A Review on Smart Charging Station for Electric Vehicle

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Abstract-Although, fossil fuels are still the main source that used to balance the global demand/supply dynamics of energy; most countries have embarked on a quest to reach a solution and started changing their direction from fossil resources (especially oil and gas) to other resources by creating new opportunities with a focus meeting the increasing energy demand by reducing it via energy efficiency. “Transportation” is one of the biggest items of global energy consumption with 24% usage percentage and most of this amount is supplied by conventional energy resources. However, worldwide supporting policies and regulations are positively affected the starting period of environment-friendly use of energy resources. It expedited the process of new technological developments that minimize waste, lower the level of air pollution caused by fossil fuel-powered internal combustion engines, conserve forests and decrease the emissions of greenhouse gases. Worldwide extension of “Electric Vehicle Development and Production” is one of the main concern of these regulations. However, increasing the number of electric vehicles also brings sustainability problems such as; supplying the electricity from renewable resources in an efficient and sustainable way, handling the electricity load on the grid, and establishment of new charging stations.

Keywords: direct charging, electric vehicle, fast charging, wind energy, pv cell.

1. INTRODUCTION

Electric motor technology involves machine constructions, materials, electronics, sensors and control technologies. A suitable converter and control techniques need to be developed for different kind of motors in order to generate a high performance drives. The important aspect of various converter designs is the converter efficiency and its dynamic response.. There are many reasons why people are moving to Electric Vehicles (EV) to get them to the places they need to be. These include:

- EVs are fun to drive because they are fast and smooth.
- Many studies show that the emissions from burning fossil fuels such as gasoline produce harmful greenhouse gases. EV’s produce no smelly fumes or harmful greenhouse gases.
- EVs are innovative and cool.
- EVs only cost approximately $360 a year to operate compared to $3600 for a gasoline vehicle.
- EVs are a smart and convenient choice.

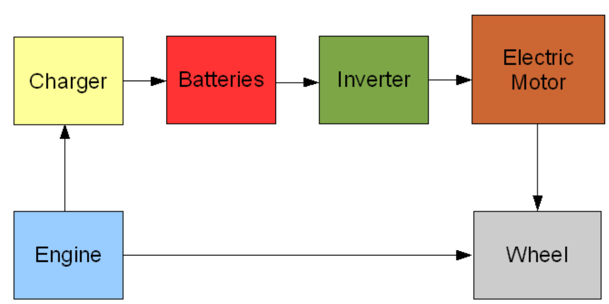

Fig 1 Basics of EV Block diagram.

2. HYBRID RENEWABLE ENERGY

Nowadays, the park stations, roadside units, and the standard home outlets are used to charge the battery packs of EVs. The storage system present in the EV takes a prolonged period for recharging the battery packs and it will vary depending upon the capacity. A new charging method is introduced by Chellaswamy et al. for recharging the EVs. The control system present in this mechanism automatically charges the battery packs without the contribution of the driver. The performance analysis has been done and the result is compared with other EVs [1]. The plug-in EVs are used to reduce the green house gas emissions. The high-frequency ac-dc converter is used to charge the traction battery packs and an electromagnetic interference (EMI) filter is connected with the high-frequency transformer to suppress the EMI noise has been studied in [2]. A high sampling rate camera with a sensor is used to estimate the slip angle measurement of EV. The performance of this model based estimator has been studied by Yafei et al. with the help of multi-rate Kalman filtering [3]. A linear programming is used to estimate the operating cost, optimal scheduling, and CO2 emission of a hybrid EV under European regulation. This mechanism also controls the electricity consumption of EVs [4]. A control algorithm has been developed to equally maintain the state of charge (SOC) of all the NiMH battery packs which are present in the EVs. The SOC variation for different temperature and the percentage of improvement has been studied by Man et al [5, 6]. To limit the rate of charge and the cost a smart algorithm has been developed and the performance is studied by Mosaddek et al. An experimental setup has been implemented and electrifying the plug- in EVs by parking garage standard outlet. A comparative analysis has been performed for SOC under different temperature conditions [7]. Hybrid renewable energy (RE) based power generation become popular because of anxiety over the atmosphere. To eliminate the transmission loss and grid connectivity problems, RE based power generation is carried out in [8]. The wind power generation system has a less harmful impact compared to fossil fuels. The wind energy potential and electricity generation for recharging the storage system present in the EV has been studied in [9, 10].

EV motor controller is assumed to be an ideal controller with no power loss and no time lag. The controller simply raises the battery voltage to meet the higher voltage needs of the motor. The dimensionless constant gain or K ratio of the input and output voltages is determined in order to meet the motor's needs. The same K ratio is used to adjust the current so that input and output power values are equal. High side voltage is equal to K times the low side voltage:

$V_H = K*V_L$ --- Eq (1) Controller High Side Current: High side current is equal to 1/K times the low side voltage:

$I_H = (1/K)*V_L$ --- Eq(2)

The battery is modelled as a voltage source with an internal resistance. The model accounts for internal power loss in the resistance of the battery. There is no time lag component in the model. The battery is assumed to have a constant internal voltage, EB . The battery terminal voltage V_B, is equal to the sum of the internal voltage and resistance voltage drop. The battery voltage and battery current are equal to the controller low side voltage and current.

V_B(Volt) = I_A(Amp) *R_A(Ohm) + E_B(Volt) --- Eq(3) Battery model calculation:

V_L (Volt) = I_L(Amp) *R_A(Ohm) + E_B(Volt) --- Eq(4)

Assuming: $V_B = V_L$ and $I_A = I_L$

The battery model uses the current and voltage information from the Motor Controller to calculate the required battery's internal voltage.

3. EV CHARGING STATIONS

Fast-charging technology is key to increasing the expansion of EV adoption, because it removes one of the barriers that have stopped many consumers from purchasing their first EVs. However, establishing fast-charging points not only requires a parallel increase in the power supply from the utility companies but also induces significant adverse impacts on the grid and degrades its power quality [4]. Hardman et al. reviewed the consumer preferences for EV charging infrastructure, including the fast-charging technology and its impact on the electricity grid [5]. However, with this extensive review, the authors could not draw definite conclusions on several aspects, such as payment for charging, charging locations, the time at which charging occurs, and any impacts these fast charges may have on electricity grids, suggesting that further research in the field is needed. It is known that DC fast chargers are considerably more expensive than other lower rate chargers and have a very high power demand when large numbers of EVs are charged at the same time, inducing problems in the utility supply. These impacts can be seen as deviations in the power line voltage, frequency, and total harmonic distortion (THD). The use of renewable energy systems is one promising method for mitigating these impacts [1].

4. LITERATURE SURVEY

Shakti Singh, "Feasibility of Grid-connected Solar-wind Hybrid System with Electric Vehicle Charging Station": Recently, renewable power generation and electric vehicles (EVs) have been attracting more and more attention in smart grid. This paper presents a grid-connected solar-wind hybrid system to supply the electrical load demand of a small shopping complex located in a university campus in India. Fur- ther, an EV charging station is incorporated in the system. Economic analysis is performed for the proposed setup to satisfy the charging demand of EVs as well as the electrical load demand of the shopping complex. The proposed system is de- signed by considering the cost of the purchased energy, which is sold to the utility grid, while the power exchange is ensured between the utility grid and other components of the system. The sizing of the component is performed to obtain the least levelized cost of electricity (LCOE) while minimizing the loss of power supply probability (LPSP) by using recent optimization techniques. The results demonstrate that the

LCOE and LPSP for the proposed system are measured at 0.038 $/kWh and 0.19% with a renewable fraction of 0.87, respectively. It is determined that a cost-effective and reliable system can be de- signed by the proper management of renewable power genera- tion and load demands. The proposed system may be helpful in reducing the reliance on the over-burdened grid, particularly in developing countries [1].

Abdullah Azhar Al-obaidi, "Adaptive Optimal Management of EV Battery Distributed Energy for Concurrent Services to Transportation and Power Grid in a Fleet System Under Dynamic Service Pricing": Deployment of electric vehicles (EVs) in a fleet system to deal with environmental issues has been at the center of attention over the past several years. While the battery of each EV offers small storage, hundreds of EVs collectively can offer large energy storage to serve a power grid. This article develops a model for a central controller in a fleet system that allows adaptive utilization of EV batteries distributed energy for concurrent services to the transportation and power grid. The optimization model integrates various slack variables and control parameters for managing real-time fare prices, adaptive energy, and reserve margin allocation, interaction with the grid operator, and meeting the fleet target revenue. The proposed model incorporates EV driver's input into the scheduling process to allow the driver to flexibly manage their battery capacities based on their availability and assessment of the transportation services demand. A dynamic pricing mechanism is developed for real-time calculation of fare rates to allow the EV fleet optimization problem to achieve a daily revenue target while limiting fare prices in a competitive market. Numerical results indicate that the model can manage several EVs for various services while enhancing the fleet financial metrics [2].

Yongsheng Cao, "Smart Online Charging Algorithm for Electric Vehicles via Customized Actor–Critic Learning": With the advances in the Internet-of-Things technology, electric vehicles (EVs) have become easier to schedule in daily life, which is reshaping the electric load curve. It is important to design efficient charging algorithms to mitigate the negative impact of EV charging on the power grid. This article investigates an EV charging scheduling problem to reduce the charging cost while shaving the peak charging load, under unknown future information about EVs, such as arrival time, departure time, and charging demand. First, we formulate an EV charging problem to minimize the electricity bill of the EV fleet and study the EV charging problem in an online setting without knowing future information. We develop an actor–critic learning-based smart charging algorithm (SCA) to schedule the EV charging against the uncertainties in EV charging behaviors. The SCA learns an optimal EV charging strategy with continuous charging actions instead of discrete approximation of charging. We further develop a more computationally efficient customized actor–critic learning charging (CALC) algorithm by reducing the state dimension and thus improving the computational efficiency. Finally, simulation results show that our proposed SCA can reduce EVs' expected cost by 24.03%, 21.49%, 13.80%, compared with the eagerly charging algorithm, online charging algorithm, reinforcement learning (RL)-based adaptive energy management algorithm, respectively. CALC is more computationally efficient, and its performance is close to that of SCA with only a gap of 5.56% in the cost [3].

Mostafa M. Mahfouz, "Autonomous Operation of the DC Fast-Charging Station": This article develops, evaluates, and verifies a supervisory controller (SC) to transfer from the grid-connected mode and operate a battery-enhanced electric vehicles' (EVs) dc fast charging (DCFC) station in the autonomous mode, when the supply grid is not available. The SC is designed based on the supervisory control theory (SCT) of discrete event systems and is based on a rigorous mathematical process; nonblocking, i.e., avoids entering an operational deadlock scenario that leads to the system collapse; minimally restrictive with respect to the station's discrete behavior; modular; and scalable. The SC also operates the station in the grid-connected mode and provides a seamless transition between the two modes and thus the DCFC station is also synonymous with a dc-microgrid. The SC is implemented on an industrial programmable logic controller and its performance is verified in a real-time hardware-in-the-loop environment using an OPAL-RT testbed [4].

Cihat Keçeci, "Analysis of EV Charging Coordination Efficiency in Presence of Cheating Customers": Charging coordination is employed to efficiently serve electric vehicle (EV) charging requests without overloading the distribution network. Parameters such as parking duration, battery state-of-charge (SoC), and charging amount are provided by EVs to the charging coordination center to schedule their charging requests efficiently. The existing literature assumes that the customers always provide correct information. Unfortunately, customers may provide false information to gain higher charging priority. Assessing the impact of cheating behavior represents a significant and open problem. Herein paper, the impact of providing false information (e.g., parking duration) on the efficiency of the charging coordination mechanism is investigated. The charging coordination strategy is formulated as a linear optimization problem. Two different objectives are used to assess the impact of the objective function on the amount of performance degradation. Our investigations reveal that the degradation of the efficiency of the charging coordination mechanism depends on the percentage of cheating customers and cheating duration versus the typical parking duration. In addition, the impact of cheating behavior increases with the number of deployed chargers. Thus, the severity of the cheating impact will increase in the future as more fast chargers are allocated in charging networks [5].

Ahmed S. Khwaja, "Performance Analysis of LSTMs for Daily Individual EV Charging Behavior Prediction": In this paper, we evaluate and analyze the performance of long short-term memory networks (LSTMs) for individual electric vehicle (EV) charging behavior prediction over the next day. The charging behavior consists of the charging duration level within a certain upper and lower range, the time slots in which charging will take place, the number of times charging will take place in each time slot, and whether the next day will be a charging day or not. Unlike existing work, we evaluate the behavior prediction performance for increasing resolutions of charging duration levels and charging time slots, using varying lengths of training data. The performance of the proposed approach is validated using real EV charging data, and comparison with other machine learning methods shows its generally superior prediction accuracy for all resolutions. We show that the best performance is achieved when around 8–10 months of data are used as training data. It is also shown that although the performance of the LSTMs degrades with increasing resolution, the performance for charging time slot prediction is affected less compared to that for charging duration prediction. We further propose, analyze and evaluate a new technique that improves the charging duration prediction performance [6].

Zhonghao Zhao, "Capacity Planning for an Electric Vehicle Charging Station Considering Fuzzy Quality of Service and Multiple Charging Options": Electric vehicles (EVs) have received considerable attention in dealing with severe environmental and energy crises. The capacity planning of public charging stations has been a major factor in facilitating the wide market penetration of EVs. In this paper, we present an optimization model for charging station capacity planning to maximize the fuzzy quality of service (FQoS) considering queuing behavior, blocking reliability, and multiple charging options classified by battery technical specifications. The uncertainty of the EV arrival and service time are taken into account and described as fuzzy numbers characterized by triangular membership functions. Meanwhile, an α -cuts-based algorithm is proposed to defuzzify the FQoS. Finally, the numerical results illustrate that a more robust plan can be obtained by accounting for FQoS. The contribution of the proposed model allows decision-makers and operators to plan the capacity of charging stations with fuzzy EV arrival rate and service rate and provide a better service for customers with different charging options [7].

Willy Stephen Tounsi Fokui, "Optimal Placement of Electric Vehicle Charging Stations in a Distribution Network With Randomly Distributed Rooftop Photovoltaic Systems": The increasing number of electric vehicles (EVs) in today's transport sector is gradually leading to the phasing out of petroleum-based vehicles. However, the rapid deployment of EVs largely depends on the coordinated and fast expansion of EV charging stations (EVCSs). The integration of EVCSs in the modern distribution network characterized by increased penetration of randomly distributed photovoltaic (PV) systems is challenging as they can lead to excessive power losses and voltage deviations beyond acceptable limits. In this paper, a hybrid bacterial foraging optimization algorithm and particle swarm optimization (BFOA-PSO) technique is proposed for the optimal placement of EVCSs into the distribution network with high penetration of randomly distributed rooftop PV systems. The optimization problem is formulated as a multi-objective problem minimizing active and reactive power losses, average voltage deviation index, and maximizing voltage stability index. The IEEE 69 node distribution network is used as the case network. The simulation is done using MATLAB to integrate the EVCSs in five cases of randomly sized and placed PV systems in the distribution network. For all five cases, a minimal increase in power losses is recorded with minor changes in the voltage deviation and stability indices due to the placement of the EVCSs. But for the voltages of nodes 29 to 48, the other node voltages remain unchanged upon placement of the EVCSs. The largest increase in power losses due to the EVCSs being brought into the network with PVs was noticed in case 3 (from 142.27kW, and 62.90kVar to 147.65kW, and 72.48kVar) [8].

Mohd Rizwan Khalid, "A Comprehensive Review on Structural Topologies, Power Levels, Energy Storage Systems, and Standards for Electric Vehicle Charging Stations and Their Impacts on Grid": The penetration of electric vehicles (EVs) in the transportation sector is increasing but conventional internal combustion engine (ICE) based vehicles dominates. To accelerate the adoption of EVs and to achieve sustainable transportation, the bottlenecks need to be elevated that mainly include the high cost EVs, range anxiety, lack of EV charging infrastructure, and the pollution of the grid due to EV chargers. The high cost of EVs is due to costly energy storage systems (ESS) with high energy density. This paper provides a comprehensive review of EV technology that mainly includes electric vehicle supply equipment (EVSE), ESS, and EV chargers. A detailed discussion is presented on the state-of-the-art of EV chargers that include on-/off-board chargers. Different topologies are discussed with low-/high-frequency transformers. The different available power levels for charging are discussed. To reduce the range anxiety the EV chargers based on inductive power transfer (IPT) are discussed. The last part of the paper focuses on the negative impact of EV chargers along with the remedies that can be adopted. The international standards decided by different institutions and adopted universally are discussed in the latter part of this paper and finally, this paper concludes with the near to future advancement in EV technology [9].

Zhi Kai Liu, "Enhancing the DC Voltage Quality in EV Charging Station Employing SMES and SFCL Devices": The fast-response energy compensating feature from a superconducting magnetic energy storage (SMES) device is favored for suppressing instantaneous voltage fluctuations, while the self-triggering current limiting feature from a superconducting fault current limiter (SFCL) suits to suits to achieve automatic load protections in the electric vehicle (EV) charging stations. This paper investigates a new DC voltage quality enhancing scheme by using a combined superconducting power technology employing SMES and SFCL devices. Preliminary simulations demonstrate the feasibility of this SMES-SFCL-based voltage quality improver to avoid the voltage fluctuations during the EV load transients and suppress the fault current effectively during the short circuits simultaneously [10].

A. N. Archana, "A Novel Reliability Index Based Approach for EV Charging Station Allocation in Distribution System": Large-scale deployment of electric vehicles (EVs) is deleterious for distribution system operations. Unplanned installation of EV charging station (EVCS) deteriorates the voltage stability, reliability, and power quality of the distribution system leading to customer discontentment. This article proposes a novel approach for the proper placement of EVCS in a distribution network maintaining the system performance. The design of a test station with vehicle-to-grid (V2G) capability is outlined in this work. The test station is developed with five charging columns taking into consideration the standards and guidelines outlined in the Government of India EV policy. The charging station is connected to the power grid by a dc bus to which numerous EVs are attached. EVCS placement in the IEEE-33 bus radial distribution system is performed by developing six test scenarios. The test case results substantiate the potency of the reliability-index based approach for allocating EVCS both slow and fast chargers in a distribution network. Further, the maximal threshold value for placing the EVCS in various buses in a distribution system is determined using a novel electric vehicle placement index (EVPI). The novelty of the approach lies in the fact that it can include all operational parameters influenced owing to EV deployment, thereby maintaining the overall system performance without any physical restructuring of the network. The efficacy of the approach and the severity level of EVCS placement are validated for a real-time distribution system in Kerala, India [11].

Benoit Sohet, "Hierarchical Coupled Driving-and-Charging Model of Electric Vehicles, Stations and Grid Operators": The decisions of operators from both the transportation and the electrical systems are coupled due to Electric Vehicles' (EVs) actions. Thus, decision-making requires a model of several interdependent operators and of EVs' both driving and charging behaviors. Such a model is suggested for the electrical system in the context of commuting, which has a typical trilevel structure. At the lower level of the model, a congestion game between different types of vehicles gives which driving paths and charging stations (or hubs) commuters choose, depending on travel duration and energy consumption costs. At the middle level, a Charging Service Operator sets the charging prices at the hubs to maximize the difference between EV charging revenues and electricity supplying costs. These costs directly depend on the supplying contract chosen by the Electrical Network Operator at the upper level of the model, whose goal is to reduce grid costs. This trilevel optimization problem is solved using an optimistic iterative algorithm and simulated annealing. The sensitivity of this trilevel model to exogenous parameters such as the EV penetration and an incentive from a transportation operator is illustrated on realistic urban networks. This model is compared to a standard bilevel model in the literature (only one operator) [12].

Mohamed Mokhtar, "A Customer-Centered Smart Charging Strategy Considering Virtual Charging System": Electric vehicle (EV) charging is considered as one of the main issues that face EV drivers. Thus, there should be a facility to suggest the best charging station based on the customer requirements. However, the routing process of EVs in most of the literature was generally implemented centrally based on the charging station/operator perspective. On contrary, this paper proposes a smart charging strategy that routes EVs drivers to the best charging station based on their priorities. In the proposed smart strategy, various charging stations will cooperate through a virtual charging system (VCS) to serve all EVs charging requests with a high satisfaction level. The drivers' requirements are achieved through a new scoring criterion which ranks the participating charging stations based on EV driver's perspective. Then, the EV driver will select individually the charging station based on his priorities [13].

5. PROBLEM IDENTIFICATION OF LITERATURE REVIEW

Following problem identify in previous work are as given blow-

1. Higher transient time in previous method.

2. Lower steady state time.

3. Higher complexity design of Electric vehicle system modelling.

4. Problem of synchronization for motor and solar controller.

5. Problem occurs to calibration of vehicle controlling parameters.

6. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

The economic value of the foregoing is mainly reflected in the following aspects.

I. A reasonable EV charge planning achieves valley-filling and peak-clipping. That is, by smoothing the load curve, it becomes possible to reduce the cost of electric generation and delay the investment on a new charging facility set that depends on the grid as power source to reduce the peak load.

II. The electrical energy stored in a large number of EV batteries may be used for frequency and voltage regulation by investing on discharge facilities and improving the reliability of the power system.

III. The efficient management of charging and discharging of a large number of EVs and the coordination of intermittent renewable energy sources can improve the capacity of the electrical system to accommodate these power supplies and thereby improve the cost-effectiveness of system operation. In other words, although the electricity grid has a limited capacity to accept intermittent renewable energy sources, the widespread use of EVs contributes to increase the power system capacity.

Some studies published in literature have considered the first two aforementioned aspects; however, no systematic research has ever been conducted on the third, although a few studies have this problem. So far, there is no rigorous analytical tool to assess the economic value of different EV distributions and grid penetration rates for different combinations of intermittent renewable energy sources. The economic value is mainly the potential savings on the operating and investment costs of the electricity grid. A comprehensive mathematical model is required to assess the economic value and study the appropriate load and management strategies to maximize the economic value of EVs and their facilities in power system planning and operation.

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