A STATISTIC APPROACH TO SUPPLY PHEVS IN TYPICAL MICROGRID IN IRAN

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ABSTRACT

This work is focused on load modelling in distribution network planning in appearance of plug in hybrid electric vehicle (PHEV). The model has been developed in real network in Iran. The candidate point of EV charging station was established based on network characteristics. PHEV Energy consumptions are modelled statistically due to uncertain behaviour of usage of cars. This process resulted in optimum (load model stochastically) and network configuration. The surplus load imposes to network supply by distribution generation (based on an Act) is One of important issues that is considered, so finally, the new DGs placement in town is studied. The optimization is achieved based on two different types of preliminary assumptions. In the first one, it is assumed to have only general charging stations in town, while in the second one possibility of having multi-stations; general and home parking; is considered. The methodology could easily use in load model to distribution planning in beside of EVs. The real micro grid example is analysed in order to practical usability of model. Finally, the price scheme which is regulate the load that's imposed by EV, is considered, therefore the smooth load of EVS is the most attractive solation to protect networks beside phevs is studied

INTRODUCTION

The integration of Electric Vehicles, (EV's) in car fleets will change the mobility paradigm and their connection to electricity grids for charging purposes will have important impacts on these grids [1]. EV's will increase the demand of power systems impacting in the operation of the electric grids and eventually requiring large investments to adapt networks to larger power flows [4].

To reduce additional stress on the power system, vehicle charging must be flexible. Reference [1] describe opportunities presented by electric vehicles as power sources for electric utilities, and the possibilities offered thanks to adequate controls for "valley filling", limiting charging when the networks are overloaded, or discharging inside the grid. Of course, this means that the vehicles must be connected to the grid. This is not really a problem if we consider the usual daily trips in areas such as France [2], Germany [3] or New York City [4] with mean values between 30 and 50km. As an example, let us consider a battery capacity of 24 kWh and a maximum range of 150 km; the rate of use is from 20% to40% per day. Thus the length of a 3kW recharging session will be between 1 hour 30 minutes and 4 hours. When the vehicles recharged at home, the recharging session can be scheduled during the night when prices are lower than at medium or peak times. Moreover, the vehicles are mainly parked during the day: if we consider a two-hour round-trip between home and office, the vehicles could stay connected to the grid for a total period of 22 hours, either at home or at the office. Thus battery vehicles could be considered as distributed storage systems available for vehicle-to-grid services to help grid balancing. [2]

In a research conducted in Tehran by a Japanese company named JICA, each day, 1192 tons of pollution is produced from which 88 % is emitted from the vehicles [1].

Those problems lead into the idea of a massive change in the entire transportation structure. In spite of reliability and cleanliness, electrical energy has never been a primary resource in transportation system due to the lack of power grid infrastructures. With the huge investment of big carmakers in this field in the few recent years, this industry has grown a lot and nowadays electrical vehicles with high efficiency and reasonable price are produced.

With the increase of EVs, the quick access to charging system becomes a main concern. These EVs with their huge sized batteries (some even up to 1.7m long) ranging from 5kWh to 30 kWh will represent a huge load which can create a major problem for the power grid. Charging these batteries through mains is so time taking and as one of the most critical issues upon growth of these cars, imposes the establishment of fast charging stations in cities. Since fast charging stations extract a lot of energy in a short time from the grid, they can overload the system temporarily.

Fast charging (less than 10 minutes) of a typical 20 kWh battery through 220V mains, requires a current of approximately 500A which is obviously much larger than the rating of a house outlet. Thus fast charging is only available through public stations in which the appropriate conditions are met. High current in grid, in addition to the decrease in life time of the equipment, is not economic too (high power loss and higher electricity rate). Thus it is desired to deliver the power to the stations on higher voltages rather than mains voltage. As a result, the optimum siting of the stations considering the 20kV lines is of interest. [3]

Another concern of the connection of vehicles to the grid is that it will impose massive loading on distribution

Tehran regional electricity distribution company transformers [2]. Connections of vehicles to the grid during peak times, increases the transformer current more than its nominal value. This will decrease the expected life time of transformer and other components in the system [3].

Availability of fast charging facilities (i.e. charging stations) plays a major role in solving consumers concern against their EVs recharging process. While the environmental and economic issues impose the use of EVs, yet fast charging plays an important role for pursuing people into use of EVs. Most of these problems on grid (due to EV's loading) could be minimized with proper regulations by distribution companies and slight changes in EV stations structure. One of these changes is the installation of storage devices in stations. Charging EVs during peak and shoulder hours cause excessive loading of the charging stations and consequently the grid. This is not desirable from the vehicle owner and the retailer point of view. By installing the storage devices, and saving energy in off-peak hours, the demand on peak hours would decrease and up to 60% in daily costs could be saved [5].

The siting of EV charging stations has been analyzed in [3] with considering the traffic constraints. The simulation in this work is based on multi Objective function optimization method which determines the location of charging stations with considering a preplanned location.

In this work, a micro grid in city of Tehran is defined with its specific electrical and geographical characteristics and load impose is determined. This solution is based on uncertain load in Tehran and realizing the parameters such as the price of Electricity, energy, and finally electricity price is considered to show the load curve of this kind of consumer that would help in distribution planning. [3]

MODELING

Today's Electrical Network Planning in Iran Distribution Company is based on customer's category and hourly Load curve. The hourly load curve obtains from simulation of sample load data of each customer's class. Finally this Modeling shows consumption in all hours of the year. This model presents the consumption rarely well.

Load modeling

In this papers it has been studied the effect of EVS charging station on Electrical Distribution Network. EVS Energy consumptions are modeled statistically. The loads obey normal distribution with certain mean value (µ) and standard deviation (δ). The PHEVs load is modeled as follow:

Pph =µPph+ZδPph

Qph = = µQ ph +ZδQph (1)

Where p_{ph},Q_{ph} means active and Reactive load of PHEV respectively. ꞔ is a coefficient determined by applied confidence level and µ is mean value and δ is standard deviation. The load of each radial line of distribution network is considered as equation (2)

$$\sum_{k=1}^{n} I_{k,h} = \sum_{i=1}^{16} Pois_h\left(\frac{BS}{V_{line}}\right) \tag{2}$$

Where the subscripts used are:

i: charging station number

k: DG number

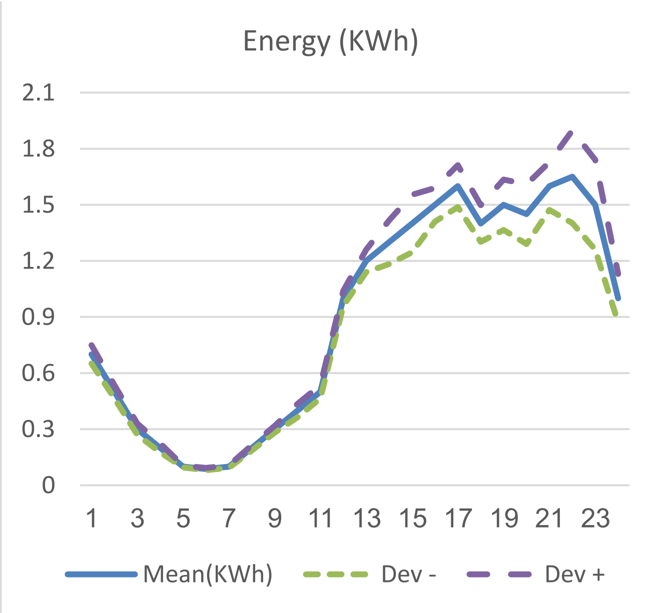

Figure 1. shows the load curve of typical home charging station after assessment that is contain mean and standard deviation value.

PHEV CHARGING STATION MODELING

As mention before the general charging station in town was established base on the travelling time in city. Figure 2 shows normal distribution of EVs uses the charging station. This model was estimated from the report of Traveling Study Organization.

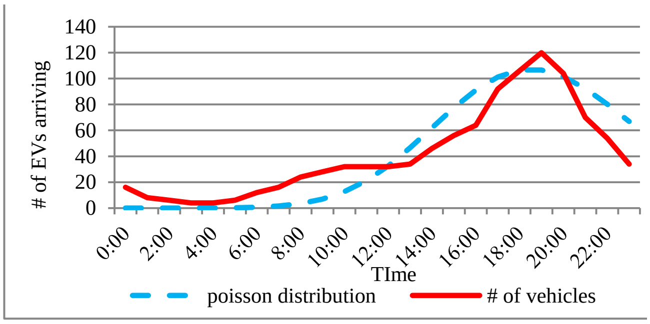

Figure 2. Poisson distribution of arrival probabilities

Battery capacities

The PHEV fleet is divided in three sized groups which obey normal distributions N (5 kwh, (0.5 kwh)2), N (10 kwh, (1.0 kwh)2), and N (15 kwh, (1.5 kwh)2). Thus, in each sub fleets vehicles have battery packs whose usable capacities are formed randomly and are normally distributed with 10% (of the mean value) standard deviation. This distribution assumes that there are mainly three different categories of cars, for example small "city cars," mid-sized passenger cars, and bigger family cars or SUVs. [4]

Specific Electricity Consumptions

In our study we used distribution as with the battery capacities. The cars were again divided in three equal sized sub fleets whose specific electricity consumptions obeyed normal distribution with mean values of 0.15 kwh/km, 0.20 kwh/km and 0.25 kwh/km and 10% (of the mean value) standard deviations.

The sub fleets correspond with the ones of the battery capacities. Thus, the cars with the smallest battery packs have also on average the smallest specific electricity consumptions.

In the following examples we assume that charging can take place in two different locations: at home and at the workplace. This is relevant assumption as most of the charging would be made at homes and the workplaces, because the cars are parked to these places for very long times.

Lithium-ion batteries can be charged using different charging rates which are usually expressed as C values. A rate of NC corresponds to a full charge in approximately 1/Nh starting from empty state. A certain charging rate with a certain battery energy capacity corresponds to a certain average charging power. Available maximum charging power in different places can vary significantly especially in the future.

The behavior of charging power during the charging process depends on battery chemistry. It is still an open issue, which of the lithium-ion chemistries will be successful in the PHEV market. Toyota Prius PHEV is using a lithium nickel-cobalt-aluminum oxide (NCA) based positive electrode, as it gives a high energy density. (LMO) and lithium nickel-cobalt-manganese oxide (NCM). This combination is cheaper and safer than NCA. The choice for Frisker Karma is lithium iron phosphate (LFP), as the LFP chemistry offers very good safety properties and a good cycle life. [7]

Fig. 4 presents the behavior of charging power, measured by the authors of this paper, of two different lithium-ion battery cells with charging rates of 0.2 C and 0.5 C. additionally; charging power of a 1 kWh battery pack with 0.2 C charging rate was measured. The cells have different capacities and the capacity of the battery pack is much higher than that of the cells. Therefore, charging power in Fig. 4 is presented as a percentage of the maximum power of each charging process. In this way we can compare the forms of the charging profiles of different cases. The first cell, by Samsung, has a NCA positive electrode, and the second cell, by European Batteries 1td, has a LFP positive electrode. Both cells have graphite negative electrodes. The 1 kWh battery pack includes similar cells as the individual LFP cell.

In the example studies, charging powers are assumed to be constant during the charging process. It would be possible to take the variable charging power into account as we model the SOC of the battery packs of every car. However, modeling this would make the choice of the battery chemistries etc. mandatory, and the battery chemistries of the future's PHEVs is an open question today.

With the integration of EVs it will be necessary to create the EV's Aggregator, an entity in charge of making bids to buy and sell electricity in electricity markets [5]. This entity will also be responsible for managing EV's charging period using a technology called "smart-charging". This option is of difficult immediate implementation since it is related with the concept of smart grids, which is expected to be fully available in the next years. An alternative approach is to adopt a dual-tariff system, to induce EV owner's to charge their vehicles when this causes less impact to the system both from the technical and economical points of view. If no incentives are adopted, EV's charging can ultimately correspond to the "dumb charging". These can be very undesirable, since it implies having no control on the charging period that becomes decided only by EV users. [1]

PRICE INCENTIVE

One of major impact of EVS to network is the load of Phev in different hours. Figure (1) shows the energy consumption of different hour of day. As shown the peak demands for charging phevs similar to load curve of electricity in Iran.

It might impose to use network in critical point because of surplus load connect to network in peak hour although the network has vacant capacity in other hours. It's possible to regulate load by price incentive.

Three different way for price regulation are studied here

A. Constant price (non-pricing scheme)

B. Market price

C. Tariff scheme

Non-pricing scheme

In this price model there is no different in price in different hours, so the cars owners haven't any limit to use EVs to connect them to network, and it is completely based on the car's owner decision. The figure (3) shows the load profile of this kind of pricing scheme.

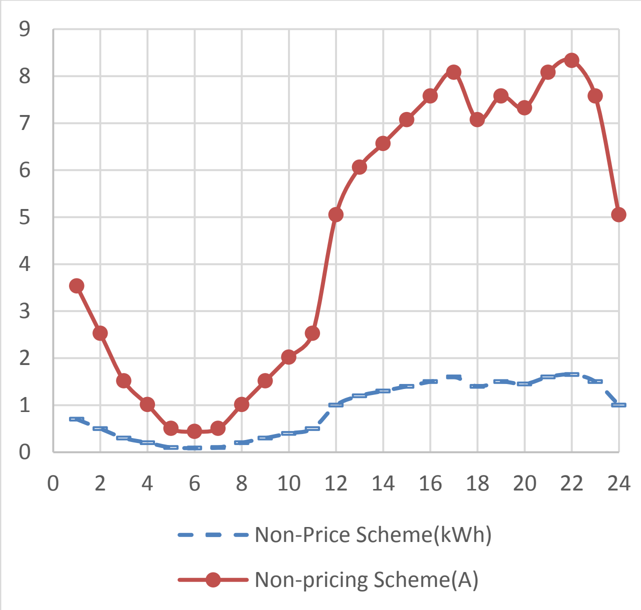

Figure 3. the energy consumption and the current of EV in non-pricing scheme.

As observed in figure (3) the load of each car is extremely high in 16 to 23. The peak load impose network about 2 kW for each EV and it long about 7 hrs. This scheme extremely impact network and needs mandatory expansion, so at this time it's not propose any way.

market price

The second price scheme is based on market price, which is referring to electricity market. This price contains all parameters in electricity network and Generation competition. Figure (4) shows the result of use of electricity by Evs in this price scheme. The price leads to different Manner of home charging station in specific hours.

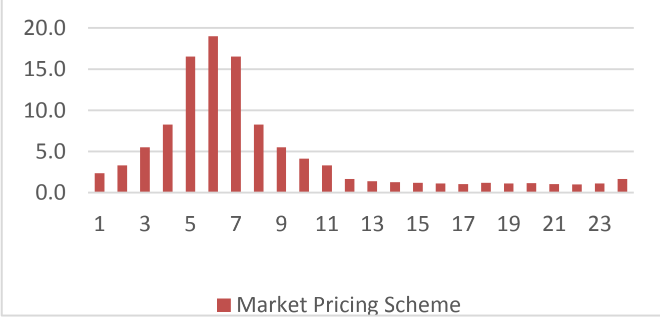

Figure 4. The current of EV in market price scheme

In low demand time (2 to9) which is the competition is very high and the prices are low, the usage of electricity spikes and this manner lead to an unexpected load in distribution network which would break out the network.

Therefore this kind of price regulation did not useful at this time because of the behavior of consumers would intense impact to network.

Tariff scheme

The final model of price is tariff that defines by government. The result of this price scheme is modeled as current consumption. Figure (5) shows the result and it's shown the smooth load that imposes to network. So the load would pass from network without any unexpected situation and the current network would carry out the imposed load by EVS.

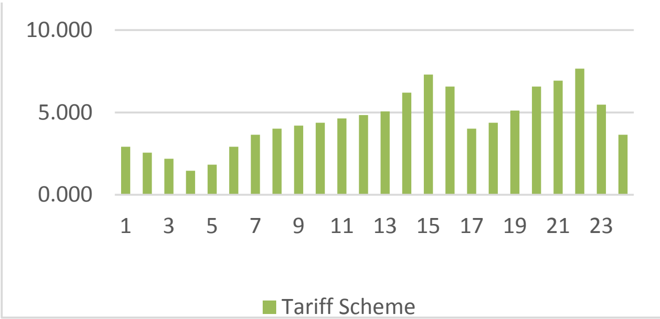

Figure 5. The current of EV in tariff scheme

The figure (6) shows three models. The smoothest load curve is modeled in Tariff base pricing. After that the non-price scheme is smooth load curve but it has peak load more than the tariff model.

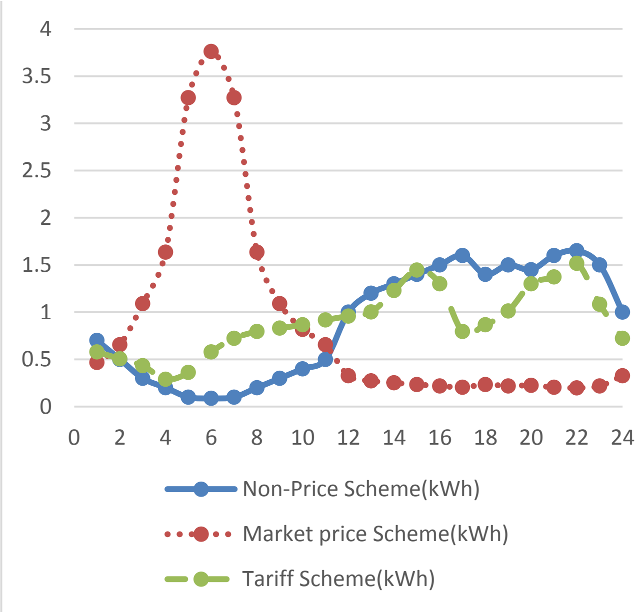

Figure 6. three different price schemes

RESULT

An approach propose in this paper is pricing scheme to manage the consumption. Three different models are considered to find the best case of supply EVs without obligation of network expiation. The constant price scheme lead to increase consume electricity in the same hours which is peak load occurs, so it needs network expansion and it is not useful at this time. The second price scheme is market based and the results show load spike which is over load network in specific hours and lead to network breakout. The last scheme is studied as the tariff and the results show the smoothest increase in load and define good operation beside of EVs charging station. The models are considered Iran situation and the price incentives.

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