

Review Article

Renewable Energy Powered Charging Stations - A Brief Review

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DOI: <https://doi.org/10.24321/2455.3093.202005>

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How to cite this article:

Sharma S. Renewable Energy Powered Charging Stations -A Brief Review. *J Adv Res Alt Energ Env Eco* 2020; 7(1): 28-32.

Date of Submission: 2020-05-18

Date of Acceptance: 2020-05-20

A B S T R A C T

Vehicular pollution is one of the major sources of pollution. To facilitate the green mobility initiative in India the Government is putting lots of effort. The increase in the number of cars on roads increased the need for more fuel. After the industrial revolution in the 18th century, cars slowly started becoming a necessity. More people started buying cars. Recent studies showed that the use of conventional fuels leads to global warming and also increased stress on non-renewable resources. The introduction of electric vehicles and subsidies provided is a good welcome. These measures would be useful when one of the factors i.e. the power for these e-vehicles is provided from clean sources. The authors in this paper have tried to review and explore the various clean options available for the charging stations.

Keywords: Electric Vehicles, Charging Stations, Renewable Resources

Introduction

In this modern era, there have been increasing talks about global warming impacts and the subsequent sea-level rise. To counter this effect, vehicle manufacturers have been trying to manufacture electric vehicles. The vehicles running on alternative sources have been welcomed. But there is a certain problem with this vehicle. When these vehicles are charged using the grid supply, then we are actually depending on the non-renewable source, because electricity is mostly produced from coal. Recently there have been surges in the number of charging stations – the points where e-vehicles can be recharged. These are similar to gas stations but having a point with electric supply to recharge the cars' battery (Figure 1).

There have been various researches in the recent past, to make such charging points standalone, i.e. supplying source to the charging stations from sources other than the grid. This means the installations of renewable sources – solar, wind, tidal, geothermal, or any other form of energy in the

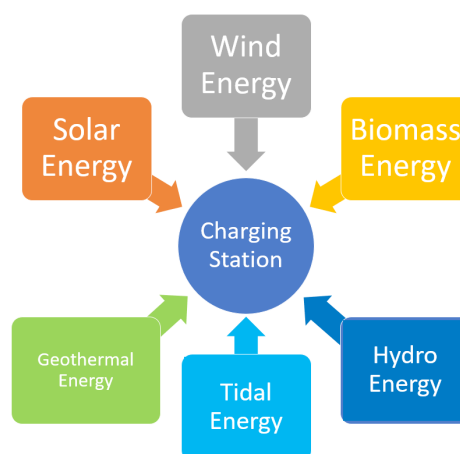


Figure 1. Various Energy Sources for Replenishing the Charging Station

background to make sure the energy from the charging point is completely clean. In this present paper, a various compilation of the different studies have been presented together, to provide the reader with a holistic view of the

different possibilities of having a charging station with clean energy source.

The size and the source of energy available in the various charging stations depend on a number of criterion, such as – number of e-vehicles in the area, the geographical conditions of the site to choose the perfect source of energy, etc. (Moradi et al. 2015). There have also been a number of different algorithms which have been formulated to design the charging stations with the apt requirements (Mozafar, Moradi, and Amini 2017).

Literature Review

The below table summarizes the various works of the past researches, in the most relevant order. The work which has the most significant application based result has been put on the top, followed by other researches.

This table has a summary of the most relevant and recent studies in the field of charging stations that use renewable sources of energy. From this table it is also clear that there are certain charging stations that have multiple sources. There have also been some stations that have the ability

Table I. Review of Past Studies

S.no	Source	Application sector	Source of energy	Findings
1	(Domínguez-Navarro et al. 2019)	Fast charging for cars	Solar energy	The research mainly tries to improve the charging pace of the vehicle. The time taken to charge any vehicle should be reduced to increase the popularity of the vehicle.
2	(Fathabadi 2017)	Charging vehicle, with additional possibility of vehicle-to-grid possibility	Wind energy	The charging station is not only a place for charging the cars but also makes a vehicle to grid supply possible to maintain the load demand in the grid.
3	(Mehrjerdi and Hemmati 2020)	Multi-type charging point for e-vehicles	Wind energy	The study proposes a unique design of charging stations with features such as slow, moderate, and fast charging options to suit the requirements of the different vehicles. Such a design is accomplished by using stochastic mixed-integer linear programming
4	(Fathabadi 2020)	Plug-in charging of hybrid vehicles	Combination of solar and wind energy in the presence of fuel cell	The lifetime cost of the entire charging station is very less, as compared to other stations. No emission or other effects is arising from the charging station, because of its stand-alone capability.
5	(Jochem, Szimba, and Reuter-Oppermann 2019)	Charging stations on highways	Renewable source depending on the geographical conditions of the charging stations' location	The paper has made an overall evaluative study of the highways in different European countries and devised a formula, to establish the correct number of charging stations required for the specific countries based on the number of vehicles and the distance of the highways.
6	(Kumar et al. 2019)	Charging stations for e-vehicles in sub-urban and remote areas	Off-Grid Charging Stations (OGCS) using Renewable Energy Sources (RES)	The authors have designed a charging station using PV cells to charge the e-vehicles more cleanly, and the station also has the flexibility of passing on the excess energy to the grid.

7	(Karmaker et al. 2018)	Charging station for cars	Solar PV module along with a biogas generator	The paper presents a design for the charging station based on the combination of solar PV module and biogas generator, so that there are no emissions for the charging point.
8	(Meng et al. 2020)	Charging point for taxis	Using real time analysis to find the best source of energy as per the site location	The authors state that the construction of the charging point should be sequential, i.e., instead of building a huge charging station first and then downscaling it, a proper analysis should be done of the location. This will prevent fund loss.
9	(Chellaswamy, Balaji, and Kaliraja 2019)	Charging stations for hybrid as well as e-vehicles	Solar panels and/or wind generator	The design was made in the MATLAB-Simulink model, which described the automatic charging of the battery. This would prevent the necessity of stopping the vehicle at a charging point for recharging.
10	(Colmenar-Santos et al. 2019)	For charging cars in Europe	Renewable source of energy as available at the site	The study focuses on making the European Union fulfill its climatic requirement by 2050. This can be achieved by analysing the peak energy-saving, ancillary services, stable frequency, and stable load requirements.
11	(Othman et al. 2020)	Electric charging of electric buses	Source not mentioned, preliminary study for finding optimal location of point.	The study mostly focussed on finding out the crucial junctions to have the charging point on the long route bus so as to get the optimal performance. For this study, the Voronoi diagram and algorithms were used.
12	(Bartolucci et al. 2019)	Standalone recharge stations	PEM fuel cell	The paper presents a practical approach to the system of charging of the e-vehicle on the highways. The power supply for the charging stations is not derived from the grid supply but comes from a clean source.
13	(Gong et al. 2020)	Charging station for all e-vehicles	Stabilised supply from renewable sources	The authors have analysed certain drawbacks in traditional renewable-based charging stations arising due to fluctuations in the output supply. This problem can be overcome by applying the spatial-temporal characteristics algorithms.
14	(Huang et al. 2019)	Charging station in cities with dense population	Solar panels installed right above the stations	This paper uses the Geographic Information System (GIS) to present the apt locations for the charging stations inside cities, so that they do not affect the pedestrian movement and at the same time provide easy movement to the cars.

15	(Liu et al. 2018)	Charging point for cars in urban locations	Renewable sources as available at the desired site	The study proposes a design in which the possible location of a charging site can be confirmed with a formula, based on the number of e-vehicles and the other infrastructure available at the location.
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to provide excess to the grid, thereby contributing to the overall improvement of the society.

Conclusion

From the above table, and the other literature, it is clear that the charging stations using renewable sources are the need of the hour. The increase in the e-vehicles can be counted to have proper environmental benefits only when they are being charged using renewable sources. This is because when an e-vehicle is charged using the grid supply, it leads to the consumption of non-renewable sources, again contributing to the greenhouse effect.

The past studies also have designs that use multiple combinations of renewable sources, to prevent fluctuation. There have also been designs that have a reverse grid supply when there is excess power in the charging station. This can be helpful to the overall environmental impact. The design of the grid supply with the excess current holds a lot of confidence. (Quddus, Kabli, and Marufuzzaman 2019). Following points can be concluded from the following:

- The usage of renewable sources of energy as the source of replenishing the charging station can be considered to be a pollution-free and alternate source for fossil fuels.
- But the usage of which type of renewable energy depends on its availability and accessibility and needs to be researched before setting up a charging station.
- Usage of correct analysis method will not only tell which energy source to be used but also reduce excessive spending or financing on the project.
- Solar and wind are already considered a viable choice for charging stations and are often integrated to cover each other shortcomings.

Overall, it can be stated that the performance of the charging station and the impact on the environment can be lowered when the charging station is powered using renewable sources of energy. This is the need of the hour and more work can be done on improving the stability of the charging station running on the renewable sources of energy.

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