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DECISION-MAKING METHOD FOR THE OPTIMUM ALLOCATION OF CHARGING STATIONS Of ELECTRIC VEHICLE IN DISTRIBUTION NETWORKS

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Electric vehicles are becoming prominent nowadays and playing an important role in the transportation sector as conventional vehicles affect the environment. The rising number of vehicles requires increasing the charging stations, which affects the distribution network if placed randomly. Therefore, selecting the optimal place for these charging stations is very important to mitigate the effect on the distribution system. This paper presents a decision-making method to select the location of the charging station in a radial distribution system optimally. The fixed point algorithm was used for the analysis of load flow. The analysis was carried outand tested on the 33 bus IEEE and a real case study in Iraq was used for the study. The result of the charging station placement is compared with other research and showed its efficiency in work. The analysis showed the effectiveness of the proposed method in reducing the effect of charging stations on voltages and losses under different conditions. References 27, Figures 10, Tables 6.

Keywords: optimal placement, load flow, charging stations, losses reduction, electric vehicles.

1. Introduction. Rising prices of oil and rising energy demand are major challenges that the transportation sector is currently facing [1, 2]. This is because the transportation sector's heavy reliance on oil as the primary energy source has a number of unfavorable influences that can have an impact on those sectors. In terms of the environment, the transportation industry is responsible for a significant amount of carbon dioxide released into the atmosphere, which results in a significant rise in the amount of emissions of greenhouse gases. As a direct consequence of this, the demand for electric vehicles (EVs) has been growing at a rapid pace as a direct response to the dramatic reduction in CO2 emissions and operation costs [3, 4]. However, the widespread use of electric vehicles could pose a significant risk to the nation's power infrastructure because of the potential for an increase and variation in the amount of electricity required by EV charging stations(CS). They present an entirely new obstacle for the infrastructure of the distribution network as well as the operators of the distribution network. In point of fact, the distribution network could be negatively impacted by high electrical power demand brought on by the integration of electric vehicles (EVs), bus voltages, power loss, stability, voltage mismatch, and power efficiency. In addition, the increase in the number of electric vehicles calls for the installation of more dependable electric vehicle charging station (EVCS) systems [5, 6]. The availability of charging setup is a major aspect of promoting the widespread adoption of electric vehicles [7]; however, due to the limited electric range of EVs, it is necessary to use public charging stations when traveling long distances. As a result of this, the provision of a public charging service to act as a supplement to charging at home will be an essential requirement [8]. The adoption of electric vehicles will be slowed, and the operation of the electric grid will be impacted by inadequate planning for the implementation of charging infrastructure, especially the voltage and the losses. As a result, the placement of the charging stations should be done optimally [9]. Many studies on the topic of the optimal locations for charging stations of electric vehicles have been published.

In [10], the authors suggested that the objectives be investment costs, operation costs, maintenance costs, and network loss costs. The modified primal-dual interior-point algorithm was used to find the best location for charging stations. The authors in [11] proposed a multi-objective optimization based on the cost of lost energy during transportation, the cost of building a charging station, and the cost of lost energy at a substation. The binary lighting search algorithm was used to solve this problem. In [12], the

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ORCID ID: [*] https://orcid.org/0000-0002-9945-4947 ; [**] https://orcid.org/0000-0003-4568-1818; [***] https://orcid.org/0000-0002-0162-4064 city feeder of the Pokhara distribution network is used to allocate the charging stations for electric vehicles optimally. Genetic Algorithm is used to find the best place for charging stations. The effect of installing EV charging stations on voltage stability, reliability, and power loss is measured before and after the stations are put in place. When charging stations are allocated, the voltage in the bus drops because the load goes up. Power loss also goes up, but the reliability doesn't change. In [13], the authors provided four solutions to the problem of placement of the charging station, which is: greedy approach, iterative mixed integer linear program, chemical reaction optimization, and effective MILP. In [14], the authors used the Harries Hawk Optimization and Teaching Learning Based Optimization algorithms to find the best place for charging stations. This was done to minimize real power loss and average voltage deviation while increasing the voltage stability index, and they also made sure that the distributed generators were the right size and placed in the best places so that the charging stations would have the least impact on the network. Based on the fuzzy Analytical Hierarchy Process and Technique for Order Preference by Similarity to Ideal Solution, the authors in [15] proposed the Geographic Information System-based Fuzzy Multi-Criteria Decision Analysis approach to choose an optimal location of a charging station. In [16], a two-tiered intelligent energy management strategy is advocated as the best way to integrate EVs into the distribution network. This plan relied on two distinct layers: one for real power management at the nodes, with the goal of reducing the daily total cost of EV charging and discharging, and another for reactive power management at the system level, with the goal of lowering overall power loss by making better use of the EVs' reactive power capacity. In [17], the authors gave a method for solving the Route Node Coverage problem, which is used to find the best placement for charging stations for electric vehicles in a road transportation network. The author in [18] employed the cost as the primary objective function in the problem of the placement of charging stations, and the Binary Firefly Algorithm was used to find a solution to the problem. In [19], the mixed integer linear model is suggested as a way of allocating Charging, taking into account both transit systems and traditional systems. The suggested method finds where the stations should be and what they should be able to do so that EVs don't have to travel too far to reach them and the waiting time for the transport network charging facility is cut down.

From the mentioned studies, it can be said that placing the charging stations optimally in the power system is necessary. This paper proposes a new decision-making algorithm for the selection of electric vehicle charging stations. In this work, the IEEE 33 bus and a real network of Iraq/Baghdad/alghazalya systems are used for the placement of charging stations, and the opendss program is used through the Matlab program; the analyses of the networks is carried out using the fixed point method.

2. Impact of integrating EVs on the distribution system

2.1. Impact on power losses

The impact of EV integration on power losses is the more EVs that are used, the greater the power losses due to increased load. The relationship between power losses and EV penetration is linear; to address this issue, the dual tariff scheme is used [15].

2.2. Impact on Voltages.

Uncontrolled integration of EVs with Microgrids results in a significant drop in voltage that may exceed the limits. But, with the dual-tariff charging scheme and the integration of DG, the voltage drop is less significant. This demonstrates the effective use of distributed energy resources in microgrids by charging EVs preferentially from renewables [20].

3. Methodology

3.1 Fixed point algorithm

In OpenDSS software, fixed-point algorithm is the default method to analyze load flow. This algorithm constructs a nodal admittance matrix to iteratively solve the power flow of distribution networks [21]. This approach varies from previous methods used in load flow studies such as Gauss-Seidel and Newton Raphson since it does not employ data of energy that is injected directly into the network. It generates an admittance matrix of the elements of the power distribution system. To compensate for the nonlinear part, elements of power conversion, which are loads and generators, are designed as

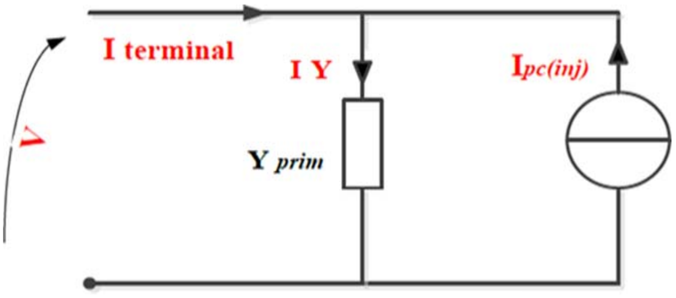

Fig. 1

a Norton's equivalent network with a fixed admittance matrix (Yprim) and a compensation current Icomp(inj), as shown in Figure 1 [22]. The algorithm is described in [22] as follows:

1. Opendss determines the system's nodal admittance matrix before beginning the algorithm. After that, disconnect all power conversion (components from the network. Finding the initial value of the node voltage to use it with the system admittance (Y_{system}) for iterations as below:

$$V^{0}_{a..n} = [Y\ system]^{-1} \times Isource\ . \tag{1}$$

2. Connect all of the (PC) components with the system. Finding each (PC) element's compensation (injection) current ($I_{Comp,\ inj}$) using its admittance (Y_{system}), powers and voltages as shown in Figure 1. The current of compensation (I_{comp}), is the subtraction between the current of the linear portion of the power conversion element and the nonlinear element, if any, embedded in the Ysystem matrix, as in Eq 2:

$$I^{k}_{comp,inj} = I^{k}_{y} - I^{k}_{terminal}\ . \tag{2}$$

3. To create a compensation current matrix, the ($I_{comp,inj}$) from each (PC) element is used. Matrix operations can be used to calculate node voltages using the compensation current matrix and the (Y_{system}) matrix, as shown in Eq 3:

$$\begin{bmatrix} V^{k}_{a} \\ \vdots \\ V^{k}_{n} \end{bmatrix} = [Ysystem]^{-1} \times \begin{bmatrix} I_{source} \\ \vdots \\ I^{k}_{comp,inj} \end{bmatrix} . \tag{3}$$

4. The above steps keep repeating until convergence is reached, as shown in Eq 4:

$$error^{k}_{a..n} = \frac{V^{k}_{a..n} - V^{k-1}_{a..n}}{V_{source}}\ , \tag{4}$$

where k denotes the number of iterations, (Isource) denotes source current, (Vsource) denotes source voltage, and (Va..n) Denotes node voltage. (Iterminal): terminal current, I^{k}_{y} : is the current of the nonlinear element of power conversion, Ipc, comp, inj =, injection, or compensation currents from elements of Power Conversion in the circuit, which could be nonlinear, n=1,2, 3,..: the total number of iterations. The flowchart in Figure 2 summarizes the algorithm's working steps.

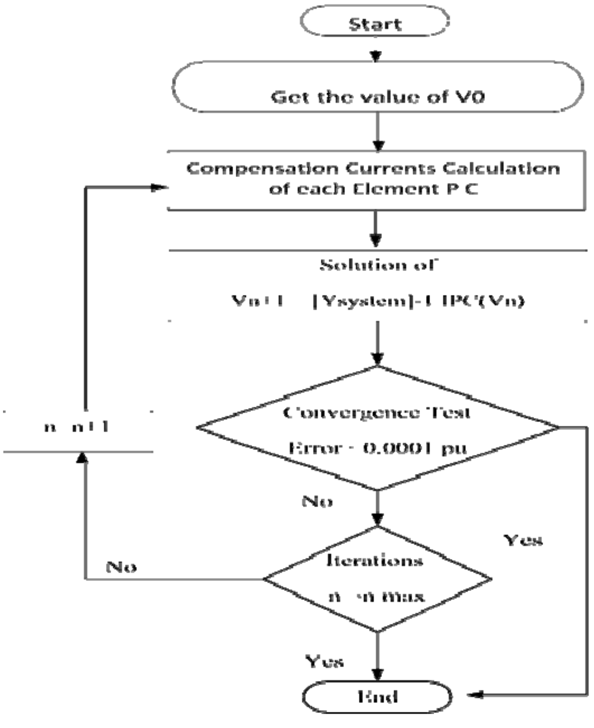

Fig. 2

4. Proposed method for charging stations allocation

Electric vehicles are becoming prominent nowadays, and they are expected to grow rapidly in the future, but at the same time, they act as a high load and affect the grid, so they need to be optimally placed to reduce the impact on the grid. This algorithm is a simple algorithm that works through the Matlab com interface and Opendss, it selects the bus that gives the best performance with minimum losses, as shown in Figure 3, and the procedure of the method is explained in the following steps:

Step 1: Read the parameters and data of the system

Step 2: Analyze the load flow using the fixed point method.

Step 3: Determine the total losses in the base case without charging stations.
Step 4: Run the load flow analysis again with the addition of a charging station for bus i.
Step 5: Determined the value of the losses with the addition.
Step 6: Record the losses.
Step 7: Run the load flow analysis for bus i+1.
Step 8: Compare the new losses with the recorded losses value and store the lower.
Step 9: Repeat 7 &8 until reaching bus n.
Step 10: Show the optimal location for the addition of charging stations.

4.1 Objective function

Charging stations should be put in places where the increased load from EVs has the least effect on how well the distribution system works. The radial Distribution System has a high ratio of R/X, which means that basic load flow methods like gauss seidel or Newton Raphson approaches do not give accurate results. The objective of this study is to reduce power losses as much as possible, as given in the equation below:

$$f = min \sum_{i=1}^{n} R_i * I_i^2 , \qquad (5)$$

where R_i represents the resistance of the i_{th} branch, I_i represents the current that flows in the i_{th} branch, i is the branch number, and n is the total number of branches.

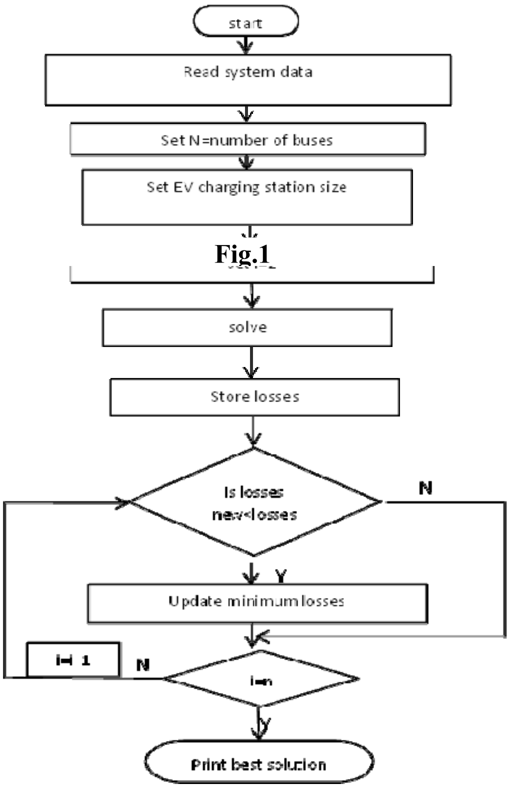

Fig. 3

5. Results and discussion

In this proposed work, the IEEE 33 bus and a real case network of Baghdad/alghazalya are considered for the placement of electric vehicle charging stations, and the effect on losses and voltages is recorded and compared with other studies and taking into consideration the distance between the CS, the number of working stations, and the level of EVs presented at the CS to show the efficiency of the proposed method.

5.1 Case 1: IEEE 33 bus system

The 33 bus IEEE system is shown in Figure 4. It has 33 buses and 32 branches. The voltage of the system is 12.66 kV, and the base power is 1000 kW. The limits of voltages are within ±5%. The active power of the system is 3.715 MW, and the reactive power is 2.3 MVAR. The total losses of the system is 202.6, and the minimum voltage is 0.91308 at bus 18. The electrical parameters of the system are from [23]. The fixed point method was used for power flow analysis; the result of the analysis showed that the loss is 202.6 kW and the minimum voltage is 0.91308 at bus 18, which are the same results when compared with the studies in [24-26]. Figure 5 shows the voltages for the base load.

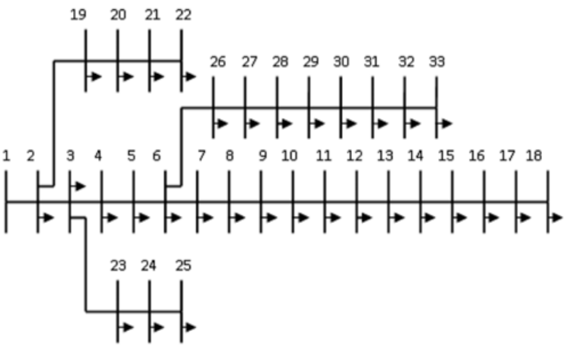

Fig. 4

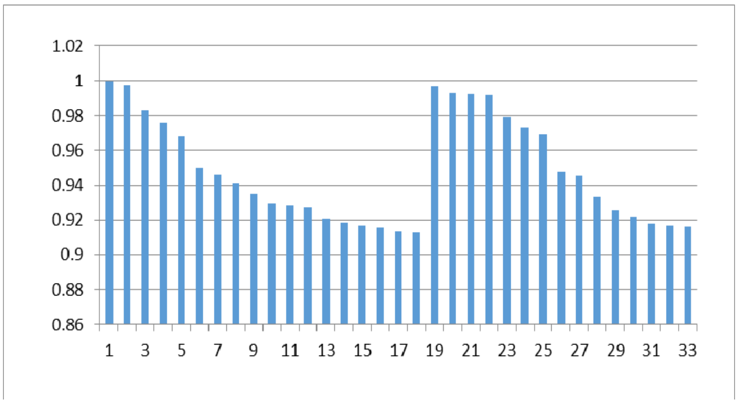

Fig. 5

The proposed method was used to test the method and select the optimum location for the placement of the charging station in the 33 bus IEEE system; Table 1 shows the features and details of the EVs used in this study under charging mode 2 in which the rate of charge is 7kW [27]. The results of adding three charging stations with a size of 975 kW each and the comparison with other studies are shown in Table 2.

Table 1

Type of EV	EVRating (kW)	No. of EVs	Stations rating
Chang An Yidong	3.75	20	75
Chevrolet Volt	2.2	25	55
Tesla Model X	13	15	195
BMW i3	44	10	440
SAE J1772 Standard	7	30	210
Total power rating of CS (kW)		100	975

Table 2

Algorithms	Charging station location	Size of charging station	Minimum voltage	Losses in kW
Proposed Algorithm	2,19,25	975,975,975	0.89826	295.5
HHO [27]	2,19,25	975,975,975	0.89826	295.5
TLBO[27]	2,19,25	975,975,975	0.89826	295.5
PSO [28]	2,19,25	975,975,975	0.89826	295.5
FPA [29]	2,19,25	975,975,975	0.89826	295.5

Figures 6 and 7 show the impact of the addition of charging stations on voltages and losses. From the results of implementation, it can be seen that the voltages and losses weren't largely affected by the addition of charging stations even with their large size, which makes the proposed method very reliable in selecting the optimal location of charging station that improves the network's performance.

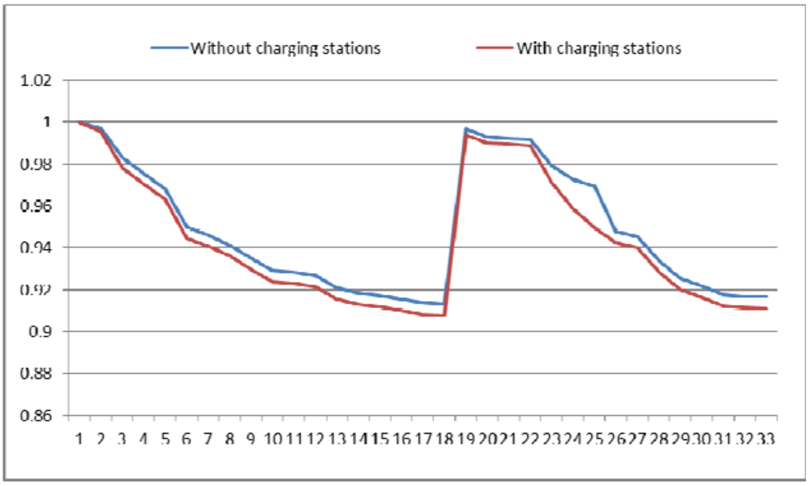

Fig. 6

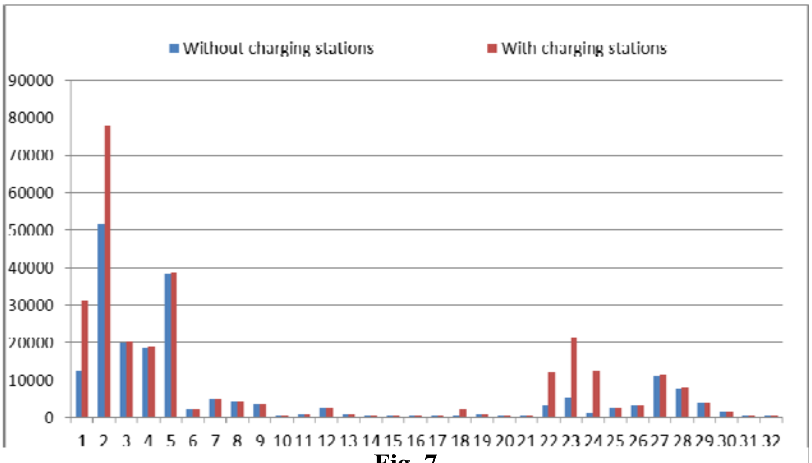

Fig. 7

5.2. Case2: the realistic network of Baghdad/alghazalya

The network of Baghdad/alghazalya is shown in Figure 8. It consists of twenty-five buses and twenty-four branches. The voltage of the system is 11 kV. The total active load of the network is 5.4598 MW and the reactive load is 3.31764 MVAR. The loss of the system is 244.11 kW and the minimum voltage is 0.94485 at bus 14. The electrical parameters of the system are presented in Table 3.

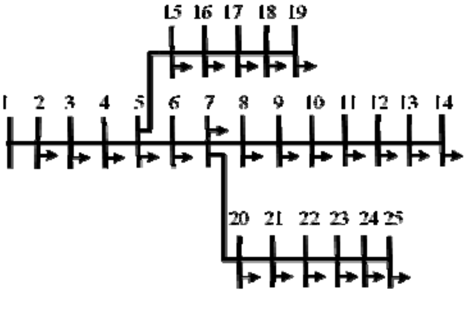

Fig. 8

The proposed decision method was used to select the optimum location for the placement of the charging station in the real case network; Table 4 shows the details of the EVs used in this study.

Table 3

Bus1	Bus 2	Active power kW	Reactive power kVAR	Resistance (ohm/km)	Reactance (ohm/km)
1	2	205	124	0.0492	0.0267
2	3	205	124	0.423	0.221
3	4	340	210	0.07481	0.09131
4	5	205	124	0.04987	0.060879
5	6	205	124	0.19618	0.2174
6	7	205	124	0.0278	0.0317
7	8	205	124	0.0278	0.0143
8	9	205	124	0.0712	0.0869
9	10	205	124	0.0356	0.0434
10	11	340	210	0.0973	0.1188
11	12	205	124	0.0855	0.104
12	13	205	124	0.0374	0.0511
13	14	340	210	0.054	0.049
5	15	205	124	0.0308	0.0376
15	16	205	124	0.0594	0.0724
16	17	205	124	0.1306	0.159
17	18	205	124	0.0183	0.0223
18	19	205	124	0.0235	0.0287
7	20	205	124	0.0214	0.0261
20	21	340	210	0.01544	0.0188
21	22	205	124	0.0475	0.05798
22	23	205	124	0.0736	0.089
23	24	205	124	0.0594	0.0724
24	25	205	124	0.0178	0.0217

Based on the total load of EVs of 1620 kW it is decided to add three stations of 502 kW each to cover the residential city of alghazalya and take into consideration the number of stations working together in the work and the distance between the stations. Table 5 show the placement of charging stations under fully load condition . Figures 9 and 10 show the impact of the addition on losses and voltages of the real case system.

From the results, it can be seen that the voltages and losses weren't affected by adding the charging station even with their large size, which makes the proposed method very reliable in selecting the optimal location of charging station that improves the network's performance and designing microgrids. Table 6 discuss the operation of these stations under three cases where in case A all the stations are working, B station one and two are working and C only station one is working under different EVs levels. The results of Table 6 show a different penetration levels of EVs in wich each station has a total number of charging ports of 53 that equals number of EVs in the CS at full capacity under different working cases with considering the distance constaraint between the stations to cover the real network of Iraq/Baghdad/al-ghazalya correctly. As it can be seen the minimum voltage hase slightly affcected by the addition and the losses didn't rise high compared to the base case even under under the full load of EVs of 1502 kW and that makes the method reliable to select the best locations of CS with reducing the impact coming from the addtition under different cases.

Table 4

Type of EV	EVRating (kW)	No. of EVs	Stations rating
Chang An Yidong	3.75	30	112.5
Chevrolet Volt	2.2	38	83.6
Tesla Model X	13	25	325
BMW i3	44	16	704
SAE J1772 Standard	7	40	280
Total power rating of CS (kW)		160	1506

Table 5

Algorithms	Location	Size of CS kW	Losses in kW
Proposed algorithm	2,15,25	502,502,502	323.3

6. Conclusion

A newly proposed method for the placement of charging stations has been introduced and used in this paper. The IEEE 33 bus system and a real study case of Iraq/Baghdad/alghazalya have been used for the test of the method and the work. The impact on voltages and losses has been analyzed. The fixed point method was used for power flow analysis, and the proposed method was used for the placement of charging stations. The results showed the efficiency of the proposed method in selecting the optimal place for the charging stations in terms of losses reduction, voltage reduction, and operating time under different conditions of stations working and EVs level, where the voltages and losses weren't affected that much when compared with the base system, and the operating time is several seconds. This work can be developed by integrating distributed generators into the system and managing the network with the connected charging stations to provide storage for intermittent sources such as (PV and wind).

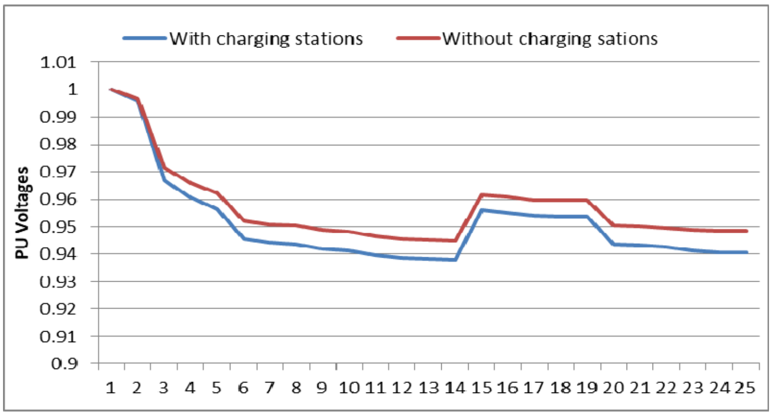

Fig. 9

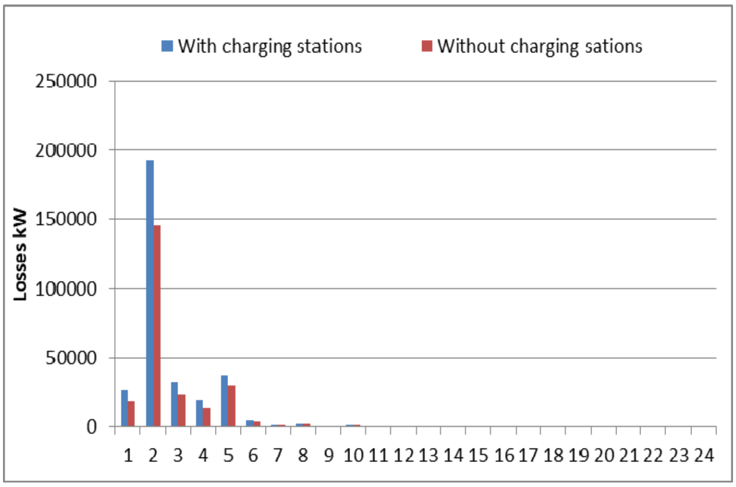

Fig. 10

Table 6

EVs level	Case	Location of CS	Size of CS	Losses	Minimum voltage&bus
100%	A	2,15,25	502,502,502	323.35	0.93804(14)
	B	2,15	502,502	278	0.94191(14)
	C	2	502	246.6	0.94466(14)
80%	A	2,15,25	401.6,401.6,401.6	306	0.93942(14)
	B	2,15	401.6,401.6	271.04	0.94251(14)
	C	2	401.6	246.1	0.9447(14)
60%	A	2,15,25	301.2,301.2,301.2	289.66	0.94079(14)
	B	2,15	301.2,301.2	264.07	0.9431(14)
	C	2	301.2	245.6	0.94475(14)
40%	A	2,15,25	200.8,200.8,200.8	273.82	0.94216(14)
	B	2,15	200.8,200.8	257.26	0.9437(14)
	C	2	200.8	245.1	0.94479(14)

1. Trofimenko Y.V., Komkov V.I., Donchenko V.V., Potapchenko T.D. Model for the assessment greenhouse

gas emissions from road transport. Periodicals of Engineering and Natural Sciences (PEN). 2019. Vol. 7(1). Pp. 465-473. DOI: https://doi.org/10.21533/pen.v7i1.390

2. Kyrylenko O.V., Basok B.I., Baseyev Ye.T., Blinov I.V. Power industry of ukraine and realities of the global warming. *Tekhnichna Elektrodynamik*a. 2020. No 3. Pp. 52-61. DOI: https://doi.org/10.15407/techned2020.03.052. (Ukr)

3. Parker N., Breetz H.L., Salon D., Conway M.W., Williams J., Patterson M. Who saves money buying electric vehicles? Heterogeneity in total cost of ownership. *Transportation Research Part D: Transport and Environment*. 2021. Vol. 96. P. 102893. DOI: https://doi.org/10.1016/j.trd.2021.102893.

4. Sabzi S., Vajta L., Faghihi T. A Review on Electric Vehicles Charging Strategies Concerning Actors Interests. *Periodica Polytechnica Electrical Engineering and Computer Science.* 2022. Vol. 66(2). Pp. 148-162. DOI: https://doi.org/10.3311/PPee.19625 .

5. Zeb M.Z., Imran K.; Khattak A., Janjua A.K., Pal A., Nadeem M., Zhang J., Khan S. Optimal Placement of Electric Vehicle Charging Stations in the Active Distribution Network. *IEEE Access*. 2020. Vol. 8. Pp. 68124-68134. DOI: https://doi.org/10.1109/ACCESS.2020.2984127 .

6. Avdakovic S., Bosovic A. Impact of charging a large number of electric vehicles on the power system voltage stability. *Electrotechnical Review*. 2014. Vol. 81. Pp. 137-142.

7. Akhavan-Rezai E., Shaaban M.F., El-Saadany E.F., Zidan A. Uncoordinated charging impacts of electric vehicles on electric distribution grids: Normal and fast charging comparison. *IEEE Power and Energy Society General Meeting*. San Diego, CA, USA, 22-26 July 2012. 13170647. DOI: https://doi.org/10.1109/PESGM.2012.6345583

8. Alhazmi Y., Mostafa H., Salama M.M.A. Optimal allocation for electric vehicle charging stations using Trip Success Ratio. *International Journal of Electrical Power & Energy Systems*. 2017. Vol. 91. Pp. 101-116. DOI: https://doi.org/10.1016/j.ijepes.2017.03.009.

9. Golla N., Sudabattula S., Suresh V. Optimal Placement of Electric Vehicle Charging Station in Distribution System Using Meta-Heuristic Techniques. *Mathematical Modelling of Engineering Problems*. 2022. Vol. 9. Pp. 60-66. DOI: https://doi.org/10.18280/mmep.090108.

10. Liu Z., Wen F., Ledwich G. Optimal planning of electric-vehicle charging stations in distribution systems. *IEEE transactions on power delivery*. 2012. Vol. 28(1). Pp. 102-110. DOI: https://doi.org/10.1109/TPWRD.2012.2223489

11. Islam M.M., Shareef H., Mohamed A. Optimal location and sizing of fast charging stations for electric vehicles by incorporating traffic and power networks. *IET Intelligent Transport Systems*. 2018. No 12. Pp. 947-957. DOI: https://doi.org/10.1049/iet-its.2018.5136

12. Chaudhary R., Karki M., Khan S. Optimal Placement of Electric Vehicle Charging Stations by Genetic Algorithm in Pokhara's Radial Distribution Network. Proceedings of 9th *IOE Graduate* Conference. 2021. Vol. 9. Pp. 94-101.

13. Lam A.Y.S., Leung Y.W., Chu X. Electric Vehicle Charging Station Placement: Formulation, Complexity, and Solutions. *IEEE Transactions on Smart Grid*. 2014. Vol. 5(6). Pp. 2846-2856. DOI: https:/doi.org/10.1109/TSG.2014.2344684 .

14. Ponnam V., Swarnasri K. Multi-Objective Optimal Allocation of Electric Vehicle Charging Stations in Radial Distribution System Using Teaching Learning Based Optimization. *International Journal of Renewable Energy Research*. 2020. No 10. Pp. 366-377.

15. Alquthami T., Alsubaie A., Alqahtani M., Alqahtani K., Alshahrani S., Anwar M. Investigating the Impact of Electric Vehicles Demand on the Distribution Network. *Energies*, 2022. Vol. 15(3). 1180. DOI: https://doi.org/10.3390/en15031180 .

16. Mehta R., Verma P., Srinivasan D., Yang J. Double-layered intelligent energy management for optimal integration of plug-in electric vehicles into distribution systems. *Applied Energy*. 2019. Vol. 233-234. Pp. 146-155. DOI: https://doi.org/10.1016/j.apenergy.2018.10.008.

17. Fredriksson H., Dahl M., Holmgren J. Optimal placement of Charging Stations for Electric Vehicles in large-scale Transportation Networks. *Procedia Computer Science*. 2019. Vol. 160. Pp. 77-84. DOI: https://doi.org/10.1016/j.procs.2019.09.446.

18. Islam M.M., Mohamed A., Shareef H. Optimal allocation of rapid charging stations for electric vehicles. *IEEE* Student Conference on *Research and Development (SCOReD)*. Kuala Lumpur, Malaysia, December13-14, 2015. DOI: https://doi.org/10.1109/SCORED.2015.7449360.

19. Hashemian S.N., Latify M.A., Yousefi G.R. PEV Fast-Charging Station Sizing and Placement in Coupled Transportation-Distribution Networks Considering Power Line Conditioning Capability. IEEE Transactions on Smart Grid. 2020. Vol. 11(6). Pp. 4773-4783. DOI: https://doi.org/10.1109/TSG.2020.3000113 .

20. Hassan A.S., Firrincieli A., Marmaras C., Cipcigan L.M., Pastorelli M.A. Integration of electric vehicles in a microgrid with distributed generation. 49th *International Universities Power Engineering* Conference (UPEC). Cluj-Napoca, Romania, Sepember 2-5, 2014. DOI: https://doi.org/10.1109/UPEC.2014.6934641.

21. Dugan R.C., McDermott T.E. An open source platform for collaborating on smart grid research. *IEEE Power and Energy Society General Meeting*. Detroit, MI, USA Detroit. July 24-28, 2011. DOI:

https://doi.org/10.1109/PES.2011.6039829.
22. Nasser R., Ali M.I.I., Alkhafaji M.H. Optimal Placement and Size of Distributed Generators Based on Autoadd and PSO to Improve Voltage Profile and Minimize Power Losses. *Engineering and Technology Journal.* 2021. Vol. 39(3A). Pp. 453-464. DOI: https://doi.org.10.30684/etj.v39i3A.1781.
23. Vita V. Development of a Decision-Making Algorithm for the Optimum Size and Placement of Distributed Generation Units in Distribution Networks. *Energies.* 2017. Vol. 10(9). P. 1433. DOI: https://doi.org/10.3390/en10091433
24. Rao R., Narasimham S., Ramalingaraju M. Optimization of Distribution Network Configuration for Loss Reduction Using Artificial Bee Colony Algorithm. *World Academy of Science, Engineering and Technology, International Journal of Electrical and Computer Engineering.* 2008. Vol. 2. No 9. Pp. 1964-197.
25. Soliman M.E., Abdelaziz A.Y., El-Hassani R.M. Distribution power system reconfiguration using whale optimization algorithm. *International Journal of Applied Power Engineering*. 2020. No 9. Pp. 48-57. DOI: https://doi.org/10.11591/ijape.v9.i1.pp48-57
26. Abdelaziz A.Y., Osama R.A., Elkhodary S.M. Distribution Systems Reconfiguration Using Ant Colony Optimization and Harmony Search Algorithms. *Electric Power Components and Systems*. 2013. Vol. 41(5). Pp. 537-554. DOI: https://doi.org/10.1080/15325008.2012.755232.
27. Ponnam V.K.B., Swarnasri K. Multi-Objective Optimal Allocation of Electric Vehicle Charging Stations and Distributed Generators in Radial Distribution Systems using Metaheuristic Optimization Algorithms. *Engineering, Technology & Applied Science Research*. 2020. Vol. 10(3). Pp. 5837-5844. DOI: https://doi.org/10.48084/etasr.3517.

МЕТОД ПРИЙНЯТТЯ РІШЕНЬ ЩОДО ОПТИМАЛЬНОГО РОЗПОДІЛУ ЗАРЯДНИХ СТАНЦІЙ ЕЛЕКТРОМОБІЛЯ В РОЗПОДІЛЬНИХ МЕРЕЖАХ

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Електричні транспортні засоби сьогодні стають помітними та відіграють важливу роль у транспортному секторі, оскільки звичайні транспортні засоби впливають на навколишнє середовище. Зростаюча кількість транспортних засобів вимагає збільшення зарядних станцій, що впливає на розподільчу мережу, якщо вони розташовані випадково. Тому вибір оптимального місця для цих зарядних станцій є дуже важливим для пом'якшення впливу на систему розподілу. У роботі представлено метод прийняття рішень для оптимального вибору розташування зарядної станції в радіальній системі розподілу. Для аналізу потоку навантаження використовувався алгоритм фіксованої точки. Аналіз проводився та перевірявся на 33 шині IEEE, а для дослідження використовувався реальний приклад в Іраку. Аналіз показав ефективність запропонованого методу щодо зменшення впливу зарядних станцій на напруги та втрати за різних умов.
Бібл. 27, рис. 10, табл. 6.

Ключові слова: оптимальне розміщення, вантажопотік, зарядні станції, зменшення втрат, електромобілі.

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