direct e-mail: **rve@circutor.es**

Joan Pallisé

Electric Vehicle Smart Recharge division

Development and trends in Electric Vehicles and charging infrastructures

Canopies that integrate solar panels are a great option because in addition to shading the EVs, they supply energy, significantly improving the aesthetics of the parking area

Image courtesy of Parkgreen
www.parkgreen.es

Historians of science are well aware of the opposition of existing technology to the emergence of any innovation or change, putting up stiff resistance to its entry. An example of such a change scenario was experienced during the period when steamers established themselves at the expense of sailing ships. The same thing happened with the appearance of electricity, before it could replace gas lighting or steam power and all the chaos that went with them. In more modern times, with the eruption of the new communication technologies and information systems, obsolete typewriters, telegraph and telefax systems put up stubborn resistance before being entirely replaced.

When the new EVs were just starting out, barely half a decade ago, clear opposition and scepticism could be perceived from the old (**fossil fuel vehicles - ICVs**) towards the new (**electric vehicles - EVs**) at various congresses and conferences in the automotive and mobility world.

From the beginning, CIRCUTOR has maintained that, although change is inexorable, particularly if the expectations of the new generation of batteries are fulfilled, it is not going to happen suddenly or immediately because, like all great innovations based on a pattern of exponential growth (as in the example of mobile phones), initial development is slow and almost imperceptible until a turning point is reached during a particular period, when extraordinary expansion begins. This is a characteristic feature of all exponential functions.

The Tesla is a top of the range EV, but most car manufacturers are currently working on the development of the electric car. There are more affordable models already on sale and in circulation, and in the coming months and years we will have a wide range of models available

www.teslamotors.com

We wish to highlight three main challenges among the ones that EVs must overcome in order to achieve a sizeable presence in our towns and cities:

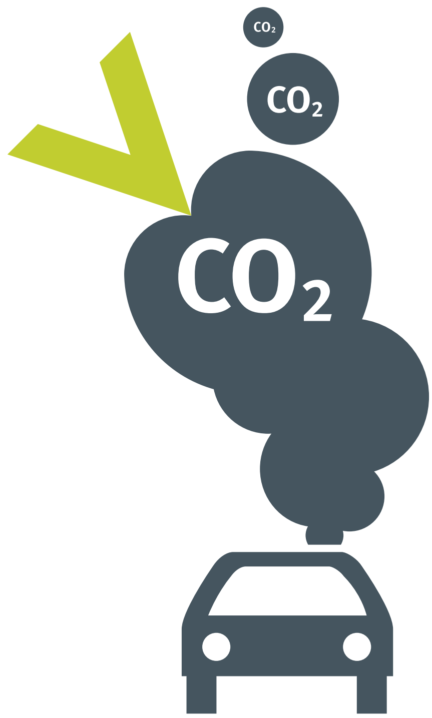
- A reduction in the cost of the lithium ion batteries, along with an increase in its energy storage capacity or, to put it another way, greater autonomy for EVs.
- A reduction in their purchase price. This will be achieved partly by improving the batteries, and with the mass production of EVs, which is being prepared by the major international manufacturers.
- A development of EV charging infrastructures, with the establishment of charging points of all types and application segments.

Various experts and international automotive and energy bodies place the period of change on the horizon 2015 to 2020, moving from the current 50,000 EV sold at world level to 1.5 million by 2015 and an estimate of more than 7 million for 2020, according to recent estimates by the World Energy Agency (WEA).

We must avoid falling into paralysing pessimistic attitudes or unachievably optimistic ones, making realistic forecasts. Along these lines, the majority of predictions about the development of EVs specify that, in the next few years, it will be difficult to exceed the figure of 5% of the total vehicle fleet, although it is true that there are more optimistic expectations, placing this percentage at around 10% for the end of the period we have mentioned.

In general, we believe the huge advantages of EVs over ICVs, lying in their high energy efficiency, have not been explained. While the new EVs show energy efficiency of more than 80%, in the best cases the figure for ICVs is around 30%, which makes replacing all these devices with their poor performance and efficiency an extraordinarily important objective, particularly in a world with a continuously increasing population that wants to improve its standard of living, thirsty for energy but lacking resources. As if

While new EVs exhibit energy efficiency exceeding 80%, ICEs are around 30% in the best case scenario



this were not enough, poor efficiency is always synonymous with increased pollution, with the respective emissions and hazardous wastes involved. It is easy to establish a simple equation relating poor energy performance to increased pollution.

The final triumph of EVs is undoubtedly related to the change of paradigm of the “electric universe” as we know it, with the possibility of storing electricity in large quantities for the first time in history. The system will be optimised if users can be encouraged to use electricity for charging at so-called off-peak times, and the scenario will be notably improved if most of the energy can come from renewable sources. All this comes via a set of technologies that should be highlighted: the new generation of lithium ion batteries with all their variants, supercondensers and wind and photovoltaic generation…

Charging modes (**IEC - 61851-1**)

Output Mode	Specific connector for EV	Type of charge	Maximum current	Protections	Special features
Mode 1	No	Slow in AC	16 A per phase (3.7 kW - 11 kW)	The installation requires earth leakage and circuit breaker protection	EV connection to the AC network using standard power connections
Mode 2	No	Slow in AC	32 A per phase (3.7 kW - 22 kW)	The installation requires earth leakage and circuit breaker protection	Special cable with intermediate electronic device with pilot control function and protections
Mode 3	Yes	Slow or semi-quick Single-phase or three-phase	In accordance with the connector used	Included in the special infrastructure for EV	EV connection to the AC power supply using a specific device (SAVE)
Mode 4	Yes	In DC	In accordance with the charger	Installed in the infrastructure	EV connection using a fixed external charger

fig.1

Types of connectors

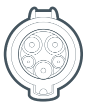
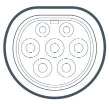
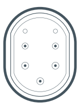
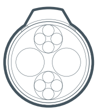
	Connector type	No. pins	Maximum voltage	Maximum current	Regulations	Special features
AC	 1	5 (L1, L2/N, PE, CP, CS)	250 $V_{a.c.}$ Single-phase	32 A single-phase (up to 7.2 kW)	**IEC 62196-2**	**SAE J1772** regulation
AC	 2	7 (L1, L2, L3, N, PE, CP, PP)	500 $V_{a.c.}$ Three-phase 250 $V_{a.c.}$ Single-phase	63 A three-phase (up to 43 kW) 70 A single-phase	**IEC 62196-2**	One type for single-phase or three-phase charge
AC	 3	4, 5 or 7 in accordance with the model (L1, L2, L3, N, PE, CP, PP)	500 $V_{a.c.}$ Three-phase 250 $V_{a.c.}$ Single-phase	16 / 32 A single-phase 32 A three-phase (up to 22 kW)	**IEC 62196-2**	Different types in accordance with power level
DC	 4	9 (2 Power, 7 signal)	500 $V_{d.c}$	120 $A_{d.c}$	**IEC 62196-1** **UL 2551**	Fast charging in DC In compliance with **JEVS G105** Type **CHAdeMO**

fig.2

The conventional "Schuko" sockets continue to be the most commonly used for existing EVs and will maintain their role in the future, particularly for two-wheeled EVs, hybrid cars and small cars (quadricycles)

RVE-Mode3 Semi-fast outdoor charging posts

A highly recommended option is to select equipment from the mixed range with two sockets, allowing the charging of any kind of EV that accesses the charging point.

During the last two years (2010-12) the communications media have quite regularly highlighted the appearance of new electric vehicles and the need for the consequent charging infrastructures to plug them into the mains. However, it is true that they have reflected the difficulties more often than the positive, innovative aspects they offer. From Circuitor's point of view, the establishment and development of a strong charging infrastructure for EVs in our society should not cause more problems than those involved in the mass introduction of air conditioning into our homes and commercial and service buildings. The only importance difference lies in the fact that the consumption point for the new application will, in most cases, lie outside our homes (in the parking space in our garages, in car parks and public roads, at work centres, in the new charging stations or at special service points).

As regards infrastructures, development of the technology itself has gradually clarified the **forms of charging and types of socket to be used (see fig.1 and 2)**, although to achieve a complete solution to the challenges raised the technological advances will have to be accompanied by relevant regulations, such as the amendment of the REBT and the new ITC 52, clarifying and facilitating their implementation. So, issues such as the authorisation of installations, administrative simplification and the ability of distributor companies to apply super off-peak tariffs, etc. are key elements for speeding up their implementation.

From a practical point of view, in order to establish a charging point or network of them, we can follow a simple process tree allowing us to clarify our needs. So, the first branch to be considered is whether it is an indoor (car park, garage, industrial unit...) or outdoor (public road, shopping centre, open air car park...) charging point, thereby determining two completely different product families: **wall boxes and posts**.

Once the application (indoors or outdoors) is known, the charging method and type of socket must be considered. The charging method concerns both the type of vehicle and the electrical power we have available for charging. From any point of view, the most interesting option is charging in mode 3 (3.7 kW, or semi-rapid 7.3 kW in single-phase, or semi-rapid up to 22 kW if a three-phase distribution lines is available).

For types of socket, the two main alternatives are oriented towards type 1 connectors (SAE J1772) connecting directly to the EV, and the type 2 seven-pin socket allowing single-phase and three-phase charging (see attached

The most reliable choice

CIRCUTOR has supplied over 2,000 charging points in recent years

RVE in Bergen (Norway)

CHAdeMO model (Fast mode)

RVE in Birmingham (United Kingdom)

The electric car represents an important element in the solution to our energy problems and the protection of the environment

RVE in Andorra (Andorra)

RVE in Formentera (Balearic Islands)

tables page 18). Optionally, equipment can be supplied with type 3 sockets, although this is used in only a small number of countries.

Despite this, it must not be forgotten that the conventional Schuko type conventional sockets will continue to be most commonly used for existing EVs and will continue to play their role in the future, particularly for two-wheeled EVs, hybrid cars, or small cars (quadricycles). A highly recommended option is to select equipment from the mixed range, with two sockets allowing the charging of any kind of EV that goes to the charging point.

The last consideration concerning charging points is rooted in the type of features we want from them. In the simplest, most basic version, there is not even any access control and the EV is just connected to the charging point, which makes the relevant checks and, if everything is correct, proceeds to charge it. The normal thing would be to ask for some additional features, such as access control using an RFID card, with the additional possibility of achieving a simple way to control energy consumption (using credits), so the energy requested can be invoiced as a service while the regulations relating to tariffs and ways of invoicing EV charging are developed.

Until there is a critical mass of EVs charging, we believe the viability and application of charging managers will not be viable. Until this happens, as many facilities and alternatives as possible for their development must be implemented. To achieve this, CIRCUTOR has a range of equipment making it possible to integrate consumption and the subsequent invoicing of charging costs using RFID cards or with the integration of car park cards with their own magnetic strips or using the great potential allowed by communication systems that have a general server.

Among the options and variants in charging points, the one which shows the greatest versatility involves storing all information in situ using a data server with a SCADA program allowing incorporated energy management, while all this information can be transmitted by ethernet or using 3G type wireless systems. The incorporation of equipment like the **EDS (Efficiency Data Server)** not only carries out these functions, it can also manage several charging points.

All our equipment that does not operate on its own, in complete isolation, has RS-485 communication, allowing any specialised company to develop customised applications.

As well as a wide range of equipment for all kinds of users and applications, there are special options for ultra-rapid charging, with an initial version with CHAdeMO protocol directly accessing the EV's batteries in DC, with an output power of 50 kW, making it possible to charge EVs with this option (largely the Japanese ones) in just a few minutes. In future two new possibilities will appear, such as CHAdeMO rapid charging with power modularity (20 kW or other values) or the European option (still under development) combined with AC and DC in a single socket and connector of the so-called Combo type.

This brief summary is an attempt to provide a view of the current situation and new developments on the 2015 horizon. However, we cannot ignore the fact that, in conjunction with the development of EVs, smart grids are appearing, providing the possibility of using the energy from the EV itself in emergency situations or in times of need in our homes, known as V2H (vehicle to home), or the new potential represented by the self-generation and own consumption of distributed renewable sources. All this could represent an important technological, economic and social boost, with a change of scenario from the current "electric universe", and we are only at the beginning.

CIRCUTOR offers a wide variety of intelligent charging solutions for EVs

RVE-CP2 MIX
Indoor charging posts with 2 connections, Modes (1,2) and 3

RVE
Outdoor charging posts

RVE-CP / RVE-WB
indoor charging cabinets

RVE-CM and **RVE-SL**
Multipoint system for car parks with various connections

CHAdeMO
Outdoor ultra-fast charging post, charges vehicles in just 15 minutes

RVE-CB
Outdoor charging posts for 2-wheel vehicles

CIRCUTOR is the leading Spanish manufacturer in all modes of charging

modes 1, 2, 3 and 4