HYBRID RENEWABLE ENERGY EV CHARGING STATION: SOLAR AND WIND INTEGRATION

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Abstract. The prospective spread of electric vehicles (EV) and plug-in hybrid electric vehicles leads to the need for fast charging rates. Higher charging rates lead to high power demands, which cannot be supported by the electrical grid. Thus, the use of on-site sources alongside the electrical grid for EV charging is a rising area of interest. In this dissertation, a photovoltaic (PV) source is used to support high power EV charging. However, the PV output power has an intermittent nature that is dependent on the weather conditions. Thus, battery storage is combined with the PV in a grid-tied system, providing a steady source for on-site EV charging in a renewable energy based fast charging station. Renewable energy based fast charging stations should be cost effective, efficient, and reliable to support the high charging rates demanded when a large number of EVs are connected to the electrical grid. However, fast charging stations, especially super-fast charging stations may stress power grid with potential overload at peaking time, sudden power gap and voltage sag. This project discusses the detailed modeling of a multiport converter based EV charging station integrated with PV power generation and battery energy storage system. This study introduced the concept of charging electric vehicles using a local hybrid solar/wind power system. The PV and wind farms are linked to EV stations using power converters. Furthermore, in the time of peak demand, the proposed system can be connected to the grid to balance the load demand. In this project, the control scheme and combination of PV power generation, EV charging station and battery energy storage (BES) provides improved stabilization including power gap balancing, peak shaving and valley filling, and voltage sag compensation.

Keywords: Hybrid renewable energy systems, Solar and wind power Challenges ,Opportunities, Policy implications,

1 Introduction

As Electric vehicles (EVs) are considered to be the future mode of transportation. The Paris Declaration on Electro-Mobility and Climate Change and Call to Action, calls for the global deployment of 100 million electric vehicles by 2030. EVs are much more energy efficient than gasoline/diesel powered vehicles and they do not produce any tailpipe emissions. They have a much simpler drivetrain, are much less noisy and require little maintenance. However, EVs are only sustainable if the electricity used to charge them comes from renewable sources and not from fossil fuel based power plants [1]–[3]. This is highlighted in Fig.1.1, where the well-to-wheel greenhouse gas emissions (GHG) from a fuel perspective of a conventional gasoline car is compared with those of a hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV) and plug-in electric vehicle (PEV) for different cases of the fuel mix for electricity generation It is evident that any form of an electric car, be it an HEV, PHEV or PEV always has lower well-to-wheel emissions from a fuel perspective than a comparable gasoline car. At the same time, the emissions of the electric car are itself dependent on how clean the fuel mix is [1]–[3]. If EVs are charged from a grid that is predominantly powered by fossil fuels like coal or natural gas, the emissions are significant and not zero, contrary to popular belief. On the other hand, if EVs are charged from a grid which is largely powered by renewable energy, then the net emissions are close to zero. The challenge, then, is to power EVs in the future using sustainable sources of energy. Wind, solar, hydropower, geothermal, biogas or tidal energy are excellent sources of renewable energy to power electric vehicles in the future. Amongst these, the use of solar photovoltaic panels to charge EVs is an attractive option due to several reasons:

1. The cost of solar PV has been continuously falling over the past decades and is less than 1$/Wp [4]. 2. PV power has high accessibility to EV users as PV modules can be installed on the roofs and as solar car parks, close to where EVs will be, as shown in Fig.1

Fig.1 An impression of a solar powered EV charging station

EVs are charged from PV installed on rooftop and as solar carport (By M. Leendertse)

2. The PV potential of rooftops or parking places is largely unutilized today, and this can be exploited in the future. 3. There is both reduced energy and power demand on the grid due to EV charging as the charging power is locally generated in a 'green' manner through solar panels [5]–[7]. This reduces/delays the need for grid reinforcement. 4. Conventionally, PV systems use a battery to store the solar energy to manage the seasonal and diurnal variations in solar generation. In the case of charging EVs from PV, the EV battery can serve as an energy storage for the PV, and no additional battery will be required [8]–[11]. 5. The cost of charging the EV from solar is cheaper than charging it from the grid, and it reduces the impact of low PV feed-in tariffs [12], [13]. 6. PV systems have low noise, have no rotating parts and are practically maintenance free.

Hence, the charging of electric vehicles from PV panels can make EVs truly sustainable and reduce the net cost of the charging infrastructure. This is the vision and motivation for this thesis. A connection to the conventional alternating current (AC) grid is provided in order to feed any excess PV power or draw power for EV charging if PV generation in insufficient. This ensures that neither the PV generation nor EV charging is hindered in the case the other is insufficient/absent.

2. Literature Review

Itie Goswami et al. (2020) This work presents an energy management strategy for multi-power mixed (VV) vehicles, of which the fuel cell (FC) is the main source of energy, and the batteries and super capacitors (SC) are the second most powerful. Electric cars draw the energy they need from fuel cells, while auxiliary energy is used to compensate for power shortages during high-speed or overpower during braking. The use of secondary energy efficiency has proven to be effective in improving vehicle performance, significantly reducing hydrogen consumption, and bringing reliability and reliability to the operation of the entire system. The proposed strategy regulates the distribution of power to various energy sources in the best possible way to meet power needs.Matlab / Simulink are used as a simulation platform.

T.Porselvi et al. (2019) introduced the amount of power supply, which is highly reliable for electric vehicle steering systems. Batteries, solar photovoltaic power supplies, and super capacitors play an important role in this long-lasting power supply. The main power source is the battery, which connects to the super capacitor during transient processes such as overload and start-up.To purchase mixed electric vehicles, hybrid energy storage systems (HESS) with super capacitors and batteries are widely used to improve the charging and discharging characteristics of the batteries, thereby increasing the power of immediate discharge. To reduce energy loss in a hybrid battery storage system, a bidirectional DC / DC converter should be used with a flexible conversion solutions.technology. Initially, the power received from the PV sequence was used to charge the super capacitors and batteries. When PV cannot provide enough power to charge the EV, it can use battery power and super capacitors. With the help of MATLAB software, you can also compare the performance of existing and non-super capacitors systems.

Zheng Guan et al. (2019) research on hybrid power sources that combine batteries and super capacitors is a hot spot in the field of electric vehicle research. Batteries have a high energy density, and super capacitors have high density. To moderately control the output power of both and make the electric car run more efficiently, it conducted a detailed analysis of how hybrid energy systems work and proposed energy management strategies based on speed and energy Logical level control. In the world of MATLAB / SIMULINK simulation, the power supply of electric vehicles and control strategies are proposed. The simulation results show that the super capacitors waveform can accurately track the current deer, and the proposed control strategy can normally divide the output of the battery and the super capacitors to meet the energy output according to different power requirements.

Amir Rezaei et al. (2018) Energy management of hybrid plug-in (HEV) vehicles is usually divided into two parts: heavy power modes and power maintenance methods. This paper presents the best adaptive laws for a variety of adaptive energy reduction strategies (ECMS) under the heavy-duty hybrid plug-in method. To implement the best law, a special ECMS adapter, called Capture Energy Saving Opportunity (CESO) was selected. CESO has been used in hybrid and hybrid vehicles in a maintenance free manner. Here, by introducing the rules governing the best sports, CESO's strategy extends to how power is consumed in hybrid vehicles.

K. Chaudhari et al. (2018) Energy storage systems (ESSs) are often used to manage renewable energy (RES) characteristics. Proper control strategies are needed to preserve power balance among RES, demand, and ESS. The traditional control system for vigor storage systems (HESS) utilizes high/low power steering systems for power generation and ESS power distribution. This paper proposes a new DCbased photo catalytic system for heating with battery and super capacitor (SC) as HESS. The new control strategies utilize the power of non-electrical in the system to improve the overall HESS process. Compared to conventional control strategies, the advantages of the proposed control strategy are the recovery of fast DC voltage and efficient power distribution between the battery and the SC.

3. Methodology

We use relay as charge controller for our project. We know that charge controller regulates the direction of power from the producing end to the batteries and load. Controller can keep the batteries completely charged without overcharging. When the AC load side consumes electricity, the mechanism turns out that the controller allows the AC load side to flow from the producing end to the batteries, the AC load side, or two of them together. When the controller determines that the batteries are completely charged, it will reduce/ stop the transmission of electric power from the generating side. When the AC

loads have drawn too much power from the batteries and stop flowing until the batteries are sufficiently charged again . This last feature can significantly extend the life of batteries.The main heart of solar systems is required to observe and control the energy that goes to and fro to the battery. To make sure whether the batteries overcharging or not the way we can organize it by managing the generation of power by the solar panel. The charging controller should also ensure that connected AC loads do not overcharge and damage the battery of solar panels. Solar panels usually emit 15-17 volts and the charge controller converts this to 12-14 volts and charges the battery. The battery often requires a higher voltage than it already needs to charge the battery. The charge regulator prevents the batteries from being overcharged and it stops loading when the batteries are completely charged and that will provide higher battery efficiency. Failure to use the charge controller damages the battery. If we are planning to use large solar panel system, the best one is to have an advanced charge controller. This will provide us comprehensive data’s on how many volts & amps the battery has charged. Advanced charge controllers will notify us the amperage in the batteries The charge controller can automatically disconnect the battery when it becomes empty. For larger systems such as pipelines or water pumps, high pressure charge controllers are used called MPPT (Maximum Power Point) which can convert DC-DC voltage. .

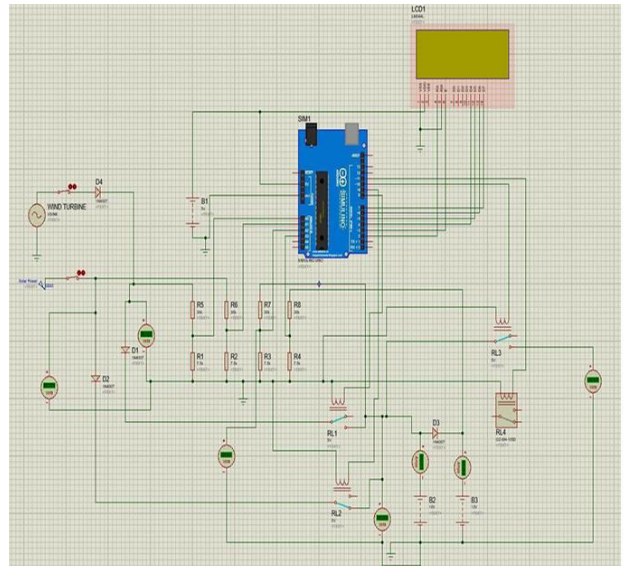

Fig. 2: Circuit Diagram of system

For the simulation part as we want to show our current status for both wind and turbine therefore, we used a lcd display. Furthermore, we used an extra battery as backup in case our main functional battery faces any shortage of power. We used an ammeter with the battery to see if it was charging or not. Now, if we turn on the solar panel, we can see the status ON in the display as well as on the ammeter it will show positive volts which mean our main battery is charging with solar power. Now if we start the wind turbine, we will also see the variation on the ammeter as the voltage we get from the wind is not constant. Finally, if we start both wind and turbine together it will show the status on the display and both of them continuously will charge the battery. We used relay as a switch or charge controller to manage the charging system of the battery for both wind and solar turbine and used voltage sensor1, voltage sensor2, voltage sensor3 and voltage sensor4 with Arduino UNO to show the voltages of battery in the display.

4. Conclusion

The For remote areas around the world, hybrid systems are considered a viable alternative to utilities or traditional fuel-based electricity. However, the demand for clean energy and improved alternative energy technologies has great potential for the widespread use of such systems. In order to ensure the widespread adoption of this new technology, solar photovoltaic and wind energy technologies need to be further developed and improved to reduce the cost of hybrid power systems. Firstly, to start the project we need to generate power. For this generation of power, we need to use wind turbine and solar panel. But while looking for a wind turbine, we cannot find it in miniature way so we used a DC Motor as wind turbine. The Arduino is used as a microcontroller that works to trip the circuit on and off.

We have also added the load calculations in details from he miniature project that proves we can use the project in bigger format. We have faced some troubles in coding while generating the hex files. Another difficulty we have faced, while using the DC Motor as the wind turbine when the motor rotates, we observed the voltage was fluctuating. For that reason, we increased the threshold voltage a bit in the coding. We have also faced problems in distributing the loads because the load we assumed was so high to overcome the problem for that reason we worked with the limited load that was possible to generate. After overcoming all those problems, we were able to finish the project successfully. We have also briefly discussed below about the upcoming future work as well.

By enlarging this miniature project into big scale, we want to implement this in any of the coastal areas . In those coastal areas, this project is a good solution to the shelter center's that suffer from power disruption problem for a long time due to natural calamities. Integrated power system (IPS) could be a solution here but if the power disruption is lengthy enough, then the IPS cannot meet the demand for long time power supply. We planned to implement this project in the midst of shelter center's only whereas we are also planning to do this in the educational institutions, hospitals and in other important places in the coastal areas. We are planning about to add hydropower with this smart hybrid renewable energy system where maximum output can be expected..winning.

References

1) Miller, J.," A brief history of super capacitors, Batteries & Energy Storage Technology", autumn 2007, pg 61-78.
2) L. C. Rosario, "Power and Energy Management of Multiple Energy Storage Systems in Electric Vehicles", PhD. dissertation, Cranfield University, United Kingdom, 2007.
3) M. Ortúzar, J. Moreno, and J. Dixon, "Ultra capacitor-based auxiliary energy system for electric vehicles: Implementation and evaluation," IEEE Trans. Ind. Electron., vol. 54, no. 4, pp. 2147–2156, Aug. 2007.
4) Emadi, J. L. Young, and K. Raja shekara, "Power electronics and motor drives in electric, hybrid electric, and plug-in hybrid electric vehicles," IEEE Trans. Ind. Electron., vol. 55, no. 6, pp. 2237– 2245, Jun. 2008.
5) S. M. Lukic, J. Cao, R. C. Bansal, F. Rodriguez, and A. Emadi, "Energy storage systems for automotive applications," IEEE Trans. Ind. Electron., vol. 55, no. 6, pp. 2258–2267, Jun. 2008.
6) L.Q. Jin, Y. Zheng, J.-H.Li, and Y.-L. Liu, "A study of novel regenerative braking system based on super capacitor for an electric vehicle driven by in-wheel motors," Advances in Mechanical Engineering, vol. 7, no. 3, pp. 1–12, 2015.
7) S. Hala, N. Khalil Faris, and N. Khaled Faris, "Ultra capacitor: modeling and characterization for electric vehicle application," International Journal of Engineering Research, vol. 5, pp. 681– 686, 2015.
8) Xiao Peng, Quan Shuhai and Xie Changjun, "A New Super capacitor and Li-ion Battery Hybrid System for Electric Vehicle in ADVISOR, journal of physics, vol.806, No.1,pp. 1-6, 2015.
9) J. Yang, et al., "An improved PSO-based charging strategy of electric vehicles in the electrical distribution grid," Applied Energy, vol. 128, pp. 82–92, 1 September 2014.
10) B. Hredzak, V. G. Agelidis, G. D. Demetriades, "A Low Complexity Control System for a Hybrid DC Power Source Based on Ultra capacitor-Lead Acid Battery Configuration", IEEE Trans. Power Electron., vol. 29, no. 6, pp. 2882- 2891, June 2014.
11) JunyiShen, Serkan Dusmez, Alireza Khaligh, "Optimization of Sizing and Battery Cycle Life in Battery/Ultra capacitor Hybrid Energy Storage Systems for Electric Vehicle Applications,"IEEE Transactions on industrial informatics, vol.10, no.4, pp.2112-2121, 2014.
12) M.-E. Choi, J.-S. Lee, and S.-W. Seo, "Real-Time Optimization for Power Management Systems of a Battery/Super capacitor Hybrid Energy Storage System in Electric Vehicles," IEEE Trans. Veh. Technol., vol. 63, no. 8, pp. 3600–3611, 2014.
13) Vikas Shrivastava, chris salter "Future Trend To Smart Grid Automation Architecture by IES 61850" International, Conference, Electrical, Electronic, Communication, Mechanical, Computing (EECCME)-2018, IEEE Madras Section, CFP18037, 978-1-5386-4303-7, Vellore District Tamilnadu India, January 2018.
14) Vikas Shrivastava, "Research on Structure for Flywheel Energy Storage System in Long Lifetime UPS", India. Int. Journal of Engineering Research and Application, ISSN: 2248-9622, Vol. 7, Issue 11, (Part -3) November 2017, pp.22.
15) Vikas Shrivastava, Seema Deshmukh "Analysis and Study Between Two Soft Switching Techniques Used in Boost Converter Implementation" International Conference on Electrical, Electronics, Communication, Mechanical, Computing (EECCME)-2018, IEEE Madras Section, CFP18037, 978-1-5386-4303-7, 01-2018-1111, Vellore District Tamilnadu India, January 2018.
16) Vikas Shrivastava, "Industrial Design Aspects of High-Speed Electrical Machines among Active Magnetic Bearings designed for Compressor Applications" India. Int. Journal of Engineering Research and Application, ISSN: 2248-9622, Vol. 7, Issue 11, (Part -3) November 2017, pp.22-27.