IJEASM
International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 2 Issue 5, May 2021

Electric-Vehicle Distribution Charging Stations by optimal placement system

Swapnil H Suryawanshi (M.Tech Power System)[1],Prof. Alka Thakur (Associate Professor)[2]
Department of Electrical Engineering
Sri Satya Sai University of Technology & Medical Sciences, Sehore (M.P.) India
Swap3599@gmail.com[1], alkathakuree@gmail.com[2]

Abstract: *As the vehicles are becoming the basic need of the human being for the transportation, importance of fuel increased to very high level, and research started on different types of fuels. With the fossil fuels like oil, natural gas, petroleum, coal is expected to last a little longer, not for longer duration, and the high awareness on the protecting our environment, creates very high importance of Electric Vehicles (EVs). But, the use of EVs is not much as the use of Petrol or Diesel vehicles. One of the reasons for this is the mesh of the charging stations is very poor cross the globe. Inappropriate siting and sizing of EV charging stations, the city traffic mesh, and a degradation in voltage profiles at some nodes could have negative effects on the development of EVs. This is due the commercial profit in a charging station. This paper discusses one of the solutions for this issue. In this paper we first identify the optimal site of EV charging stations, for that two steps screening method is used in which first step considers environmental factors and second service radius of EV charging stations, using this method we are finding an optimal cost to state up an EV charging station. Then, a mathematical model employed to find the optimal solution on fast charging. At the end, this paper has a demonstration of simulation results test feeder, which says developed model and method cannot only attain the reasonable planning scheme of EV charging stations, but also reduce the network loss and improve the voltage profile.*

Keywords: *Electric Vehicles, siting and sizing, Distribution system.*

1. Introduction

In the last decade, electric vehicles (EVs) have grown rapidly in some countries, due to the good improvement in the batteries [1]. The global electric vehicle market size is projected to grow from an estimate of 3 million units in 2019 to reach 27 million units by 2030. BYD Auto Co., Ltd. (China), Nissan Motor Company Ltd. (Japan), Tesla Motors (US), and Volkswagen (Germany) are some of the leading players in the electric vehicle market. These companies have launched electric vehicles in different segments to cater to the increased demand. Tesla Model S, Nissan Leaf, and BYD Tang are some of the most successful models that have attracted customers toward electric vehicles. Additionally, Panasonic Corporation (Japan), Automotive Energy Supply Corporation (Japan), BYD Auto Co., Ltd. (China), and Samsung SDI (South Korea) are some of the largest battery manufacturers that cater to the global demand for EV batteries.

2. Proposed methods

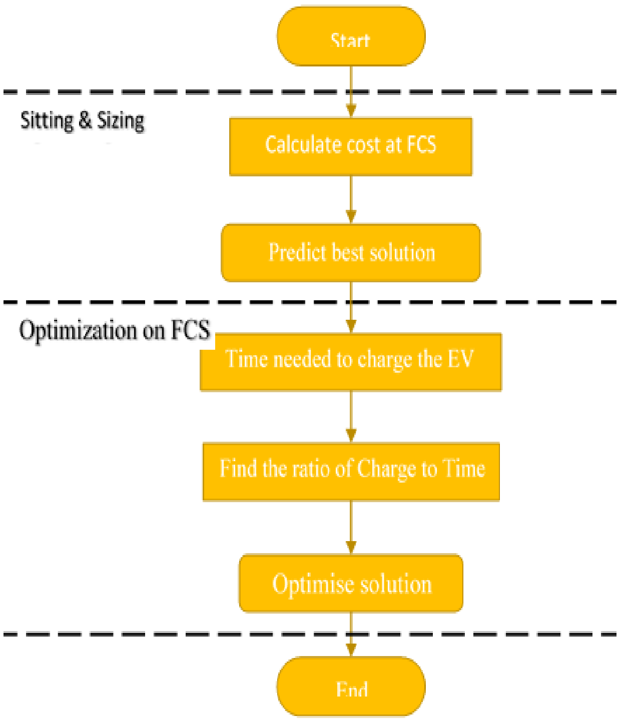

Fig. 1 shows the flow chart of the proposed system, flowed by the stepwise explanation.

1. Siting and sizing

The developed mathematical model for the optimal sizing of EV charging stations can be described as

$$\begin{cases} \min & f(\boldsymbol{x}) \\ \text{s.t.} & \boldsymbol{g}(\boldsymbol{x}) = 0 \\ & \boldsymbol{h}_{\min} \le \boldsymbol{h}(\boldsymbol{x}) \le \boldsymbol{h}_{\max} \\ & \boldsymbol{x}_{\min} \le \boldsymbol{x} \le \boldsymbol{x}_{\max} \end{cases} \quad \text{.... (1)}$$

Where $\boldsymbol{f(x)}$ is the objective function, $\boldsymbol{g(x)}$ is the vector of the equality constraints, $\boldsymbol{h(x)}$ is the vector of the inequality constraints, $\boldsymbol{h}_{max}$ / $\boldsymbol{h}_{min}$ is the vector of the maximal/minimal limits of $\boldsymbol{h(x)}$, $\boldsymbol{x}$ is the vector of continuous decision variables consisting of the capacities of all EV charging stations, and $\boldsymbol{x}_{max}$ / $\boldsymbol{x}_{min}$ is the vector of the maximal/minimal limits of $\boldsymbol{x}$.

The problem described by (1) is a typical nonlinear constrained programming problem. Up to now, many optimization algorithms are available for solving this problem in the field of operations research. In this paper, the modified primal-dual interior point algorithm (MPDIPA) is employed due to its fast convergence rate, strong robustness, and insensitive starting points. The calculation amount of the primal-dual interior algorithm mainly involves solving correction equations. To speed the solving procedure, the correction equations are simplified by taking full advantage of their sparse structures.

2. Optimization on fast charging

Fig. 2 show the proposed method. This system generates the power from different source like Solar i.e. PV, Wind turbine, Diesel engine etc., the generated power then stored in the storage and used as and when needed.

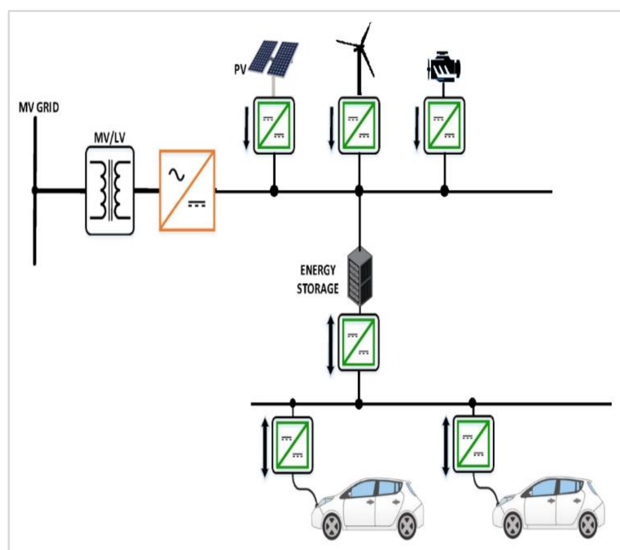

Figure 2 Proposed method

3. Levelized cost of energy

The average total cost to theory and work a source of energy mostly depends upon the levelized cost of energy. Optimization of such component is done to get proper economic solution. In this study, the LCOE is not calculated for the entire lifespan, but for a year.

LCOE, is nothing but the average between the total annual costs to the total annual power output. The cost and power components is been showed above and the equation to calculate LCOE is given by:

$$LCOE = C_{an}/P_{an} \text{ …. } \textbf{(2)}$$

The total cost of component can be derived by using formula:

$$C_{an} = C_{pv} + C_{wt} + C_{bat} + C_{de} \text{ …. } \textbf{(3)}$$

3. Case Studies

Optimizing the sizes of components of a system depends on various factors such as the resources, cost, drivetrain, load requirement, blackouts, and so on. Since in this problem, the loads and resources were known, the optimization was greatly dependent on the drivetrain. The variables considered in the code are:

1. The number of solar panels.
2. Number of wind turbines.
3. The radius of the Wind turbine blades.
4. The number of diesel engines required
5. The total battery loads.
6. The number of batteries.

In this problem, the demand and supply are considered for one year of 8640 hours, where there is Sunlight for half that time, and the rest of the time, the diesel engine is on so as to meet the load requirements.

There can be many approaches considered which are all logical in some sense or the other. The rationale behind this drive train is that solar PV will be unable to function during the night due to obvious reasons, and the deficit is filled by the use of diesel engines (which is why it remains off in the morning). Therefore, an if-else statement is used to switch on and off the diesel engines according to the load.

Although Irradiance and Wind velocities are variables that determine the power output of the system in an exponential fashion, they are taken as constants in the code. But each iteration yields a different value for each of these inputs, making it a little more volatile and practical. A random number between the mentioned values is generated so that each iteration can assume a different value, even though they are decided deterministically.

The solutions obtained are documented below. The Range of function value varied from 0.06 to 1.4 $/kW.

Solutions	No. of PV panels	No. of Wind turbines	Radius of the Wind Turbines	No. of diesel Engines	No. of Batteries	total Maximum instantaneous load on the batteries	Levelised cost of Energy
1	358	1	3	3	19	8	0.24
2	24	3	2	2	22	24	0.062
3	92	2	1	3	28	32	0.077

Table1: List of solutions

When the number of Wind turbines is constrained to only 1, the first solution is obtained. The solution prompts to have 358 PV panels in the system, 3 diesel engines, and the total load on the battery is comparatively low. When the number of components is not constrained, solution 2 was obtained. When the number of diesel Engines were constrained to be 3, solution 3 was obtained.

All the three power inputs have incremental effect on each other. Since the load is constant, the solution naturally, compensates for it by increasing the number of the other inputs. Solution provided by the algorithm is the size of each component in the system. On an average, the size of each component determined by the algorithm is as represented in the pie chart.

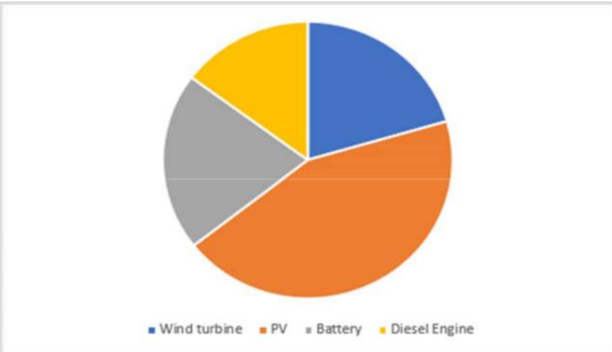

Figure 3 Average size of components

4. Conclusion

To solve the problem of optimal placement of the EV charging station, this paper a method combining the two-step screening method and the modified primal-dual interior point algorithm (MPDIPA) is developed. In those two steps first identify the optimal site of EV charging stations, for that two steps screening method is used in which first step considers environmental factors and second service radius of EV charging stations. Then, a mathematical model for the optimal sizing of EV charging stations is developed with the minimization of total cost associated with EV charging stations to be planned as the objective function and solved by a modified primal-dual interior point algorithm (MPDIPA).

At the end, this paper has a demonstration of simulation results test feeder, which says developed model and method cannot only attain the reasonable planning scheme of EV charging stations, but also reduce the network loss and improve the voltage profile.

.

References

[1] C. G. M. K.-M. a. R. F. K. Schneider, "Impact assessment of plug-in hybrid vehicles on pacific northwest distribution," *in Proc. IEEE Power Eng. Soc. Gen. Meeting-Convers. Del. Elect. Energy in 21st Century, Pittsburgh, PA,* pp. 1 - 6, Jul. 20–24.

[2] K. C. a. J. S. M. Etezadi-Amoli, "Rapid-charge electric-vehicle stations," *IEEE Trans. Power Del.,* vol. vol. 25, no. no. 3, p. 1883–1887, Jul. 2010.

[3] G. Q. Y. L. F. G. a. H. Z. F. Xu, "Tentative analysis of layout of electrical vehicle charging stations," *Proc. East China Elect. Power,* vol. vol. 37, no. no. 10, p. pp. 1677–1682, Oct. 2009.

[4] C. L. D. a. J. C. C. Y.Wu, "Amethod for electric vehicle charging infrastructure planning," *Autom. Elect. Power Syst.,* vol. vol. 34, no. no. 24, p. pp. 36–39, Dec. 2010.

[5] C. A. C. M. W. F. a. A. E. A. Hajimiragha, "Optimal transition to plug-in hybrid electric vehicles in Ontario, Canada, considering the electricity-grid limitations," *IEEE Trans. Ind. Electron,* vol. vol. 57, no. no. 2, p. pp. 690–701, Feb. 2010.

[6] C. A. C. F. S. a. A. E. A. H. Hajimiragha, "A robust optimization approach for planning the transition to plug-in hybrid electric vehicles," *IEEE Trans. Power Syst.,*, vol. vol. 26, no. no. 4, p. pp. 2264–2274, Nov. 2011.

[7] S. D. P. S. M. M. A. S. M. a. A. A.-S. A. S. Masoum, "Smart load management of plug-in electric vehicles in distribution and residential networks with charging stations for peak shaving and loss minimisation considering voltage regulation," *Inst. Eng. Technol. Gen., Transm. Distrib.,* vol. vol. 5, no. no. 8, p. pp. 877–888, Aug. 2011.

[8] Z. F. L. a. H. Z. L. F. Kou, "Modeling algorithm of charging station planning for regional electric vehicle," *Modern Elect. Power,* vol. vol. 27, no. no. 4, p. pp. 44–48, Aug. 2010.