HYBRID & EV PRESENTATION

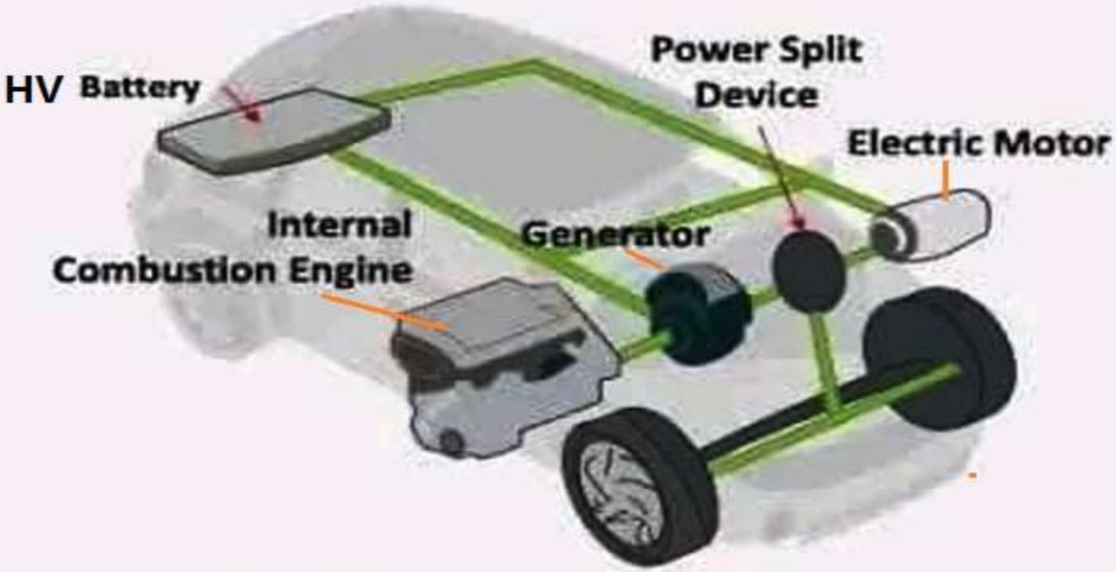
by

Chit Aung

HYBRID

HYBRID CARS

What is a Hybrid Car?



HYBRID CARS

A car with more than one propulsion system is generally known as a hybrid car, and it consists of a combination of petrol or diesel engine with an electric motor. This allows the car to burn less gasoline, achieving better fuel efficiency than a traditional engine that solely uses fuel. Electric power serves to boost the performance of the engine. Hybrids, except for plug-in hybrids, charge the battery through their internal system, so they do not need recharging. Plug-in hybrids are a halfway house between conventional cars and all-electric vehicles. So, they run on both an electric motor and an internal combustion engine but can charge its battery by "plugging in" to an outside electrical source.

WHAT IS A HYBRID VEHICLE?

Any vehicle which combines two or more distinct power sources to move the vehicle.

Power Sources- CNG (Compressed Natural Gas), LPG (Liquefied Petroleum Gas), Electricity, human power, hydrogen, solar, wind, etc.

HYBRID Types by nature of Power Drives

1. Electric-internal combustion engine hybrid

There are many ways to create an electric-internal combustion hybrid. The variety of electric-ICE designs can be differentiated by how the electric and combustion portions of the powertrain connect (series, parallel or combined), at what times each portion is in operation, and what percent of the power is provided by each hybrid component. Many designs shut off the internal combustion engine when it is not needed in order to save energy.

2. Fuel cell hybrid

Fuel cell vehicles have a series hybrid configuration. They are often fitted with a battery or supercapacitor to deliver peak acceleration power and to reduce the size and power constraints on the fuel cell (and thus its cost).

3. Human power and environmental power hybrids

Many land and water vehicles use human power combined with a further power source. Common are parallel hybrids, e.g. a boat being rowed and also having a sail set, or motorized bicycles. Also some series hybrids exist. Such vehicles can be tribrid vehicles, combining at the same time three power sources e.g. from on-board solar cells, from grid-charged batteries, and from pedals.

The following examples don't use electrical power, but can be considered as hybrids as well:

4. Pneumatic hybrid

Compressed air can also power a hybrid car with a gasoline compressor to provide the power. Moteur Developpement International in France produces such air cars. A team led by Tsu-Chin Tsao, a UCLA mechanical and aerospace engineering professor, is collaborating with engineers from Ford to get Pneumatic hybrid technology up and running. The system is similar to that of a hybrid-electric vehicle in that braking energy is harnessed and stored to assist the engine as needed during acceleration.

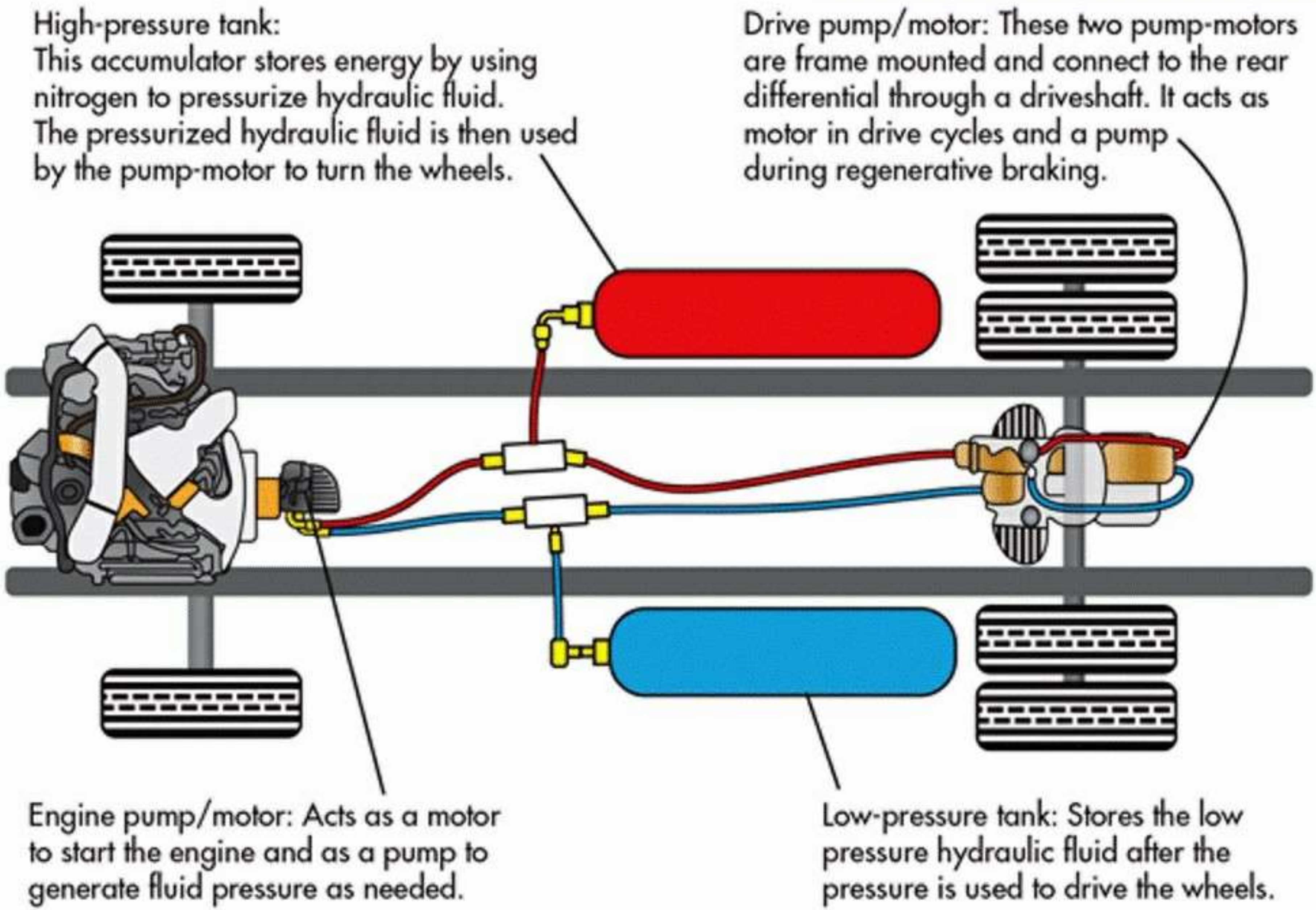
5. Hydraulic hybrid

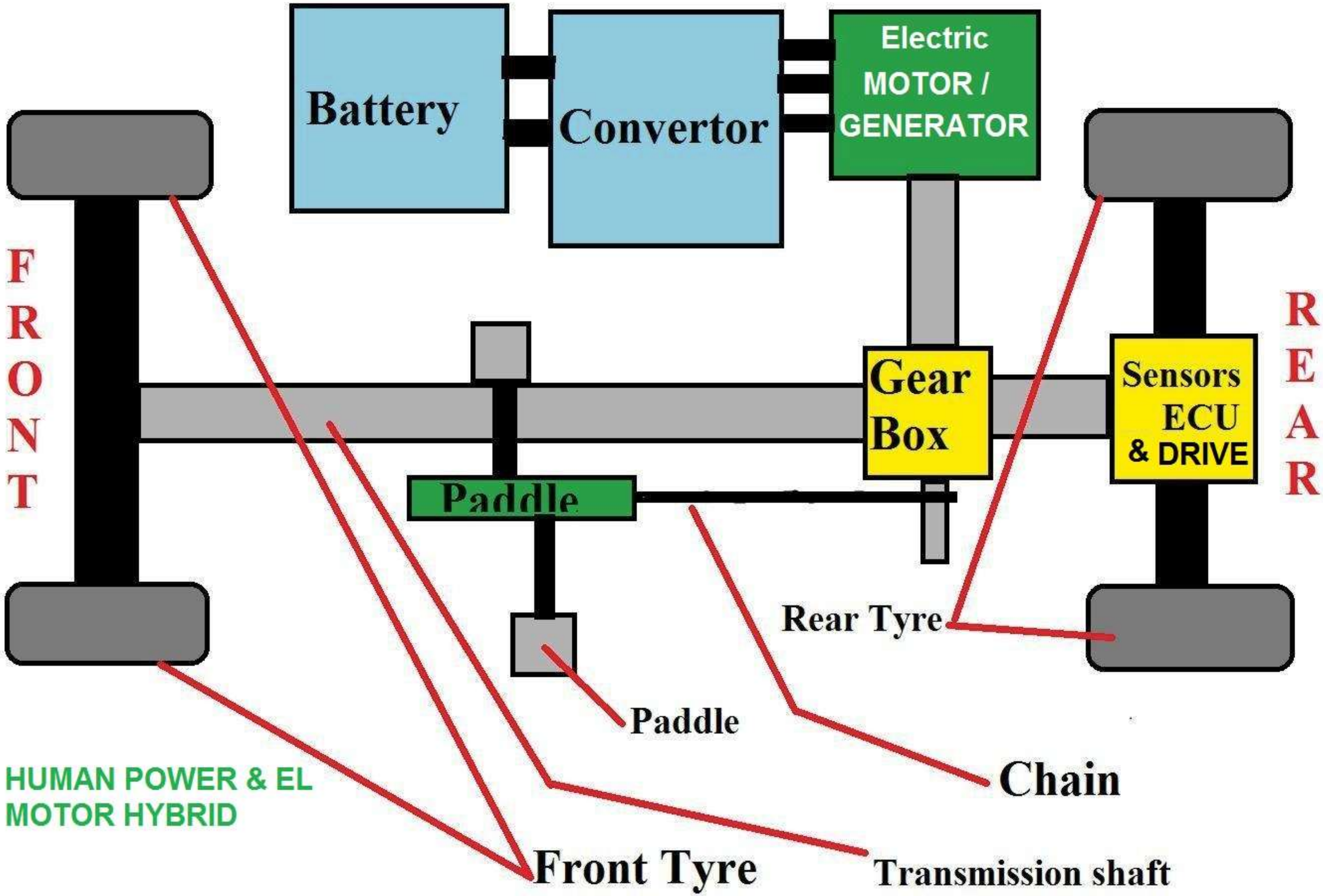
A hydraulic hybrid vehicle uses hydraulic and mechanical components instead of electrical ones. A variable displacement pump replaces the motor/generator, and a hydraulic accumulator (which stores energy as highly compressed nitrogen gas) replaces the batteries. The hydraulic accumulator, which is essentially a pressure tank, is potentially cheaper and more durable than batteries. Hydraulic hybrid technology was originally developed by Volvo Flygmotor and was used experimentally in buses from the early 1980s and is still an active area.

Initial concept involved a giant flywheel (see Gyrobus) for storage connected to a hydrostatic transmission, but it was later changed to a simpler system using a hydraulic accumulator connected to a hydraulic pump/motor. It is also being actively developed by Eaton and several other companies, primarily in heavy vehicles like buses, trucks and military vehicles. An example is the Ford F-350 Mighty Tonka concept truck shown in 2002. It features an Eaton system that can accelerate the truck up to highway speeds.

HYDRAULIC HYBRID

Note:- In a BHEV the high voltage battery is very costly and it's weight is heavy.




Battery
Convertor
Electric
MOTOR /
GENERATOR
FRONT
REAR
Gear
Box
Sensors
ECU
& DRIVE
Paddle
Rear Tyre
Paddle
Chain
HUMAN POWER & EL
MOTOR HYBRID
Front Tyre
Transmission shaft

AIR HYBRID

Car that runs on air: New Peugeot hybrid doesn't need a battery and 'is greener than its electric rivals'

Car that runs on air: New Peugeot hybrid doesn't need a battery and 'is greener than its electric rivals'

- The Peugeot 2008 Hybrid Air runs on nothing more than air
- Current 'green' vehicles combine electric engines with traditional ones
- The car has a conventional engine linked to hydraulic air motor and pump
- It can provide zero-emissions air power for lower-speed driving in cities
- The sports utility vehicle will available from 2016 for around £16,000

Battery Electric Hybrids

Why Battery Hybrids ?

AIM - (1) To reduce EXHAUST EMISSIONS

(2) To reduce FUEL CONSUMPTION

The following are the most common features of hybrids that improve fuel economy:

- **Idle stop**
- **Regenerative braking**
- **Power assist**
- **Engine-off drive-- Electric Drive mode**

The electric motor, for instance, is highly efficient at producing torque and aiding steering, while combustion engines are better at maintaining high speeds. A combination of both propulsion types produces excellent results in terms of energy efficiency, while also producing fewer emissions and therefore being kinder to the environment.

Electric-IC engine Hybrid

Hybrid Electric Vehicle: Not all hybrids are alike. There are many ways to combine the engine, motor/generator, and battery. Three basic hybrid configurations are the series, parallel, and split (or through-the-road) designs.

Series. The engine never directly powers the car. Instead, the engine drives the generator, and the generator can either charge the batteries or power an electric motor that drives the wheels.

Parallel. The engine connects to the transmission, as do the batteries and the electric motor. So both the engine and the generator/motor can supply power to the wheels, switching back and forth as driving conditions vary.

Split. The engine drives one axle and the electric motor drives the other. There is no connection between the engine and the electric components except "through the road."

BHEV

3-BASIC

(a) SERIES
(b) PARALLEL
(c) SERIES-PARALLEL or *POWER SPLIT*

Three basic hybrid configurations are the series, parallel, and split *(Series / Parallel)*

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Parallel. The engine connects to the transmission, as do the batteries and the electric motor. So both the engine and the generator/motor can supply power to the wheels, switching back and forth as driving conditions vary.

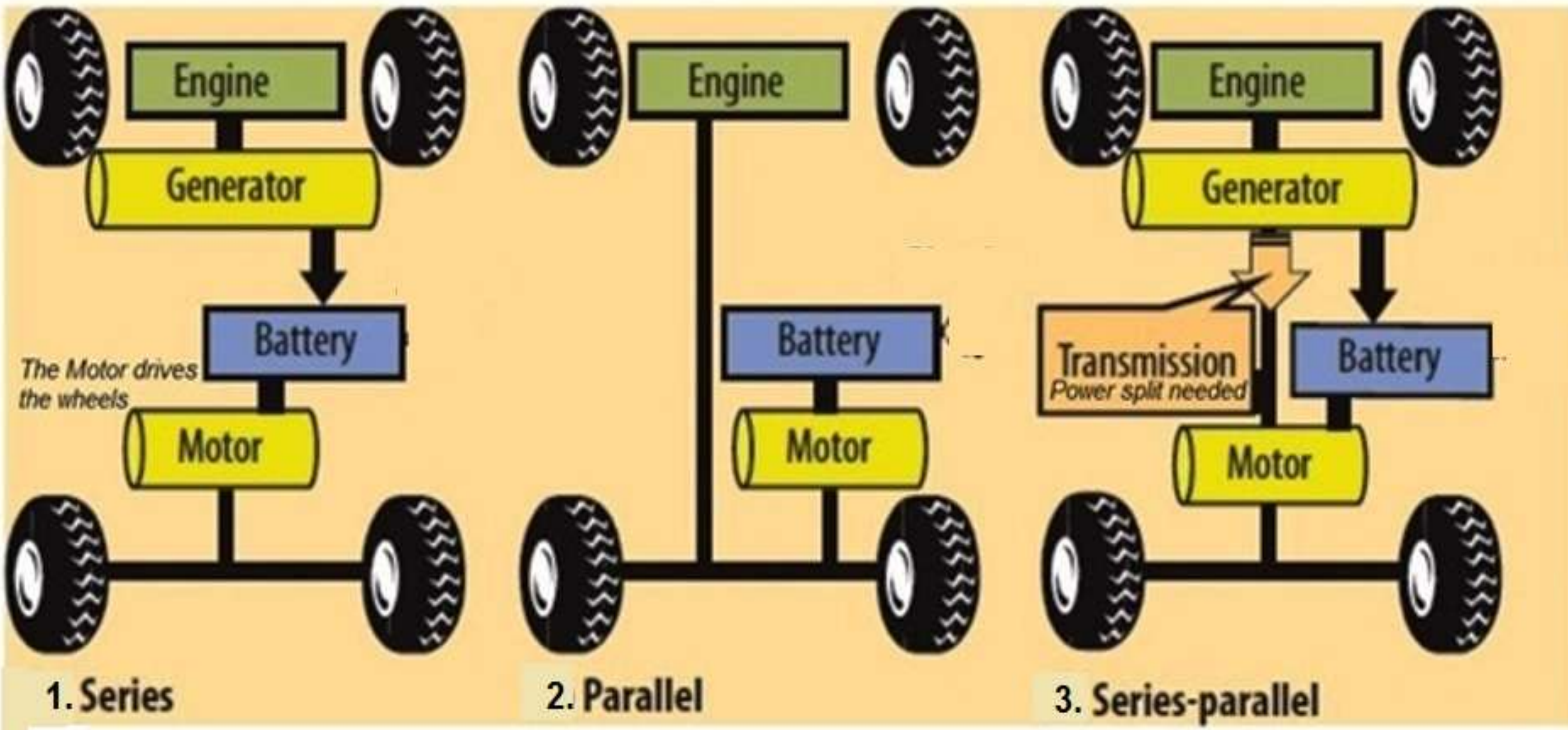
Split. The engine drives one axle and the electric motor drives the other. *(or through the POWER SPLIT Device)*

BHEV

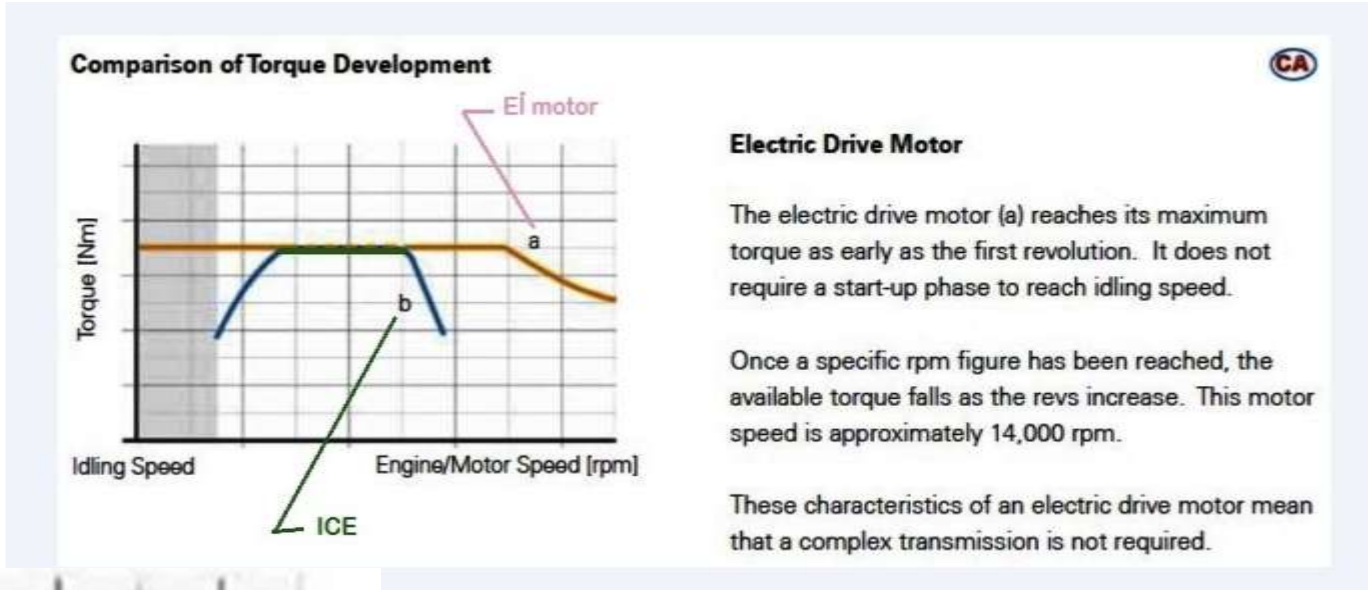
FULL Hybrids 3-Basic Types

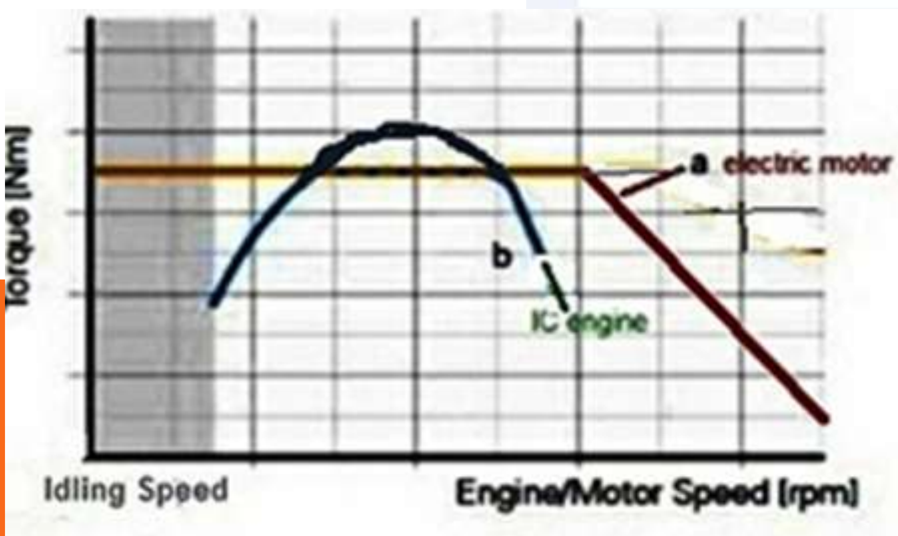
1 SERIES Hybrid
2 PARALLEL Hybrid (Medium Hybrid) (Assist}
3 SERIES/ PARALLEL Hybrid (Full or Strong Hybrid)

series hybrid — the gasoline engine turns a generator, and the generator can either charge the batteries or power an electric motor that drives the transmission. Thus, the gasoline engine never directly powers the vehicle.



TORQUE Development between an Electric Motor and an IC Engine



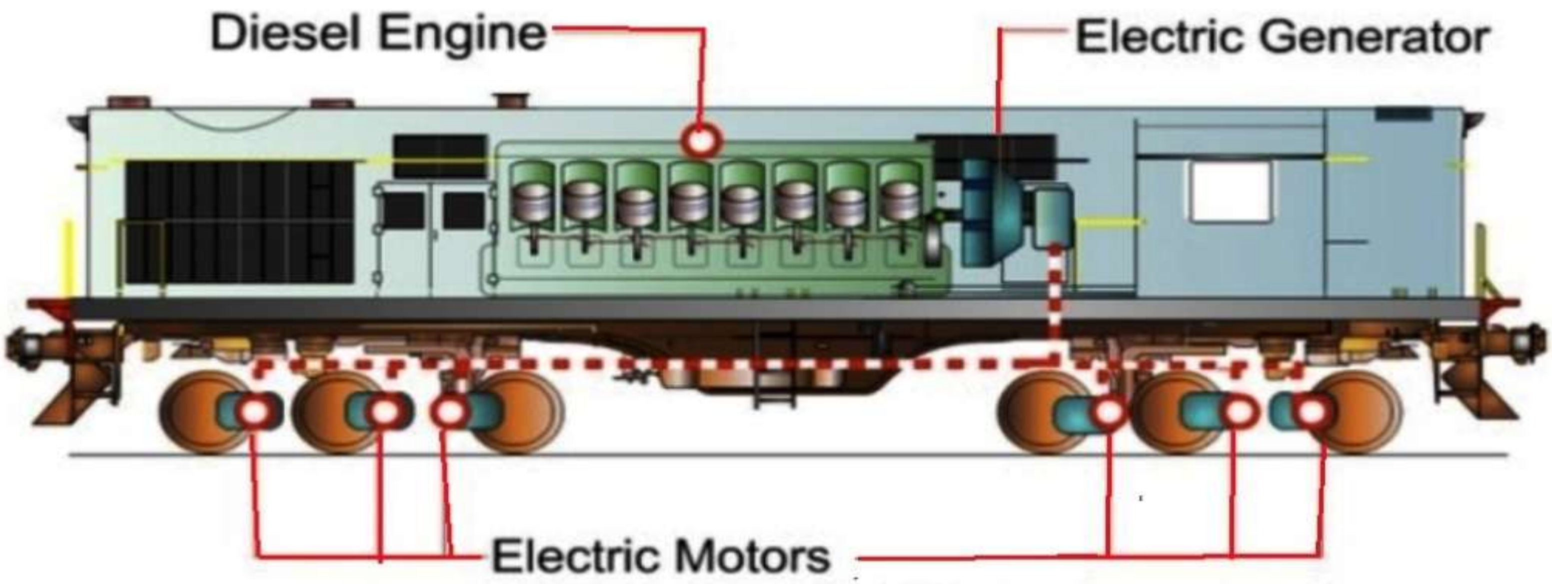


BHEV SERIES HYBRID Applications

In a SERIES HYBRID, the gasoline engine turns a generator, and the generator can either charge the batteries or power an electric motor that drives the transmission. Thus, the gasoline engine never directly powers the vehicle.

SERIES HYBRID is used mainly in : -
locomotives or monster mining trucks :- The reason is that the electric motor can produce enormous torque at startup without needing a container-sized gearbox. The 2nd advantage is that power can be directly applied to all 10 or 12 locomotive wheels without needing any gearing or coupling rods.

Note the lack of a gearbox and the comparatively small diesel engine....



BHEV

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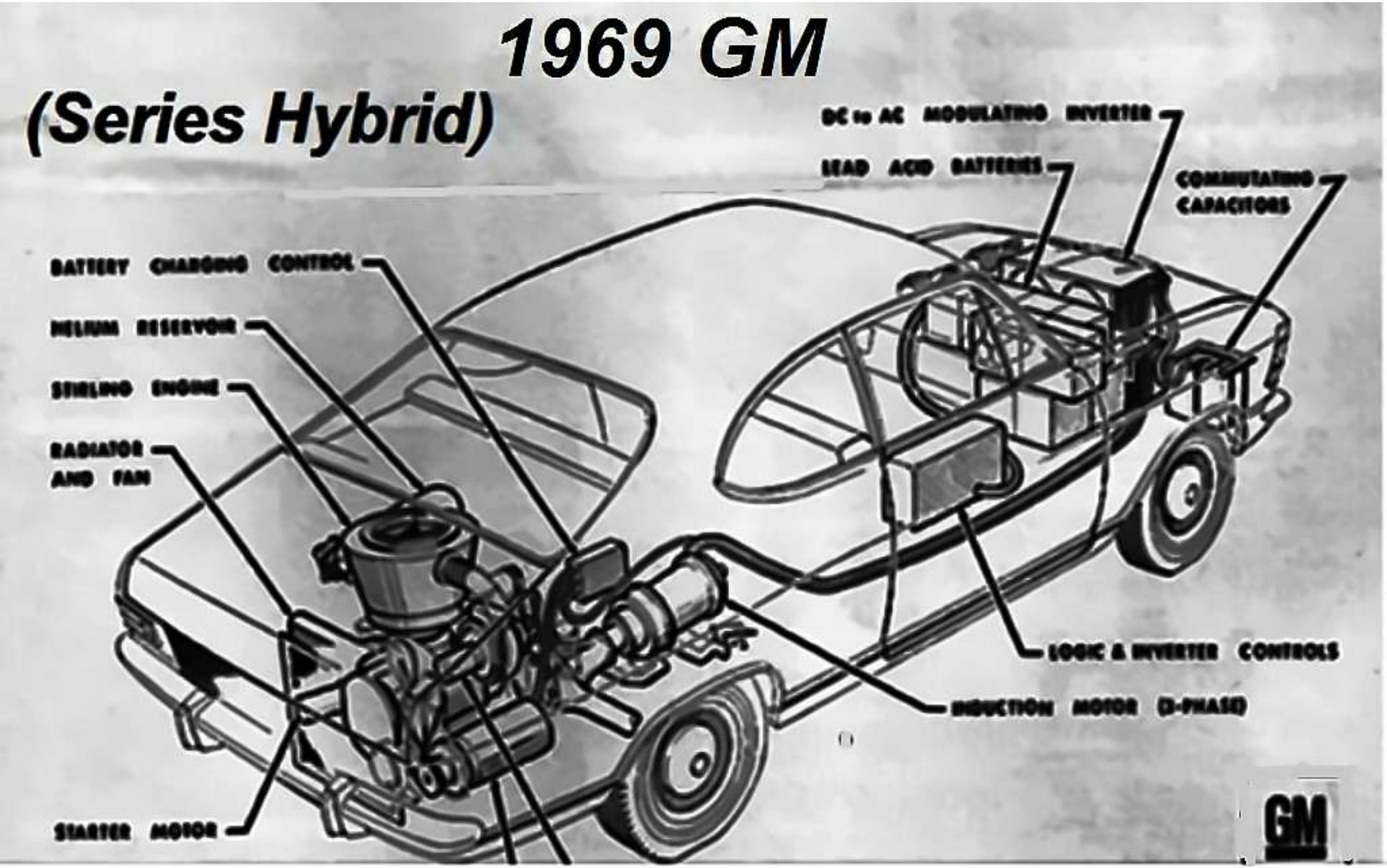


PARALLEL HYBRIDs

BHEV

PARALLEL HYBRID (Also Known as ASSIST Hybrid)

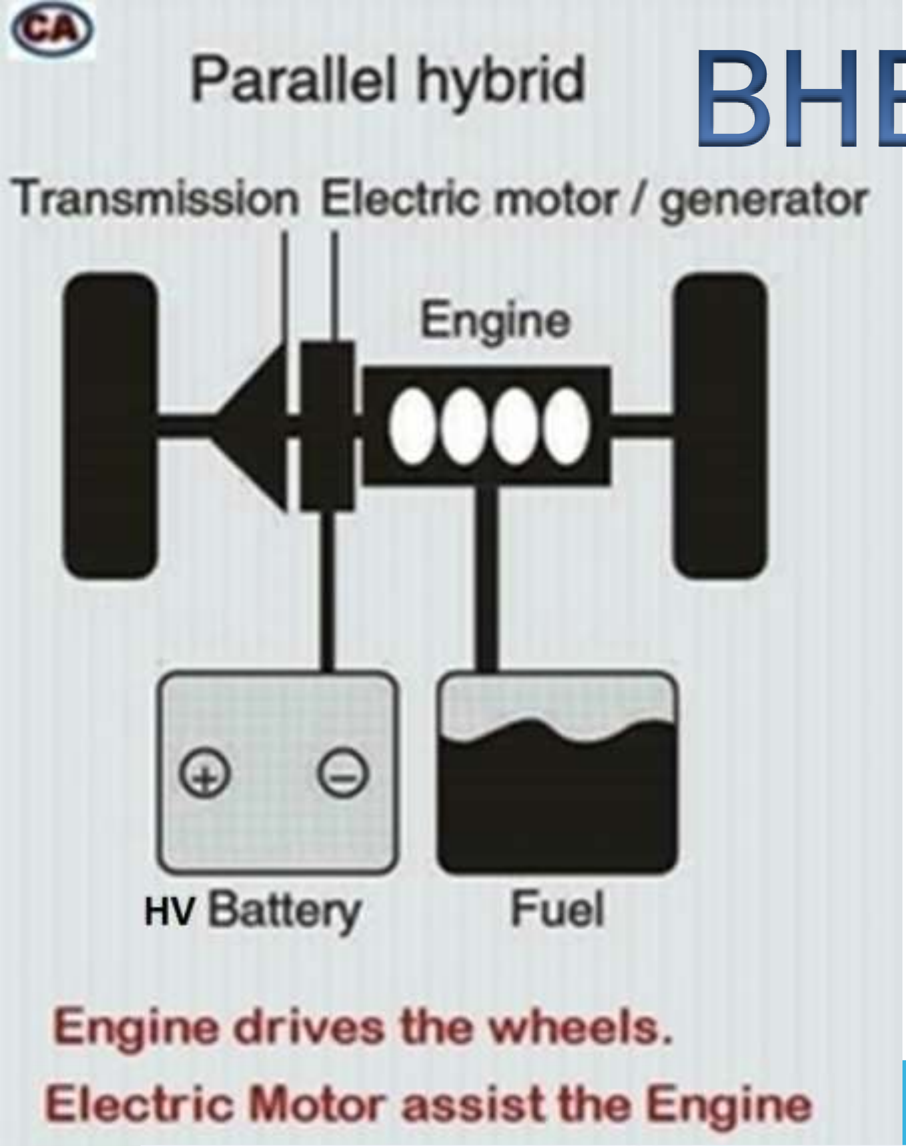
The Honda Insight is a simplified **parallel hybrid**. It has an electric motor coupled to the engine at the spot where the flywheel usually goes. Honda calls this system "Integrated Motor Assist." The Insight has either a conventional, five-speed manual transmission or an automatic CVT (continuously variable transmission).

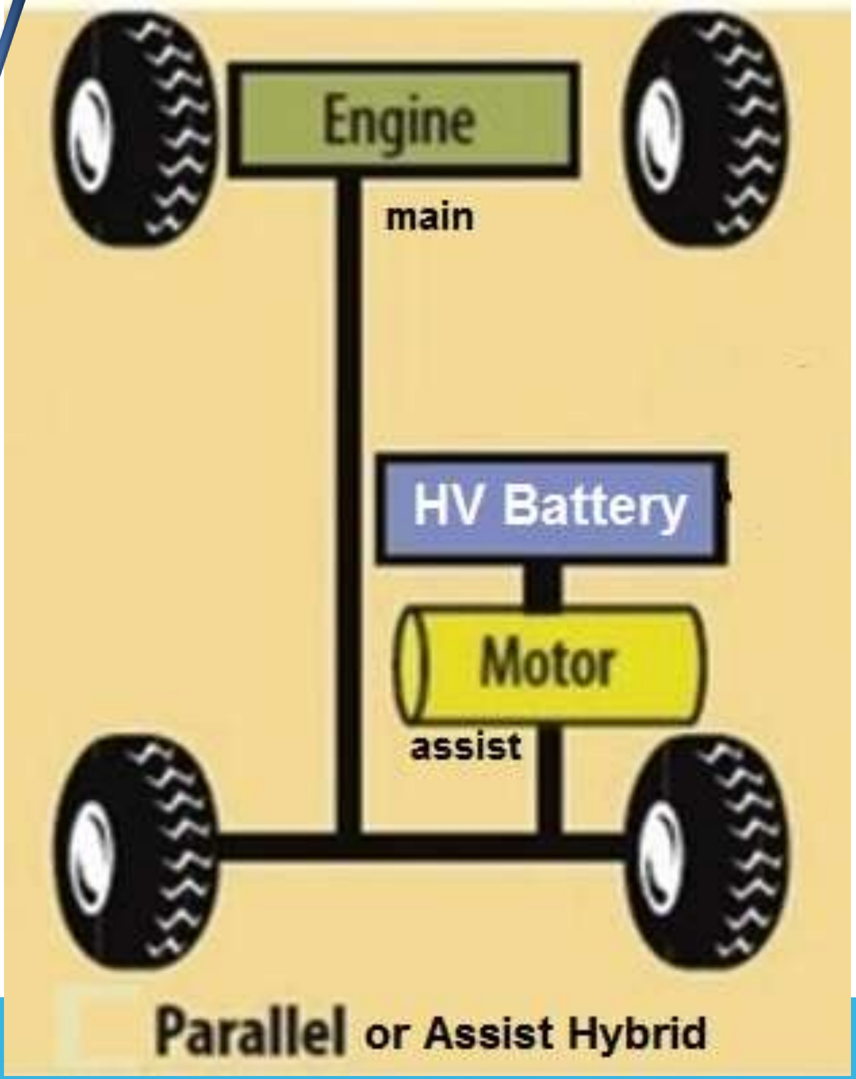
The electric motor on the Insight helps in several ways. It can:

- Assist the gasoline engine, providing **extra power** while the car is accelerating or climbing a hill
- Provide some **regenerative braking** to capture energy during braking
- **Start the engine**, eliminating the need for a starter

However, the motor cannot power the car by itself; the gas engine must be running for the car to move.

BHEV





The alternator of a combustion engine does NOT generate free electricity, it takes engine power to turn it, this slows the engine down and therefore uses fuel. It is a load on the vehicle like having some more weight on board.

(Thus No Alternator in HEV engines.)

Parallel Hybrid (ASSIST)

BHEV

There is no separate generator in a parallel hybrid. Whenever the generator's operation is needed, the motor functions as a generator. In a parallel **or mild hybrid** the vehicle can never drive in pure electric mode. The electric motor turns on only when a boost is needed.

SERIES-PARALLEL Combined STRONG HYBRID

The Toyota and Ford hybrids are classified as **series-parallel hybrids** because they can operate using electric motor power alone or with the assist of the ICE.

Series-parallel hybrids combine the functions of both a series and a parallel design.

When a hybrid electric vehicle is operating at low speeds, it is often being propelled by the electric motor alone, sometimes called **motoring mode.**

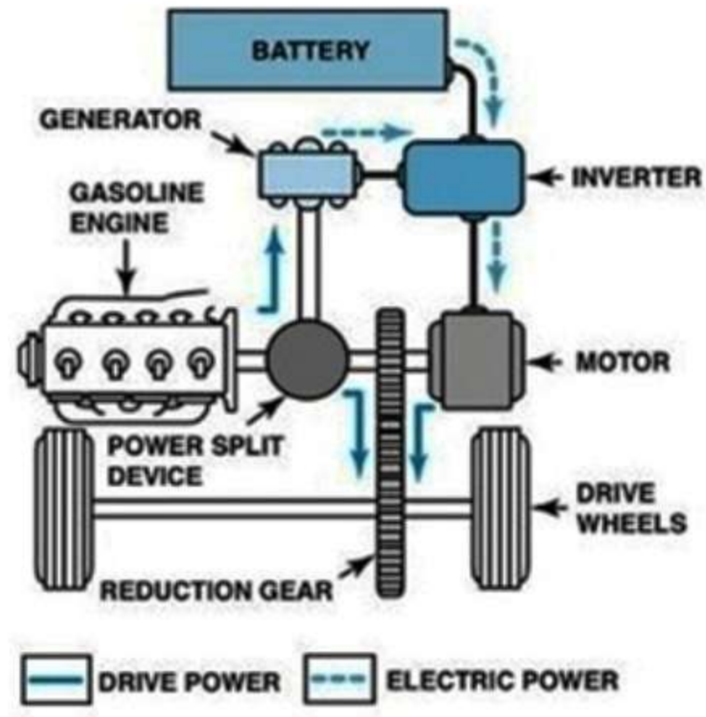


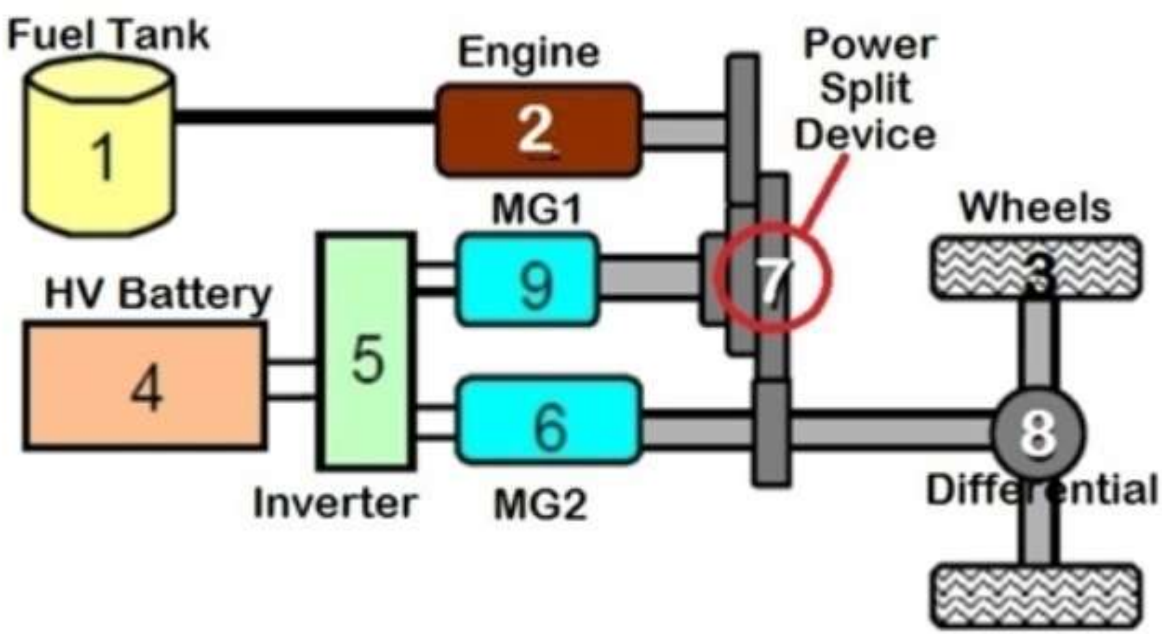
FIGURE 2–7 A series-parallel hybrid design allows the vehicle to operate in electric motor mode only or in combination with the internal combustion engine.

Combined hybrid -also known as SRONG HYBRIDS

Combined hybrid systems have features of both series and parallel hybrids. There is a *double connection between the engine and the drive axle: mechanical and electrical*. This split power path allows interconnecting mechanical and electrical power, at some cost in complexity.

Power-split devices are incorporated in the powertrain. The power to the wheels can be either mechanical or electrical or both. This is also the case in parallel hybrids. But the main principle behind the combined system is the *decoupling of the power supplied by the engine from the power demanded by the driver*. (can use El motor only or Engine only mode)

Series / Parallel - Combined HEV (Toyota Prius)



1: Fuel tank
2: Engine
3: Wheels
4: Battery
5: Convertors
6: MG2
7: Power Split device
8: Differential
9: MG1

The Power Split Device

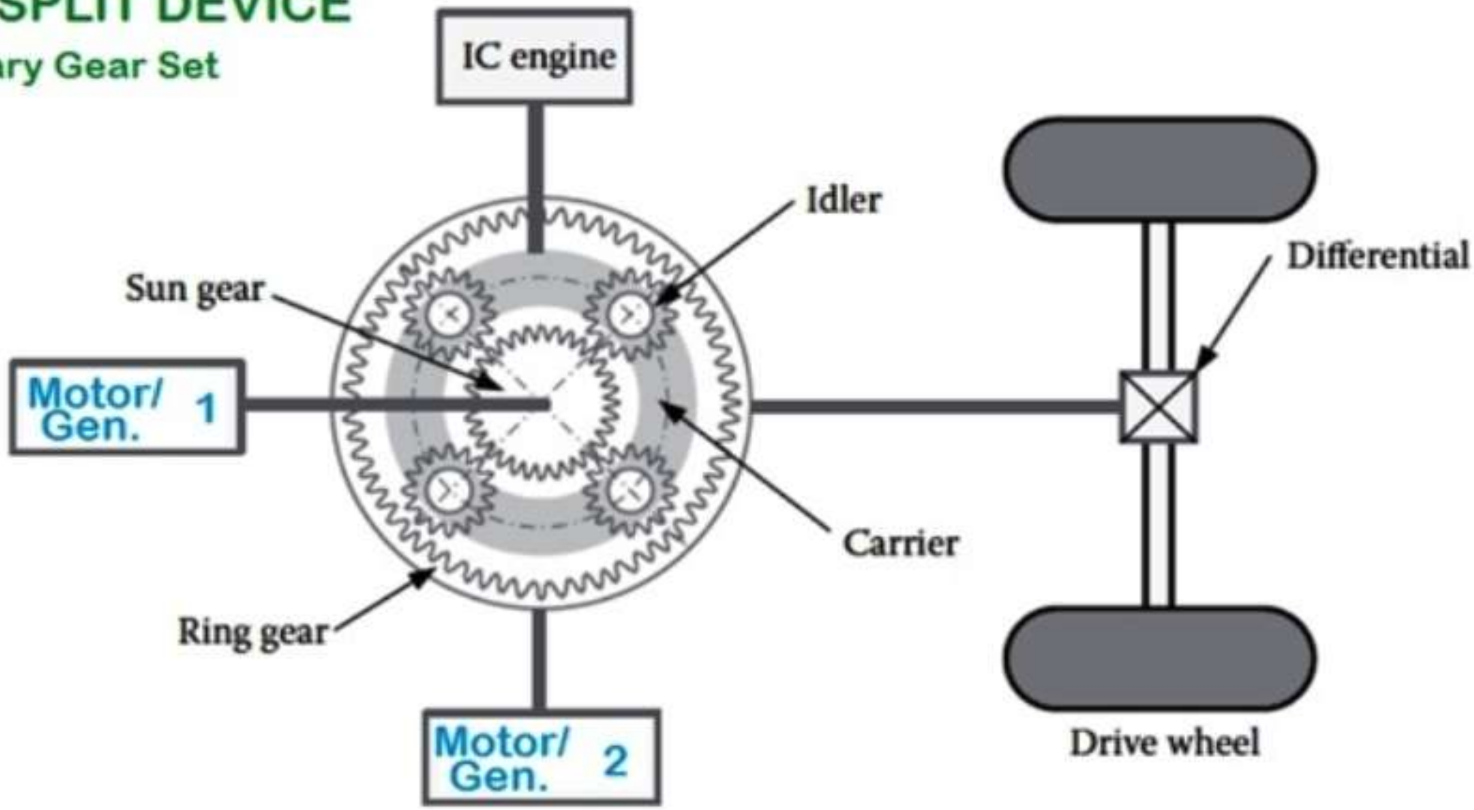
The **power split device** is the heart of the Toyota Prius. This is a clever gearbox that hooks the gasoline engine, generator and electric motor together. It allows the car to operate like a **parallel hybrid** -- the electric motor can power the car by itself, the gas engine can power the car by itself or they can power the car together. The power split device also allows the car to operate like a **series hybrid** -- the gasoline engine can operate independently of the vehicle speed, charging the batteries or providing power to the wheels as needed. It also acts as a **continuously variable transmission** (CVT), eliminating the need for a manual or automatic transmission. Finally, because the power split device allows the generator to start the engine, the car does not need a starter.

The power split device is a planetary gear set The electric motor is connected to the ring gear of the gear set. It is also directly connected to the differential, which drives the wheels.

When a hybrid electric vehicle is operating at low speeds, it is often being propelled by the electric motor alone, sometimes called **motoring mode.** As a result, the vehicle is very quiet and is said to be operating in **quiet mode.**

POWER SPLIT DEVICE

Planetary Gear Set



Planetary gear system and the connection diagram of propulsive systems in series–parallel hybrid electric vehicles.

Strong Hybrids

At low speeds or idling, the electric motor takes over, reducing the load on the ICE and improving fuel efficiency. But, when the car needs more power for acceleration, the ICE steps in and provides additional power.

In STRONG HYBRIDS and also in Series Hybrid car :--

After driving a few miles in the all-electric mode, the HV battery pack becomes partially discharged. When the hybrid ECU detects the lower voltage (about 70% discharge), it starts the internal combustion engine to propel the vehicle and recharge the HV battery pack.

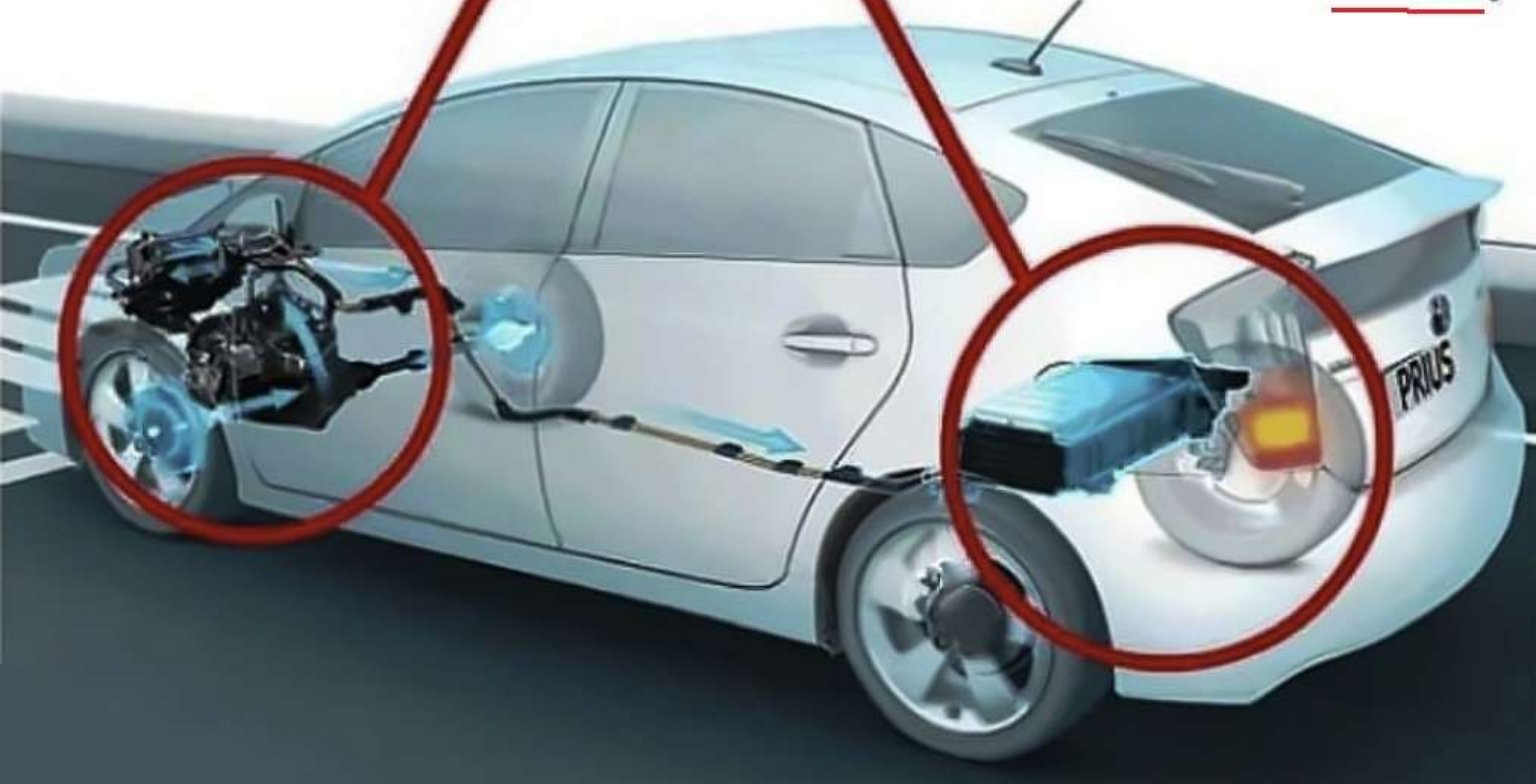
The engine crankshaft spins the motor-generator, which in turn sends electricity to the power control module and battery pack.

What drives a hybrid?

Over 40 years of continuous research and development, which began way back in 1969

Two key technologies - the power split device and sophisticated energy management

Kinetic energy is normally discarded as friction heat when braking but we regenerate the energy into electricity to charge the car's battery



REGENERATIVE BRAKING

- **Electric motor** - The electric motor on a hybrid car is very sophisticated. Advanced electronics allow it to act as a motor as well as a generator. For example, when it needs to, it can draw energy from the batteries to accelerate the car. But acting as a generator, it can slow the car down and return energy to the batteries.

A main advantage of an electromotor is the possibility to function as generator. In all HEV systen mechanical braking energy is regenerated.
The max. operational braking torque is less than the maximum traction torque; there is always a mechanical braking system integrated in a car.

What is Regenerative Braking?

Regenerative braking is a technology used in hybrid and electric vehicles to convert kinetic energy into electrical energy and store it in the vehicle's battery. During regenerative braking, the electric motor in the vehicle acts as a generator, converting the energy generated by the vehicle's motion into electrical energy, which is then stored in the battery.

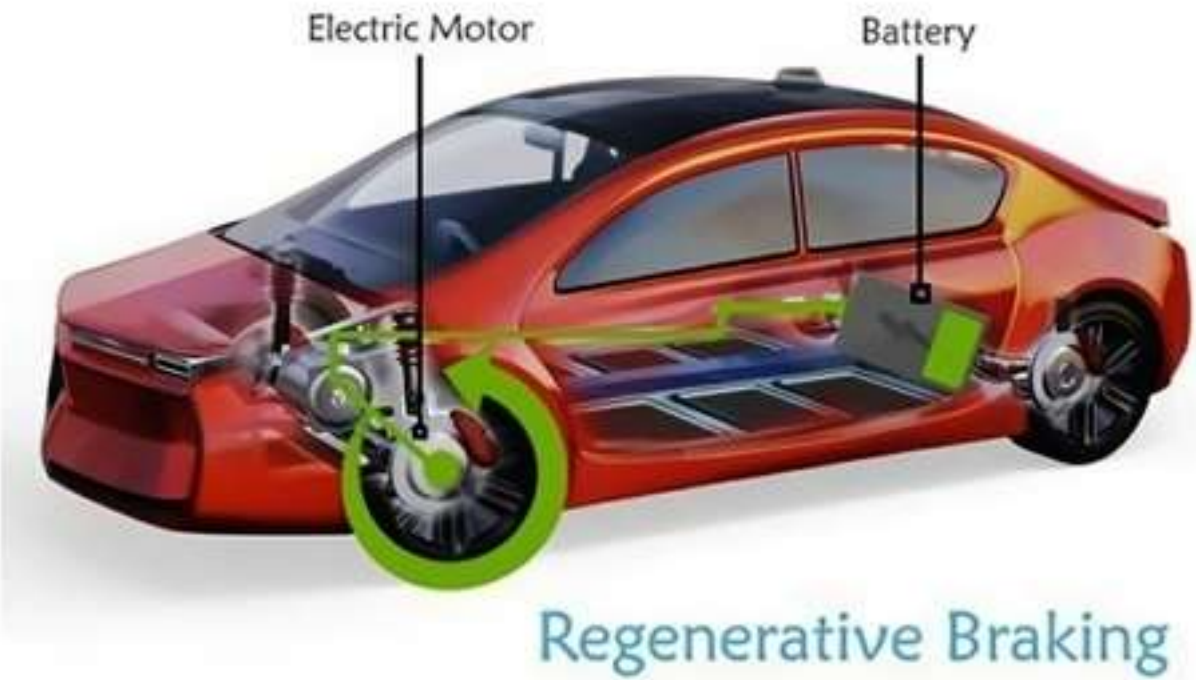
When the driver applies the brakes, the electric motor in the vehicle slows down the wheels and converts the energy generated by the vehicle's motion into electricity. This process reduces the amount of energy lost as heat through friction brakes and instead puts it back into the battery, where it can be used later to power the vehicle.

The result is improved fuel efficiency, longer battery life, and reduced wear and tear on the friction brakes.

Regenerative braking

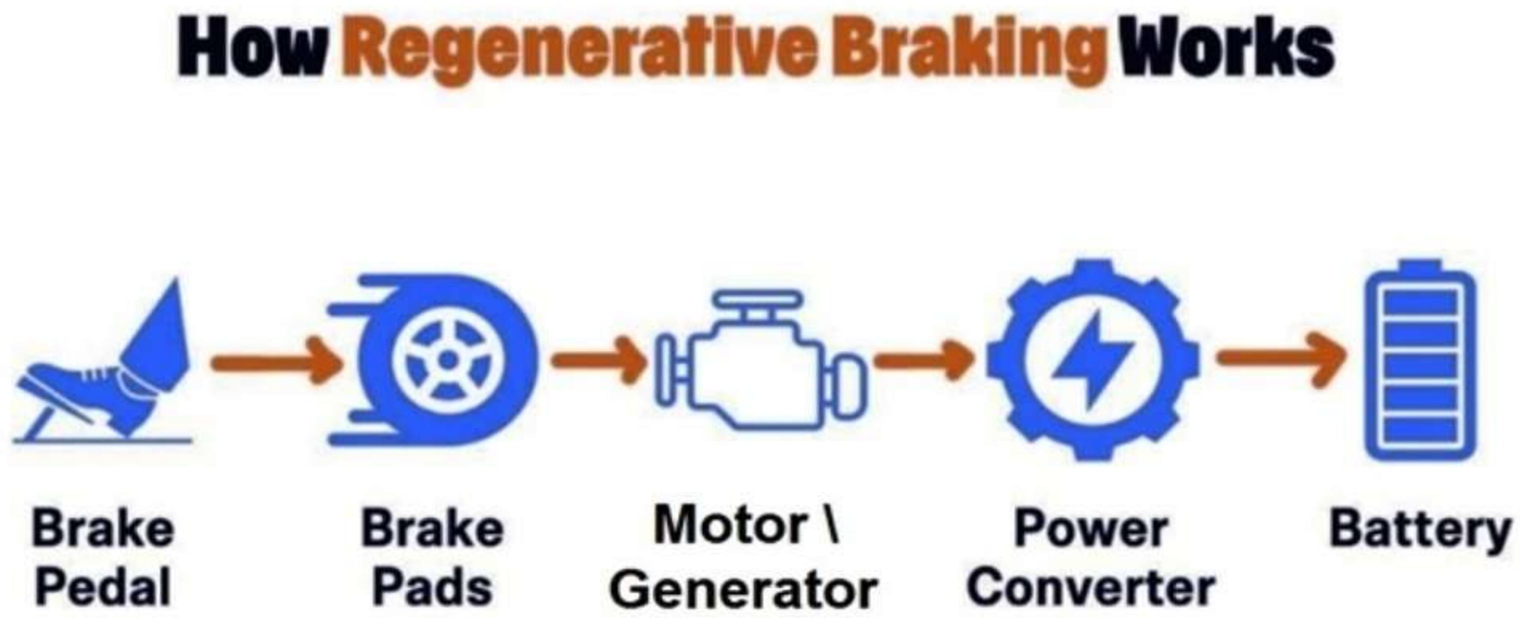
©Provided by Move Electric

This is where energy created under braking is harnessed and then used to charge the batteries while on the move. More modern electric cars are fitted with this feature, with many allowing the driver to set the effectiveness of the regenerative brakes. In fact, the force of the regenerative system - instigated when lifting of the accelerator - is so strong that you don't even need to press the actual brake pedal.



The mechanism is quite straightforward: when the car stops, its kinetic energy is directed to the motor shaft, which drives the generator and transforms it into electrical energy, which is then stored in the battery. As a result, every time the car stops, it receives a small amount of electricity that can be stored, at the very least charging the battery a bit.

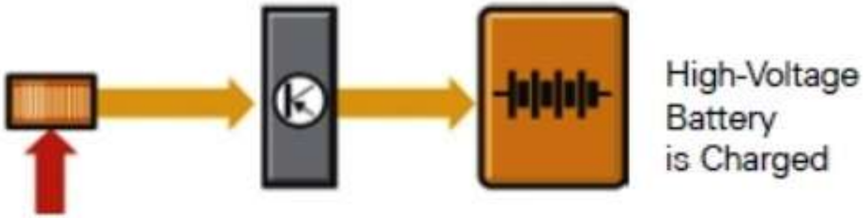
Regenerative braking converts otherwise wasted energy from braking into electricity and stores it in the battery. The electric motor is reversed so that instead of using electricity to turn the wheels, the rotating wheels turn the motor to create electricity.



Hybrid cars produce their own energy

Simply decelerating and braking generates energy that charges the batteries, ensuring that energy efficiency is maximised.

An electric car uses the forward momentum of the motor to recharge the battery. This process is called regenerative braking.



Electric Motor/Generator Runs as Alternator

Regenerative Braking

If the electric vehicle "coasts" (the vehicle moves without drive torque from the electric motor), part of the kinetic energy is fed into the high-voltage battery by the electric motor which functions as an alternator.

Brake System

An electric vehicle has two independent brake systems. One system is the traditional mechanical/ hydraulic brake system. The second brake system is formed by the electric drive motor as an "engine brake". The advantage of this "engine brake" compared with the combustion engine is that the energy released by the electric motor/generator during braking and deceleration is recovered and fed into the high-voltage battery. This regenerative braking contributes to the high efficiency of the electric vehicles in particular in city traffic. In addition, the wear of the vehicle brakes is reduced by the regenerative braking system.

In STRONG HYBRIDS and also in Series Hybrid car :--

After driving a few miles in the all-electric mode, the HV battery pack becomes partially discharged. When the hybrid ECU detects the lower voltage (about 70% discharge), it starts the internal combustion engine to propel the vehicle and recharge the HV battery pack.

The engine crankshaft spins the motor-generator, which in turn sends electricity to the power control module and battery pack.

BEHVs do not need to be plugged into an electric outlet in order to be recharged. They charge themselves by using energy normally lost during coasting and braking, and can also be charged by the car's gasoline engine.

HYBRID COMPONENTS

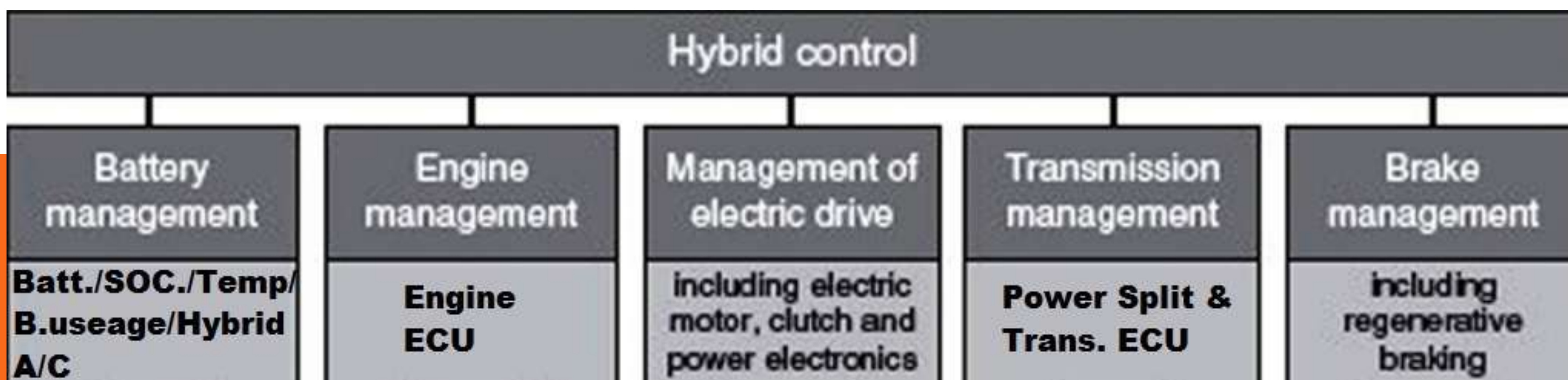
Component	Purpose
Motor/generator	Provides drive to the wheels and generates electricity when the vehicle is slowing and braking
Inverter	A device to convert DC into AC
Rectifier (Inverter)	A device to convert AC into DC (the inverter and the rectifier are usually the same component)
DC–DC converter: regenerative	This converts the AC from the motor during braking after it has been rectified to DC. The conversion is necessary to ensure the correct voltage level for charging
DC–DC converter: subsystem (To charge the 12v Aux. Batt.)	A device to convert high-voltage DC into low-voltage DC to run the general vehicle electrics
DC subsystems (12V Auxiliary Battery)	The 12 V (or 24/42 V) systems of the vehicle such as lights and wipers – this may include a small 12-V battery
Battery (high voltage) (HV Package)	Usually lithium-ion or nickel–metal hydride
Battery control (Battery Module)	A system to monitor and control battery charge and discharge to protect the battery as well as increasing efficiency
Motor control	Arguably the most important controller, this device responds to sensor signals and driver input to control the motor/generator during the various phases of operation (accelerating, cruising, braking etc.)
Internal combustion engine	Internal combustion engine used on HEVs and PHEVs only – it hybrids with the motor.

The **high-voltage (HV) battery** in an HEV must be able to provide large amounts of electrical current for acceleration, then recharge quickly as the vehicle is cruising and braking.

The **auxiliary battery** in an HEV must provide electrical current for operation of all the other traditional circuits on the vehicle, as well as starting in some situations.

A normal 12V Battery in Hybrids & EVs **(Auxiliary 12V Battery)**

Just about any electric car has one other battery on board. This is the normal 12-volt lead-acid battery that every car has. The 12-volt battery provides power for accessories – things like headlights, radios, fans, computers, air bags, wipers, power windows and instruments inside the car. Since all of these devices are readily available and standardized at 12 volts, it makes sense from an economic standpoint for an electric car to use them.



BHEV Components

- High-voltage (HV) battery pack—large number of voltaic cells wired in series to produce a high-voltage, high-power storage battery.
- Motor-generator—armature and stator assembly that can function as a high-power motor or a high-power generator.
- Power control module—high-voltage electronic circuit that can change dc to ac or ac to dc. It can also amplify or reduce voltage.
- Hybrid drive ECU—electronic control unit that monitors driving conditions to help control the operation of the power control module, battery pack, and motor-generator.
- Power cables—large insulated conductors that electrically connect the battery pack, power control module, and motor-generator assemblies together.
- Internal combustion engine—gasoline or diesel engine that propels the vehicle at highway speeds and spins the motor-generator armature to recharge the battery pack.

Hybrid Drive Vehicle

In a gas-electric hybrid, the internal combustion engine and electric drive system work in unison under computer control to propel the vehicle and operate its electrical accessory systems. There are six major assemblies in a gas-electric hybrid drive system, **Figure 38-2.**

1 • High-voltage (HV) battery pack—large number of voltaic cells wired in series to produce a high-voltage, high-power storage battery. 1 HV Battery

2 • Motor-generator—armature and stator assembly that can function as a high-power motor or a high-power generator. 2 Motor / Generator

3 • Power control module—high-voltage electronic circuit that can change dc to ac or ac to dc. It can also amplify or reduce voltage. 3 Inverter

4 • Hybrid drive ECU—electronic control unit that monitors driving conditions to help control the operation of the power control module, battery pack, and motor-generator. 4 Intelligent Power Control Unit

5 • Power cables—large insulated conductors that electrically connect the battery pack, power control module, and motor-generator assemblies together.

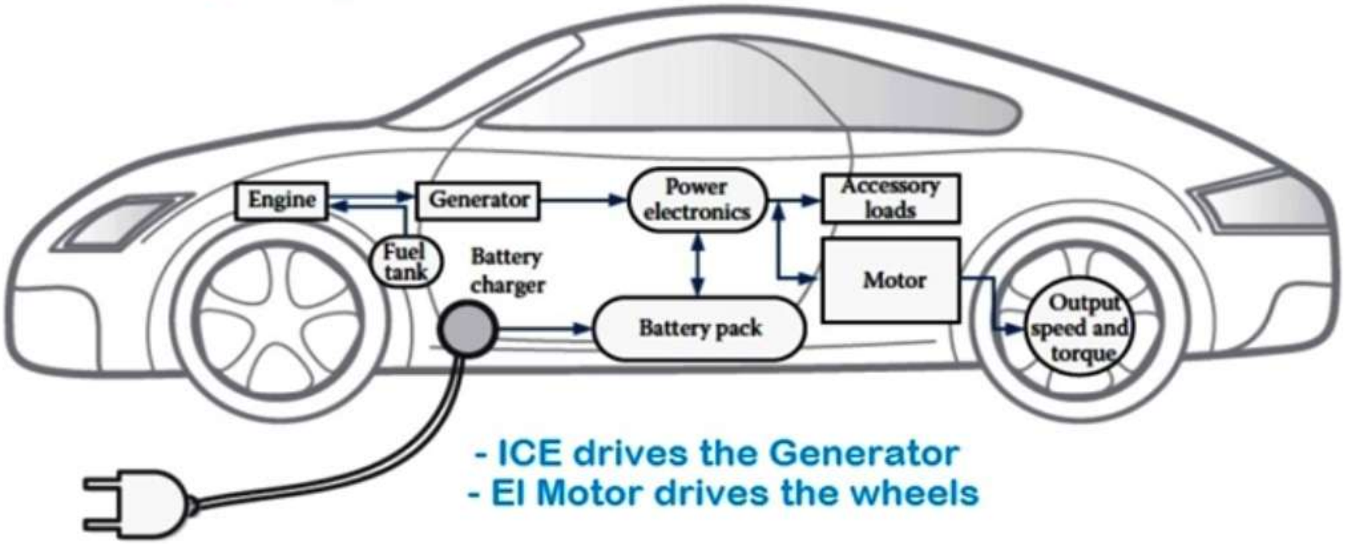
6 • Internal combustion engine—gasoline or diesel engine that propels the vehicle at highway speeds and spins the motor-generator armature to recharge the battery pack.

Plug-in Vehicles

BEHVs do not need to be plugged into an electric outlet in order to be recharged. They charge themselves by using energy normally lost during coasting and braking, and can also be charged by the car's gasoline engine.

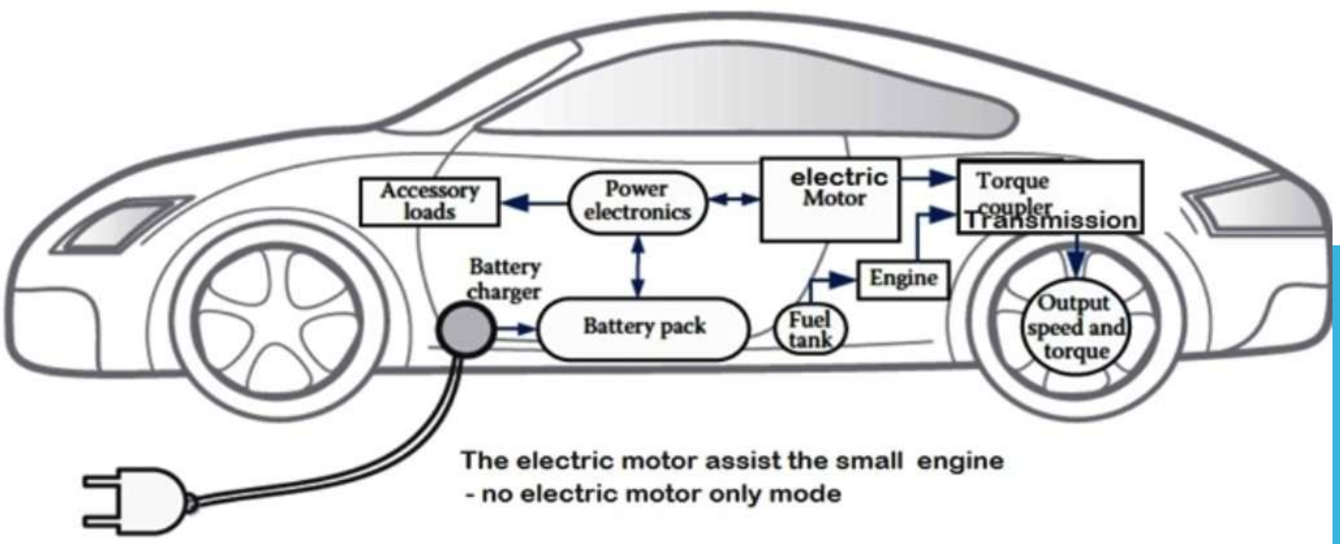
In order to increase electric motor cruising time, some manufacturers are creating plug-in hybrids that have more powerful batteries which can be recharged by "plugging in" the vehicle to normal household current. This feature allows the vehicle to perform more like a true electric car and less like a conventional gasoline car, all the while delivering exceptional fuel mileage.

Series Plug-in Hybrid

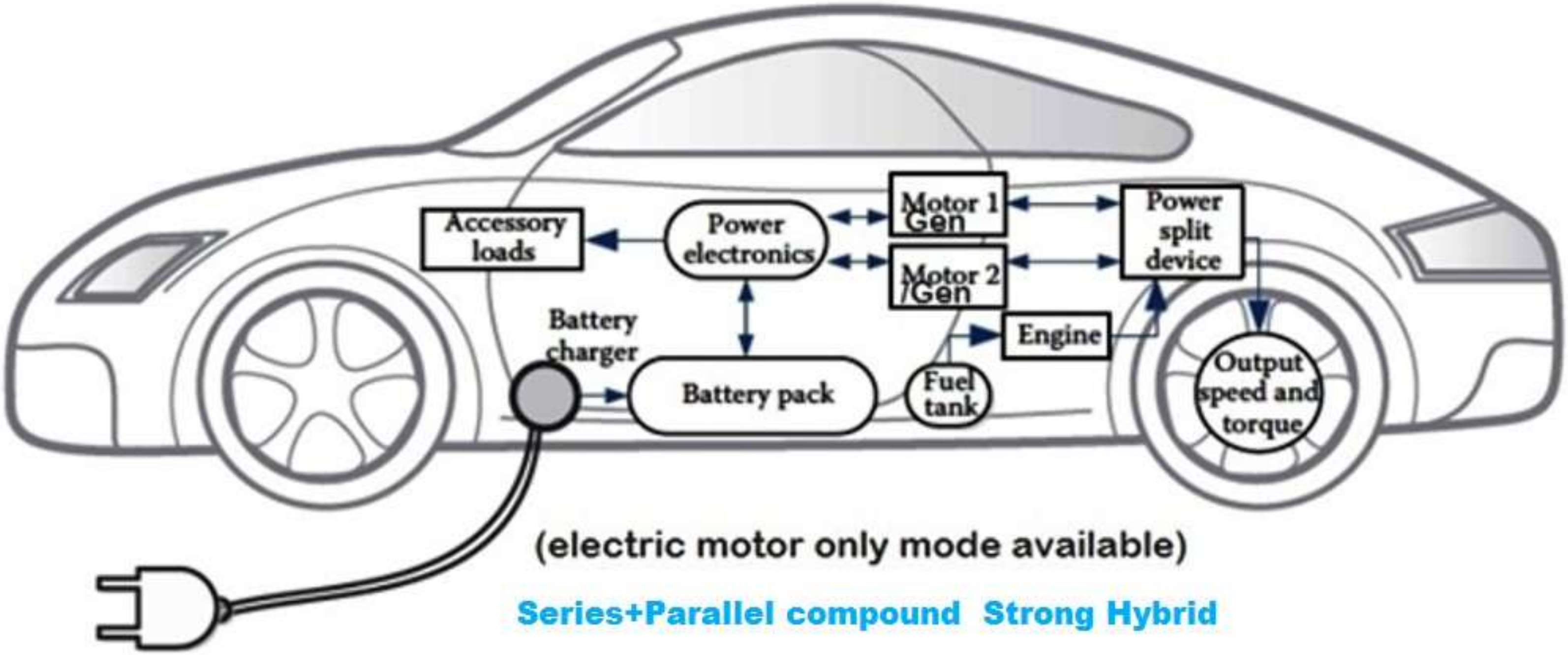


Configuration of series PHEV.

Plug-in Parallel (assist) Hybrid



Parallel hybrid architecture.



Compound PHEV architecture.

All EVs must have a Plug-in

HIGH VOLTAGE BATTERY

(VOLTAGE HIGHER THAN 60V IS TERMED AS HIGH

Most current HEVs use nickel-metal hydride battery technology for their high-voltage battery packs. NiMH is an alkaline battery design that operates through the movement of hydrogen ions between the battery electrodes.

Lithium-ion technology is a possible replacement for NiMH in HEV applications due to its higher nominal voltage and specific energy.

Lithium Batteries

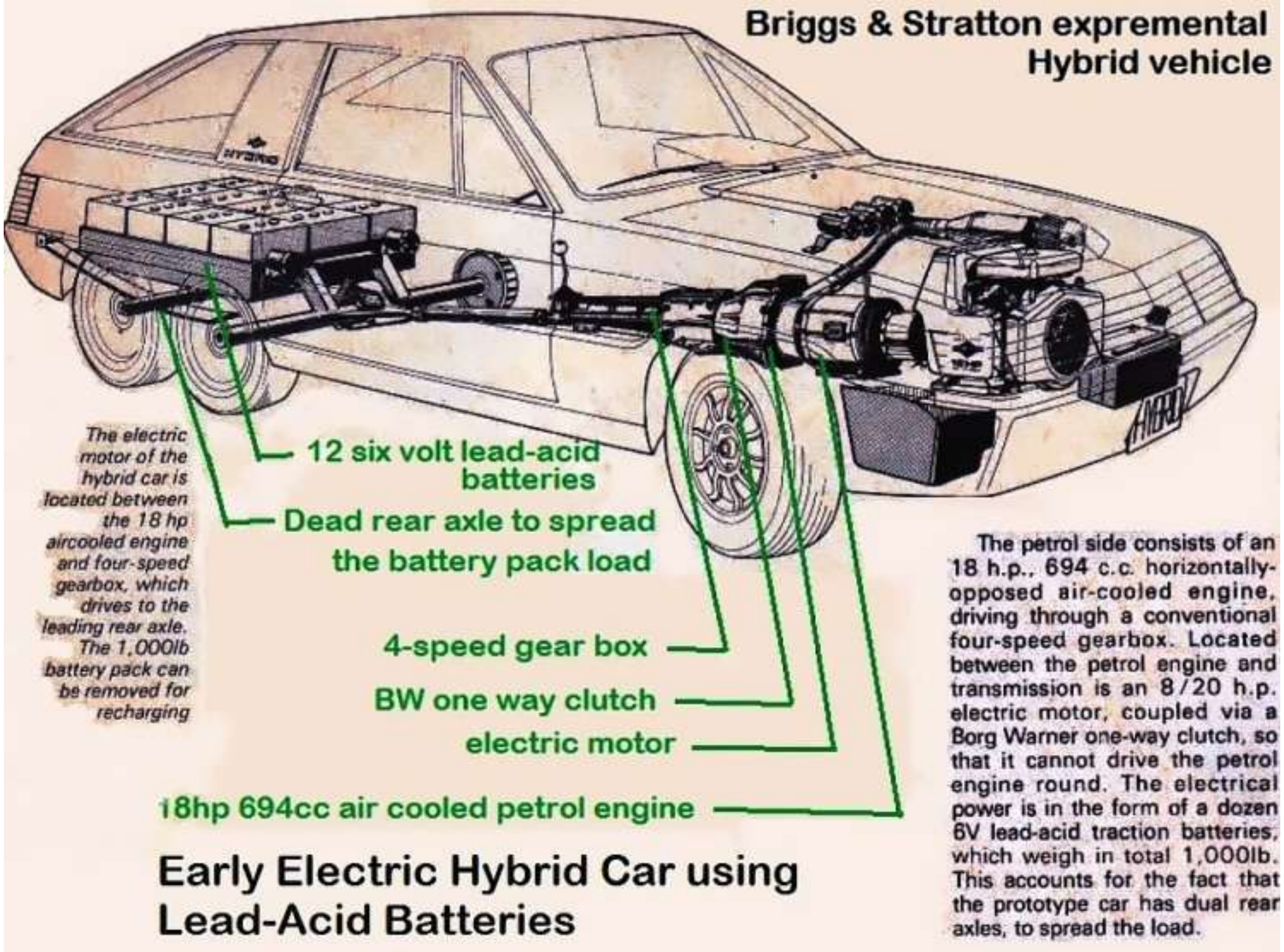
Lithium batteries in case you did not notice have become a very essential part of our everyday lives.

They are known for their lightweight and how powerful they are. Their weight does not define their power.

Typically they weigh less than one-third of a lead-acid battery and they provide up to 50% more energy along with more power.

Because they offer really low resistance they can charge much faster than traditional lead-acid batteries.

Another benefit of lithium batteries is how long their life span is. They cycle 5,000+ times vs up to 1,000 cycles (on a high-end lead-acid battery).



NOTE: Lithium is the lightest metal and provides the highest energy density of all known metals.

The bestselling Tesla Model 3, for example, weighs 2.2 tons fully loaded. Electric cars are roughly twice as heavy as standard models,

Li-ion vs NiMH batteries

- They're generally much lighter than other types of rechargeable batteries of the same size. The electrodes of a lithium-ion battery are made of lightweight **lithium** and **carbon**. Lithium is also a highly reactive element, meaning that a lot of energy can be stored in its atomic bonds. This translates into a very high **energy density** for lithium-ion batteries. Here is a way to get a perspective on the energy density. A typical lithium-ion battery can store 150 watt-hours of electricity in 1 kilogram of battery. A **NiMH (nickel-metal hydride) battery** pack can store perhaps 100 watt-hours per kilogram, although 60 to 70 watt-hours might be more typical. A **lead-acid battery** can store only 25 watt-hours per kilogram. Using lead-acid technology, it takes 6 kilograms to store the same amount of energy that a 1 kilogram lithium-ion battery can handle. That's a huge difference

- They hold their charge. A lithium-ion battery pack loses only about 5 percent of its charge per month, compared to a 20 percent loss per month for NiMH batteries.
- They have no **memory effect**, which means that you do not have to completely discharge them before recharging, as with some other battery chemistries.
- Lithium-ion batteries can handle hundreds of charge/discharge cycles.

EV BATTERY BASICS

The batteries used for EV are lithium-ion batteries,
The same type used for your mobile phones and laptops.

Compared to regular batteries, they are much more lightweight.
They also have a much higher energy density,
Meaning they can squeeze out a larger amount of energy from a small battery.
They are also less prone to losing their charge when not being used.

An EV battery capacity is measured in kilowatt-hours or kWh.
The higher kWh rating of a battery pack,
The longer you can drive before needing to charge the battery.
This capacity is also referred to as the battery's "range".

How long do electric car batteries last?

Many factors affect EV batteries' lifespan. In general, you can expect most EV batteries on
The market today will last you at least 8 years or around 100,000 miles (ca. 160,934 km).
Most batteries in EV cars sold in the United States also have warranty for
At least 8 years or 100,000 miles (ca. 160,934 km).

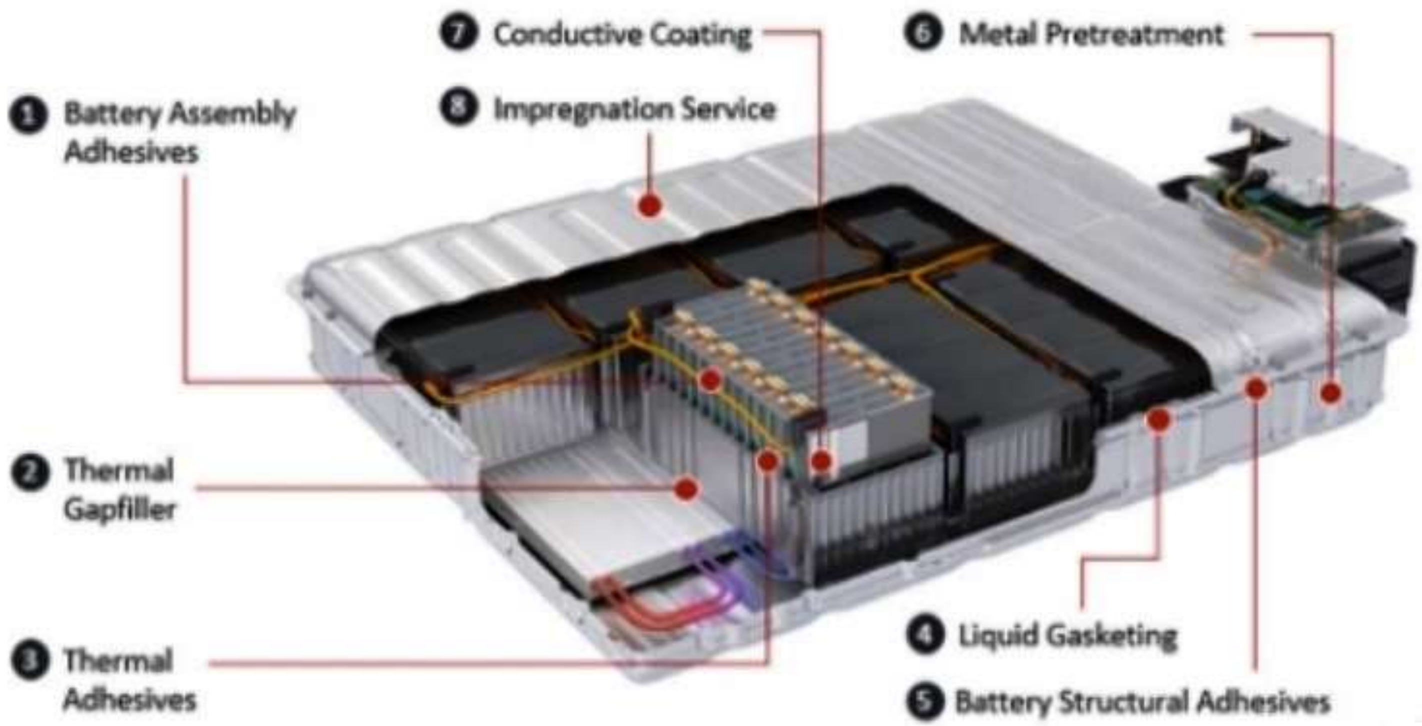
Another statistics for your peace of mind from Consumer Reports,
An independent, not-for-profit research organization. It estimates that a typical EV
Battery pack would last " around 200,000 miles (ca. 321,869 km), or almost 17 years of use if
driven 12,000 miles (ca. 19,312 km) a year.

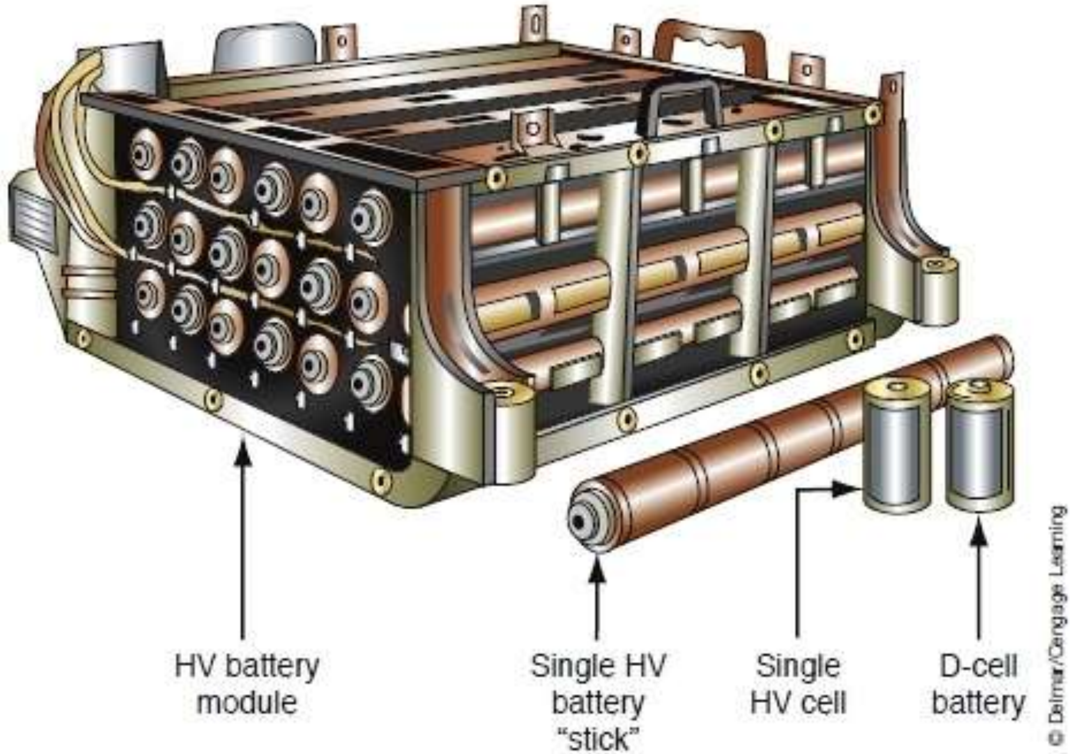
The battery pack is the single most expensive (and largest) component

Inside a Lithium Battery Pack

To get a better understanding of lithium we are going to go over what they look like inside

The cells inside a lithium battery pack can either be square or rectangular or cylindrical.





HV battery constructed of cylindrical cells.

Electric cars use multiple small batteries instead of just one large battery.

Lithium-ion Battery Case

As with most batteries you have an outer case made of metal. The use of metal is particularly important here because the battery is pressurized. This metal case has some kind of pressure-sensitive **vent hole**. If the battery ever gets so hot that it risks exploding from over-pressure, this vent will release the extra pressure. The battery will probably be useless afterwards, so this is something to avoid. The vent is strictly there as a safety measure. So is the **Positive Temperature Coefficient (PTC)** switch, a device that is supposed to keep the battery from overheating.

Reasons of using multiple small Batteries instead of a single large one

- easier to manufacture
- easier to cool and heat
- easier to repair
- modular, so easier to form different configurations and shapes
- Easier to make connections in parallel and series for giving required design voltage and power output
- safer in an accident
- stronger
- Small cylindrical cells can also be used in traditional power applications like flashlights
- Quality assurance is easier, and if one cell is ruined it doesn't ruin the whole battery
- cells can be made in one location and easily transported to a different location for aggregation into a large battery
- standardization is easier
- The design and manufacture of cell Manufacturing equipment is made easier

Battery sizes and Cooling

You may have noticed that high voltage batteries come in a variety of physical sizes and power ratings. Most modern High Voltage (HV) automotive batteries can be categorized into three major groups:

1. **Small size Hybrid Electric Vehicle (HEV) batteries.** These are typically rated at 1.5 kWh at 300V or less. These batteries are typically air cooled/heated with a blower fan. Example vehicles: Toyota Prius, Ford Fusion, Honda Civic.
2. **Medium size Plug-In Hybrid Electric Vehicle (PHEV) batteries.** These are typically rated at 18 kWh at 390V or less. (A typical driver can drive 3 miles per kWh). These batteries are air cooled/heated with blower fans or liquid cooled/heated (Volt). Example vehicles: Chevrolet Volt, Ford Fusion Energi, Honda Accord, Toyota Prius Prime.

Large size Battery Electric Vehicles (BEV) batteries. These are typically rated at 100 kWh at 390V or less. These batteries are typically liquid cooled, refrigerated (BMW), or not cooled at all (Nissan). Example vehicles: Tesla Models S, X, and 3. Chevrolet Bolt EV, BMW i3, Nissan Leaf.

HV BATTERY COOLING
NEED FOR COOLING

- High operating temperatures can lower performance and cause damage to a NiMH battery pack.
- All current production HEVs use air cooling to control HV battery pack temperature.
- Cabin air is circulated over the battery cells using an electric fan and ducting inside the vehicle.

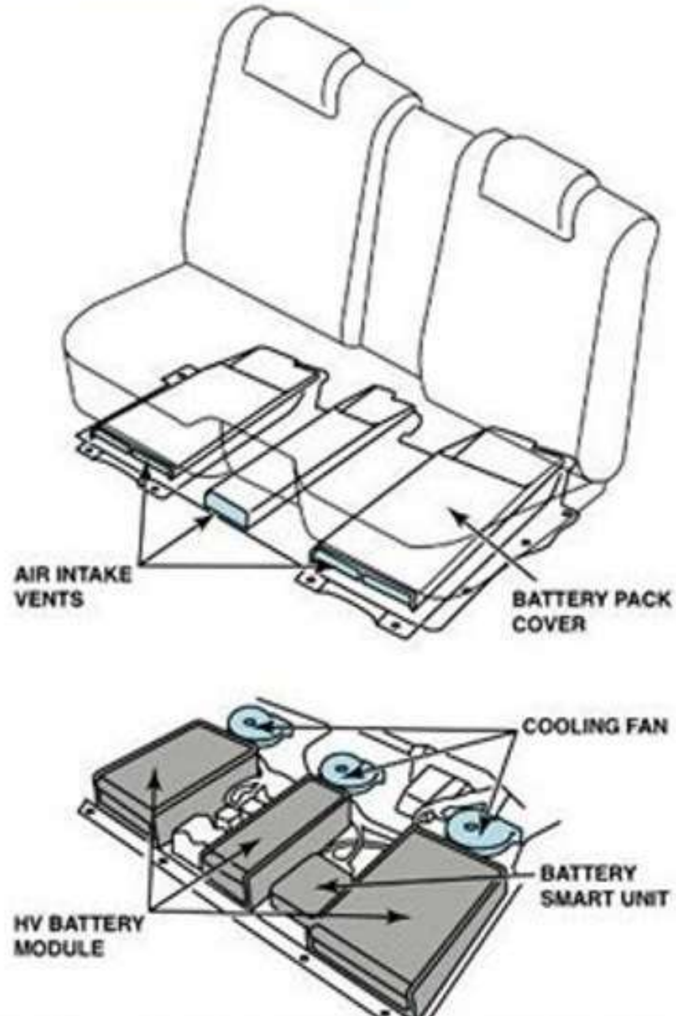


FIGURE 7–45 The battery cooling system for a Toyota hybrid SUV. All production hybrid HV battery packs are air cooled. Note the air intake vents located under the seats.

Sensitive To High Temperature

Li-Ion motor batteries are overheated.

The overheating of the device or overcharging of the battery generally leads to more heat.

HV Battery COOLING is very important

Battery cells can degenerate faster than normal due to heat.

Safety Concerns

The chances of Li-ion battery exploding due to overheat or overcharge are always high.

The decomposition of electrolytes leads to the formation of gases. The electrolyte can be ignited and it can trigger a fire.

Operating temperature and cooling

CA

The cooling arrangement is the single most important factor in determining the output from any given motor.

LIQUID COOLING is the better option

Liquid-cooling may add complexity to battery packs. Even so, it is the best option under all weather conditions: it allows for more precise and effective temperature control in the most expensive component for electric cars. The Nissan Leaf and the Renault ZOE opted for air-cooling for cost reasons **but in use, --the over heating,** that may be more expensive in the long term – for customers.

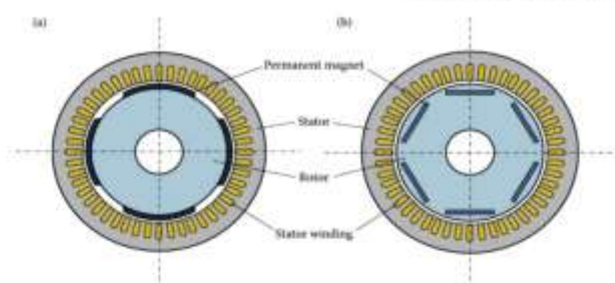
Colors of Wiring

- BLACK conduit -12 to 42 volts. This voltage level usually does not represent a shock hazard.
- Yellow conduit or Blue- Usually represents a 42 volt circuit. This level could cause an arc to be maintained if a live circuit is broken.
- ORANGE conduit- High and dangerous voltage levels of 144 to 650 volts

ELECTRIC MOTORs

1. Both AC & DC motors are used in BHEVs and EVs.
2. Brush less motors are used
3. The electric motor in a hybrid or electric car can run in two directions – forwards and backwards.
4. The motors used are very sophisticated. The electronics allow it to act as a Motor as well as a Generator.
5. Electric cars don't have (or need) gearboxes - so they are neither automatic - nor manual. They don't even need a reverse gear - they can just run the motor backwards.
6. PERMANENT MAGNET MOTORS ARE USED.

Advanced Electric Drive Vehicles

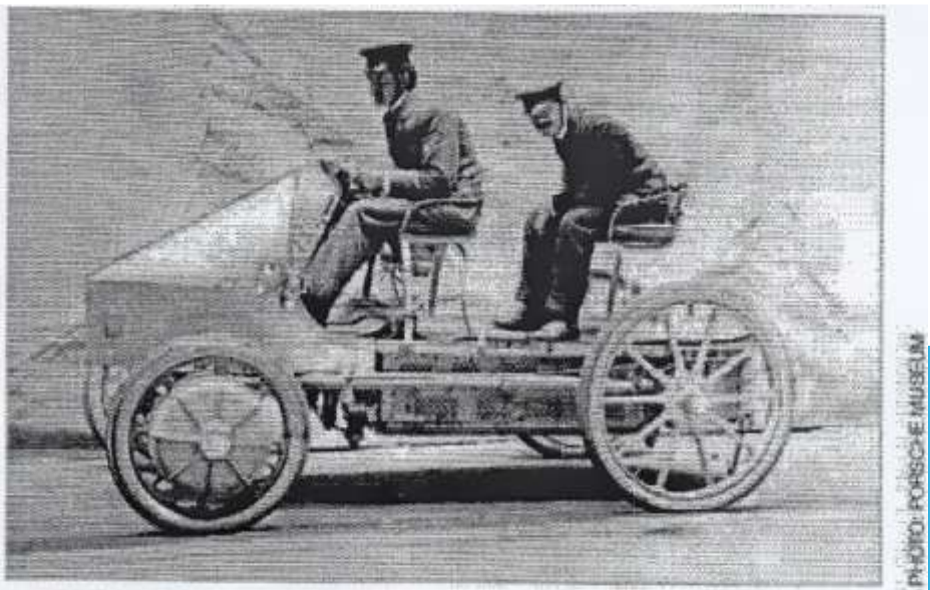


Cross section view of permanent magnet machines (a) surface permanent magnet machine (SPM) (b) interior permanent magnet machine (IPM).

Various types of Electric Motors used in Electric Vehicles

1. DC Series Motor
2. Brushless DC Motor
3. Permanent Magnet Synchronous Motor (PMSM)
4. Three Phase AC Induction Motors
5. Switched Reluctance Motors (SRM)

HUB MOTOR



THE LOHNER-PORSCHE "MIXTE" TOURING CAR from 1903. Ferdinand Porsche is at the wheel. The wheel hub motors can be seen mounted to the front wheels.

A disadvantage of wheel hub motors is that they add un-sprung weight. This adversely affects handling and steering. For example, GM used wheel hub motors that added 15 kg to each 18-inch wheel. However, this can be offset to some extent by tweaking suspension damping and spring rates.

Key Fact

A disadvantage of wheel hub motors is that they add un-sprung weight.

The integration of electric drive motors and various vehicle components into a vehicle's wheels has the potential to enable new vehicle designs by freeing up the space traditionally occupied by the powertrain and related accessories (Source: http://www.sae.org/mags/AEI/8458).

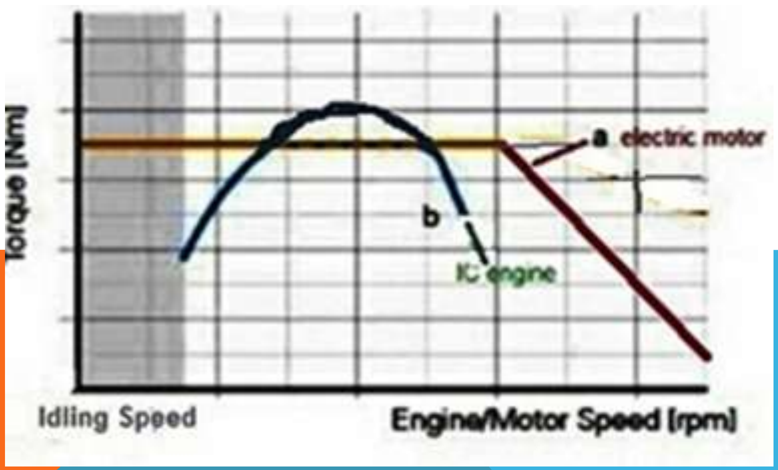
HUB MOTOR OR IN-WHEEL ELECTRIC MOTOR

In 1898, Jacob Lohner, a coach builder, teamed up with Ferdinand Porsche who had recently invented the electric wheel-hub motor. The motor fit inside the wheel's hub and was powered by lead-acid batteries. Using one of Lohner's coaches, at the time a more common term than "car," Porsche fitted two wheel-hub motors and a battery to create an all-electric vehicle — the Elektromobil.

It suffered from the same problem that electric cars face today — limited range due to battery technology.

Electric Motor Comparison	
AC Motor	DC Motor
Single – speed transmission	Multi-speed transmission
Light weight	Heavier for same power
Less expensive	More expensive
95% efficiency at full load	85-95%efficiency at full load
More expensive controller	Simple controller
Motor/Controller/Inverter more expensive	Motor/controller less expensive

Electric cars don't have (or need) gearboxes - so they are neither automatic - nor manual. They don't even need a reverse gear - they can just run the motor backwards.



Since an electric motor develops instant torque, a BEV doesn't need complex GB.

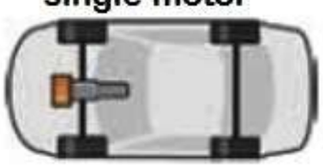
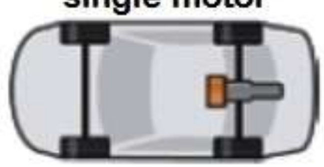
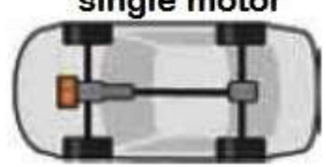
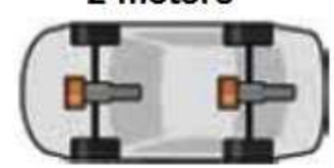
Transmission

Pure electric vehicles (BEV) do not require the traditional transmission with several speeds. The polarity of the electric motor is simply reversed when you want to reverse the vehicle. This means that the direction of rotation of the electric motor changes. This is done with a gear selector lever, which simply has the positions "Neutral", "Forward" and "Reverse". The speed can be regulated infinitely with the accelerator pedal.

One-Speed Transmissions

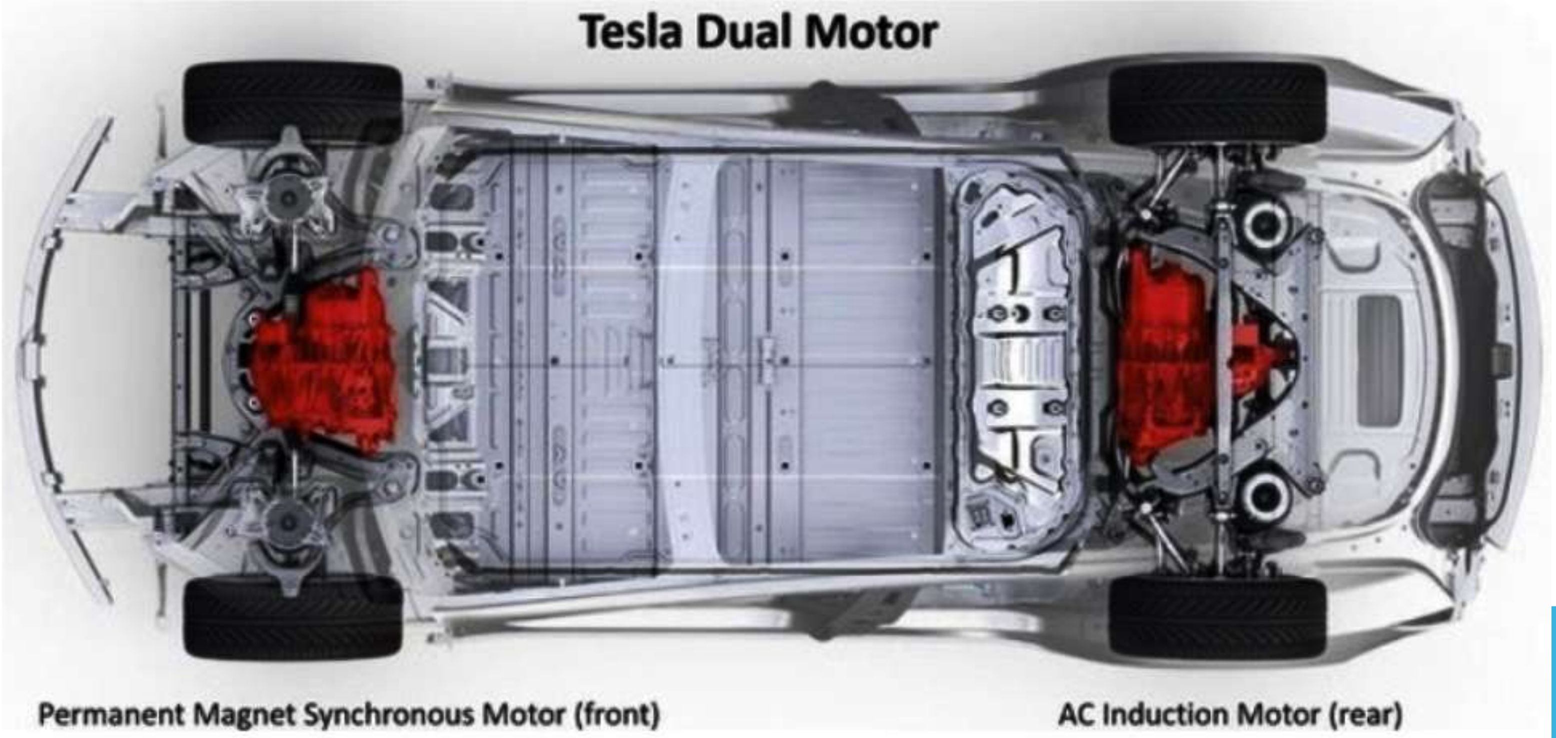
For most electric vehicles, a single-speed transmission has been sufficient. An electric motor's ability to develop full torque from 0 rpm eliminates the need for a low gear to overcome inertia and get the vehicle moving from a stop. Intermediate gears are also unnecessary. **(Just one fixed gear ratio)**

EV DRIVE TRAINS

Front-Axle Drive single motor	**Rear-Axle Drive** single motor	**Four-Wheel Drive** single motor	**Four-Wheel Drive** 2-motors
			
1x central electric motor and two drive shafts	1x central electric motor and two drive shafts	1x central electric motor and five drive shafts plus transfer case	2 x central electric motors and four drive shafts

: **Dual-motor vehicles typically don't use the same *types* of motors, and they usually don't use use *both* motors.** One motor is optimized for acceleration (high torque) and the other for cruising (low torque).

This is the configuration for a Tesla Dual Motor:



Permanent magnet synchronous motors are smaller, lighter, cheaper, and more energy efficient, but they lack the high torque of an AC induction motor.

So, when cruising, a Tesla Dual Motor uses **only** the front (permanent magnet) motor. The rear (AC induction) motor *only kicks in when accelerating* (or in low traction situations).

Cars spend more time cruising than accelerating, so a dual-motor car will **usually** use *only* the permanent magnet motor on the front wheels; the rear wheels are usually unpowered. This also extends the life expectancy of the more expensive AC Induction Motor.

Most EVs use a single AC induction motor.

Dual-motor cars combine these two types to optimize efficiency and performance.

Components of an All-Electric Car

1. Battery (all-electric auxiliary): 12V battery
In an electric drive vehicle, the auxiliary battery provides electricity to power vehicle accessories.

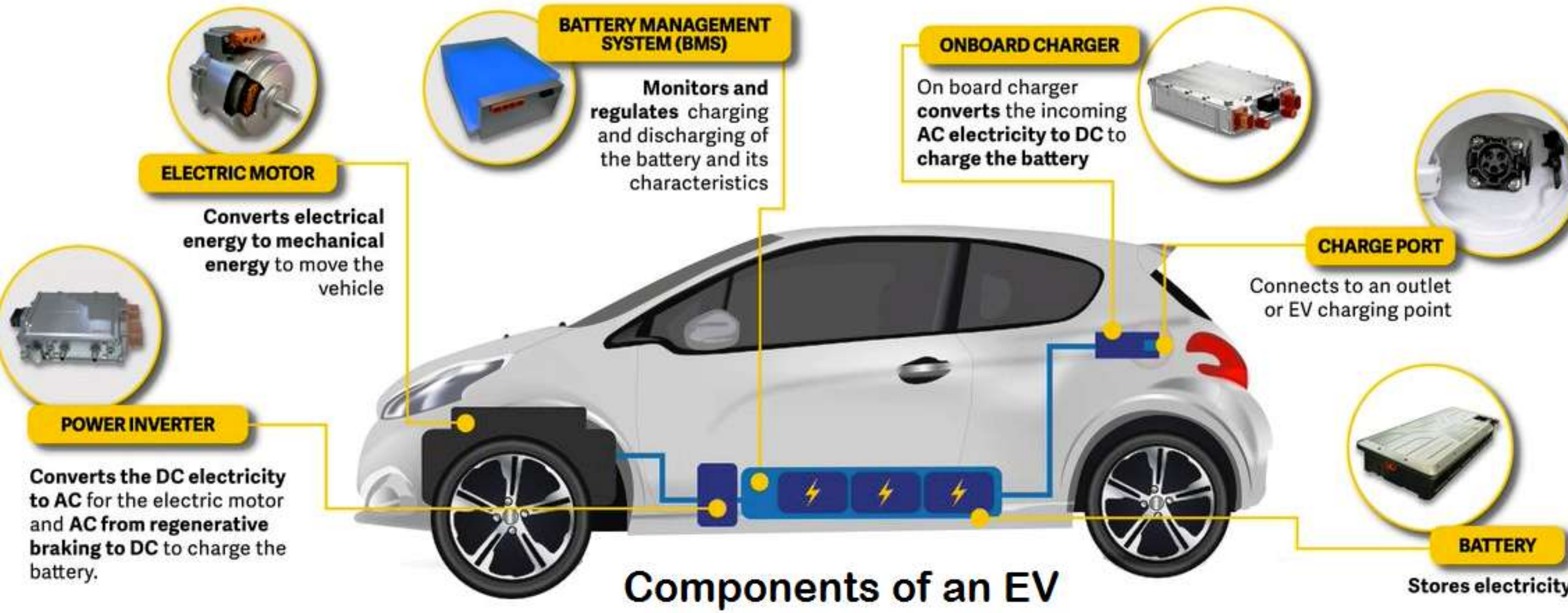
2. Charge port:
The charge port allows the vehicle to connect to an external power supply in order to charge the traction battery pack.

3. 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.

4. 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.

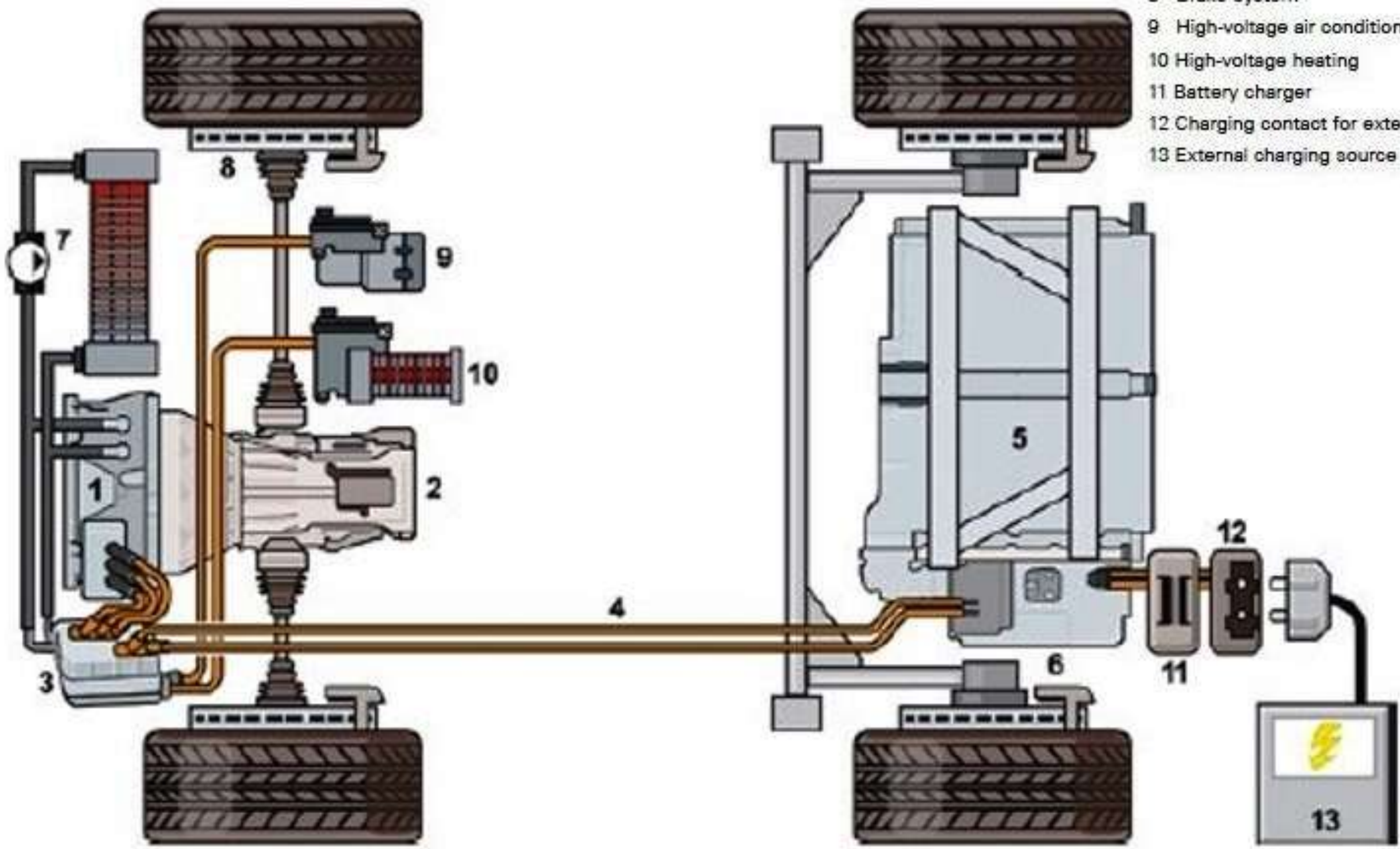
5. Onboard charger:
Takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the traction battery. It monitors battery characteristics such as voltage, current, temperature, and state of charge while charging the pack.

6. 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.

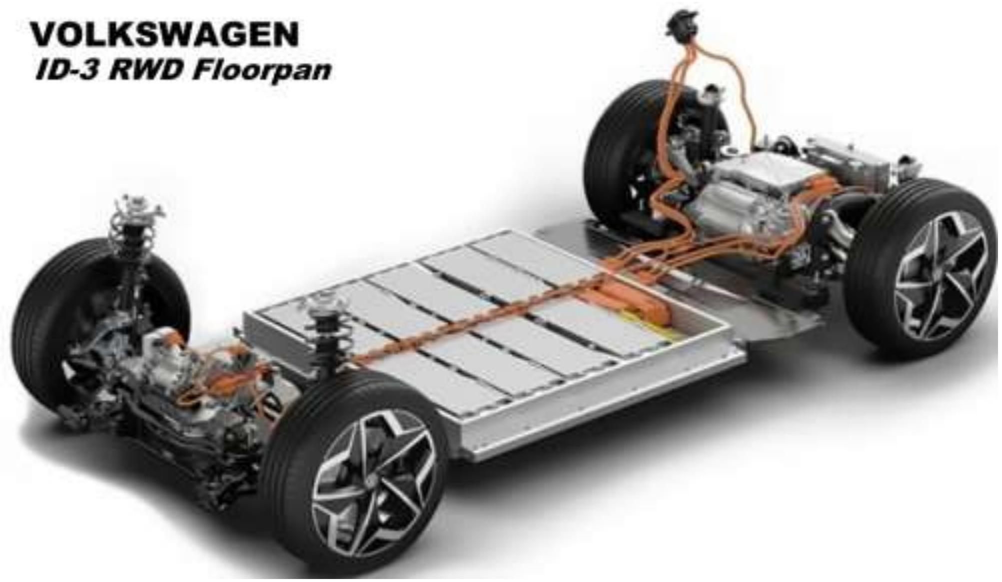

BATTERY MANAGEMENT SYSTEM (BMS)
Monitors and regulates charging and discharging of the battery and its characteristics
ONBOARD CHARGER
On board charger converts the incoming AC electricity to DC to charge the battery
ELECTRIC MOTOR
Converts electrical energy to mechanical energy to move the vehicle
CHARGE PORT
Connects to an outlet or EV charging point
POWER INVERTER
Converts the DC electricity to AC for the electric motor and AC from regenerative braking to DC to charge the battery.
BATTERY
Stores electricity
Components of an EV

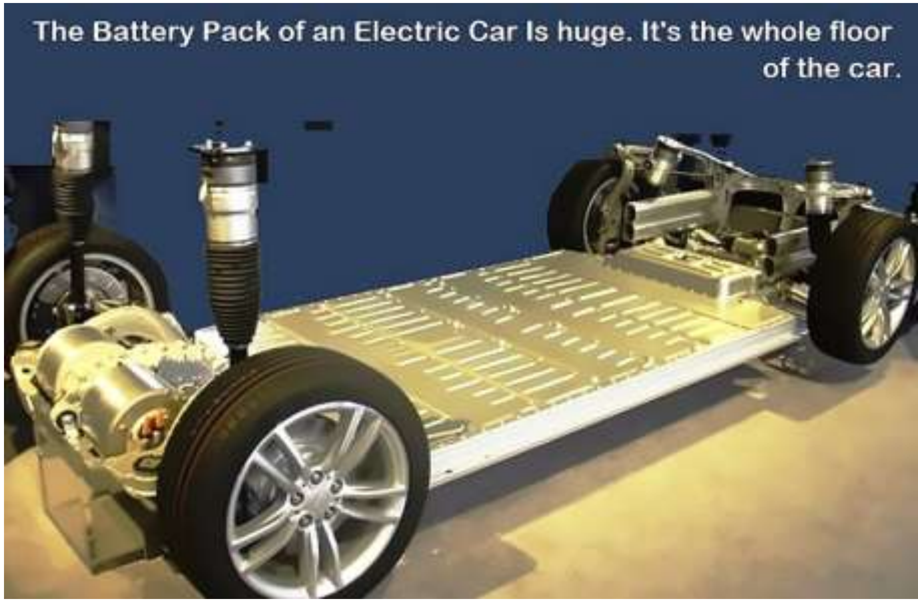
EV DRIVE SYSTEM components

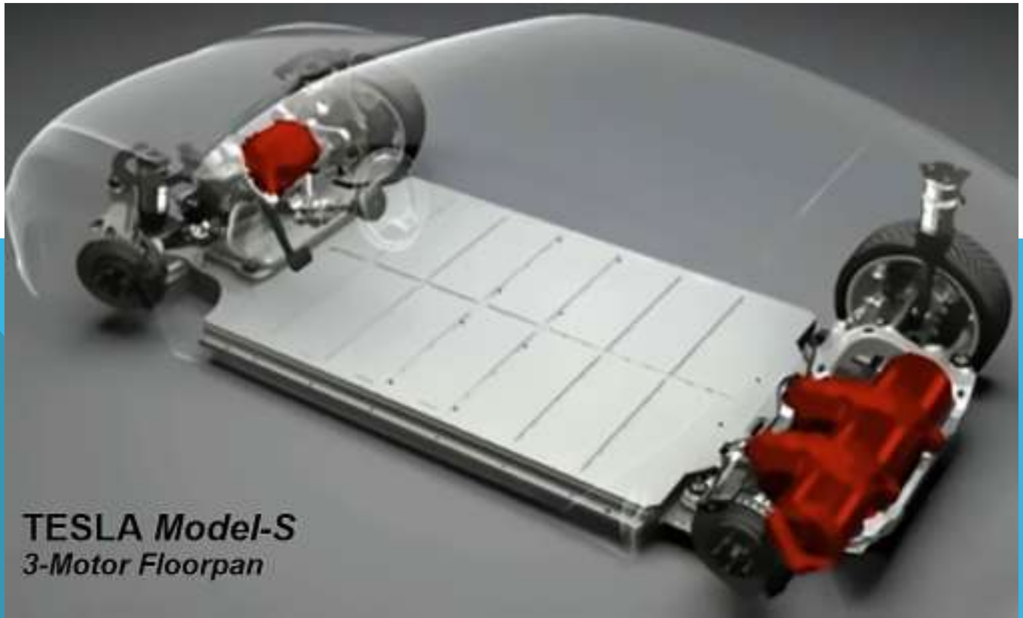
1 Electric motor/generator
2 Transmission with differential
3 Power electronics
4 High-voltage lines
5 High-voltage battery
6 Electronics box with control unit for battery regulation
7 Cooling system
8 Brake system
9 High-voltage air conditioner compressor
10 High-voltage heating
11 Battery charger
12 Charging contact for external charging
13 External charging source



EV Floor Plans







E- Vehicles Range per Full Battery Charge

RANGE

Range remains a top concern of Considerers, who expect a range of about 240 miles but ultimately are looking for a range of 300 miles, which is more in line with current gas-powered vehicles.

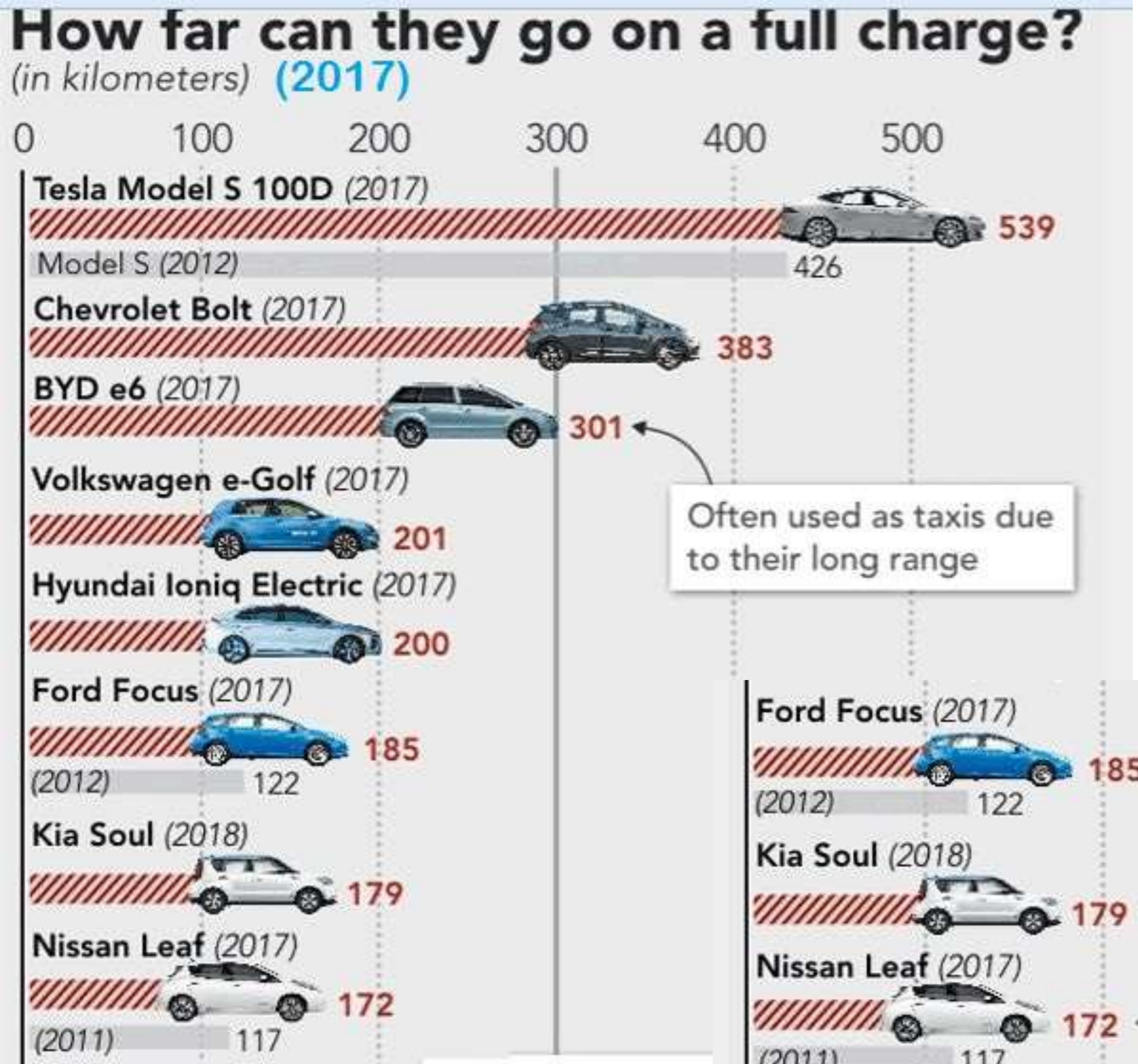
Reducing the road load through better tire technology and better aerodynamics would significantly reduce the energy consumption on the highway.

Average Watts useage with Speed

Speed	Total resistance	Required power	
35 mph	374 N	6 kW =	8 hp
60 mph	558 N	15 kW =	20 hp
80 mph	775 N	28 kW =	38 hp
100 mph	1053 N	47 kW =	64 hp
120 mph	1393 N	75 kW =	102 hp
140 mph	1795 N	112 kW =	152 hp
160 mph	2259 N	162 kW =	220 hp
180 mph	2785 N	224 kW =	304 hp
200 mph	3372 N	301 kW =	409 hp
220 mph	4022 N	395 kW =	537 hp
250 mph	5112 N	571 kW =	776 hp

Range depends on :-

1 HV Battery capacity
2 Vehicle load & weight
3 Vehicle speed
4 Aerodynamic coefficient
5 Road Surface
6Tyres
7 Outside Temp.
8 How you Drive



How far can they go on a full charge?
(in kilometers) (2017)
0
100
200
300
400
500
Tesla Model S 100D (2017)
539
Model S (2012)
426
Chevrolet Bolt (2017)
383
BYD e6 (2017)
301
Volkswagen e-Golf (2017)
201
Often used as taxis due to their long range
Hyundai Ioniq Electric (2017)
200
Ford Focus (2017)
185
(2012)
122
Kia Soul (2018)
179
Nissan Leaf (2017)
172
(2011)
117

Ford Focus (2017)
185
(2012)
122
Kia Soul (2018)
179
Nissan Leaf (2017)
172
(2011)
117
Best-selling highway-legal electric car of all time
BMW i3 (2016)
130
i3 BEV (2014)
130
Mitsubishi i-Miev (2017)
95

Range in kilometers per full battery charge (2025)

Average	378 km
Mercedes-Benz EQS 450+	690
Lucid Air Grand Touring	665
Mercedes-Benz EQS 450 4MATIC	660
Mercedes-Benz EQS 500 4MATIC	645
Mercedes-Benz EQS 580 4MATIC	640
Audi A6 Sportback e-tron performance	600
Mercedes-Benz EQS AMG 53 4MATIC+	585
Audi A6 Sportback e-tron quattro	585
Lucid Air Touring	580
Porsche Taycan Plus	575
Tesla Model S Dual Motor	575
Porsche Taycan 4S Plus	565

Range in miles per one full charge

2023 Lucid Air

516 miles

2023 Tesla Model S

405 miles

2023 Hyundai Ioniq 6

361 miles

2023 Tesla Model 3

358 miles

2023 Mercedes-Benz EQS

350 miles

Make and model (2025)	Range (miles)
Acura ZDX	313
Audi S e-tron GT	300
Audi Q4 E-Tron SUV, Sportback	258
Audi Q8 e-tron	285
BMW i4 eDrive40	318
BMW i5 eDrive40	295
Tesla Model 3 Long Range RWD	363
Tesla Model S AWD	402
Tesla Model X AWD	329
Tesla Model Y Long Range RWD	337
Toyota bZ4X XLE FWD	252

Tyres and wheels can also have an impact on your EV's range.

Low-rolling resistance tyres and lightweight wheels can improve your vehicle's range by reducing the amount of energy needed to move the car.

How EV Wheel Sizes Impact the Range

Many new EVs come with tires designed to reduce friction and rolling resistance, such as the Sailun ERange EV tire. They feature a unique tread pattern, specialized rubber compounds, and other features that help maximize EV range while retaining pleasant driving dynamics, low sound levels, and superior durability.

Do EVs have a range extender?

Many new EV models have more impressive driving ranges than ever before. Extended range electric vehicles (EREVs) run primarily on electricity, but **they also include an auxiliary power unit (APU) called a "range extender."** ...

RANGE EXTENDER

A range extender is a small gas engine that generates electricity and extends the range of your battery.

REx

REx stands for Range Extended electric vehicles that use an electric motor as their main means of propulsion but also feature a small petrol engine to help generate electricity when the battery is depleted.

The GM Volt is an REV, a range-extended EV. The second-generation model has a range of 53 miles, with greater efficiency and stronger acceleration.

The total driving range is achieved using the on-board generator and is stated as 420 miles.

IN-WHEEL MOTOR

In-Wheel Motor Electric Vehicle

17 January 2021 | EV Motor Technology

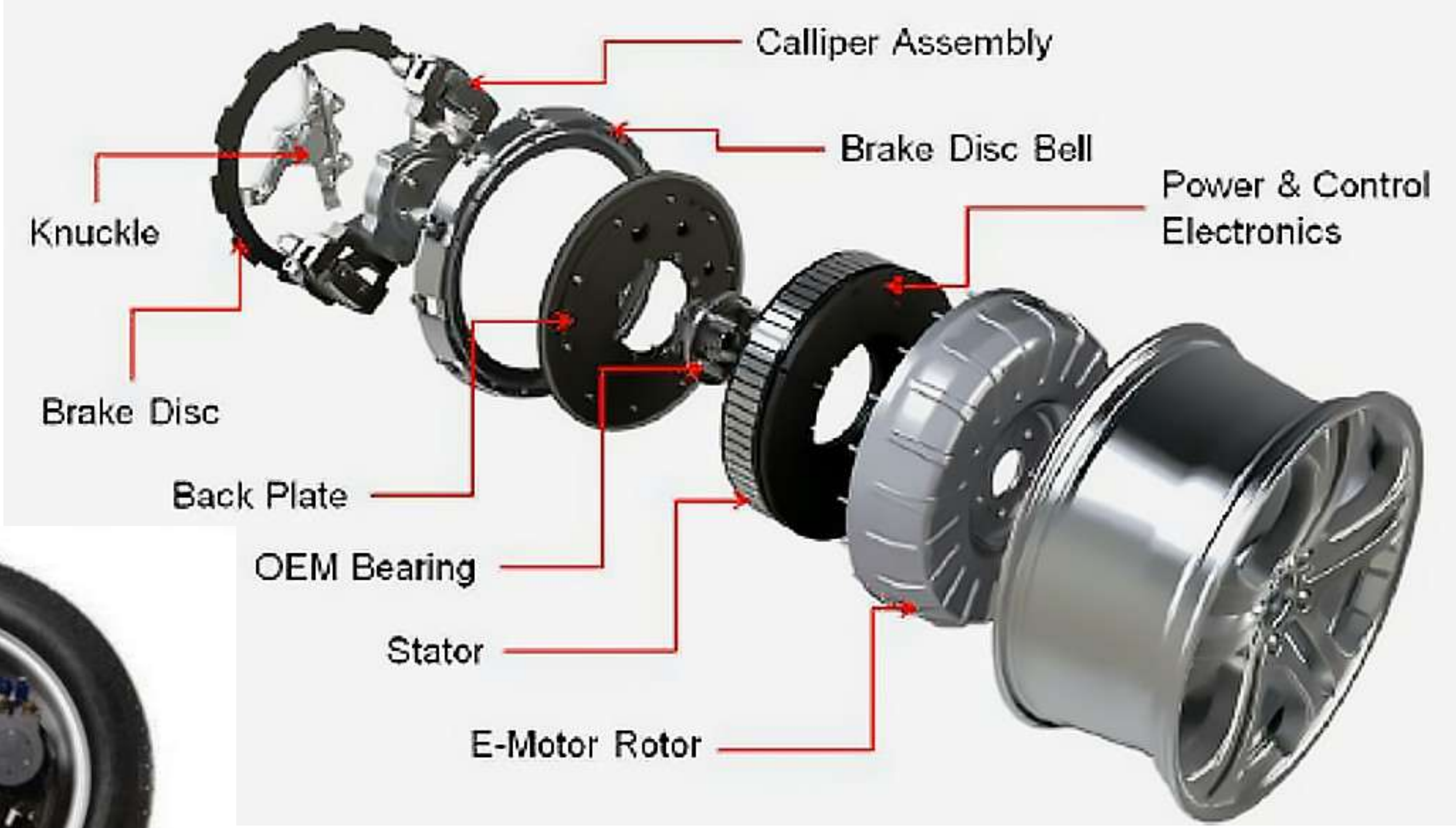
Electric-vehicle in-wheel motor systems replace the transmission, drive shaft, axles, and differentials normally used in a conventional vehicle.

In-Wheel Motor Electric Vehicle

In-Wheel Motor

New in-wheel motor systems modify the hub of each electric-vehicle (EV) wheel by adding a complete drivetrain that supplies torque to its associated tire.

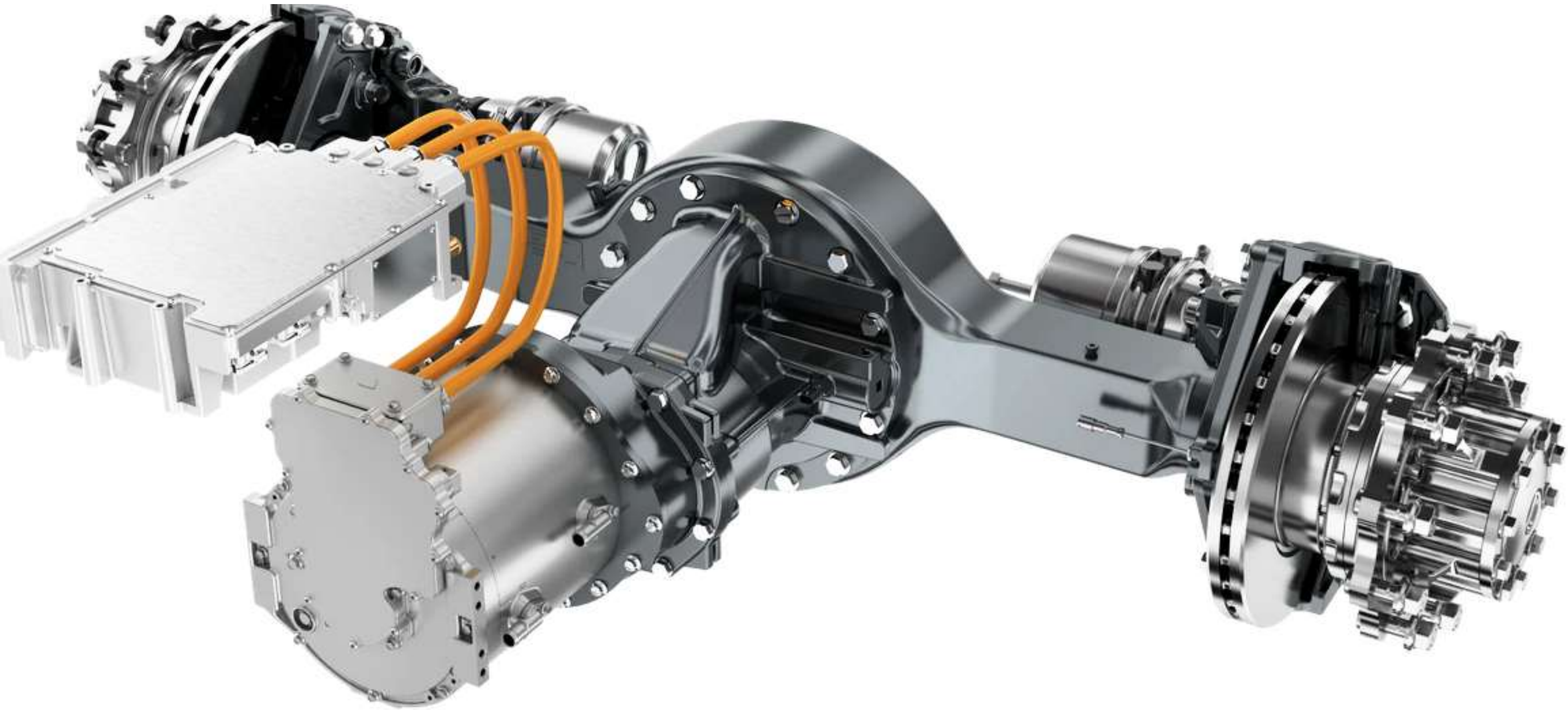
Also included with these in-wheel motor systems are braking components and the motor-drive electronics.

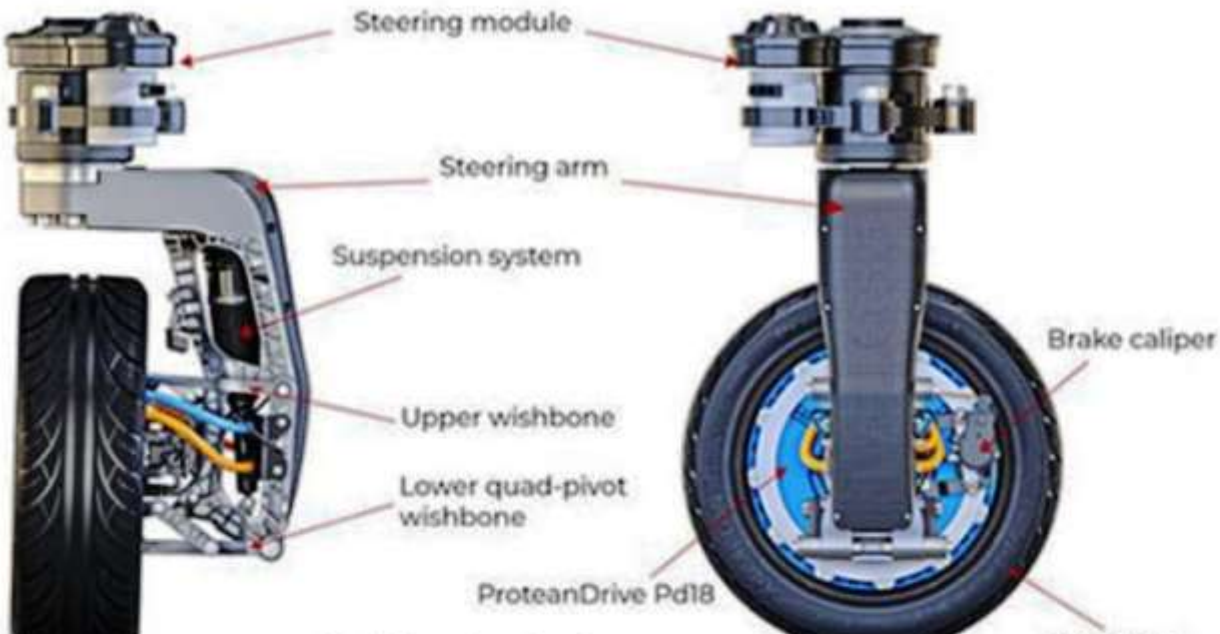


Michelin's Active Wheel system contains not only the electric motor that actually drives the wheel, but also the braking system and an active suspension system, too.

MICHELIN NORTH AMERICA, INC.

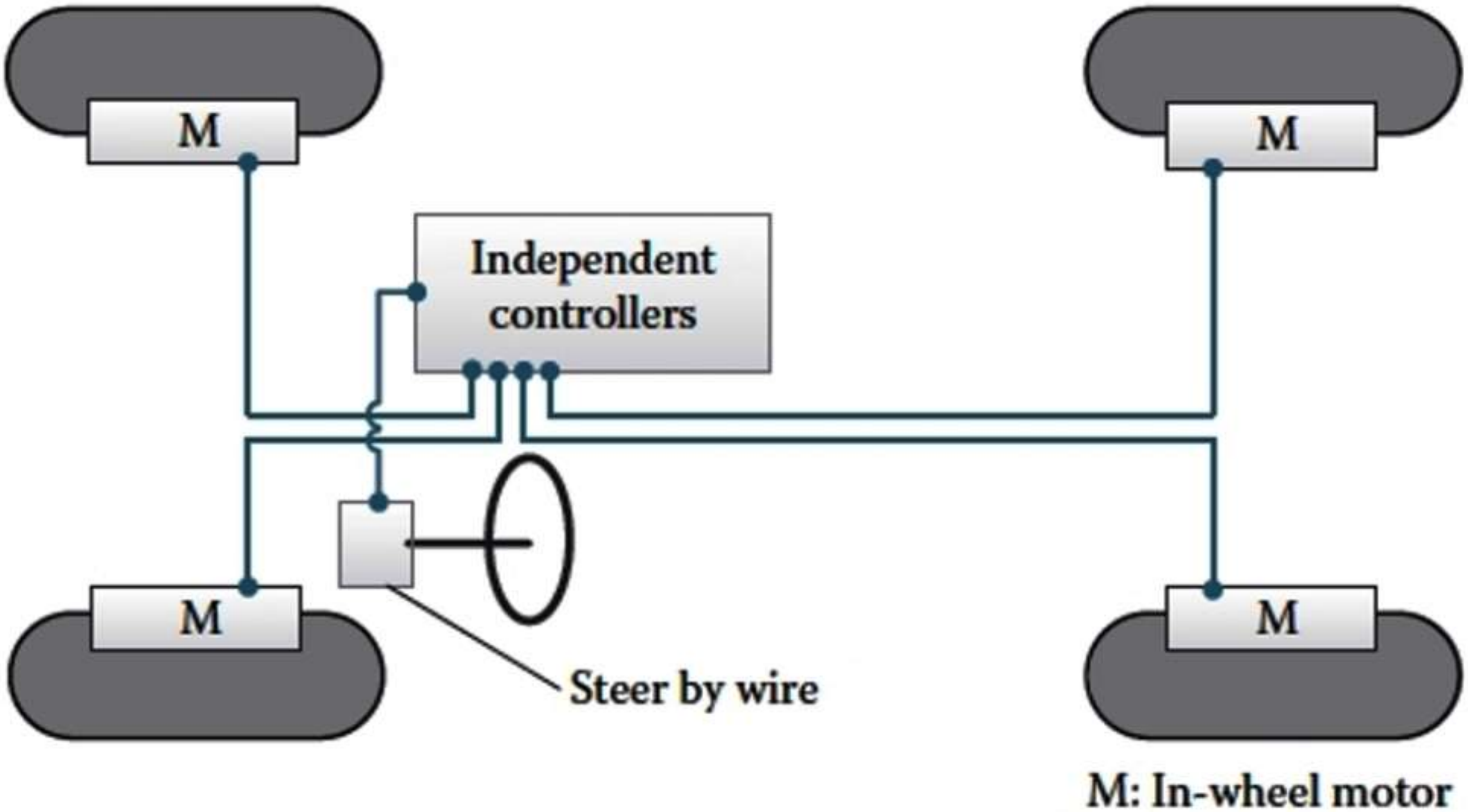

Brake Disk
Power
Electronics
Stator
Standard
Wheel & Tire
Rotor
Brake Caliper
Protective Cover
Capacitor Ring
Bearing





IN-Wheel MOTOR

In Wheel Motor Assembly



In-wheel motors in a four-wheel drivetrain.

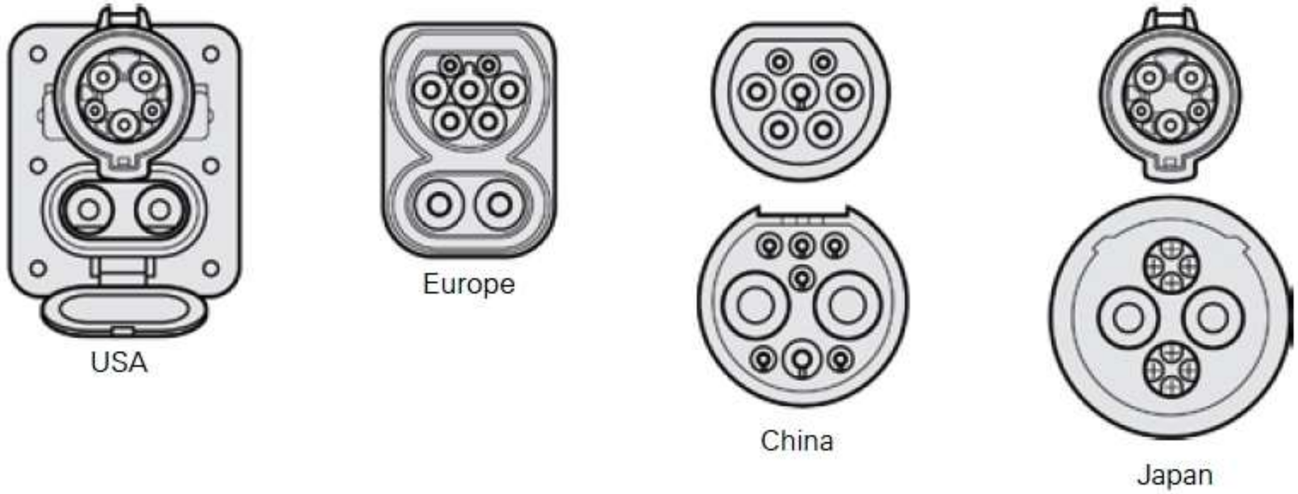
CHARGERS & CHARGINGS

EV Charging

Charging sockets on electric cars have evolved over time, but have recently started to become more uniform. Most plug-in cars now use Type 2 charger cables as standard, with one or two exceptions.

It's possible to charge an electric car using a household three-pin plug like a laptop or mobile phone, but it isn't the most efficient method.

Connector Types



Type 1 socket (Single-Phase)

This is a single-phase socket that allows a maximum charge speed of 7.4kW. They're predominantly found on older electric cars.

Type 2 socket (Common)

The Type 2 socket is the most common kind on new electric cars and on most home wallbox chargers too. Like the Type 1 socket, it allows a maximum, single-phase charging speed of 7.4kW, however it's also compatible with three-phase supplies – usually found in public places such as industrial estates – providing up to 22kW. Houses can be upgraded to three-phase, but this requires work from a qualified electrician, and is usually very expensive.

Commando socket (Rare)

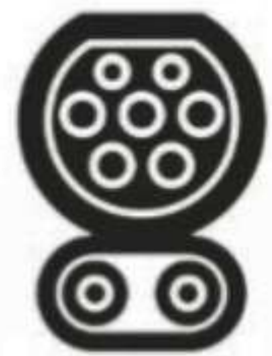
This style isn't very popular, as it was featured on cars such as the Ford Focus Electric and other lesser-selling electric vehicles. Some public charging stations feature this connector, but they are rare.

CCS socket **(DC Fast Charging)** **(Combined Charging System)**

This is a rapid DC charging connector, developed by a consortium of German and American car makers including VW, Audi, Porsche, General Motors, Ford, Mercedes-Benz and BMW. CCS stands for Combined Charging System, and it's the favourite among European manufacturers as well as some Asian makers such as Hyundai.

CHAdeMO sockets **(Japanese DC Fast Charging connector)**

While CCS is a rapid DC charging technology developed by German and American manufacturers, CHAdeMO is its Japanese counterpart. Developed by Nissan, Toyota, Mitsubishi and a host of electrical appliance firms, CHAdeMO is Japan's answer for rapid DC charging connectors. Again, cars have to feature a specific CHAdeMO socket to be able to use the connectors provided at public charging stations. The good news is that all rapid DC charging stations that supply CCS connectors also supply CHAdeMO connectors – capable of supplying power at around 50kW.

	REGION			
	Japon	**China**	**America**	**Europe**
for AC Charging				
Type	**Type 1 - J1772**	**GB/T**	**Type 1 - J1772**	**Type 2**
for DC Charging				
Plug name	**CHAdeMO**	**GB/T**	**CCS - Type 1**	**CCS - Type 2**

Type 1

THIS is a single-phase plug with a max charge of 7.4kW. It's found mostly on mainland Europe, but some UK cars have a Type 1 connector. Some home and public chargers use Type 1, too, but no public charging station only serves Type 1 cables: if you have a Type 2 cable, you should be able to charge anywhere.

Type 2

IN 2014, the European Commission ruled that all public charging stations must feature a Type 2 connector or connecting capability. This is why new electric vehicles and plug-in vehicles sold in the UK feature Type 2 sockets and often come with a Type 2 cable included. Most of the home chargers that you can buy today also feature a Type 2 connector.

Commando

THIS style isn't very popular, as it featured mainly on low-selling electric vehicles. Some public charging stations do feature this connector but they're rare.

CCS

CCS stands for Combined Charging System; this is a rapid DC charging connector, favoured by European makers. It's available only at public charging stations with a rapid DC charging capacity of 50kW. If you want to use one, your car must have a CCS socket.

CHAdeMO

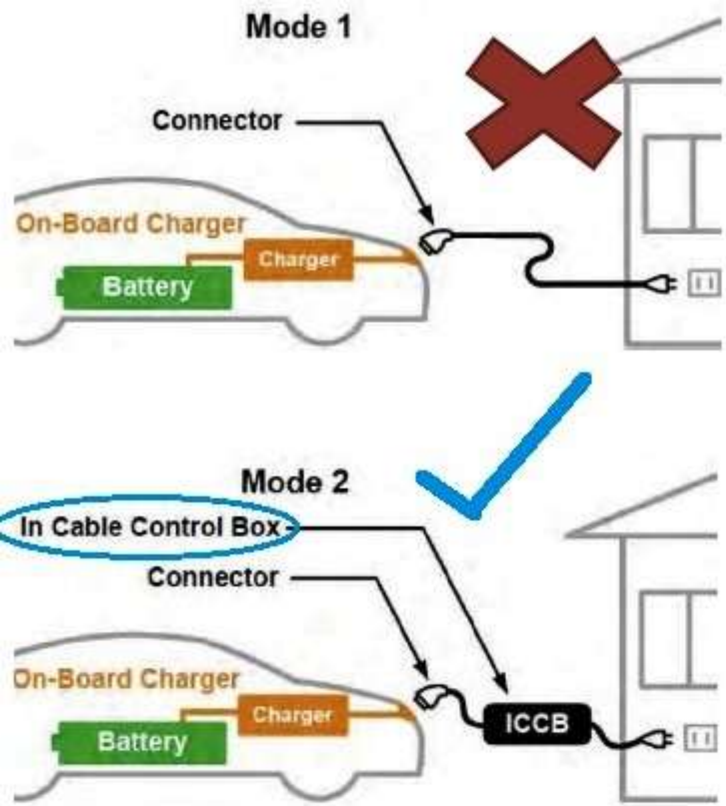
This is the Japanese counterpart of CCS (above). It also works on 50kW power and cars need a specific socket to use public chargers. But all stations with CCS also have CHAdeMO.

Slow chargers These have have a Type 1 (J1772) connector or a seven-pin Type 2 (Mennekes) connector.

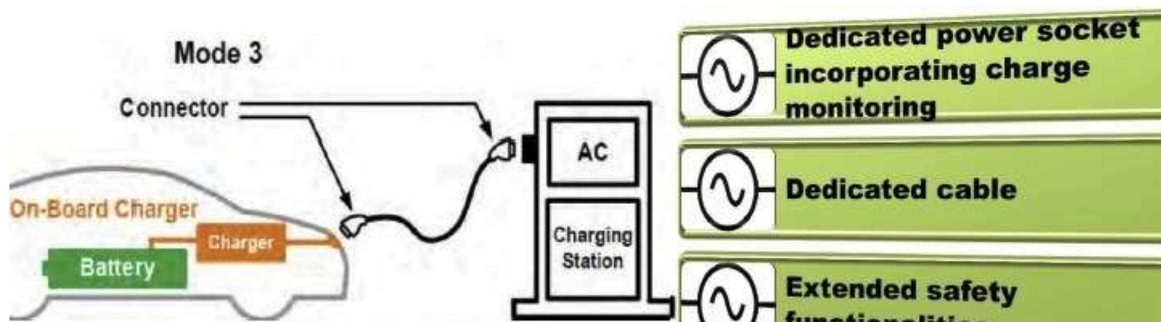
Fast chargers Almost all fast chargers have a Type 2 (Mennekes) connector, though some use a Type 1 (J1772).

Rapid chargers These come in two flavours: AC and DC. DC rapid chargers use a JEVS (CHADeMO) or a CCS (Combined Charging System) connector. Rapid AC chargers are rarer, and have only a Type 2 (Mennekes) connector.

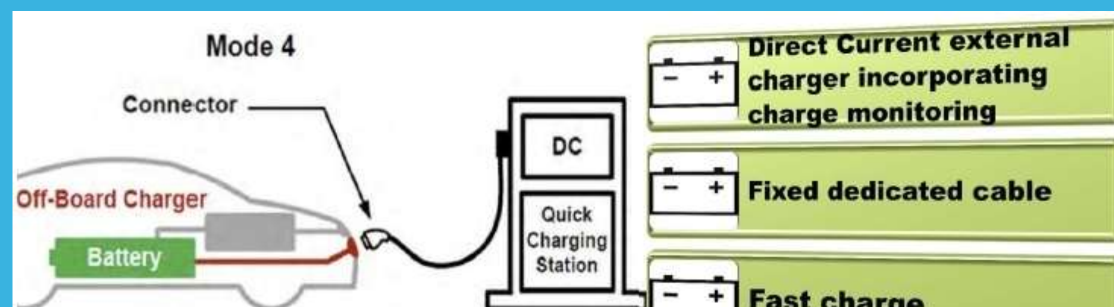
CHAdeMO connectors are of Japanese origin and are fit electric Nissans, Toyotas and Mitsubishis if they're capable of rapid charging. Volkswagen, BMW and Ford favour Type 1 (J1772) connectors and the related CCS system.



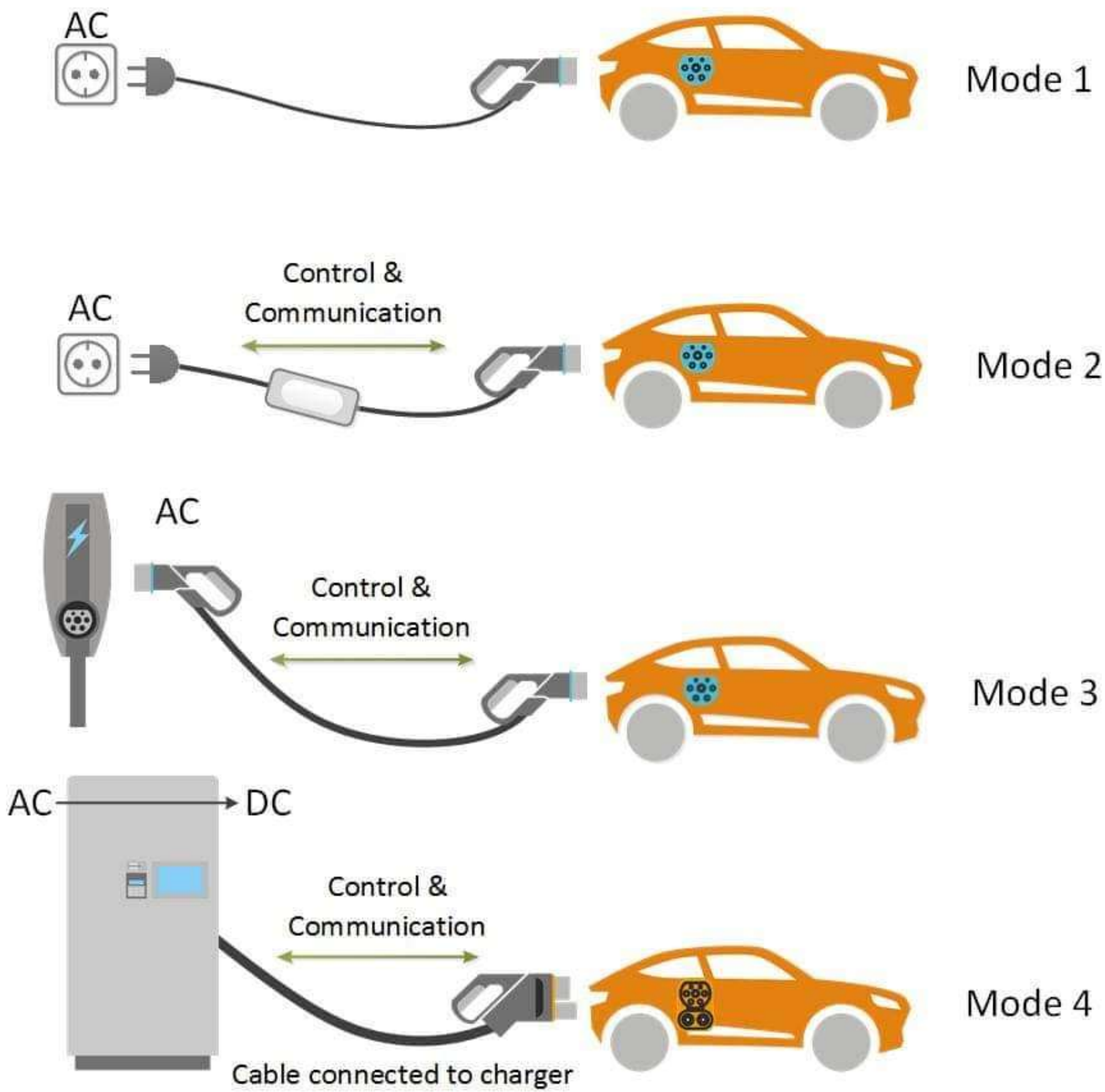
Home Charging



AC Charging Station



DC Charging Station


AC
Mode 1
AC
Control &
Communication
Mode 2
AC
Control &
Communication
Mode 3
AC
DC
Control &
Communication
Mode 4
Cable connected to charger

TYPE 2 cable &
EVSE control
အိမ်သုံး
မီးနဲ့ဆက်ရန်
ကားမှ OBC နှင့် ဆက်ရန်

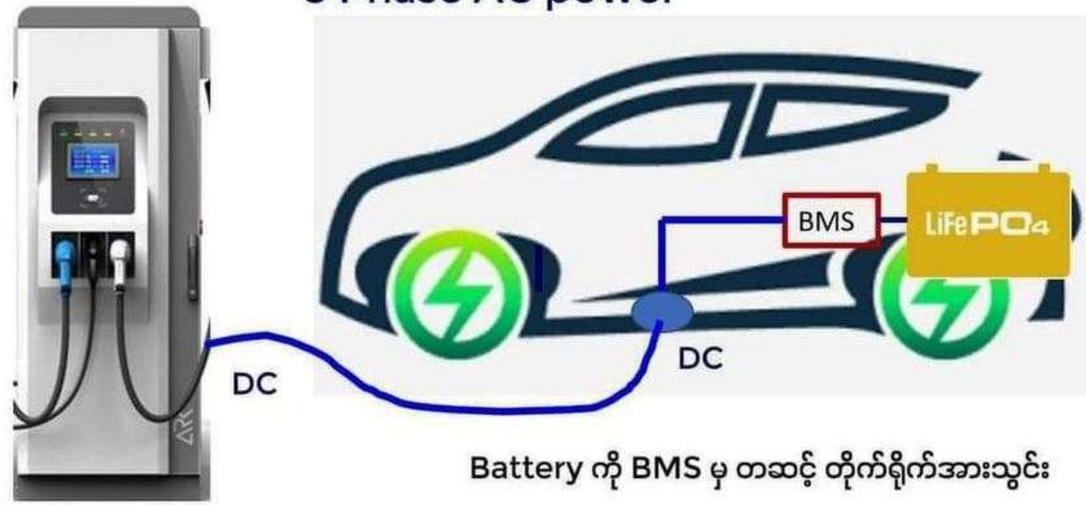
Type 2 EV Plug
Connect to electric vehicle
Fit with almost electric vehicle
Earth
Control
and
power
Control power and
comunication
Neutral
L1,L2,L3 (3 phases AC power)
PE
CP
PP
N
L1
L2
L3

Level 1 charger
အိမ်သုံးမီးနဲ့ တပ်ဆင် အသုံးပြု
အား အပြည့်သွင်းချိန် ကြာ 8 to 16 နာရီ

Level 2 charger
အိမ်သုံးမီးနဲ့ တပ်ဆင် အသုံးပြု ရ
အားအပြည့် သွင်းချိန် က 8 နာရီ အောက်

Level 3 charger station
ပါဝါကြီး တွေ နဲ့ တပ်ဆင် အသုံးပြု ရ
Public မှာတည်ဆောက်ထား
အားသွင်းချိန် ကြာ ၃၀ မိနစ် အောက်

Level 3 charger (သဘောတရား)
3 Phase AC power



Battery ကို BMS မှ တဆင့် တိုက်ရိုက်အားသွင်း

EVSE + RECTIFIER CHARGER

Table 1.3 Charging power levels (based on SAE Hybrid Committee [17])

Charging method	Voltage	Usage	Power (kW)	Charging time
Level one	110 V_{AC}	Home/public	1.4	12–18 h
Level two	220 V_{AC}	Home/public	3.3–6.6	4–8 h
DC levels 1–3 (fast-charging)	200–600 V_{DC}	Public	20–50	15–30 min

[1] We refer to level one and two charging as slow charging, and DC charging as fast charging.

Estimated charging times

Charging time for 100-km range	Power supply	Power	Voltage	Max. current
6–8 hours	Single phase	3.3 kW	230 V AC	16 A
3–4 hours	Single phase	7.4 kW	230 V AC	32 A
2–3 hours	Three phase	10 kW	400 V AC	16 A
1–2 hours	Three phase	22 kW	400 V AC	32 A
20–30 minutes	Three phase	43 kW	400 V AC	63 A
20–30 minutes	Direct current	50 kW	400–500 V DC	100–125 A
10 minutes	Direct current	120 kW	300–500 V DC	300–350 A

Charging a car's battery to 100% all the time is not good for the battery's life. The default setting in Tesla is to charge to 90% and stop. Elon Musk suggested in a Twitter post to charge to 80% instead.

Given the variety of electric cars and charging stations, it probably won't surprise you to learn that the time taken to charge an EV can vary too. The length of time an EV's batteries take to recharge is determined by how many kilowatts (kW) the charging station can provide and how many the car can accept – the higher the wattage, the faster the charge. Three different rates exist:

Slow charging. Rate: 3kW. If you charge your car from 'empty' (either at home or at a station), a full slow charge will take around eight hours. This charging rate is fine if you plan to top up overnight.

Fast charging. Rate: 7-22kW. A fast charging point will take around three to four hours to fully replenish an electric car's batteries from zero charge. The majority of public charging stations offer this rate, and you can also have a fast charge box installed at home.

Rapid charging. Rate: 43-50kW. Only a few electric cars are compatible with rapid charging, but if you own a car such as the Tesla Model S or **Kia Soul EV**, a rapid charger will give you an 80% charge in as little as 30 minutes. Public charging points that offer rapid charging aren't as common as fast chargers (Zap-Map puts their numbers at just around 5,000), but Tesla has its own proprietary network for use exclusively with its cars.

Remember that not all cars can accept fast charging. The entry-level **Nissan Leaf**, for example, can accept a maximum charge rate of 3.7kW. This means it'll take around eight hours to fully charge. Go for Nissan's 6.6kW option and that time halves.

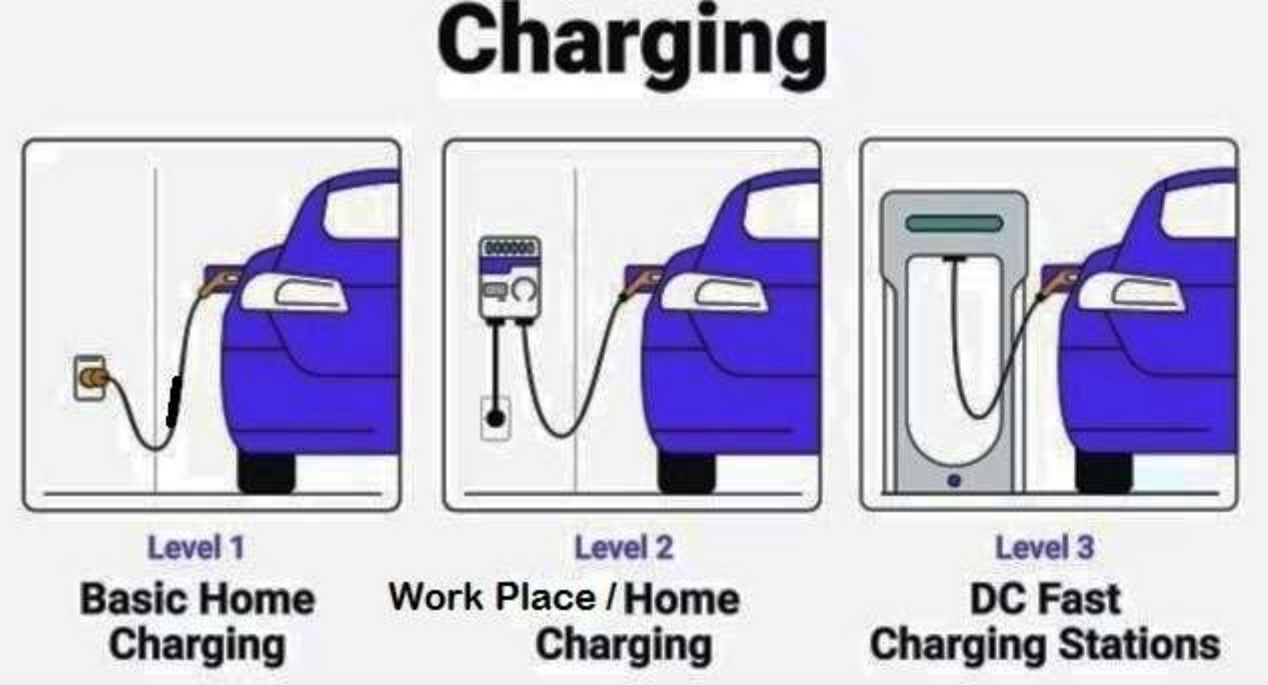
7.1.4 Standardization

So that electric vehicles can be charged everywhere with no connection problems, it was necessary to standardize charging cables, sockets and methods. The IEC publishes the standards that are valid worldwide, in which the technical requirements have been defined. Table 7.2 below lists some of the most important standards associated with the charging of EVs:

Types of charging cables: IEC 61851-1 defines the different variants of the connection configuration:

Table 7.2 Charging standards

IEC 62196-1	IEC 62196-2	IEC 62196-3	IEC 61851-1	IEC 61851-21-1	IEC 61851-21-2	HD 60364-7-722
Plugs, socket-outlets, vehicle connectors and vehicle inlets. Conductive charging of electric vehicles	Dimensional compatibility and interchangeability requirements for AC pin and contact tube accessories. The permissible plug and socket types are described	Dimensional compatibility and interchangeability requirements for dedicated DC and combined AC/DC pin and contact-tube vehicle couplers	Electric vehicle conductive charging system. Different variants of the connection configuration, as well as the basic communication with the vehicle, are defined in this standard	Electric vehicle conductive charging systems. Electric vehicle on-board charger EMC requirements for conductive connection to an AC/DC supply	Electric vehicle conductive charging systems EMC requirements for off-board electric vehicle charging systems	Low-voltage electrical installations. Requirements for special installations supply of electric vehicles

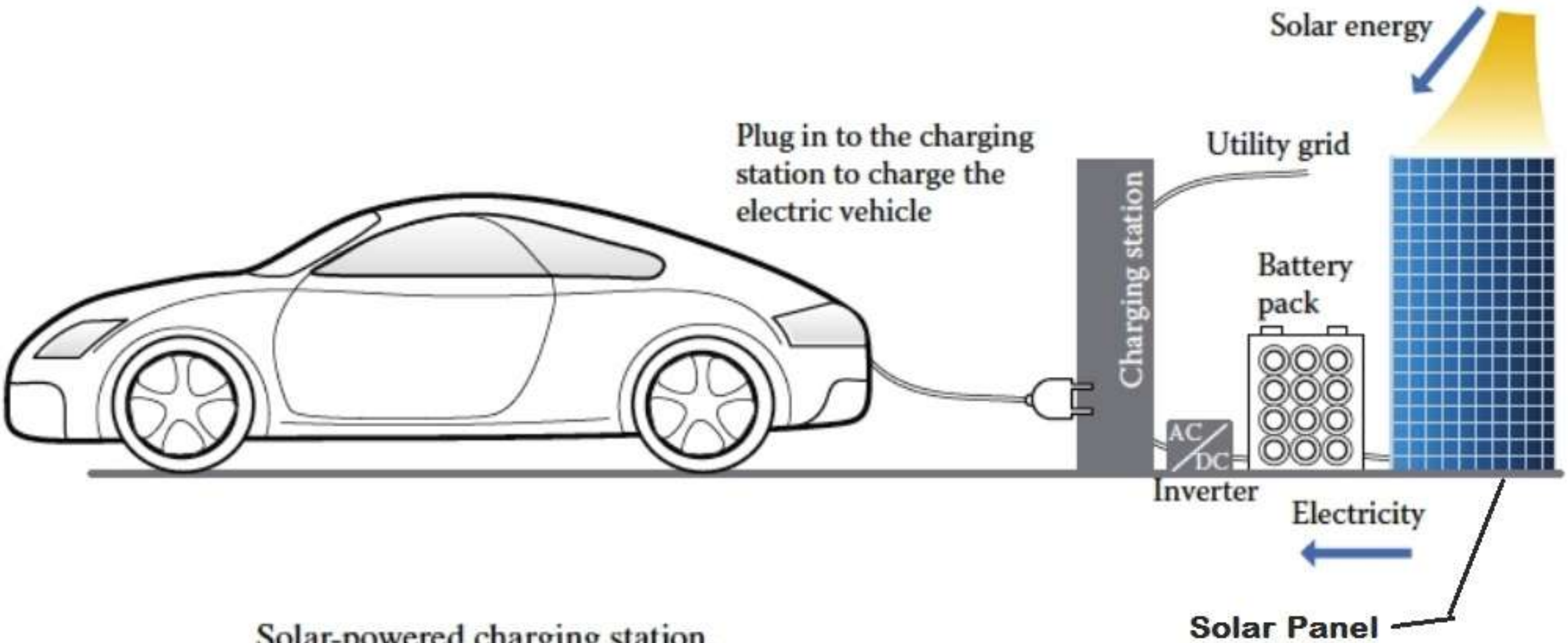


HOME CHARGING

Today, by far the majority of electric-car miles come from batteries charged either at home or at work. There are two kinds of home charging. The first, called Level 1, uses a standard 120-volt wall outlet; the second, called Level 2, employs a more powerful 240-volt circuit .


SOLAR CHARGING
BATTERY SWAP
DYNAMIC CHARGING
CHARGING LANE
WIRELESS CHARGING
AC CHARGING
DC CHARGING

EV charging system – Standards in Thailand



Solar-powered charging station.


PER ENVISION EV ARCH 2020
(Solar Charge)
ENVISION

A DIESEL GENERATOR FOR AN ELECTRIC CAR CHARGING POINT.

Electric car Charging On Diesel generator

Can you charge an EV with a portable battery pack?

Yes. There are several companies which offer this, including SparkCharge (I have no affiliation with the company.. and not an endorsement!):

Electric Vehicle Mobile Charging | SparkCharge

SparkCharge is a company dedicated to making EV ownership easy ...

https://www.sparkcharge.io/

AAA has a service for electric cars just as they have for gasoline or diesel cars:

The oil giant already operates a network of nearly 8,000 EV charging points. **6 Jan 2022**

INSIDEEVS.COM

Shell Converts Gas Station Into EV Charging Hub

European oil companies are getting into the EV charging business. ...

Here is the Tesla supercharger the fastest and easiest to use on road trips. There is no screen, no buttons, no card to swipe, no app to use to activate Just plug in and walk away to grab a snack or use the restroom. It talks to the car and they will bill you later.

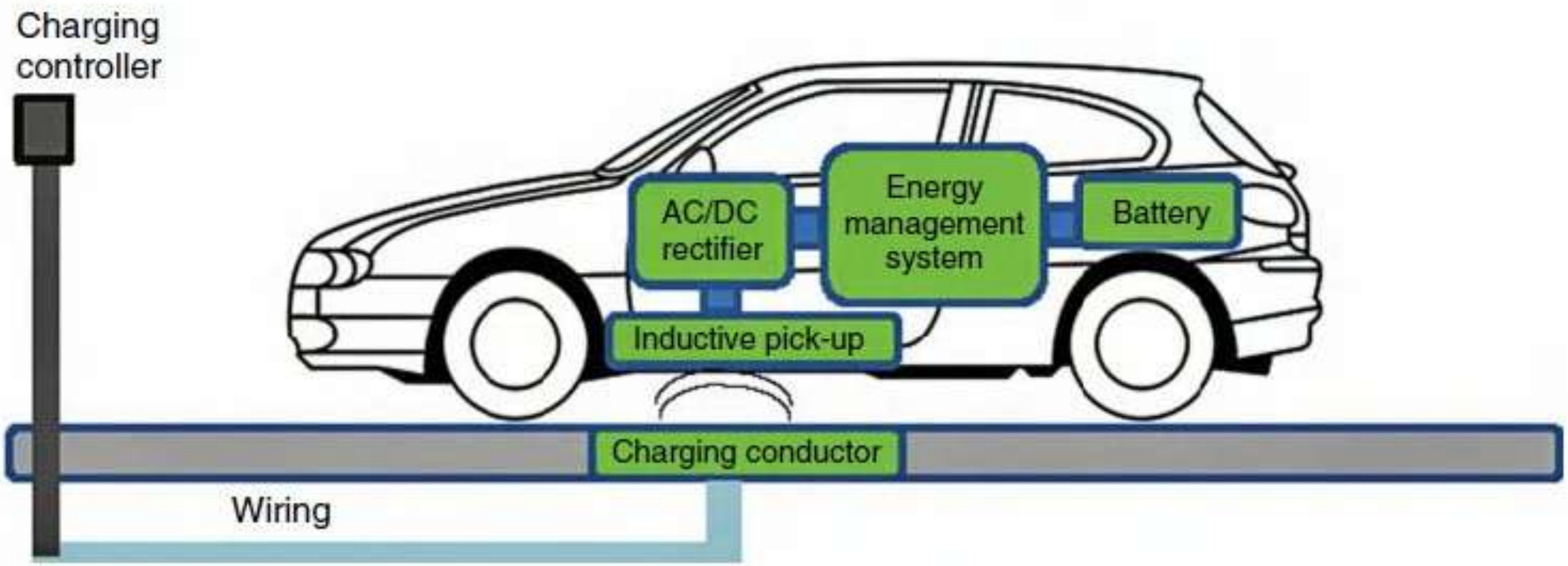


Figure 1.15 Illustration of the inductive charging technology.

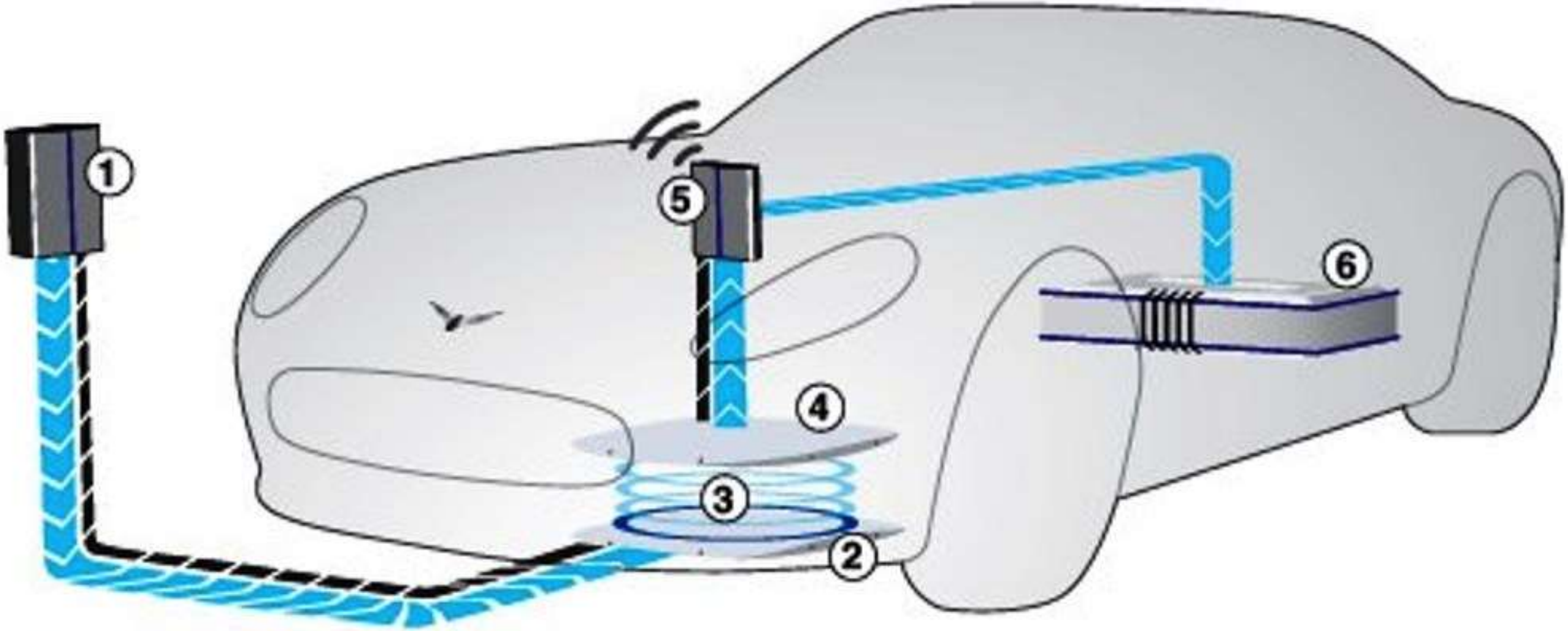
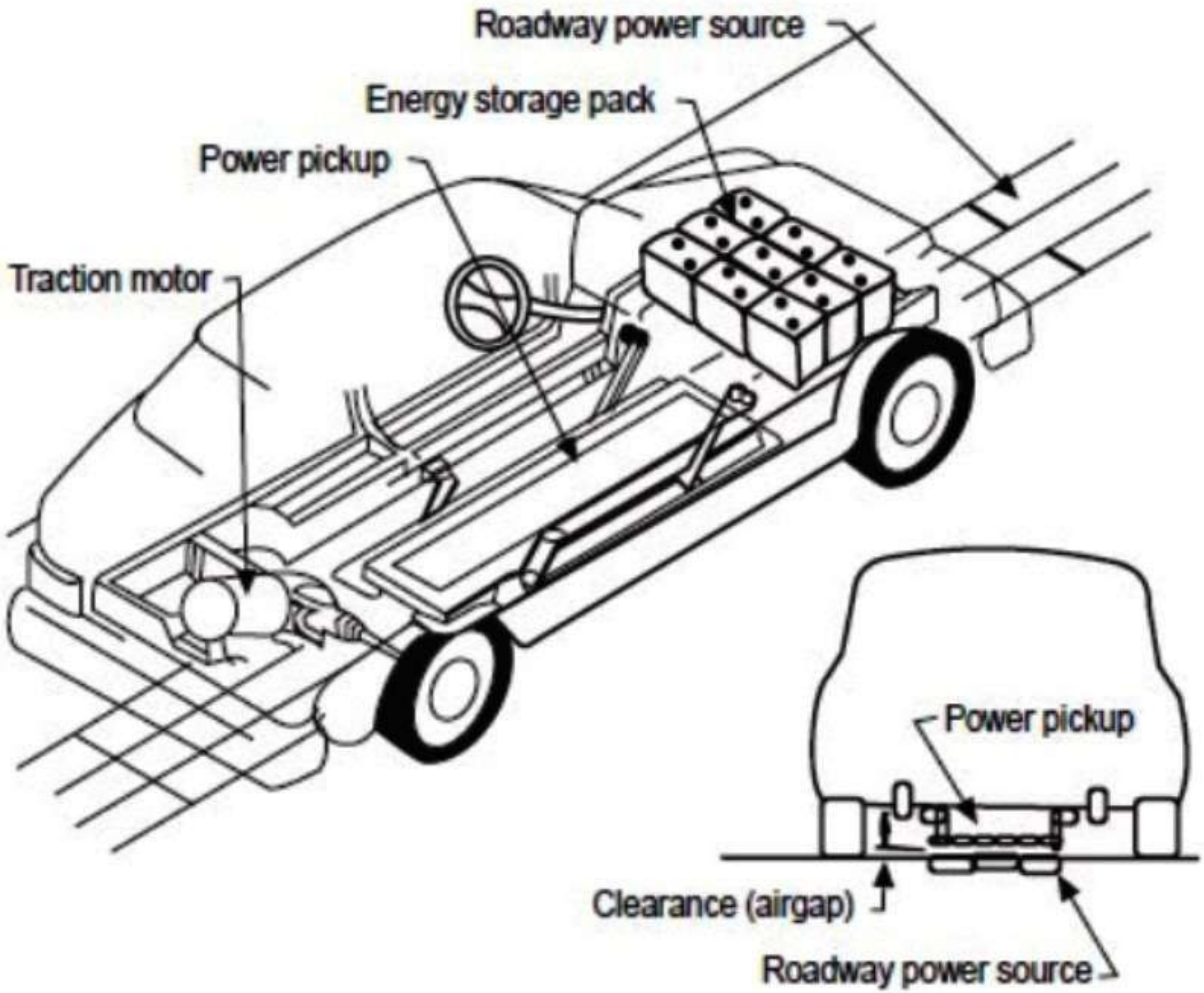


Figure 7.19 An inductive wireless charging system for statically charging an EV: 1, power supply; 2, transmitter pad; 3, wireless electricity and data transfer; 4, receiver pad; 5, system controller; 6, battery (Source: haloIPT)



ROAD INDUCED ELECTRICITY

For more information visit https://www.qualcomm.com/products/halo

7.2.3 Dynamic WPT

It seems illogical in many ways but the prospect of wirelessly charging an EV as it drives along a road is already possible and being trialled in a number of countries. The principle is fundamentally the same as static wireless charging but even more complex.

A number of feasibility studies and trials are ongoing (2015) and it is expected that this system will be available in the near future. The following image shows the principle of dynamic WPT.

Driver assistance systems may play a role in combination with wireless charging. With stationary wireless charging, a system could be developed where the vehicle is parked automatically and at the same time primary and secondary coils are brought into

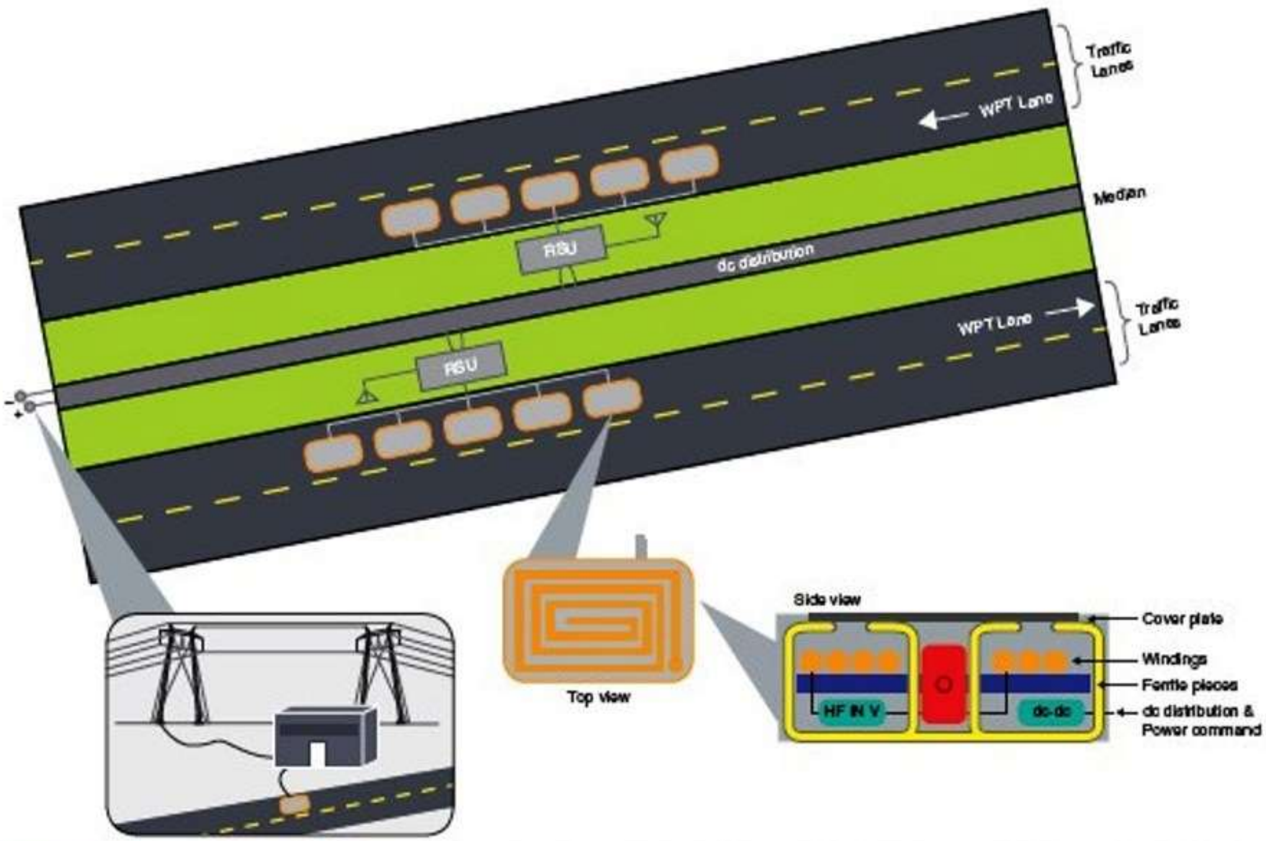
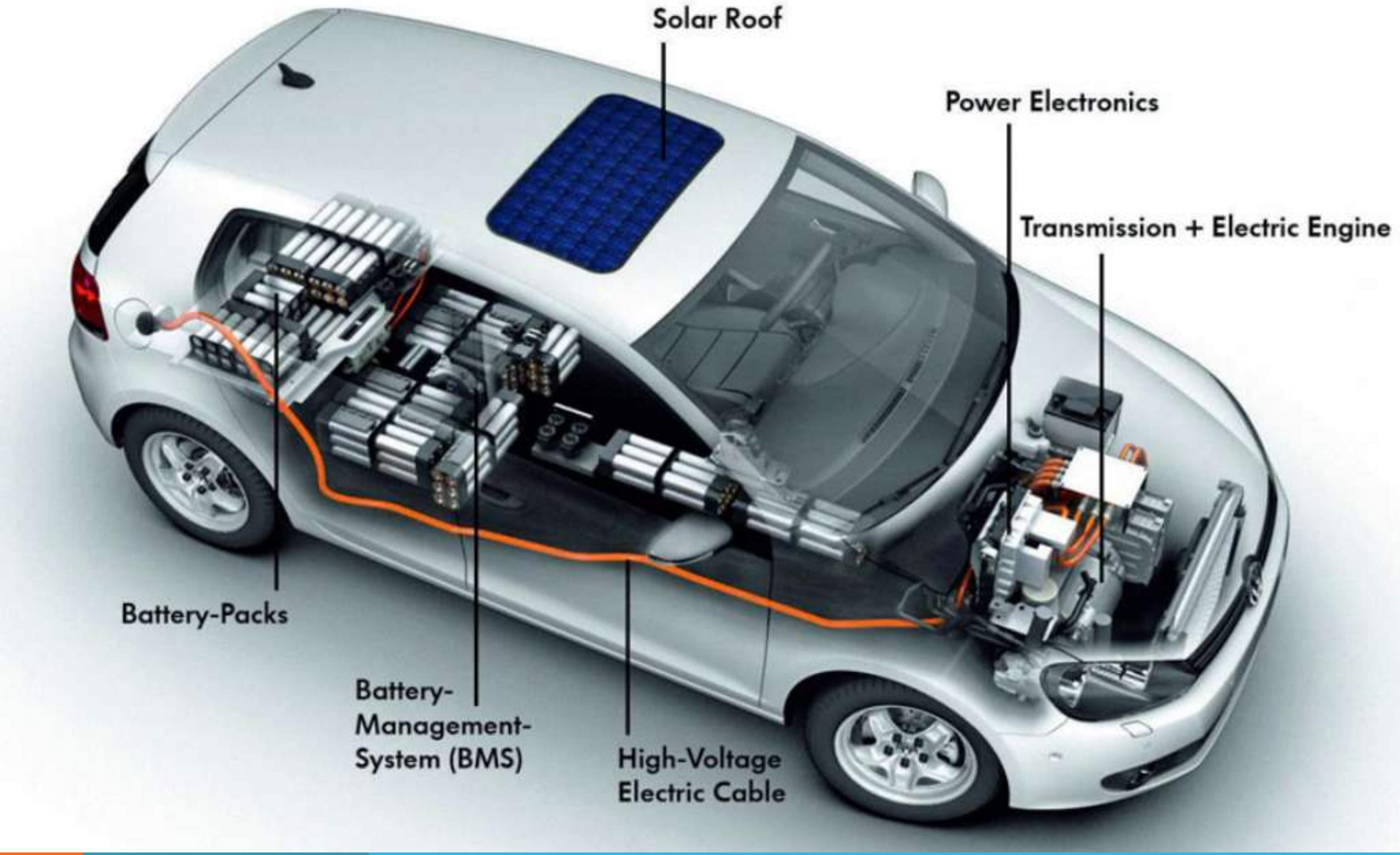


Figure 7.22 Principle of dynamic wireless charging – RSU is a road side unit (Source: Oakridge National Lab)

Can you charge a Nissan Leaf with solar panels?

Early versions of the Nissan Leaf (24 kWh batteries) offered an optional solar panel on the "spoiler." This was (obviously) not suitable to charge the car, but it might run minimum accessories while the car is in the parking lot, and it would keep the 12-volt battery topped-off without drawing from the small traction battery. When you only have 24 kWh, every little bit helps.


Solar Roof
Power Electronics
Transmission + Electric Engine
Battery-Packs
Battery-
Management-
System (BMS)
High-Voltage
Electric Cable

A solar-powered electric car that runs without needing charging may sound impossible, but Toyota, Sharp, and NEDO (New Energy and Industrial Technology Development Organization of Japan) have joined forces to hopefully make it a reality.

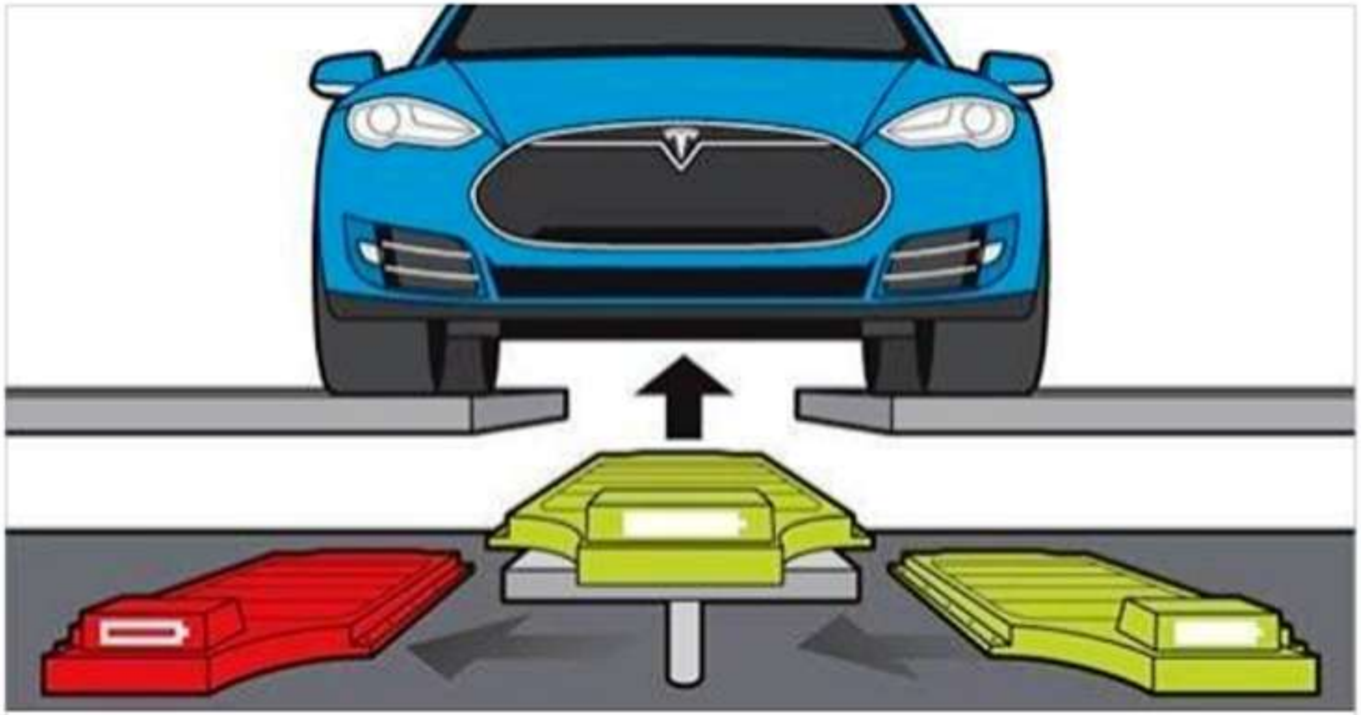
By pairing together the best solar panels on the market with the most efficient batteries available — not to mention years worth of experience with car-manufacturing — the companies are hoping, theoretically, to produce a vehicle that might run forever.

"The solar car's advantage is that, while it can't drive for a long range, it's really independent of charging facilities," said project manager at Toyota, Koji Makino to Bloomberg.

Car and Driver

More from THE FUTURE file: Tesla Motors owners soon will be able to swap out their empty battery packs for fully charged ones in a couple of minutes. (2014 concept)

http://cardrive.co/battery-swap



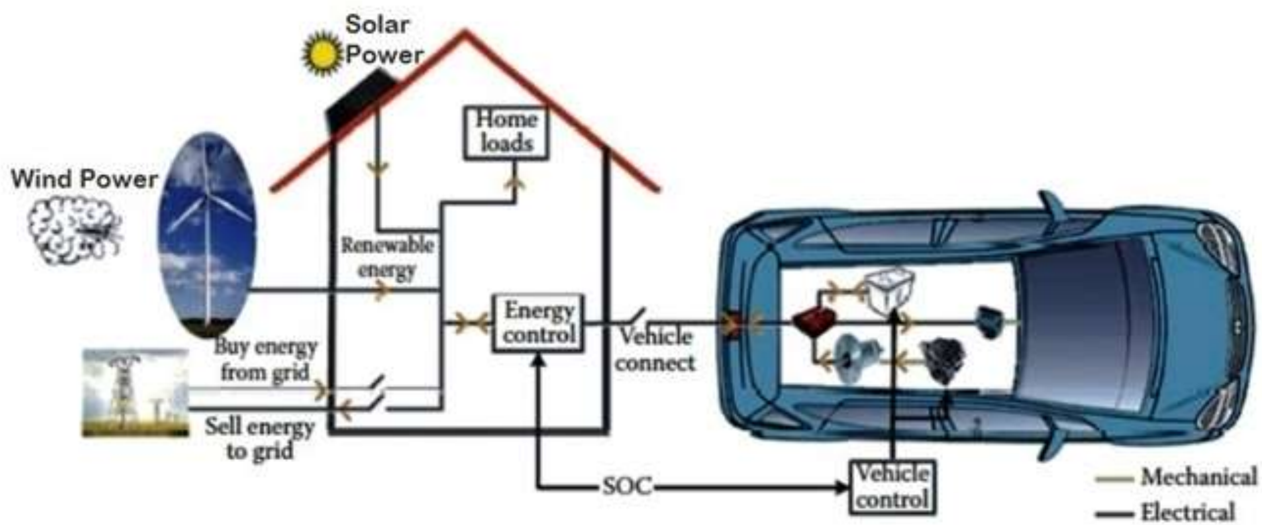
Tesla Launching Battery-Swap Pilot Program

Tesla's long-promised battery-swap technology, making charging up as quick as filling your gas tank, is finally here.

BLOG.CARANDDRIVER.COM

VEHICLE-TO-GRID: TEST CASE (Reverse - to power home loads from BHEV)

The EV/PHEV battery does not completely solve the problem during peak production. However, it can be used as an external storage system, which can help the AC grid to supply the home and decrease peak production. As most renewable energy sources are intermittent, ESSs as well as advanced controls will have to be well developed. EV/PHEV batteries can have an important role to play in such an infrastructure as a storage system as well as an energy producer. A typical house powered from an AC grid, renewable wind energy, and PV, connected to a plug-in PHEV is as shown in Figure 16.20. This is the concept of net-zero energy consumption power system.



What can shorten the life of an electric car battery faster?

Without doubt there are two things you can do to wreck your EV's battery:

- Charging the battery to 100% and leaving it like that for a long time.
- Draining the battery to 0% on a regular basis.

An EV battery should last over **10 years and 400-800 full recharges**.

800V Batteries

Consider voltages. We look to performance electric vehicles, land, water and air, for the future. One clear message is voltages are rising, giving lighter-weight, smaller motors and interconnects, greater efficiency, less heat, faster charging. Pure electric vehicles going to 800 volts include Fisker's Emotion launching in 2019, the planned Chevrolet Camaro race car, Porsche Taycan coming to market, the Audi supercar prototype and Aston Martin Rapide E GT-supersaloon. An 800V Genovation Corvette achieves top speed over 200mph.

They have to be charged of course but Ricardo works with Fisker on a proprietary 800V charger, 800V battery pack and e-axle powertrain. Wild card is a solid state battery to be launched at an undefined date that will be more suitable for high voltages and fastest charging without fire risk. Meanwhile, a range of 200 km is promised within 9 minutes of charging. Dräxlmaier is starting series production of the 800V battery system for the Porsche Taycan. Porsche has even begun installing 800V electric charging stations at dealerships evidence of Volkswagen Group applying formidable talent and money to leapfrog Tesla. Back in 2016, Porsche developed an 800V charging system (as well as wireless charging) for the Mission E concept. If this system goes into production, VW is likely to use it in other EVs.

HIGH VOLTAGE Built-In Safety Measures in EVs

High Voltage Cables consist of the following main components: **(coloured in orange)**

- **Conductive core:** Typically made of copper or aluminum. Copper offers higher conductivity but is heavier, while aluminum is lighter but has lower conductivity. The conductive core is responsible for conducting electricity.
- **Insulation layer:** Usually made of XLPE (Cross-linked polyethylene) or other insulating materials. This layer prevents electrical leakage, protecting the user and other electrical components.
- **Protective layer:** Made of materials such as PVC, TPE, or rubber. The protective layer shields the cable from mechanical, chemical, and environmental impacts.

International and national standards, such as ISO and IEC, strictly regulate the quality, durability, and safety of HV cables. Requirements for resistance, heat resistance, moisture resistance, oil resistance, etc., must be met to ensure the cable's stable operation in the harsh working conditions of electric vehicles.

Electric vehicle orange cabling indicates high voltage wiring & components operating at 400V+ All electric vehicles run high voltage (HV) wiring through orange conduit to connect HV components within the drive system.

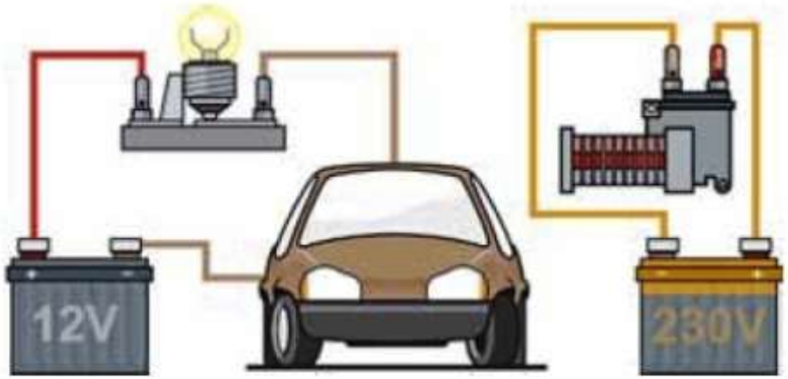
Electric vehicle orange cabling indicates high voltage wiring & components operating at 400V+

Charging cables --- by design, modern EVs and their charging equipment are just incredibly protective of their high-voltage battery connections, and so electrocutions are exceedingly rare.

The Electrical Isolation of the High-Voltage System and 12 V Onboard Supply

Purpose

The isolation of the high-voltage system and 12 V onboard supply is designed to prevent unintentional short-circuits with the vehicle ground. This isolation of the high-voltage system from the body ground is also called electrical isolation.



12 V Onboard Supply High-Voltage System

s499_242

How it Works

To achieve this isolation, the high-voltage system has its own equipotential bonding. The high-voltage system and the 12 V onboard supply are electrically isolated from each other so that there can be no accidental short-circuit and a flow of current to the body ground.

While the circuit in the 12 V onboard supply normally runs via the vehicle ground, all high-voltage components have two wires that form the electrical circuit. There is no connection to the body ground.

In case of accidents or careless services

1. By established standards, all electric cars completely isolate the high voltage inside the sturdy battery case when the car is turned off or, instantaneously in a any crash sufficiently severe to trigger the airbags or seat belt tensioners.

2. Electric cars are powered by DC power from a bunch of little 3.5 to 4 volt cells connected in series (i.e in a long string, positive-to-negative). To get a shock from such a source, a person has to close a circuit with their body (not just a limb) between a positive pole of a cell in the battery string and the negative pole of a cell sufficiently down the string to produce a high voltage. Someone almost has to engage in a deliberate effort to get electrocuted in this way.

3. Positive and negative poles of the battery pack are routed to the motor controller, heater and A/C via cables with a distinct orange color per EV safety standards. When the car is turned on, these cables are energized. But once again, you have go out of your way to grab a bare positive wire in one hand, and a bare negative wire in the other hand, to get electrocuted. This also requires deliberate effort.

High-Voltage Safety

Safety During External Charging

If the vehicle has a charging contact for external charging, protective relays are located in the charging circuit of the high-voltage system. They only connect the high-voltage battery to the charging contacts if the system detects that the charging contact has been connected and a voltage is present. The charging procedure can be performed safely in rain or if the contacts have been exposed to moisture.

Monitoring the Insulation Resistance

The battery regulation control module transmits a test voltage while the high-voltage vehicle is in use. The test voltage is 500V and has a low current which is not dangerous for humans.

If all high-voltage components and wires are correctly insulated and shielded, the control module calculates and compares the previously set total resistance of the high-voltage system.

If the insulation of a wire is damaged externally, for example, by a vermin bite, the insulation resistance changes. The control module detects an insulation fault due to this change in resistance.

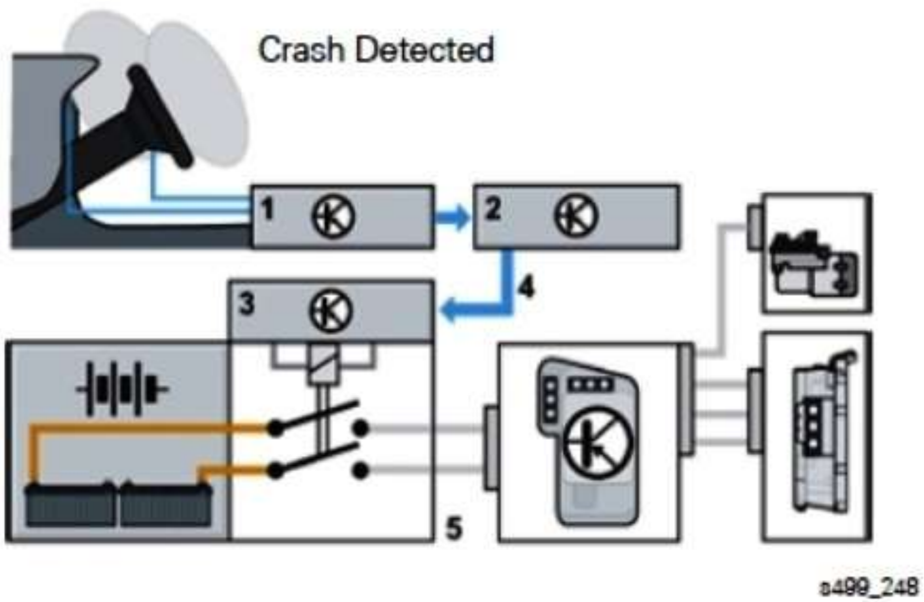
Depending on the severity of the fault, various messages can appear in the vehicle instrument cluster.

s499_277

Crash Safety

Purpose

Deactivation of the high-voltage system and the de-energization of the high-voltage system is important for occupant protection in accidents, the safety of rescue personnel and safety of accident vehicles that have been brought in for repair. As a result, the high-voltage safety is linked to the crash detection system via the airbag control module.



1. Airbag control module
2. Data bus diagnostic interface
3. Control unit for battery regulation
4. CAN message
5. High-voltage system

How it Works

As soon as the airbag control module detects an accident and deploys the belt tensioner or airbags, the battery regulation control module is instructed via the CAN data bus to open the protective relays.

If just the belt tensioners are deployed (single-stage crash deployment), it is possible to close the contactor by turning the ignition on and off again. The belt tensioners and airbags are deployed in the second crash stage. The contactors can then be closed again only with the VAS tester.

DO'S & DON'TS

1 USE ——

Safety First
For EVs, DC voltages between 60 V and 1500 V are referred to as 'high voltage'.

Personal protective equipment (PPE)

In addition to the normal automotive-related PPE, the following are also recommended for work on high-voltage systems:

- overalls with non-conductive fasteners
- electrical protection gloves
- protective footwear; rubberized soles; non-metallic protective toe caps
- goggles (when necessary).

Safety First
Electrical safety gloves are NOT the same as general working gloves.

Insulated gloves

The following pictures show the location of high-voltage components and wires (orange) together with some warning stickers:

Orange high-voltage cables

Danger sticker

2 DO NOT ——

The high voltage components are bright orange. DO NOT TOUCH ANY BRIGHT ORANGE WIRING OR COMPONENT WITHOUT FOLLOWING THE VEHICLE MANUFACTURER'S PROCEDURE AND WEARING THE PROPER PROTECTIVE GEAR.

3 USE ---- *When lifting an EV use JACKING POINTS*

4 DO NOT TOW----

DO NOT TOW ELECTRIC VEHICLES

The wheels are always connected to the motor, unlike in a gas car, where an engine can completely disconnect from the wheels. So when you try to move the EV, even if its in neutral, the motors will induce a current and that will damage the electronics and possibly fry the motor by getting extremely hot. This is why you always want a flat bed or something like this:

5 DO ----

CAUTION

In handling EV Motors, make sure you disconnect the high-voltage system before beginning any work. Also, if the electric motor is sandwiched between the engine and transmission **(for Hybrids)** make sure you follow all procedures. The permanent magnet used in the motor is very strong and requires special tools to remove and install it.

ELOTROCUTIONS

Will people get electrocuted inside their electric vehicle if their running car pass a quite high flood?

No. Electric motors are actually quite resistant against water. The elegance of AC motors is that the wired part (stator) does not move at all. Its only job is producing a rotating magnetic field. So we can just seal off the stator windings completely. The moving parts (rotors made of permanent magnets, squirrel cages or soft magnets) OTOH are not connected to any power sources, but pulled forward by the rotating magnetic field. Because there is no direct connection between the stator and rotor, even water infiltration won't result in short circuit or electrocution.

EVs have a lot of waterproofing and corrosion resistance to prevent against damage to the car during rainstorms and small floods.

According to the US National Highway Transportation Safety Administration (NHTSA), an estimated **42,915 people died in motor vehicle traffic crashes in 2021. Of these, 0 were electrocutions from an electric vehicle (EV) traction battery.** This is largely because the power circuits are cut when an accident is detected, and the chances of a still-functioning internal battery circuit being exposed and connected across a surviving human body is exceedingly small. (The battery may catch fire, though with much less frequency and with a much slower rate of spread than with gasoline vehicle fires, and when a lithium-ion battery catches fire it's more difficult to extinguish than a gasoline fire. But that's not *electrocution*, which is the topic of this question.)

FUTURE

1 — Hydrogen fueled IC engine vehicles

2 — Hydrogen Fuel-Cell vehicles

3 — New SOLID-STATE High Voltage Battery

Toyota Says Its EV Batteries Will Soon Give 1,200-KM Range From Only 10 Minutes Of Charging

4 — NEW TATA EVISION ELECTRIC CAR NO FUEL REQUIRED. ONLY ONE CHARGE IT CAN RUN 1000 KMS. 10 YRS BATTERY WARRANTY FROM TATA

5 — This Car Is Powered By Salt Water: 760HP, Top Speed 186 MPH, 621 Miles/Tank

QUANT

6 — NEW SOLAR PAINT BY MERCEDES COULD BOOST ELECTRIC VEHICLE RANGE BY 7,456 MILES

6 —

7 —

This Mysterious Thorium Car Can Run Continuously For 100 Years With Just 8 Grams of Fuel

THANK YOU