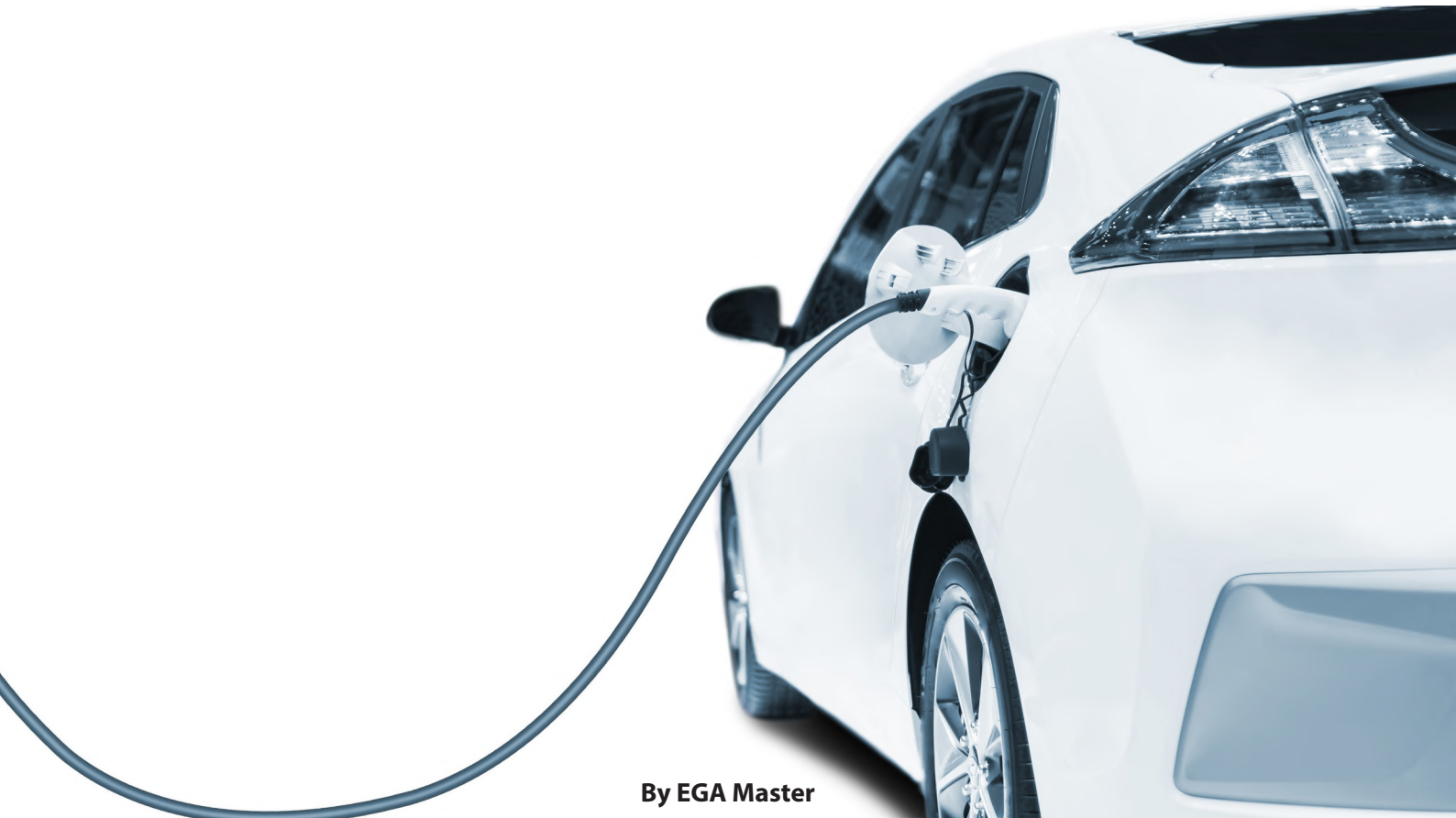
Electric Vehicle

Engineering, maintenance and repair



By EGA Master

The irruption of electric vehicles (EV) is going to revolutionize, not only the way in which the mobility is conceived, but also the way of working of those who are responsible for their manufacture, maintenance and repair.

For this reason, the tools and accessories to be used will be totally different, and therefore there will be a need to get training in their use.


Plug into your future
EV

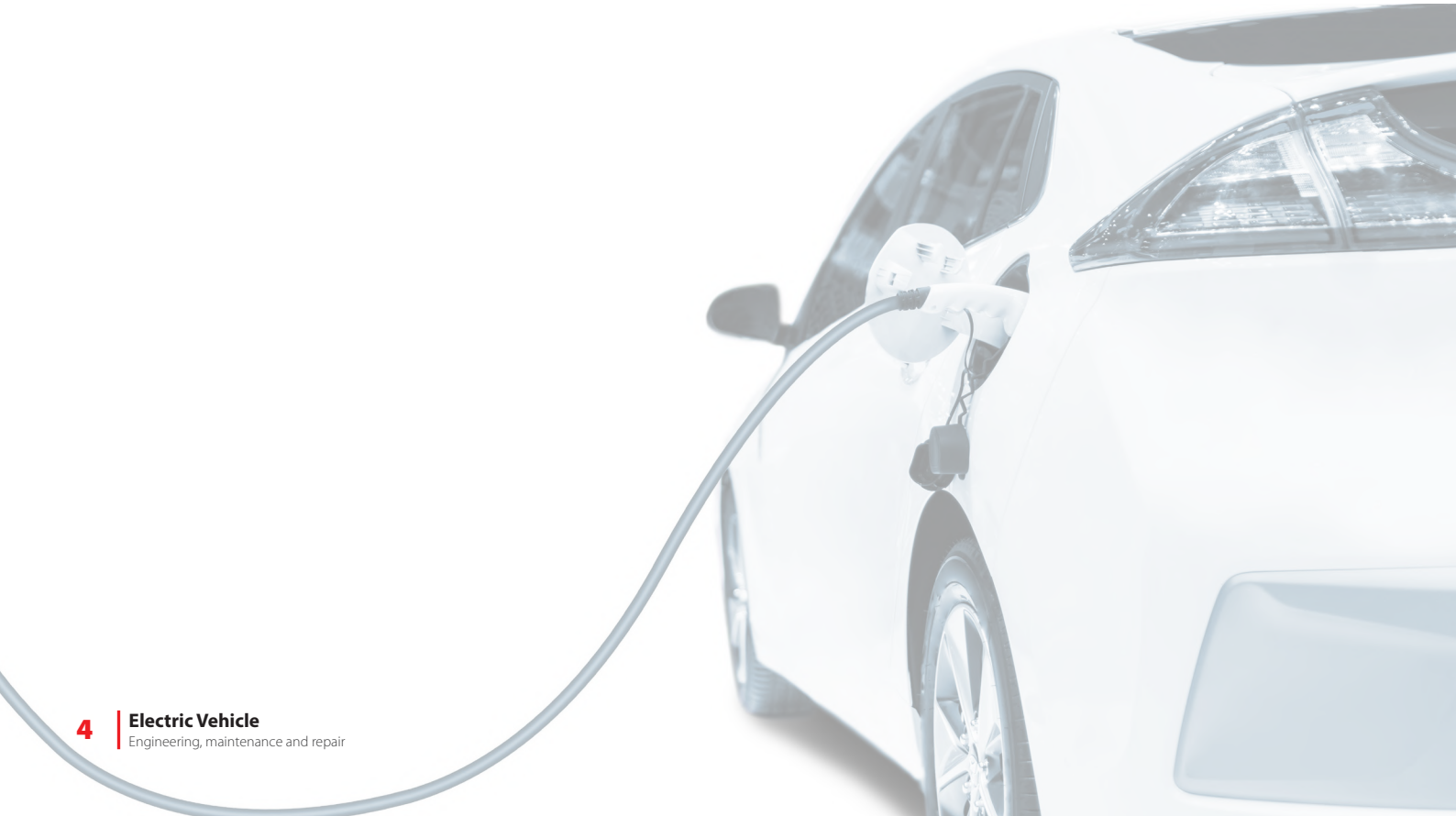
1

TYPES OF ELECTRIC VEHICLES

Despite the strong influence of the explosion engine, electric vehicles are taking up that historic prominence that it lost in the early 20th century.

While some progress has been seen since the 1990s, they have been timid, and when more insistence has been placed on the development of these new means of transport it has been during the 2010s.

These developments have allowed a variety of types of electric cars to exist today, depending on the type of technologies used for their operation. This accelerated development has come not only because of the demands of the market, but also because of legislation, such as that of the European Union.



Among the types of electric vehicles, we can see as follows:

1.1 BEV

The acronym comes from ***Battery Electric Vehicle.*** It could be said they are purely electric vehicles. They move thanks to the built-in electric motor or motors that are powered by a battery that recharges in the grid.

1.2 FCEV

These acronyms come from ***Fuel Cell Electric Vehicle***. This could also be considered purely electric.

1.3 EREV

These are ***Extended Range Electrical Vehicles.*** They are not as purely electric as the previous two, since they are composed of a combustion engine, and one or more electric motors. The gasoline engine is a power supply for battery recharge

1.4 PHEV

These are ***Plug-in Hybrid Electrical Vehicle.*** These are also made up of a petrol engine and an electric engine, but the difference with EREVs is that both engines work to move the vehicle, separately and in combination.

1.5 HEV

Hybrid Electrical Vehicles, non-pluggable hybrids, or hybrids as they are generally known, differ mainly in that they are composed of a small battery, giving the vehicle little autonomy and that it is recharged by the combustion engine or the energy generated by braking

Among the types of electric vehicles, we have battery, fuel cell, extended range, plug-in hybrid and hybrid electrical vehicles

2

BATTERIES AND TYPES

If it is intended to make much of the car park to be composed of electric vehicles, it is necessary to use a battery that allows greater autonomy, charging efficiency, and does not harm the environment due to its use.

A battery consists of two or more electrical cells attached together. Cells convert chemical energy into electrical energy. Cells consist of positive and negative electrodes joined by an electrolyte. It is the chemical reaction between the electrodes and the electrolyte that generates electricity from DC. In the case of secondary or rechargeable batteries, the chemical reaction can be reversed by reversing the current and battery back to the charging state.

The concepts to consider in the design of a battery are:

- **Specific energy:** This is the amount of energy stored per kilogram of battery mass (Wh/Kg)
- **Power Density:** This is the amount of energy stored per battery volume (Wh/L)
- **Specific power:** This is the amount of power acquired per kilogram of battery. The power emitted by the battery depends much more on the charge connected to it than on the battery itself. It is measured in W/kg.
- **Efficiency in amps per hour:** In an ideal world, a battery would return all the charge put on it, i.e. the efficiency of amps per hour is 100%. However, no battery does; its load efficiency is less than 100%. The exact value will vary with the different battery types, temperature and charge rate. It will also vary with the charging status.
- **Energy efficiency:** It is defined as the relationship between the electrical energy supplied by a battery and the amount of electrical energy needed to return it to the pre-discharge state. This efficiency will depend not only on the type of battery, but also on how it is used. If the battery is charged and discharged quickly, for example, energy efficiency decreases considerably.
- **Commercial availability**
- **Economic cost**
- **Operating temperatures**

It is necessary to use a battery that allows greater autonomy, charging efficiency, and does not harm the environment due to its use

- **Self-discharge rates:** Most batteries are discharged when not in use, known as self-discharge. This is important, as it means that some batteries cannot be left unsused for extended periods of time. The speed of this rate varies with the type of battery and with other factors such as temperature. Higher temperatures generally greatly increase self-discharge.
- **Number of life cycles:** Most rechargeable batteries only undergo a few hundred deep cycles up to 20% of the battery charge.
- **Recharge rates**
- **Battery geometry:** Normally packaged in rectangular blocks. Some batteries can only be supplied with fixed geometry. Others can be supplied in a wide variety of heights, widths, and lengths.
- **Loading methods**
- **Cooling or heating needs:** Although most batteries operate at room temperature, some of them operate at higher temperatures and need to be heated to start and then cool down when in use.

  In others, battery performance decreases at low temperatures, which is not desirable, but this problem could be overcome by heating the battery.

There is a manifold of types of batteries on the market; lead-acid, nickel-cadmium, hybrid nickel metal, sodium-sulfide, molten salt and lithium-ion batteries

A. TYPES OF BATTERIES

There is a manifold of types of batteries on the market, with their pros and cons.

- **Lead-acid batteries:** One of the most notable features is its extremely low internal resistance. This means that the voltage drops as the current is consumed is very small.

  Its discharge rate will depend on the temperature at which the battery operates. The higher the temperature, the faster it will discharge.

- **Nickel-cadmium batteries:** The NiCad battery has advantages of specific high power, a long-life cycle (up to 2500 cycles), a wide range of operating temperatures from -40oC to +80oC, low self-discharge and good long-term storage.

  This battery is a very stable system, with reactions equivalent to the self-discharge of the lead-acid battery, but they occur more slowly.

- **Hybrid Nickel Metal Batteries:** In terms of energy density and power density, the metal hydride cell is somewhat better than the NiCad battery. Nickel metal batteries have a nominal specific energy of approximately 65 Wh/kg and a nominal energy density of 150 Wh/m3 as well as a maximum specific power of approximately 200 W/kg.

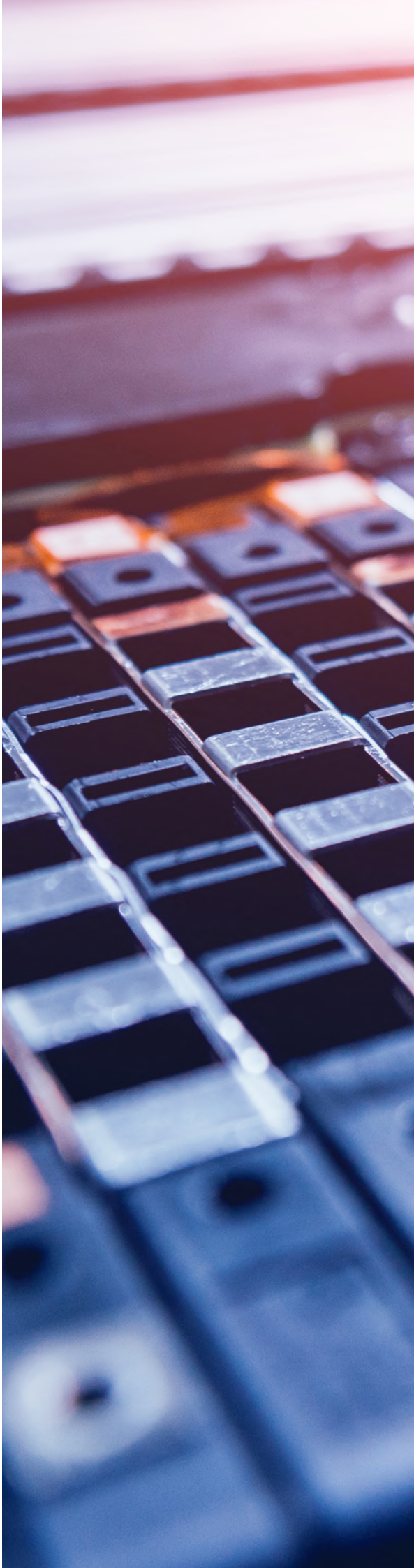
- **Sodium-sulfide batteries:** They operate at temperatures between 300oC and 350oC. To keep the heat in the battery, the cells are locked in a vacuum box. Basic sodium-sulfide cells have a specific high energy, six times that of lead-acid batteries.

  When in use, the cells are spontaneously heated due to the electric current passing through the internal resistance of the battery. When not in use for more than a day, the inside of the battery should be kept warm by using electric heaters.

- **Molten salt batteries:** The main problem with the battery is that it needs to operate at a temperature of approximately 320oC, like sodium-sulfur.

  Thermal insulation is maintained by using a double wall stainless steel case, with 2-3 cm of insulation between the two layers.

  All air is removed from the insulation and vacuum is maintained for several years. However, unless for a very short period, a few hours, these batteries should be kept connected to the grid when not in use. This is to keep the battery warm and is an important limitation for its application.



- **Lithium-ion batteries:** Electric energy is obtained from the combination of lithium carbon and lithium metal oxide to form carbon and lithium metal oxide.

  An important point about lithium-ion batteries is that precise voltage control is needed when charging lithium cells. If it is slightly too high, it can damage the battery, and if it is too low, the battery will not be sufficiently charged. However, specific chargers have been developed for this type of battery.

  But what has made her the queen of batteries is, among other reasons, her specific energy, which is 3 times that of lead-acid batteries.

Her specific energy, which is 3 times that of lead-acid batteries, is among other reason what has made the Lithium-ion battery the queen of batteries

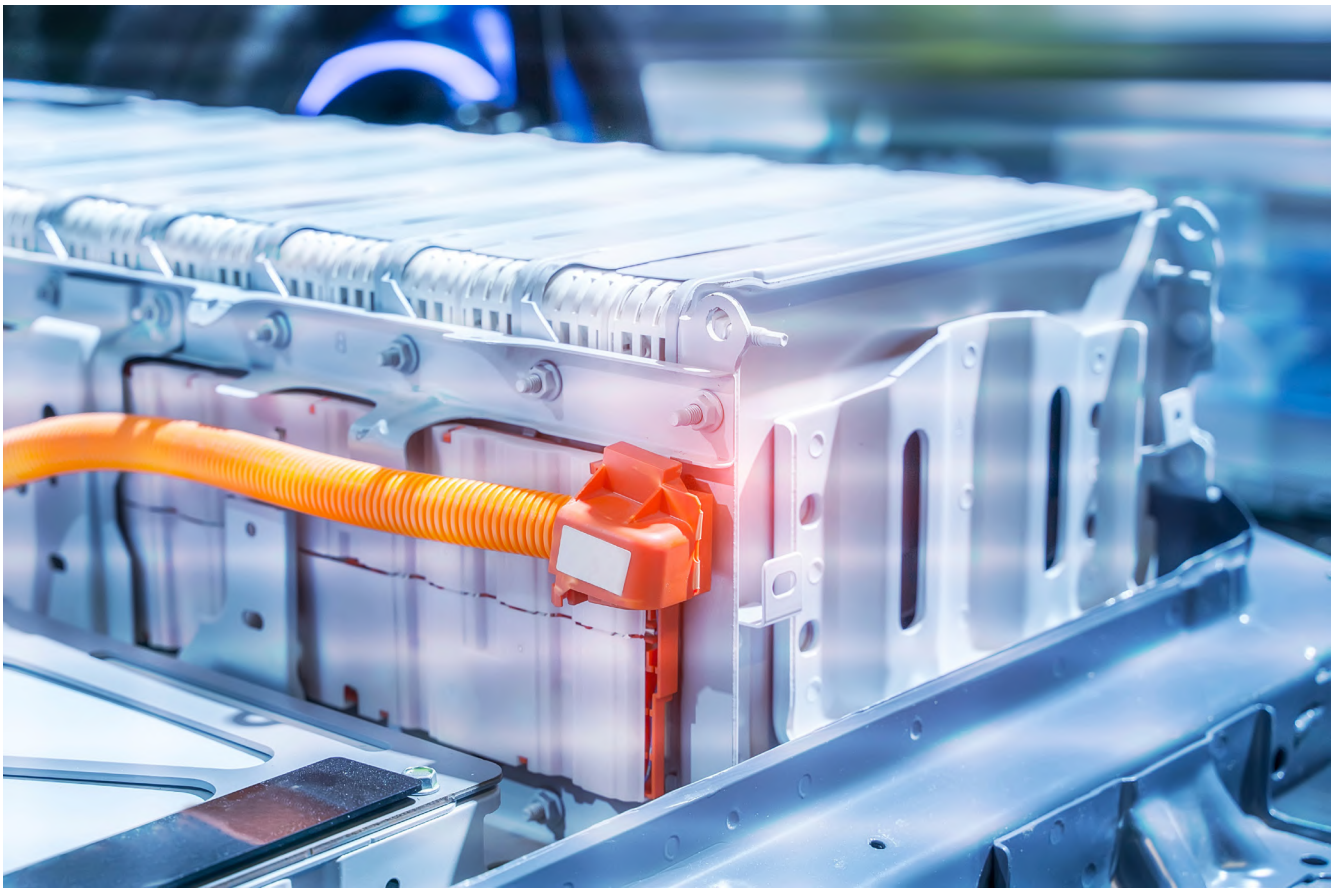
B. LITHIUM-ION BATTERIES: The queens of the electric vehicle

As we have seen in the previous section, there are a variety of batteries. There are more than those mentioned as aluminum air, or zinc air.

However, it is the lithium-ion batteries that predominate so far.

Over the past decade, many improvements have been made to the efficiency of this type of battery. And they are believed to have a lot of room for improvement. This has also been motivated by a desire to electrify the car market.

Thanks to these improvements, the range of electric vehicles can be longer, and they are also managing to minimize charging times. Precisely, it is in the latter that more improvements are being searched.



As seen in the sub-charging of batteries, there is always that dilemma: Fast charge regarding energy density. If charging time is reduced (charge intensity increases), it can negatively affect the battery life cycle.

Because of this, a project called FastCharge was carried out in July 2016, driven by Porsche, BMW, Siemens, Allego and Phoenix Contact.

BMW provided its i3 with a high voltage battery, with 57KWh of net power. It was recharged for 15 minutes with a power of up to 175KW. Porsche provided its Panamera with a capacity of 90KWh, achieved a load capacity of 400kW, reaching a range of 100km in the first 3 minutes of recharging.

In December 2018, it was shown that a 3-minute load was possible and 100km of autonomy was provided to the car.

It is true that new technologies are emerging based on lithium-ion, which are solid-state batteries. They use the same material (lithium-ion), the only difference is that the electrolyte (the conductor) is a lithium salt, and not a liquid material as in today's lithium-ion batteries. What does this allow? That, being the most compact battery, contains a higher energy density, providing greater autonomy.

However, until such batteries are developed, for the time being of "traditional" lithium-ion will remain the ideal candidates to drive vehicles with electric motors for the following reasons:

- **High energy density:** this allows more energy to be stored in less space, which in turn is an advantage in terms of the space that the battery should occupy within the vehicle structure
- **They can withstand up to 2,000 charge cycles**
- Improvements in this technology **are allowing energy density to double by 2030**, compared to what they currently have (500Wh/L)

Until solid-state lithium-ion batteries are developed, the "traditional" lithium-ion ones will remain the ideal candidates to drive vehicles with electric motors

3

MAINTENANCE AND REPAIR

3.1 MAINTENANCE

The maintenance of the electric car, in terms of economic cost, is much lower compared to that of the combustion engine. Precisely, the absence of such an engine (with all its auxiliary elements) is a cause of this lower cost.

The following systems are removed from:

- **Timing belt** maintenance processes and accessories disappear
- **Fuel:** Pump maintenance costs, filters...
- **Air intake:** There is no associated air filter
- **Tailpipe:** Catalysts disappear, particle filters...
- **Lubrication:** No oil change, along with your filter
- **Clutch**

A cooling system, with a specific design for electric vehicles, is maintained because the electric motor(s), battery pack, controllers and on-board chargers must be cooled.

This implies the need to install electric pumps that drive the cooling fluids, to maintain the optimal temperature of the different elements mentioned above. It should be noted that such elements have different optimal temperature ranges.

As for the gearbox, two cases can occur.

- Electric vehicle with central motor, with front and rear axle, which will be coupled to an automatic gearbox.

- Electric vehicle with motor in wheel, and therefore complete removal of the gearbox, removing the power transmission system at the same time.

The fact that there is no gearbox means that there would be no lubrication system, so there would be no oil

In electric cars, the timing belt, accessories related to fuel (pump, filters..), air intake, tallpipe, lubrication and clutch systems are removed

The maintenance of the electric car, in terms of economic cost, is much lower compared to that of the combustion engine

changes, nor filters. On the other hand, depending on the type of vehicle, the cooling system would also be removed from the gearbox.

In contrast, new components that require maintenance are installed.

These are:

- **The electric traction motor (or motors)**: It is maintenance-free because the designs allow for longer durability than the life of the vehicle; however, shaft bearings require maintenance. But since there are no spare parts, the only alternative would be the replacement of the whole electric motor.
- **The battery packs**: A cooling liquid is required to keep the batteries at an optimal temperature for operation. Therefore, a coolant change interval is required. But these intervals range from 100, 000 to 150,000 kilometers.
- **Inverters**
- **The on-board charger**

3.2 REPAIR

1. **Disconnecting the high voltage battery pack power supply:** This means having a safety protocol when carrying out the repair of electric vehicles.

   Disconnection means physically separating the electrical circuit from the battery pack. The CEPE 100 regulation sets out several safety specifications for the electrical connector.

2. **Step to repair:** There must be at least 2 people, with their corresponding PPEs. To avoid any problems with high voltage circuits, a label should be placed indicating that the circuit is activated, if so.

Electric protection gloves and electric shock protective jumpsuit are some of the PPES needed to repair in case of electric shock or electric arc

2.1 Types of PPES needed

In case of electric shock:

- Electric protection gloves UNE-EN 60903 (Class 00 or 0)
- UNE-EN 50365 Electricity Insulating Helmet
- UNE-EN 50286 electric shock protective jumpsuit
- UNE-EM 50321 insulating footwear

In case of electric arc:

- Face screen or mask EN 160 / EN 170
- UNE-EN 61482-1-2 Power Protection Gloves
- Protective jumpsuit UNE-EN 61482-1-1

It is important to have extinguishers (model 571), since lithium batteries can catch fire, generating a Class D fire, i.e. they enter spontaneous combustion if it meets water.

3. **Make sure the ignition key is disconnected:** This ensures that the AC circuit is disconnected.
4. **Disconnect the main electrical connector from the battery:** It takes at least 5 minutes for the high voltage capacitors of the electric motor controllers to discharge completely.
5. **Check for the absence of electricity between terminals at the end of the main battery connector.**

Battery Packs: Not repaired. In any case, replacement of complete modules is allowed. Repair is not allowed for the risks involved in handling lithium cells, as well as their economic unviability.

Electric motor(s): These are considered black boxes, i.e. as with gearboxes. In the event of a breakdown, a cutting operation is not carried out, but is changed directly. This also happens with inverters and on-board chargers.

On the other hand, as far as diagnostic systems are concerned, they follow the same procedures and protocol as in combustion vehicles. This means that two-way communication can be established with all vehicle control units: electric motors, inverters, charger, and battery pack.

It is important to have extinguishers (model 571), since lithium batteries can catch fire, generating a Class D fire

As for the last point, the operator will be able to see each of the modules that make up the battery pack, which means being able to see the average voltage of each of these modules, as well as the measurement of the internal resistance of each of these.

4

THE SOLUTIONS OFFERED BY EGA MASTER AND EGA SOLUTIONS

As has been seen grossly in the previous point, there are safety protocols when carrying out the disconnection process, to avoid electric shocks, or something more serious: electric arcs.

However, residual voltage may have been left in the circuit itself, with the consequences that this entails when entering to handle areas of the electric circuit of the car.

4.1 1000V ISOLATED TOOLS

Because of mentioned above is why from EGA Master we consider 1000V insulated tools are an effective solution in operations involving electric vehicles.

These are used for work in voltage or close to active parts that are, whose rated voltage reaches 1,000V in alternating current and 1,500V in direct current.
There are two ways to generate the 1000V isolated layer:

- **By Immersion:** Insulated tools manufactured by immersion process feature two layers of insulation in contrasting colors (red and yellow, or orange and yellow). In addition, the inner layer also acts as a safety indicator. When this layer becomes visible through the outer one, the tool is no longer safe to use and must be replaced.

- **By injection:** What it is done is inject molded handles with insulating material.
  While design may be more of a personal preference, they need to comply with IEC60900.

4.1.1 IEC 60900

While they are said to be 1000V isolated, the regulations require that they be tested at a voltage 10 times higher, and that they satisfactorily meet 4 additional tests:

- **Adherence test:** Tests the adherence of the insulating material to the metal elements of the tool.

1000V insulated tools are an effective solution in operations involving electric vehicles

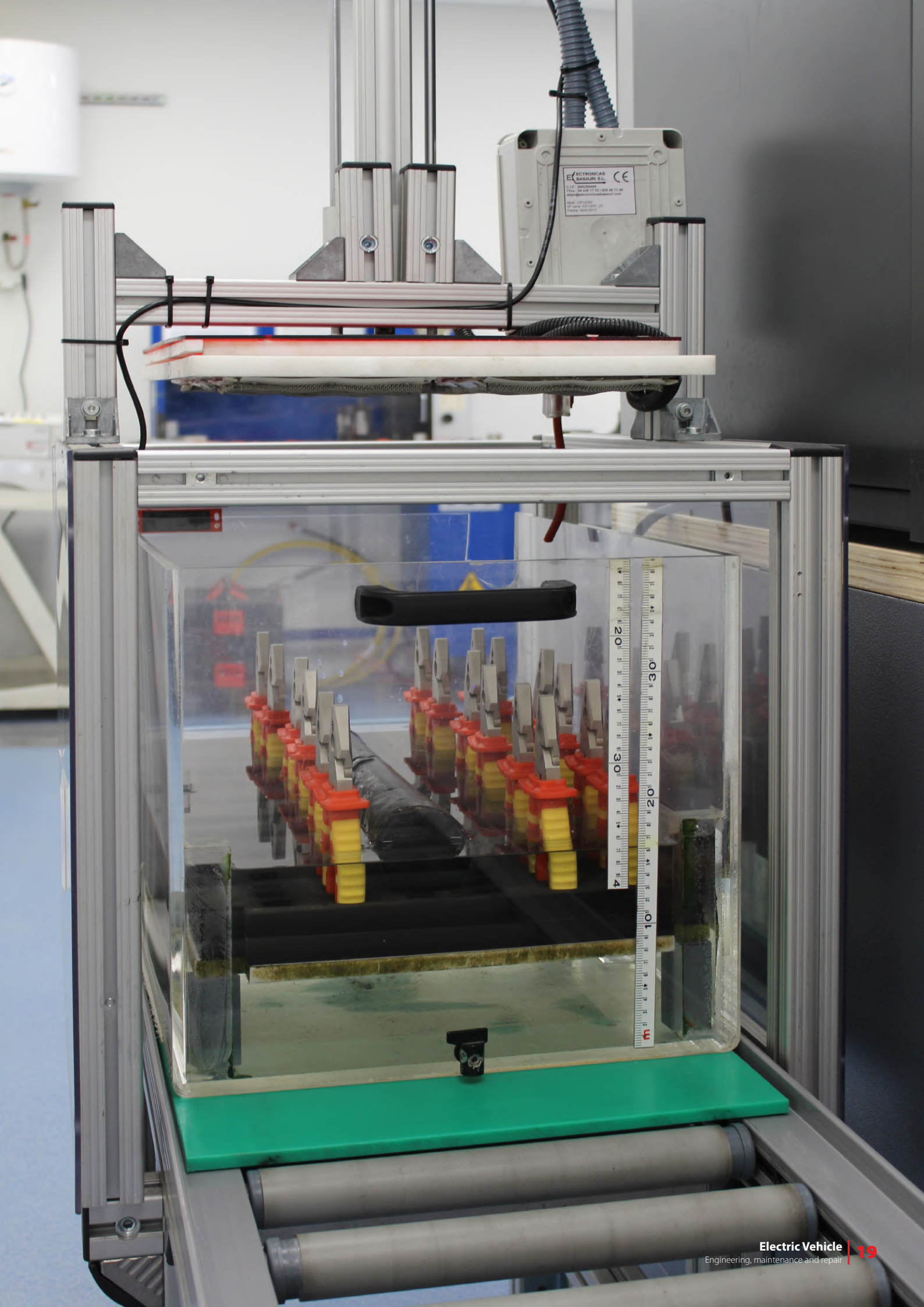
- **Impact test:** Tests the resilience of the insulating part to external impacts and falls.
- **Heat Resistance propagation test:** Tests whether the insulating material does not propagate flames.
- **Dielectric Penetration Tests:** Measures and leakages through the insulated material.

Our insulated tools follow the verification process indicated above, and therefore meet the requirements indicated by the international standard IEC 60900. These offers:

1. The double insulation of hard-soft PVC provides maximum adherence and safety in case of possible unforeseen events.
2. Anti-shock guards and ends.
3. Un-erasable laser marking.

Therefore, they are safe for use with or near objects under voltage (up to 1000V A.C. or 1500V C.C). **However, it is important to remember the following points:**

EGA Master 1000V insulated tools meet the requirements indicated by the international standard IEC 60900



1. Never use tools under voltage if they present pores, fissures, encrusted elements or if the yellow insulation layer is visible.
2. Insulating floors and safety shoes are recommended to work under voltage.
3. Avoid contact with water while working under voltage.
4. Do not ever directly touch any item that may.

Finally, since most tools can be designed to have some isolated part (commonly the handle) to be used with or near objects under electrical voltage, we can develop tailor-made insulated tools, and also offers the world's widest range of 1000V insulated industrial premium tools.

4.1.2 The world's widest range

We have the widest range in the world in premium industrial tools isolated 1000V.

- All kinds of tools for working with cables
- Pipe cutters and pipe tools
- Open and ring wrenches in millimeters and inches
- Long and short socket wrenches, 6 edges, 12 edges, in mm and inches
- Torque wrenches
- 1000V insulated non-sparking tools

4.1.3 Tailor-made development and manufacturing

Thanks to our long experience and knowledge in the most demanding industries, we develop and manufacture 1000V custom insulated tools that fit the specific needs of each customer.

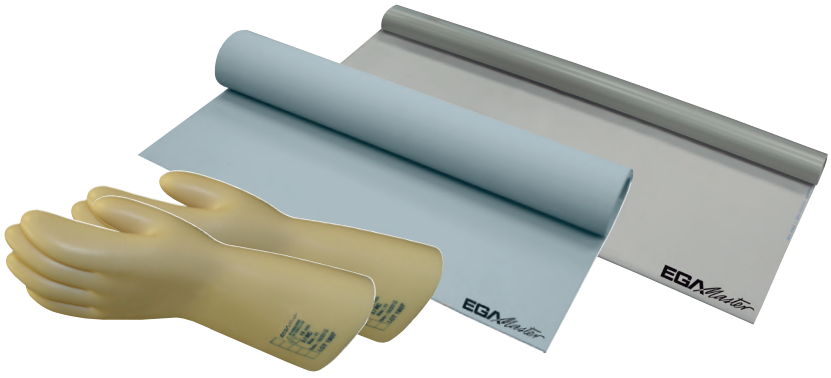
In addition, once manufactured they are subjected to the

EGA Master can develop tailor-made insulated tools, and also offers the world's widest range of 1000V insulated industrial premium tools

5 tests set by IEC 60900, thus ensuring that the quality of our 1000V insulated tools are suitable for working near, or in environments where there is voltage up to 1000V AC and 1500V DC.

4.1.4 Other safety elements for work under high-voltage

- Insulating blankets
- Insulating carpets
- Insulating gloves and testers



4.2 TRAINING ON SAFETY

At EGA Master we offer consultancy in the appropriate selection of necessary equipment, as well as safety training seminars, also in environments under tension.

EGA Master offers consultancy in the appropriate selection of necessary equipment, as well as safety training seminars

4.3 TOOL CONTROL SYSTEM

While 1000V insulated tools are ideal for electric car manufacturing and maintenance, we also need efficient and safe management of electric car inventory.

Therefore, we have also developed different tool control systems, essential in many applications, especially in cases where "lost" or forgotten tools increase risks and decrease security.

Therefore, we offer as a solution an exclusive and personalized tool control system avoiding the loss or loss of these.

The EGAWARE sotfware controls which tool is taken from or returned to the stock

4.3.1 EGAWARE Software

EGA Master offers a unique stock control system, that will control which tool is taken from or returned to the stock.

A. The user logs in with its username and password.

B. The worker picks up the tool that he will work with.

C. The worker scans the barcode.

D. The software detects that the tool has been taken.

E. The worker returns the tool and scans the code again.

F. The software detects that the tool has been returned.

4.3.2 Smart opening system for drawers

Avoid mistakes in the tool selection, increasing efficiency and therefore, productivity.

Each door is assigned a radio frequency card that is passed through the RFID reader of each roller cabinet allowing the opening and locking of the drawers.

Laser technology that detects errors such as a drawer that has not been completely closed.

LEDs in the drawers facilitate the visual recognition of the status of each drawer (open / locked).

The smart opening system for drawers avoids mistakes in the tool selection

5
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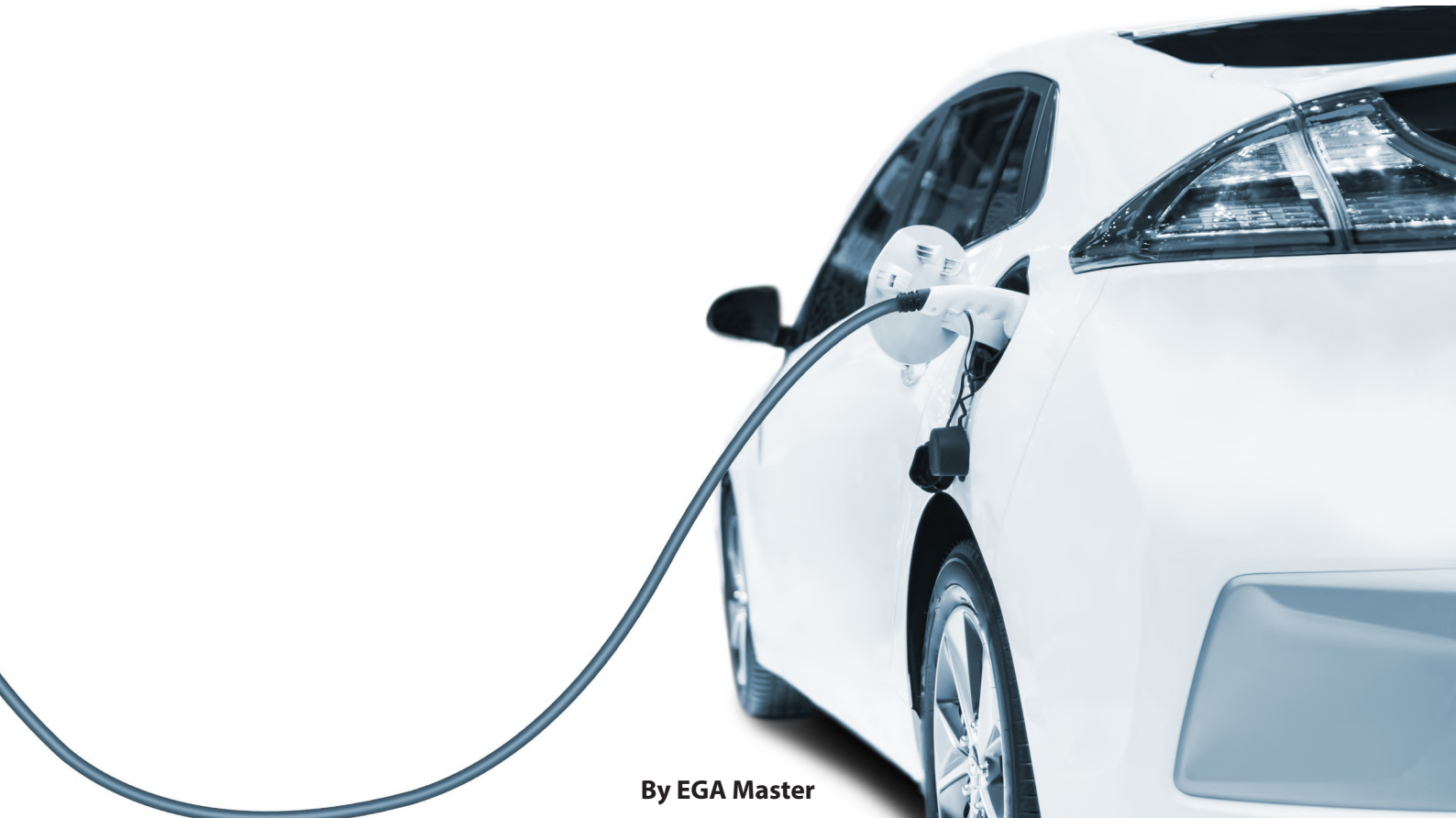

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