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Feasibility study, analayze and assessment of Electrical bike usage based on locating of parkings, case study region No. 22 of Tehran

Eng.Elham Alipourtarzanagh[1], Eng.Kourosh Apornak[2], Eng.Amir tajik Khavas

Islamic azad university, Sciense and Research Branch, Tehran, Iran

1-elham.alipour1984@gmail.com

2-apornakkourosh@rocketmail.com

3- tajik1358@yahoo.com

***Abstract*—Bicycles could be considered as one of the vehicles which are easy to use, affordable, lightweight and compact. In today's world because of the large volumes of traffic, congestion, environmental issues and high consumption of fossil fuels, the use of bicycles has been considered more. Because of the life style of people normal bike cannot effort all transportation purposes. Electrical bikes which works with the electrical power transmitted from a battery to the relevant drive. In this paper the feasibility, analyze and implement of the use of electric bikes, with an emphasis on the locating of parking in the 22nd region of Tehran as a case study has been done based on questionnaires and simulation methods in order to find the optimum location for the charging station of the electric bikes. In other words, this article will help to investigate optimal rate of charging electric bikes in accordance with investment costs and network lines capacity and transformers.**

Keywords— Electrical bike, genetic algorithm, charging, parking, optimization, voltage

I. INTRODUCTION

In the recent years problems related to the both air pollution and to the use of petroleum have been caused, by the increasingly vehicular traffic. Therefore, a vehicle like the electrical bike can be considered a promising alternative vehicle for both personal mobility and goods delivery, especially for small and medium distances [1].

Cycling as an innovative, environmentally friendly and energy efficient form of transportation has been developed well globally specially in Europe, North America and Asia [2] and as a result the number of electric bicycles has increased substantially. In reference [3] some cities the e-bike sharing system is used as a starting step for fundamental changes in urban and transport planning and it is increasing continuously. The number of cities with bike sharing systems increased from 68 in 2007 to over 675 by the end of 2013. As a result around 700.000 bikes, distributed at 33.000 stations, currently float through cities around the world.

II. HEALTH BENEFITS

By using e-bike, residents chose an active transport system which increases their physical activity. Consequently, they protect their health and prevent disease. According to the scientifically references just 20 minutes of cycling per day has a noticeable, positive effect on health[1].

The power of e-bikes is provided from rechargeable battery and their driving performance is influenced by battery capacity, motor power, road types, operation weight, control, and particularly the management of assisted power.

There are some factors which make e-bikes favorite. The factors such as lower energy cost per distance travelled for a single rider; savings in other costs such as insurance, licenses, registration, parking; improvement of the traffic flow; environmental friendliness; and the health benefit for the rider.

III. THE E-BIKE STRUCTURE

An electric bile is consists of the electrical motor, battery pack, the mechanical transmission. Figure 1 shows different parts of an electrical .

Fig. 1. E-bike structure

IV. THE DISTRIBUTED ENERGY RESOURCES (DER)

Environmental protection issues and the technology development caused the application of some distributed energy resources (DER), such as internal combustion (IC) engines, gas turbines, micro turbines, photovoltaic, fuel cells and wind-power, which have emerged within the distribution system [4].
Venkataramanan and Illindala conducts that a lead–acid battery is considered the most suitable for MG applications. They are capable of providing large currents for a very short interval of time [5].

The usage of EVs (electric vehicles) and PHEVs (plug-in hybrid electric vehicles) has many benefits due to the issues such as air pollution, energy saving, reduction in fossil fuels consumption, etc [6].

V. FORMULATION AND MODELING OF THE ELECTRIC BIKE CHARGING STATION

In order to model the locating problem in the first step, the goals of the locating have to be defined. In this paper the objective function of the locating problem, consists of various components. Less losses, improve voltage profile and the installation cost of the parking are the components of the objective function in this study. In the following the components of the objective function will be done.

A. Voltage profile improvement

Development of usage of the digital and sensitive devices has dramatically raised the level of the costumers' expectations and as a result, the power quality improvement has been considered more. In this regard, improvement of the voltage profile of the grids in the most of the studies has been raised as the one of main purposes for locating distributed generation. In this paper, improvement of the voltage profile is considered as one of the main components of the objective function as per equation[7]:

$$V_1 = V_{i-with\ parking\ lot}$$
$$V_2 = V_{i-without\ parking\ lot} \qquad (1)$$
$$\mathrm{F}_1 = \sum_{i=1}^{N} \left({|V1-1|}/{V2} \right)$$

B. Reduce losses

The reduction of losses of electrical energy in general is the increase of the production capacity and increasing the capacity of the transmission and distribution networks without investment in production. Energy losses is one of the most important issues which the power generation industry is facing with. Trying to reduce such losses is an inevitable necessity. In this regard, t electric bike charging stations which are connected to the network have different effects on the losses of the grids in accordance with the output power and location of the parking.

The impact of the reducing the losses on the objective function has been modeled in equation (2)

$$P_1 = P_{loss-with\ parking\ lot}$$
$$P_2 = P_{loss-without\ parking\ lot} \qquad (2)$$
$$\mathrm{F}_2 = \mathrm{K} \sum_{i=1}^{N} \mathrm{Max}\,(0\,, \mathrm{P1} - \mathrm{P2})$$

C. Investment costs:

Investment costs include the cost of construction of a parking with the capability of V2G. The cost depends on the location and capacity of the parking[8] . The establishment cost of parking for kth is modeled as equation (3).

$$C_L = C_{ac} * \frac{CP(k)}{P_k} \qquad (3)$$

Where CP(k) is the capacity of the kth parking

$0 \leq P_k \leq 1$

D. Objective function and limitation of the problem for locating of electric bike charging station

The objective function for locating consists of two main parts:

1. Technical Section:

Technical section includes technical aspects of objective function which covers reduce in losses and improvements of voltage profile which is indicated in equation (4)

$$F_{thecnical} = w_1\, F_1 + w_2\, F_2$$

2. Economical Section:

Economical section includes economic aspects of objectives function which covers investment costs of installation of electrical bike charging station, incomes of power delivery of electrical bike during pick hours to the grid and costs of electrical bike charging including battery depreciation, etc[9] . as equation (5).

$$F_{economical} = k_1\, C_p - k_2\, R_p + k_3\, C_L \qquad (5)$$

where C_L is investment costs of charging station installation, Rp is income of power deliver to the grid during pick time and Cp is costs of charging electric bike.
Considering the above explanations the objective function of the optimizing of electrical bike charging station locating is defines as the following:

$$Min\, F_{total} = F_{economical} + F_{thecnical} \qquad (6)$$

Location and capacity of parkings should be defined so that the objective function of equation (6) is minimized and simultaneously the following conditions of the operation should be considered:

1. Transfer of power from bus i to bus j

Apparent power crossing the lines according to equation (7) must be less than the maximum authorized pow er transmission lines and distribution transformer of the considered grid.

$$S_{(i',j')} \leq S_{(i',j')max} \quad (7)$$

2. Range of voltage in each bus

According to equation (8) all bus voltage should be in the range of standard voltage

$$V_{min} \leq V_{bus} \leq V_{max} \quad (8)$$

3. The voltage profile index

One of the benefits of optimal locating of distributed generation is “improved voltage profile” [10]. Employing these indexes causes the definition of optimized locate and capacity so that the bus voltages do not be different from nominal value. Therefore, whatever the index is closer to zero, the better network performance. This index is defined as shown in equation (9).

$$VPI = \max(\frac{V_n - V_{bus}}{V_n}) \quad (9)$$

Also according to equation (10) locating of charging stations is done in such a way that the index is less than a maximum considered value[3-5].

$$VPI \leq VPI_{max} \quad (10)$$

4. Parking capacity

Considering the number of the existing electrical bikes in the studies region and the other conditions the maximum capacity of the parking cannot be more than a defined value[6] . This limitation is shown in equation (11).

$$CP(k) \leq CP_{max}(k) \quad (11)$$

5. Optimized locating of electrical bike

The purpose of optimized electrical bike locating is reduce of system losses, improvement of grid voltage profile and minimizing the THD voltage[9-10] .

$$Min: F = Z_1F_1 + Z_2F_2 + Z_3F_3 \quad (12)$$

Where:

$$F_1 = \sum_{i=1}^{N}(v_i - 1)^2 \quad (13)$$

$$F_2 = \sum_{b=1}^{B} R_b * {I_b}^2 \quad (14)$$

$$F_3 = \frac{1}{N}\sum_{i=1}^{N} THD_i \quad (15)$$

F_1: The variable which shows the status of profile voltage
v_i: Voltage of i[th] bus
N: Number of system buses
F_2 : Losses of the system (w)
R_b : Resistance of b[th] branch
I_b: Current of b[th] branch
B: Number of system branches
Average of F_3: THD voltage of the system
THD_i : THD Voltage of I[th] Bus
Z_1: Weighting of the voltage profile
Z_2 : Weighting of the losses
Z_3: Weighting of THD Voltage at objective function
F: Objective function

VI. Effect of Electric Bike Parkings on THD Voltage

Parkings of electrical bike is counted as a harmonic source because of the existence of power electrics devices such as inverters and they increase the THD voltage of the grid. Simulink MATLAB is used for the modeling of the effect of Parking on THD voltage of the grid

5.1. Algorithm of calculation of THD

A 9 bus system in Simulink of MATLAB has been simulated. This system is modeled with 9 parkings which each parking is connected to a bus.
While Genetic Algorithm is performed, the independent variable has saved the buses which parkings are installed on with the capacity of each one. Independent variable of X enters in CostFun in order to define the cost. In CostFun the information function of THD-Fun is recalled and the THD voltage of buses are calculated as per equation (4). The procedure of THD-Fun starts with preparing a backup of System9Buses.slx which is a simulating file and then holds the parkings related to available buses in vector x and deletes the other parkings. The simulation is performed in the next stem and the THD voltage of system buses are calculated and finally, it delivers the average in output.
The losses and value of the system voltage is calculated by backward_forward_sweep.m.

5.2 The specification od the studied region: Region No. 22 of Tehran

Region No. 22 of Tehran is located in North-West of Tehran and its area is 6000 hectares of urban area and 30,000 hectare of suburbs. Daily population growth and economical extensive developments have great reflection in physical changes of Tehran, and one of its results is the formation of District 22, which whit any doubt was the greatest and vastest urban development linked to Tehran. With approximately 10000 Hectares area, this region has been created for resolve definition of western areas of Tehran and also displacing the people who live in central Tehran’s worn-out regions and accommodation parts of Tehran city’s population.

In the last 30 years, District 22 of Tehran covered special construction activities of planning and implementation and since frothy decade, construction of this area came to Tehran practitioners and manufacturer's attention.

After approval of comprehensive plan of Tehran, this area has been define as a new city and named Kan New City, and it's domain has been designed by Farmanfarmayan Consulting Engineers and Partners.

From 1340 to 1358 approximately 20% of these territories has been breakdown and found partial owners and the rest of the lands was divided into large pieces (1000 meters). After the victory of Islamic Revolution, Farmanfarmayan and Firouzgar were nationalized and some of them were assigned to the Urban Land Organization and 500 hectares of them announced as endowment by Ayatollah Mola Ali Kani who was the owner of these lands since Qajar era.

During the war between Iran and Iraq, because of easy accessing, 25% of lands of this area was used by military organizations for construction, and in some part of these area housing cooperatives began to make settlements. When Authorities confronted with problems of the city and concluded that it is possible to convert this part of city to an area consistent with the patterns of urbanization, and according to the possibility of Tehran city extension in District 22, which was has been foreseen in the Comprehensive plan of Tehran, Municipality of Tehran decided to add the North-West lands of Tehran into the services area of the city, so in 1370 and according to the recommendation of High Council of Urban, the Master plan of District 22 was put on the Bavand Company agenda, with aiming of restoring the lost concepts such as identity, legibility of orientation and positioning for perfect urban spaces. In 1373, studies made by Bavand Company were approved as the Master Plan of District 22. After the approval of master plan, its implementation was faced by various issues, which according to the actual necessity was reviewed by Bavand and Arman Shahr Company again, and the new master plan was approved by Section 5 Commission, and finally after years of effort and study, the Master Plan of District 22 was delivered by Section 5 Commission in 1379/06/08, and Municipality of District22 was officially activated.

From 6200 hectares of this area, 1365 hectares belong to green area and park, 62 hectares belong to educational spaces, 168 hectares belong to higher education, 238 hectares belong to services, 327 hectares belong to sport spaces, 355 hectares belong to lake, and 162 hectares are residential. Residential density divided in three categories which are Low density (100 units per hectare), Medium density (135 units per hectare) and High density (200 units per hectare).

6.1 Collected relevant statistics and information through the questionnaire

In order to analyze the feasibility study and implement of using electrical bike, some questionnaires have been prepared and the information and statistics have been collected which resulted in better acknowledge of the region. Table No.1 shows the travel of people sorted by gender.

TABLE 1- TRAVEL OF PEOPLE SORTED BY GENDER

Gender	Age range	0-5 km		5-10 km		10 km and up		No comment		Total
Female	14-20	68%	13	15%	3	%5	1	10%	2	19
	20-30	31%	9	10%	3	17%	5	19%	12	29
	30 and up	35%	11	19%	6	35%	11	%9	3	31
Male	14-20	65%	11	18%	5	25%	7	14%	4	27
	20-30	25%	5	%5	1	%5	10	20%	4	20
	30 and up	15%	4	%7	2	61%	16	15%	4	26
Total		34%	53	13%	20	32%	50	21%	23	152

According the above table, considering the value of travel less than 10 km for the society, electrical bike could be a proper vehicle for everyday trips of people.

Figure 2 shows the interest of people habited in the region in the sportive activities and the activities related to riding bicycle.

Table 2 shows the riding bicycle skills in the region.

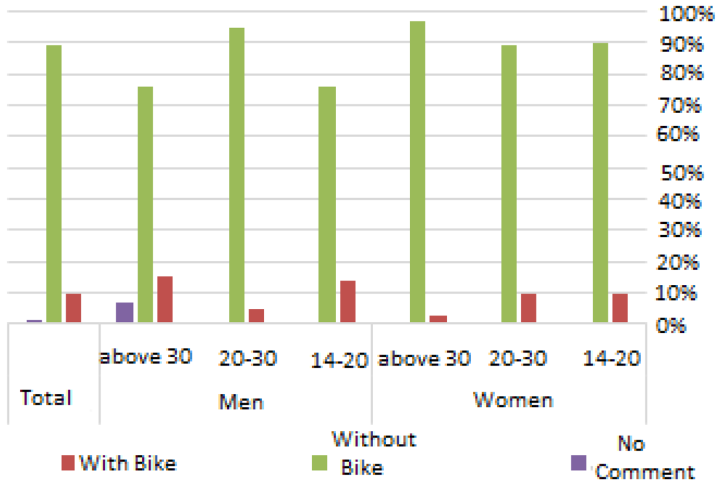

Fig. 2. Interest of people in sportive activities

TABLE II- THE RIDING BICYCLE SKILLS IN THE REGION

Gender	**Age range**	***Is skilled***		***Weak***		***No comment***		***Total***
Female	14-20	%73	14	%27	5	--	--	19
	20-30	%82	22	%18	6	%3	1	29
	30 and up	%74	23	%26	8	--	--	31
Male	14-20	%100	27	---	--	--	--	27
	20-30	%100	20	---	--	--	--	20
	30 and up	%84	22	%3	1	%11	3	26
Total		%84	128	%13	20	%3	4	152

Figure 3 shows the habitants preference in using bicycle in different places.

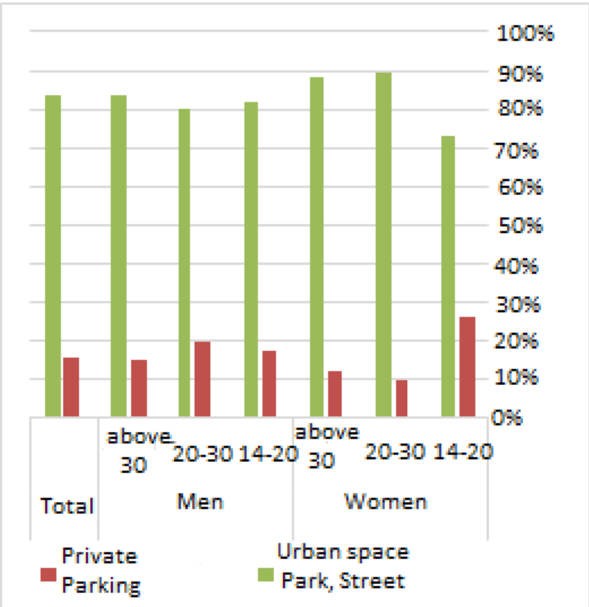

Fig. 3. the habitants preference in using bicycle in different places

Table 3 indicates the methods of using the bicycle and figure 4 shows the level of knowledge of people about the bicycle as a public transport vehicle.

TABLE III- METHOD OF USING THE BICYCLE.

Gender	**Age range**	***Public***		***Private***		***Total***
Female	14-20	%35	7	%65	13	19
	20-30	%27	8	%72	21	29
	30 and up	%35	11	%64	20	31
Male	14-20	%59	16	%41	11	27
	20-30	%15	3	%85	16	20
	30 and up	%53	14	%67	12	26
Total		%39	59	%61	93	152

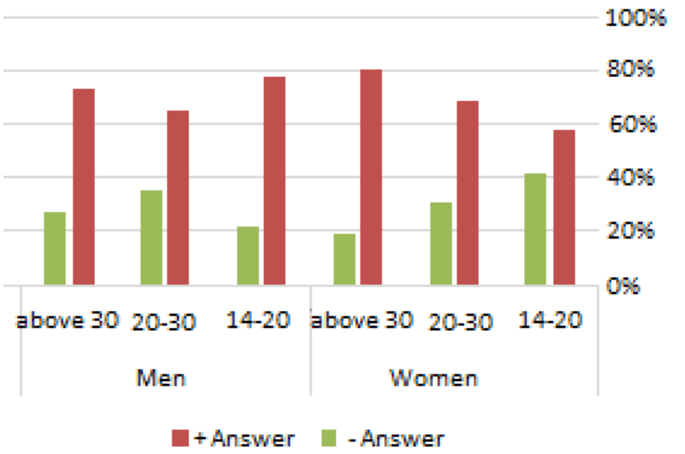

Fig. 4. *Knowing bicycle as a public transportation vehicle*

6. Simulation and results:

In the current simulation, the ability of parallel processing of MATLAB software is used in order to increase the running speed of the program. Available Genetic Algorithm in function ga of MATLAB software is designed in the way that it can recall and run “CostFun.m” simultaneously. This ability used all cores of the CPU. For instance, in 2 core CPUs (e.g. Core i5 of Intel) two CostFun.m files are run simultaneously and in 4 core processors (e.g. Core i7 of Intel) four CostFun.m files are run simultaneously.

Therefore, the speed of the program in the different computers will be different and more processors of CPU will result in more speed of running program.

Figure 5 shows a schematic of a 9 bus standard system.

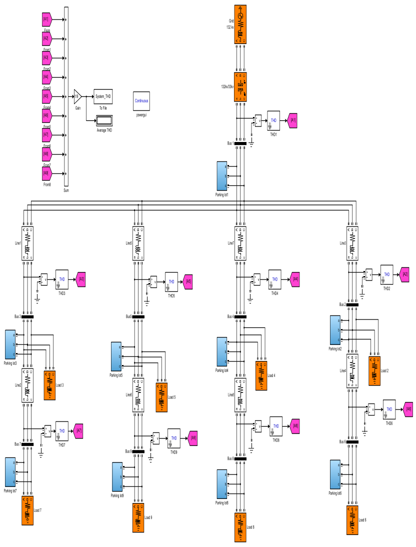

Fig. 5. *model of 9 bus system in Simulink of MATLAB software*

In order to run the simulating the programs which are shown in figure 6 have to be run all together.

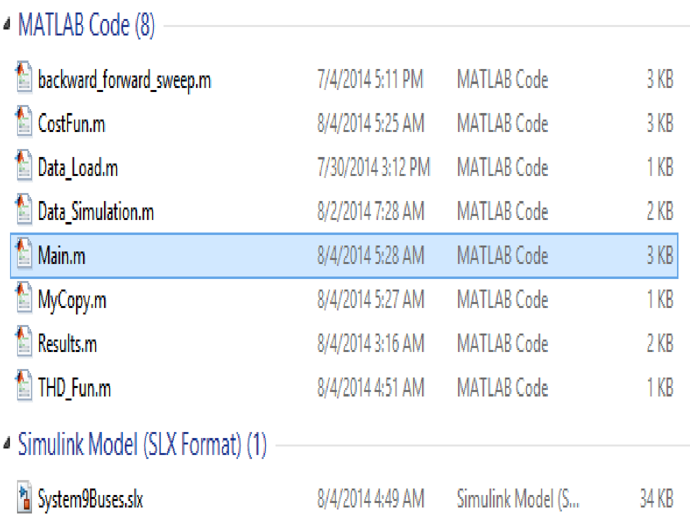

Fig. 6. The files in simulation folder

After running the simulation the results will be showed as figure 7 and table 4. Figure 7 shows the voltage profile of the grid and table 4 shows the place and size of parkings.

TABLE IV: SIZE AND LOCATION OF PARKING INSTALLATION IN A 9 BUS SYSTEM

Bus Number	**3**	**4**	**6**
Optimum number of EVs	296	337	**202**

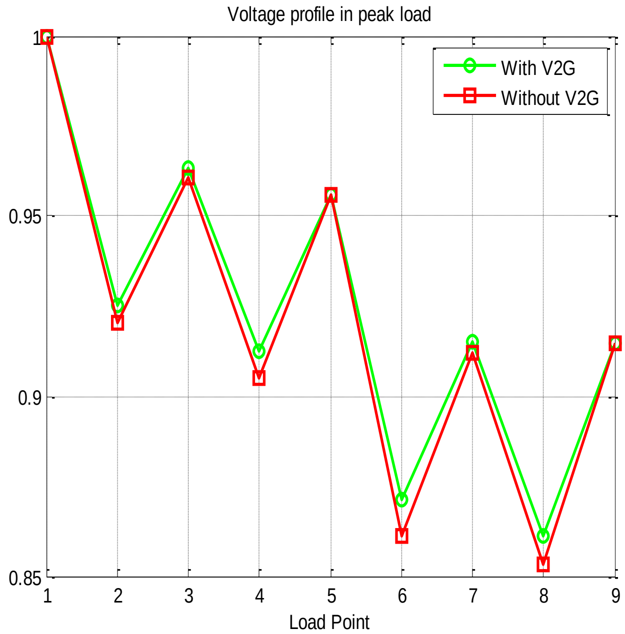

Fig. 7. Voltage profile in peak load

VII. CONCLUSION

In this paper the locating of electrical bikes charging station has been studied and 3 main scenarios have been considered. The results could be expressed as the following:

- In order to optimize the locating of parkings definition of the optimized charging rate in accordance with the investment costs in each charging rate, lines capacity and available transformers is essential.
- By increasing the number of electrical bikes in the network, grid losses decrease.
- By increasing the rate of charge/decharge profile voltage improves.

The nobilities of this paper is as the followings:

- A novel model for electrical bike parkings considering these units as a component of programing distribution grids is presented.
- The locating of the parkings in distribution networks is modeled considering the limitations of the distribution grid operation.

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