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Eure!TechFLASH

THE UP-TO-DATE TECHNICAL INSIGHT IN AUTOMOTIVE TECHNOLOGY & INNOVATIONS

EDITION 10

ELECTRICAL VEHICLE

IN THIS ISSUE

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INTRODUCTION

There have been a number of technological advances in the automotive sector over the years, but there is no doubt that the introduction of the electric vehicle was one of the most significant.

The first generations of electric vehicles date back to 1839, with Robert Anderson the manufacturer. Electrical energy was stored in non-rechargeable batteries. With the invention of rechargeable batteries in 1880, electrical vehicles began to be mass produced before combustion vehicles.

In 1899 the speed record was broken by an electric vehicle called “La Jamais Contente” (English: “The Never Satisfied”), which reached the speed of 105 km/h thanks to the NiFe batteries of Thomas Edison. At the peak, 90 % of sales were electric cars.

Nevertheless, production of these vehicles stopped as they had relatively low ranges and performance. On the other hand, combustion vehicles were evolving more rapidly, mainly as a consequence of aircraft engine development.

Nowadays, thanks to the development of IGBT transistors and batteries with higher capacities, many manufacturers are under increasing pressure to invest in electric vehicles. The main objective is the more efficient use of energy and the consequent reductions in fossil fuel emissions.

In the short term, the battery charging infrastructure does not allow the electric vehicle to replace internal combustion vehicles, and many models are limited by battery life and charging times. These factors are holding back its full implementation

Nevertheless, the majority of electric vehicles nowadays travel less than 60 km per day, generally in urban areas, therefore these are distances that the majority of these vehicles could complete without any problem.

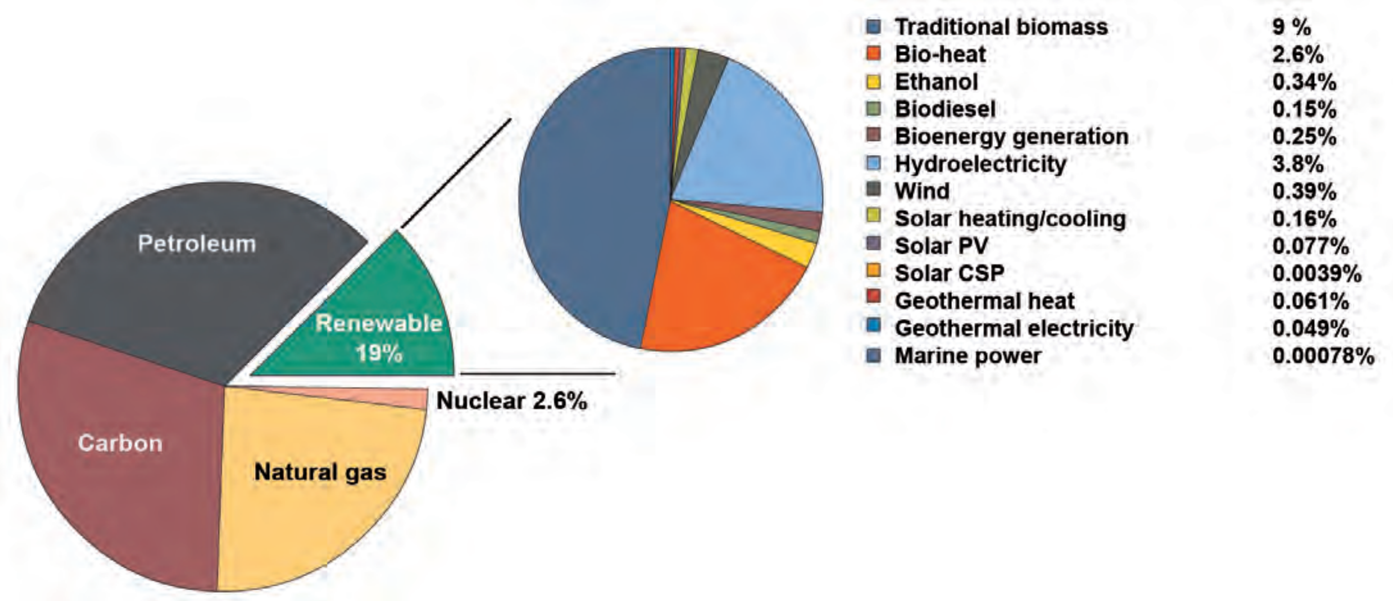
In addition, the development of faster charging systems (direct current) and new generations of lithium-ion rechargeable battery promise a more prosperous future for electric vehicles.

DETERMINANTS OF AN ELECTRIC VEHICLE

Energy supply

Today’s society, whatever the level of well-being, cannot function or survive without an adequate and regular supply of energy, meaning that the whole energy cycle process (procurement, processing and supply) constitutes a significant portion of the global economic system.

The following chart from the year 2013 classifies energy consumption according to its source at global level. Of all the known energy sources, some are more polluting and economical than others.

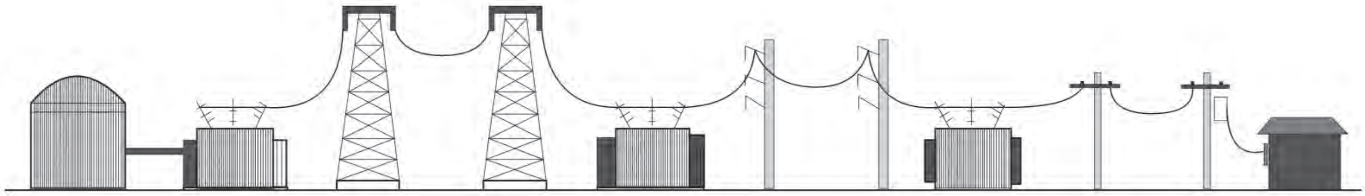


For electrical energy to bring sustainability advantages, its origin must not be from nuclear fission plants or stations, but from renewable energy and the nuclear fusion power stations of the future.

Furthermore, forecasts of future demand predict an increase that could compromise the sustainability of the current energy system. For this reason, attempts are being made to develop renewable energy and improve power distribution efficiency.

In order for the electric vehicle to be available on a grand scale, depending on the country, it will be necessary to make a profound change to the current energy system from production to the final step in the distribution chain.

The result is that much of the energy must be consumed in the same place it is generated.



Energy efficiency

If a vehicle with a combustion engine has its performance analysed from the fuel tank to the wheels, and a current electric vehicle has its performance analysed from the batteries to the wheels, we can see that the performance of an electric vehicle is far superior to that of a combustion engine (diesel with Start-Stop, Euro V, regenerative braking and other improvements to efficiency).

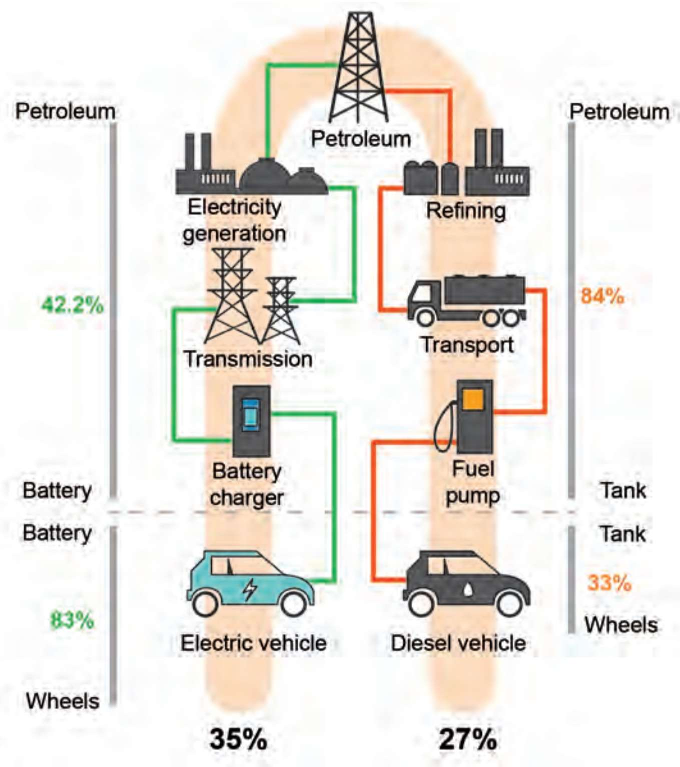
83%

33%

However, based on the comparison of generating electricity from petroleum, if we take into account the analysis from the oil well to the wheels, the efficiency of the electric vehicle is not much better than that of a diesel vehicle.

Consequently, electrical energy must not be derived from hydrocarbon sources.

In addition, as far as possible, it should be obtained at the point of consumption itself.



Environmental impact

The main advantage of an electric vehicle is that it does not emit any polluting gases wherever it may be operating. There are studies that show that with the introduction of 1,000 electric vehicles in a city, 30,000 kg of polluting gases and more than two tons of CO2 would cease to be emitted per year.
Another great advantage of electric vehicles is that they emit virtually no noise; electric motors emit very few decibels. Driving a silent vehicle with no vibrations from the combustion engine is a valuable positive fact.
On the other hand, the absence of noise affects the "hearing" safety of pedestrians or cyclists on the road.

EUROPEAN APPROVALS AND REGULATIONS

An electric vehicle driving along the road must comply with a set of approval regulations, above all in matters concerning safety and the environment where specific requirements are defined.

In Europe there is **ECE Regulation 100**, which includes the specific requirements for electric vehicles with regard to their manufacture and operational safety. On 4 December 2010 the series of amendments 01 of said regulation came into force and became binding two years later.

ECE Regulation 100.00: Applicable only to electric vehicles and excludes hybrids and vehicles of category M and N with maximum speeds in excess of 25 km/h. This regulation sets out the construction requirements (protection against electrical contacts, insulating and load resistance), the operating requirements and the hydrogen emissions requirements.

ECE Regulation 100.01: Is the evolution of the previous regulation. This regulation includes hybrid vehicles within the scope of application. Other items of the regulation have been added or modified, such as the redefinition of high-voltage to be between 60 V and 1500 V in direct current and between 30 V and 1000 V in alternating current. In terms of safety, requirements are set out for the connectors, the high-voltage cable insulation must be marked in orange and measurement procedures separating DC and AC circuits modified amongst other points.

Listed below are other general articles specifically affecting electric vehicles:

- **R10**: Defines the **electromagnetic compatibility** of the vehicles for electromagnetic wave emissions and immunity to them.
- **R13 and R13H**: Consists of the **braking of passenger and commercial vehicles**, where the regenerative braking system of electric vehicles is also taken into account.
- **R79**: With regard to **steering systems**, defines the construction characteristics, the maximum forces on these mechanisms and other regulations governing the electronic control systems of the vehicle.
- **R85**: Defines the **power of the motors**. To one annex is added the calculation of the power of the electric drive motors on a net power test and another at maximum power for 30 minutes.
- **R94 and R95**: Refer to the protection of occupants in a front and rear collision in a vehicle.
- **R101**: Consists of the **CO_2** emissions and the consumption of fuel in combustion or hybrid engines, and the consumption and range of electric vehicles.

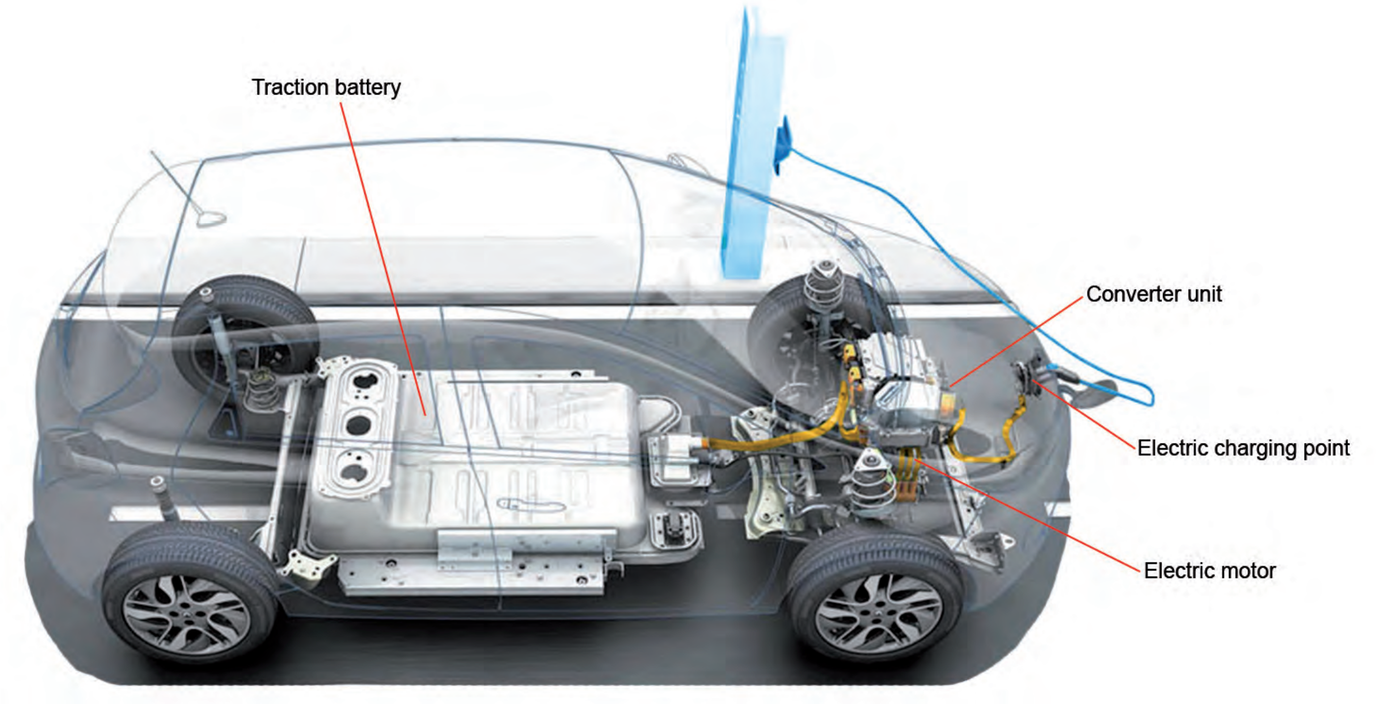
Directive 2000/53 defines the end of life of a vehicle and **directive 2005/64** defines the approval of a vehicle and its aptitude for reuse, recycling and value. For an electric vehicle, these regulations are important as they should be designed and produced taking into account the environmental impact of the batteries, in terms of their manufacture, use and recycling.

Outside of Europe, **other regulations** exist that are specific to electric vehicles such as the U.S. "Federal Motor Vehicle Safety Standards" and the Japanese "Attachment 110 & 111". These global powers are pioneers in the design and manufacture of said vehicles.

At European level, each manufacturer trains their operators to carry out high-voltage work on the electric vehicle. The European Regulations governing high-voltage work are **EN 50110-1** and **EN 50110-2**. They cover a number of sections such as **Directive 89/391/CEE**, referring to the implementation of measures to promote improvement of the health and safety of the workers.

ELECTRIC VEHICLE GENERAL ARCHITECTURE

Generally, the majority of electric vehicles use very similar components for their operation. Below we can see the most significant electrical components in a Renault ZOE.



Type of network

As a general rule, an electric vehicle is made up of a 12-volts network, a group of multiplex networks for communication between the different control units and a high-voltage network of between 150 and 400 volts.

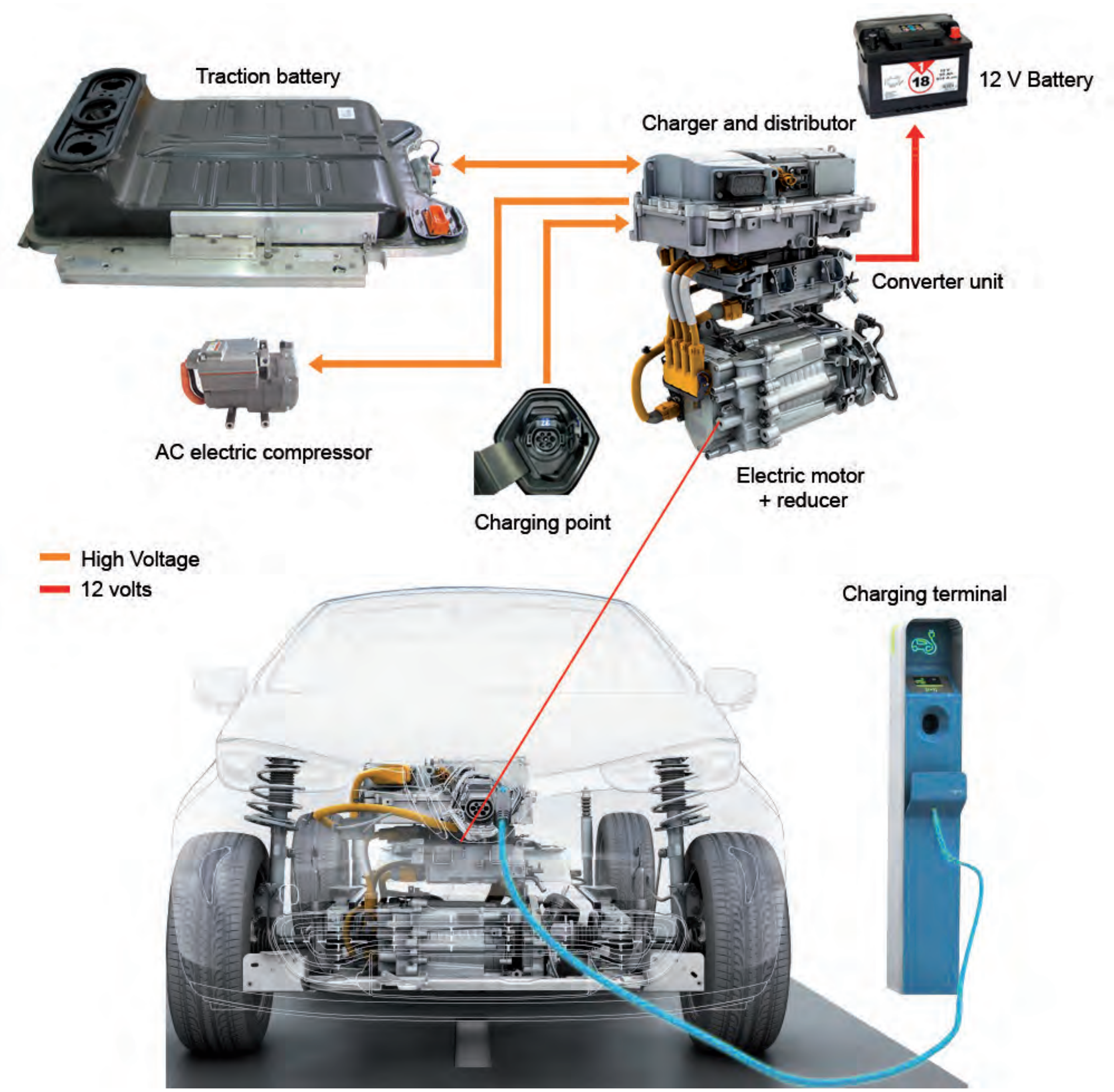
12-volt network: The function of this network is the same as that for a conventional vehicle. It is used in all the safety systems (active and passive), 12 V battery charging, lighting, comfort, power to electronic units, etc.

Multiplexed networks: All the systems in an electric vehicle, including the one for high-voltage management, are controlled by control units which need to communicate with each other. As in a conventional vehicle, communication between units is through a multiplexed system.

High-voltage network: In order to manage an electric drive system it is necessary to have a specific group of components. These are usually: an electric charging point, a traction battery, a converter unit and a braking system which combines the electric regenerative electric brake with the mechanical brake. It also includes a climate control system both for the traction battery and the cabin. The remaining components of the vehicle are similar to those of a conventional vehicle.

General operation of the electric drive system

These vehicles are powered by electric current from the domestic electricity network, from an urban fast-charging station and from the regenerative braking.
The power used by the electric drive system is stored in a large-capacity battery called a traction battery. The battery supplies direct current to the converter unit via the distributor, where this current is transformed into alternating current. The alternating current supplies the electric motor so that it generates rotating movement. The rotation movement is transformed in a reduction assembly to obtain the proper running of the drive wheels.



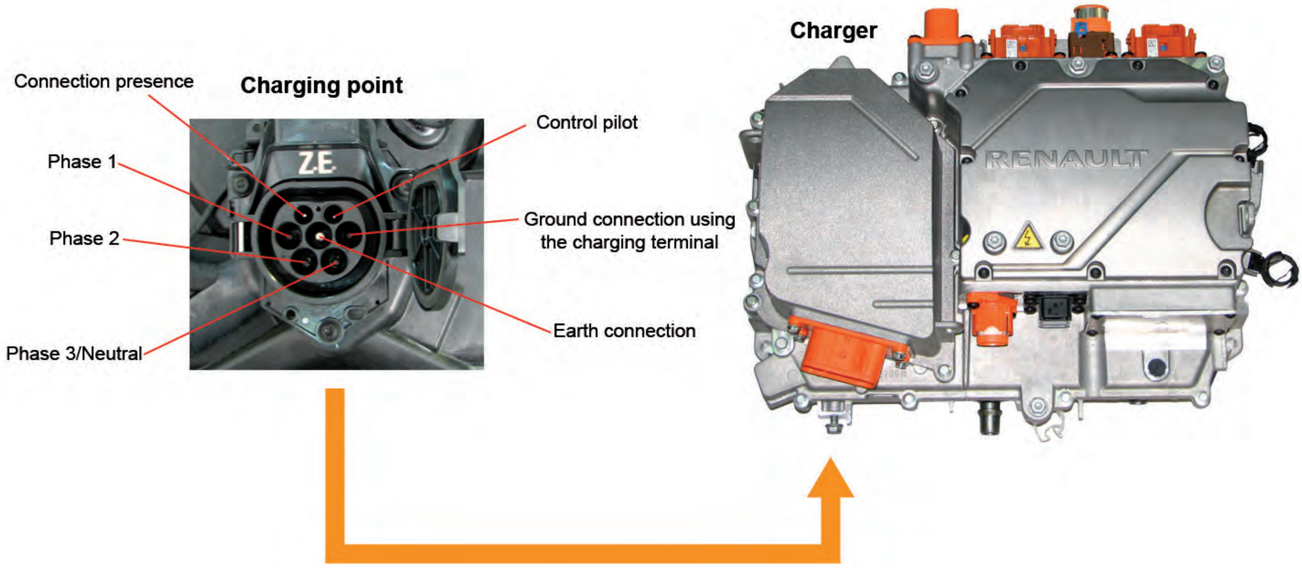
MAIN COMPONENTS OF THE DRIVE SYSTEM

Electric charging point and charger

Whenever an electric vehicle is purchased, a charging terminal is required where the vehicle can be plugged in and the battery charged. The connection to the vehicle is made using a charging point, which can receive different feeds depending on whether the charge is single or three-phase.

Domestic current is alternating. Due to its nature, it cannot be stored in a battery. The current stored and provided by a battery, of whatever kind, is direct. Therefore a transformer is needed to adapt the alternating domestic current to the direct current of the battery.

For greater comfort and in order to connect directly to 220 V, most manufacturers choose to supply a charger with the vehicle itself. This charger controls the charging process and converts the alternating current into the direct current required for the traction battery to operate. In addition, communication is established between this charger and the charging terminal.



The disadvantage with these chargers is that they take up space and increase the weight of the vehicle.

Types of charge

Each type of battery requires charging in a specific way. This implies that there are a large variety of different chargers on the market, and the manufacturer should be consulted for the one that is most suitable. The more electrical power you have available, the less time will be required to charge the battery. Depending on the power and the type of electric current available, there are three types of charging:

- **Conventional charging:** Uses the intensity and conventional electrical voltage of a home with single phase current (depending on the contracted power: 3.7-11 kW, 230 volts).
- **Semi-fast charging:** Used in urban and garage charging terminals which normally use three-phase alternating current. Provides higher power than domestic networks, reducing the charging time considerably (1 hour).
- **Fast charging:** Fast chargers work with 125 amp currents and voltages of 500 volts, which provide a power output of around 60 kW. This charging must be viewed as range extension or convenience charging. The battery charging time is considerably reduced compared with other types of charging.

Charging protocols and connectors

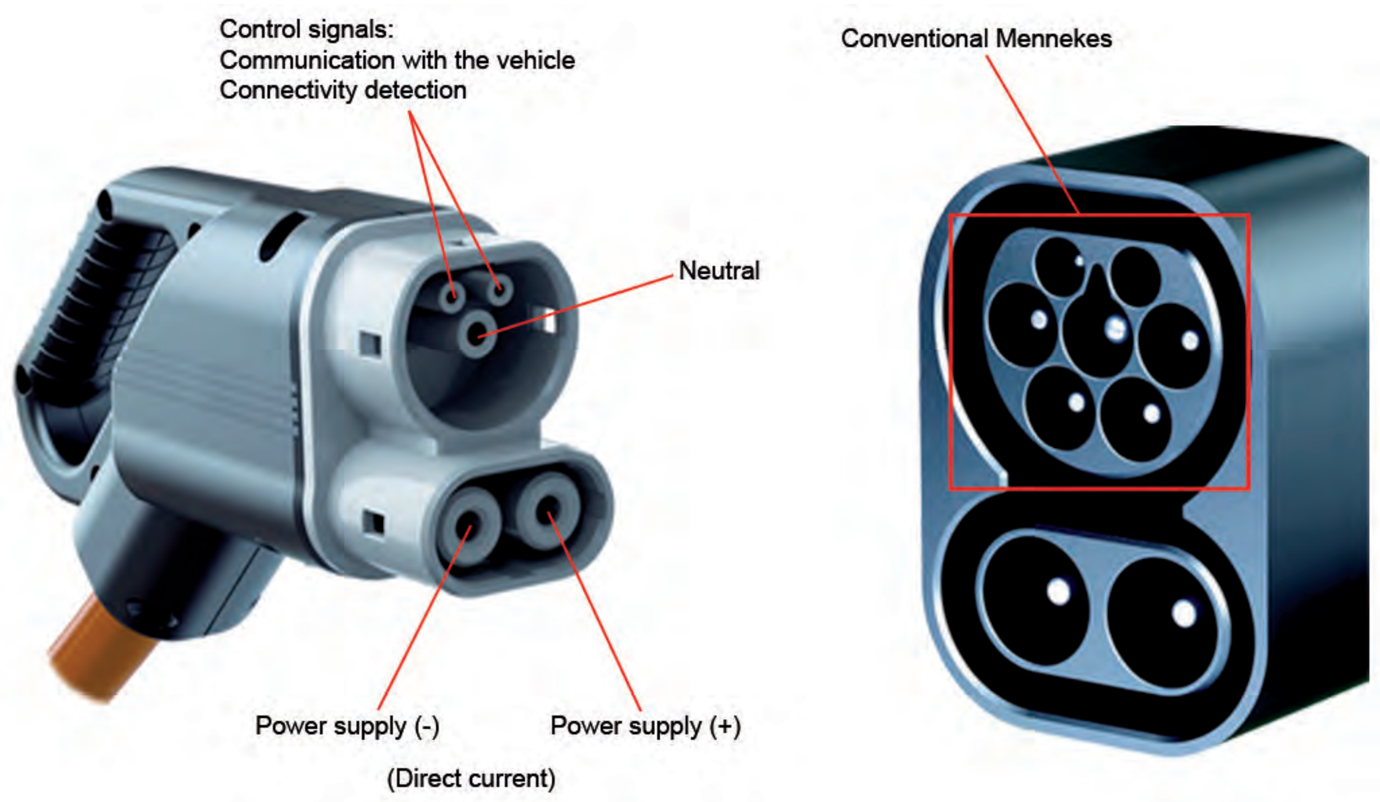
Electric vehicle manufacturers have set out their own communication protocols which form part of the battery charging processes. These protocols report on battery status, charge level, protection during charging and the charging process itself. Due to incompatibility between different protocols and connectors, both in communication and in the construction of the connector, manufacturers are trying to standardize their charging systems with some difficulty.

Depending on the different markets we can find various standardized charging protocols:

- **Mennekes Connector:** This is the standard one in Europe. It is based on the international standard IEC 62196 (International Electrotechnical Commission).

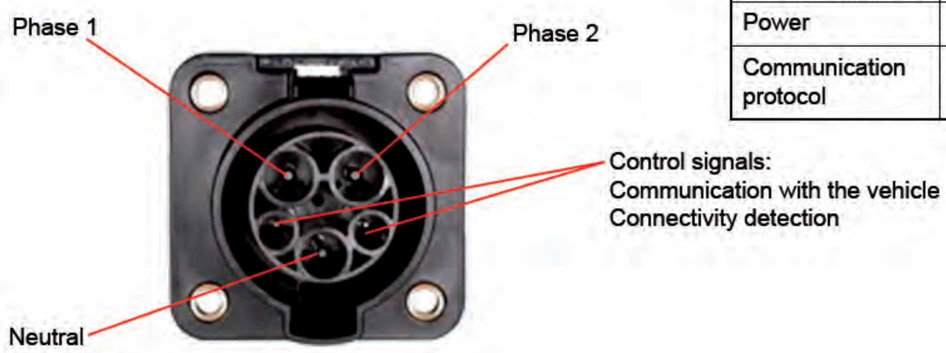
Alternating current	Single and three-phase up to 16-63 A
Voltage	100-500 V
Power	Up to 43.8 kW
Communication protocol	PLC (Power Line Communications)

There is a mixed variant from Mennekes for charging with direct current. It is called **Mennekes CCS** Combined Charging System, and consists of two more pins for + and – DC. This enables fast charging with power up to **100 kW**.



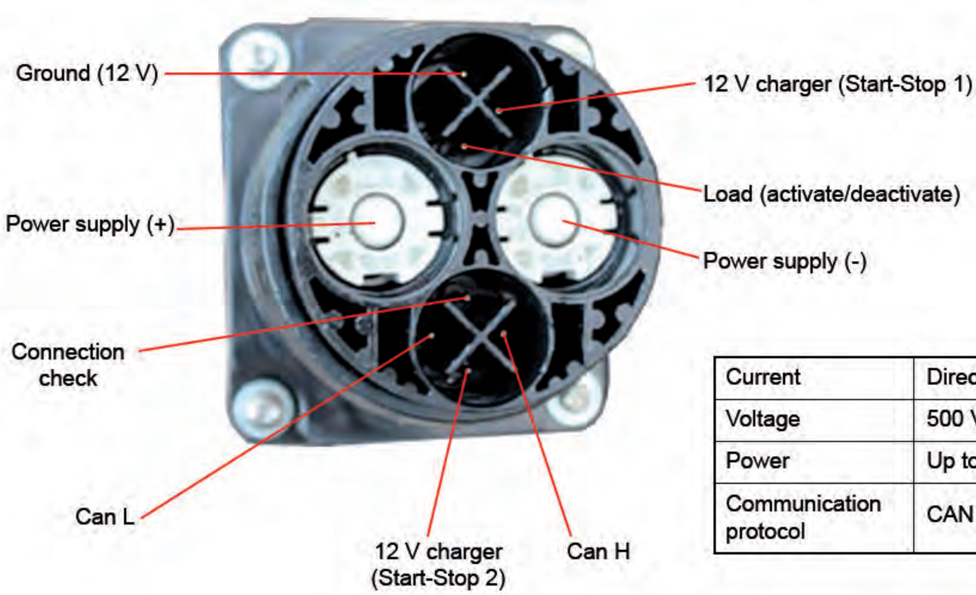
- **SAE J1772 or Yazaki:** This is developed in the US. Only for the American standard.

Alternating current	Single phase from 10 - 80 A
Voltage	110-250 V
Power	1.92 kW; 7.4 kW; up to 19.2 kW
Communication protocol	PLC (Power Line Communications)



There is a mixed variant SAE J1772 for charging with direct current. It is called **SAE CCS** *Combined Coupler System*, and consists of two more pins for **+** and **–** DC. This enables fast charging with power up to **90 kW**.

- **CHAdeMO Connector:** **CH**Arge de **MO**ve (charge to move) from the Japanese for "let's have a coffee". This is the Japanese standard for fast charging. It is designed solely for direct current and the locking system is manual.



Current	Direct of up to 125 A
Voltage	500 V
Power	Up to 62.5 kW
Communication protocol	CAN Bus (Controller Area Network)

Due to the wide variety of connectors, some manufacturers choose to fit their vehicles with more than one type of connector (one for conventional charging at home and another for fast charging).

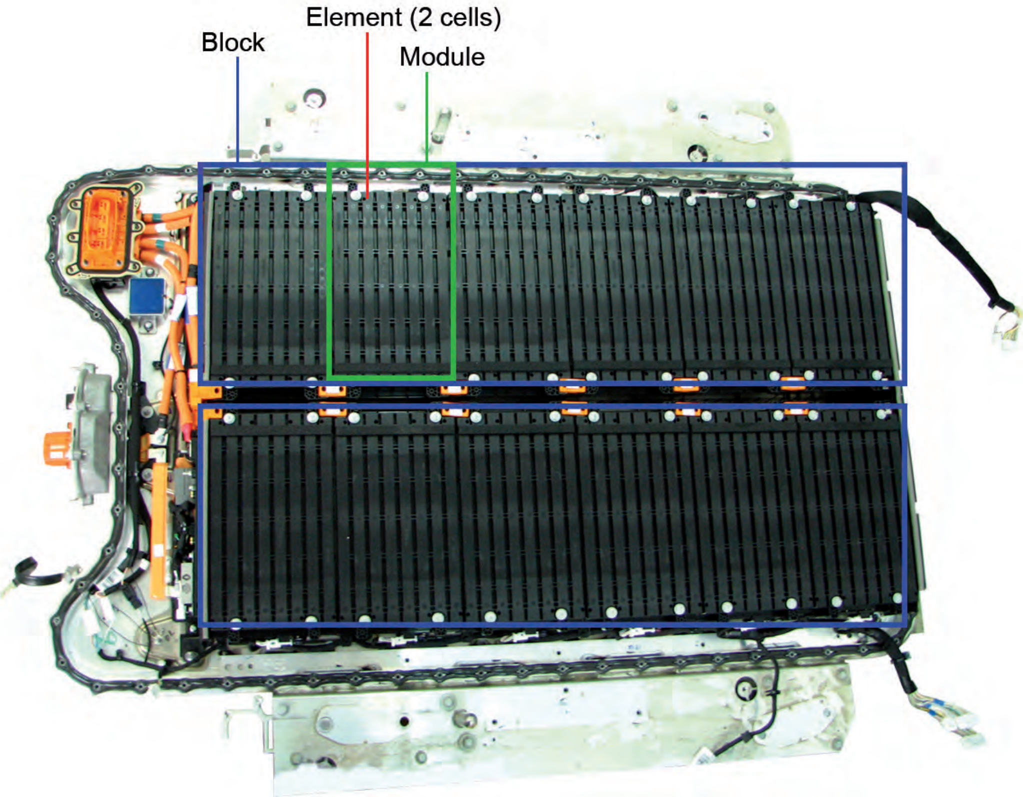
Traction battery

This is an element which stores energy in a chemical form which, when connected to an electrical circuit, is transformed into electrical energy and carries out work. It is usually located underneath the floor of the vehicle, which helps to balance the weight between the front and rear of the vehicle and maintain a low centre of mass. This facilitates optimum traction and gives the vehicle excellent stability.

There are various types; the main difference between the batteries and the power and voltage they deliver basically lies in the production material of the positive and negative electrodes. The best known batteries are:

Type of battery	Lead-acid	Nickel-cadmium	Nickel-metal hydride	Sodium-nickel (Zebra)	Lithium-ion
Material of the negative electrode	Lead	Cadmium	Metal hydrides	Sodium	Graphites, nitrides and lithium alloys
Material of the positive electrode	Lead oxide	Nickel hydroxide	Nickel hydroxide	Nickel	Lithium cobalt oxide, vanadium oxide…
Electrolyte	Sulphuric acid	Potassium hydroxide	Potassium hydroxide	Sodium-nickel-chloride	Organic solvent + lithium salt
Energy/weight (Wh/kg)	30 - 50	48 - 80	60 - 120	120	110 - 160
Voltage per element (V)	2	1.25	1.25	2.6	3.70
Duration (charge/discharge cycles)	1000	500	1000	1000-2000	4000
Charging time (h)	8 - 16	10 - 14	2 - 4	-	2 - 4
Self-discharge per month (% of total)	5	30	20	-	25
Charge efficiency	82.5	72.5	70	92.5	90

Lithium ion batteries are the most recent. The use of new materials such as lithium has made it possible to achieve high energy densities, high efficiency, removed the memory effect, eliminated the need for maintenance and made recycling easier.
A battery of this type is made up of a large number of cells which are grouped into modules and divided into blocks. The following image shows an example of a traction battery with 192 cells divided into 96 elements and connected in series. Specifically, this battery has a rated voltage of 360 V and can operate at a maximum voltage of 400 volts. Its energy capacity is around 22 kWh and it provides a range of about 150 km.



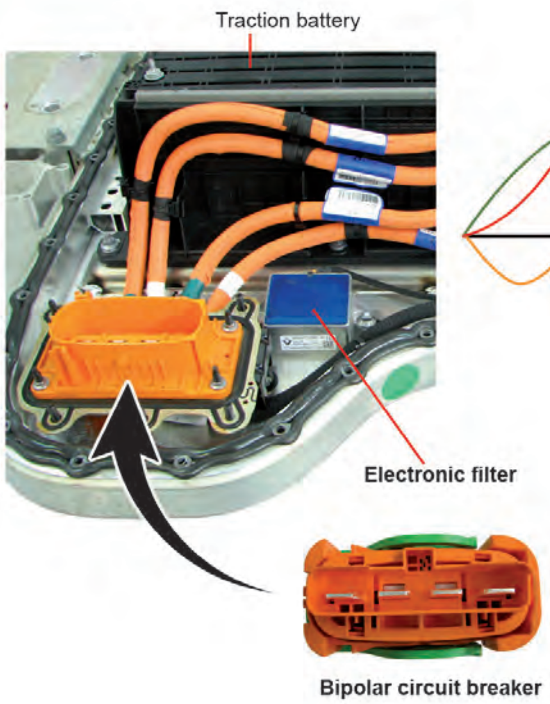
Note: Some of the more sophisticated vehicles such as the Tesla Model S includes more than 8,000 cells in its battery. The capacity provided is 100 kW/h and a range of more than 500 km between charges.

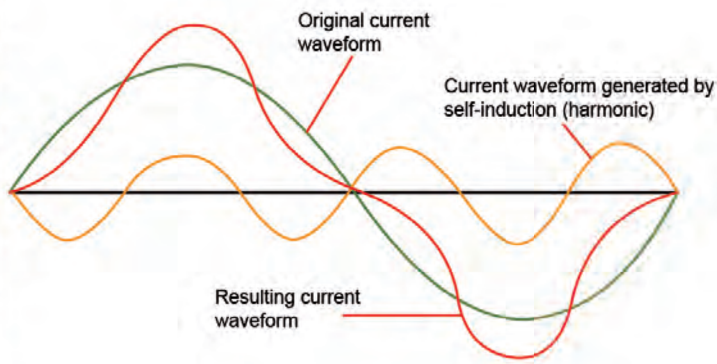
To improve energy efficiency, these batteries have an autonomous cooling system which maintains the cells at optimum working temperature. In this case, air conditioning refrigerant is used which, through the use of an evaporator and blower, cools an air flow which passes through all the battery modules.

The charge and discharge voltages per cell in these traction batteries should be included in the limits set by the manufacturer. This is done by incorporating an electronic management system which monitors and balances the charge/discharge cycles and their correct operation. This management system requires components such as temperature sensors, current sensors, fuses, resistors, etc.

For safety in these batteries, a bipolar circuit breaker is included which allows the positive and negative terminals of the traction battery to be disconnected from the rest of the vehicle installation. It is a safety system which prevents hazardous currents in the rest of the wiring and high voltage components.

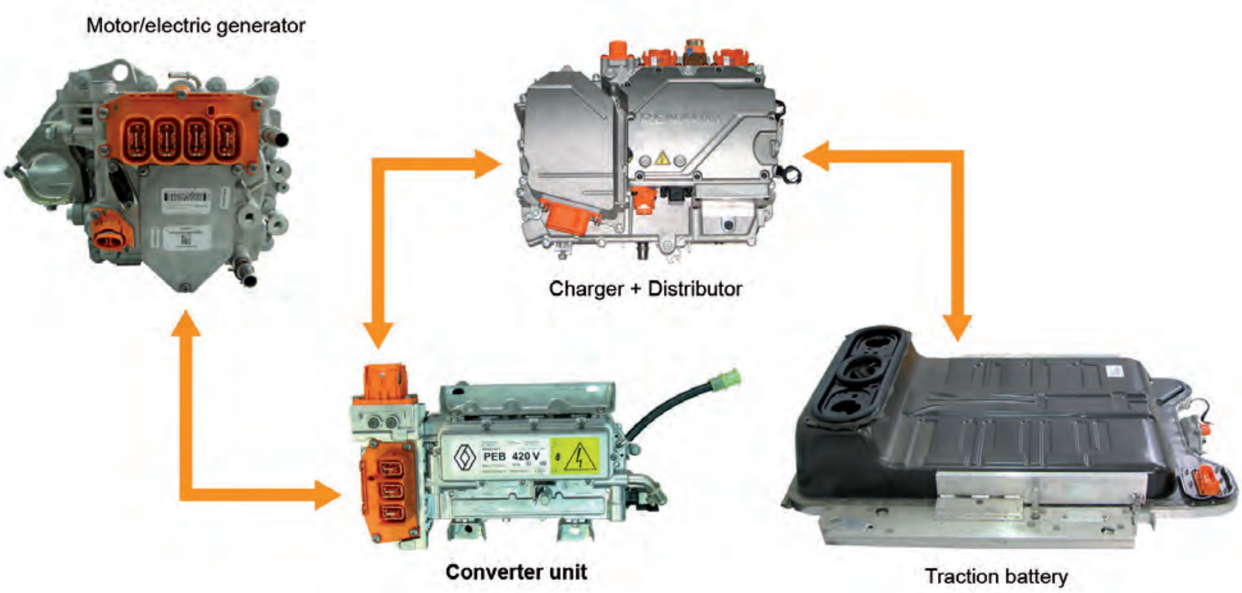
Another necessary component to ensure lasting durability and correct operation of the traction battery is the inclusion of an electronic filter connected to the negative terminal. This filter absorbs the harmonics in the current entering and exiting it.





Converter unit

This is for transforming the direct current of the traction battery into three-phase alternating current so that the high performance motor can operate. Additionally, when decelerating, it converts the electrical energy generated by the motor back into direct current to return it for storage in the battery.



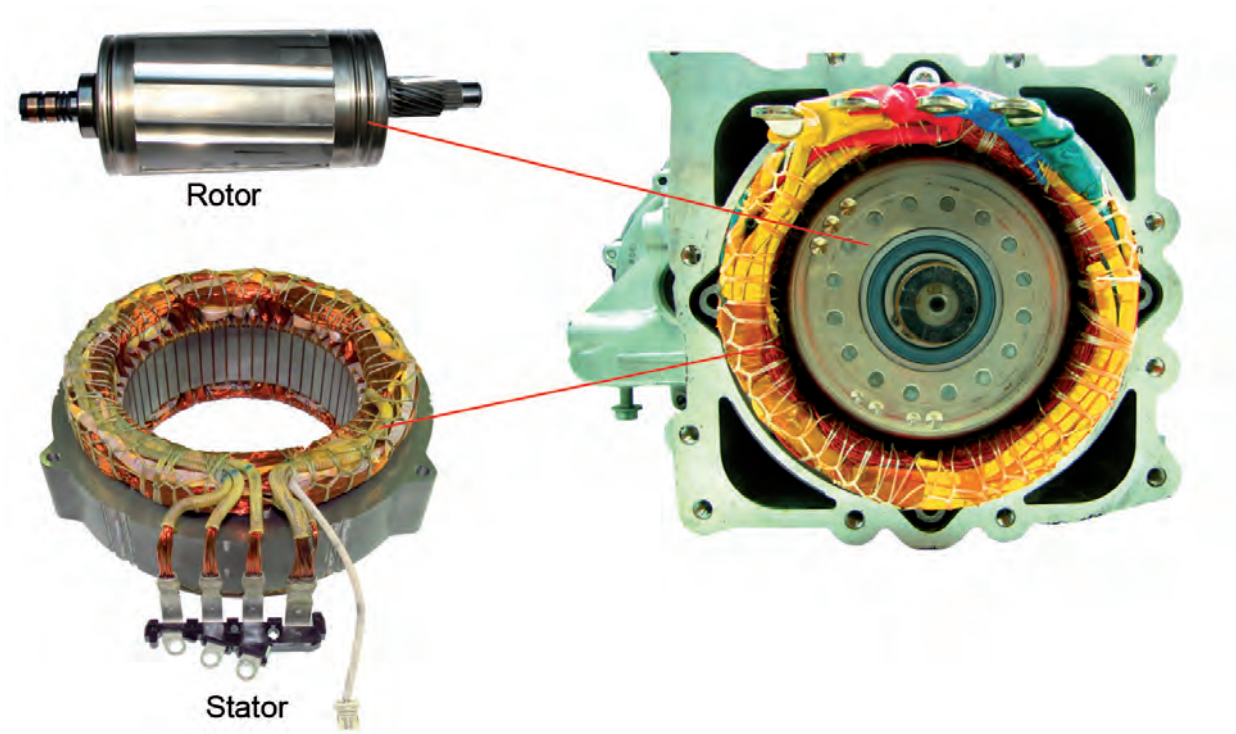
Communication between the converter unit and the electric motor is via special wiring. All the high voltage cables are shielded to prevent parasites as much as possible.
In turn, the converter manages switch on of the phases of the stator depending on the rotor position, the power demand, the regenerative braking and whether or not the vehicle is moving forwards or in reverse.
Furthermore, the converter reduces the voltage of the traction battery to low voltage in order to supply 12 volt consumers, also charging a small 12 volt battery.

Important: In these electric vehicles, do not use the 12 volt system to start any other conventional vehicle. The electrical power supplied by the low voltage system is not designed to support the demanded power consumption required by the starter motor of an internal combustion vehicle.
In order to prevent the components of the powertrain from overheating (converter unit, charger, electric motor, reduction assembly, etc.), a water cooling system is installed. The temperature in this cooling system oscillates around 50 ºC, and with the use of a temperature sensor a thermostat is not required.

Electric drive motor + reduction assembly

The drive motor is an important component within the architecture of the electric vehicle. It transforms the electrical energy into mechanical energy applied to the wheels.
The operating principle of an electric motor consists of inducing a magnetic field generated by a stator which interacts with the magnetic field generated in the rotor. This interaction or "clash" between both fields causes the shaft of the electric motor to turn. These motors are also capable of operating as a generator when the vehicle is decelerating, providing alternating current which is then rectified into direct current (in the converter) to be stored in the battery.

The main components of these devices are the stator, which remains immobile, where the inductance coils are located and which form the copper windings shown in the image. And the rotor, which is the magnetic core which, on turning, transmits movement to the reduction assembly.



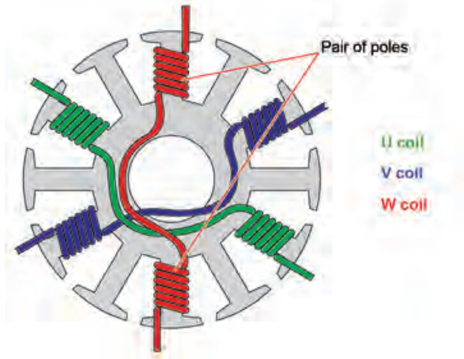
Engine type

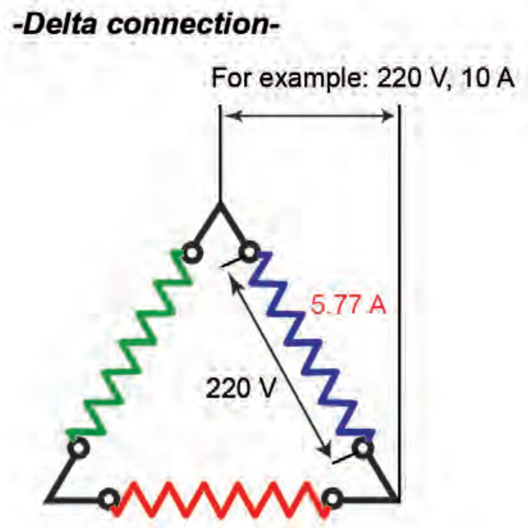
Electric motors can be basically classified into two types: synchronous and asynchronous. The difference between them lies in how they operate.
In synchronous motors, the rotational speed of the rotor is the same as the rotational speed of the magnetic field of the stator. While in asynchronous or induction motors, the speed of the rotor is always lower than the rotational speed of the magnetic field of the stator.
As an example, the Renault ZOE and the Nissan Leaf use synchronous motors and the Tesla uses asynchronous motors.

The stator

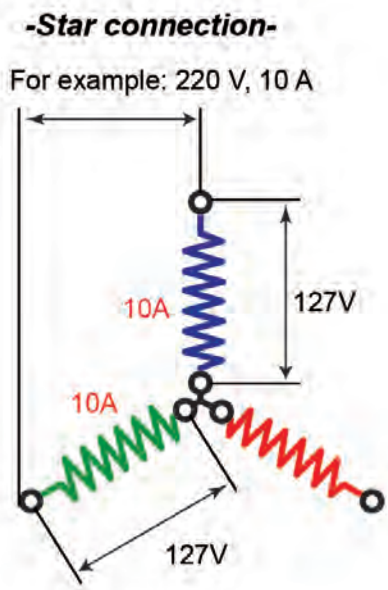
This component is practically the same in the synchronous and asynchronous motors. Usually, the stator is three-phase and is made up of three coils distributed uniformly around its casing. The name of the coils is usually U, V and W.

Depending on how the coils are distributed around its casing, a larger or smaller number of magnetic poles is obtained.





$$I\ phase = \frac{I\ line}{\sqrt{3}} \qquad V\ phase = V\ line$$



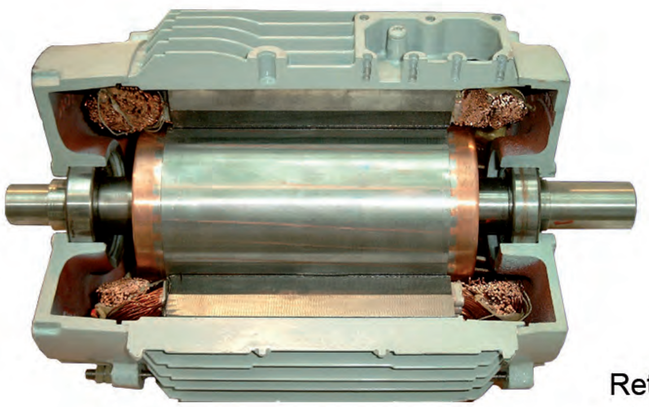
$$V\ phase = \frac{V\ line}{\sqrt{3}} \qquad I\ phase = I\ line$$

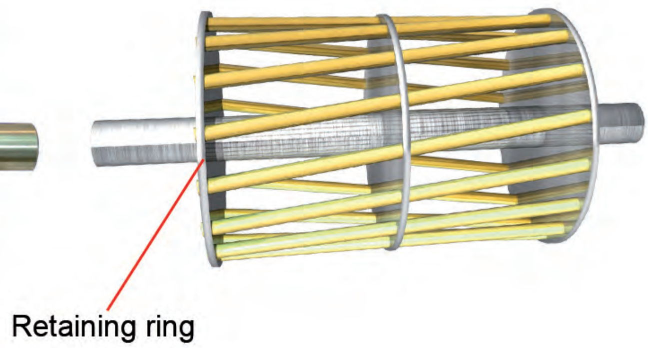
The rotational power of a motor connected in star or in delta is the same. However, when the phases are connected in delta, the intensity and motor torque is lower compared to one connected in star, while its rotational speed and voltage are higher. On the other hand, when the phases are connected in star, the speed and voltage are lower compared to a delta configuration, while the intensity and motor torque are higher. Thus, the motors used in electric vehicles are usually connected in star to achieve the maximum motor torque.

The rotor

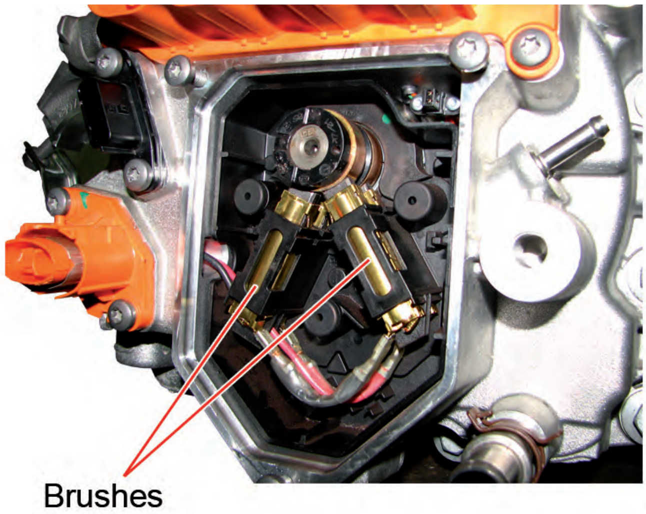
Depending on whether the motor is synchronous or asynchronous, it may have one rotor or another. Asynchronous motors include a squirrel cage rotor. While synchronous motors normally use a permanent magnet rotor.

- **The squirrel cage rotor :** consists of some wires distributed around the edges of the rotor (normally copper). The ends of these wires are short circuited through a retaining ring, unless it is possible to connect the rotor winding to the exterior. The magnetic field of the stator induces a current in the rotor which is then transformed in the magnetic field required for the shaft to start rotating.





- **The wound rotor :** includes a copper winding wrapped inside which is connected to the outside through two slip rings mounted on the same shaft itself. These rings receive constant power via some brushes to power the rotor winding whose purpose is to generate a magnetic field in the latter.



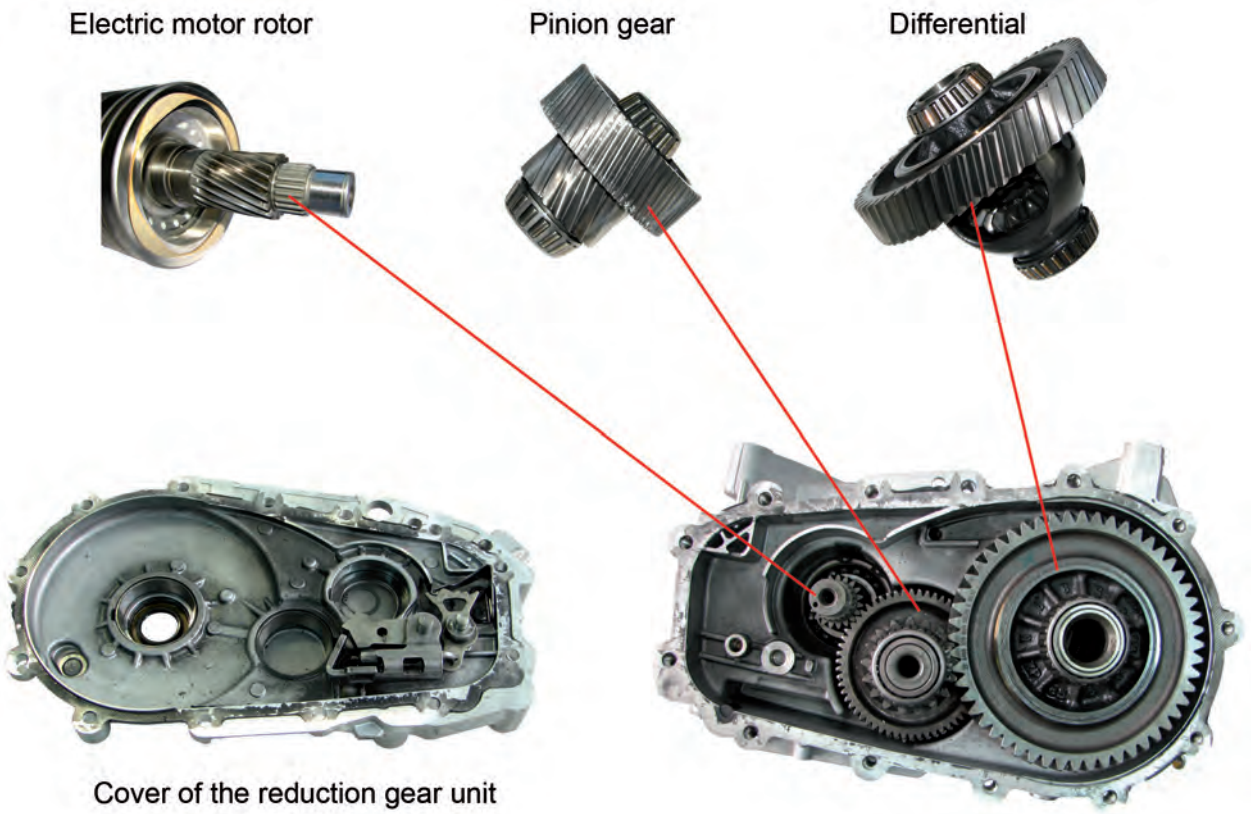
- **The permanent magnet:** rotor does not have to "create" a magnetic field by absorbing current from a power source, as the magnets themselves already generate this magnetic field. Neodymium is a material that is often used for this type of magnet.

Reduction assembly

The high number of revolutions of the electric motor (12,000 rpm) and the high torque available means that electric vehicles do not need any kind of gearbox. Likewise, as the electric motor can deliver power from moment 0 (idling not required), this also removes the need for a clutch system.

However, it is necessary to mount a reduction system (reduction assembly) to transform the high number of electric motor revolutions into drag torque.

The reducer consists of the electric motor shaft (rotor), a reduction pinion and a conventional differential.



For the reverse operation, the coupling of a third pinion is also not required, as it is enough to reverse the rotation of the electric motor.

REGENERATIVE BRAKING SYSTEM

It is normal to find different braking systems in an electric vehicle, but for the purposes of the driver, the braking system must perform as if it was a single braking force. The braking equipment consists of the classic hydraulic system and the regenerative braking system, where the electric traction motor intervenes (when operating as a current generator).

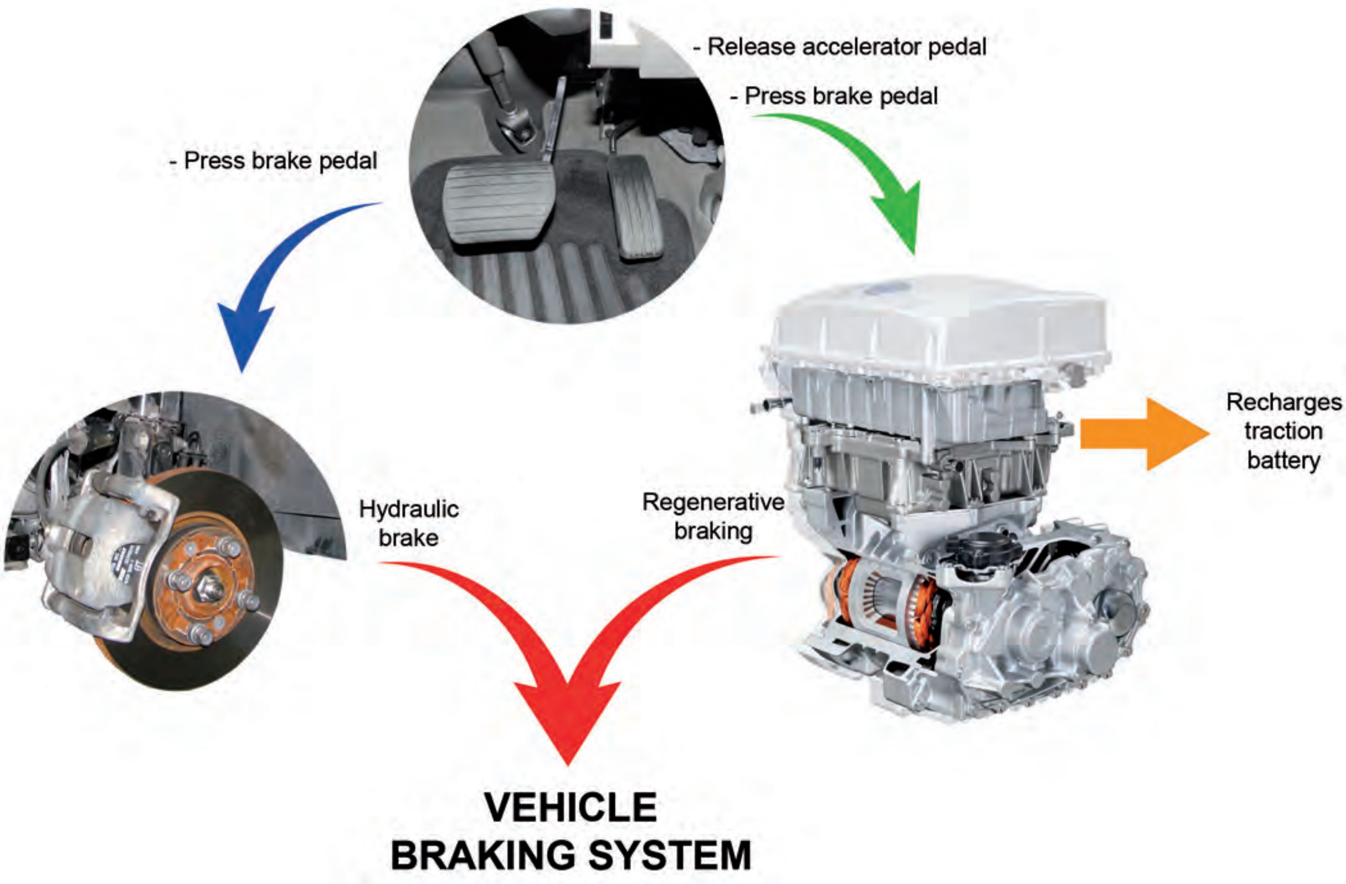
The conventional braking system (hydraulic) usually has a brake booster which operates in a vacuum. In a conventional vehicle, the vacuum comes from the intake manifold (petrol engine) or brake pedal (diesel engine). In the case of an electric vehicle, this vacuum can only be created, generally speaking, in two ways:

- With an electric vacuum pump, where it is activated according to the signal from a pressure sensor mounted on the brake booster itself.
- Or, the electric motor used for the ABS system generates the hydraulic pressure to be used in the hydraulic circuit.

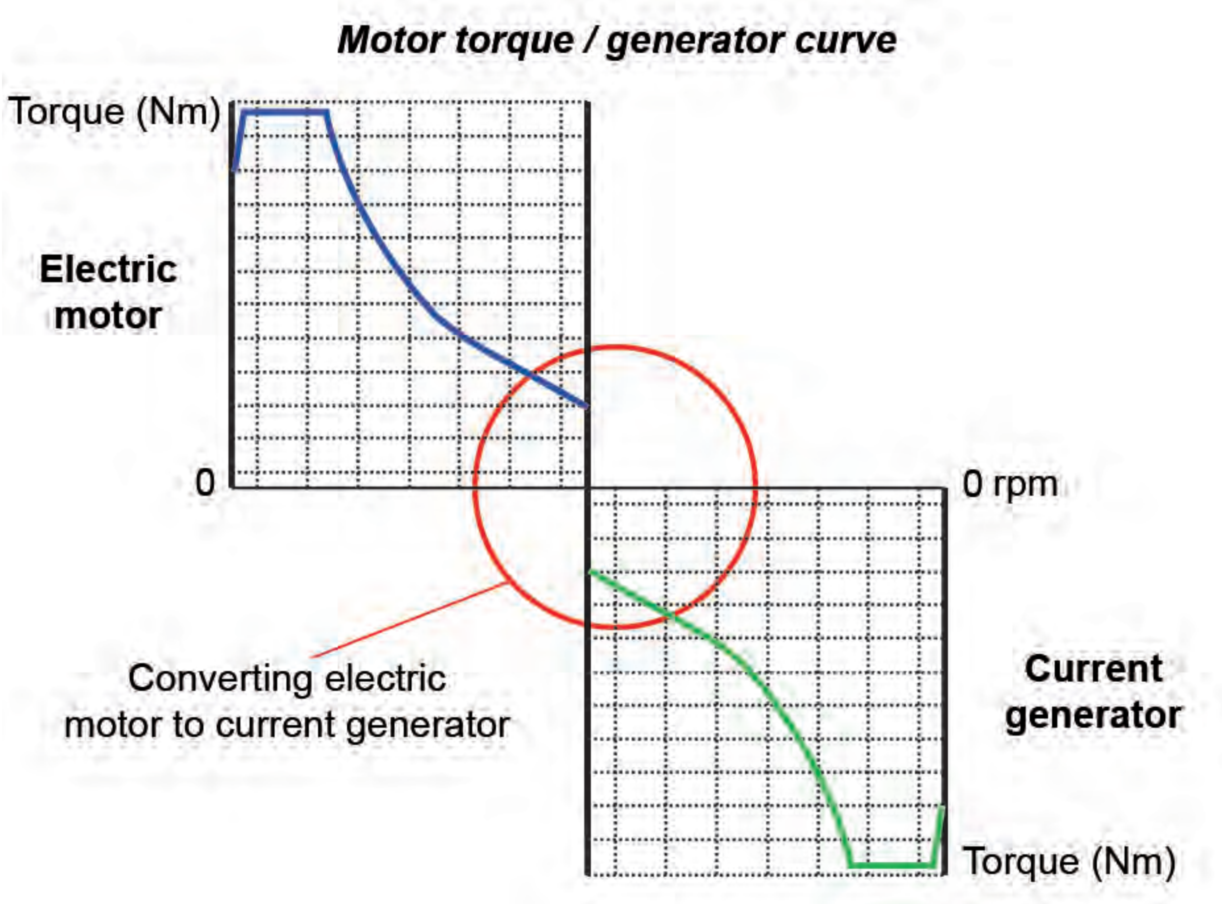
Regenerative braking in these types of vehicle comes into operation when the accelerator pedal is released. At this moment, the electric motor stops giving traction to the wheels in order to invert its function to generator. The inertia of the rotor causes an electromagnetic induction in the stator coils, therefore generating an alternating current. This alternating current is rectified to direct current by the converter unit for later storage in the traction battery. The more the brake pedal is pressed and the pressure increased on it, the more energy is absorbed by the battery over the generator, leading to more retention.

With regenerative braking, the vehicle's range is increased considerably, especially when driving in the city. At the same time, wear on the brakes is also reduced.

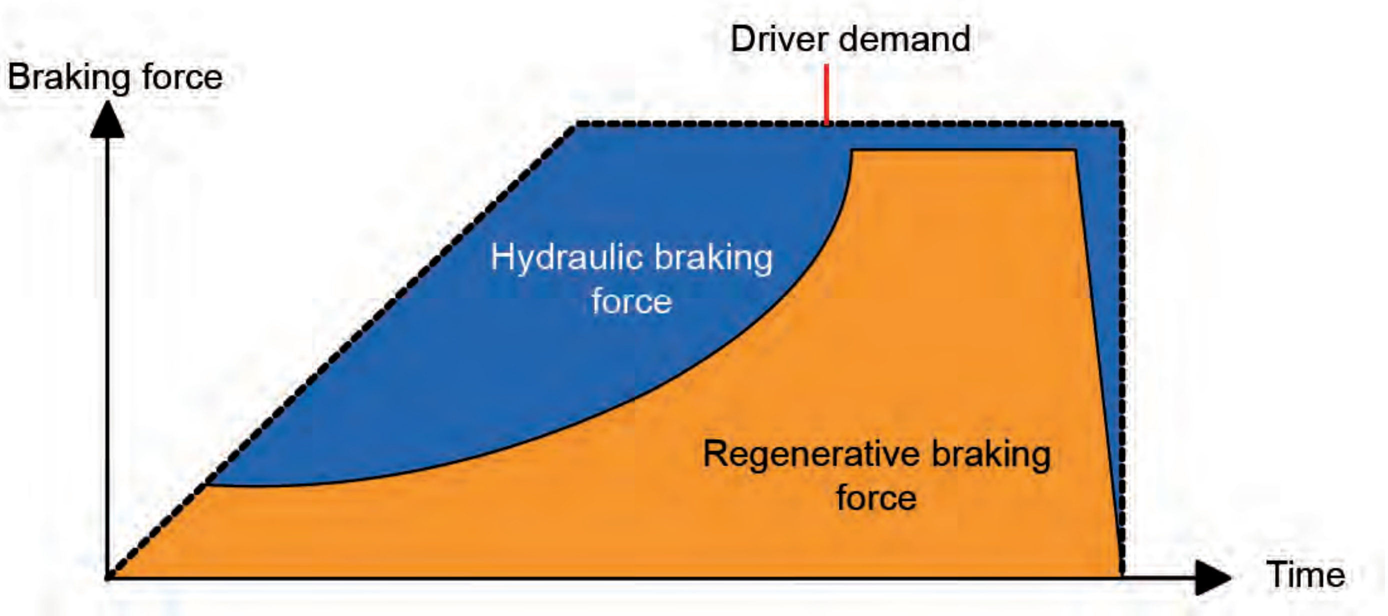
In order for the electric vehicle to brake effectively and, in turn, gain the most benefit from regenerative braking for charging the traction battery, a braking system is required which continuously combines both braking systems.



The resistive torque of a generator depends, in part, on the number of revolutions it turns at. When passing from electric motor to current generator, there is a short period of time in which there is no type of torque available, when braking has to be 100 % hydraulic. As soon as the resistive torque is available again, the braking system is capable of reducing or even eliminating the hydraulic braking in order to benefit from the regenerative braking. With the decrease in rotational speed of the generator, resistive torque is not possible. At that moment, hydraulic braking has to be applied again.



Therefore the braking system of an electric vehicle shuts off the pressure generated by the driver on the brake pump, in order to combine hydraulic and regenerative braking depending on the braking requirements demanded.



CLIMATE CONTROL SYSTEM

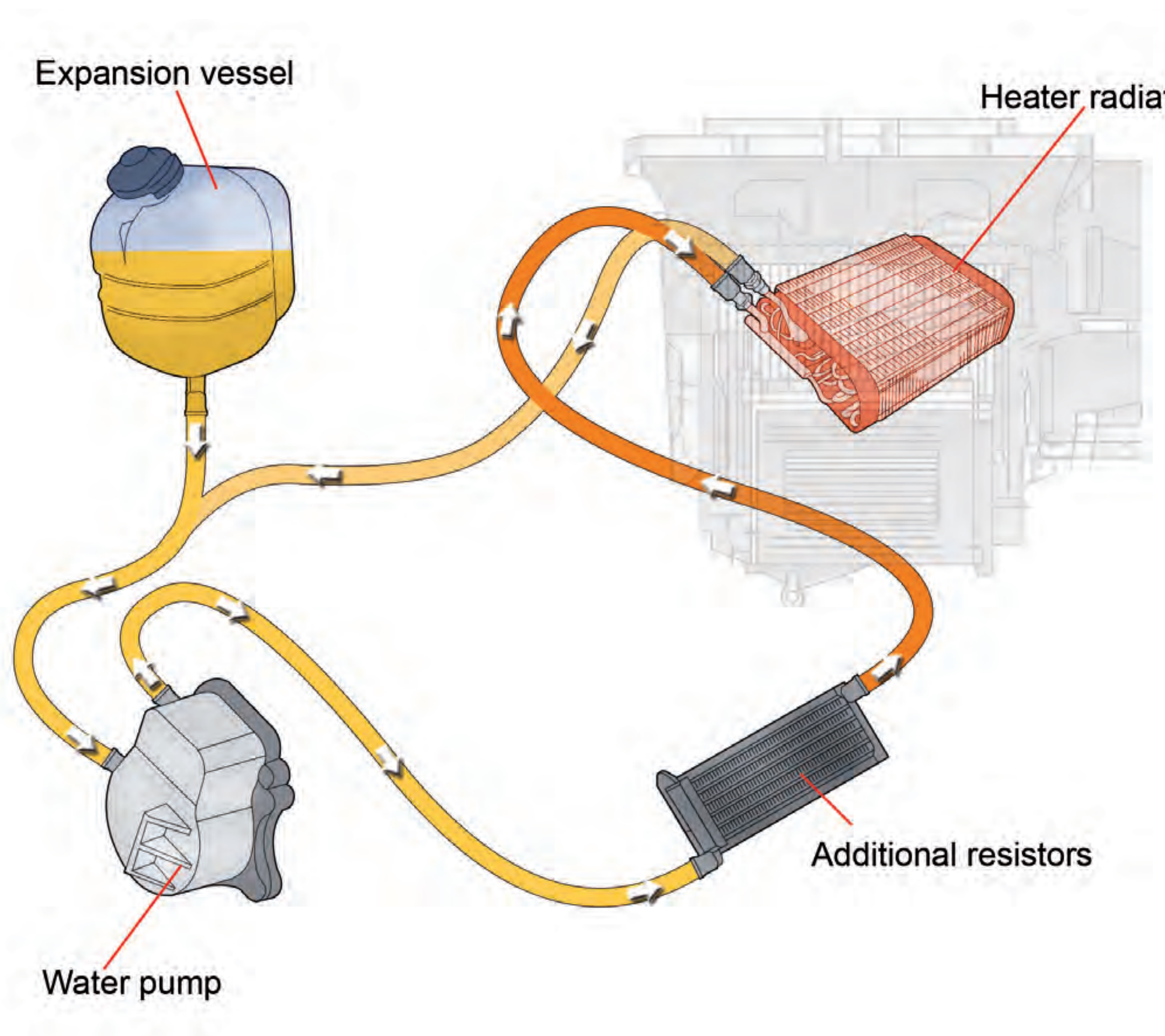
As there is no internal combustion engine, electric vehicle manufacturers asked two questions:

- How to operate the A/C compressor.
- And how to have a heat source for the heating.

Regarding the heat source for the heating, the first electric vehicles were fitted with stationary heating which operated via a small fuel tank (petrol or diesel); somewhat similar to home heating.

Another more modern option adopted is the use of additional resistors which work at the voltage of the traction battery. The system also consists of the following components:

The additional resistors heat the fluid circulating through the circuit. They operate whenever the vehicle is running and the heating function is requested.



In the cold loop, the same components are used as in a conventional vehicle, the only difference being that the air conditioning compressor is operated by an electric motor installed in its interior.

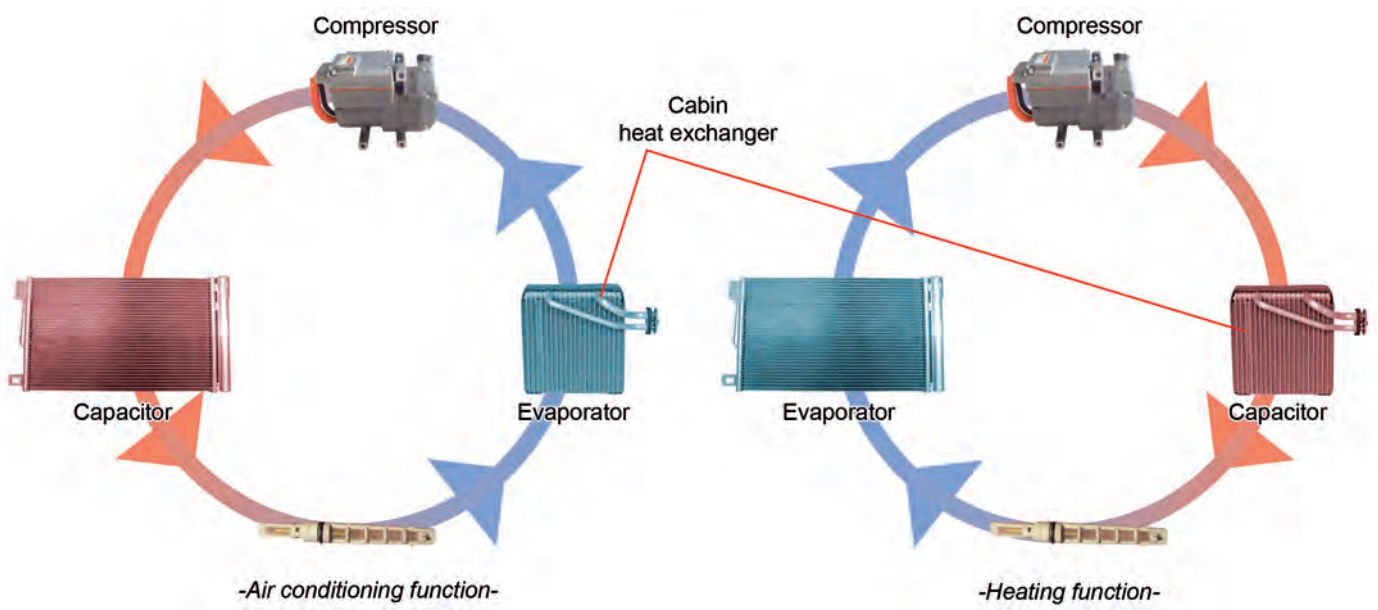
These types of compressor are usually of the Scroll type and their position is the same as for a conventional vehicle, that is, in the engine compartment.

The gas used depends on the vehicle's year of manufacture. The most usual are the R-134a and the 1234-yf.

For the purposes of increasing range, many electric vehicles have a program which can anticipate the heating or cooling of the cabin while the vehicle battery is charging. In this case, the energy required for this process comes from the domestic electrical system instead of the vehicle battery.

In turn, the vehicle's climate control equipment also intervenes in the cooling of the traction battery.

Other vehicles, such as the Renault ZOE use a reversible climate control system, which refers to a system that enables the heating and cooling of the air. The heat exchanger in the cabin operates as a condenser for giving off heat, or as an evaporator for emitting fresh air. A set of electrovalves are used to reverse the function of both heat exchangers.



MAINTENANCE

As in internal combustion vehicles, electric vehicles also have their own maintenance. The following inspections and reviews are notable in the most generic maintenance services:

- Changing the coolant liquid every 5 years or every 150,000 km. This should be done in accordance with the manufacturer's specifications.
- Replacement of the brake fluid, manufacturers recommend that this is carried out every 120,000 km or 4 years. At the same time it should be pointed out that the brake pads in these vehicles usually last longer than in a conventional vehicle, as the regenerative braking in electric vehicles reduces the wear on the brake pads.
- The reduction assembly uses oil for the gear transmission. It is recommended to check the oil level every 30,000 km (these figures are based on the vehicle inspection).
- Some manufacturers recommend that the 12 V battery in these electric vehicles is replaced every 3 years as a precaution.
- It is recommended that the cabin filter is replaced every 30,000 km.

Regarding the tyres used in many electric vehicles, it should be noted that they are of a special type.

Due to the high torque of these vehicles, tyres have been designed with a high friction coefficient. Some manufacturers opt for the use of tyres with a larger diameter but with a narrow section width, which provide a low rolling resistance in order to increase the range of the vehicle (increase of 10 % depending on the vehicle). Their replacement period depends on the wear sustained.

- The air conditioning dehydrator filter is recommended to be changed every 2 years. When the air conditioning circuit has to be opened it is important to have in mind the compressor oil specifications, because this oil must be POE type. It is oil that has to have specific electrical insulation properties that protects the compressor from electric shock produced by the motor.

As in a conventional vehicle, it is also necessary to regularly check the tyres, windscreen washer fluid, wipers, bulbs and maintain and replace if necessary moving components such as:

- hydraulic brake parts
- ball joints
- bearings
- steering and suspension parts

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Hybrid technology

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