

Integration of Electric Vehicle Charging Station Using Conventional Approach on System

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ABSTRACT

Petroleum and diesel, which are used in the conventional transportation system, release greenhouse gases into the atmosphere. Due to the expanding selection of electric vehicles, oil-powered vehicles are becoming more and more popular in the current transportation sector. The growing interest in electric vehicles led to the development of electric vehicle charging stations (EVCS). Unplanned EVCS integration may result in a weaker voltage profile and higher power losses in the radial distribution system (RDS). As a result, EVCS needs to be installed at the best location on the RDS. This article proposes a conventional approach to EVCS placement in RDS. The three RDS zones are categorized using the voltage deviation criteria, which leads to the appropriate buses in the RDS. Real power loss (P_L) and voltage variation (VD) on the IEEE 33 bus system with EVCS were then compared and reported. By optimally integrating EVCS, the power losses are decreased from 272.44 kW to 247.39 kW and the minimum voltage is increased from 0.8850 pu to 0.8960.

Keywords: EVCS, RDS, VD and P_L .

1 INTRODUCTION

The primary issues facing humanity in the 21st century are more demand for energy, as the finite availability of fossil fuels, and increase in the environment temperature. One of the greatest producers are emission of CO₂ pollutant, issues like droughts and rising ocean levels and the transportation industry that are the main cause of climate change. Numerous studies have proved that electrification would be extremely beneficial to the transportation sector because it will eventually replace conventional vehicles, becomes in vehicles that are more efficient and produce less noise pollution and exhaust emissions [1,2]. The rising use of electric vehicles will help lower the amount of hazardous and atmosphere temperature, even though charging of EVs could result in some distribution system issues[3, 4].The use of EVs has increased in the transportation business in recent years, and this trend is anticipated to continue. The speedy acceptance of electric vehicles is restricted by numerous issues, including their high cost, a small environment for charging them, and an overburdened infrastructure that disrupts the power supply. The introduction of ElectricVehicleChargingStation (EVCS) into the current grid puts additional strain on it, leading to voltage deviation, heat and power losses that may lead an electrical failure.

The unfavourable impacts of integration of EVCS are voltage deviation, peak load, power loss, and weak power factor have been studied in a number of research works [5–8]. According to a review study, the issue of where to locate EVCS is a large area of study that is addressed from many angles [9]. Cost optimization, which includes land, investment, operation, and installation cost are studied by some researchers. On the other hand, several researchers concentrated on maintainance or enhancement of the functioning conditions of the distribution system. Further, employing renewable energy sources (RES) is advised to lessen the major drawbacks of EVCS integration [10–14]. To minimize the load on a convinced time frame in an economical way, the scheme of optimal location for EVCS is recommended [15–17].

The proposed research proposal focused on the EVCS impact on radial distribution system and intrgration of EVCSs in such a way that managing total power losses and voltage deviation, the optimal balanced state is preserved. The suggested work is implemented on the IEEE 33-bus system by using a traditional approach to solve the problem. A redesigned load flow algorithm is applied on an unbalanced 25-IEEE bus RDS in order to decrease real power loss in traditional unbalanced radial distribution systems and enhance the efficiency [18]. To estimate power losses and increase the effectiveness of unbalanced load flow solutions, ambient branch resistance circumstances are considered. The proposed approach has been tested on an unbalanced RDS with 19 and 25 buses. An enhanced load flow algorithm is proposed for an unbalanced RDS that takes weather conditions into account [19]. To highlight how important the integration is to modernize the energy system and to achieve environmental objectives. The study focuses on

companionable problems, largely performance indicators, and the challenges faced by on-grid power structure. It shows a thorough examination of the characteristics of different RES hybrid systems in addition to solar, wind, battery, and biomass technologies. The integration of RES with combined heat and power system structures is examined to emphasize the significance of inventive solutions within the dispersed technical environment [20]. A dependable design for a stand-alone distributed generation system that supports isolated applications and is based on battery storage, solar and wind. In order to optimize synchronization between the load and renewable energy sources, the system creates an adaptive controller using an Adaptive Normalized Least Mean Absolute Deviation algorithm, by improving the overall system dependability and power quality [21].

The hybrid renewable energy configurations for the electrification of Khadva hamlet in the Kutch district of Gujarat, India, are the subject of a techno-economic analysis. HOMER Pro software is used to report three distinct scenarios based on the following criteria: total net present cost, levelized cost of energy, capital and operational expenditures, renewable proportion, and grid dependency [22]. 6. A three-phase, three-wire (3P-3W) renewable hybrid charging infrastructure that includes sources to power modest consumer loads, storage batteries, a solar system, a wind-powered self-excited induction generator, and AC and DC charging stations. To reduce the harmonics produced by the charging stations, a modified filtering generalized integrator-based control technique is used. Reactive power compensation, continuous power to loads, frequent switching of EV loads and small consumer loads, and maintaining the isolated system's power quality are examples of ancillary services offered by the system [23].

The proposed hybrid approach combines the genetic algorithm (GA) with particle swarm optimization (PSO) to find the optimal energy-efficient solution. The voltage stability index (VSI) and actual real power loss (PL) are objective functions. The usefulness of the suggested method is demonstrated using IEEE-33 bus and IEEE-69bus RDS [24]. By making it possible to drastically reduce energy waste and carbon emissions, these advancements help achieve global sustainability goals. This paper combines these data to offer a comprehensive evaluation of the practical implications and contemporary influence of artificial intelligence. The proposed study addresses these problems by offering engineers and researchers useful suggestions for improving sustainable energy systems [25]. An average daily energy use of 50 kWh is reported to account for home needs (lighting, fans, and mobile charging), community services (schools and medical facilities), and agricultural loads (water pumping and equipment). The inquiry focuses on areas in Rajasthan like Jaisalmer and Barmer that have a great potential for renewable energy. By proving that hybrid systems—which comprise wind, solar, battery storage, and grid connectivity—offer substantial cost savings, reliable supply, and environmental advantages, the sustainable development and energy resilience in rural areas are validated [26].

The present paper is arranged as follows: The problem formulation for proposed work is presented in Section 2. Section 3 provides methodology for optimization of EVCS location. Section 4 introduces a case study. A detailed presentation of the simulation findings is given in Section 5. Section 6 is the conclusion that was reached in light of the study findings.

2. Problem formulation

EVCSs must be located optimally due to adverse effects such as decrease in voltage profile, a rise in real power losses, abrupt peak loads, and system overloading. This relationship is based on power loss and voltage deviation. In order to examine the interconnection of EVCS on RDS, the goal function combines power loss and voltage deviation minimization as following equation:

$$\min\{w_1 \times f_1 + w_2 \times f_2\} \quad (1)$$

Here, w_1 and w_2 are weight factors for the functions f_1 and f_2 .

2.1. Power Loss (P_L):

The formula to determine the active power losses is given as:

$$f_1 = \min \left[\sum_{k=1}^m I_k^2 * R_k \right] \quad (2)$$

Where, I_k : branch current

m : total no. of branches

R_k : branch resistance.

2.2. Voltage Deviation (VD):

The formula used to determine voltage deviation:

$$f_2 = \min \left(\sum_{k=1}^m (1 - V_k)^2 \right) \quad (3)$$

Where, V_k is k th bus voltage, m total buses.

2.3. Equality constraints

EVs, load demands, and system losses should all be covered by the electrical power supplied by the grid.

$$P_T = P_{Loss} + \sum_{k=1}^m (P_{load\ k} + P_{EVCS\ k}) \quad (4)$$

2.4. Inequality constraints

The constraints are given as:

$$\text{Active power } P_k^{\min} \leq P_k \leq P_k^{\max} \quad k = 1, 2, \dots, m \quad (5)$$

$$\text{Reactive power } Q_k^{\min} \leq Q_k \leq Q_k^{\max} \quad k = 1, 2, \dots, m \quad (6)$$

$$\text{Bus voltage } V_k^{\min} \leq |V_k| \leq V_k^{\max} \quad k = 1, 2, \dots, m \quad (7)$$

Where, P_k : kth bus real power

Q_k : kth bus imaginary power

3. Methodology for objective function optimization

- i. Initialize the input data in terms of bus and line data of 33-bus system
- ii. Compute the power loss from equation (2) & voltage deviation from equation (3) through the forward/backward sweep load flow method with considering the constraints.
- iii. Check all buses are taken into consideration or not
If yes move forward
Otherwise, go to step ii
- iv. Update the parameter to get the optimal location of EVCS on RDS.
- v. Print the results and stop.

4. Case study

The proposed approach for determining the optimal position of electric vehicle charging station on IEEE 33-bus system using MATLAB is implemented. The system is divided into three zones such as: 1, 2 and 3 which are divided on the basis of voltage deviation (VD). 1st Zone is selected based on VD ranging from 0 to 0.095 pu, VD ranging from 0.105 pu to 0.582 pu is 2nd zone and in 3rd zone, VD range is from 0.621 pu to 0.82 pu. Henceforth, P_L and Q_L of 3 EVCSs are 120 kW & 75 kVAR, 75 kW & 47 kVAR and 150 kW & 95 kVAR were considered respectively. Each zone has only one bus to locate EVCS. This article has three cases as under:

Case 1: Without EVCS (base case).

Case 2: Randomly 3 EVCSs are placed in respective zones.

Case 3: Optimal integration of 3 EVCSs in each zones.

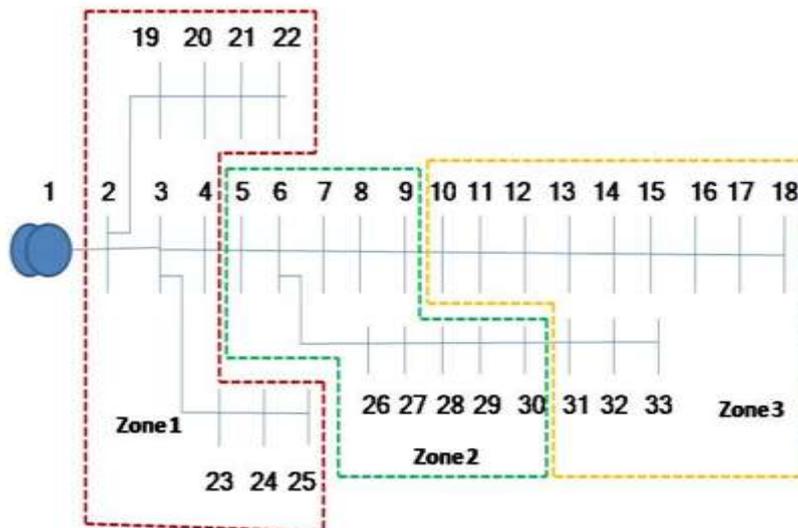


Figure 1. IEEE 33 bus system with zones

5. RESULT ANALYSIS

This system is divided in three zones according to voltage deviation as shown in Figure 1. In the first zone, there are buses 2, 3, 4, 19, 20, 21, 22, 23, 24 and 25. The second zone having buses 5, 6, 7, 8, 9, 26, 27, 28, 29 and 30. In the third zone, there are buses 10, 11, 12, 13, 14, 15, 16, 17, 18, 31, 32 and 33. The base case has low power losses as compared to others. Case 2 has EVCS load values respectively 120 kW / 75 kVAR (Bus 25), 75 kW / 47 kVAR (Bus 30) and 150 kW / 95 kVAR (Bus 18) in zone 1, zone 2 and zone 3. In case 3, the EVCS load values are respectively 120 kW / 75 kVAR (Bus 2), 75 kW / 47 kVAR (Bus 5) and 150 kW / 95 kVAR (Bus 10) in zone 1, zone 2 and zone 3.

Table 1. Performance outcomes of proposed cases

Cases	P_L (kW)	Q_L (kVAR)	Min. Voltage (pu)
Case 1	210.9	142.96	0.9066
Case 2	272.44	186.45	0.8850
Case 3	247.39	167.81	0.8960

The results of all cases are demonstrated in table 1. The P_L , Q_L and the voltage of all cases are given in figure 2, figure 3 and figure 4 respectively.

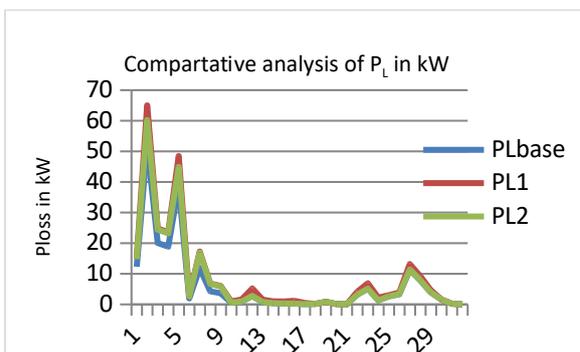


Figure 2. Comparative analysis of PL in kW

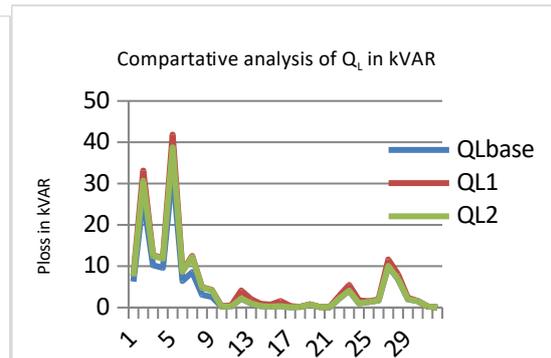


Figure 3. Comparative analysis of QL in kVAR

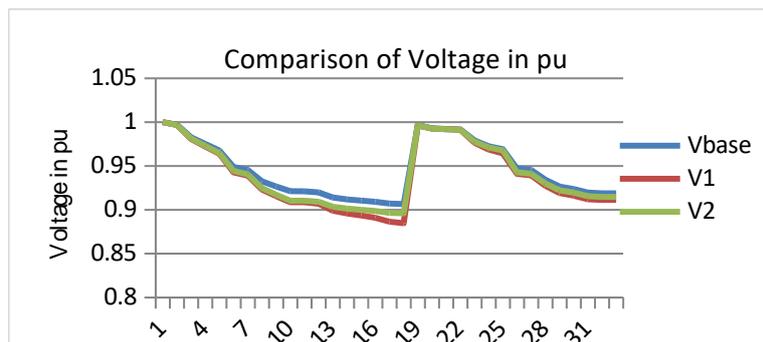


Figure 4. Comparison of voltage in pu

6. CONCLUSION

The optimal location for EVCSs in order to reduce power losses and voltage variance is estimated in this proposal. While determining where to install EVCS, voltage variation is taken into consideration. In order to increase the realistic aspect of the solution, three scenarios were analyzed, the first of which is the base case, and extra constraints were applied to each. In Case 3, the P_L and V_D are low as compared to case 2. In case 2, the location of 3 EVCS are at bus 18, 25 and 30 but the optimal locations are at bus 2, 5 and 10 in case 3 which improves the results.

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