Electromobility - Integrating electric charging infrastructure with the business model and network operator

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Abstract

The possibility of introducing the electric car as a model of sustainability is directly linked to the volatility of oil prices in the world market and increasing scientific evidence attributed to the greenhouse effect and its consequences on Earth.

Revisiting the theories of sustainable growth that contributed to the emergence of new paradigms of development, such as the electric vehicle, the problem of energy supply in cities with electric vehicles (EV) and plug-in hybrids (PHEV), is also an obstacle to their widespread generalisation and use.

Next, is a case study based on the MOBI.E pilot project, implemented in Portugal.

Key words*:* Electromobility, Electric Vehicle (EV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Smart Grid

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1. Introduction

1.1 Objectives for sustainability

According to the IEA (2009), 93.5% of energy consumption for transportation came from oil products and only 1% came from electric resources. This shows the almost total dependence of mobility on oil.

There are concrete objectives in some countries, as well as in the EU, geared towards to sustainable development directly related to the global greenhouse gas (GHC), and there are several initiatives related to the ways of achieving these objectives. One of these objectives relates to human mobility, in particular with the massive introduction of the electric vehicle (EV) and hybrid electric vehicle (HEV). The EU has set macroeconomic targets for 2020, as per Decision 2009/406/EC and the European Directive 2009/28/EC on renewable energy.

According to Master, M. *(2011) "Oil industry analysts suggest the world has barrels of crude enough for about forty years at current rates of consumption -- long enough, surely, for the electric alternative to assume the mantle. Meanwhile sceptics argue that reserves are far lower than the OPEC countries will ever admit and that oil prices will soon rise sharply, long before battery technology and electric transport infrastructure is sufficiently advanced."* In fact, the development of electric cars is directly linked to the evolution of oil prices along the years (Chan, 2007).

Currently, and given the continued rise in oil prices, we are witnessing an increase in the concept of sustainability related to electric mobility. Agreeing with Andersen et al. (2009), Chan (2007) and Duvall (2002), the present technological concept is focused on HEV and PHEV hybrid vehicles. However, the rate of development of new solutions targeting more efficient batteries reveals the electric vehicle (EV) potential for city travel. At the same time that electric vehicle models are launch on the market, there is also technological development to deal with the several problems inherent to the electric vehicle project, particularly electrical charging. There are several pilot projects in progress since 2008 in Israel, Denmark, Australia and the USA (California) (Andersen, Mathews, Rask, 2009). This article will cross-reference the existing models of electric supply and the MOBI.E project currently in the pilot stage and being implemented in Portugal since 2009 and until 2012.

1.2 A concept of integration

Observing the need for a framework to integrate the element of electrical load within a business model and a network of operators, this paper is based on a case study on the

Portuguese MOBI.E solution for charging electric vehicles. It intends to respond to some problems related to this system.

There is a political issue underlying electromobility projects, both in Europe and the United States and China. The attempt to become economically independent from oil and to reduce the greenhouse effect, has led governments to seek out electromobility.

However, the problems related to the dissemination of the electric vehicle are important and specific, particularly insofar as to autonomy, price, and battery-charging time. Research in this sensitive area is constantly being redirected as scientists verify their chances of developing new solutions. One can cite as example the existence of ultracapacitors (which store energy in charge electrodes instead of storing the electrolyte) IEA (2009) and the eventual association of lithium batteries with ultracapacitors (Chan, 2007).

One of the problems of the expansion of electromobility is the lack of a network that allows charging the electric vehicle in cities or even at home. Additionally, the problems inherent in the electrical charging are related to safety, compatibility and interoperability.

2. The analysis methodology

The analysis methodology of this paper is related to a case study. According to Yin (2003), when there is a single case study on a particular matter, it is deemed to be a critical case, in order to test an accepted formulation.

Agreeing with Yin (2003), the presentation of the MOBI.E case will be justified by rational analysis of two characteristics that define single cases since they are revelatory cases. This occurs when you can immediately analyse a phenomenon. The second characteristic of the single case is the longitudinal case, where it is possible for the same single case to be studied at two different times. This study will consider a holistic design approach.

The MOBI.E is a pilot project and will be studied as a pilot case study. Therefore, it requires collecting theoretical, as well as technical information. This case study presents a research study related to electromobility (Adene, 2010), as well as the description of an intelligent charging system, in an open platform.

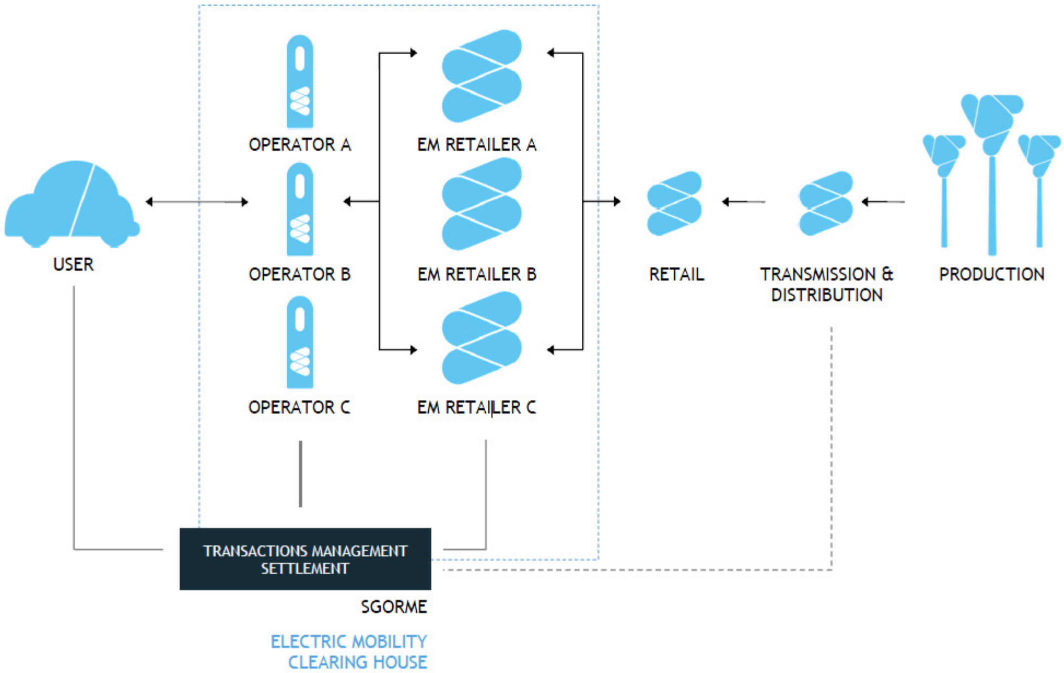
To obtain evidence, interviews were conducted with supervisors of the Pilot Project, which produced both quantitative and qualitative data, through the formulation of open and closed questions. A chain of evidence was attempted, but the fact that it is a pilot project did not allow for a concrete analysis of the consequences of the project itself.

3. The case study

This case study was selected because it represents a wager on the open platforms business and, thus, represents a step forward in the development of the issue of electromobility - charging service for EVs or PHEVs. Interoperability is a matter of relevant importance and MOBI.E appears to be an integrator. It constitutes a business model in itself, associated with the predictable growth of electromobility. The resolution of this integration problem requires the interaction of several entities, whose roles are not only regulatory but also involve the development of a prototype, cash flows, electrical software, and charging solutions. Harmonising this integral framework for the electric vehicle charging system is presented as the best way to attract new users to electrical mobility.

As Hajer (2011) said "*The frame of the energetic society encourages governments to take a different approach, and requires the various tools already available to governments to be used in new ways*". The initiative's pilot project MOBI.E was established by the Portuguese government under the "Programme for Electric Mobility", which is integrated in a major instrument – the "National Plan for Energy Efficiency – Portugal 2015", approved in 2009, with the aim of expanding the use of the electric vehicle in Portugal. The pilot project MOBI.E began its development in 2008, and is a smart electrical charging solution, based on an open platform.

The partnership formed between various Research and Development entities, such as RENER Living Lab, CEIIA-CE, REMOBI, the communication entity Brandia Central, the energy entity EDP INOVAÇÃO, the software technology entities Novabase and Critical, and the technology entities Efacec, Siemens and Magnum Cap, led by a government entity INTELI, enabled the design of equipment and a software platform. This joint venture provides a complete solution, not of a product, but of a service.



Source: APEC workshop Hong-Kong

MOBI.E is characterised by five characteristics considered to be important and advanced:

1) Interoperability via electronic platform hardware and software developed specifically for this project (for example, it allows realizing in time which available charge point is closest to the vehicle; make the reservation at the charging point and monitor the charging of the vehicle on the MOBI.E Portal, by smartphone or tablet);

2) Communication – it is designed to be implemented in any geography, proposing a system approach that can surpasses the lack of communication between the various existing systems;

3) Integrated network through a single card, where the customer can choose the electricity supplier, at any point of charging;

4) Integration of other services, such as toll, public transport and car park payments;

5) Intelligence through Mobility Smart Center – it is possible to send information between energy service providers, and financial information in order to act as a chamber of compensation for all parties involved.

The network grid for electromobility is spread across the country and consists of 1300 normal charging points at 3.7 kW, on alternating current (100% in 6h-8h), which are located in 25 cities and in all capital districts. The location of the charging points were selected by the municipalities and the MOBI.E partners, and 50 fast 50kW, DC current (80% in 15 to 20 minutes) charging points were placed in the service areas of highways and roads.

Under the pilot project MOBI.E a survey was carried out that produced the following results:

According to the survey (table 1), one can observe that the average daily use corresponds to 1:11:59 hour, travelling as average 13,483 kilometers a year. Admitting this possibility, the use of EVs or PHEVs in Portuguese cities seems feasible.

As noted in Table 2, consumers are willing to pay 5.2% more for an EV than for an ICE vehicle. This percentage is in line with surveys conducted by BCG Consumer Barometer (March 2011) for EU (9%) and U.S. (6%) consumers. However, 74.1% said the price of an EV should be lower than an ICE vehicle.

4. Other types of charging systems

A All around the world, there are companies and organisations that develop alternative electric charging systems for EVs and PHEVs. The system of replacing batteries designed by Better Place is an example of this. This system has a relatively complex technology. According to Better Place, the driver enters the lane, the car proceeds along the conveyor while the automated switch platform below aligns the vehicle under the battery. The battery release process begins. Afterwards, a new, charged battery is then placed in the car. Better Place states that "the team switch process takes less than a stop at the gas station and the driver and passengers may remain in the car throughout."

Another charging system that is currently being studied and developed is the use of inductive transmission via the wireless system. As Slovick (2011) states, “Contactless energy works on the principle of induction, similar to how a transformer transfers energy from its primary winding to its secondary winding. In induction charging when the process starts an electric current begins to flow through the primary coil; the resulting electromagnetic field induces an electric current in the secondary coil, which recharges the battery." Currently in the process of scientific research, electric induction will probably become, in the coming years, a new form of electric charge.

5. Smart Grids

Hajer (2011) stated that 'smart grids', are created by coupling electricity flows with information flows. (IEA, 2011). Smart grids enable a balance between energy supply and demand and lower prices. They are an automated system that uses software to measure network power in real time.

The possibility of renewable electricity produced by wind energy, for example at night, can be used for charging EVs, when they are parked in garages and car parks. This form of supply, requires smart grids and smart meters in order to enable efficiently supplying electric vehicles (Hajer, 2011).

Barkenbus (2009), states that the price of electric vehicles is a major disincentive to electromobility. Indeed, the cost of electric vehicle batteries is the greatest obstacle to its massive dissemination despite the fact that there are studies that show that people are willing to use environmentally-friendly products.

Conclusions

Current knowledge on EV and PHEV charging is low, despite the fact that there are several on-going regional experiments being carried out in different countries, as well as one being carried out nationwide - MOBI.E. The perception is that if there are no electric vehicles, you cannot concretely analyse the reliability of the MOBI.E system or of the systems already installed in many countries. This reality is, however, dynamically changing given the commitment demonstrated by several governments through environmental regulation. Additionally, automobile manufacturers are developing and launching EVs and PHEVs on the market, for example: Nissan Leaf, Mitsubishi I-Miev, Renault Twizy, Chevrolet Volt, Opel Ampera, Mercedes Classe A E-Cell.

Alongside technology, there is a marked development, with other systems and/or forms of charging being studied, including the induction system. This is an important advantage with regards to charging points, that despite having an appealing design, occupy space and require a charging cable, both of which can be subject to vandalism (Svenningsson, 2009).

There already seems to be a clear view as to the problem of whether smart grid points associated to charging points on the market for electric vehicles should come first or if electric vehicles must precede the charging system. Effectively, despite the fact that charge points are becoming outdated given the emergence of other forms of charging, this system is currently best suited to market circumstances, including the solution in the MOBI.E open system.

Another important issue is the view reflected in the submitted consumer market study. This type of study is a small step to understand the concept of electromobility but studies should also be carried out on the impact of the potential success of the EV and PHEV, as well as on electric coverage needs for the housing market and city market. There should also be studies carried out on the problem of peak load, bottling traffic jams at car parks, vandalism and the degree of safety of the charging points.

Also noteworthy of study is the introduction of the charging system in open parking for apartment buildings, which would allow absorbing the electrical peak flow produced in wind farms and hydro-electric dams. This matter, at this stage, is related to the cost of investment and amortisation and does not constitute, in advance, a technological problem. On other hand, the possibility of injecting power in the electrical network - the vehicle-to-grid concept – leads batteries to act as storage units that can then sell their unused energy back onto the grid when needed. This is a technical problem still to be resolved in the years to come.

Portuguese Cities	ONE VEHICLE		TWO VEHICLES				
			MOST USED VEHICLE		LESS USED VEHICLE		
	Mean km/year	Mean n. hours/day a)	Mean km/year	Mean hours/day a)	Mean km/year	Mean hours/day a)	Most common use
Almada	12 659	01:17:03	23 143	01:45:43	8 619	01:00:00	Home - Work
Aveiro	12 242	01:01:49	22 886	01:26:34	9 914	00:42:00	Home - Work
Beja	11 333	00:57:30	22 757	01:38:07	7 946	00:53:31	Home - Work
Braga	9 257	01:06:00	17 486	01:55:43	7 829	00:51:26	Home - Work
Cascais	14 839	01:10:39	23 000	01:59:17	9 619	00:47:52	Home - Work
C.Branco	10 860	01:04:11	25 440	01:50:24	14 080	01:04:48	Home - Work
Coimbra	13 971	01:14:07	25 439	01:42:26	9 488	00:42:26	Home - Work
Évora	12 897	01:10:00	20 963	01:24:26	8 593	00:45:34	Home - Work
Faro	15 297	01:22:42	19 333	01:44:33	8 636	00:53:38	Home - Work
Guarda	13 829	01:06:52	21 667	01:36:40	10 833	00:50:50	Home - Work
Guimarães	17 375	01:16:53	17 641	01:04:37	8 436	00:37:41	Home - Work
Leiria	12 813	01:21:34	19 500	01:44:13	8 632	00:48:10	Home - Work
Lisboa	12 955	01:17:55	19 942	01:25:23	8 596	00:51:55	Home - Work
Loures	12 897	01:14:37	18 704	02:05:34	8 444	00:55:34	Home - Work
Porto	13 000	01:10:00	23 776	01:40:25	9 286	00:44:41	Home - Work
Santarém	10 212	01:01:49	20 025	01:46:30	7 625	00:49:30	Home - Work
Setúbal	14 830	01:26:49	23 682	02:34:05	9 273	01:06:49	Home - Work
Sintra	10 725	00:50:15	23 412	01:54:43	9 000	00:47:39	Home - Work
T.Vedras	18 816	01:10:16	23 690	01:26:54	9 276	00:49:40	Home - Work
V.Castelo	15 762	01:09:17	23 333	01:57:30	9 625	00:50:00	Home - Work
V.N.Gaia	16 651	01:31:24	21 350	01:57:45	8 675	00:54:00	Home - Work
Mean	13 483	01:11:59	21 618	01:42:57	9 089	00:50:01	Home - Work

a) hours: minutes: secondes

Table 1 – Use of the vehicle (Source: Survey MOBI.E, 2010)

THE PRICE OF AN EV SHOULD BE...THAN AN ICE VEHICLE				
City	N. Interviews	Lower (%)	Higher (%)	Equal (%)
Almada	**75**	82,7	9,3	8,0
Aveiro	**76**	63,2	7,9	28,9
Beja	**74**	77,0	6,8	16,2
Braga	**76**	81,6	0,0	18,4
Cascais	**76**	68,4	7,9	23,7
C.Branco	**75**	74,7	4,0	21,3
Coimbra	**81**	66,7	9,9	23,5
Évora	**70**	78,6	2,9	18,6
Faro	**75**	74,7	4,0	21,3
Guarda	**74**	71,6	5,4	23,0
Guimarães	**75**	77,3	1,3	21,3
Leiria	**75**	76,0	2,7	21,3
Lisboa	**125**	82,4	2,4	15,2
Loures	**76**	75,0	2,6	22,4
Porto	**105**	66,7	6,7	26,7
Santarém	**75**	77,3	2,7	20,0
Setúbal	**81**	71,6	7,4	21,0
Sintra	**62**	72,6	4,8	22,6
T.Vedras	**68**	72,1	5,9	22,1
V.Castelo	**74**	78,4	4,1	17,6
V.N.Gaia	**95**	68,4	7,4	24,2
TOTAL	1663			
Mean		**74,1**	**5,1**	**20,8**

Table 2 – The Price of an EV should be…Than ICE Vehicle (Survey: MOBI.E, 2010)

Data of the Survey:

Universe: Residential buildings of the cities that joined the project MOBI.E in Portugal.

Almada, Aveiro, Beja, Braga, Cascais, Castelo Branco, Coimbra, Évora, Faro, Guarda, Guimarães, Leiria, Lisbon, Loures, Porto, Santarem Setubal, Sintra, Torres Vedras, and Viana do Castelo Vila Nova de Gaia

Sample: 1663 interviews

Sample with statistical significance (error not exceeding ± 2.4%), for the confidence interval at 95%

Collection Method: Telephone interview using the CATI (Computer Assisted Telephone Interview)

Fieldwork took place between 8 and 19 February 2010

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