Electric Vehicle Systems Program

Welcome

EVS Basics Course

What are Electric Vehicles and Charging Stations?

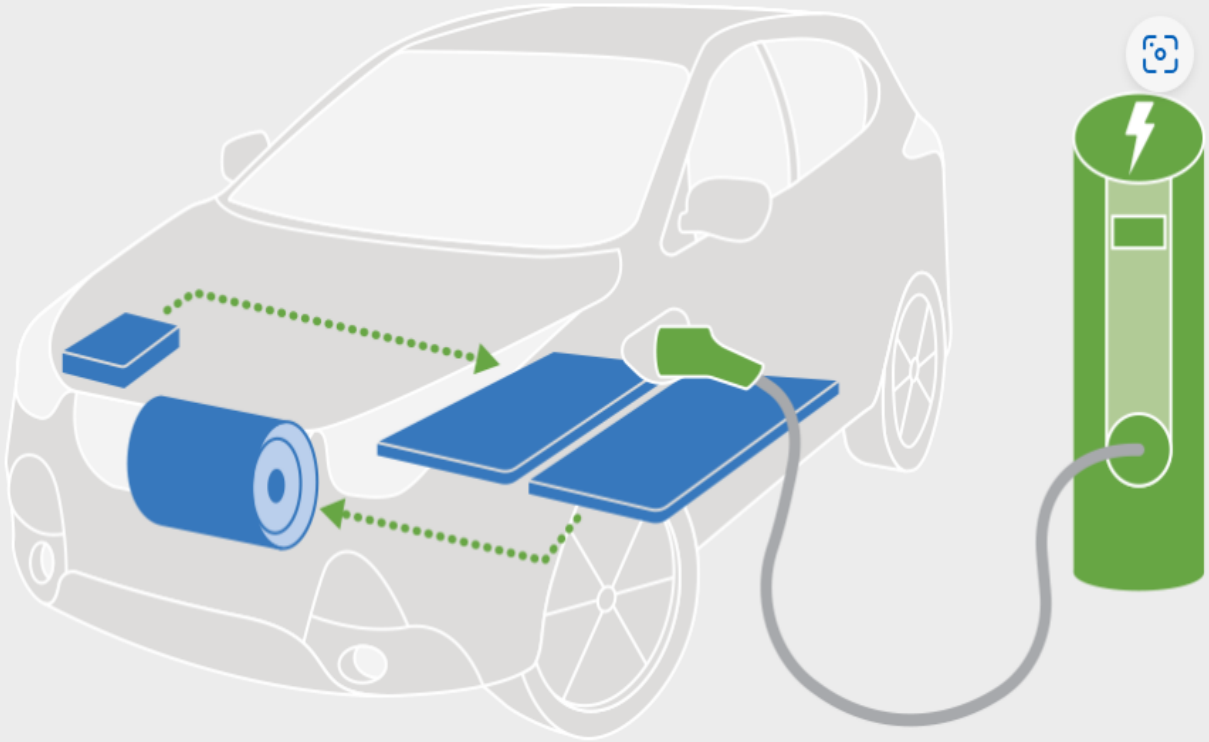
Consumers and fleets considering electric vehicles—which include all-electric vehicles and plug-in hybrid electric vehicles (PHEVs)—need access to charging stations. For most drivers, this starts with charging at home or at fleet facilities. Charging stations at workplaces and public destinations may help bolster market acceptance by offering more flexible charging opportunities at commonly visited locations. Community leaders can find out more through EV readiness planning, including case studies of ongoing successes. The EVI-Pro Lite tool is also available to estimate the quantity and type of charging infrastructure necessary to support regional adoption of EVs by state or city/urban area and to determine how EV charging will impact electricity demand.

The Combined Charging System (CCS), also known as the SAE J1772 combo, charge port on a vehicle can be used to accept charge with Level 1, Level 2, or DC fast charging equipment.

Charging the growing number of EVs in use requires a robust network of stations for both consumers and fleets. The Alternative Fueling Station Locator allows users to search for public and private charging stations. Quarterly reports on EV charging station trends show the growth of public and private charging and assess the current state of charging infrastructure in the United States. Report new charging stations for inclusion in the Station Locator using the Submit New Station form. Suggest updates to existing charging stations by selecting “Report a change” on the station details page.

Source: U.S. Dept. of Energy https://afdc.energy.gov/fuels/electricity_stations.html

What are Electric Vehicles ?



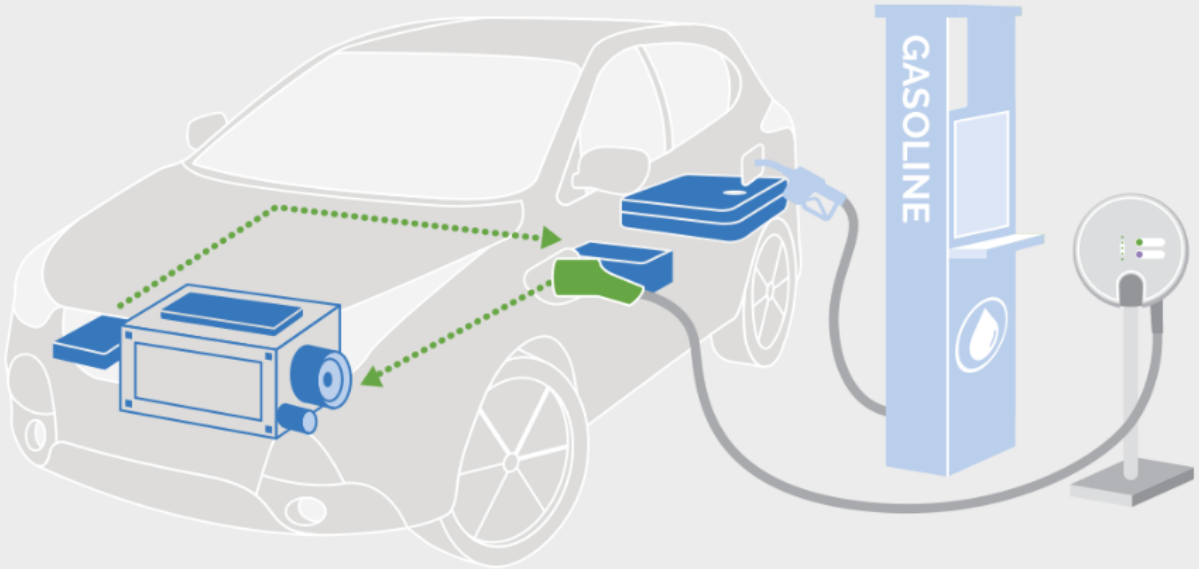
All-Electric Vehicles

All-electric vehicles (commonly referred to as EVs or BEVs) don't use gasoline, and instead have a large battery that powers one or more electric motors. Currently, all-electric vehicles have a driving range of 80 to more than 300 miles, with ranges increasing as new models are introduced. In addition to driving past the gas station, all-electric vehicles don't require much maintenance (such as oil changes, smog checks, spark plug changes and replacing a catalytic converter or various other parts that wear out and break down) compared to gas cars.

All-electric vehicles can be charged at home using standard 120-volt or 240-volt house plugs, or away from home at public or workplace charging stations. One benefit of all-electric vehicles over plug-in hybrids is the capability to use DC fast chargers, which provide more than 100 miles of range in 30 minutes.

Source: https://www.electricforall.org/

Plug- in Hybrid Electric Vehicles

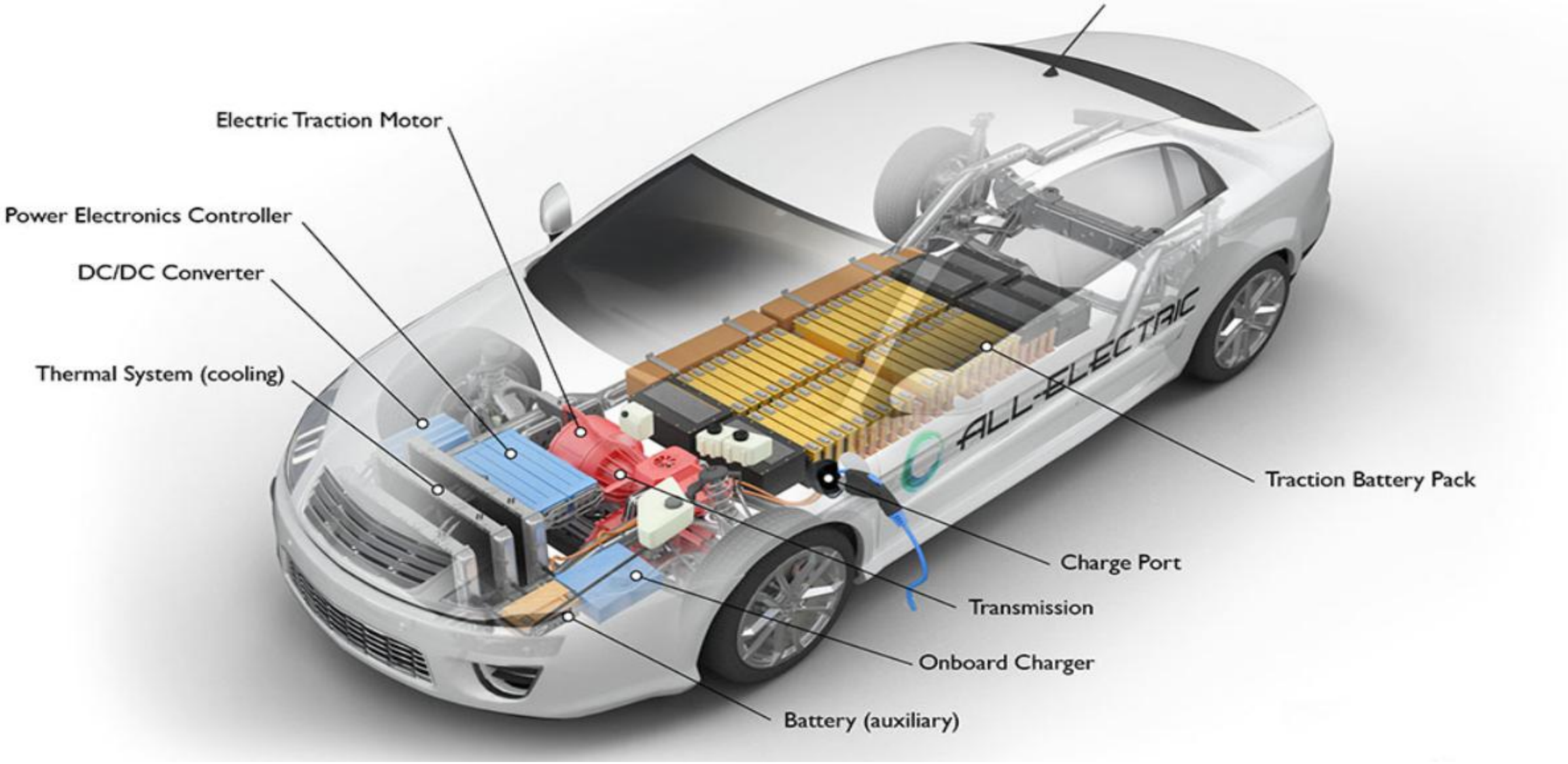


Plug-In Hybrid Electric Vehicles

Plug-in hybrid electric vehicles (commonly referred to as PHEVs) offer both gas-only and electric-only driving—even at relatively high speeds. With smaller batteries than battery electrics, plug-in hybrids achieve an electric-only range of 20-55 miles, during which they produce no tailpipe emissions. When the car uses up its electric range, it switches to gas and drives just like a conventional car.

Because most Californians commute less than 30 miles, most plug-in hybrid electric driving can be done in electric-only mode.

Overview of Electric vehicle



Source: [Alternative Fuels Data Center: How Do All-Electric Cars Work? (energy.gov)]

Key Components of an All-Electric Car

- **Battery (all-electric auxiliary):** In an electric drive vehicle, the auxiliary battery provides electricity to power vehicle accessories.
- **Charge port:** The charge port allows the vehicle to connect to an external power supply in order to charge the traction battery pack.
- **DC/DC converter:** This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.
- **Electric traction motor:** Using power from the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.
- **Onboard charger:** Takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the traction battery. It also communicates with the charging equipment and monitors battery characteristics such as voltage, current, temperature, and state of charge while charging the pack.

Key Components of an All-Electric Car :

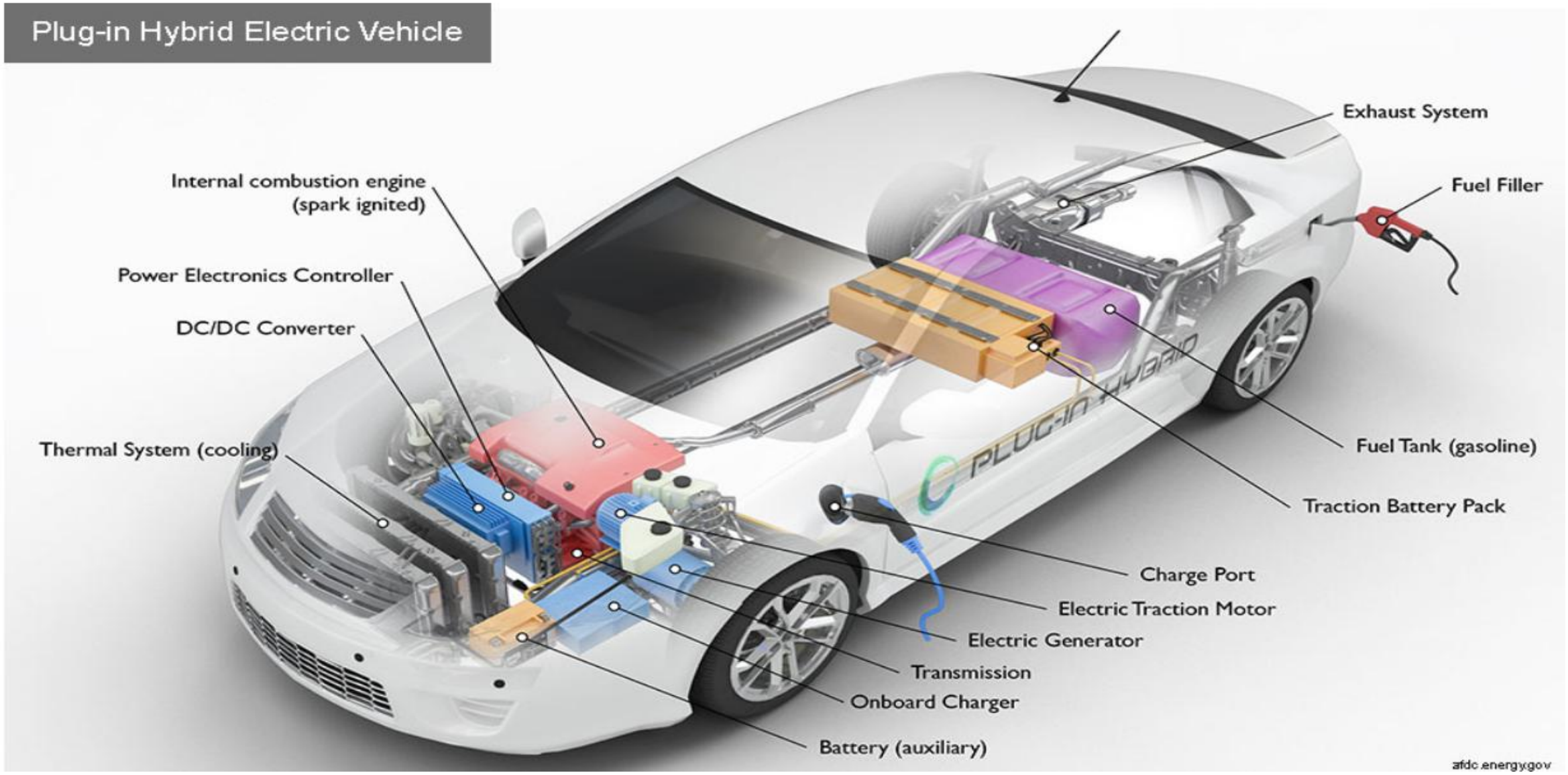
- **Power electronics controller:** This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.

- **Thermal system (cooling):** This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.

- **Traction battery pack:** Stores electricity for use by the electric traction motor.

- **Transmission (electric):** The transmission transfers mechanical power from the electric traction motor to drive the wheels

Overview of Plug-in-Hybrid Electric Vehicle



Source: Alternative Fuels Data Center: How Do All-Electric Cars Work? (energy.gov)

Summary

- Electric cars run at least partially on electricity. Unlike conventional vehicles that use a gasoline or diesel-powered engine, electric cars and trucks use an electric motor powered by electricity from batteries or a fuel cell.

- Battery-electric cars use electricity as their only fuel, so it is important to match the battery range to the intended use of the vehicle. However, recharging away from home is becoming easier as public and workplace charging stations become more widely available. And since battery-electric cars have no tailpipe emissions and replace gasoline with electricity, they can be some of the greenest cars available, perfect for climate-conscious commuters or multi-car households that take lots of short-distance trips.

Charging Infrastructure Terminology

The charging infrastructure industry has aligned with a common standard called the Open Charge Point Interface (OCPI) protocol with this hierarchy for charging stations: location, EV charging port, and connector. The Alternative Fuels Data Center and the Station Locator use the following charging infrastructure definitions:

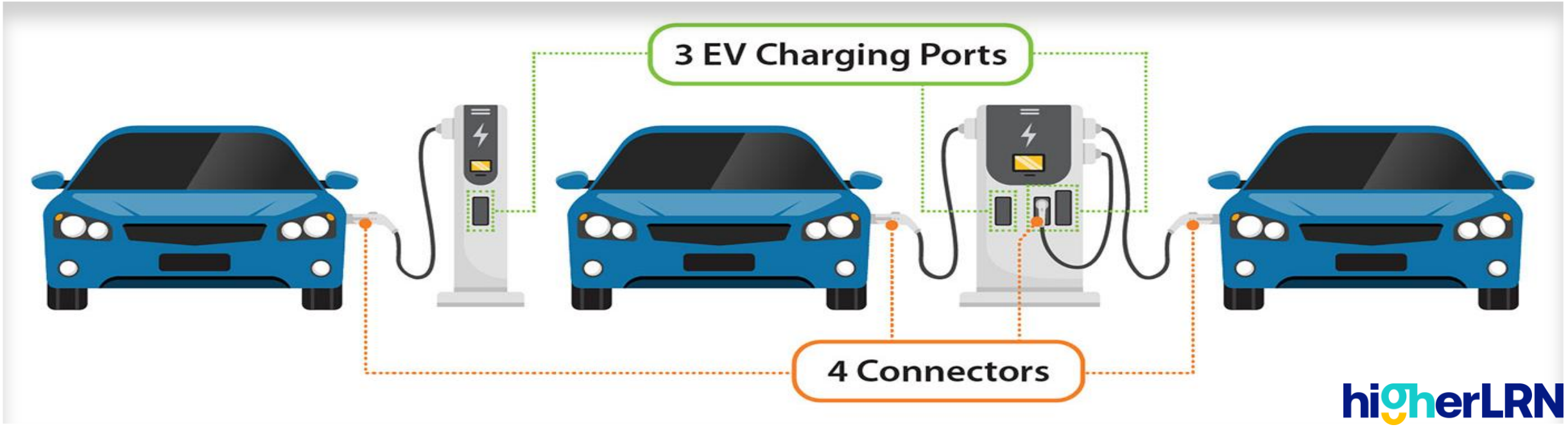
Station Location: A station location is a site with one or more EV charging ports at the same address. Examples include a parking garage or a mall parking lot.

EV Charging Port: An EV charging port provides power to charge only one vehicle at a time even though it may have multiple connectors. The unit that houses EV charging ports is sometimes called a charging post, which can have one or more EV charging ports. EV charging ports are also sometimes referred to as electric vehicle supply equipment (EVSE) ports.

Connector: A connector is what is plugged into a vehicle to charge it. Multiple connectors and connector types (such as CHAdeMO and CCS) can be available on one EV charging port, but only one vehicle will charge at a time. Connectors are sometimes called plugs.

Charging Equipment

Charging equipment for EVs is classified by the rate at which the batteries are charged. Charging times vary based on how depleted the battery is (i.e., state-of-charge), how much energy it holds (i.e., capacity), the type of battery, the vehicle's internal charger capacity, and the type of charging equipment (e.g., charging level, charger power output, and electrical service specifications). The charging time can range from less than 20 minutes using DC fast chargers to 20 hours or more using Level 1 chargers, depending on these and other factors. When choosing equipment for a specific application, many factors, such as networking, payment capabilities, and operation and maintenance, should be considered.



What Is Level 1, 2, 3 Charging?

40 miles can be easily replenished overnight.

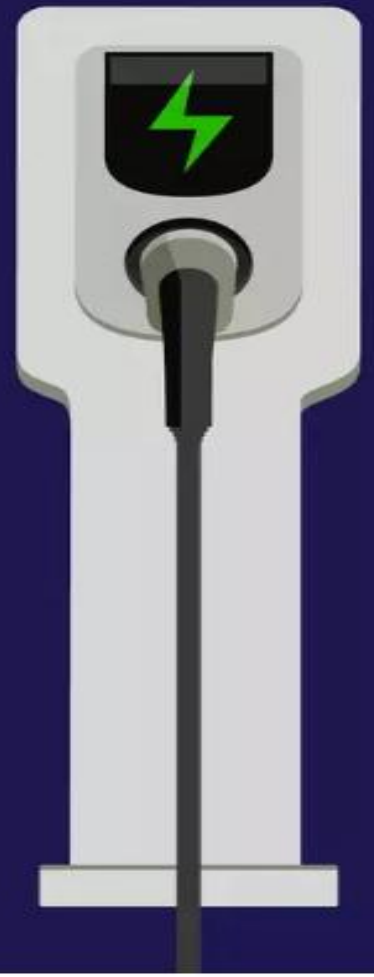
120 Volts

40 miles average daily commute in less than 2 hours.

240 Volts

10 to 20 miles of range per minute.

480 Volts



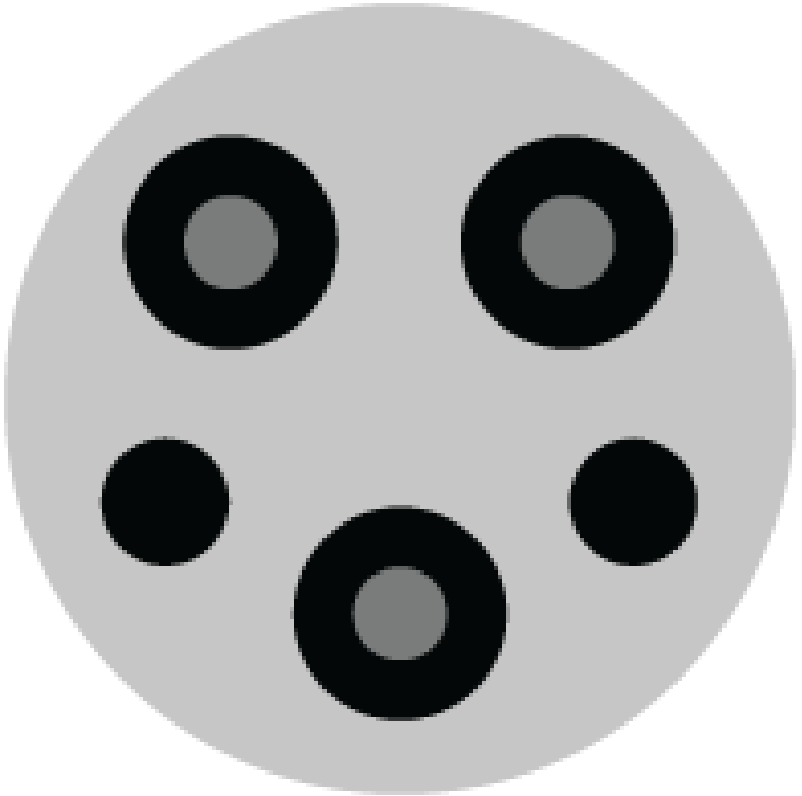
Cars.com illustration by Paul Dolan

higherLRN

Charging Levels

Level 1 Charging

Approximately 5 miles of range per 1 hour of charging*



J1772 connector

Alternating Current (AC) Level 1 equipment (often referred to simply as Level 1) provides charging through a 120 volt (V) AC plug. Most, if not all, EVs will come with a portable Level 1 cord set, so no additional charging equipment is required. On one end of the cord is a standard NEMA connector (for example, a NEMA 5-15, which is a common three-prong household plug), and on the other end is an SAE J1772 standard connector (often referred to simply as J1772, shown in the above image). The J1772 connector plugs into the car's J1772 charge port, and the NEMA connector plugs into a standard NEMA wall outlet.

Level 1 charging is typically used when there is only a 120 V outlet available, such as while charging at home, but can easily provide charging for most of a driver's needs. For example, 8 hours of charging at 120 V can replenish about 40 miles of electric range for a mid-size EV. As of 2022, less than 1% of public EV charging ports in the United States were Level 1.

* Assumes 1.9 kW charging power

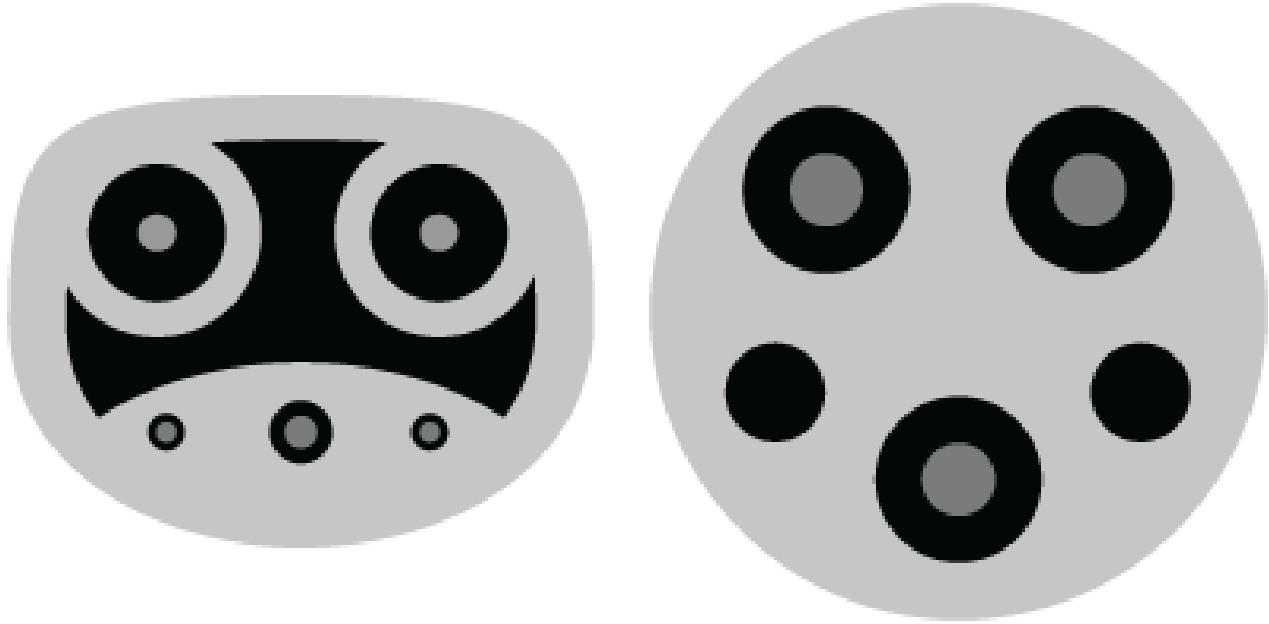
Charging Levels – Level 2

Level 2 Charging

Approximately 25 miles of range per 1 hour of charging†

J1772 connector

J3400 (NACS) connector



AC Level 2 equipment (often referred to simply as Level 2) offers charging through 240 V (typical in residential applications) or 208 V (typical in commercial applications) electrical service. Most homes have 240 V service available, and because Level 2 equipment can charge a typical EV battery overnight, EV owners commonly install it for home charging. Level 2 equipment is also commonly used for public and workplace charging and can operate at 40 to 80 amperes (Amp). Most residential Level 2 chargers operate at up to 30 Amps, delivering 7.2 kW of power. These units require a dedicated 40-Amp circuit to comply with the National Electric Code requirements in Article 625. As of 2022, nearly 80% of public EV charging ports in the United States were Level 2.

Level 2 charging equipment uses the same J1772 connector that Level 1 equipment uses. All commercially available EVs in the United States have the ability to charge using Level 1 and Level 2 charging equipment.

Vehicles with a J3400 (also referred to as NACS, or North American Charging Standard) connector (currently only Tesla vehicles) can use the connector for all charging levels, including Tesla's Level 2 Destination Chargers and chargers for home. All Tesla vehicles come with a J1772 adapter, which allows them to use non-Tesla Level 2 charging equipment.

† A Level 2 unit can range from 2.9 to 19.2 kW power output.

Charging Levels – DC Fast Charging

DC Fast Charging

Approximately 100 to 200+ miles of range per 30 minutes of charging‡

CCS connector

CHAdeMO connector

J3400 (NACS) connector

Direct-current (DC) fast charging equipment (typically a three-phase AC input) enables rapid charging along heavy traffic corridors at installed stations. As of 2022, more than 20% of public EV charging ports in the United States were DC fast chargers. The availability of DC fast charging is expected to increase as a result of federal funding to build a national EV charging network, such as the National Electric Vehicle Infrastructure Formula Program or national Alternative Fuel Corridors grant program. Additionally, DC fast charging is projected to increase due to fleets adopting medium- and heavy-duty EVs (e.g., commercial trucks and vans and transit), as well as the installation of fast charging hubs for transportation network companies (e.g., Uber and Lyft) and other applications.

There are three types of DC fast charging systems, depending on the type of charge port on the vehicle: SAE Combined Charging System (CCS), CHAdeMO, and J3400.

The **CCS** connector (also known as SAE J1772 combo) lets drivers use the same charge port with AC Level 1, Level 2, and DC fast charging equipment. The only difference is that the DC fast charging connector has two additional bottom pins. Most EV models on the market can charge using the CCS connector.

The **CHAdeMO** connector is another common DC fast connector type among Japanese automakers.

SAE International is standardizing the **J3400** connector based on Tesla's design for the NACS connector, which works for all charging levels, including Tesla's fast charging option, called a Supercharger. Although Tesla vehicles do not have a CCS or CHAdeMO charge port, they come with a limited CCS or CHAdeMO adapter that supports charging up to 19.2 kW. Tesla does sell full power adapters for both connector types. Several vehicle manufacturers have announced adopting the J3400 connector as early as 2025, which will allow non-Tesla EVs to charge at Tesla stations with the J3400 connector.

‡ A DC fast charging unit can range from 25 to 350 kW. Charging power varies by vehicle and battery state of charge.