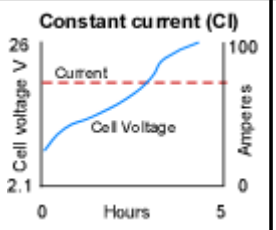
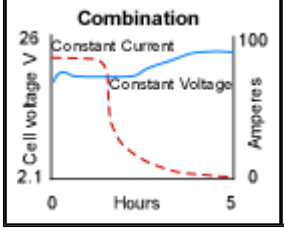
U.S. Department of Energy - Energy Efficiency and Renewable Energy
Vehicle Technologies Program – Advanced Vehicle Testing Activity

Battery Chargers for Electric Vehicles

Battery chargers replenish the energy used by an electric vehicle much like a gasoline pump refills a gas tank. One significant difference is that an electric vehicle operator can fully charge the vehicle overnight, at home, rather than refueling at a gasoline station. The battery charger converts the alternating current distributed by electric utilities into the direct current needed to recharge the battery. Different types of battery chargers control the charging rate in different ways.

	A constant voltage is applied and the current flows into the battery (high current when the battery is discharged, low current when the battery is nearly charged.)
	A constant current is applied until the battery voltage reaches a set value.
	The charge cycle starts with a high constant current until the voltage reaches a set value, then changes to a constant voltage control.
	A series of very high current and voltage pulses are applied until the battery voltage reaches a set value.

Charge Levels

Chargers are also classified by the level of power they can provide to the battery pack:

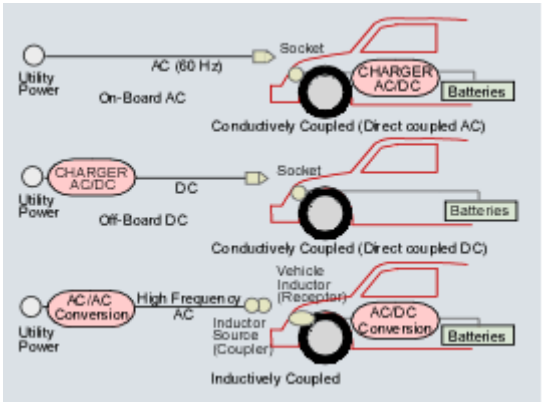
- Level 1: Common household circuit, rated to 120 volts AC and 15 amperes. These chargers use the standard three-prong household connection, and they are usually considered portable equipment.
- Level 2: Permanently wired electric vehicle supply equipment used especially for electric vehicle charging; rated up to 240 volts AC, up to 60 amps, and up to 14.4 kilowatts.
- Level 3: Permanently wired electric vehicle supply equipment used especially for electric vehicle charging; rated greater than 14.4 kilowatts. Fast chargers are rated as Level 3, but not all Level 3 chargers are fast chargers. This designation depends on the size of the battery pack to be charged and how much time is required to charge the battery pack. A charger can be considered a fast charger if it can charge an average electric vehicle battery pack in 30 minutes or less.

Coupling Alternatives

Two basic coupling methods are used to complete the connection between the utility power grid, the battery charger, and the vehicle connector. The first is conductive coupling, which uses the common plug. With this connection, the vehicle is plugged into the appropriate outlet (i.e., 110 or 220 volts) to begin charging. This type of coupling can be used with the charger in the car (onboard) or out of the car (offboard).

The second type of coupling is called inductive coupling. This type of coupling uses a paddle that fits into a socket on the car. Rather being transfered by a direct wire connection, power is transferred by induction, which is a magnetic coupling between the windings of two separate coils, one in the paddle, the other mounted in the vehicle.

Charger Location



Electric vehicle battery chargers may be onboard (in the electric vehicle) or offboard (at a fixed location). There are advantages and disadvantages with both types. If the battery charger is onboard, the batteries can be recharged anywhere there is an electric outlet. But onboard chargers are limited in power output because of size and weight restrictions dictated by vehicle design. Offboard charges are limited in power output only by the ability of the batteries to accept the charge. While a high-power offboard charger needs less time to recharge batteries, the flexibility to charge at different locations is restricted.

Summary

With existing electric vehicles and battery chargers, it usually takes from several hours to overnight to recharge an electric vehicle battery pack. The time required to recharge electric vehicle batteries depends on the total amount of energy that can be stored in the battery pack, and the voltage and current (i.e., power) available from the battery charger.

New developments in battery recharging decreases the time required to recharge electric vehicle batteries to as little as 10-15 minutes. Pulse battery chargers have demonstrated that a battery pack can be recharged in under 20 minutes without damaging it. When this technology is fully deployed, electric charging stations, similar to gas stations, will allow the electric vehicle operator to quickly recharge the battery pack. This new charger technology, coupled with advanced batteries with a range of 200 miles between recharging, will allow the electric vehicle operator the same freedom of the road currently enjoyed by today's operators of gasoline-powered vehicles.