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# Review on Renewable Energy Based Electric Vehicles Charging Technology

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**Abstract - Many different types of electric vehicle (EV) charging technologies are described in literature and implemented in practical applications. This paper presents an overview of the existing and proposed EV charging technologies in terms of converter topologies, power levels, power flow directions and charging control strategies. An overview of the main charging methods is presented as well, particularly the goal is to highlight an effective and fast charging technique for lithium ions batteries concerning prolonging cell cycle life and retaining high charging efficiency. Once presented the main important aspects of charging technologies and strategies, in the last part of this paper, through the use of genetic algorithm, the optimal size of the charging systems is estimated and, on the base of a sensitive analysis, the possible future trends in this field are finally valued.**

**Keywords - Electric vehicle · Plug-in electric vehicles · Battery charger · Charging infrastructure · Vehicle-to-grid · Grid-to vehicle, Charging methods etc.**

## I. INTRODUCTION

Electric vehicles are gaining popularity because they emit less pollution and are less reliant on fossil fuels [6]. By integrating smart grid charging stations with distributed renewable energy sources, energy efficiency and carbon reduction can be achieved [7]. It is possible to have a Microgrid that is both linked to the grid and separated from it, where dispersed energy sources and storage devices are used locally by a variety of load types. However, widespread adoption of high-capacity EV charging stations increases demand for charging infrastructure, which in turn increases demand on the power grid [8]. Power converter topologies and local renewable energy sources are used to help people who have trouble using a lot of energy. Tesla and Nissan are two of the companies that make electric cars. They build the infrastructure for charging stations. As a result, electric-vehicle charging stations that use renewable energy cut charging costs and emissions while improving the synchronization of utility grid [9].

Renewable energy sources utilized in distribution networks, in conjunction with the electrification of charging stations in smart grids, offer a means of increasing power conversion efficiency and reducing emissions. The Microgrid is made up of a collection of dispersed energy sources and storage devices that are used locally by a variety of load types and are function in either a grid-connected or islanding mode. Figure 1.1 illustrates a typical EV charging station as part of a Microgrid system. However, as the number of EV charging stations grows, so does the strain on the power grid. This is because more people are using electric cars. In this case, local renewable energy sources are used with the right power converter topologies to meet power consumption concerns.

**DC Charging-** For the most part, DC charging systems are meant to be used outside, unlike their AC counterparts. Using DC means that there is more wiring, but it is more efficient and faster to charge. High-power DC charging for electric cars starts at 48 kW and goes up as the EV off-board charger is made to transfer DC power directly into EV's battery. Because off-board chargers don't have to be small or heavy, they can charge a lot of power quickly. Batteries in electric cars (EVs) are better served by charging stations that automatically change the voltage of direct current (DC). Charging systems like CHAdeMO, Tesla, and CCS/Combo are used to connect the EVSE and these chargers to each other. These systems are called "charging systems."

**Level 1:** This level delivers up to 36 kW of charging power at 250–450V and 80 A.

**Level 2:** This level is identical to level 1, except for the fact that it has a current rating of 200 A and an operating voltage of up to 450 V.

**Level 3**: This system is rated at 600 volts. It has a maximum current rating of 400 A and a power rating of 240 kW.

DC chargers, in comparison to their AC counterparts, allow quick charging due to their large power capabilities. Three types of standard connections are used in DC systems:

1. Integrated charging systems capable of delivering about 65 kW of power;
2. CHAdeMO connections capable of delivering quick DC charging; and

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Electric cars may also benefit from extra services provided by the energy they use. As a side note, it's important to note that stand-alone renewable systems have a lower penetration rate than those that are connected to the power grid. [13]. the reliance on the main grid as a reliable source/load capable of compensating for the volatility in renewable energy sources. Solar energy is the preferred renewable energy source for EV charging since it may be produced during high-cost power grid tariff hours. Thus, solar-powered EV charging stations may help lower the cost of electricity. The photovoltaic module has a basic construction, a compact footprint, is lightweight, and is easy to carry and install.

Additionally, the photovoltaic system doesn't take long to build and can be connected in a variety of ways based on how much electricity it can charge. To be used as a source on site, it is easy to find. Photovoltaic energy production is, on the other hand, very dependent on the temperature and and sunlight in the area. In other words, PV electricity isn't continuous during the course of a single day of operation. It's also short-lived, meaning it happens at timed periods (minutes to hours). When PV panels are connected to loads without using an auxiliary system, this has an effect on the charging system. As a result, storage devices may play a critical role in stabilizing and moderating the unpredictability of solar energy production [53-56].

This thesis suggests the use of an energy storage device in conjunction with a photovoltaic system to provide constant power to the EVs load regardless of PV power variations. Integration of storage devices with photovoltaic panels and power grid maximizes the use of renewable energy, resulting in reduced operating costs and increased efficiency.

DC Microgrid systems are widely employed in DC-powered households and industrial 0applications because to their easy voltage management and real-time control [9–11]. Figure 1.2 depicts a schematic representation of an EV charging station with a grid-connected ESU. DC microgrids are developed and operated in an unique topology that incorporates hybrid energy sources [12,13]. Low voltage microgrids were initially suggested in 2002 and are presently undergoing significant enhancements as a result of distributed generating [14]. This low voltage microgrids system is comprised of a variety of dispersed energy sources coupled to a variety of AC or DC loads. AC microgrids saw a similar evolution in 2004, with the addition of 10 kW, increased dependability, increased efficiency, and simplified control [15]. Similarly, DC micro grids are utilized for data transmission and ESUs with shared renewable energy [16]. An EV-PV converter connects the microgrids to EV charging stations, which allows them to run only on renewable energy, like electricity from the sun or the wind. [17–19]. Most of the time, a grid link is used to control how much solar energy is made. As a bonus, it has other benefits, such as high-quality products.

*(a)*

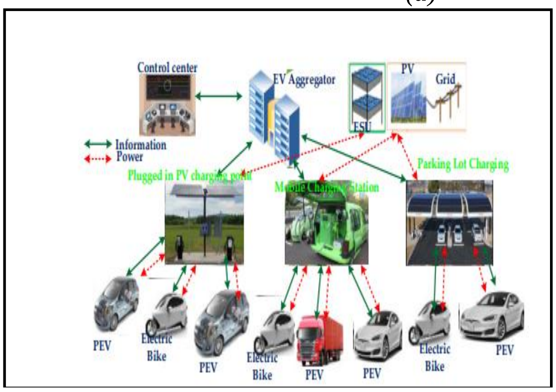

Figure1. A general schematic of a charging station.

## II. RELATED WORK

**Soumia Ayyadi (2020):** This research proposes a new method for anticipating the coordinated charging and discharging of Electric Vehicles (EVs), which will reduce the cost of charging EVs. This technique will be based on the day-ahead electricity price (DAEP), subject to the constraints specified by the state of charge (SOC) of the EVs, the EVs' maximum power charger, and the EVs' batteries being fully charged at the end of the charging time. In addition, the electric vehicle's initial state of charge (SOC 0) has been determined based on its daily driving miles, and Latin Hypercube Sampling (LHS) has been used to account for the uncertainty surrounding the EV's arrival time, departure time, and SOC 0 value. The optimal solution offered allows electric vehicle owners to create a profit of 14.79 euros, but in the uncoordinated situation, EV owners must pay 2.17 euros to charge their vehicles. In addition, a comparison of actual and estimated data reveals that the charging cost based on the actual SOC 0 values is 2.88 percent and 27 percent more than the charging cost based on the estimated SOC 0 values for coordinated and uncoordinated scenarios, respectively. This owes to the greater accuracy of the actual SOC 0 values.

**Murat Akil (2021)** since real charging data for Electric Vehicles (EVs) cannot be shared among distribution service providers; it is hard to estimate the energy profile of a group of EVs. This makes it hard to figure out the energy profile. For this study, a dataset was used that had information about both weekdays and weekends over the course of a single day. This information came from real electric vehicle charging sessions that took place in the Perth and Kinross area. This dataset includes the start and end charging times for electric vehicles. At 15-minute intervals, this data was used to get 5000 sets of vehicle session data for Monte Carlo Simulation (MCS). Every session was 15 minutes long.

Based on the data that was collected, uncoordinated AC charge load profiles of bulk electric vehicles with a battery capacity of 50 kWh and a maximum power of up to 22 kW were made according to IEC 61851-1 standards. This means that there was no loss of power, no limits, and no timing. Because of this, the peak loading and peak loading times of 5,000 electric vehicles (EVs) on the distribution line were looked at during the week and on the weekends in the Perth and Kinross districts. This was done under the assumption that the charging wasn't coordinated. The results told distribution service providers in the city of Perth about the peak hours of EV load during the week and on the weekends.

**O. Alatise; (2021):** Chargers for electric cars will add to the amount of work that distribution networks have to do. Several studies have focused on home charging of electric vehicles (usually 3 or 7 kW single-phase), with expected power peaks happening after work hours (after 4 p.m.). However, work-based home charging of electric vehicles at higher power levels (22 kW 3-phase, 50 kW DC and higher) between 9 a.m. and 4 p.m. has received less attention. This is because the expected power peaks are likely to happen in the evening when people aren't at work. By letting people charge their electric cars at work, industrial employers who use a lot of electricity and run their own distribution networks can take some of the load off the central power grid.

This document is a summary of the results of an exploratory study about charging electric vehicles at a 750-acre industrial/commercial complex with more than 5,500 employees, 6,000 parking spaces, about 10 MW of peak power demand, and 4 MW of combined heat and power generation. On the 11 kV distribution circuit, MATLAB/Simulink was used to do a load flow analysis. Using the IEC 60076–7 standard, there was also an investigation into how the increasing load from charging electric vehicles will affect the main transformer's thermal limits. Since the CHP is so important, the results show that the peak charging capacity in winter and the peak charging capacity in summer are very different. Some suggestions are made about how to best prepare future distribution systems for a rise in the number of charging stations for electric cars.

**Zhen Chen(2021):** The goal of this study is to come up with a way to charge electric vehicles (EVs) that takes into account the idea of an EV charging cooperation factor. This idea is part of the EV's goal, which is to lower the cost of charging the vehicle. This idea is called a "factor," and it is defined by the parameters and needs of electric vehicles (EVs). Some of these parameters and requirements are capacity, state of charge, charging power rate, amount of energy needed, and time to leave. People think that each EV can work in either a non-cooperative state or a cooperative state. When it is not cooperating, the charging cooperative factor has the highest value possible. This is because it works best this way.

The fact that the value of the charging cooperative factor is less than the maximum in the cooperative stage means that the related EV will be able to give other EVs its charging time slots without hurting its own charging costs to help charge other EVs that need it. This sets up a way for electric vehicles (EVs) to work together. This means that EVs can help each other lower their charging costs by working together. The problem of charging electric vehicles (EVs) is looked at as a generalized Nash equilibrium problem, and a consensus network is used to solve the problem in a decentralised way. The results of the simulation show that the suggested distributed charging control could work well and save money on the cost of charging electric vehicles.

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**Yanping Liu(2021):** Power electronics technology will be an important part of the evolution of the distribution network in the future. This will help modernize the system, allow multi-terminal flexible closed-loop operation, and greatly increase the power supply capacity. Even though there is a lot of support for electric vehicles, the random way people charge them is a risk to the reliability of the distribution system. In light of this, it is important to figure out how the ability to charge EVs affects the flexible infrastructure for distributing power. Testing is done in the IEEE 33 interconnection system. After that, operational limits are made based on how the flexible distribution network works, and the EV charging load model is made based on how EVs access the grid at different times. The results show that the adaptable interconnection may be able to improve the distribution of tides over time and reduce voltage changes.

**Wenlang Deng et al., (2017)** proposes a Dual-Stage Matrix Converter (ZS-NS-TSMC). It uses the Series Z -Source between the Rectifier and the inverter stage, which improves the shoot through capability of the Dual-Output Converter and the voltage transfer ratio greater than unity, achieved. It has the advantages of limited inrush current and unity power factor and adjustable output voltage amplitude. The system uses dual space-vector modulation scheme for controlling the two different loads of the inverter section.

**Kun Yu et al., (2016)** proposed a novel implementation scheme of maximum boost control and constant boost control methods for three phase Z-Source Inverters based on SVPWM theory. The Comparison of the proposed method with the existing carrier based modulation strategies have been conducted, and it is found that the proposed method has less switching actions, compared to the existing carrier-based modulation strategies.

**Omar Ellabban et al., (2016)** proposed a Quasi-Z-Source inverter scheme for overcoming the problem of limited voltage transfer ratio of 0.866 and achieved both buck and boost operations using reduced switch count. The Proposed Quasi-Z-Source with continuous and discontinues current mode of operation compared with the existing Z-Source inverter topologies in terms of harmonic content, efficiency, voltage stress on the switches, ripple content and the proposed method is found to be effective.

**Xuyang You, et al., (2015)** presents a quasi-Z- source with the merits of conventional Indirect Matrix Converter. Quasi-Z-source inverter has certain features including absence of DC link capacitor, compact in size with bidirectional power flow, adjustable input power factor, and high voltage gain; without any additional input filter, the continuous quasi-Z-source network used along with the LC filter function.

## III METHODOLOGY

**Battery Charging -**There are a lot of filtering functions that can be built into the charger, and they can be very cheap in low-power applications. These include AC-to-DC conversion and the ability to give the battery a variable DC voltage. In order to have a battery, there must be some way to manage the battery (BMS). It keeps an eye on the battery's voltage, current, and temperature, and it changes the charging rate to keep the CC/CV charging profile the same at all times, no matter what. In the event that the battery's working limits are exceeded, the battery's protective circuits are turned on, and the battery is isolated if it's safe to. The way the battery is charged is shown in the next image.
II.

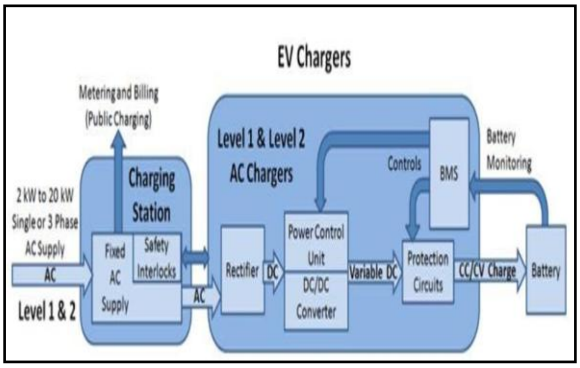


Fig 2 Battery Charging

Bidirectional- V2G Bidirectional [2] V2G power flow, which is also called V2G, can help electric cars and the power grid. It has an AC/DC converter and a DC-to-DC converter, as shown in Fig.3 [8]. The AC/DC converter converts alternating current from the grid into DC power that can be used to charge an electric vehicle. It then converts DC power back to alternating current from the grid so that it can be used to charge an electric vehicle again. It is the job of the DC/DC converter to control bidirectional power flows using the current control method. There are two types of DC/DC converters: buck and boost converters. When the battery is being charged or discharged, the converter acts like a buck converter.

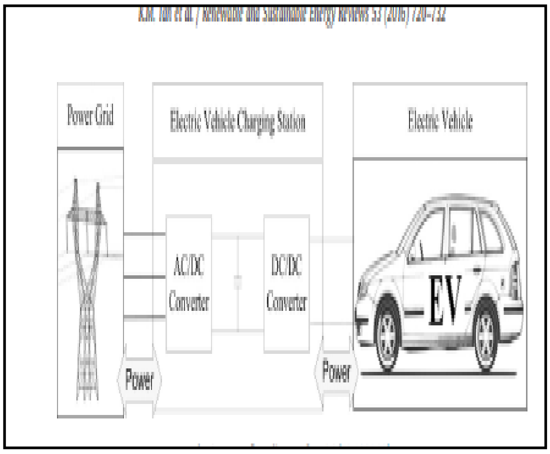


Fig.3 AC/DC converter and DC/DC converter

With the help of utility companies, the electric grid is able to work better. As well as renewable energy sources, this technology helps to make them better. By cutting down on peak load shaving and distributing the load, a bidirectional V2G could help cut down on load and keep things balanced. Electric cars can be charged during off-peak hours. Peak hours are better for putting more EV energy into the power grid. In Bidirectional V2G, both active and reactive power can be used to change the voltage of the grid [29]. DC link capacitor size and control switch are important for this service. Because one of its main functions is to control the power factor, bidirectional V2G technology may also help cut down on power grid losses.

It also makes it easier for renewable energy sources to be added to the power grid because V2G makes it easier for them to do so For example, wind turbines and solar photovoltaic systems, which are very dependent on the weather, give off power in a way that can't be predicted. When renewable energy is in short supply, electric cars could act as energy buffers and suppliers for V2G when electric cars are used. As soon as two people use V2G at the same time, there are a lot of things that go wrong. This is because bidirectional V2G requires a lot of charging and discharging cycles, which could cause the battery to get weak. Hardware and money are needed to make a battery charger that can charge both ways work. In addition, the use of bidirectional V2G in society faces a big problem. For their own safety, people who own electric cars want to make sure that their batteries are fully charged. Because of this, they won't be able to use the bidirectional V2G services. In order for V2G to work properly, it is very important that technical changes be made. Many countries have started using one-way V2G to make it easier for people to use electric cars. As a result, the number of electric cars on the market has gone up. V2G that goes both ways may happen when the market and technology are ready.

## IV. CONCLUSION

The first part of this paper reviews the current conditions of EV battery charging technologies. The most common topologies which are suitable candidates for each level of an EV charger have been presented. Level 1 and level 2 charger topologies are usually mounted inside the vehicle forming in this way the so called onboard charger. On the other side level 3 chargers are installed of board the vehicles, in this way their collection leads to the creation of the so called FCSs which are promising candidates for future EV high penetration. The most common technologies used in a FCS are multilevel converters which have a high power density and a lower current harmonic distortion. To reduce the impact on the grid, almost all the FCSs are integrated with RESs and ESSs. Li-ion batteries can be recharged according many different charging techniques which can more or less complicate the charger architecture and control. In particular, the standard charging strategy is simplest since they don't require model information to charge the battery. Furthermore, they can be realized with very basic circuits, keeping the costs of the charger to a minimum. On the other hand, the charging strategies based on electrochemical models, taking into account the internal dynamics of the battery, consider also the aging of the battery and other constraints, hence resulting in greater accuracy and. All this is at the expense of cost and computational difficulty

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