第 48 卷第 6 期
2021 年 6 月

湖南大学学报（自然科学版）
Journal of Hunan University（Natural Sciences）

Vol. 48. No. 6.
June 2021

Open Access Article

OPTIMAL LOCATION OF EV CHARGING STATIONS IN THE DISTRIBUTION SYSTEM CONSIDERING PSO OPTIMAL TECHNIQUES

Sai Goutham Golive
Research Scholar, Department of Electrical & Electronics Engineering, Annamalai University, Annamalai nagar, India, saigoutham248@gmail.com

B Paramasivam
Associate Professor, Department of Electrical & Electronics Engineering, Annamalai University, Annamalai nagar, India

J Ravindra
Assistant Professor, Department of Electrical & Electronics Engineering, Bapatla Engineering College, Andhra Pradesh, India

Abstract: Infrastructure for EV Charging stations and its electrification in congested cities take steps in this direction, as shown by the proliferation of metro stations, electric trams, BRT EV corridors, and general promotion of EV adoption in many countries. This is expected to lead in future to more traditional charging stations in suburban areas. The best PSO based optimal location in the IEEE-33 distribution system was proposed in this article for Electric vehicles (EV's) charging station. At provided interconnection nodes a 24-hour load demand is varied and the resulting sensitivity indexes are determined for the correct location. These indexes are derived from the Jacobian reverse matrix of the power flow test Newton-Raphson and help to determine the best charge location. The paper then used PSO optimal algorithm calculate the charging station's size. Electric cars are paid at a certain node utilizing the pricing information in real time.

Keywords: EV, Charging Station, Distribution System, IEEE 33 bus.

摘要： 电动汽车充电站的基础设施及其在拥挤城市中的电气化朝着这个方向迈进，地铁站、电动有轨电车、BRT 电动汽车走廊的激增以及许多国家对电动汽车的普遍推广都表明了这一点。预计未来这将导致郊区出现更多传统的充电站。本文针对电动汽车 (EV) 充电站提出了 IEEE-33 配电系统中基于最佳 PSO 的最佳位置。在提供的互连节点上，24 小时负载需求是变化的，并且为正确的位置确定了由此产生的敏感度指数。这些指标源自潮流测试 Newton-Raphson 的雅可比逆矩阵，有助于确定最佳充电位置。论文随后使用PSO优化算法计算出充电站的大小。电动汽车在某个节点实时使用定价信息进行支付。

关键词：电动汽车，充电站，配电系统，IEEE 33 总线。

Received: March 4, 2021 / Revised: April 4, 2021 / Accepted: May 8, 2021 / Published: June 13, 2021

About the authors: Sai Goutham Golive, Research Scholar, Department of Electrical & Electronics Engineering, Annamalai University, Annamalai nagar, India, saigoutham248@gmail.com

Corresponding author Email: Sai Goutham Golive, saigoutham248@gmail.com

Introduction

Delivery network needs at least one feeder and each feeder stores the electricity, so it is known that the network requires at least one. If charging at home is not appropriate, then there must be a charging station situated at a feeder close to home in order to charge EVs in an effective manner. In [1] The aim was to reduce maintenance costs including power loss and voltage variance. In certain situations, batteries may have fluctuating voltages. In addition, the power storage capacities would be limited in order to preserve the voltage and frequency on the delivery network. The heat storage device must be placed well away from a potential shortfall in the energy grid in order to guarantee that all critical demand is satisfied except in the case of a power outage. The stand on the side of a bus can help to alleviate the voltage issues. Over the next few years, the larger percentage of taxis and public transit buses in suburbs would definitely be hybrid. EVs would be connected to the power grid by charging stations. Delivery network can be used to service the elderly.

Refer to demand for cars in the metropolitan sprawl. An EV requires more electricity than a regular electric appliance in charging mode. Another strong example for the car to be charged with is Tesla Model S.[4] It requires 5 kW of power for charging purposes. On the distribution network, voltage drops may occur due to the electrical automobile charging. Electric vehicle charging would affect the supply mechanism because it would allow the peak demand align with the EV charging frequency. A research indicated in [6] how to charge during off times. Methods to supply more resources to electrical services for delivery in grids are discussed in [7]. In [8], the electric vehicle (EV) battery acts as a bidirectional power source to reduce the adverse consequences of peak charging. Some strategies have been suggested in sources [9]-[12] on voltage breach and power loss minimization. Further research [13] and [14] use identical charging guidelines.

The problems of planning EV charging stations and distribution network expansion taking into account the location and size of these charging stations can be solved by [15]. The costs of the car and expansion of the EV charging station to create an integrated network for the EVs are included. The issue of EV charging stations' optimally-sited is effectively solved by understanding the objective function of minimizing the integrated costs of customers and charging stations. This topic has been widely studied in the scenario domain by [17]. First of all, given the environmental factors, we defined the best places for EV charging stations. A second stage is devised to overcome optimal number of Electric Vehicle (EV) charging stations in the region. There is a system built for effective preparation of batteries' exchange charges at swap stations. In [19], I proposed an innovative scheme for public charging points and roadside fast chargers in an urban climate. The government goal to reduce the environmental effects of a PEV initiative. The new innovative load control techniques in electric vehicles is explored in this post.

Case Study:

The study concentrates on an improved IEEE-33 distribution system [20]. The initial system consisted of 50 Hz, 24.9 kV and 12 MVA with many fixed loads and was connected to the main power supply at bus 800. No distributed generation (DG) tools are used in the system. In this test network the voltage levels are changed to 12 kV and other components, including loads and line impedances are also sized. Figure 1 shows the planned distribution system. Load demand can be divided into two groups for a supply network with redundancy for EV connections: controllable demand and fixed demand. The controllable demand for load is regulated so that it has no impact on the everyday intake of the user. Every EV can be powered by two-way information sharing between consumer and utility in smart grid operations. The study considers hourly demand for load to be set while EV loading to be considered a controllable demand. It is estimated that the utility would provide an hourly energy and a 24-hour demand outlook for charge, as seen in Fig. 2. The goal of this research is to depart from the network stability constraints the best optimal positions of electric vehicles within the charging (G2V) and discharge (V2G) distribution system. Analysis also reveals how price data for real-time electric car charging can be optimised. This completes the aim of transferring load peaks to low real-time valley regions.

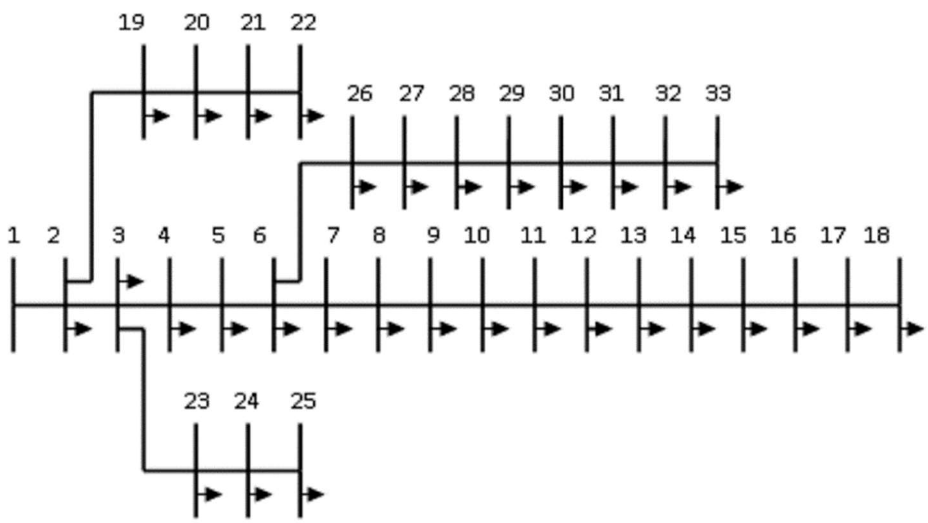
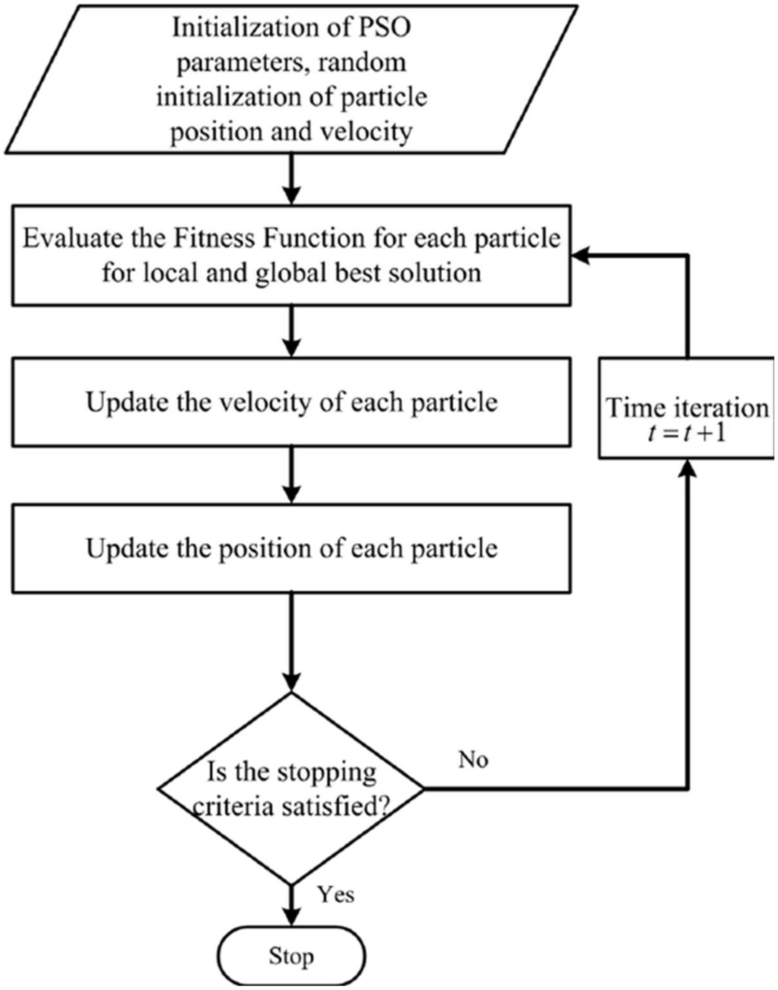


Fig: 1 Proposed IEEE 33 Bus System

PSO Optimal Algorithm:

PSO is the computational strategy to refine the issue by trying iteratively to create a candidate solution in a given coherence measure of computer science. It resolves a problem by creating a population of candidate solutions known as particles and by using a simple math-related approach based on position and speed. The movement of each particle depends on their locally best known spot, but it is often directed at the best known search space locations, which change as other particles find better places. As a result, the swarm can migrate towards the right alternatives. The flow chart for PSO optimal algorithm is shown in Fig: 2.



Results and Discussion:

In this paper Optimal allocation of EV charging station in the real time IEEE 33 bus distributions system is implemented using PSO optimal algorithm. The effectiveness of the proposed algorithm is compared with Type 1, 2, 3, 4 loads. The loss sensitivity factor in the real time IEEE 33 bus distributions system for Type 1 load is shown in Fig: 3

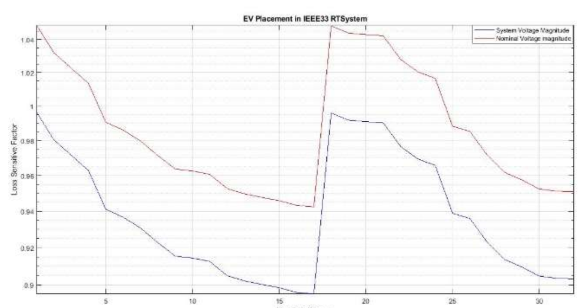


Fig: 3 Loss Sensitivity Factor in Type 1 Load

The loss sensitivity factor in the real time IEEE 33 bus distributions system for Type 3 load is shown in Fig: 4

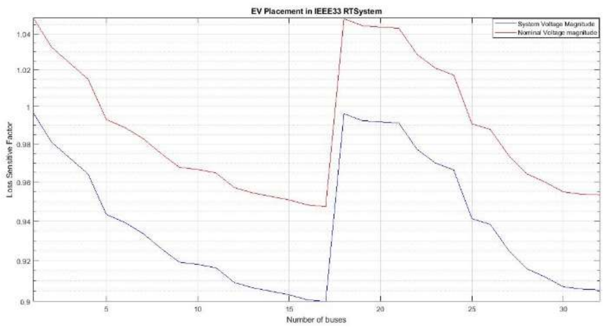


Fig: 4 Loss Sensitivity Factor in Type 2 Load

The loss sensitivity factor in the real time IEEE 33 bus distributions system for Type 3 load is shown in Fig: 5

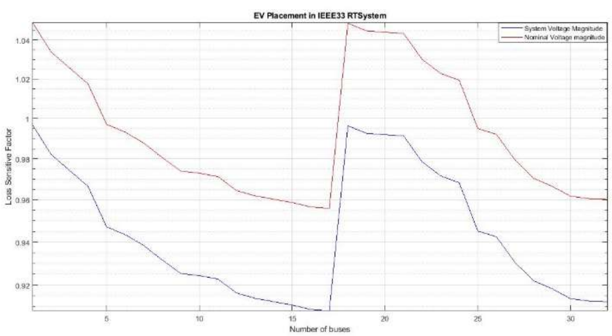


Fig: 5 Loss Sensitivity Factor in Type 3 Load

The loss sensitivity factor in the real time IEEE 33 bus distributions system for Type 4 load is shown in Fig: 6.

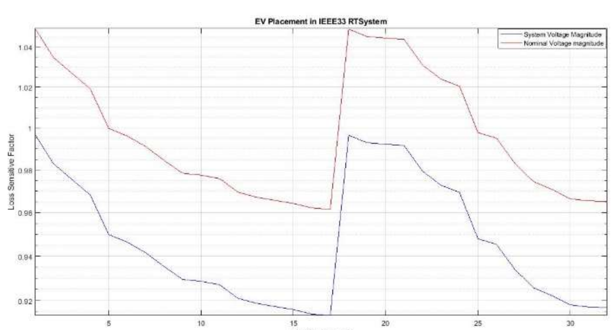


Fig: 6 Loss Sensitivity Factor in Type 4 Load

The loss sensitivity factor in the real time IEEE 33 bus distributions system Proposed PSO optimal algorithm is shown in Fig: 7

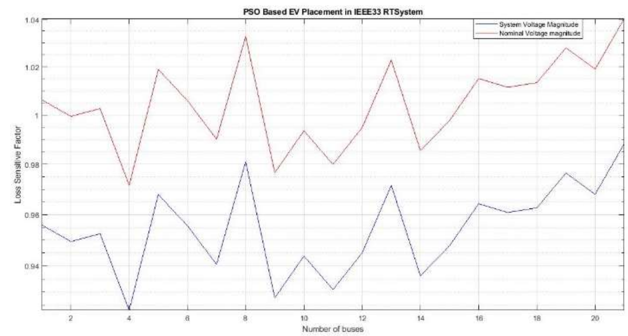
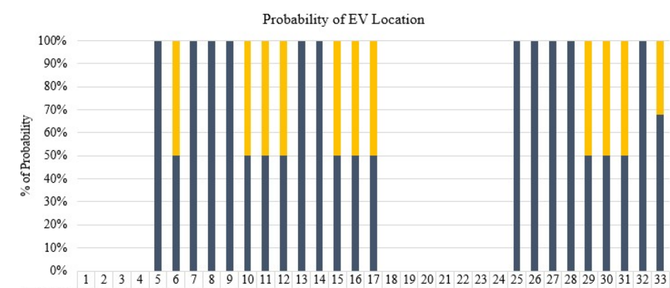


Fig: 7 Loss Sensitivity Factor with Proposed PSO EV placement

The probability of EV charging station location in the real time IEEE 33 bus distribution system with PSO and without PSO is shown in Fig: 8.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
EVPSO	0	0	0	0	0	1	0	0	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	10
EV	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	21

Fig: 8. Probability of EV Charging Station Location.

From the above Fig: 8. Shows the marks performance of Proposed PSO algorithm for optimal location of EV Charging station in the distribution system.

Conclusion:

The study proposes a PSO algorithm for optimal location of EV charging station in IEEE 33 bus distribution system. The paper then describes a method to calculate the charging station's size. The proposed methodology included the loss sensitivity indexes to ensure that no deviations of load occur when EV charging stations are allocated. This was done dependent on real-time performance in distribution system with the right charge policy. This improvement lets EV owner's economies on their bills of services. In addition, switching the charge to another period than peak reduces network demand and enhances the stability of the system.

References:

[1] N. Neyestani, M. Yazdani Damavandi, M. Shafie-Khah, J. Contreras, and J. Catalão, "Allocation of plug-in vehicles' parking lots in distribution systems considering network-constrained objectives," IEEE Trans. Power Syst., vol. PP, no. 99, pp. 1-14,Oct. 2014.

[2] S. Deilami, A. S. Masoum, P. S. Moses, and M. A. S. Masoum, *"*Realtime coordination of plug-in electric vehicle charging in smart grids to minimize power losses and improve voltage profile," *IEEE Trans. Smart Grid*, vol. 2, no. 3, pp. 456–467, Sep. 2011.

[3] National Grid USA. (2012). *National Grid Residential Load Data* [Online]. Available: http://www.nationalgridus.com/energysupply.

[4] Kejun Qian, Chengke Zhou, Malcolm Allan, Yue Yuan, "Modeling of Load Demand Due to EV Battery Charging in Distribution System," *IEEE Trans. Power Systems*, vol. 26, no. 2, pp. 802-810, 2011.

[5] S. Babaei, D. Steen, T. A. Le, O. Carlson, and L. Bertling, "Effects of plug-in electric vehicles on distribution systems: A real case of Gothenburg*," in Proc. IEEE Innov. Smart Grid Technol*. Conf.Eur. (ISGT), Gothenburg, Sweden, Oct. 2010, pp. 1–8.

[6] M. Pipattanasomporn, S. Rahman, and S. Shao, "Grid integration of electric vehicles and demand response with customer choice*," IEEE Trans. Smart Grid,* vol. 3, no. 1, pp. 543–550, Mar. 2012.

[7] W. Kempton and J. Tomi, "Vehicle-to-grid power implementation: From stabilizing the grid to supporting large-scale renewable energy*," J. Power Sources*, vol. 144, no. 1, pp. 280–294, Jun. 2005.

[8] E. Sortomme and M. A. El-Sharkawi, "Optimal charging strategies for unidirectional vehicle-to-grid*," IEEE Trans. Smart Grid*, vol. 2, no. 1, pp. 131–138, Mar. 2011.

[9] K. C. Nyns, E. Haesen, and J. Driesen, "The impact of charging plug-in hybrid electric vehicles on a residential distribution grid*," IEEE Trans. Power Syst.*, vol. 25, no. 1, pp. 371–380, Feb. 2010.

[10] L. P. Fernandez, T. G. S. Roman, R. Cossent, C. M. Domingo, and P. Frias, "Assessment of the impact of plug-in electric vehicles on distribution networks*," IEEE Trans. Power Syst*., vol. 26, no. 1, pp. 206–213,Feb. 2011.

[11] T. Kristoffersen, K. Capion, and P. Meibom, "*Optimal charging of electric drive vehicles in a market environment*," *Appl. Energy*, vol. 88, no. 5, pp. 1940–1948, 2011.

[12] E. Sortomme and M. A. El-Sharkawi, *"*Optimal combined bidding of vehicle-to-grid ancillary services*," IEEE Trans. Smart Grid*, vol. 3, no. 1, pp. 70–79, Mar. 2012.

[13] R. C. Green, II, L. Wang, and M. Alam, "The impact of plug-in hybrid electric vehicles on distribution networks: A review and outlook," *Renew. Sustain. Energy Rev*., vol. 15, no. 1, pp. 544–553, 2011.

[14] D. B. Richardson, "Electric vehicles and the electric grid: A review of modeling

approaches, impacts, and renewable energy integration," *Renew. Sustain. Energy Rev.*, vol. 19, pp. 247–254, Mar. 2013.

[15] Z. Hu, and Y, Song, "Distribution network expansion planning with optimal siting and sizing of electric vehicle charging stations," *Universities Power Engineering Conference (UPEC),* 2012 47th
International, pp. 1-6, 2012.

[16] L. Jia, Z. Hu, Y, Song, and Z. Luo "Optimal siting and sizing of electric vehicle charging stations," *IEEE International Electric Vehicle Conference*, 2012, pp. 1-6, 2012.

[17] Z. Liu, F. Wen, and G. Ledwich, "Optimal Planning of Electric-Vehicle Charging Stations in Distribution Systems," *IEEE Trans. Power Delivery*, vol. 28, no. 1, pp. 102-110, 2013.

[18] Y. Zheng, Z. Y. Dong, Y. Xu, K. Meng, J. H. Zhao, and J. Qiu, "Electric Vehicle Battery Charging - Swap Stations in Distribution Systems - Comparison Study and Optimal Planning," *IEEE Trans. Power System*., vol. 29, no. 1, pp. 221-229, 2014.

[19] H. Zhang, Z. Hu, Z. Xu, and Y. Song, "An Integrated Planning Framework for Different Types of PEV Charging Facilities in Urban Area," *IEEE Trans. Smart Grid*, In Press, 2015.

[20] IEEE 34 Node Test Feeder—*IEEE Distribution System Analysis Subcommittee*[Online].Available:http://www.ewh.ieee.org/soc/pes/dsacom/testfeeders.html

[21] ComEd. (2012). *Comed Real Time Saving* [Online]. Available: https://www.thewattspot.com/rtsavings.php.

[22] Olle Suudstrom, Carl Binding, "Flexible Charging Optimization for EV Considering Distribution Grid Constraints," *IEEE Tran. Smart Grid*, vol. 3, no. 1, pp. 26-37, 2012