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Electrical Car – Implications in the infrastructures, usage installations and electrical regulation

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Abstract. The energy and environmental problems we are facing today, characterized by a strong dependence on fossil fuels which produce many greenhouse gases, makes us look for new solutions to solve these two problems. The electrical cars will contribute to solve these problems, but on making their loading on electrical systems, situations may appear in which electrical grids won't be able to feed these new loads.
The main goal of this article is to identify the impact that electrical cars will create in the existing electrical grids and the changes that are needed in legislation to address them.

Keywords

Renewable energy, electricity, electrical cars, energy distribution.

1. Introduction

The evaluation of the power to define the premises for use in the design stage is of the utmost importance, since it will establish the characteristics of the infrastructure of power supply and if it will be badly determined it will condition the operation of installations.
Electric energy use in usage installations is perfectly defined and the dimensioning of the infrastructure and hiring power to them is duly set in legal and normative terms.
The paradigm shift in the power supply of cars may, however, change the set, since the use of electrical cars implies the loading of batteries, which are storage elements for the electrical cars.
The battery charge may happen specific places for that purpose, an example of network supply points, which is already being developed in our territory, but there will certainly be those who will want to charge their batteries at home and / or in their working place, in off-peak hours, when the energy cost is cheaper.
Considering the power and time needed to charge electrical cars, the existing infrastructures and the hired power, may not be dimensioned for the needs which may occur in the future with the emergence of this type of cars.
This article aims to identify the impacts due to the new paradigm of electrical car in the existing infrastructures and in the necessary revision of statutory regulations and norms that frame the project of the infrastructures and electrical installations.

2. Electrical cars

In recent years, the oil price has rise up to $150 USD in the international market, triggering a new oil shock. Unlike the previous ones, this new shock was caused by excess demand, caused by increased consumption in emerging economies, specially the asiatic ones.
The energetic situation still got worse, because of the rise of the oil price also causes a general rise of other primary energy sources prices, specially the fossil ones, such as the natural gas and the coal.
In the last months, due to the world crisis that we are going through, the oil prices has fallen, but it has now stabilized in the range of 70 to 80 dollars, much more above the initial value.
Furthermore there are many doubts about the existing oil reserves. Many people defend that we have already exceeded the production top, being now in the descending part of the curve.
On the other hand the great dependence of cars in relation to fossil fuels and the low efficiency of engines due to their technological restrictions cause a great contribution of their sector for the production of greenhouse gases which are affecting the environment and causing climatic changes. It is crucial that there is a reduction in the release of this kind of gases as the defined in the Quioto Protocol.

Another aspect to be considered is the pollution level in the great cities, caused by the cars, and which is degrading the quality of the air, causing a serious problem of public health.

The electrical car will contribute, significantly for the resolution of the several problems formerly mentioned.

Having a high efficiency, about 90% it will increase the efficiency of the sector, since it will lower the necessary energy per km.
With the inclusion of electrical energy proceding from renewable sources, in electrical nets, the electrical energy used in the charge of its batteries, will also procede from renewable sources.

3. Charging electrical cars

Portugal has been one of the first countries in the world to define a global strategy of electrical mobility, which implies the creation of a politics of financial and fiscal incentives to private people and enterprises which decide for the purchase of electrical cars, for the celebration of agreements in the car industry and for the creation of an Electric Mobility System in Portugal.
The Electric Mobility System, called Mobi-e, will have points of slow charge with duration of 6 at 8 hours and, points of fast charge, with duration from 20 to 30 minutes.
The Electric Mobility System already includes the adherence of 21 cities from north to south of the territory of Portugal. It is already foreseen the availability of 100 points of charge still in 2009. We can foresee that the number may reach the 1300 in 2011.
In the Table 1 we present the necessary power for the charge of some electrical cars wish we foresee that between 2010 and 2012 will be commercialized.
From the capacities of storage of the batteries and the hours of charge that the manufacturers indicate as necessary for the charge, we have calculated the power wish is necessary for the installation. For the estimated of the fast charge it has been considered the charge of 80% the energy stored in the battery.
The existence of a national Electric Mobility System won't certainly make cars owners, not want to charge their cars in the homes or working places, since it will be certainly more comfortable and safer.
As we can see in the Chart I, for the analyzed cars, it will be necessary an available power between 2,3 and 3,4 kW (slow charge), this being the most advisable to take place at home. The fast charge using power between 26 and 38 kW (see Chart 1), will have to take place in the national Electric Mobility System - Mobi-e.
This situation will change in a significant way the traditional usage of power in the usage installations, and it will have a very significant impact in the infrastructures of electrical energy distribution.

4. Evaluation of the power of the installations

The evaluation of the power in the installations stands, essentially in the knowledge of the existent equipments and in the consideration of its operation simultaneity.
The evaluation of the power in the distribution networks and MV/LV transformer substations stands in the knowledge of the defined power for each one of the installations and in the consideration of the simultaneity of usage of their power.

As far as low voltage electrical installations concerned the definition of the power to stipulate, is based on "Regras Técnicas de Instalações Eléctricas de Baixa Tensão (RTIEBT)", approved by the "Portaria n.º 949-A/2006 de 11 de Setembro".
In this particular the law above referred, in its paragraph 801.1.1 refers that the minimum power and the usage and simultaneity factors to be considered in the Project of electrical installations should be settled according to the needs and the exploitative conditions of the respective places, as well as the electrical installations which had not been foreseen to feed 3 phases receivers, which are feed by the low voltage public distribution networks and whose total power doesn`t exceed 10,35kVA (45A, in 230V) should be single phase. However the installations with more than 10,35 kVA, should be fed in three phases.
In what concerns the residential consumers, the diplome in its 801.5.2 paragraph indicates the minimum power to foresee for the installations:

- 3,45 kVA, single phase (15A, 230V), in one compartments places;
- 6,90 kVA, single phase (30A, 230V), in places with two to six compartments;
- 10,35 kVA, single phase (45A, 230V), in places with more than six compartments.

In the case of installations with three phases receivers, the feeding should be three phases and the minimum values of the power to consider to the installation should be the following:

- 6,90 kVA, three phases (10 A, 400 V), in places with no more than six compartments.
- 10,35 kVA, three phases (15 A, 400 V), in places with more than six compartments.

We must consider that when counting the number of compartments we should only take into account those that have an area bigger than $4m^2$, excluding the kitchens, the bathrooms and the corridors.
In particular, in what concerns the collective installations, the law in the paragraph 803.2.4, refers that, should be considered, at least:
In the house places:

- 3,45 kVA, single phase (15A, 230V), in one compartments places;
- 6,90 kVA, single phase (30A, 230V), in places with two to six compartments;
- 10,35 kVA, single phase (45A, 230V), in places with more than six compartments.

In the case of installations with three phase's receivers:

- 10,35 kVA, three phases (15 A, 400 V).

In the outbuildings (cellars, deposits, garages, etc.) where it is foreseen a specific feed:

- 3,45 kVA, single phase (15A, 230V).

In other places, not destined to residence (no included in the above point) the power should be defined from the foreseen characteristics for each one of the installations, with the minimum of 3,45 kVA, in single phase (15A, in 230 V).

Marca/Modelo	Bateria (kWh)	Autonomia (km)	Consumo por 100 km (kWh)	Carga Lenta		Carga Rápida	
				Potência (kW)	Carga (horas)	Potência (kW)	Carga (horas)
Ford Focus BEV [1]	23	120	19,2	2,9	8	-	(*)
Mitsubishi i MiEV [2]	16	160	10,0	2,3	7	25,6	0,50
Mercedes BlueZERO [3]	20	100	20,0	3,3	6	-	(*)
Nissan Leaf [4]	24	160	15,0	3,0	8	38,4	0,50
Peugeut iOn [5]	16	130	12,3	2,7	6	25,6	0,50
Volvo C30 BEV [6]	24	150	16,0	3,0	8	-	(*)
(*) - Não fornecido pelo fabricante							

Chart I. - Power for the load of the electrical cars

In collective installations, the power to be considered for the dimension of the feeds should be obtained from the sum of the power electrical installations, being distinguished two situations:

a) of the places intended for residence and their outbuildings, affected by the simultaneity factors;
b) of the places not intended for residence (including their outbuildings), affected by the simultaneity factors defined by the designer according to objective criteria.

The simultaneity coefficients indicated in chart II, should be applied to the building collective infrastructures.

Number of electrical installations (of usage) situated downstream	Simultaneity coefficients
2 a 4	1,00
5 a 9	0,75
10 a 14	0,56
15 a 19	0,48
20 a 24	0,43
25 a 29	0,40
30 a 34	0,38
35 a 39	0,37
40 a 49	0,36
≥ 50	0,34

Chart II - Simultaneity coefficients for places of residence and their outbuildings

For shops and of small commercial establishments, paragraph 801.2.6.3 of the RTIEBT, refers that their electrical installations should be dimensioned for powers not inferior to 30 VA/m^2, with the minimum of 3,45kVA, in single phase (15 A, in 230 V).

The existence of a national Electric Mobility System won't certainly make cars owners, not want to charge their cars in the home or working places, since it will be certainly more comfortable and safer.

This procedure, and, in particular, in the already existent installations of residential use, will involve the following consequences:

- The need of increase of power contracted in the installations of use
- The need of reinforcement of the collective installations of distribution of energy;
- The need to change the electrical boxes of the installations.

When the future installations are projected, this situation must be taken into account, effectuating the definition of the nominal power of the usage installations, considering the possibility of batteries charges of electrical cars.

This reality forces the need of revision of the RTIEBT in what concerns the consideration of minimum power, because although it is clear the fact that its minimum power, the practice shows in many cases, it is the power effectively considered by the responsible technicians, which with this new paradigm, leads to insufficient powers for their effective usage.

This situation is particularly important in residences of one single family and in collective buildings, in which the autonomous fractions (residences) may have boxes for parking the cars, where the electrical cars will be charged, fed by that fraction.

In the particular case of collective installations, it will be necessary to revise the simultaneity coefficients, since the conditions of their definition will be significantly altered, and their application may lead to insufficient power of the collective installations, which later will not have the capacity to guarantee the real needs of the installations owners.

In what refers to the public feeders and the MV/LV power substations the definition of power to be considered for its dimension, has as a base the "Regulamento Subestações e Postos de Transformação e Seccionamento", the "Regulamento de Redes de Distribuição de Energia Eléctrica em baixa Tensão" and the normative documents of the public distributer of energy "EDP – Distribuição – Energia S.A.".

In this particular area it is of the biggest importance the "Guia técnico de Urbanizações, DIT-C11-010/N de Maio de 2006, EDP Distribuição – Energia S.A.", and the" Guia técnico condomínios fechados, DIT-C11-030/N de Julho de 2005, EDP Distribuição – Energia S.A.", which define the rules for the conception, approval and connection to the net of electrical infrastructures projects. In this matter, they determine that in the dimension of the elements of net necessary to the connection of infrastructures it should be considered the usage of simultaneity coefficient (C), characteristic of the type of usage installations.

- Residence places

$$C = 0{,}2 + \frac{0{,}8}{\sqrt{n}} \quad (1)$$

where n = number of usage installations of the net

- Remaining cases

$$C = 0{,}5 + \frac{0{,}5}{\sqrt{n}} \quad (2)$$

where n = number of usage installations of the net.

It happens that the evaluation of power carried out according to the defined in the documents formerly referred, leads to values of power and dimensions, effectively insufficient, taking into account the usage and the real needs of the installations, which will certainly, place restrictions when the charge of electrical cars batteries in residences (individual or collective) will begin to take place massively.
This situation will have impact in the definition of installed power in the MV/LV power substations and in the dimension of electrical energy public feeders.
This way, it will be necessary to revise, in general, the regulations of support to the realization of the electrical projects and, in particular, the power values suggested for the usage installations, as well as the coefficients to be applied to that power, to determine the total powers at stake in the installations.

5. Conclusions

The electrical car and the respective battery charge in the houses may have a very significant impact in the electrical infrastructures of the residence installations, in the collective infrastructures, in the public feeders and in the MV/LV power substations.
Even considering the charge of the electrical cars in empty hours, where, on one hand, the energy is cheaper and the consumptions in the installations is lower in a general way, considering the time of charge and the power at stake in the battery charge, the characteristics and the power at stake in the installations will certainly be different from what they are today, occurring consequences in the infrastructure installations, in the collective infrastructures, in the public feeders and in the MV/LV power substations.
This way, it will be urgent to revise the technical regulations which control the definition of power in such a way that in the future installations this new reality and its impacts in the installations is already taken into account.
This way we emphasize the need of the revision of the "Regras Técnicas de Instalações Eléctricas de Baixa Tensão (RTIEBT) - Portaria n.º 949-A/2006 de 11 de Setembro", the "Guia técnico de Urbanizações, - DIT-C11-010/N de Maio de 2006, EDP Distribuição – Energia S.A." and the "Guia técnico condomínios fechados, - DIT-C11-030/N de Julho de 2005, EDP Distribuição – Energia S.A.", in what concerns the definition of minimum power and simultaneity factors.

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