10

Eure!TechFLASH

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

EDITION 10

ELECTRICAL VEHICLE

IN THIS ISSUE

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ESITTELY

Autoteollisuudessa on tapahtunut useita teknisiä edistysaskeleita vuosien varrella, ja on selvää, että sähköajoneuvojen käyttöönotto oli yksi merkittävimmistä.

Ensimmäiset sähköajoneuvosukupolvet ovat vuodelta 1839, jolloin niitä valmisti Robert Anderson. Sähköenergiaa varastoitiin kertakäyttöisissä paristoissa. Kun ladattavat akut keksittiin vuonna 1880, alettiin sähköajoneuvoja massatuottaa, jo ennen polttomoottoriajoneuvoja.

Vuonna 1899 teki uuden nopeusennätyksen sähköauto, nimeltään “La Jamais Contente” (“ei koskaan tyytyväinen”), joka saavutti 105 km/h nopeuden Thomas Edisonin NiFe-akkujen ansiosta. Huippuaikaan 90 % autojen myynnistä oli sähköautoja.

Siitä huolimatta sähköajoneuvojen tuotanto lopetettiin, koska niiden toimintamatka ja suorituskyky olivat suhteellisen alhaisia. Toisaalta polttomoottoriajoneuvot kehittyivät nopeammin, lähinnä lentokoneiden moottorikehityksen seurauksena.

Nykyään IGBT-transistorien ja suuremman kapasiteetin akkujen kehittämisen ansiosta ovat monet valmistajat yhä suuremman paineen alla investoida sähköautoihin. Päätavoite on energian tehokkaampi käyttö, ja sen seurauksena fossiilisten polttoaineiden aiheuttamien päästöjen vähentäminen.

Lyhyellä aikavälillä akkujen latausinfrastruktuuri ei salli polttomoottoriautojen korvaamista sähköautoilla, ja akkujen antama toimintamatka sekä latausajat rajoittavat monia malleja. Nämä tekijät estävät sähköautojen täysimääräistä yleistymistä.

Kaikesta huolimatta suurimmalla osalla sähköautoista kuljetaan nykyään alle 60 km päivässä, ja yleensä kaupunkialueilla. Tällaiset matkat suurin osa sähköautoista voi kuitenkin suorittaa ilman ongelmia.

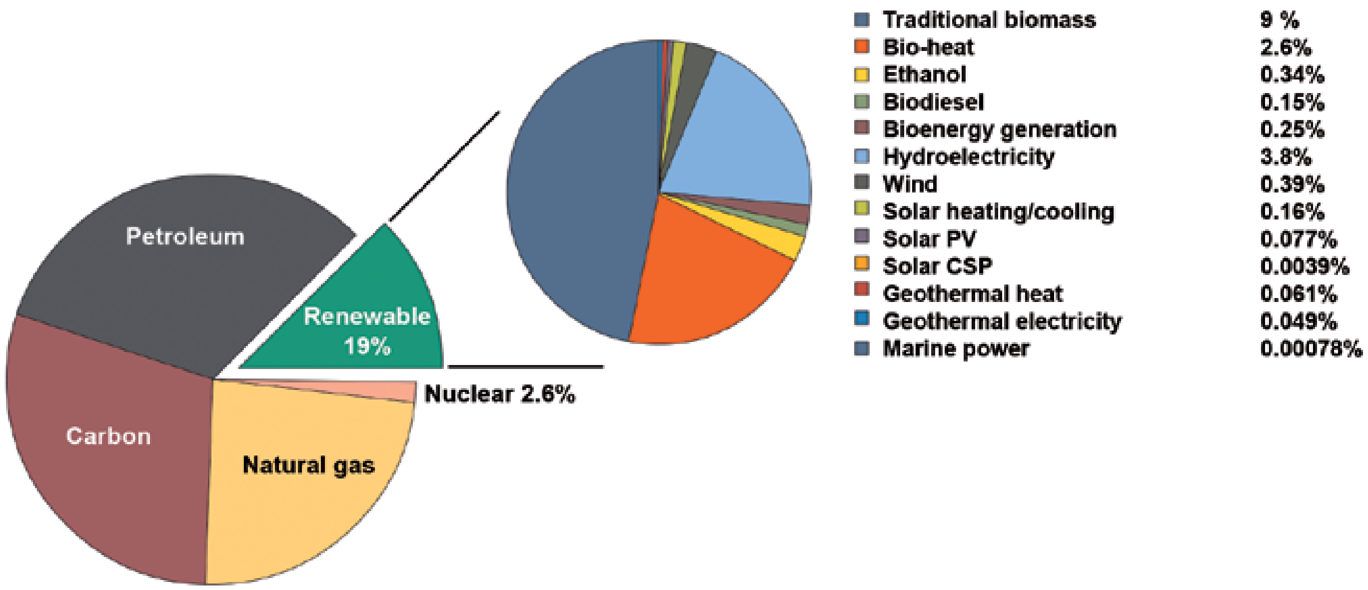
Lisäksi nopeampien latausjärjestelmien (tasavirtalataus) ja uuden sukupolven litium-ioni-akkujen kehittäminen lupaa parempaa tulevaisuutta sähköajoneuvoille.

AUTOJEN SÄHKÖISTYMISEN VAIKUTTAVAT TEKIJÄT

Energian tuotanto

Nykypäivän yhteiskunta, hyvinvointitasosta riippumatta, ei voi toimia tai selviytyä ilman riittävää ja säännöllistä energian saantia, mikä tarkoittaa, että koko energian tuotantoprosessi (hankinta, käsittely ja toimitus) muodostaa merkittävän osan maailman talousjärjestelmästä.

Seuraava kaavio vuodelta 2013 luokittelee kulutetun energian globaalilla tasolla lähteensä mukaan. Kaikista tunnetuista energialähteistä jotkut ovat saastuttavampia ja jotkut taloudellisempia kuin toiset.

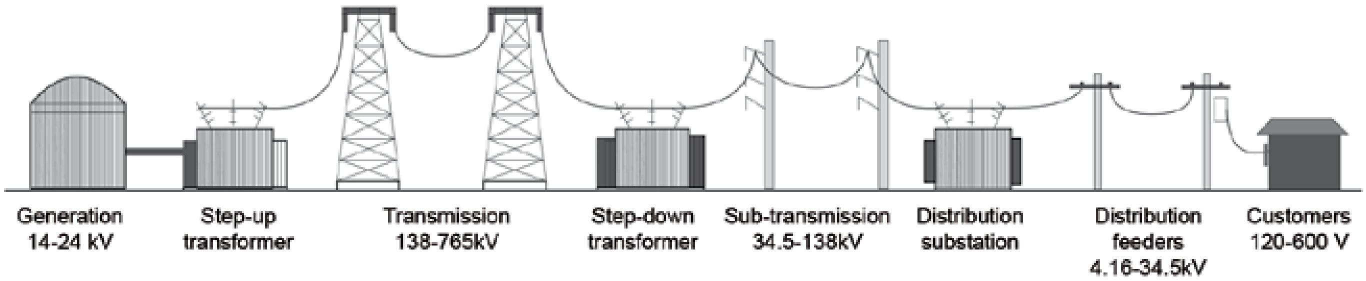


Jotta sähköenergian tuotanto olisi kestävää, sen ei tarvitse olla peräisin ydinfissiovoimaloista, vaan uusiutuvasta energiasta ja tulevaisuuden ydinfuusiovoimaloista.

Lisäksi tulevaisuuden kysynnän ennusteissa ennustetaan kasvua, joka voisi vaarantaa nykyisen energiajärjestelmän kestävyyden. Tästä syystä yritetään kehittää uusiutuvaa energiaa ja parantaa sähkönjakelutehokkuutta.

Jotta sähköajoneuvoja voisi olla saatavana suuressa mittakaavassa, on maasta riippuen tehtävä nykyiseen energiajärjestelmään perusteellinen muutos, aina tuotannosta jakeluketjun viimeiseen vaiheeseen saakka.

Lopputuloksena on, että suurin osa energiasta on kulutettava samassa paikassa, jossa se syntyy.



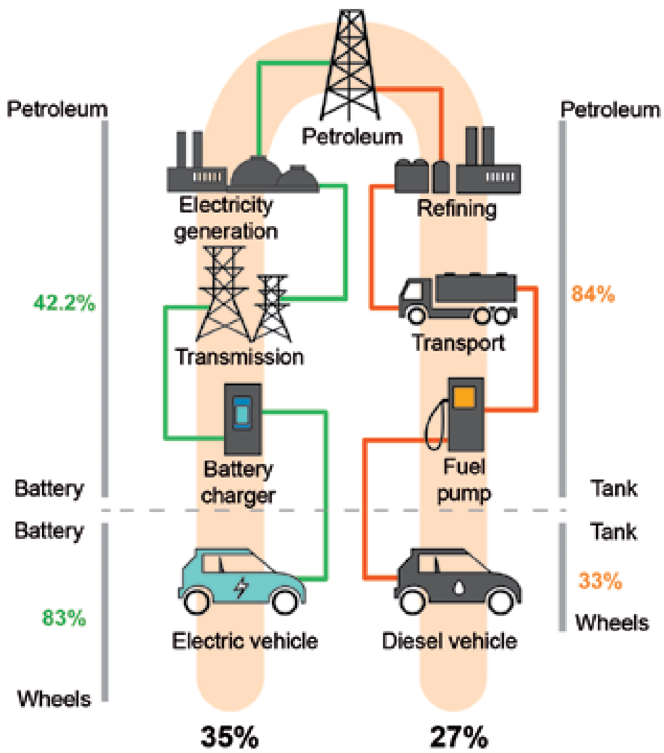
Energiatehokkuus

Kun analysoidaan polttomoottorilla varustetun auton suorituskykyä polttoainesäiliöstä pyöriin, ja nykyisen sähköauton suorituskykyä akustosta pyöriin, voimme nähdä, että sähköauton suorituskyky on paljon parempi kuin polttomoottorillisen, huolimatta energiatehokkuuden parannuksista kuten Euro-5 dieselauto Start-Stop-järjestelmällä ja regeneratiivisella jarrutuksella.

Kuitenkin kun vertaillaan sähkön tuottamista öljystä, ja otetaan huomioon koko ketju aina öljylähteestä pyörille saakka, ei sähköauton hyötysuhde ole enää paljonkaan parempi kuin dieselkäyttöisen ajoneuvon.

Siksi sähköenergiaa ei tule tuottaa hiilivetylähteistä.

Lisäksi sähköenergia olisi mahdollisuuksien mukaan saatava vasta itse kulutuspisteessä.



Ympäristövaikutus

Sähköauton tärkein etu on se, että se ei päästä saastuttavia kaasuja. Tutkimukset osoittavat, että 1 000 sähköauton ottamisella kaupunkikäyttöön, vähenevät ilmaan pääsevät saastuttavat kaasut 30 000 kg ja hiilidioksidipäästöt yli kaksi tonnia vuodessa.
Toinen suuri hyöty sähköautoista on, että ne eivät juurikaan tuota melua; sähkömoottoreista lähtee vain hyvin vähän desibeleitä. Hiljaisen ja värinättömän auton ajaminen on positiivinen ja arvokas tosiasia. Toisaalta melun puuttuminen vaikuttaa jalankulkijoiden ja pyöräilijöiden kuuloon perustuvaan turvallisuuteen tien päällä.

EUROOPPALAISET HYVÄKSYNNÄT JA ASETUKSET

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.

Euroopassa on käytössä **ECE-asetus 100**, joka sisältää sähköajoneuvojen erityisvaatimukset niiden valmistuksen ja käyttöturvallisuuden suhteen. Mainitun asetuksen muutossarja 01 tuli voimaan 4. joulukuuta 2010, ja siitä tuli sitova kaksi vuotta myöhemmin.

ECE-sääntö 100.00: Sovelletaan vain sähköajoneuvoihin, lukuun ottamatta hybridejä ja M- ja N-luokan ajoneuvoja, joiden suurin nopeus on yli 25 km/h. Tämä asetus määrittää rakenteelliset vaatimukset (sähkökontaktien suojaus, sekä eristyksien ja kuormituskohteiden vastusarvot), toimintavaatimukset, ja vetypäästövaatimukset.

ECE-asetus 100.01: edellisen asetuksen kehitysversio. Tämä asetus kattaa myös aiemmasta puuttuneet hybridiajoneuvot. Muita säädöksen kohtia on lisätty tai muokattu, kuten korkeajännitteen uudelleenmäärittely siten, että se on välillä 60 V – 1 500 V tasavirtaa, ja välillä 30 V – 1 000 V vaihtovirtaa. Muun muassa liittimille on nyt asetettu turvallisuusvaatimukset, lisäksi korkeajännitekaapeleiden eristys on merkittävä oranssilla värillä, ja mittausmenetelmät, jotka erottavat tasavirta- ja vaihtovirtapiirit, on muutettu.

Alla on lueteltu muut yleiset artiklat, jotka koskevat erityisesti sähköajoneuvoja:

- **R10**: Määrittelee ajoneuvojen **sähkömagneettisen yhteensopivuuden** sähkömagneettisten aaltojen tuottamisen ja niiden häiriöiden suhteen.
- **• R13 ja R13H: Käsittelee henkilö- ja hyötyajoneuvojen jarrutusta ottaen huomioon myös sähköajoneuvojen regeneratiivisen jarrujärjestelmän.**
- **R79**: Määrittelee **ohjausjärjestelmien** osalta niiden rakenteelliset ominaisuudet, mekanismien enimmäisvoimat, ja muut ajoneuvon sähköisiä ohjausjärjestelmiä koskevat määräykset.
- **R85**: Määrittää **moottorien tehon**. Liitteeseen lisätään sähkökäyttöisten moottorien tehon laskenta sekä nettotehokokeessa että maksimiteholla 30 minuutin ajan.
- **R94 ja R95**: Viittaa matkustajien suojaamiseen ajoneuvon edestä ja takaapäin tapahtuvassa törmäyksessä.
- **R101**: Sisältää **hiilidioksidipäästöt ja polttoaineen kulutuksen** polttomoottori- ja hybridiajoneuvoissa, sekä sähköajoneuvojen kulutuksen ja toimintasäteen.

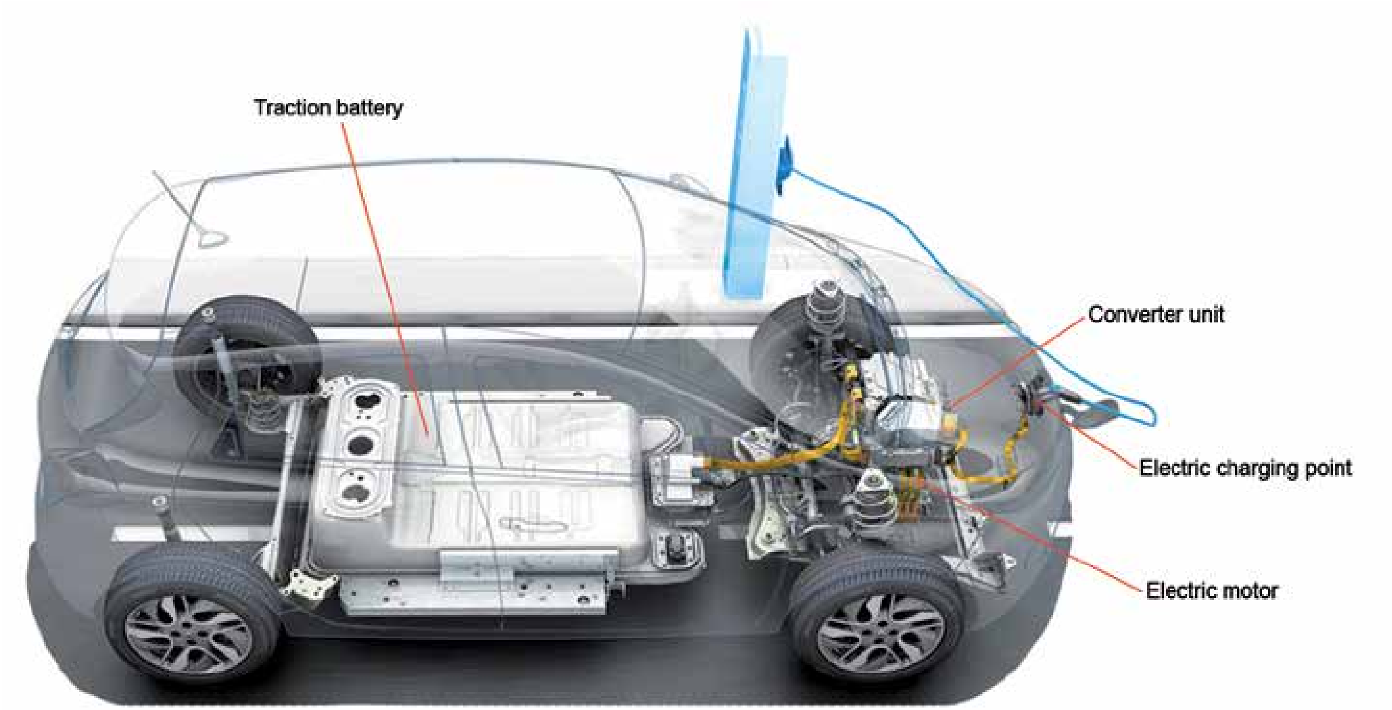
Direktiivissä 2000/53 määritellään ajoneuvon käyttöikä, ja **direktiivissä 2005/64** ajoneuvon hyväksyntä, sekä sen soveltuvuus uudelleenkäyttöön ja kierrätykseen. Sähköajoneuvoille nämä määräykset ovat tärkeitä, koska niiden suunnittelussa ja tuotannossa tulee ottaa huomioon akkujen ympäristövaikutukset niiden valmistuksen, käytön ja kierrätyksen suhteen.

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.

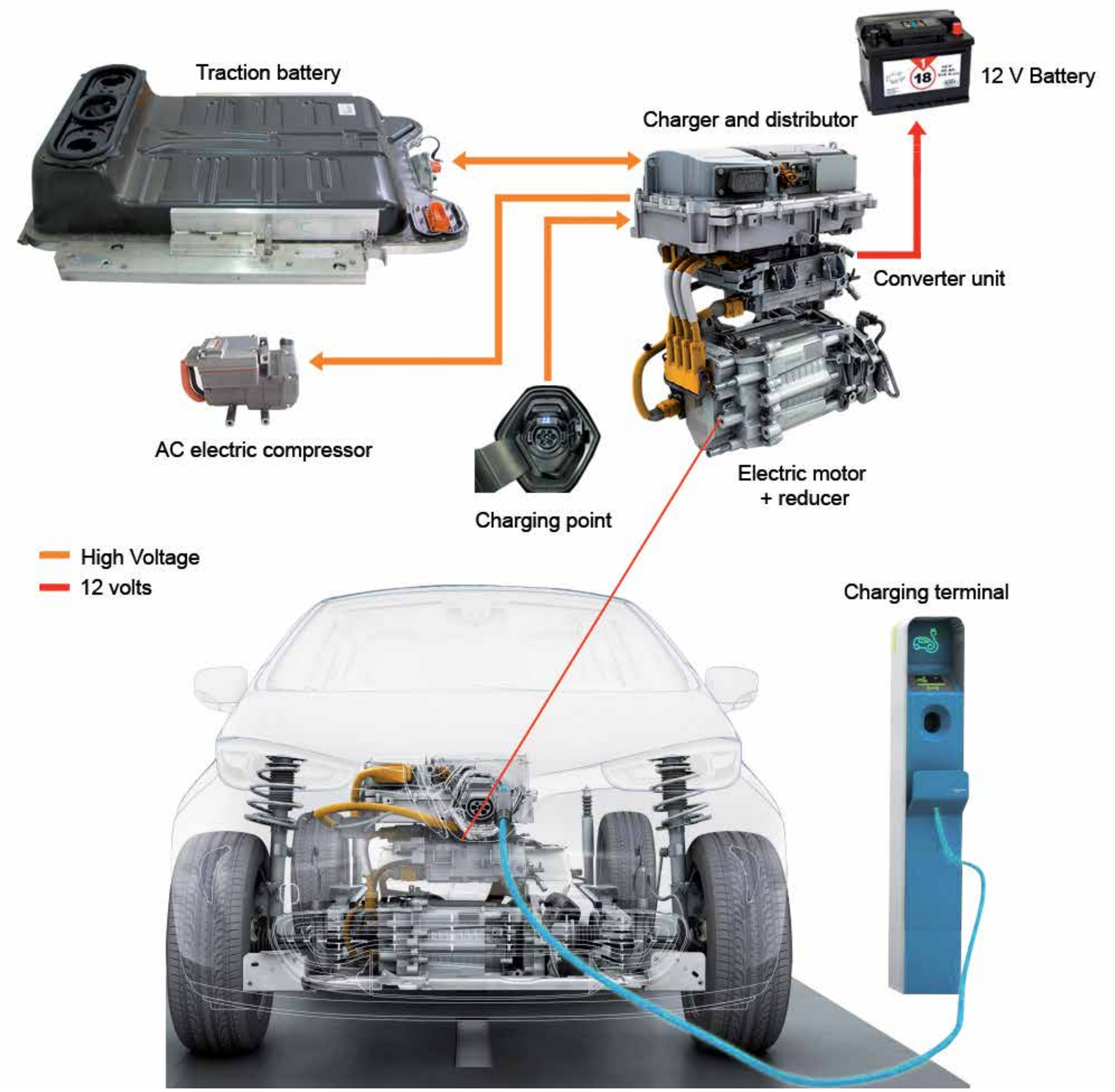
12-volt network: The function of this network is the same as that for a conventional vehicle. It is used in all the safety systems (active and passive), 12 V battery charging, lighting, comfort, power to electronic units, etc.

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.



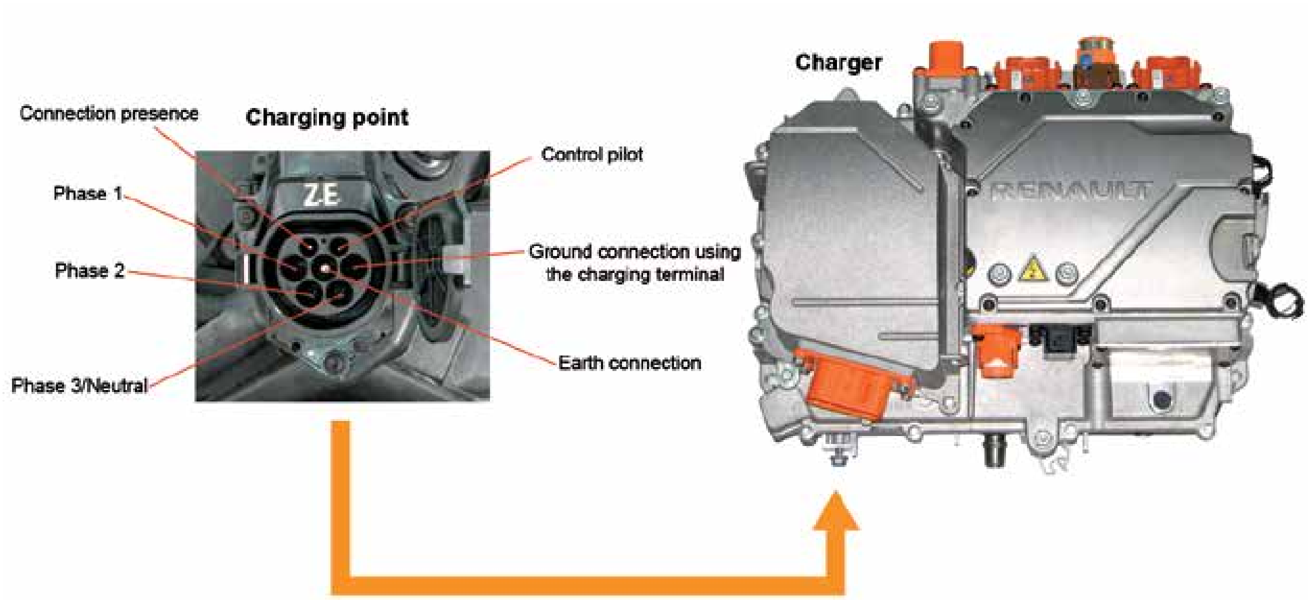
MAIN COMPONENTS OF THE DRIVE SYSTEM

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

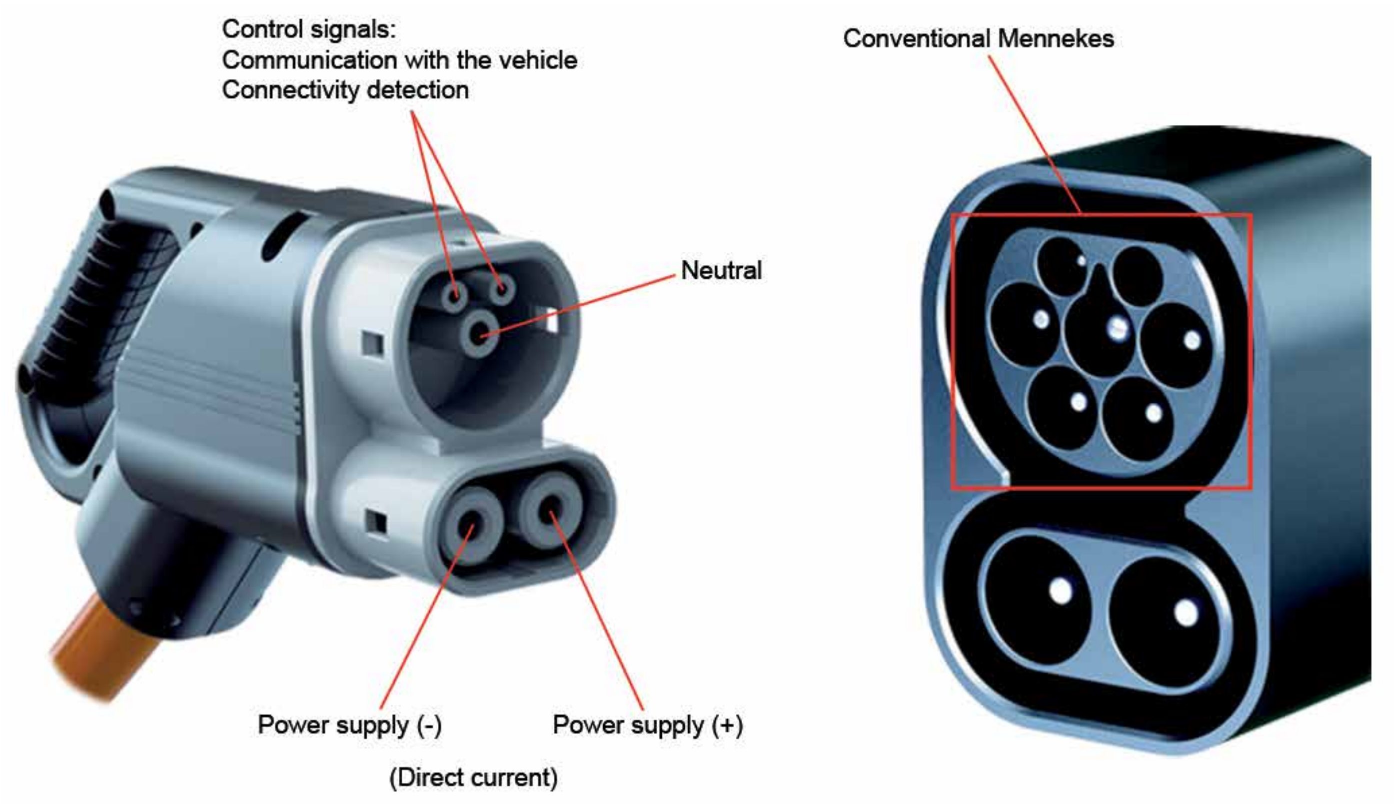
Electric vehicle manufacturers have set out their own communication protocols which form part of the battery charging processes. These protocols report on battery status, charge level, protection during charging and the charging process itself. Due to incompatibility between different protocols and connectors, 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).

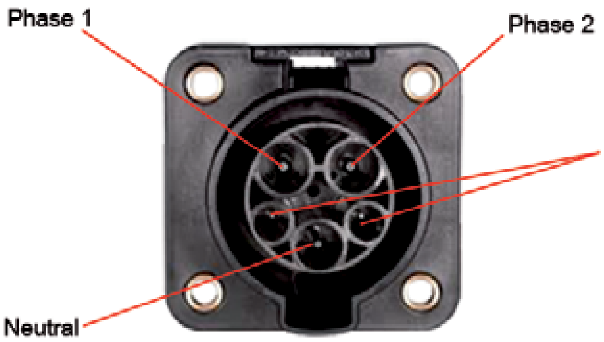
Alternating current	Single and three-phase up to 16-63 A
Voltage	100-500 V
Power	Up to 43.8 kW
Communication protocol	PLC (Power Line Communications)

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**.



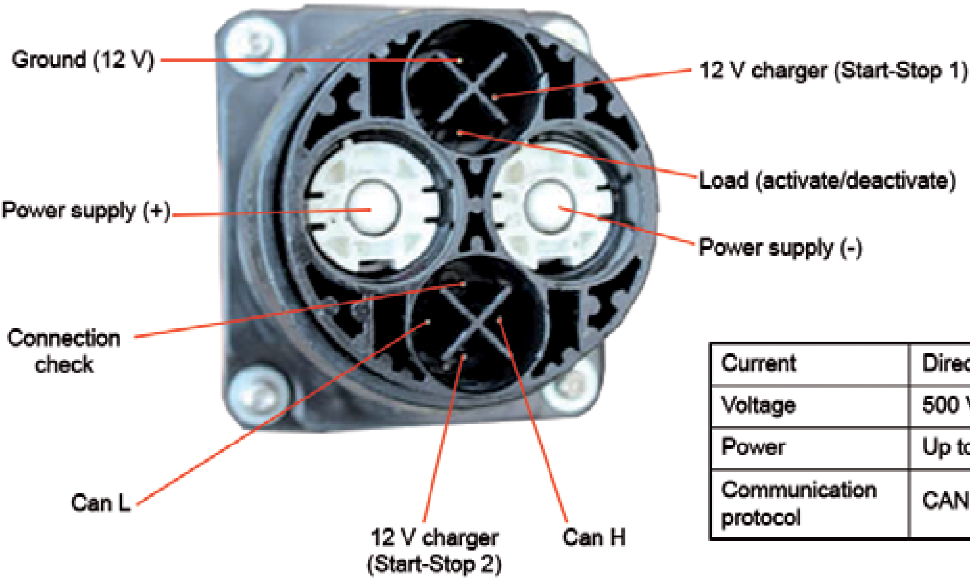
- **SAE J1772 or Yazaki:** This is developed in the US. Only for the American standard.

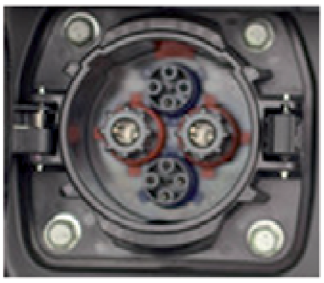
Alternating current	Single phase from 10 - 80 A
Voltage	110-250 V
Power	1.92 kW; 7.4 kW; up to 19.2 kW
Communication protocol	PLC (Power Line Communications)



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).

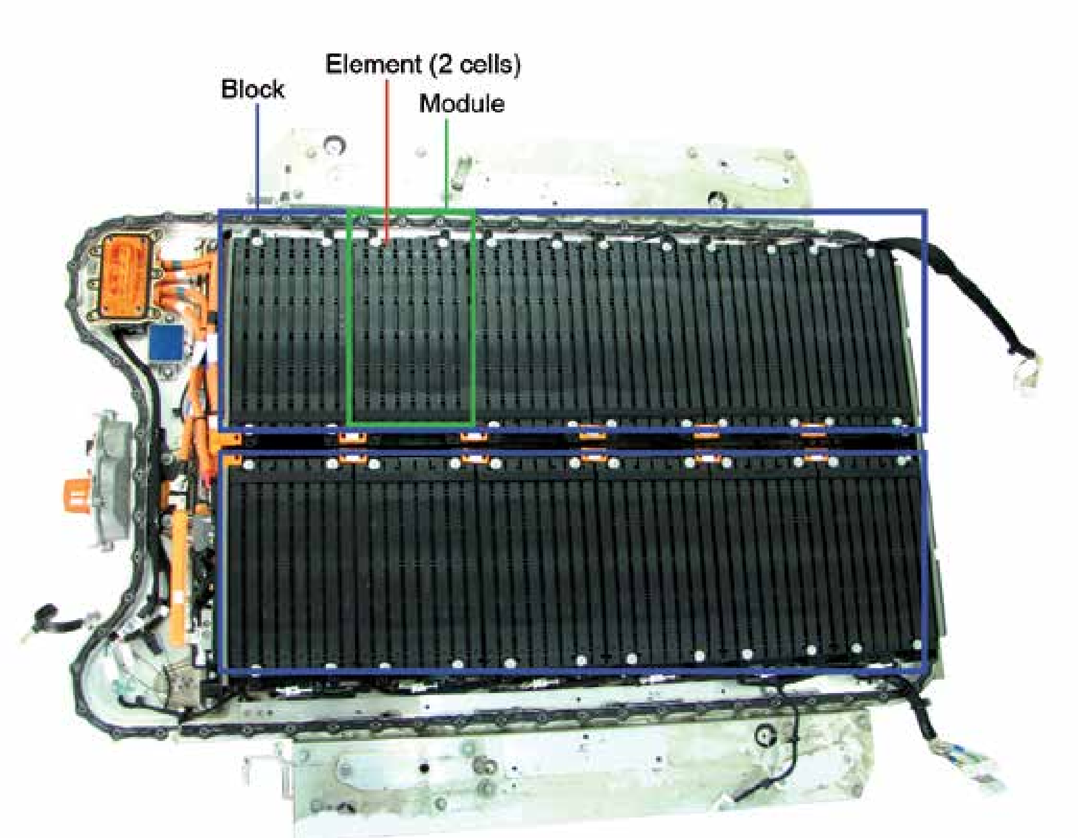
Traction battery

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.



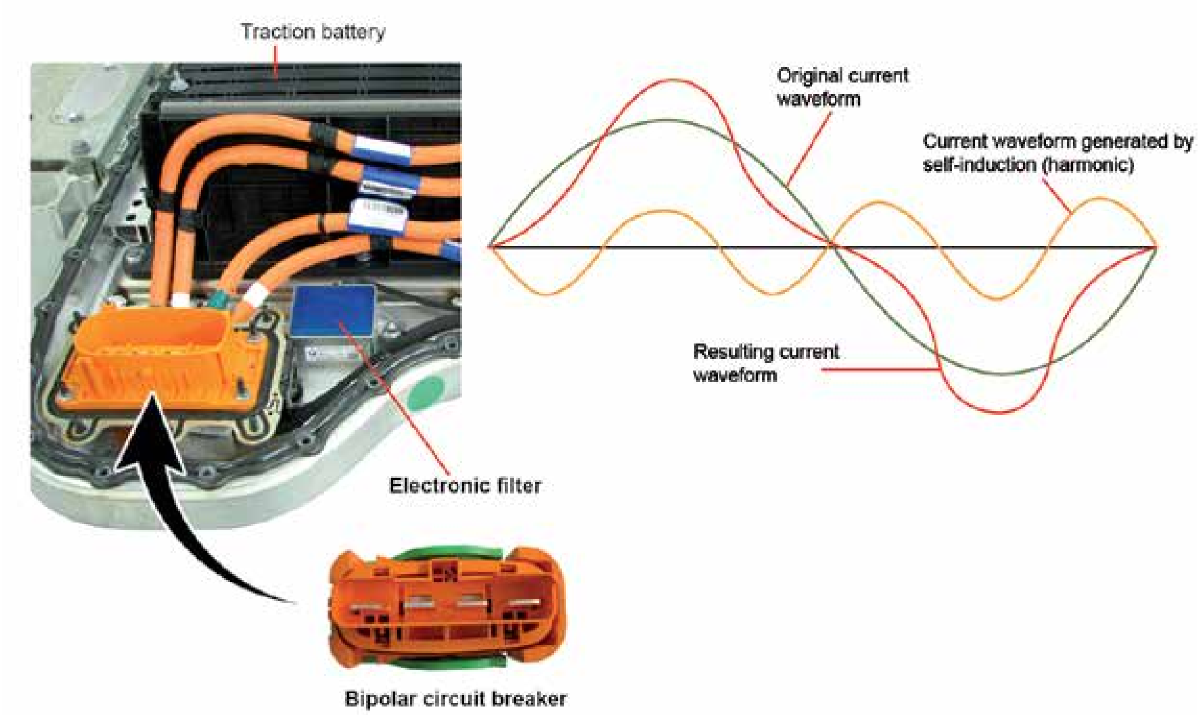
Note: Some of the more sophisticated vehicles such as the Tesla Model S includes more than 8,000 cells in its battery. The capacity provided is 100 kW/h and a range of more than 500 km between charges.

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.

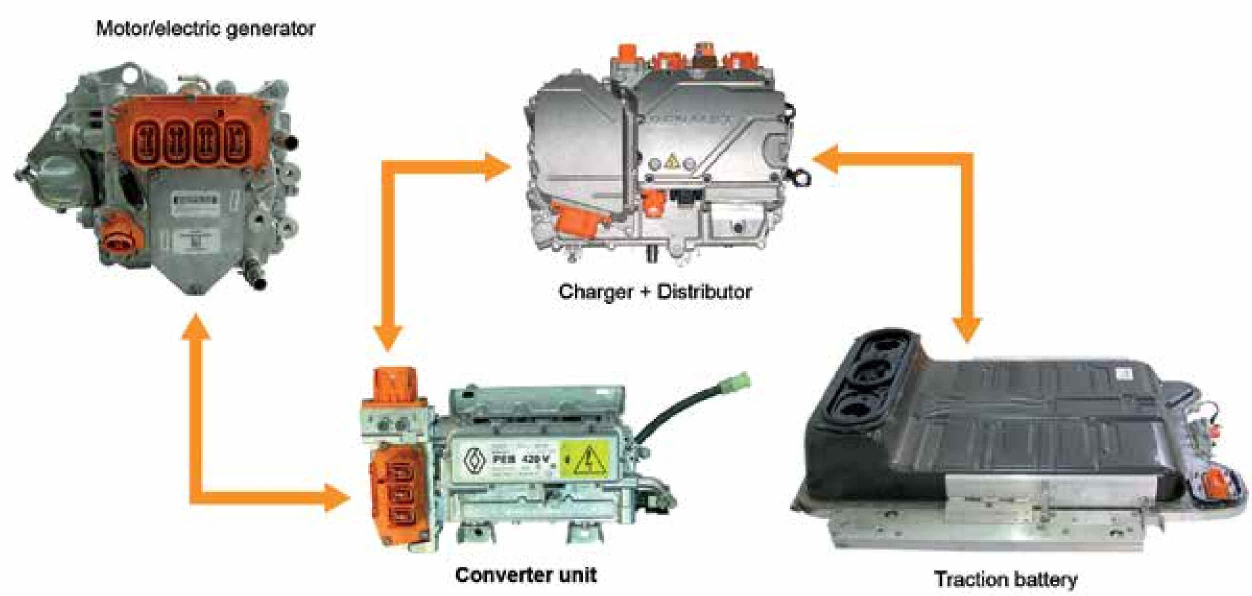
For safety in these batteries, a bipolar circuit breaker is included which allows the positive and negative terminals of the traction battery to be disconnected from the rest of the vehicle installation. It is a safety system which prevents hazardous currents in the rest of the wiring and high voltage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



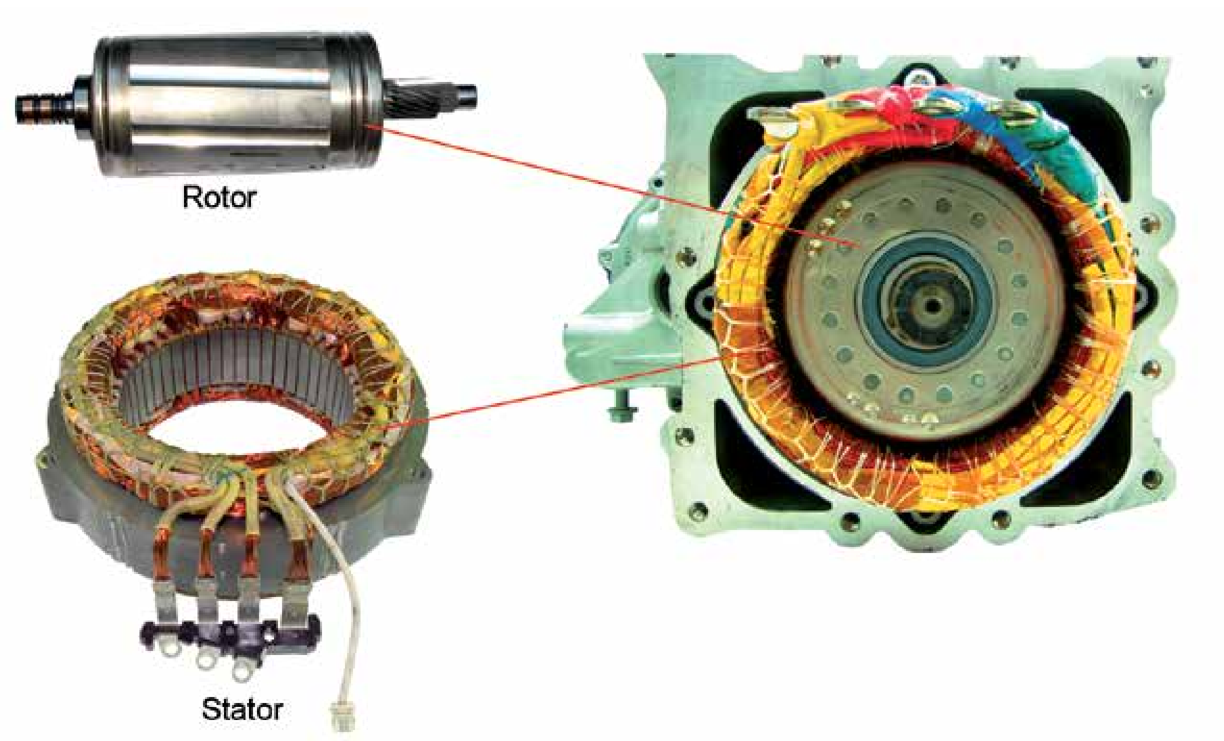
Communication between the converter unit and the electric motor is via special wiring. All the high voltage cables are shielded to prevent parasites as much as possible.
In turn, the converter manages switch on of the phases of the stator depending on the rotor position, the power demand, the regenerative 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.



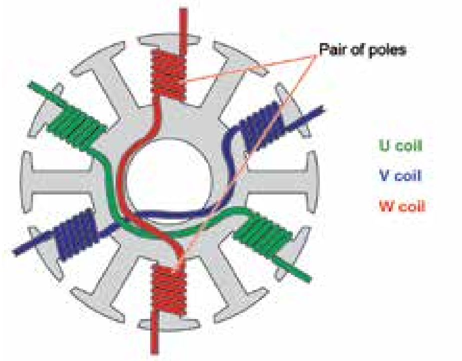
Engine type

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.

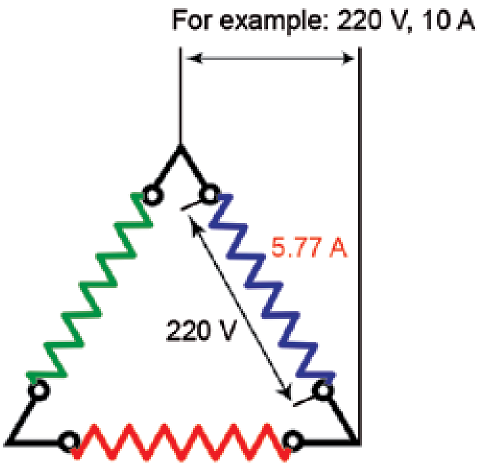
The stator

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.

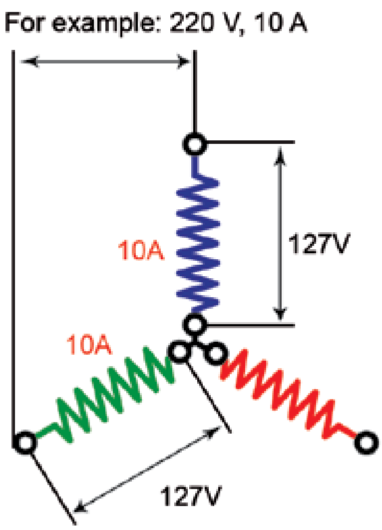


-Delta connection-



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

-Star connection-



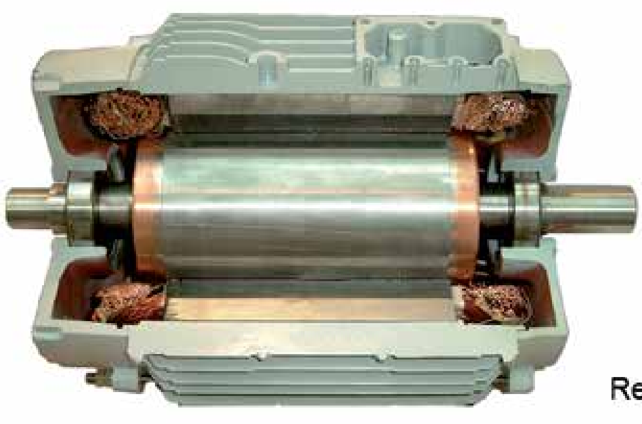
$$V\ phase = \frac{V\ line}{\sqrt{3}} \qquad I\ phase = I\ line$$

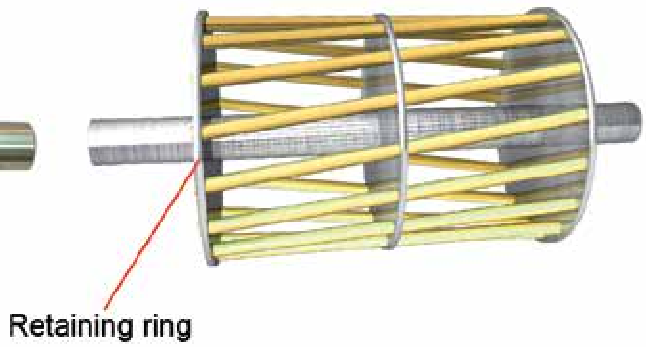
The rotational power of a motor connected in star or in delta is the same. However, when the phases are connected in delta, the intensity and motor torque is lower compared to one connected in star, while its rotational speed and voltage are higher. On the other hand, when the phases are connected in 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

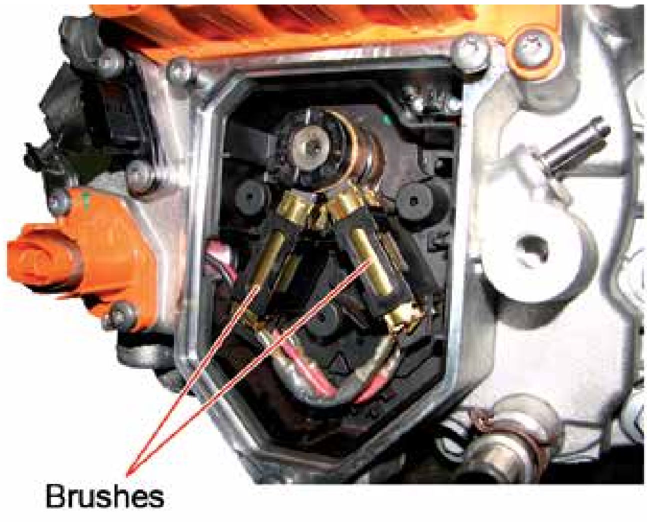
Depending on whether the motor is synchronous or asynchronous, it may have one rotor or another. Asynchronous motors include a squirrel cage rotor. While synchronous motors normally use a permanent magnet rotor.

- **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.



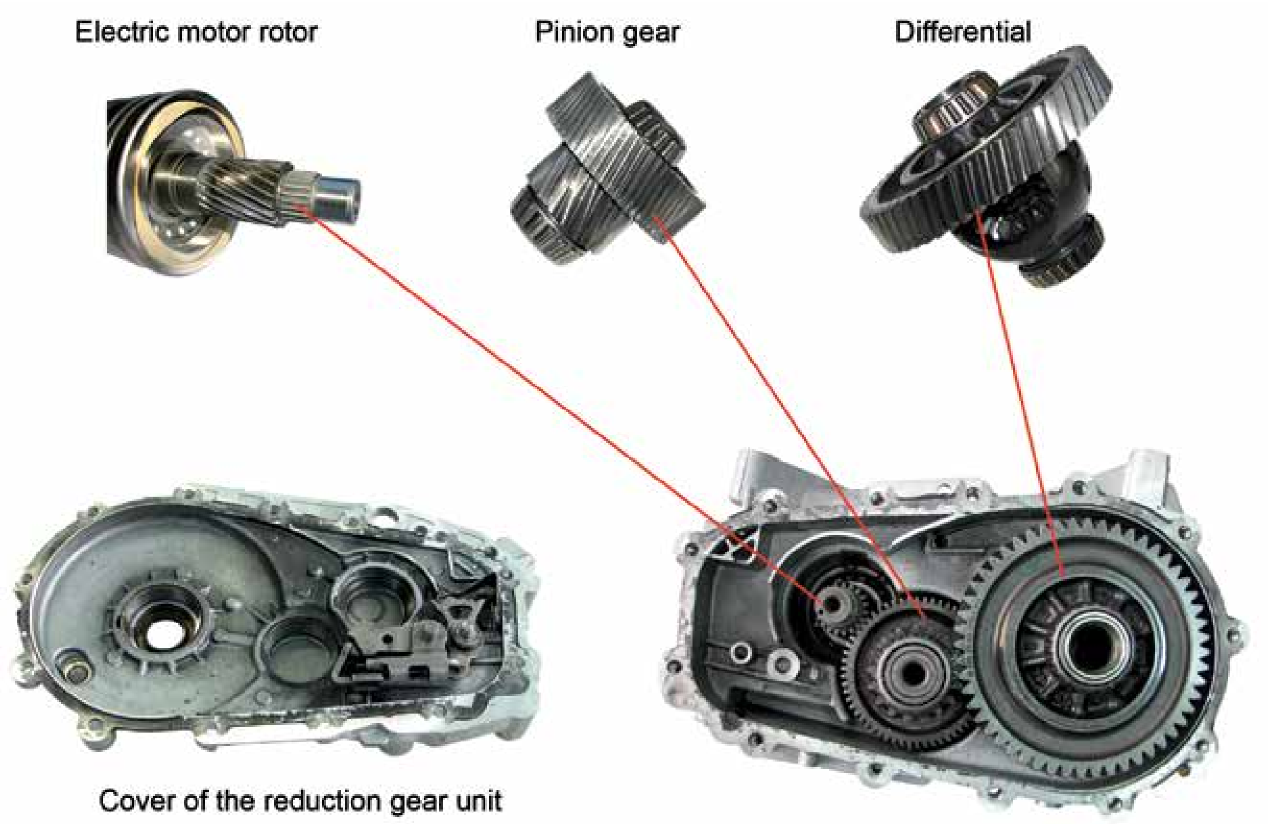
- **The permanent magnet:** rotor does not have to “create” a magnetic field by absorbing current from a power source, as the magnets themselves already generate this magnetic field. Neodymium is a material that is often used for this type of magnet.

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).

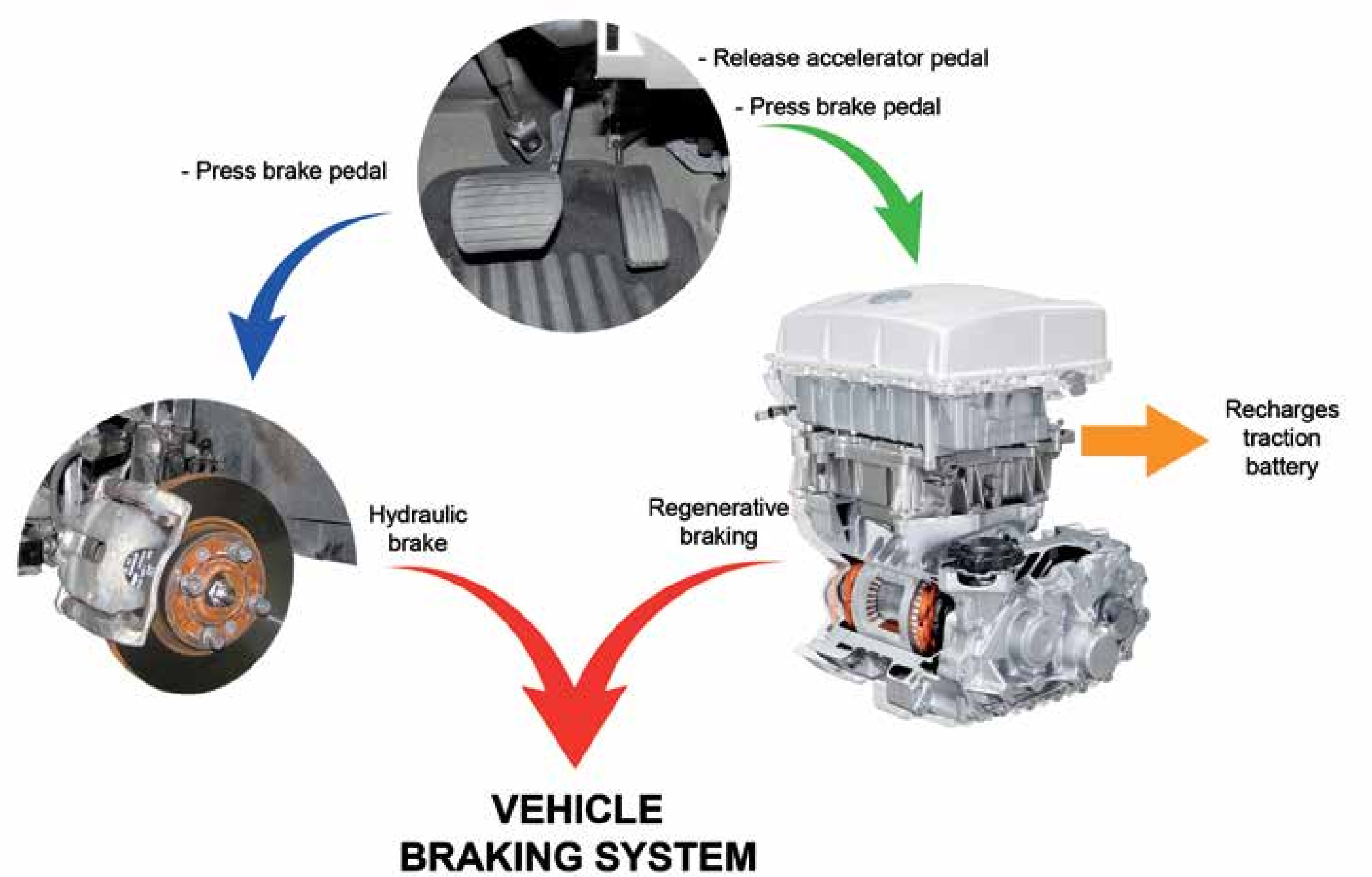
The conventional braking system (hydraulic) usually has a brake booster which operates in a vacuum. In a conventional vehicle, the vacuum comes from the intake manifold (petrol engine) or brake pedal (diesel engine). In the case of an electric vehicle, this vacuum can only be created, generally speaking,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

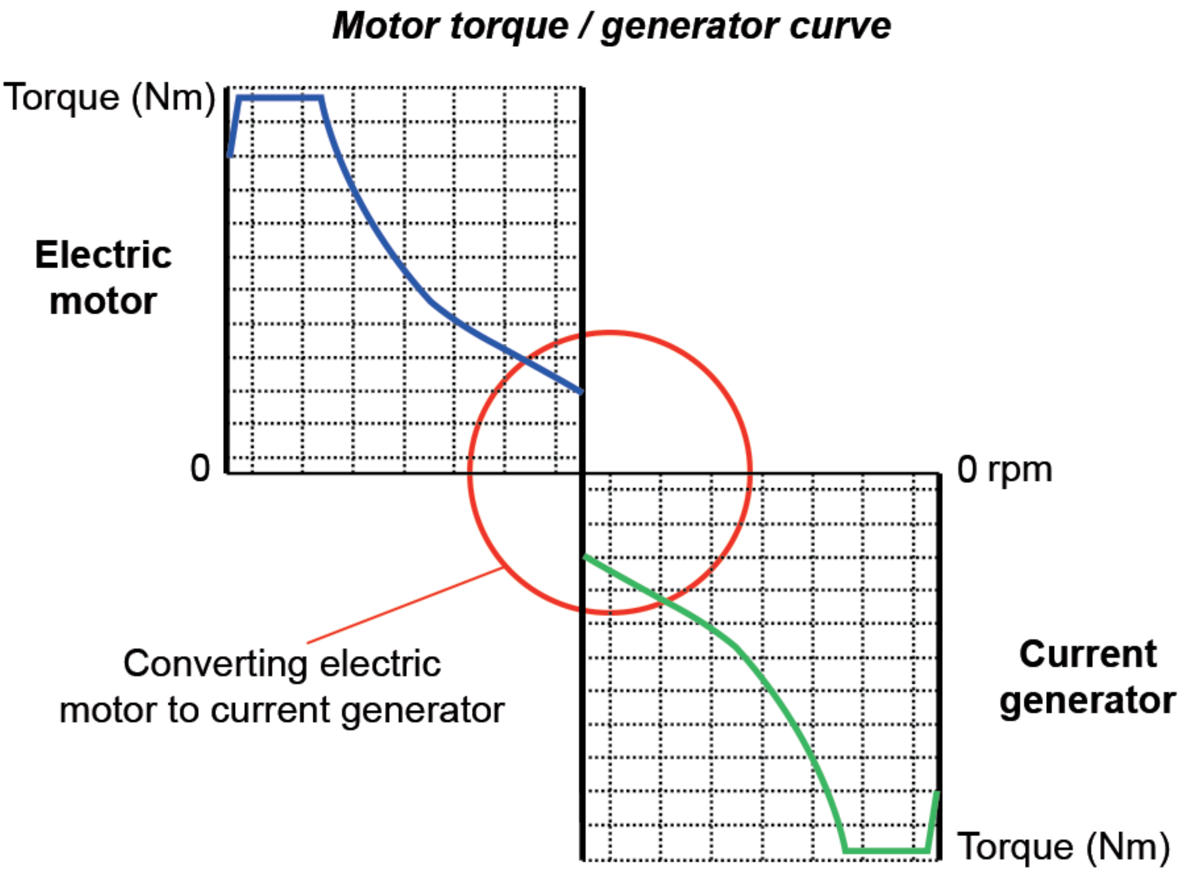
Regenerative braking in these types of vehicle comes into operation when the accelerator pedal is released. At this moment, the electric motor stops giving traction to the wheels in order to invert its function to generator. The inertia of the rotor causes an electromagnetic induction in the stator coils, 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.

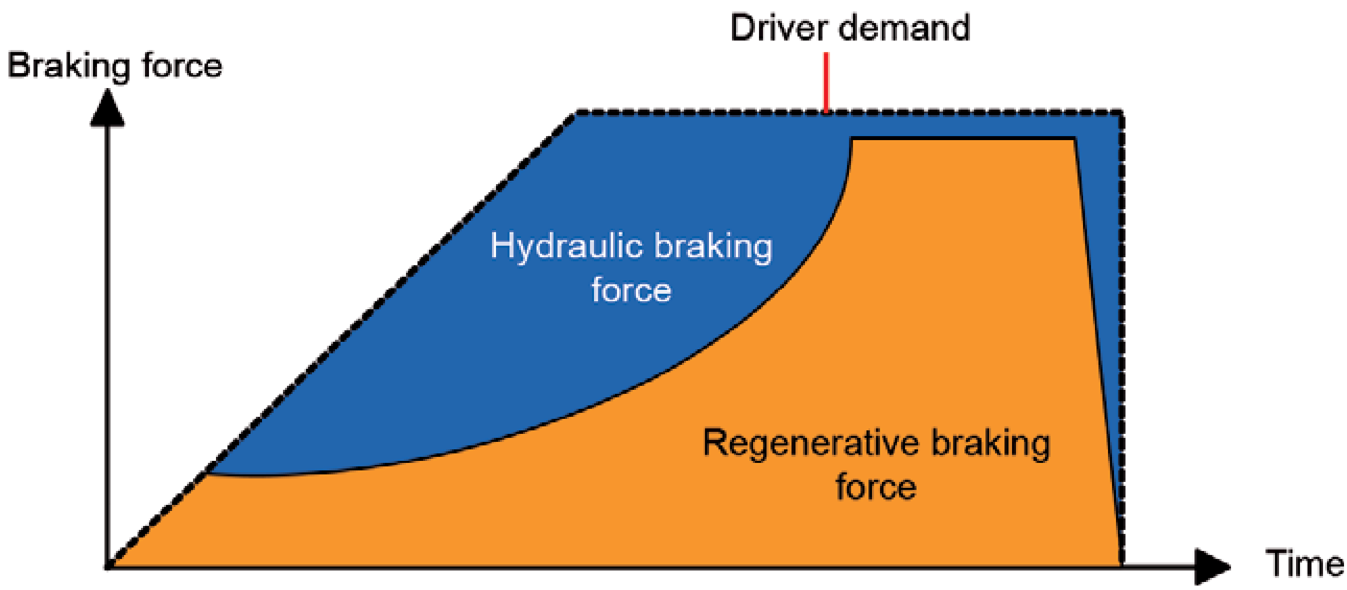
In order for the electric vehicle to brake effectively and, in turn, gain the most benefit from regenerative braking for charging the traction battery, a braking system is required which continuously combines both braking systems.



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

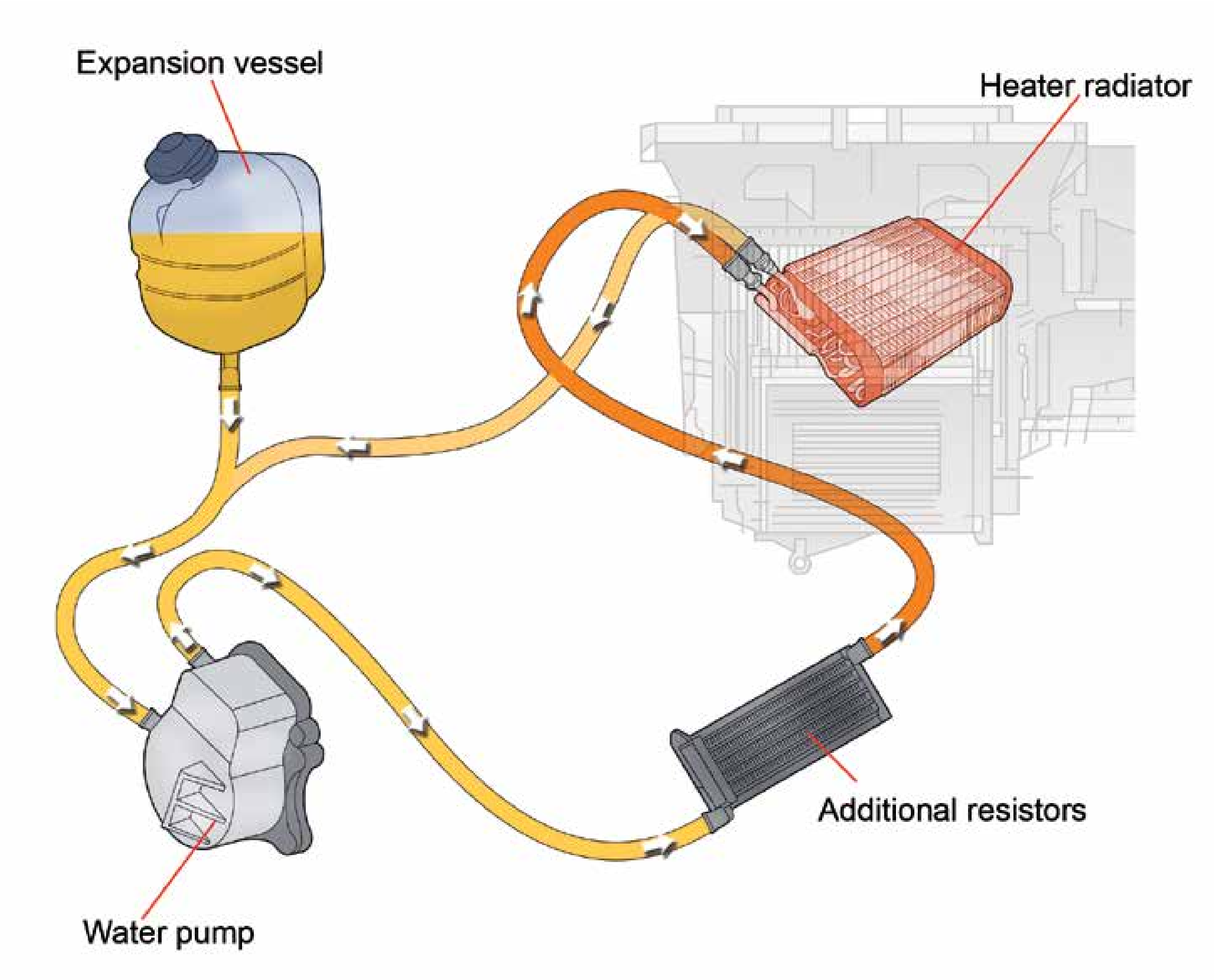
As there is no internal combustion engine, electric vehicle manufacturers asked two questions:

- 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.

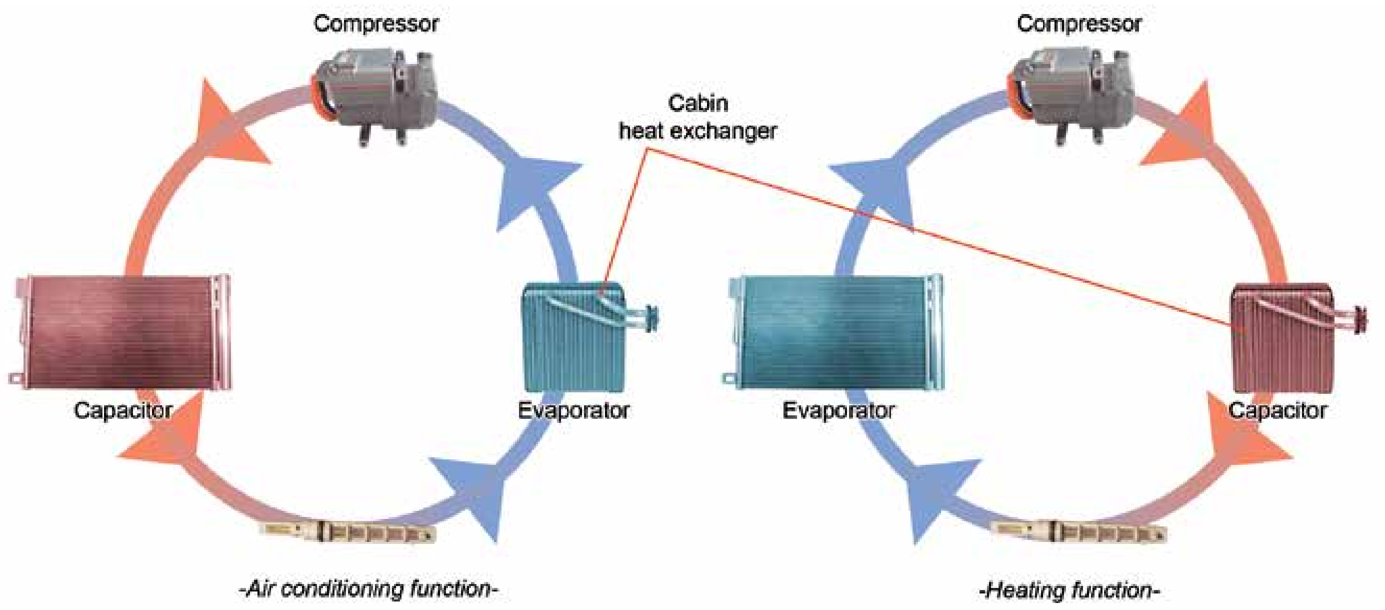
These types of compressor are usually of the Scroll type and their position is the same as for a conventional vehicle, that is, in the engine compartment.

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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