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Considerations about Electric Vehicles Impacts on Daily Load and Environment

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Abstract: - The city transportation mix increase towards the use of battery powered vehicles. In view of the latter technological improvements provided by the makers of these cars there are potential gains for the electric utilities companies supply these vehicles. Furthermore, this means an effective oil fuel consumption reduction, and additional air and noise pollution decrease. This text purposes a probabilistic analysis of the impacts on daily load curves in view of vehicle battery recharges. Also discuss some energy and environmental effects.

Key-Words: - vehicles, batteries, planning, environment, energy.

1 Introduction

The technical literature at present is discussing more frequently the use of electric vehicles (EVs) as an effective way to provide the atmosphere pollution reduction, mainly in the major urban areas, usually affected by the emissions exhausted by the internal combustion engine powered vehicles (ICVs). The autonomy increase, the required recharge time reduction and the manufacture's concern with regard to the development of specific projects, instead of adaptations of existing ICVs, are important present factors providing increasing acceptance of EVs by the public. Furthermore, the community cares for a better quality of living, mainly in the bigger cities where the air pollution means by far more than a nuisance, but a serious contribution for the development of eyes and lungs diseases. On the other hand, a big number of countries are importers of oil and derivatives, and they are concerned with the reduction of those imports for economic purposes, which demand the evaluation of alternative energy solutions, because of the heavy burden of transportation cost on their budgets.

The electric utility companies have an important role in this matter because of the EVs battery recharge operation. New potential consumers are an interesting prospect because they are attractive and strategic markets, in principle. In order to go deeper in this discussion, further developments of some concepts and evaluations are presented. The aim is to support the decision process, in planning level, regarding the evaluation of the main effects on the load demand curves, generated by recharging of batteries of an hypothetical number of EVs in operation into an urban area. Random aspects of the problem like the batteries recharging time and supply conditions were taken into consideration. The evaluation made allows estimating the energy end environmental yields. More than 90% of the electric power generating capacity set up in Brazil comes from hydroelectric power plants, while the oil fields don't supply all the national demand, which stimulated the subject of this paper.

2 EVs Recent Story

EVs modern story, according DeLuchi [1], starts in middle 1960, because of the attention given to the environmental and energy problems. In 1969 The EVs First International Symposium was held in Phoenix, USA. Because of the first oil shock crisis, and the following consequent waves, generated a trend in several occidental countries toward the research and manufacturing of improved performance EVs. However, the oil crisis ends up before the EVs use increased. By the 80's decade, the environment problems together with surpass of the established environmental standards regarding air pollution, have grown up again, once the goals were not achieved. The very high levels of nitrogen oxide and the acid rains in USA, Europe and Japan, grown worse together with the greenhouse effect up in the atmosphere, started again the trend toward the research and development of better performance EVs. As a matter of fact, the end of 1987, only in USA, found 107 urban areas violating the authorized upper limits for carbon monoxide and nitrogen oxides, in spite of the strong regulations in force.

An important decision was taken by the USA California's Air Resources Chamber Act, enforcingbeginning 1998 that an increasing percentage of the state future car sales be ZEV (“Zero Emission Vehicles”) models. Because of this decision, an important action is happening in Los Angeles area, where 184 electric stations are designed for start up soon. [2]. This isn’t a sole fact, once in several countries it is possible to notice a growing demand for EVs, as a way to improve the environment conditions. In 1997, in Paris central area there were 21electric stations, and 8 more nearby. In France, a major part of the electric energy is generated by nuclear power plants, so the use of EVs results in important benefits for improve of the environment conditions in the central area of Paris. In this period of time, the Japan’s Office for International Industry and Trade, in view of the technological improve gains, and has set up performance minimum standards to be reached in short range. The standards for new EVs are: an autonomy of 250 km, velocity of 120 km/h and a battery life not bellow to 4 years

In Brazil, one of the early EVs was a bus owned by the late The Rio de Janeiro Tramways, Light and Power Co. Ltd. [4]. By the time of the second oil shock wave, the government took several steps toward the reduction of oil imports, driving to an increase of concern for use of EVs. In 1984 it was held in São Paulo “The First Seminar of Battery Powered Vehicles”, and in Rio de Janeiro happen “The Technical Meeting on Use of EVs” sponsored by ELETROBRAS (Federal Government Holding Company) . Some papers were presented evaluating the use of EVs by electric utilities companies, which have bought some pioneer models of EVs from GURGEL, at this time the unique native electric car manufacturer. Also COPEL, an electric utility from Parana, Brazil, presented a paper with some associated industries, focusing a prototype of an EV. Another contribution was a computer program for EVs performance evaluation presented by CEPEL (Electric Energy Research Center) [5].

The meeting have driven to the conclusion that it was feasible to manufacture and to use EVs in the country provided that official agencies and private industries get together for the improvement of the quality of the local made EVs, the management of human, financial and information resources, and promoting the market acceptance for those vehicles.

In 1975 was consolidated the “PROALCOOL” (National Program for Production of Ethanol), and 8 years late*r*, by 1983 the Brazilian auto industry has produced one million cars powered by ethanol fuel engines. Besides some technical and economic inconsistencies of that program, the country succeed in saving imports of oil in the 1980’s. By the end of the 80-decade no action was happening in the country with respect to EVs. Only few universities, as the UNICAMP (Campinas State University), and some research centers had supported some plans in this area [7]. During this period, because of that no longer technological advances happen.

The global economy is a must to look for new opportunities in this field. Therefore it is important to discuss the models that provide the analysis of EVs use by the Brazilian market. In fact there are potential economic gains to be explored by the strategic advantages available.

3 Expected Impact on Daily Load Demand Curve

The EV relationship with the energy distribution network is made through the battery charger. Basically it is composed by a rectifier element that has a voltage control system that consistently supplies current into the battery. The process ends up automatically. After the consumed energy recharge, a low current supply can be maintained to compensate the inner battery losses

This paper will focus the operation of home battery charger, which usually is a vehicle accessory. A typical average shape recharge cycle, which represents the time rated network power supply, is shown in following Figure 1.

The plotted periods of recharging are estimated, in accordance with Helton [8] and Rice [9], showing the joint current and voltage control procedure. The power percents in the vertical axis are expressed in battery set nominal power values.

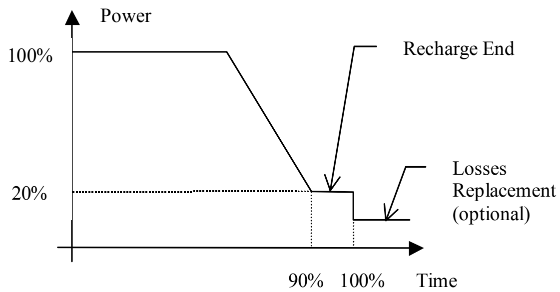

Fig. 1. Typical Recharge Battery Curve

A simulation of the proposed methodology is presented and a fleet of 10,000 EVs was considered into an urban area where the average daily traveling distance is about 55 km. The passenger EVs recharge specific energy supposed to be 0.29 kWh/km will result in a daily energy consumption of 16 kWh. In addition a recharge time was estimate in 5 hours. This means a peak load power demand of 35 MW and the total energy to be supplied would be 175 MWh for the whole fleet recharge, considering the geometric shape of Figure 1. It should be noticed that the specific energy considered is the one required by a rectifier operating at 220 V, and both the rectifier and battery set efficiency are taken into consideration.

The above estimates didn't consider the random battery recharge starting time of the whole fleet, as well as the previous battery state of charge, that is to say, the amount of previously consumption of energy, once the car users travel different distances in the period. For this purpose, an algorithm was introduced in a simulation process which consider the typical probability density functions [10], provided that the events, recharge time and the traveled routes may be analyzed independently. Considering, for instance, a recharge process of the whole set of batteries in 5 hours, Figure 2 shows the resulting graphics, followed by the related comments.

The Graphic 1 represents the EVs fleet's traveled route probability density function. The turning point in the right side comes out from the supposed autonomy of 115 km for the whole fleet. It should be taken into consideration that some users might have an option for another alternative transport, in view of such a limitation. In this case, 9508 EVs will be computed for calculation purposes, what is to say that 5% of the users would have an expectation bigger than the 90% of the autonomy (100 km), once at least a 10% margin is usually considered for casual purposes. Therefore, this function may be associated with the battery states of charge by the end of the route.

The Graphic 2 represents the percentage of vehicles starting the recharge on a daily period. It shows an histogram associated to a roughly normal probability density function which average recharge starting time was taken as 22 hours, considering the eventual utility companies incentives for recharging out of the peak load periods.

The Graphic 3 shows the batteries recharge load along a 5 hours period. It is possible to see that the intensive recharge period was affected by a small voltage change, enough to make the power grow up to 6 kW. It is possible to realize that even the home and small commercial installations have enough capacity for the use of typical home recharging kits. Whilst future restrictions occur, a longer recharging period time would solve the problem.

The indication of the maximum required power to supply the considered EVs, didn't exceed 11 MW, once the recharging process is spread out along 24 hours, being the peak load at 11 PM, as shown on Graphic 4. The total accounted energy in the delivered points amounted circa l32 MWh. It is important to notice that this amount is lower than the energy considered regarding the average route, 175 MWh, once this latter value didn't take into consideration the random characteristics mentioned before, and, usually, is a conservative estimate of the evaluated process.

4 Energy and Environment Remarks

The evaluation made so far allows obtaining other daily energetic expected conditions, as a consequence of this case study. Thus, the proposed model provides the generation profile evaluation to supply the EVs recharge energetic requirements. Based on a typical percent sample of the electric power generation in Brazil it is possible to indicate the generated energy, transmission losses included, supplying EVs needs, per type of existing power plant, as shown on Table I.

Substitution of ICVs by equivalent EVs allows the fuel consumption savings quantification. The several steps to supply gasoline, beginning with the oil refining up to the gas station, as well as the energy transformation balance, considering a consumption rate of 12 km/liter for ICVs, and the typical standards for the Brazilian car fleet, where the used fuel is the "gasohol" (mixture of hydrated ethanol and gasoline in prefixed percentages) is considered and summarized on Table II.

It is interesting to notice that the introduction of the considered EVs fleet, would provide an equivalent saving of 13,505 toe. Furthermore, an emission reduction of about 34,500 tons of CO2 and 20 tons of methane would happen, which relationship with the greenhouse effect is well known. The other emissions of local effect, also would be, in the same basis, 783 t of CO, 100 t of HC and NOx, respectively.

5 Conclusions

In this text a discussion was made regarding the availability of more consistent elements to evaluate the introduction of EVs into the market, with respect to power demand required for the batteries daily recharges. The influence of some random aspects in the batteries recharge process was emphasized, mainly with respect to recharge starting time and the battery state of charge, as discussed. The subject and model analysis foresee the EVs potential regarding the energy and

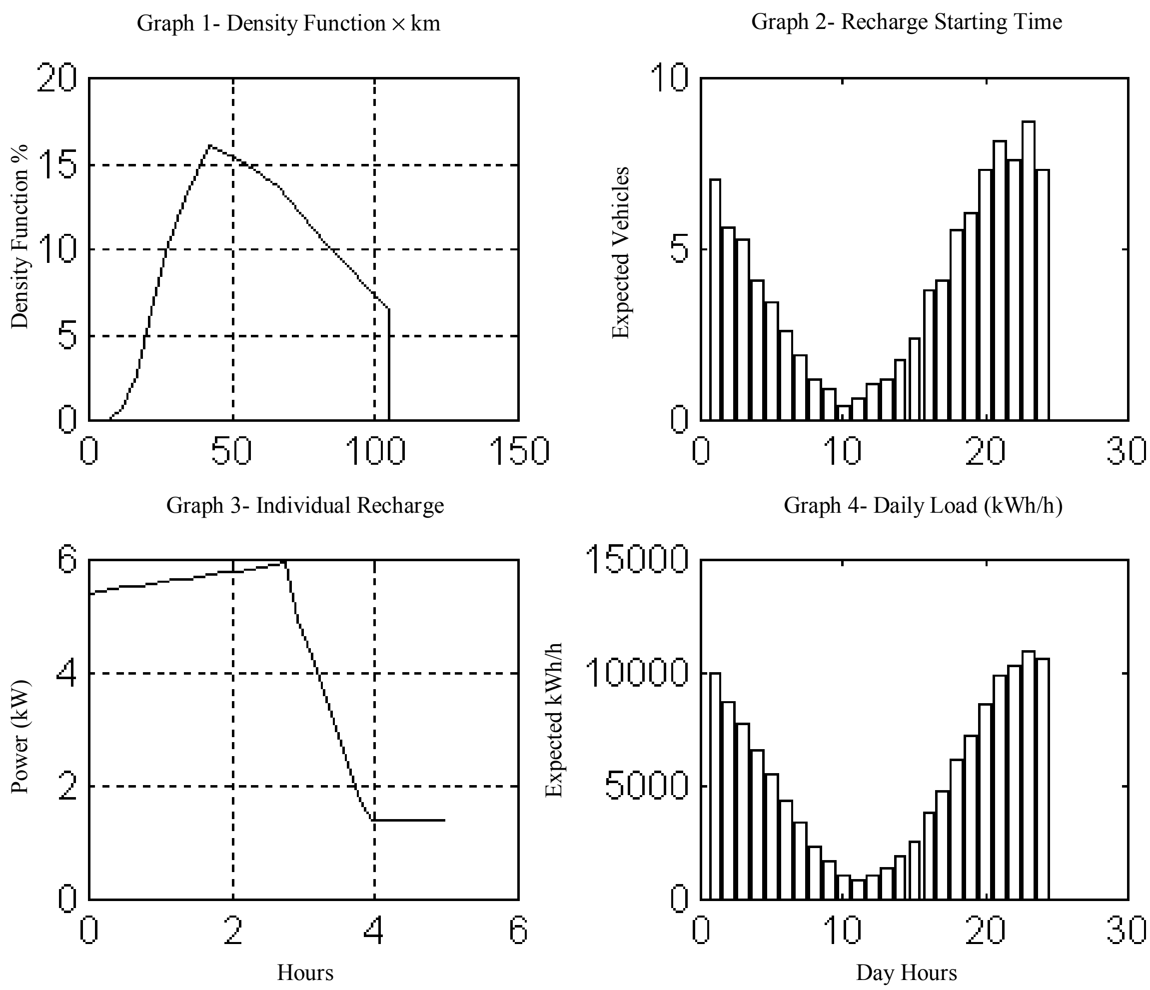

Fig. 2. Resulting Simulation Graphics

Table I. Plant Type and Generated Energy

PLANT TYPE	**OIL**	**COAL**	**NATURAL GAS**	**NUCLEAR**	**HIDRAULIC**
PERCENTS	0.67	1.91	0.13	1.01	96.28
ENERGY(MWh)	0.95	2.72	0.19	1.44	137.17

Table II. Avoided Daily Emission (Tons)

CO	**HC**	**NOx**	**CO2**	**Methane**
2.145	0.274	0.274	94.437	0.055

Note: Above symbols are: carbon monoxide, hydrocarbon, nitrogen oxides and carbon dioxide.

environment benefits, especially in Brazil.

The bigger hydroelectric power generation rate in the mix, results in minor influence for the emissions from the oil, coal and natural gas thermal power stations, that is an additional advantage in favor of EVs use. Furthermore, the percentage of electric power for transportation purposes in the country is bellow 1% [11]. Therefore, it is desirable to analyze more further this subject, providing a better understanding of the existing metropolitan areas in Brazil.

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