Electric Vehicles, Are You Plugged In?

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The author of this lesson has been the official IAHCE photographer at your annual conference for several years. What you don't know is that for over 40 years, he worked in industry on electrical motors and motor controls very similar to what is now installed in electric vehicles. This technology has been in use for over 20 years and the cost of equipment was always excessive. These expensive components are now readily accessible and affordable. He wishes to pass on some of his knowledge even though at his elderly age, will probably never own an electric vehicle. Please present this lesson at unit meetings and remember, everything in this lesson will change over time.

The Electric Vehicle, (or EV), still looks and works like previous gas models. The 2023 Chevy Bolt and 2024 Chevy Equinox EV are used as examples during this lesson. Most EV's will have safety features like, Automatic Emergency Braking, Lane Keep Assist, Lane Departure Warning and Collision Alert. Don't forget that big on-dash display to distract your driving.

Several items an EV does not need like a gas car

1. Transmission
2. Gas Tank
3. Fuel Pump
4. Oil Pump
5. Muffler
6. Starter
7. Gas Engine
8. Air Filter
9. Oil Filter
10. Alternator
11. Spark Plugs
12. Exhaust Pipes
13. Catalytic Converter
14. Power Steering Pump

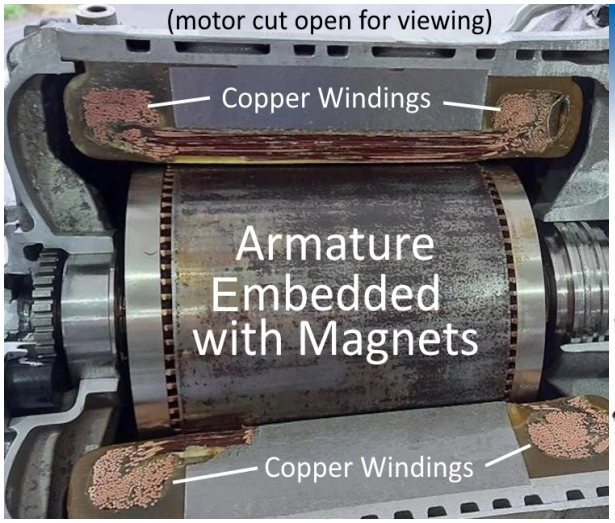
Components needed to allow an EV to operate

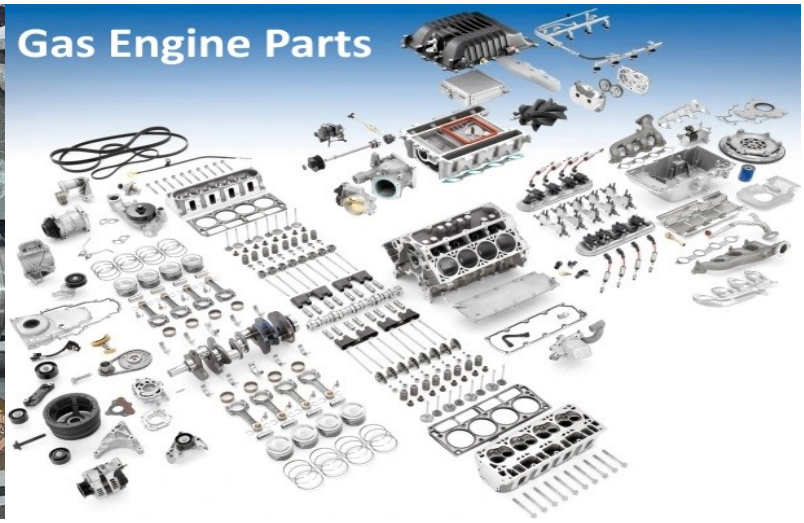
To Be Talked About in this Lesson

The **MOTOR**, can be in the front or rear of the car. Some EV's have 4 motors. Under the hood, the view is much different in an EV. The motor may not be visible.

The motor in all EV's are made with one (1) moving part, (called an armature), that rotates on ball bearings. Look at the photo on page 2. The armature does not contain wired windings or brushes like motors of the past but contains several very strong permanent magnets embedded into the rotating center. For an electric motor to rotate, 2 magnetic fields are required to attract or oppose each other. By pressing your foot on the accelerator pedal, voltage is applied to the copper windings in the outer part of the motor that does not rotate, creating the 2nd needed magnet to react with the armature containing the permanent magnets. Motor rotation speed increases as the voltage and pulse frequency increases, so does your speed. See the following pictures below which show the simple makeup of the electric motor verses the many mechanical pieces needed for the gas engine to operate.

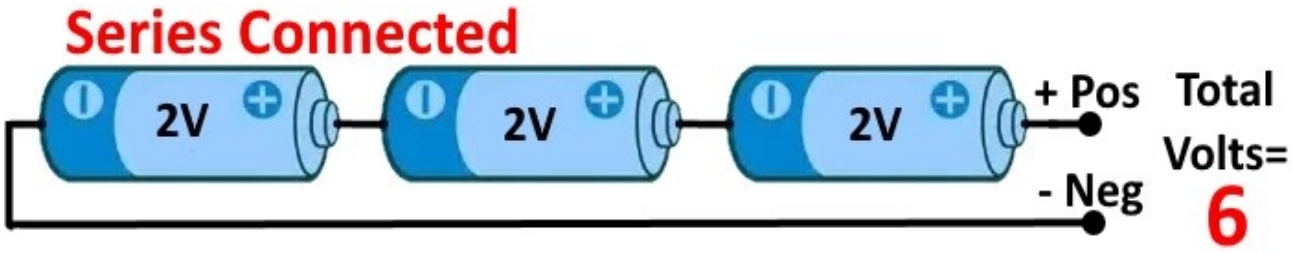
The EV motor is balanced and can exceed 10,000 revolutions per minute or more with little or no vibration or damage. Maximum RPM is limited to protect the motor and you.

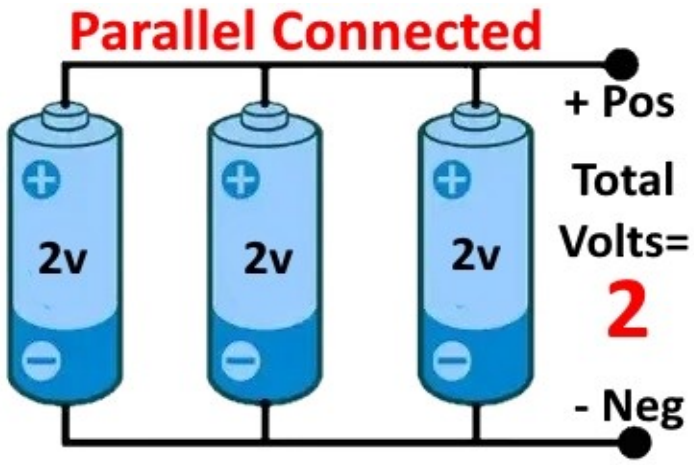




The **BATTERY** is the heart of the car. If you look at the picture below, notice that the battery unit is part of the floor. Placing batteries on the bottom of vehicle provides a lower center of gravity for stability where a gas car tends to lean when going around a corner due to engine weight and placement. Pictured below, are 16 battery modules, 8 per side, each holding hundreds of individual cells connected together. These modules are using small tubular "AA" or "AAA" rechargeable batteries connected together to produce an output voltage of about 200 to 800 volts. Battery size and shape will constantly change. Some EV manufacturers are providing a battery warranty of 10 years or 100,000 miles.

How do they get 200, 360 or 800 volts from "AA" batteries? Look at the following diagrams. By using a combination of SERIES and PARALLEL connections, any voltage is obtainable with enough batteries. For simplicity and math purposes, a battery cell of 2 volts is shown, where in reality, the voltage per battery cell may be above 3.





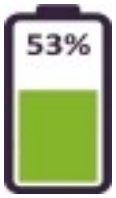
1000 "AA" 2 volt batteries connected in series would equal **2000** volts.

1000 "AA" 2 volt batteries connected in parallel would equal only **2** volts.

The EV's battery modules are configured using a combination of series and parallel connections as needed.

The Chevy Bolt uses a 360-volt main battery. All EV batteries will lose some charge capacity over time. The loss of driving range after 100,000 miles could be 20%.

Did you know that along with the large high voltage bank of batteries under the seats, there is a standard 12-volt car battery under the hood in an EV?



There are two very different electrical systems in an EV. The 12-volt battery operates every small electrical devices. The entertainment and onboard display, power door locks, power windows, power seats, windshield wipers, HVAC fan and safety systems including airbags, backup cameras, all lighting and more. 12-volts is safer in the cabin area to prevent shock hazards.

The main battery, on different vehicles, varying from 200 volts to 800 volts is used primarily to apply power to the propulsion motor, heaters and the auxiliary 12-volt battery. Driving range is about 350 miles max. Range is reduced with additional motors.

The **TRANSMISSION**, "What Transmission". Because the motor can rotate at very high speeds, the transmission has been replaced with a simple gearbox allowing the motor to provide more **TORQUE** to the wheels. This gearbox gives faster acceleration from a stop. No 10-speed transmission or clutches. Just smooth, quiet, from zero to maximum speed.

The **CONTROLLER**, also called an **INVERTOR** is actually a Variable Frequency Drive. Inverters convert battery, direct current (DC), to an alternating current (AC). This (AC) will change in voltage and frequency as vehicle speed changes or more power is required while climbing a hill. It also provides many limitations to protect car and motor.

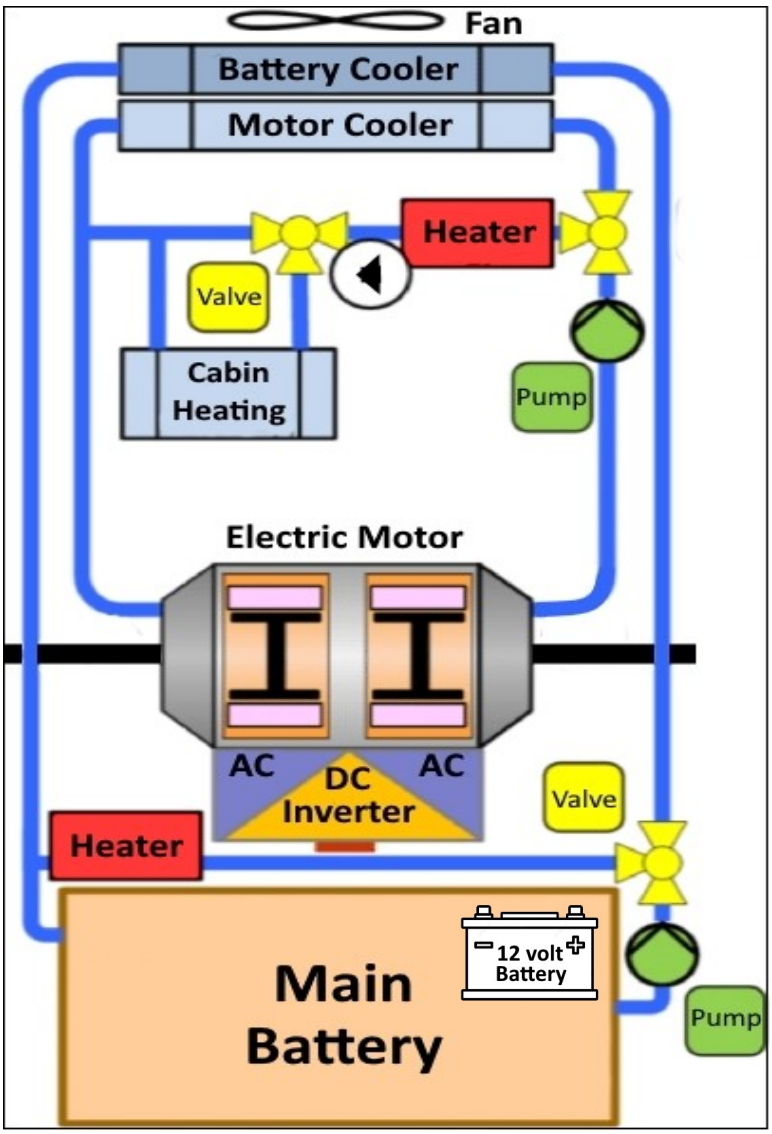
What are some limits? 1. _____ 2. _____ 3. _____ 4. _____

Another useful feature provides a way to help recharge your battery. **"REGENERATION"**, when slowing or going down a hill, the motor becomes a generator which sends a charge back to the battery. Not only are you recharging your battery, your motor is also acting like a brake to help slow the EV and extend the lifetime of your brake components.

Why is mounting location of an Inverter important. 1. _____ 2. _____ 3. _____

Does an EV need a radiator like a gas car? **YES or NO**

What produces heat that needs to be dissipated? Any time electrical current flows from the battery to the motor via wires and inverter, energy is dissipated as heat. Current flow directly influences rate of temperature change.



All components are mounted as close as possible to reduce wiring lengths, reducing heat and cost. Excessive heat will shorten the life of the battery and possibly damage the motor. Remember, when you let the smoke out of an electric motor of any kind, it's impossible to put the smoke back in. The motor is now toast.

Most manufactures install some kind of cooling system in all EVs. Less expensive EVs may use air cooling while more expensive EVs will use a radiator and coolant pump to circulate a glycol liquid, (antifreeze), through hoses to most vital components such as the Motor, Inverter, Battery and Cabin Area.

Safety sensors are used to warn of possible problems. The Main Battery has several.
Battery Current, Cell Temperature, Humidity, Charge Overvoltage and Thermal Runaway Detection for:
Temp, Pressure and Gas Concentrations.
These sensors help to prevent a fire or explosion from overheating or over-charging of the main battery.

Did your dealer charge the battery with energy? As mentioned before, there are 2 batteries in your EV. In your old gas car, it had pulleys, belts and an alternator to keep the battery charged. Now the small 12 volt battery gets its charge from the large main battery and the main battery is **your** responsibility to fill. Be sure and check the EV's charge port location. Is it easy to access when parked in your garage.

It's always good to carry a portable charger with you. It may charge slow, but is better than walking. Below is a portable charger to be carried in your car. This charger plugs into an outlet at home. Most homes do not have a 230 volt outlet in their garage. When plugged in overnight at 120 volts, 8 hours of charge only provides 32 miles of driving range. It's time to upgrade to a larger charging unit capable of an overnight full charge to your battery.

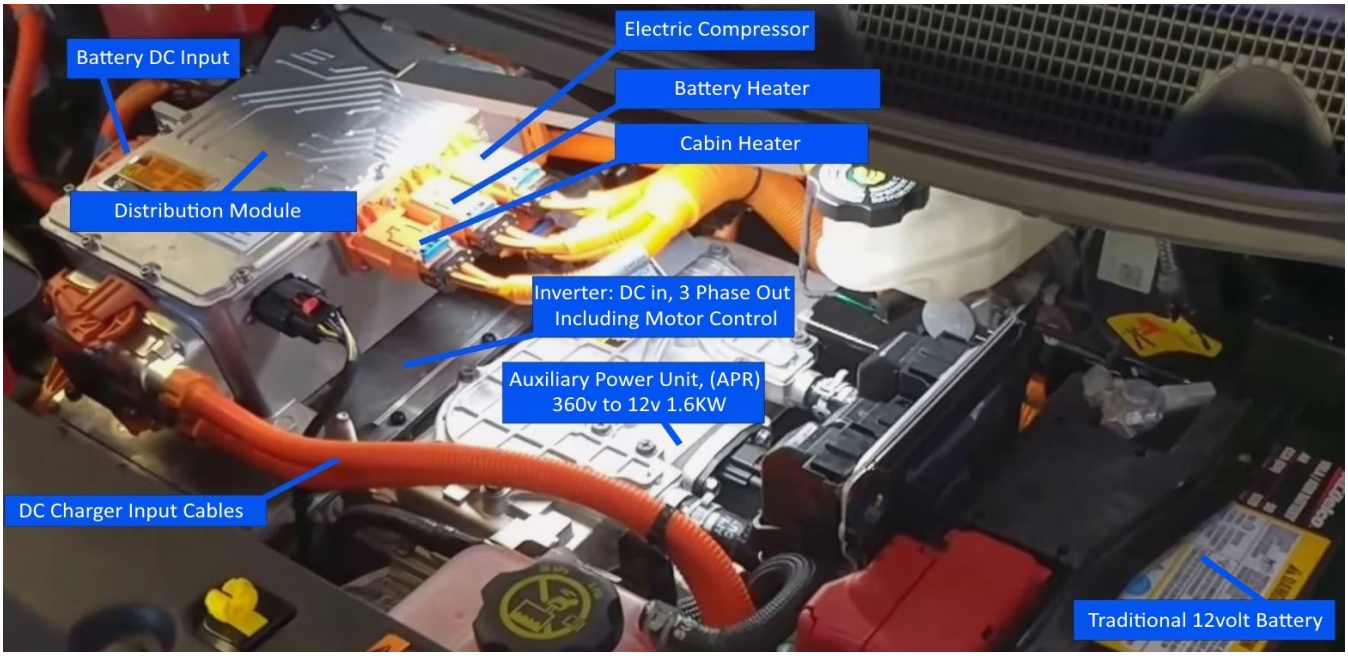
The EV charger shown on the right is hard wired into a 230 volt circuit, and will require a licensed electrician to install. Most wall chargers are capable of using 120 or 230 volts. Be sure and choose one that is compatible with your car. Charger plus labor can be around $1000 or more. With a 25 foot length of cord, just unwrap and drag to your car. Chargers are also available for mounting outdoors. Remember, heat is a batteries worst enemy. The faster the charge rate, the hotter the battery gets.

Ultra Fast chargers found while traveling can overheat a battery and shorten their life.

Do you require **Heat** or **Air Conditioning** in your EV? Many cars come with Heat Pumps like those found in homes. They work good in moderate climates, not well below freezing temperatures. Batteries work more efficiently when at 70 degrees with a 40% battery loss below 20 deg. Electric heating coils can warm the battery and cabin area but use up precious battery power and drastically reduce your driving range.

Power Steering is provided by the **EPS , Electric Power Steering,** which controls the optimal steering support and sends the information to an electric motor to provide the necessary assistance. **Power Steering Pumps** or **Hydraulics** are no longer used.

Below is a look under the hood of a 2023 Chevy Bolt showing many components with labels stating their purpose.



Your car may include the following: A sensor inside the car will detect the **Key Fob** in your purse or pocket and start the vehicle when you climb in and fasten your seat belt. Automatic reverse braking will alert you when a (child, dog) is behind you and stop the vehicle when needed.

What are some **Benefits** of Electric Vehicles?

1. Reduction in greenhouse gas emissions
2. Improved air quality
3. Mitigation of climate change effects
4. Lower operating costs and fuel savings
5. Reduced noise pollution

Authors Comments:

Solid-state batteries are the future of EVs. Safer than lithium-ion batteries, they use a solid electrolyte instead of a flammable liquid electrolyte, reducing the risk of fires and internal shorts and faster charge times. Smaller battery modules will decrease weight and increase driving range, making EVs safer and more efficient. They need rare earth metals which could lead to material shortages and recycle problems. Dependance on foreign countries. China owns most of the industrial mines in the Congo.
Don't forget a $20,000 or more replacement cost when out of warranty.

Good-bye, End of lesson

Answers to questions?

Why does an EV weigh more? Because the batteries are very heavy
Safety Limits. RPM, Acceleration Rate, Current Limit, Temperature Monitoring
Mounting Location. 1. Heat dissipation, 2. Shortest Possible Wire Length
3. Frequency Noise from variable AC current