Wireless Charging of Electric Vehicles Using Solar Energy

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Abstract- Within the past decade, since impediments in nonrenewable fuel sources and the contam- ination they cause, utilizing green energies, such as those that are sun-oriented, in tandem with electric vehicles, is a developing slant. Coordinating electric vehicle (EV) charging stations with sun-powered boards (PV) reduces the burden of EV charging on the control framework. This paper presents a state-of-the-art literature review on remote control transmission frameworks for charging the batteries of electric vehicles utilizing sun-based boards as a source of power generation. The goal of this research is to advance knowledge in the wireless power transfer (WPT) framework and explore more about solar-powered electric vehicle charging stations. To do this, a variety of solar-powered electric vehicle charging station types are thoroughly studied. Following a study of many framework elements, the types of WPT components are explored in a different section. Within the wireless power transmission framework for solar-powered electric vehicle charging, compensators and various coil structures are also investigated, along with the advantages of each coil over the others. This study also discusses the use of artificial intelligence (AI) in WPT frameworks and highlights the important aspects of developing an AI model.

Keywords- wireless power transmission; electric vehicle charging; photovoltaic system; artificial intelligence; solar energy.

I. INTRODUCTION

Due to the growing demand of consumers worldwide, the need for electricity genera- tion has increased. At the same time, rising natural gas prices and regulatory emphasis on limiting greenhouse gas emissions have increased the cost of generating electricity using fossil fuels. Because of this, there has been an increase in the usage of alternative energy sources for providing electricity, such as the solar power produced by solar systems. Utilizing EVs is another action to take to reduce air pollution. However, it needs to be taken into account that they only go a short distance on a single charge. Electric vehicles require charging stations for their batteries, as was previously mentioned. The most common and secure method of charging an electric vehicle is with a wire connected to the

grid; however, the focus of this article is on the use of renewable energy sources, such as solar power, as a power generation source for wireless power transfer (WPT) technology. To avoid the drawbacks of using cables for charging, WPT can also be employed. The structure of the charging stations, as well as their problems and potential solutions, are discussed in the following. Figure 1 illustrates the general state of charge of an electric car wirelessly using a photovoltaic panel. Solar cells and the controller section are two of the most crucial parts of the charging station. It is not feasible to obtain the maximum power from the solar panels at the output, due to weather conditions, shadows, the location of the sun according to the solar panel, and other variables. However, we can obtain and transmit the maximum power from the solar cells to the output by using maximum power point tracking (MPPT) algorithms.
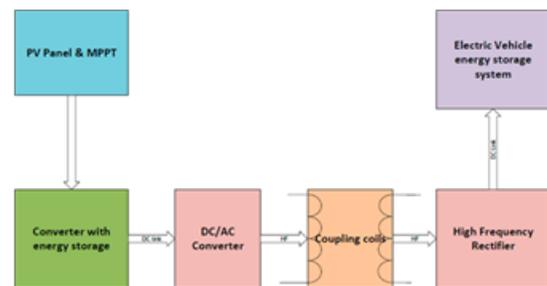

Figure 1. Overview of wireless charging powered by a solar panel.

The Perturb and Observation (P&O) method, which compares the voltage and current in every moment and the moment before and chooses the optimal value, is one of the most common and straightforward approaches in this subject. Another important component is converters, which can change the voltage level to the desired value. It falls into two broad groups, DC–DC and DC–AC converters, both of which are important. The best and most widely used converter is the buck/boost converter.

As previously mentioned, the losses that impact the system's efficiency are the main problem with power transmission; hence, several resonates are utilized to create resonances, and the best of them is LCC resonance. Using various coil structures—which can be referred to as a circular

structure, instead of the standard ones—is another technique to increase system efficiency, and after performing the above process, we can raise efficiency up to 90%. After transferring power to the secondary coil, an alternative voltage, that is, DC, is required. To accomplish this task, due to the high-frequency system, a high-frequency rectifier is required. Next, the voltage must be changed to a suitable voltage for the energy storage used in EVs. For EVs, lithium-ion (Li-ion) is frequently used, as it has a higher power density than lead-acid or nickel-cadmium rechargeable batteries. A DC–DC converter can be employed to do that. We can then wirelessly charge EVs using a solar panel after completing this method. Solar energy and electric cars may be utilized to minimize air pollution, which is a highly serious issue in recent years, owing to air pollution and the limited supply of fossil fuels.

Additionally, due to their limitations in storing energy and traveling short distances, electric vehicles need charging stations to be able to provide the energy required for electric vehicles to travel long distances. There are many ways to charge an electric vehicle, known as AC and DC charging modes. Table 1 summarizes the types of charges available for electric vehicles. Since there are several sorts, each of which needs cables and unique converter heads to charge, technology has advanced to the point where it is now possible to transmit electricity wirelessly, as is covered below.

Here, the induction wireless power transmission mode—which has issues, such as power losses—is investigated for charging all-electric vehicles, in order to do away with various types of cables and unique converter heads. The properties of various resonants are holistically discussed in, and for gaining the maximum power output from the solar panel, MPPT is employed (one of the simple and efficient method is P&O.

This article focuses on analyzing the methods and techniques required to wirelessly transmit power for electrical cars that use solar energy as a clean energy source. The objectives of the research are as follows:

The article begins with a discussion of photovoltaic systems, looking at grid-connected and off-grid options, and then looking at maximum power point tracking to maximize the amount of electricity generated by solar panels. This study also investigates energy storage to determine the best type of storage to save energy and minimize losses.

The study will explore several wireless power transmission techniques, including static and dynamic stations, to identify the distinctions and benefits of each station.

The paper will discuss coil structures to take into account the optimal and efficient structure for coils to prevent power loss, as well as to maintain safety due to magnetic waves, which are harmful to people. By reviewing these structures, the paper hopes to increase the efficiency and reliability of power transmission.

The evaluation of artificial intelligence applications used in WPT, whose primary objectives are to speed up computation, identify faults, and improve efficiency, is the last target of this article.

The architecture of the paper is organized as follows: Section 1 represents an introduction of wireless charging for electric vehicles utilizing solar cells. Section 2 discusses the fundamentals of the photovoltaic system and its components, as well as the various types of electric vehicles. The types of wireless power transmission, types of coil topologies, and their outcomes will all be covered in this section, as well. Section 3 will describe the use of artificial intelligence in WPT systems, along with the key factors that go into creating an AI model. We will review, wrap up, and make suggestions for further research in the fourth session. The final section will present the conclusion.

II. WIRELESS CHARGING STATION FOR ELECTRIC CARS USING SOLAR ENERGY

In general, all types of charging stations will be divided into two distinct categories: static and dynamic. However, first, a look at solar systems is had before discussing different kinds of charging stations.

The Solar Power Generation System

According to Figure 2, a solar system has three primary components, and an energy storage system would make it four if we included it:

- Photovoltaic array;
- DC–DC converters;
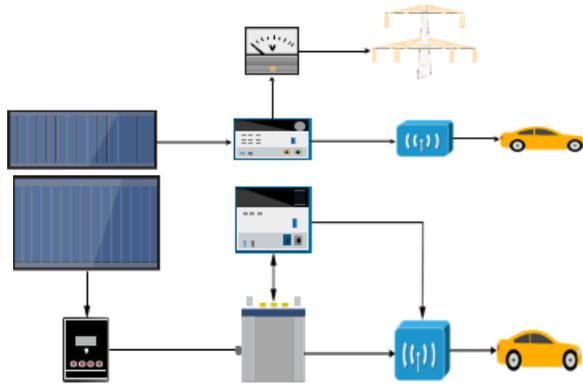- MPPT system;

Energy storage system.

Figure 2. Overview of a grid-connected photovoltaic system (a) and off-grid system (b).

Ph Photovoltaic Systems

The phenomenon by which the radiant energy of the sun is converted into electricity without the use of mechanical mechanisms is called the photovoltaic phenomenon. In general, photovoltaic systems are classified into two groups, according to their application: grid-connected units and off-grid units.

Photovoltaic Systems Connected to the Grid

In a grid-connected system, electricity generated from solar energy will be injected into the national grid. Photovoltaic systems connected to the national grid are centralized or decentralized to strengthen the national grid and prevent electrical pressure on power plants during the day, and more details about PV market could be found in. The advantages of this system include easy installation and setup, high efficiency, and no need for complex peripherals. Figure 2a shows a grid-connected photovoltaic system. Typically, this system does not require a battery to store electrical energy, but sometimes, energy storage devices, such as batteries, are utilized to improve network reliability. Therefore, the grid-connected systems of global electricity can be classified into two groups, with a storage system and without a storage system.

Grid-Independent Photovoltaic System

The off-grid system is illustrated in Figure 2b. In unfavorable weather conditions, it is necessary (or required) for the energy storage system to be able to feed the entire load of the system for several days. These devices are typically utilized in places where there is no access to the national power grid or where it is expensive to connect. For example, in mountainous telecommunication bases, nomadic areas, rural cottages, and to meet the electrical needs of areas that do not have a national electricity grid in general, a grid-independent

photovoltaic system can be used. The conceptual foundation and environmental impact of PV systems are covered in further depth in.
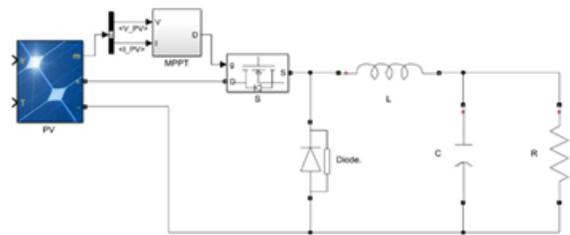

Figure 4. Perturb and observation control system.

If we are on the left side of the MPPT, increasing the voltage causes an increase in power, and vice versa, if we are on the right side, increasing the voltage causes a decrease in power (Table 2).

Table 2. Performance of P&O control method

Subsequent Changes	Changes in Power	Perturb
+	+	+
-	-	+
-	+	-
+	-	-

According to the table, and according to this algorithm, if an increase in power is observed, the perturbation should stick in this path to reach MPP, and if the power falls, the perturbation should be in the opposite direction. This process should be repeated over and over until we reach MPP. One of the problems with the P&O algorithm is that it does not perform well in the face of rapid climate change. This is shown in Figure 5. In constant weather conditions, changes A in PV voltage, move the working point to B, and due to the fall in power, the disturbance signal is reversed. In this case, the radiation level is increased, and the curve is transferred from P1 to P2 in the same time interval. The working point is shifted from A to C, an increase in power is observed, and the perturbation continues in this direction. Therefore, the working point moves far away from the MPP point, and if the radiation level increases, the algorithm diverges.

Application of Artificial Intelligence in WPT

There are several studies on the WPT system that focus on the goal of achieving higher distance transmission. The research has mainly focused on impedance adaptation and the design of resonators, transducers, and power electronics and inverters with appropriate control methods. According to the needed performance, which varies depending on the application, WPT systems were constructed. They can be used in many different ways; for example, small coils can be useful

in biomedical applications, while medium-sized coils are suitable for wireless charging, and larger coils are made for charging electric vehicles. The types and dimensions of the winding affect the power transmission efficiency and lead to other various changes in different parameters, such as mutual inductance, resonance frequency, and so on. Trial and error exercises are time-consuming when calculating parameters, and the outcome may not be altered from a theoretical, simulation-based, or computational standpoint.

WPT and ANN approaches are offered as a way to cut down on this enormous amount of time. An illustration of soft computing is artificial neural networks (ANN), which can handle complicated IT equations and numerous parameter calculations. It is used to identify unidentified parameters and computational methods that simulate an accurate answer quickly. For instance, a WPT design with a high transmission efficiency can be adjusted based on the coil design, inverters, and the volt-ampere (VA) ratings of the active and reactive elements. There is an issue which is related to a huge computational load due to the training all of the combinations of parameters and variables. The WPT design and optimization techniques nowadays can result in a speedier convergence. It is possible to generate reliable outcomes using a variety of soft computing techniques (grouped based on fuzzy, evolutionary logic algorithms, and ANNs). ANNs are analogous to a sophisticated processor with a shared aim to preserve useful data and make it accessible for additional usage. ANN functions in two stages. The initial stage is to gather information about a network across the teaching and learning process. Second, weights are the terms used to describe how neurons are connected. The output of neurons is determined by how well the consequences perform. A bigger impact on the output is provided by a connection with more weight. When tackling problems with complicated nonlinearities, neural networks are known as generic estimators, and educational algorithms are a crucial component of neural networks. A primary neural network consists of three types of layers.

Recommendations and Future Work

Today, due to the growth of using electric vehicles, the need for charging EV stations has increased, in which one of the sources that can be used in charging stations is a photovoltaic system, and we also discussed that the best method for charging electric vehicles is wireless method, which can be improved by using the following suggestions:
Using wireless charging during vehicle movement, which will reduce the cost of energy storage units.

Improving wireless power transmission by using new coil structures and using new resonances suitable for improving power transmission.

Applying the new MPPT algorithm or combine several algorithms to improve solar panel output energy.

Using new converters or a combination of existing converters that can be used for this type of system.

Creating a wireless charger that can quickly charge a vehicle, compared to the time it takes to do so using a plug-in charger.
More consideration and study must be given to enhancing shielding, in order to promote health and safety.

Implementing reinforcement learning and deep learning algorithms to reduce mis- alignment errors.

Employing quantum computing methods for better power transmission with more precision and speed.

We need to find innovative methods to reduce the cost of materials (especially for the dynamic charge method).

III. CONCLUSIONS

This paper presents and investigates current technologies for wireless charging electric vehicles with solar energy. Due to the fact that WPT technology and solar energy use are reliable, practical, and effective charging techniques, they are currently the subject of intensive research in academia and industry. In this review paper, we explored electric cars and the type of charging modes. According to the discussions, when more electric vehicles are produced, the photovoltaic system may offer a promising energy source to power them.

The method of generating electricity from solar energy and the general classification of photovoltaic systems are divided into two groups, grid-connected and off-grid, and the parts used for this purpose were discussed. Additionally, MPPT approaches were studied, and the P&O method was frequently picked for the MPPT algorithm, due to its straightforward implementation and excellent accuracy. We looked at and evaluated various storage technologies, including lithium-ion batteries, which are frequently used in electric cars due to their compact size, light weight, and high efficiency. EV connection types to the grid and static and dynamic wireless charging techniques were also explored. This paper also examined the development of wireless power transfer, as well as its various forms and uses. To improve the critical elements in wireless power transmission, we also

reviewed the crucial elements in power transmission and looked at various coil and compensator structures, as well as the important factors and shielding effect in WPT. We also review some recent papers on wireless charging EVs in Table 5. A cutting-edge analysis was performed on creating artificial intelligence for the WPT system. As a consequence of this research, we were able to identify the most crucial factors for creating an AI model for WPT systems, which we have listed in Table 6. Compared to plug-in chargers, the primary objective of WPT charging systems is to be more effective. This article identifies several significant challenges and prospective research projects. By overcoming these challenges, wireless chargers have the potential for commercial use. While deploying dynamic or static wireless chargers in the real world, ecological, financial, and performance, in terms of efficiency, sustainability, and reliability, must be carefully evaluated. Using dynamic wireless chargers as a distribution and communication line needs to be further studied. It is necessary to conduct more research on the utilization and storage of various renewable energy sources. Future advancements in WPT can be used to automate and commercialize wireless charging systems.

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