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IHSCDEA Electric Vehicle Curriculum

Topics:

- Differences Between EV and ICE Vehicles
- Charging Station Types
- Charging Strategies/Etiquette
- EV Driving Strategies
- Handling Characteristics of EVs
- Driving EVs in Adverse Conditions

IHSCDEA Electric Vehicle Curriculum

Lesson possibilities:

- Select and use the slides and videos that you want. Some slides are better suited to a student paced lesson, while others are better suited to an in class presentation.
- Future Development of slides and videos:
  - Quizlet, Pear Deck, Edpuzzle (especially with videos), Google Forms

Please share your lessons with other teachers in the shared drive!

EV

HYBRID

ICE

What’s the difference, what should I choose?

Traditional Engines

- Traditional Internal Combustion Engines (ICE) ignite fuel to create the power that moves your vehicle.
- Gasoline engines use spark plugs to ignite a gasoline/air vapor mixture.
- Diesel engines use compression to ignite a diesel/air vapor mixture.
- The two most common forms of Internal Combustion engines are Gasoline and Diesel.

How a Gasoline Engine Works

How a Diesel Engine Works

ICE vs EV

EVs and regular liquid fuel-powered combustion vehicles differ significantly in the number of moving parts. An electric motor has only one moving part, the shaft, rotated by an electromagnet and requiring little or no maintenance. An internal combustion engine, on the other hand, has hundreds of moving parts including pistons, valves, a crankshaft, fan belts, a timing belt, an oil pump, a fuel pump, fuel injectors, a cooling pump, a thermostat and other parts. None of those parts are necessary in an EV. However, the components of plug-in vehicles (the electric system including battery, motor, and electronics) will require some maintenance, which is discussed in detail below. Regular liquid fuel–powered combustion vehicles use multi-speed transmissions since internal combustion engines generate usable torque and power in a rather narrow spectrum of engine speed. Therefore, a multi-speed transmission with varying gear ratios is required to keep the engine in its optimal power band.

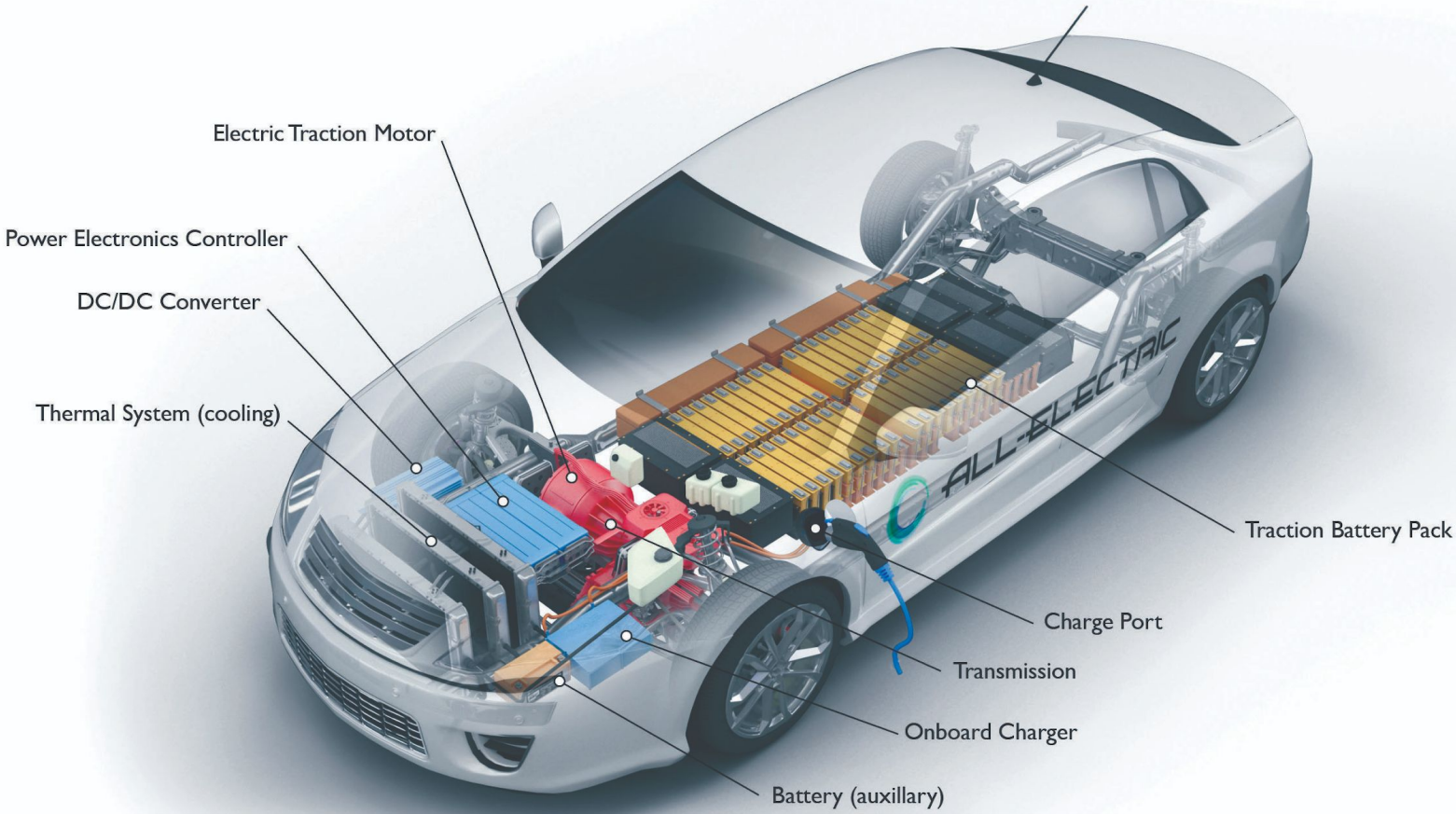
ICE vs EV

- Electric motors have only 1 moving part, the shaft, rotated by an electromagnet and requiring little to no maintenance.
- However, the components of plug-in vehicles (the electric system including battery, motor, and electronics) will require some maintenance, which is discussed in detail below.

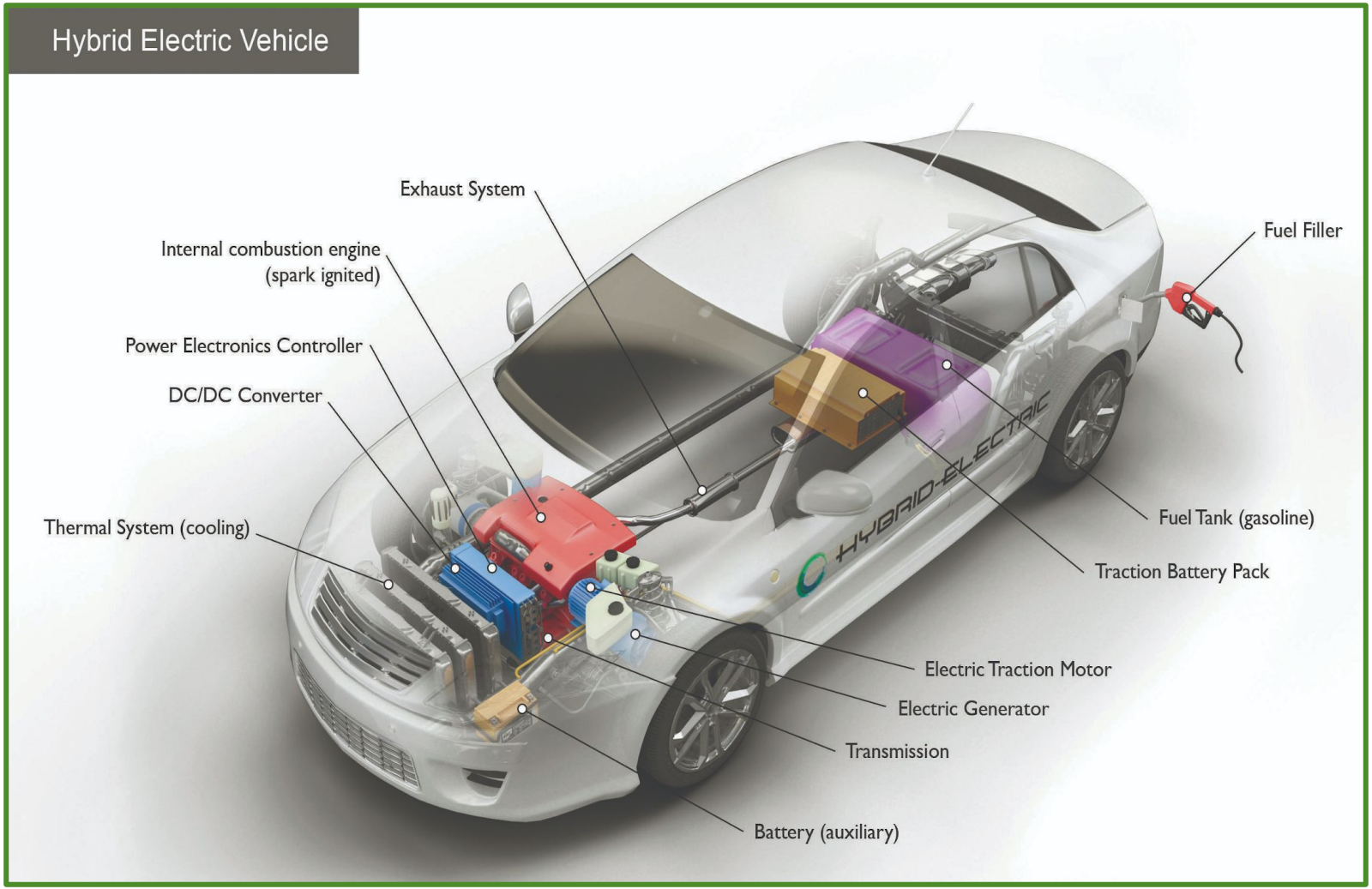
Is there a relevance to Murphy's Law?
What do you think?

- Internal combustion engines have hundreds of moving parts including pistons, valves, a crankshaft, fan, belts, a timing belt, an oil pump, a fuel pump, fuel injectors, a cooling pump, and a thermostat just to name a few. None of these parts are necessary in an EV.
- Regular liquid fuel–powered combustion vehicles use multi-speed transmissions since internal combustion engines generate usable torque and power in a rather narrow spectrum of engine speed. Therefore, a multi-speed transmission with varying gear ratios is required to keep the engine in its optimal power band.

All-Electric Vehicle



Hybrid Electric Vehicle



Types of Electric Vehicles

Hybrid (Plug-in Hybrid Electric) vehicles rely on a combination of internal combustion engines and electric engines to offer either a performance boost or an efficiency boost.

By supplementing with electricity, PHEVs help to:

- Reduce harmful tailpipe emissions and petroleum consumption.
- The batteries in Hybrid cars are between 1/4th and 1/20th the size and weight of a fully electric vehicle.

Hybrid Vehicles Explained

PHEVs are a more environmentally friendly and energy-efficient choice over conventional fueled combustion vehicles.

Types of Electric Vehicles

Full Electric or Battery Electric Vehicles (BEV)

- Fully electric vehicles rely solely on electricity, batteries, and electric motors as the power source.
- EVs have no internal combustion engine, they do not emit any tailpipe emissions and are sometimes referred to as zero emission vehicles.
- Electric motors generate maximum torque at relatively low speeds and have a much wider band of usable power.
- Electric motors generate maximum torque at relatively low speeds and have a much wider band of usable power.

How Electric Vehicles Work

Regenerative Braking

Regenerative Braking uses the vehicle's momentum to transfer kinetic energy into stored electrical energy while the vehicle is decelerating. This electrical energy is either stored in some cars as a performance boost (as in the Ferrari LAFerrari) or as extra range in standard EV's.

Benefits Include:

- Longer mechanical brake life.
- Increased range and performance.
- Enhanced Braking due to less heat production during performance braking.

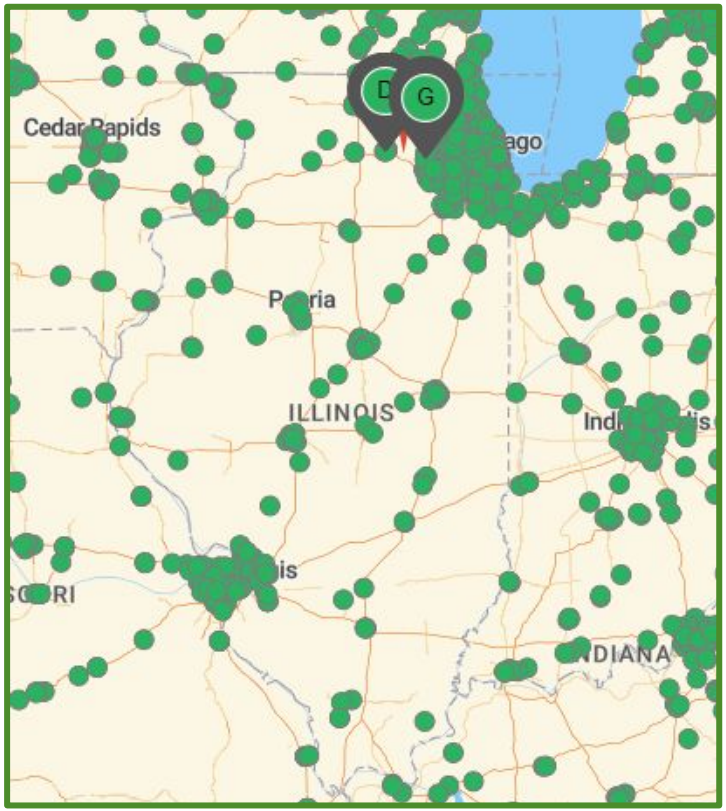
Regenerative Braking Explained

Sports car and racing fans: Be sure to watch till the end.

Charging (Fueling) Electric Vehicles

There are several methods that are currently available for charging EVs. Charging stations across the country have become more efficient and more numerous as EVs have gained popularity.

You can find EV charging stations anywhere in the country by following this link.



Level 1 Charging Stations

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 all 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 PEV. As of 2020, less than 5% of public charging outlets in the United States were Level 1.

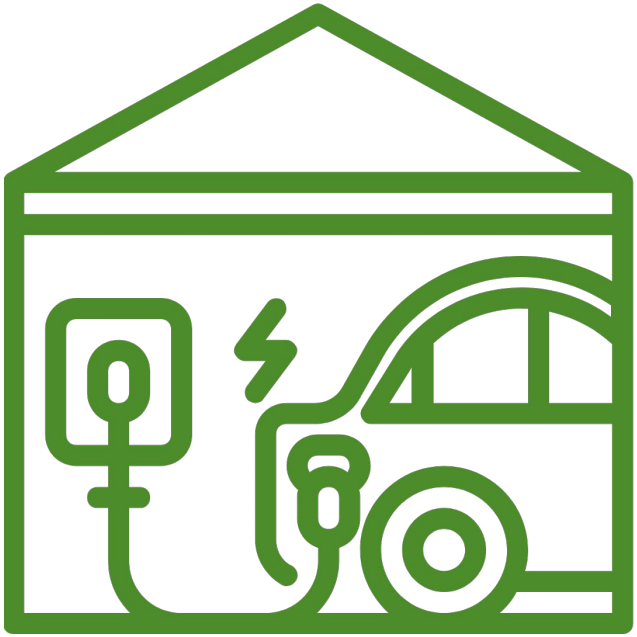
Level 2 Charging Stations

AC Level 2 equipment (often referred to simply as Level 2) offers charging through 240V (typical in residential applications) or 208V (typical in commercial applications) electrical service. Most homes have 240V service available, and because Level 2 equipment can charge a typical PEV battery overnight, it is commonly installed at PEV owners' homes for home charging. Level 2 equipment is also commonly used for public and workplace charging.

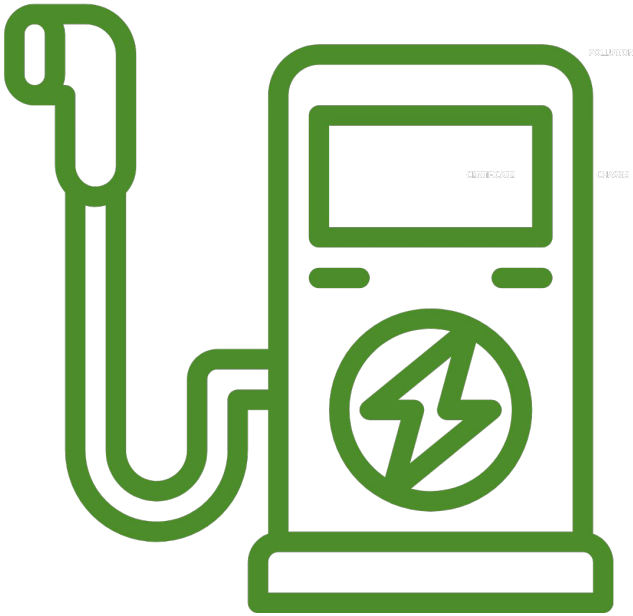
DC Fast Charging

Direct-current (DC) fast charging equipment (typically 208/480 V AC three-phase input), enables rapid charging along heavy traffic corridors at installed stations. As of 2020, over 15% of charging outlets in the United States were DC fast chargers. Thousands of public EV charging stations are available all around the United States. To locate public access charging stations, drivers can download the Alternative Fuel Data Center (AFDC) Station Locator mobile application. The AFDC Station Locator can also be accessed online at https://www.afdc.energy.gov/locator/stations.

Charging Your Vehicle at Home



Charging Your Vehicle at a Public Station



Tips for Safe EV Charging

Safety First:

1. **Practice safe charging.** Tuck the cord under the car while charging to avoid creating a tripping hazard and always return the connector back to its holster after unplugging the car. Avoid overstretching the cord and/or driving over it.

2. **Leave charging site as clean (or better than) when you arrived.** Do not leave trash at the site. Be courteous to other users. Consider wiping down the charging station after use with a clean cloth or paper towel.

3. **EV spots are for EVs.** EV charging spots are designated exclusively for EV use (EVs or plug-in hybrids). Regular vehicles with internal combustion engines are not allowed in EV spots, regardless of how frequently the EV spots are used.

Tips for Safe EV Charging Continued

4. **Charge only when necessary.** Do not charge if you do not need a charge. Leave the spot available for an EV driver who might need a charge to complete his or her trip.

5. **Don’t occupy an electric car charging space if you are not charging.** Only occupy a charging spot when your car is being charged. Once the car is fully charged or sufficiently charged to reach your destination, unplug and move your car. Charging spots are not intended for parking.

6. **All electric vehicles are equal.** Priority is not given to one type of EV over another when accessing the charging station. Owners of all-electric often feel they should get preferential treatment over PHEVs since plug-in hybrids have gasoline-powered engines as back-up. Owners of battery-EVs do not have the right to unplug PHEVs. Charging preference is given to the vehicle that arrives first. An EV driver can politely ask the driver of a plug-in hybrid to trade places in line if needed.

Tips for Safe EV Charging Continued

7. **It's OK to ask for a charge.** If a charging spot is being used and you are able to park next to it, you can leave a note to the driver asking to plug in your EV when he or she is done. Leaving your vehicle's charge port open when parked next to an occupied charging spot is a common signal to plug in your vehicle after the other driver's charging session is complete. This rule mostly applies to free public charging stations. When some form of payment or the use of a membership card is required, this rule may not be appropriate.

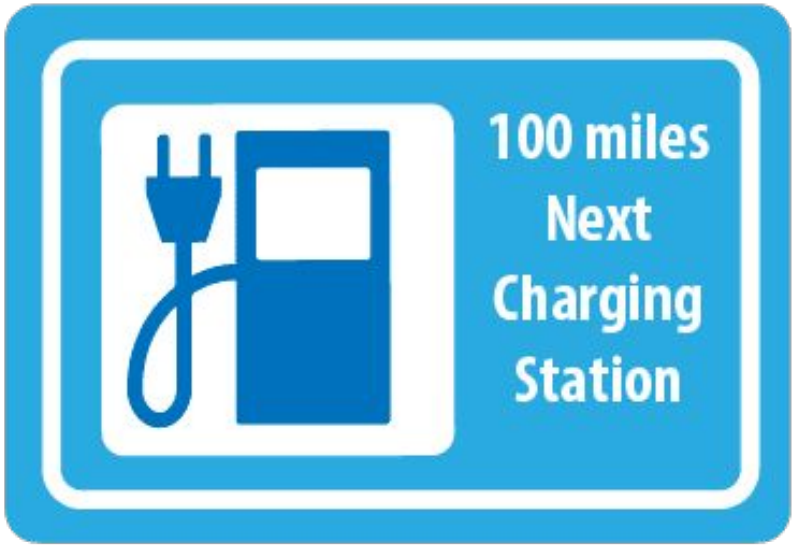
8. **Do not unplug someone else's EV.** Do not unplug another driver's vehicle unless the charge is complete, which can be seen by a blinking green state of charge indicator on the dashboard.Just as with good manners, these rules are informal, suggestive in nature and based on common sense. However, some large employers offering EV charging facilities to their employees have adopted similar etiquette rules for participants in their workplace charging programs.

DC Fast Charging

The distance (in miles) that an EV can drive on a full battery charge, referred to as **EV range**, is listed on the EPA fuel economy label of the car. For the vehicle range test, EVs are tested on city and highway driving conditions, assuming that the typical EV will have the battery charged only to 90 percent. Just like with regular liquid-fueled combustion vehicles, the range of an EV can vary significantly based on how the vehicle is driven.

Range Anxiety

Range Anxiety is often part of a potential EV driver's concern. It is the fear of not being able to reach one's destination before the run out of stored battery power.



Tips for Maximizing Range

Avoid Hard Acceleration

Fast acceleration also increases energy consumption.
It takes much more momentum and energy to accelerate the car faster than it does to accelerate gradually. The use of cruise control to maintain a constant speed on the highway in most cases will also reduce energy consumption of the vehicle.

Use Accessories Wisely

Accessories such as heating, air conditioning, and entertainment systems affect fuel economy on all vehicles, but can have a greater effect on EVs. However, using seat warmers instead of the cabin heater can save energy and extend range.

Use Economy Mode

Many EVs come with an "economy mode" or similar feature that maximizes the vehicle's fuel economy. In some vehicles, this mode can be activated by simply pressing a button. The economy mode may limit other aspects of the vehicle's performance, such as acceleration rate, to save fuel.

Tips for Maximizing Range Continued

Plan Ahead Before Driving

Pre-heating or pre-cooling the cabin of an all-electric or plug-in hybrid electric vehicle while it is still plugged in can extend its electric range, especially in extreme weather.

Avoid Hard Braking and Anticipate Braking

This allows the vehicle's regenerative braking system to recover energy from the vehicle's forward motion and store it as electricity. Hard braking causes the vehicle to use its conventional friction brakes, which do not recover energy.

Observe Speed Limits

Efficiency usually decreases rapidly at speeds above 50 mph.

Avoid Rooftop Cargo Carriers

Rooftop carriers cause aerodynamic drag and loss of range.

Remove Excess Weight

Keep Tires Properly Inflated

More mileage tips from FuelEconomy.gov

Handling Characteristics of EVs

Acceleration: Electric motors provide instant torque, which creates instant acceleration. A driver new to EVs will need to get used to this because a traditional combustion engine needs time to build the engine R.P.M.s that generate speed.

EV acceleration explained

There are some very real differences between ICE and EV vehicles when it comes to how the drive and perform. Therefore, it is important for the driver to familiarize themselves with these differences before they operate a vehicle that is new to them.

Handling Characteristics of EVs

Braking: Most EVs use regenerative braking. Regenerative braking will allow the car to slow down faster without using the brakes. A driver who is trying to maximize efficiency will need to use a driving strategy that requires the vehicle more space and time to slow down.

The level of regenerative braking can be adjusted in most EVs. If the regenerative braking mode is on its most efficient setting, the car will slow much more rapidly than the average ICE car. This could surprise other drivers. The brake lights may or may not come on when the vehicle is under regenerative braking, so it may be necessary for the driver to signal their slow down by tapping the brakes.

Regenerative Braking Explained

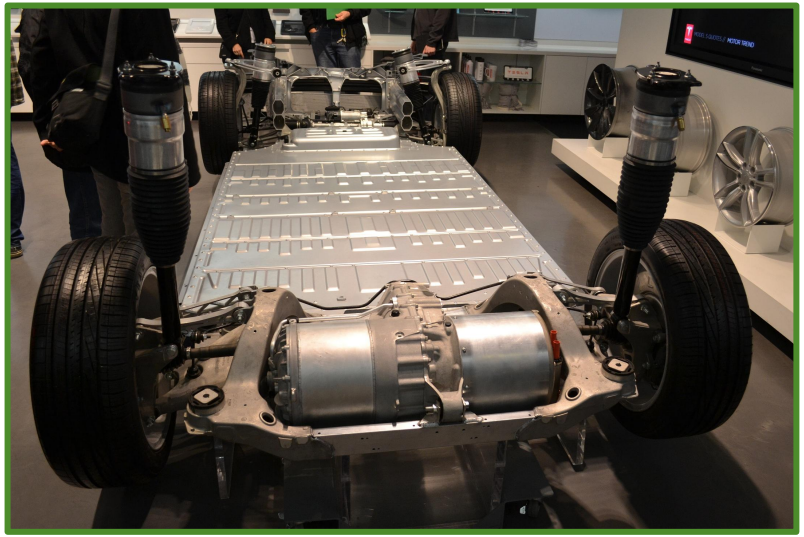
Handling Characteristics of EVs

In addition to regenerative brakes, all EVs have regular friction brakes as backup. When the driver brakes hard, the regenerative braking is not able to stop the car fast enough, so the friction brakes are applied as well. Friction brakes waste all the energy they produce in slowing the vehicle in the form of heat. Therefore, braking hard in an EV reduces the efficiency of the regenerative braking system and reduces potential vehicle range. **To maximize the efficiency of the regenerative braking system and extend the range of the car, drivers should coast to a stop as much as possible instead of braking hard.**

Thought Question: Why might the driving strategy written in green cause conflict or confusion with drivers using a more traditional strategy?

Handling Characteristics of EVs

Cornering: Because of the battery weight, EV's often outweigh their combustion based counterparts. One advantage to this is that the heaviest part of the car, the batteries, are typically mounted low. This creates a lowered center of gravity and a feeling of stability. The disadvantage to this is that the car will not feel as nimble or agile when cornering.



Driving EVs in Adverse Conditions

Drivers of EV's will need to remember that the acceleration and braking settings on their cars could lead to dangerous situations in slippery conditions. Remember that when driving any car in slippery condition sudden movements(driving inputs like acceleration, steering, and braking) cause you to lose traction. **With an EV, having the accelerator set so that max torque is available could cause you to go into a skid. Likewise, having the regenerative braking setting to max efficiency could cause the car to skid when you let off the accelerator**. Most EVs have complex torque and regenerative braking settings so that the driver can tailor the performance and efficiency that they are getting from their vehicle. **Winter Tires are recommended for EV owners who drive regularly in snowy or icy conditions.**