Electric Vehicle Charging. How, When and Where?

1.- INTRODUCTION

The Electric Vehicle (EV) is a media reality that does not represent the scarce number of vehicles circulating through our roads.
This situation will change when car dealer's showrooms (cars, motorcycles, bicycles, industrial vehicles, buses, etc.) start to exhibit these vehicles. Such a change will be effective within a few months and, in particular, during the next few years, since the major car manufacturers are developing their own EVs.

This article wishes to illustrate the EV charging infrastructure scenario, as well as the most suitable places, moments and methods to charge them.

2.- WHY IS IT NOW POSSIBLE?

The EV is not something new. The first electric car was built by the British inventor Thomas Parker in the year 1884.
Ford's first "T" models appeared by the dawn of the XX century, which was produced in series and with acceptable costs, with an internal petrol combustion engine that revolutionized the automobile industry. Such an impact has lasted until now. Various causes have made it possible to change the trends in favor of a progressive increase of the EV in our everyday reality.

The need to protect the environment, which is increasingly being harmed by the CO2 emissions (greenhouse effect), contaminating effects, such as CO (poisonous gas), in addition to the noise in large cities is also a powerful reason.
Therefore, the new generations must address such issues, increasing the awareness of developed countries (with the new global order, they pay more taxes for higher rates of contamination).
Spain, as other European countries, are highly dependent on energy from abroad. We import crude oil, gas, enriched uranium and carbon.
We generate a high amount of electrical energy with natural resources (wind, sun, water,..).
The paradox lies in the fact that the latter are often disconnected from the grid when the demand for electricity is not high enough (nuclear power or combined cycle plants need more hours or even days to stop and start-up their production systems).
Therefore, our country should reduce its current energy dependence, all the more since more than 75% of the crude oil imported is consumed by the transport sector.
Another factor that has had a big impact in the implementation of the EV is the technological advances in the electrical battery sector.
The modern Ion-Lithium batteries increase the energy capacity of traditional Lead batteries by five. Progress is being made in other high-performance electricity storage technologies, such as, for example, super-capacitors.
To this end, the governments of surrounding countries have taken these matters into their own hands and are already creating aid plans and regulations in favor of the EV.
The most popular one in Spain is the "Movele Plan" proposed by the Ministry of Industry through its organization for energy savings, the “IDAE”.
Furthermore, the “Cenelec” standard committee is launching a new standard for the EV charging, the IEC 61851, which will settle the necessary statements for a common method of EV charging in Europe, an surely will influence other word areas.

3.- TYPES OF ELECTRIC VEHICLES

Evidently, electrical motor drive can be applied to any type of vehicle, from a bicycle to a bus.
The most complex part lies in the use of an "electricity storage system" in the form of a battery that can offer a certain battery range.

Broadly speaking, there are four types of electric vehicles:

- a.- Hybrid vehicles that can NOT be connected to the grid
- b.- Hybrid vehicles that can be connected to the grid
- c.- Hybrid vehicles that can be connected to the grid, with full electrical drive
- d.- 100 % electric vehicles

- Type a is not a true EV, since the electrical motor is simply used as a support to the internal combustion. It has a battery life of 5 to 10 km with the use of the electrical drive system.
- Type b also has two drive motors: an electrical and an internal combustion motor/engine. However, it is rechargeable and its batteries offer a high battery range (50 to 80 Km).
- Type c uses an electric motor for the drive systems and a small petrol engine used to charge the batteries. It has a battery life of 100 to 200 Km with the battery and up to 1000 Km when the batteries are charged with the petrol engine.

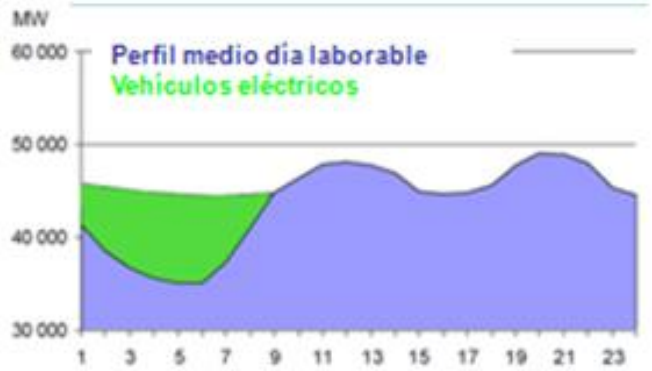
4.- EV CHARGING METHODS

The storage capacity of a battery used in an EV ranges from 15 to 30 KWh.
This would be the same as the energy used to power a 100 W light bulb between 150 and 300 hours.
The battery of an EV can be charged within minutes or in a few hours, since the 30 KWh charging process can be quick or slow.
A quick charging process (15 min.) for a battery that is completely flat would need a power of 60 KW to 120 KW. A slow charging process for the same battery (6 h) would need a power of 2.5 to 5 KW.

The most common standarised sockets in Europe can accept a maximum power of 3.7 KW (230V@16A), 7.4 KW (230V@32A) in single-phase networks (domestic) and 43.6 KW (400V@63A) in three-phase networks.
The EV battery charging process requires approximately 40 KW (three-phase system) in the quick charging mode and 3 KW in the slow charging mode (single-phase system).
All in all, the standard (or slow) charging process would require an average of 3 KW, which can take place at home or with a standard garage socket, which would charge the battery in 4 to 8 hours.
The quick charging process would require an average of 40 KW and should be carried out in tertiary or industrial environments, which would charge the battery in 21 to 42 minutes.
There are other experimental systems, such as the induction charging or 500 Vdc charging processes, although they need to be tested.

5.- IMPACT OF THE EV ON THE GRID

Unfortunately, the grid has a limited EV charging capacity.
The demand for electrical energy will vary during cycles that are similar to the 24 hour cycle. The demand will be higher during peak hours and lower during the off-peak (night time) hours.
Therefore, the electrical energy generation and transport infrastructures must be adapted to the peak demand, but these are quite idle during low demand periods.
Another factor that must be taken into account (especially in our country) is the fact that the capacity to generate wind and sun energy is usually underused due to the lack of demand during off-peak hours.
Therefore, the EV charging process must take place during off-peak hours when the demand is low and the power is being generated with renewable energies.
A series of studies have concluded that the Spanish electricity system could charge a maximum of 2.7 million EVs (10% of the current vehicles in circulation) under determined conditions, using intelligent systems in the current system and equipment to avoid a collapse of the grid (local or global.



Another aspect must be taken into account. This is the "grid quality". In fact, the EV charging processes generate alterations in the grid. The most common effects are known as "harmonics" and they can cause major problems.

6.- HOW, WHEN AND WHERE?

We have already explained that the EV charging process is not a trivial matter. The grid can accept an increase in the demand, provided that it is under a series of conditions.
The vehicles should be charged slowly (in hours, not in minutes) and during off-peak hours (to balance the daily demand curve). However, what is the most suitable place to charge a vehicle?

The charging conditions will be analysed in different locations below.
In our country, a standard home (for example, a single-family home with its own garage), has a contracted power of 4.4KW (20A) to 8.8KW (40A). Obviously, if the charging process of an EV requires 3 KW, determined precautions must be taken to prevent "fuses from blowing".

The first precaution would be to charge the EV at night, when most loads are disconnected. This offers a second advantage, which is the possibility to charge the vehicle during night-time rates, which are cheaper than day-time rates.

The situation is different in the case of community garages.
Let us assume we have a community garage with a capacity for 40 parking spaces.

The contracted power would be approximately 10KW, out of which 4 KW would be used by the lighting systems and the remaining KW would be used by the mandatory air extraction and reserve systems. A single vehicle would require 3 KW for a safe charging process, as explained above.
In the third example, we will describe the scenario for an underground car park located in the centre of the city. Let us assume that we have a capacity for 500 parking spaces.

The contracted power available would be approximately 100 KW, out of which 15 KW would be used by the lighting systems and the remaining KW would be used by the ventilation, collection and reserve systems. 5 vehicles can be charged, provided that a series of precautions are taken (for example, not extracting air at night, …)

Therefore, all examples show how an EV can be charged, but specific areas must be taken into account.
Usually, the power capacity must be expanded to charge a greater number of VEs.
Clearly, the charging process must use intelligent systems (not a simple socket).
This is the only method to charge EVs under safe conditions in a local installation and with the use of the grid.

7.- CONCLUSIONS

The electric vehicle is a reality.
Our society needs it. All major car manufacturers will be exhibiting them in their car dealers' showrooms within a few months.
Therefore, we must create the charging infrastructures in the most adequate places.
The vehicle can be charged with different methods and in different environments and there is a standard in process of launching for it (IEC 61851-1).
We must highlight the suitability of parking spaces and garages (in the centre of the city, in shopping malls, at work) to charge EVs when compared to other potential places (we do not forget the main place, the domestic charge at home).

The charging process will take a few hours and at a low power rating (not in a few minutes at high power ratings), to make the most out of the existing capacity of the grid in off-peak hours. In addition, the parking spaces or garages offer the possibility of complementary charging process that take 2 hours and a half during the rest of the day, increasing the performance and efficiency of each charging point.
The parking space or garage offer the possibility of intelligent charging processes, adapting the charge to the availability of the grid, in order to protect it against harmful alterations (harmonic currents) produced by the charging process, while offering information about the availability of parking spaces to the user and incidents and a histogram to the owner - operator in real time. Power expansions will be required in the electrical connections in the medium-term to charge a higher number of EVs.
Therefore, it is clear that the charging process of an EV does not rely on a simple socket, but on an intelligent and safe system that can communicate with other systems.

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