OPTIMAL PLACEMENT OF ELECTRIC-VEHICLE CHARGING STATIONS IN DISTRIBUTION SYSTEMS

[1]Prashant S Gadhe, [2]Prof. Harshal V. Takpire
Department of Electrical Engineering
G.H.Raisoni Univesity, Amravati[1], Assistant Prof, Department of Electrical Engineering
G.H.Raisoni Univesity, Amravati[2]
prashant.gadhe@gmail.com[1],harshal.takpire@raisoni.net[2]

ABSTRACT

As the vehicles are becoming the basic need of the human been 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 are excepted 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 are not much as the use of Petrol or Diesel vehicles. One of the reason 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 paper discuss one of the solution 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. 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 have a plan for the demonstration of simulation results of the IEEE 123-node test feeder is proposed.

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. RELATED WORKS

Given the aforementioned background, the optimal planning of EV charging stations is becoming a big problem to be resolved. EVs cannot only increase energy utilization and reduce pollution emission, but also smooth the load curve by peak load shaving and, hence, enhance the safety and economics of the facility system concerned by coordinating with intermittent renewable energies, like wind power .

However, inappropriate siting and sizing of EV charging stations could have negative effects on the event of EVs, the layout of the traffic network during a city concerned, and therefore the convenience of EV drivers. It could also cause a rise in network losses and degradation in voltage profiles at some nodes [2]. Now day's industry and academics paying exhaustion focus on the optimal planning of EV charging stations [3]- [8]. Many factors having impacts on the layout of EV charging stations, just like the charging demands, the method of energy provide, the performance and charging period of A battery, additionally as a result of the locations and setting of charging stations, are investigated in [4]. In [5], the event procedure of EV charging stations is split into 3 stages (i.e., the demonstration stage, public promotional stage, and business utilization stage). Then, associate degree improvement model for the planning of EV charging stations is planned with the interval distance magnitude relation, charging capability redundancy, and charging power redundancy thought of. In [6], the feasibleness of optimally utilizing the potential of the Ontario's grid for charging plug-in hybrid EVs (PHEVs) is analyzed for off-peak load periods by using a simplified zonal model of the Ontario's electrical transmission network and a zonal pattern of base-load generation capacities for the years from 2009 to 2025.

Environmentally and economically property integration of PHEVs into an influence system is self-addressed beneath a robust optimisation coming up with method framework with the constraints of the power system and thus the transport sector taken into account [6]. A smart load-management approach for coordinating multiple plug-in EVs chargers in distribution systems is planned, with the objectives of shaving peak demand, up voltage profile and minimizing power losses conjointly as a result of the impact of EVs charging stations and typical daily residential loading patterns thought-about as constraints [7]. In [3], a reduced price model for crucial the locations and capacities of charging stations for regional EVs is developed considering some constraints, just like the distances between the station and candidate locations of work unit charging substations, the number of EVs, and thus the put in prices of work unit charging stations.

The existing analysis work on the optimum coming up with of work unit charging stations does not consistently address all necessary factors having impacts on the candidate sites of work unit charging stations, just like the distribution options of the charging demands, the performance of battery packs, and thus the potential effects of the power system involved. With this background, a ballroom dance screening technique with the environmental factors and thus the service radius of work unit charging stations thought-about is initial bestowed to identify the optimum sites of work unit charging stations. Then, a mathematical model for the optimum size of work unit charging stations is developed and solved by a changed primal-dual interior-point algorithmic rule (MPDIPA). Finally, the IEEE 123-node take a look at feeder is employed as an example the essential options of the developed model and technique.

3. PROBLEM STATEMENTS

Develop model and method, which can be provide reasonable planning scheme of EV charging stations, and also reduce the network loss and improve the voltage profile. Which include as the minimization of the total costs associated with EV charging stations to be planned, including the investment costs, operation costs, maintenance costs, and network loss costs in the planning period.

4. PROPOSED METHOD

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

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

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

5. 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).

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