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A Review on Smart Charging Station

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ABSTRACT: The majority of nations have started shifting their focus from fossil resources (especially oil and gas) to other resources by creating new opportunities with a focus on meeting the rising energy demand by reducing it through energy efficiency, even though fossil fuels are still the primary source that is used to balance the global demand/supply dynamics of energy. With a 24% utilization rate, "transportation" is one of the major consumers of energy worldwide. The majority of this quantity is provided by conventional energy sources. However, global supportive laws and guidelines have a favourable impact on the early stages of environmentally friendly energy resource utilization. It hastened the development of innovative technologies that reduce waste, lessen air pollution from internal combustion engines that run on fossil fuels, protect forests, and reduce greenhouse gas emissions. One of the key concerns of these rules is the global expansion of "Electric Vehicle Development and Production". However, a rise in the number of electric cars also poses sustainability issues, such as the need to construct additional charging stations and provide power from renewable sources in an efficient and sustainable manner.

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

I. INTRODUCTION

Technology used in electric motor construction, materials, electronics, sensors, and control systems. To produce high performance drives, it is necessary to build converters and control methods that are appropriate for various types of motors. The converter efficiency and its dynamic reactivity are key factors in different converter designs. People are switching to electric vehicles (EV) for transportation for a variety of reasons.

- Because they are quick and smooth, EVs are enjoyable to drive.
- Numerous studies demonstrate that hazardous greenhouse gases are produced when fossil fuels like petrol are used.
- EVs don't emit any unpleasant odours or dangerous greenhouse gases.
- EVs are cutting-edge and stylish.
- Compared to \$3600 for a petrol car, the annual operating cost of an EV is only about \$360.
- EVs are a wise and practical decision.

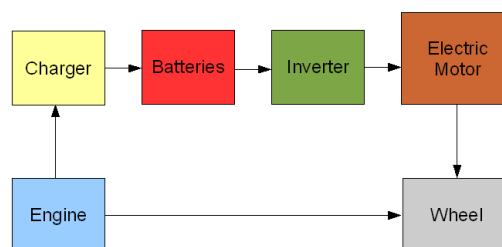


Figure 1: Basics of EV (Block Diagram)

Hybrid Renewable Energy

Today, EV battery packs are charged via park stations, roadside devices, and regular household outlets. The amount of time required by the EV's storage system to recharge the battery packs varies depending on their capacity. Chellaswamy et al. present a brand-new way of recharging EVs. Without the driver's involvement, the control system in this device charges the battery packs automatically. The results of the performance analysis are compared to those of other EVs. The adoption of plug-in EVs helps to lower greenhouse gas emissions. The traction battery packs are charged using a high-frequency ac-dc converter, which is coupled with a high-frequency transformer and an

electromagnetic interference (EMI) filter to reduce EMI noise. The slip angle measurement of EV is estimated using a camera with a sensor and a high sampling rate. Yafei et al. used multi-rate Kalman filtering to examine how well this model-based estimator performed. Under European law, a hybrid EV's running costs, ideal scheduling, and CO₂ emissions are calculated using linear programming. This process also regulates how much electricity EVs use. To maintain the state of charge (SOC) of all the NiMH battery packs found in EVs consistently, a control algorithm has been devised. Man et al. have researched the SOC fluctuation for various temperatures and the percentage of improvement. A clever algorithm has been designed to restrict the rate of charge and the cost, and Mosaddek et al. have investigated the performance of the method. The plug-in EVs are being powered by conventional parking garage outlets thanks to an experimental configuration. A comparison of SOC at various temperature conditions has been done. It is believed that the EV motor controller is a perfect controller with no power loss and no time latency. To fulfil the greater voltage requirements of the motor, the controller just raises the battery voltage. In order to satisfy the requirements of the motor, the dimensionless constant gain, or K ratio, of the input and output voltages is established. To modify the current such that the input and output power values are identical, the same K ratio is used. High side voltage is equal to K times the low side voltage:

$$V_H = K \times V_L$$

Controller High Side Current: High side current is equal to 1/K times the low side voltage

$$I_H = \left(\frac{1}{k}\right) \times V_L$$

Models of batteries depict them as sources of electricity with internal resistance. The resistance of the battery is used by the model to account for internal power loss. The model doesn't include a time lag component. It is assumed that the battery's internal voltage, E_B , is constant. The internal voltage and the resistance voltage drop are added to obtain the battery terminal voltage, or V_B . The controller's low side voltage and current are equivalent to the battery's voltage and current.

$$V_B(\text{Volt}) = I_A(\text{Amp}) \times R_A(\text{Ohm}) + E_B(\text{Volt})$$

The battery model determines the necessary battery's internal voltage using the motor controller's current and voltage data.

EV Charging Station

Fast charging technology is essential for boosting the adoption of EVs since it eliminates a hurdle that has prevented many people from buying their first EVs. However, building rapid charging points has substantial negative effects on the grid and decreases the quality of its electricity. It also necessitates a parallel increase in the power supply from the utility companies. Customer preferences for EV charging infrastructure, including the effects of fast charging on the power grid. However, despite their thorough review, the authors were unable to reach any firm conclusions regarding a number of issues, including the cost of charging, where it happens, when it happens, and any effects these fast charges may have on electricity grids. This suggests that more research in the area is required. It is well known that when several EVs are being charged simultaneously, DC fast chargers have a very high power consumption and are significantly more expensive than other lower rate chargers, causing issues with the utility supply. Total harmonic distortion (THD), voltage, and frequency variations are examples of these effects. One viable strategy for reducing these effects is the usage of renewable energy sources.

II. LITERATURE SURVEY

"Feasibility of Grid-connected Solar-Wind Hybrid System with Electric Vehicle Charging Station" by Shakti Singh: Recently, the smart grid has been paying more and more attention to renewable energy production and electric vehicles (EVs). In order to meet the electrical load requirement of a small shopping complex situated on a university campus in India, a grid-connected solar-wind hybrid system is presented in this study. The system also includes a charging station for electric vehicles. The suggested arrangement is subjected to an economic analysis in order to meet both the retail center's electrical load requirements and the demand for EV charging. The cost of the energy that is acquired and then sold to the utility grid is taken into account while designing the suggested system, and the system's other components are guaranteed to exchange power with the utility grid. Utilising current optimisation approaches, the component is sized to achieve the lowest levelized cost of energy (LCOE) while minimising the risk of power supply loss (LPSP). The findings show that the suggested system's LCOE and LPSP are calculated at 0.038 \$/kWh and 0.19%, respectively, with a renewable component of 0.87. A cost-effective and dependable system may be designed by effectively managing load needs and renewable power generation.

Author 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": Over the past several years, the use of electric vehicles (EVs) in a fleet system to address environmental challenges has received a lot of attention. Although each EV's battery only has a modest amount of storage, hundreds of EVs working together may provide a huge amount of energy storage to support a power system. This article creates a model for a fleet system's central controller that enables flexible use of EV batteries and distributed energy for simultaneous services to the transportation and power grids. In order to manage real-time ticket pricing, adaptive energy and reserve margin allocation, communication with the grid operator, and achieving fleet target income, the optimisation model incorporates numerous slack factors and control parameters. In order to give EV drivers the flexibility to manage their battery capacity based on their availability and estimation of the demand for transportation services, the suggested approach includes their input into the scheduling process. The EV fleet optimisation challenge is solved by developing a dynamic pricing system that limits fare prices in a competitive market while calculating fare rates in real-time. According to numerical data, the model can manage many EVs for different services while improving fleet financial metrics.

"Smart Online Charging Algorithm for Electric Vehicles via Customised Actor-Critical Learning" by Yongsheng Cao Electric vehicles (EVs) are becoming simpler to plan in daily life because of advancements in Internet of Things technology, which is changing the shape of the electric load curve. To lessen the damaging effects of EV charging on the power system, it is crucial to build efficient charging algorithms. In order to lower the cost of charging while lowering the peak charging load, this article looks at the scheduling of EV charging under the assumption that future information regarding EVs, such as arrival and departure times and charging demand, will be unknown. To start, we create an EV charging problem to reduce the EV fleet's power expenditure and research the EV charging problem online without knowing future facts. To plan EV charging against the uncertainties in EV charging behaviours, we created an actor-critic learning-based smart charging algorithm (SCA). Instead of using discrete charging approximations, the SCA develops an ideal EV charging strategy through continuous charging activities. By lowering the state dimension and enhancing the computational efficiency, we further improve the customised actor-critic learning charging (CALC) algorithm. Finally, simulation findings demonstrate that, in comparison to the quickly charging method, online charging algorithm, and reinforcement learning (RL)-based adaptive energy management algorithm, respectively, our suggested SCA may cut EVs' projected cost by 24.03%, 21.49%, and 13.80%. With just a cost difference of 5.56%, CALC's performance is comparable to that of SCA and is more computationally efficient.

"Autonomous Operation of the DC Fast-Charging Station" by Mostafa M. Mahfouz: In order to run a battery-enhanced electric vehicle (EV) DC fast charging (DCFC) station in autonomous mode while the supply grid is unavailable, this article designs, tests, and validates a supervisory controller (SC). The SC is designed using the supervisory control theory (SCT) of discrete event systems and is based on a rigorous mathematical process. It is non-blocking, which means it avoids situations in which the system would otherwise collapse due to operational deadlock, minimally restrictive with regard to the discrete behaviour of the station, modular, and scalable. The DCFC station is also equivalent to a DC microgrid since the SC also runs the station in grid-connected mode and enables a smooth transition between the two modes. The SC is built on an industrial programmable logic controller, and the OPAL-RT testbed is used to verify the performance of the SC in a real-time hardware-in-the-loop environment.

"Analysis of EV Charging Coordination Efficiency in the Presence of Cheating Customers" by Cihat Keçeci: To efficiently handle electric vehicle (EV) charging demands without taxing the distribution network, charging coordination is used. EVs provide the charging coordination centre with information like parking time, battery state-of-charge (SoC), and charging volume in order to efficiently arrange their charging requests. The literature now in print makes the assumption that consumers always submit accurate information. Unfortunately, some consumers may lie to get a higher charge priority. The evaluation of the effects of cheating behaviour is a serious and unresolved issue. The effectiveness of the charge coordination mechanism is examined in this research in relation to the effects of supplying incorrect information (such as parking length). A linear optimisation problem is used to represent the charging coordination technique. To evaluate how the objective function affects the degree of performance deterioration, two distinct objectives are employed. Our research shows that the percentage of dishonest customers and the length of the dishonest behaviour relative to the normal parking period determine how well the charge coordination mechanism performs. Additionally, when more charges are filed, the effect of cheating behaviour grows. As more fast chargers are added to charging networks, the impact of cheating will become more severe.

"Performance Analysis of LSTMs for Daily Individual EV Charging Behaviour Prediction" by Ahmed S. Khwaja: The effectiveness of long-short-term memory networks (LSTMs) for predicting individual electric vehicle (EV) charging behaviour throughout the next day is evaluated and analysed in this article. The degree of charging duration within a specific higher and lower range, the time slots in which charging will occur, the number of times charging will occur in each time slot, and whether the following day will be a charging day or not comprise the charging behaviour. Unlike previous research, our evaluation of behaviour prediction performance uses changing lengths of training data to account for increasing resolutions of charging duration levels and charging time slots. Real-world EV charging data is used to validate the effectiveness of the suggested strategy, and compared with other machine learning techniques, it demonstrates its typically greater prediction accuracy across all resolutions. We demonstrate that using data from the previous 8 to 10 months as training data results in the best performance. Additionally, it is demonstrated that although the LSTMs' performance suffers when the resolution is increased, charging time slot prediction suffers less than charging duration prediction. We also suggest, examine, and assess a novel method that enhances the performance of charging duration prediction.

The following is an excerpt from Zhonghao Zhao's paper, "Capacity Planning for an Electric Vehicle Charging Station Considering Fuzzy Quality of Service and Multiple Charging Options": Electric vehicles (EVs) have drawn a lot of interest as a solution to dire energy and environmental challenges. The extensive market penetration of EVs has been made possible in large part by the capacity planning of public charging stations. In this study, we provide an optimisation model for charging station capacity planning that takes queuing behaviour, blocking reliability, and a variety of charging choices categorised by battery technical specifications into account in order to maximise fuzzy quality of service (FQoS). Fuzzy numbers with triangle membership functions are used to represent the uncertainty of the EV's arrival and service time. In the meantime, a defuzzification method based on cuts is suggested. Finally, the numerical outcomes show how taking FQoS into consideration may lead to a more reliable strategy. Decision-makers and operators may better serve consumers by offering a variety of charging alternatives thanks to the contribution of the suggested model, which enables them to design the capacity of charging stations with a fuzzy EV arrival rate and service rate.

Willy "Optimal Placement of Electric Vehicle Charging Stations in a Distribution Network with Randomly Distributed Rooftop Photovoltaic Systems" by Stephen Tounsi Fokui: Today's transportation industry is progressively transitioning away from petroleum-based cars as a result of the rising number of electric vehicles (EVs). However, the coordinated and quick growth of EV charging stations (EVCS) is crucial for the quick deployment of EVs. The rising penetration of randomly dispersed photovoltaic (PV) systems in current distribution networks makes it difficult to integrate EVCSs because they might result in high power losses and voltage variations that are outside of permissible bounds. With a large penetration of randomly dispersed rooftop PV systems, a hybrid bacterial foraging optimisation algorithm and particle swarm optimisation (BFOA-PSO) approach is suggested in this research for the best placement of EVCSs into the distribution network. The multi-objective optimisation problem is designed to maximise the voltage stability index while minimising active and reactive power losses and the average voltage deviation index. The example network is the IEEE 69 node distribution network. To integrate the EVCSs into five examples of randomly sized and located PV systems in the distribution network, MATLAB is used for the simulation. Due to the positioning of the EVCSs, all five examples show a little increase in power losses and a small change in the voltage deviation and stability indices.

"A Comprehensive Review on Structural Topologies, Power Levels, Energy Storage Systems, and Standards for Electric Vehicle Charging Stations and Their Impacts on the Grid" by Mohd Rizwan Khalid: The use of electric vehicles (EVs) in the transportation industry is growing, although the majority of cars are still powered by traditional internal combustion engines (ICEs). The barriers that mostly include expensive EVs, range anxiety, a lack of EV charging infrastructure, and grid pollution from EV chargers need to be lifted in order to speed up the adoption of EVs and achieve sustainable mobility. Costly energy storage systems (ESS) with high energy density are the cause of the high price of EVs. The electric vehicle supply equipment (EVSE), energy storage systems (ESS), and EV chargers are the key topics covered in this paper's thorough examination of EV technology. On-board and off-board chargers, which are the state-of-the-art in EV charging, are covered in great depth. The use of low- and high-frequency transformers is examined in relation to various topologies. There is discussion of the various charging power levels. Inductive power transfer (IPT)-based EV chargers are suggested as a way to ease range anxiety. The final section of the essay focuses on the drawbacks of EV charging as well as possible solutions. The second half of this essay discusses the global standards established by various organisations and approved by all parties, and it finishes with an analysis of the upcoming advancements in EV technology.

Zhi Kai Liu, "Enhancing the DC Voltage Quality in EV Charging Stations Employing SMES and SFCL Devices," While the self-triggering current limiting feature of a superconducting fault current limiter (SFCL) suits to achieve automatic load protections in electric vehicle (EV) charging stations, the fast-response energy compensating feature of a superconducting magnetic energy storage (SMES) device is preferred for suppressing instantaneous voltage fluctuations. This study examines a novel technique for improving DC voltage quality that combines SMES and SFCL devices with superconducting power technology. Initial simulations show that our SMES-SFCL-based voltage quality improver may prevent voltage fluctuations during EV load transients and efficiently decrease the fault current during short circuits at the same time. "A Novel Reliability Index-Based Approach for EV Charging Station Allocation in the Distribution System" by A. N. Archana: Electric vehicle (EV) deployment on a large scale is detrimental to the performance of the distribution system. Unplanned EV charging station (EVCS) installation compromises the distribution system's voltage stability, dependability, and power quality, which leaves customers unhappy. This paper suggests a cutting-edge method for correctly positioning EVCS in a distribution network while retaining system performance. This paper describes the design of a test station with vehicle-to-grid (V2G) functionality. Five charging columns were built within the test station while taking the norms and regulations established in the Government of India's EV policy into mind. Numerous EVs are linked to a DC bus that connects the charging station to the electrical grid. By creating six test scenarios, EVCS placement in the IEEE-33 bus radial distribution scheme is accomplished. The test case findings demonstrate the effectiveness of a reliability-index-based method for distributing both slow and fast chargers for EVCS in a distribution network. Furthermore, a unique electric vehicle placement index (EVPI) is used to establish the maximum threshold value for installing the EVCS in different buses in a distribution system. The approach's originality resides in its ability to take into account all operational factors that the deployment of EVs has an impact on, sustaining system performance without requiring a physical reorganisation of the network.

Benoit Sohet, "Hierarchical Coupled Driving-and-Charging Model of Electric Vehicles, Stations, and Grid Operators": The behaviours of electric vehicles (EVs) influence operators' choices in both the electricity and transportation networks. As a result, making decisions involves a model of several interdependent operators as well as the driving and charging behaviours of EVs. The electrical system in the context of commuting, which has a typical trilevel structure, is suggested to fit into such a model. The commuters' choice of driving routes and charging stations (or hubs) is determined at the model's lower levels by a congestion game between various types of cars based on the distance travelled and the cost of the energy used. In order to maximise the gap between EV charging revenues and energy-provider expenses, a charging service operator sets the charging pricing at the hubs. These expenses are directly influenced by the providing agreement selected by the Electrical Network Operator at the model's top level, whose objective is to lower grid costs. An optimistic iterative technique and simulated annealing are both used to tackle this tri-level optimisation issue. On realistic metropolitan networks, the sensitivity of this trilevel model to external inputs like EV penetration and an incentive from a transport provider is demonstrated. This model is contrasted with a typical, one-operator bi-level model seen in the literature. "A Customer-Centered Smart Charging Strategy Considering Virtual Charging System" by Mohamed Mokhtar One of the biggest challenges faced by drivers of electric vehicles (EVs) is charging. Therefore, a feature should be available to recommend the optimal charging station based on the needs of the consumer. However, the majority of the research focused on the perspective of charging stations and operators, and the routing mechanism for EVs was often conducted centrally. In contrast, the smart charging method suggested in this research directs EV drivers to the optimum charging location depending on their preferences. In the suggested smart strategy, numerous charging stations would collaborate via a virtual charging system (VCS) to efficiently handle all EV charging demands.

III. GAP IDENTIFICATION IN LITERATURE SURVEY

The following issues from earlier research are listed below.

Transient time was longer in the earlier strategy. Reduced steady-state period. The modelling of the electric vehicle system is more difficult. Synchronisation issue with the solar controller and motor. The calibration of the vehicle's governing parameters has a problem.

IV. CONCLUSION

Valley-filling and peak-clipping are achieved with a sensible EV charging strategy. That is, by reducing the cost of electric generation and delaying the investment in a new charging facility that depends on the grid as a power source to lower the peak load, it is feasible to smooth the load curve. By making investments in discharge facilities, it is possible to utilise the electrical energy stored in a large number of EV batteries to regulate frequency and voltage while

enhancing the stability of the power system. The ability of the electrical system to accept these power supplies may be improved, which will increase the cost-effectiveness of system operation. This can be done by managing the charging and discharging of a large number of EVs efficiently and by coordinating intermittent renewable energy sources. In other words, even if the electrical grid only has a small amount of room for intermittent renewable energy sources, the widespread usage of EVs helps to expand the system's capacity.

The first two aforementioned factors have been taken into account by several studies that have been published in the literature; however, although a few studies have addressed this issue, no systematic research has ever been done on the third factor. For various combinations of intermittent renewable energy sources, there is currently no rigorous analytical technique to evaluate the economic worth of various EV distributions and grid penetration rates. The potential savings on the power grid's operational and capital expenses make up the majority of the economic value. To maximise the economic value of EVs and associated facilities in power system planning and operation, a detailed mathematical model is necessary to evaluate their economic worth and investigate suitable load and management techniques.

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