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A REVIEW ON THE IMPACT OF ELECTRIC VEHICLES ON THE ELECTRIC GRID

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Abstract. *Electric vehicles can present as advantages higher efficiency of electric motor in comparison with internal combustion engines, reduced pollutant emissions during operation and minimized noise emission. The disadvantages lie mainly on the high costs of vehicle and battery, long charging period and short battery lifetime, and the need to increase electric power generation. In a period when it is considered the introduction of smart grids in the country, including the possibility of future introduction of electric vehicles at large or moderate scale, careful studies must be conducted mainly due to the need to increase electric power generation to attend existing and imminent demands. Previous studies point out to different impact level by introduction of electric vehicles in the national electric grid, varying from small impacts for the hypothesis of substituting 100% of the fleet to impractical use if more than 20% of the fleet is replaced. This work makes a comprehensive literature review, showing as a result a summary of the expected real impacts by introduction of electric vehicles in the electric grid.*

Keywords: *electric vehicle; smart grid; energy*

1. INTRODUCTION

Taking into account the search for alternatives to reduce pollutant emissions and environmental impacts from automobiles, studies show that the electric vehicle can be an alternative for the near future. Each type of electric vehicle has its own peculiarities – hybrid electric vehicles, hybrid plug-in, fuel cells or battery-powered vehicles are not at all the same – yet, somehow, all of them allow for gas emissions reductions. According to Amjad et al. (2010), the electric vehicle, while in operation, does not emit gases; however, it is not very successful due to its high cost, battery weight, low autonomy and lack of infrastructure to recharge it. Presently, electric hybrid vehicles offer fuel economy, low emissions and have the fuel supply infrastructure, yet they still completely depend on oil to recharge the battery. Plug-in electric hybrid vehicles, conversely, can achieve a better balance and be more attractive, since they can use alternative sources, other than oil.

It is also important to emphasize the concept of smart grid, which has begun to be introduced in Brazil. This aims to incorporate sensing and monitoring network performance technologies. The smart grid renders the utilization of electric vehicles more viable, since it provides the sector with a more effective control of the energy supply and demand. Consequently, it allows for a better distribution of electricity and avoids overloading of the grid. In the light of the above, studies that comprehend both topics are necessary. In this context, this article aims to do a literature review concerning the impact of the introduction of electric vehicles on the electric grid.

2. ELECTRIC VEHICLES

The electric vehicles can be classified based on the way that electricity is provided. There are battery electric vehicles (BEV), hybrid electric vehicles (HEVs), fuel cell and plug-in hybrids (PHEV), among others. The BEV are pure electric vehicles, and have an electric engine powered by batteries that are charged directly on the grid. Some of its characteristics are: "zero emission" vehicle, high energy efficiency, and independence from non-renewable energy sources. However, the BEV has low autonomy and high initial cost (Pereira, 2010). A further factor that complicates the insertion of BEV in the market is the kind of battery that is used by the vehicle. There are many studies focusing on each type, their advantages and disadvantages, efficiency, recharge and discharge. Shukla et al. (2011) make a comparison between lithium batteries, lead acid, nickel cadmium, among others, to verify the viability of the options to store energy.

The HEV has an internal combustion engine (ICE) and an electric motor, which is powered by the energy stored in the batteries. The batteries are recharged by a regenerative braking system, and the ICE is turned off when the vehicle stops in traffic for a long time (Baran, 2012). The PHEVs are hybrid electric vehicles able to extract and store energy from the grid in order to provide propulsion for the vehicle. There is a battery charger and a fuel tank in its structure, which can be used together or separately. This system is capable of offering higher energy efficiency and lower environmental impact (Bradley and Frank, 2009).

In many countries the electric vehicle is a viable reality, but Brazil still encounters a number of barriers, such as high costs, appropriate and economically viable technology, and the lack of charging infrastructure required to supply

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electric vehicles. Basically, nowadays, in Brazil, electric vehicles are designed mostly for urban use. They have autonomy of roughly 120 km and require 8 hours to perform the refill. Note that the priority in Brazilian territory is still the hybrid vehicle. An example of a hybrid that is expected to be successful during the World Cup 2014 is the hybrid electric bus powered by hydrogen, designed by/at COPPE/UFRJ. Spacious and comfortable, the bus has a range of 300 km and pollutant emission is zero, but it is still expensive due to the high technology used and its craft production (Rocha, 2011).

According to Costa (2013), there is a bill that aims to reorient the Brazilian automotive regime in order to encourage hybrids or electric cars and foster the development of new segments. This bill intends to grant tax exemptions (such as the industrialized product tax - IPI, the social integrated plan/social security financing contribution - PIS/ COFINS and public server patrimony formation program - PASEP) for domestically produced vehicles that are equipped with electric or hybrid motor.

In many countries of Europe, North America and East Asia, the sales of electric vehicles are rising, mainly in Denmark, Netherlands, Sweden and Portugal, as it can be seen in Fig. 1.

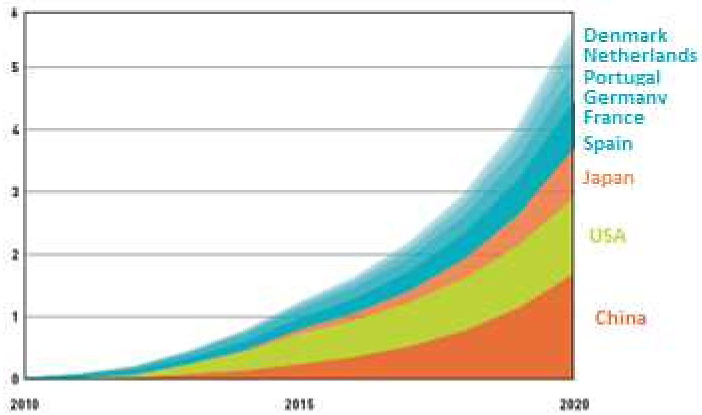

Figure 1. Sales of electric vehicles (in millions) in some countries (IEA, 2012).

The Dutch government intends to reach the mark of 10,000 electric vehicles on the road by 2015. The EVs have an ever-increasing production, and, although its cost is higher than those of vehicles with internal combustion engine, its price tends to decrease as new units are introduced in the automotive market. It is noteworthy that in 2013 there will be roughly a thousand local public charging stations, which location will be available through an internet site. The use of EVs is also encouraged in the country through a number of tax initiatives. By 2015, the government will spend €9 million to implement the National Action Plan, which is meant to stimulate electric mobility, strengthen collaboration and international partnerships and deploy communication, among others (IEA, 2012).

Barcelona, Spain, is another city that plans to reduce greenhouse emissions and oil dependency through electro mobility. There are about 280 PHEVs and HEVs in the city, and it is expected that, by 2014, 50% of the fleet will be electric. Nationwide, government's actions involve granting direct subsidies for the purchase, changing registration fees and lowering electricity taxes. At municipal level, users of electric vehicles have tax reliefs amounting to up to 75% of the tax vehicle registration and new public parking with 2% of the parking spaces reserved. Through partnerships with private companies, it is possible to find the cheapest charging stations in the city and to have information such as telephone numbers and locations (IEA, 2012).

In Japan, the cities of Nagasaki and Kanagawa also stand out as places pioneering the use of EVs. Nagasaki focuses on developing new EVs for local industries, as well as using renewable energy and smart networking that add EVs. In Kanagawa there are already over than 2100 EVs and nearly 109 fast charging points. The city government provides the customers with subsidies, tax reductions and other additional incentives, such as discounts on parking under its jurisdiction (IEA, 2012).

In the United States, Los Angeles aims to become the world capital of PHEVs. The state offers tax credits of up to US$ 7500 for those willing to purchase PHEVs. In 2015, the target is set at 80,000 electric vehicles. In New York about 44% of families only have one car, thus the goals regarding gas emission reductions in the city prioritize public transport. By this time, more than 430 electric vehicles were acquired, including light vehicles and scooters, and studies are still in progress to determine the feasibility of electric taxis.

In Portland, USA, EVs are part of a strategy of electro mobility, playing a key role in the Climate Action Plan of the city, which involves targets concerning carbon dioxide (CO_2) emission reduction. Conditions for the use of EVs are favorable, since the pathways are short, electricity is affordable, the source of energy is relatively clean and the weather is appropriate. In 2013 the EV Project, funded by the Department of Energy, will implement two thousand charging stations in Portland and its surroundings, and public charging will be free for those users who agree with anonymous data collection. The goal set by the state of Oregon is that 20% of its fleet will be electric by 2020 (IEA, 2012).

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In China, Shanghai has prioritized the development of PHEVs, EVs and hydrogen fuel cell vehicles. The city was chosen by the Chinese government as one of the twenty-five pilot cities for the demonstration of energy efficiency. These types of vehicles benefit from Chinese government subsidies. In 2011 the Test Drive/Ride Center of China was created to educate the public on the development of EVs, its history, the trends for the future, as well as to help them to understand their importance (IEA, 2012).

Sweden is another country that has favorable conditions for the use of EVs. It has a population presumably conscientious when it comes to environmental issues. Moreover, 90% of the electricity is generated from renewable sources, and the country has low electricity prices. The EVs owners are exempt from car taxes during the first five years after the purchase. Companies that use VEs benefit from tax cuts as well (IEA, 2012).

3. BRAZILIAN ENERGY MATRIX

Brazil has an extremely diverse energy matrix, compared to other countries. According to the National Energy Balance - BEN (EPE, 2012), the share of renewable sources has remained among the highest in the world, corresponding to 44.1%. The domestic energy supply comprises 15.7% of sugarcane biomass, 14.7% of hydroelectric dams and electricity, 9.7% of firewood and charcoal and 4.1% bleach and other renewable. The percentage of non-renewable sources comprehends 38.6% of oil and oil products, 10.2% of natural gas, 5.6% of coal and 1.5% of uranium. With regard to the domestic electricity supply, the main source is hydroelectric dams (81.9%), followed by biomass (6.6%) and oil (2.5%), as shown by Fig. 2. In 2011, hydroelectric generation increased by approximately 6% compared to 2010, reaching a total of 466.8 TWh. It is also interesting to note that there was a decrease in thermal generation of 8.7% in 2011. In contrast, renewable sources had an evolution in the energy matrix. As an example, wind energy can be named, which had an increase of 24.3% in 2011.

Regarding the energy consumption in Brazil, the industrial and transportation sectors were in the first place in 2011, with 35.8% and 30%, respectively. In this context, the transportation sector presented the highest CO_2 emission levels, reaching 48.2% of the total Brazilian matrix. It is also noteworthy that the Brazilian electricity sector emits eight times less CO_2 than the U.S. electricity sector, five times less than the European and 12 times less than the Chinese one.

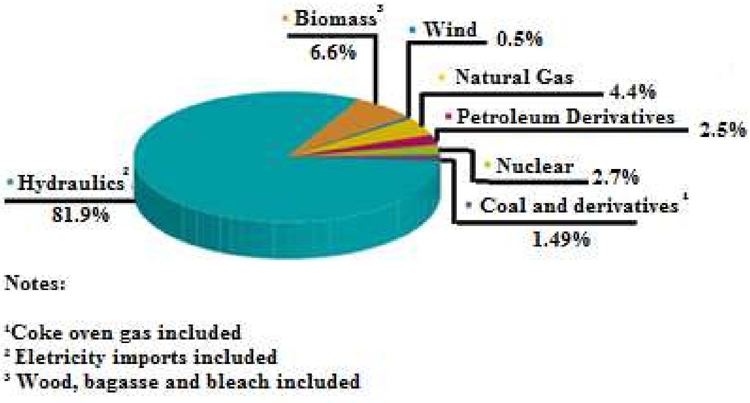

Figure 2. Domestic electricity supply breakdown by source (EPE, 2012).

According to Morgado (2012), Brazil has one of the largest and best energy potentials in the world. However, the sources of hydropower and oil present the most intense exploitation. Although each one has its own importance, the demand growth, the supply shortages, and financial, socioeconomic and environmental limitations to expansion of the electrical system are factors that lead to the use of alternative sources. The author claims that it is necessary that each source or energy resource be used strategically, so that the benefits are recovered and the negative impacts on the environment and society are minimized.

Due to the increasing demand for energy, which is an ally when it comes to gas emission reduction, the country is encouraged to use the energy more efficiently and reduce losses and failures in the system, so that overloads and possible blackouts are avoided in the near future. According to Halmeman and Rodrigues (2011), the electricity blackouts the country suffered were mainly caused by lack of investment, lack of rain, damage in transmission grid and technical failures. It was also noted that, in 2011, the energy crisis occurred not so much because of power shortages, but rather due to difficulties in the transmission of electricity.

4. BRAZILIAN ELECTRIC GRID

Considered unique worldwide, the Brazilian electric system mostly depends on hydroelectric power plants. However, these sources are not geographically close to their potential consumers. Factors such as the extensive area of

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the Brazilian territory, climatic and hydrological conditions contribute to existing surplus of hydroelectric power in certain periods of the year, while the reverse may occur in other periods (ANEEL, 2012). Basically, the current grid, which is unidirectional, consists of four sectors: generation, transmission, distribution and consumers. There are more than 87,000 km of high voltage lines and long transmission lines. Its size gives it great complexity as compared to the grids of other countries.

Coordinated by the National System Operator (ONS), the National Interconnected System (SIN) comprehends the systems of electricity production and transmission in Brazil. The SIN is formed by companies from South, Southeast, Midwest and Northeast, and only 3.4% of the production capacity of the country's electricity is out of SIN. Figure 3 shows the SIN grid interconnection.

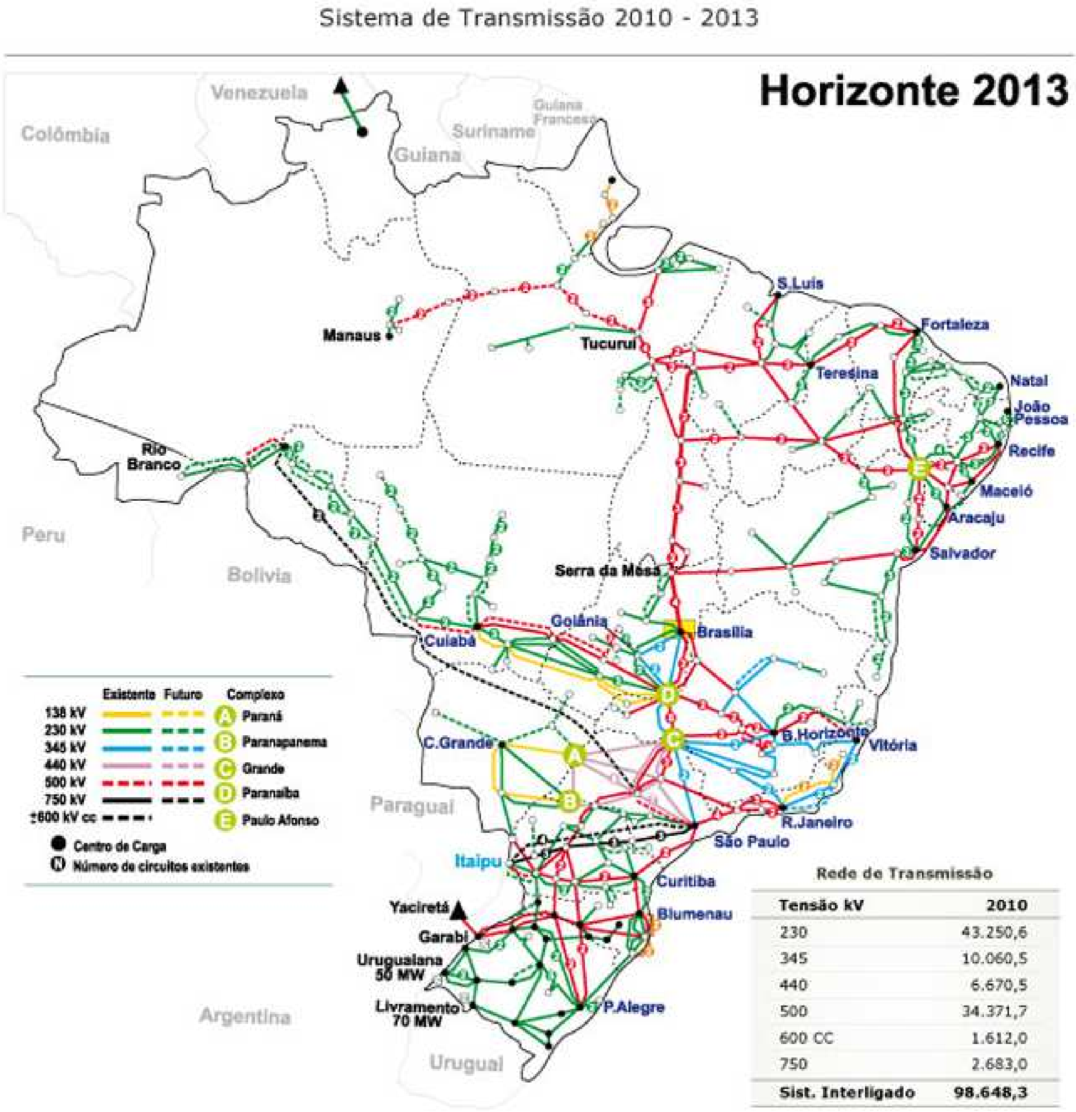

Figure 3. National Interconnected System - SIN (2010-2013).
Source: http://www.brasil.gov.br/sobre/economia/energia/ setor-eletrico/sistemas-isolados

5. SMART GRID

The continuous increase in electricity demand has been overwhelming the power system. Pinto Neto and Santos (2012) also highlight that, due the improvement of the socioeconomic conditions of the Brazilian population, the amount of acquired electronic equipment has increased, contributing to the expansion of the energy demand. Meanwhile, the electricity distribution system continued to be the same. Figure 4 shows the growth of electricity consumption in some areas of the globe from 2007 to a prediction for 2050.

Unlike the current Brazilian grid, the information flow in a smart grid is bidirectional; thus, there is communication among the sectors, which enables greater flexibility, efficiency, credibility, safety and economy (Khanna, 2012). Figure 5 illustrates the dynamics of smart grids.

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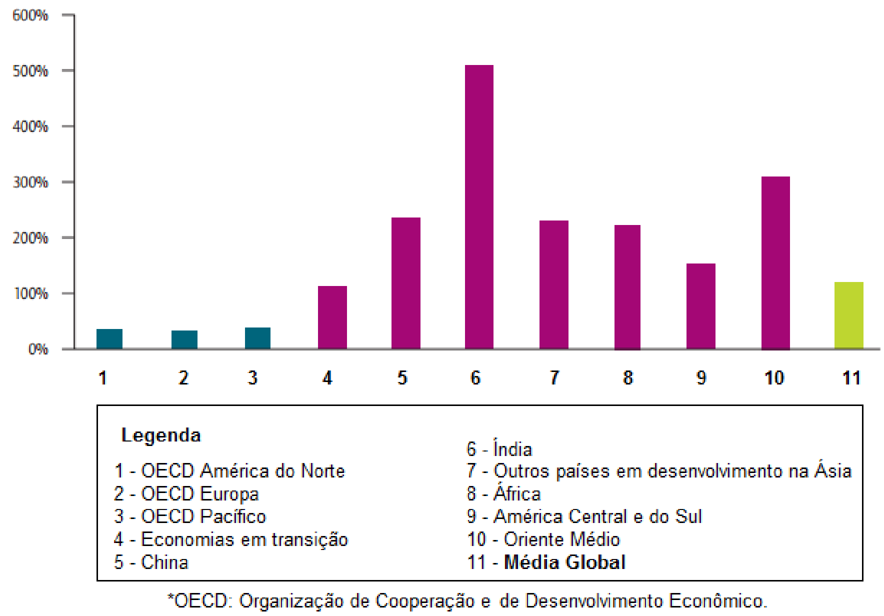

Figure 4. Increased electricity consumption 2007-2050 (IEA, 2010).

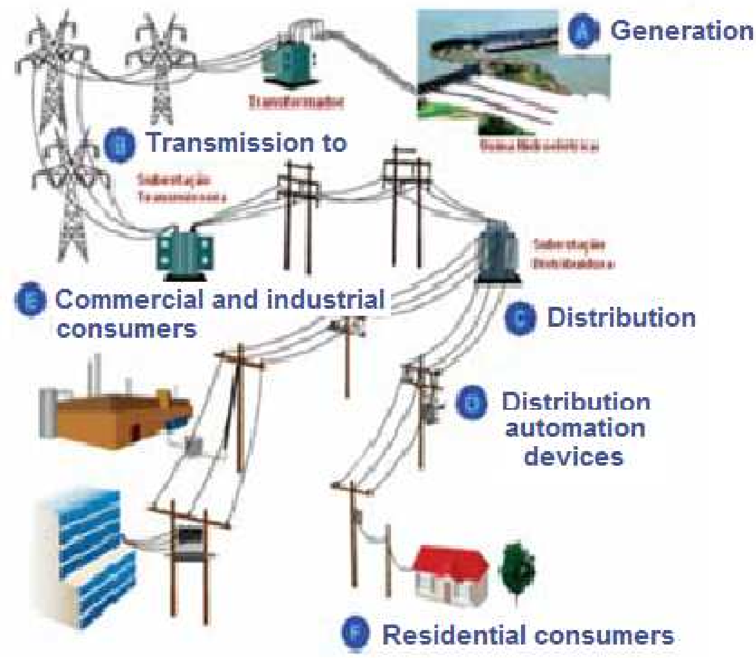

Figure 5. Smart grids (Alcântara, 2011).

Smart grids use information technology to monitor and engage in the generation, transmission, storage and electricity consumption, so as to manage the energy supply and demand (Baran, 2012). According to Pinto Neto and Santos (2012), if these intelligent networks become viable, communication between the client and the electric utility will be improved, since the information regarding the energy costs within each residence would be shared in real time. Thus, the client would be able to verify which equipment spends more energy, as well as monitor its own consumption, whether residential, industrial or commercial. Furthermore, he could even take part in the process of energy generation through micro generation, which would allow him to sell its own surplus of energy. As far as utility companies are concerned, the new system would provide the company with greater control over its operation, ensuring and improving security, energy efficiency, quality and reducing energy losses. This last factor is of outmost importance, since it is very common in today's distribution systems and power transmission to have losses of this kind. Figure 6 illustrates this problem in some of the largest countries in Europe.

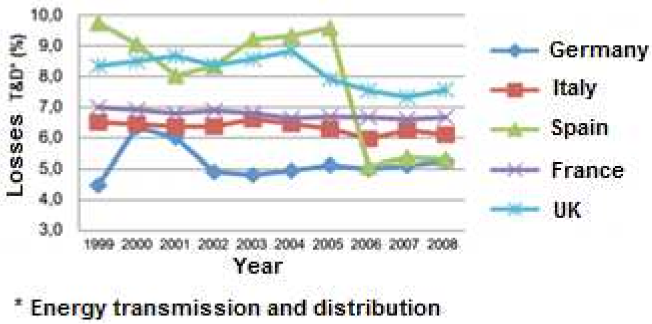

Figure 6. Losses in transmission and distribution of electricity in the largest countries in Europe (WEC, 2012).

The first step towards a change in the grid is to replace analog meters by electronic meters, which are more modern and have different functions. They are able to inform the consumption of each customer and indicate how much energy was used by each equipment. Another important step is to adapt regulations, which would allow for the adoption of measures such as increasing tariff flexibility, choosing which kind of generating source, and selling electric power. Moreover, the transmission lines will change, since they are not prepared yet to accommodate the distributed generation and to provide electricity from/to electric vehicles. According to Guimarães (2010), smart grid systems will bring forth new services that will be capable of adapting to these changes. Data communication by power line, distributed generation, electric vehicles and the sharing of remote sensing are examples of these services.

Taking into account the evolution, the complexity of interaction in intelligent grids and the monitoring process that will be conducted, the introduction of electric vehicles may have a limited impact on the grid, in contrast to what might happen if there were significant penetration of electric vehicles without proper management of the processes of loading (Silva, 2012). Silva (2012) also reported that electric vehicles will represent a highly controllable load, as it will be connected to the network for long periods when the consumer will not be using it. In addition, it could work as an energy storage device that is loaded during off-peak hours, when electricity prices will probably be lower, and sell excess power at peak times when prices will be the highest. This interaction between the consumer, electric vehicle and grid is the basis for the concept of Vehicle to Grid (V2G).

Reis (2008) understands the concept of V2G as a bidirectional link between the electrical system and the vehicle fleet that allows it to create a kind of symbiosis between the sectors. The driver’s needs and the requirements for energy storage occur at different times, which allows for a conciliation. The vehicle must have electric traction system with storage, measurement and control power. The PHEV presents these characteristics, but the biggest hurdle is related to the battery performance.

Bradley and Frank (2009) claim that the energy charging system existing in the PHEVs is responsible for connecting the vehicle to a grid, which makes it possible to each customer to manage its own consumption levels. One benefit is to replace energy from combustion with grid electricity. Additionally, to maximize the efficiency of electric energy from the grid, the PHEV recharge system should be light, compact and highly efficient. Amjad et al. (2010) emphasize the possibility of PHEV being used as an energy provider for home when the power is cut off or when no power is available in the house.

5.1 In Brazil

An article written for the Annual Examination Infrastructure (Anuário Exame Infraestrutura, 2011) showed some changes that will occur in 2013 with regard to the first step of turning the Brazilian grid into a smart grid. Initially the electromechanical meters will be exchanged for electronics, enabling control both by the energy distributor and consumers. In addition, new equipment will allow the consumer to know how much energy is being spent in real time. Residential customers will be charged differently according to the time the energy is used, which may encourage them to reduce their consumption. The Portuguese company EDP pioneered the project to test the viability of smart grids in the city of Aparecida, Brazil. The public utility’s first step was to change analogue meters for intelligent digital models (Herzog, 2013).

According to Canazio (2013), pilot projects are being implemented in the states of Rio de Janeiro and Minas Gerais, as result of an investment of $ 65 million from the partnership Cemig and Light. The program Smart Grid Light / Cemig was launched in 2010, and it aims to understand and evaluate the customers that use the energy so that afterwards the technology is applied to a broader public. Hence, the initial goal is to achieve dense areas that contain a range of social profiles, in order to evaluate different reactions to the new system. The program aims to increase the automation of homes, which will result in a more efficient and rational use of the electric energy. The program also intends to introduce electric and hybrid vehicles in the Brazilian fleet, since companies are developing outlets refills for vehicles in public places. The issue of distributed generation is another important point of the program, with the installation of photovoltaic panels on some residences in the grid simulation.

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In 2011 the company Ampla/Endesa Brazil began the project “Smart City Buzios”, which will produce about 55 GW/year for consumption, serving more than 10,000 customers. The project includes a number of avant-garde ideas: intelligent lighting, intelligent vehicles, telecommunications and control, consumer aware and informed, buildings and power generation, management and intelligent storage. Benefits include the possibility of having different tariffs, producing and selling energy, incorporating renewable sources in the network, as well as increasing the efficiency and the emissions reduction. The project also aims to use LED bulbs in streetlights, promoting energy saving and greater capacity and lighting (Canazio, 2013).

AES Eletropaulo is another public utility that is also entering the age of smart grids to test its feasibility in Barueri (SP) and then extend it to the entire concession. The project begins by exchanging the analogue meters of roughly 60,000 customers. This would allow greater control of fraud, enabling the reduction of losses. Low-voltage consumers, such as homes and small business, will be the first to be included (Canazio, 2013).

ANEEL approved the Normative Resolution No. 502/2012, which regulates the basic requirements for electronic measuring systems electricity consumption units of the following: residential, rural and other classes, except for low-income consumers and public lighting. The need to improve the quality of low voltage service, to reduce losses in the power supply and the operating costs were factors that pushed the regulator to consider the deployment of smart grids. In the new regulation, energy distributors will have a 18-month term to provide customers with smart meters, which can be chosen from two different models. The first will have no cost and will be provided for those who accept the tariff variation of the slots according to consumption. The second could be charged for the installation, and it would be more complete, since it would offer access to specific and customized information of the service provided by the company (ANEEL, 2012).

5.2 Around the world

In Portugal, the project InovGrid consists of the adoption of a smart grid that can automate power management, the result of a consortium led by EDP Distribution, incorporating companies (Janz, Efacec EDINFOR/Logic) and scientific research institution (INESC Porto). The architecture of this project is based on three layers: producer/ consumer, power boxes equipped with functions for measuring home energy management, post processing and control center, responsible for the grid operation and the quality of the service. The Portuguese government also announced, in 2009, the MOBI.E project and finished its installation in 2011. The project aimed to install an electric mobility grid on a national scale, covering 25 different cities. Some slow loading points were installed for night time use (6-8 hours) and fast loading points for daytime use (20-30 minutes). Its main advantages are: a modern power distribution system, it is possible to establish interfaces between EV and the grid, and the EV can work as power generators (Silva, 2012).

In the United States the pilot project "SmartGridCity" can be mentioned, developed by Xcel Energy in Boulder, Colorado. The main objective is to help determining which power management and conservation tools customers prefer, what technologies are most effective, the best way to incorporate them and how to launch the components of a smart grid on a large scale. The benefits given to customers were using the Internet portal to better manage daily energy consumption, reducing carbon emissions and better quality of service due to the improvement in the power outages detection (Xcel Energy, 2008).

Another project that is being developed in the United States is named AEP Ohio gridSmart, located in northeast central Ohio. In 2010, they have installed 110,000 smart meters that was the first step of the gridSmart project. They want to determine how the latest digital technology improves their ability to serve the costumers with better efficiency, reliably and securely. Furthermore, other technologies, such as plug-in hybrid electric vehicles will be tested to understand their impacts on the electric grid (Xcel Energy, 2008).

According to studies presented by Hadley and Tsvetkova (2009), several regions of the U.S. will require an infrastructure with increased capacity due to the introduction of electric vehicles in the fleet. In contrast, Lilienthal and Brown (2007) show that there will be largest pressure on the grid, but not the need for more power generation if PHEVs are reloaded off-peak hours.

In Japan, the concept of smart grid is designed, primarily, to maximize energy efficiency, increase system reliability and reduce losses in the grid. There are some pilot projects in the country, as the "Yokohama Smart City Project", which aims to build a low-carbon society in a big city, involving nearly 4,000 smart homes. Another project is the one from Toyota city, which focus is the use of energy not commonly used to generate energy. The project encompasses the study of 3,100 EVs and 70 residences equipped with an intelligent grid in order to control costs and optimize energy use. In 2011, the model houses were completed to be tested in two districts of Toyota, Higashiyama and Takahashi. Other projects may also be cited as the City of Kitakyushu and Okinawa (Ling et al., 2012).

In other countries there is high investment and research in the area of smart grids, such as China, Italy, South Korea, Spain, Germany, Australia, France and the UK. In Italy, it is interesting to note the project Telegestore. It is a remote management system for managing new electronic meters, being possible the collection of relevant data on the quality of electricity supply during monitoring, service continuity and detection of network failures. Due to the success of this project, eight projects were awarded by the Italian regulator (Autorità per l'Energia Elettrica ed il Gas). The Ministry of

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Economic Development has also awarded more than 200 million facing smart grids and grid modernization in regions in Southern Italy (IEA, 2011).

6. IMPACTS OF ELECTRIC VEHICLES IN THE GRID

Several impacts can be enumerated by the introduction of electric vehicles in the electric grid, since the products are still under study. In order to achieve success, several changes are needed, some already underway, in the electrical system, in regulations that can reduce taxes on electric vehicles, incentives for the development of national industry in the area, among others. Considering the studies surveyed on the subject, the impacts that was observed vary depending on a few factors. These are: energy sources, geographical extent, climate, customer profiling, investments, incentives and government regulations, among others. About possible reductions in emissions of greenhouse gases, Thomas (2012) reports that, in the case of the U.S., such reductions will depend on the number of electric vehicles sold to those who travel long distances and the gases emitted by power sources.

A study by Cui et al. (2012) shows some scenarios for the introduction of electric vehicles in the current installed power plant, concluding that a substitution above 20% would be unworkable in relation to demand and power generation, directly impacting the quality distribution of electricity. According to the authors, there may be an increase in demand in places where consumers VHEPs divide the circuit recharging of their vehicles. Thus, measures are needed for infrastructure development in order to maximize capacity and improve the system of power distribution.

Based on the results of their simulation studies VHEPs, Bradley and Frank (2009) concluded that the performance and electric vehicle impacts varies depending on the conditions of use in relation to the administration of vehicle power. About gasoline consumption, the study showed large reductions, but it is important to mention that it was not considered the fuel needed to generate electricity. Due to the fuel reduction, it was also observed a reduction in emissions. However, it should be noted that this reduction depends on the sources of energy. Since the electricity market is stocked with low emissions supplies, the benefits of using PHEVs are great. However, if the power source comes from coal, for example, benefits are reduced. It is also important to remember that, according to Amjad et al. (2010) inferences, people who drive less than the total battery capacity per day may never need to use the fuel.

Many studies about the impacts on the electric grid from the introduction of electric vehicles point out that there could be an excessive increase in electricity consumption. However, studies performed in the United States concluded that if the recharging of vehicles is made outside peak hours, rather than being necessary to increase the capacity of the network, there may be an increase in grid efficiency and reduce electricity costs (Bradley and Frank, 2009).

Dong and Lin (2012) conducted a study with PHEV powered by three types of batteries - PHEV-10s, PHEV-20s and-40s - analyzed in three different recharge scenarios: (1) public (2) residential and (3) residential and public. The results showed that for any battery charging and in locations that have an infrastructure for public charging (1), there were more than 30% reduction in gasoline consumption observed compared to the residential load. Furthermore, it was also found that the PHEV-10s in scenario (3) consume less energy than PHEV-20s in scenario (2). This is an indication that, to achieve the goal of reducing gasoline consumption, the availability of more opportunities for public charging can be as effective as increasing the size of the battery. Regarding costs, it was found that, if battery charging is higher, the cost of electric power will be higher.

A study performed in Dublin, Ireland, assessed the impacts of the introduction of electric vehicles in the grid according to scenarios that are represented by the peak and off-peak hours. The results indicated that the off-peak hours are ideal for recharging the vehicle and also contribute to an increase in the efficiency of the power supply, therefore, it is the preferred scenario (Foley et al., 2013).

It should also be checked the impacts from the disposal of batteries used in electric vehicles. Improper disposal can contaminate the air, soil and groundwater, offering risks to the population. The composition comprising heavy metals and other toxic elements can contribute to bioaccumulation, which is a process that a chemical accumulates in high concentrations in organisms. Recycling is an alternative to improper disposal, however, it still has high costs. In the concept of smart grid, electric vehicle owners can provide power to the grid during peak hours at a different rate. On the other hand, the study of battery life is still an issue because, with the intense process of loading and unloading, its duration may be reduced, which is a big problem in terms of its current price. It is still in debate the feasibility of this process.

7. CONCLUSIONS

Considering the studies analyzed, it was observed that there is a need for an intelligent grid for the successful introduction of electric vehicles. This fact can be explained by the current Brazilian energy grid which has no real-time monitoring, control and correction of failures, and other problems such as the difficulty to stop losses and illegal connections. In the case of a smart grid, these issues can be quickly identified, contributing to the better quality of service, security and speed. It is also worth to highlight the advantages that electric vehicle users can have such as tax cut and the possibility to make the vehicle work as a power generator to the system. Regarding the battery, it should be studied its life cycle, and there is a need for greater incentives for national development of this technology to decrease its cost, especially in relation to the high amount of taxes.

On the issue of autonomy, it was possible to verify that countries with less extensive geographical area has advantages in the use of electric vehicles, because EVs are not transiting for long time on the street. This fact allows the vehicles to be recharged overnight, outside peak hours, offering less risk of an increase in demand and an overhead power system. In relation to the reduction of greenhouse gases, if the country has more renewable energy sources in the matrix, more environmental advantages are obtained through the replacement of internal combustion engine powered vehicles by electric vehicles. If a country has thermoelectric as a based source on its energy matrix, for example, emission reduction resulting from the replacement of internal combustion engine powered vehicles by electric vehicles may be canceled by emissions from the power plants, because more electricity will need to be generated to meet the energy demand. Moreover, a country with renewable energy matrix can have higher emission reductions as power sources emit smaller amount of gas. Finally, beyond the implementation of smart grids, the success of electric vehicles may also depend on government and technological incentives, as well as a greater awareness by consumers, who are not yet adapted to the idea of electric vehicles.

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