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A STUDY ON SYSTEM DESIGN FOR A SOLAR POWERED ELECTRIC VEHICL CHARGING STATION USING PHOTOVOLTAIC ENERGY

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ABSTRACT
A solar car is a solar vehicle used for land transport. Solar cars are often fitted with gauges as seen in conventional cars. To keep the car running smoothly, the driver must keep an eye on these gauges to spot possible problems. Cars without gauges almost always feature wireless telemetry, which allows the driver's team to monitor the car's energy consumption, solar energy capture and other parameters and thereby freeing the driver to concentrate on driving. Solar cars combine technology typically used in the aerospace, bicycle, alternative energy and automotive industries. The design of a solar vehicle is severely limited by the amount of energy input into the car. Most solar cars have been built for the purpose of solar car races. Solar energy is a renewable energy which would exist for even billions of years more. In 2015, COP21 known as the 2015 Paris Climate Conference took place in Paris and the cooperation of over 190 countries agreed on climate, with the aim of keeping global warming below 2℃. In this conference many condition were imparted on developing nation like India to reduce carbon monoxide emission, which ultimately effect the transportation by road and their development. Thus the use of renewable energy like solar has to be incorporated in transportation in order to reduce the carbon monoxide emission without any lag in development. This is a review paper dealing with research paper published related to solar electric car

KEYWORDS: Solar, Car,PV Panel, Electrica Power

I. INTRODUCTION

Two major trends in energy usage that are expected for future smart grids are:
1. Large-scale decentralized renewable energy production through photovoltaic (PV) system.
2. Emergence of battery electric vehicles (EV) as the future mode of transport.

Firstly, the use of renewable energy sources such as solar energy is accessible to a wider audience because of the falling cost of PV panels [1]. Industrial sites and office buildings in the World harbor a great potential for photovoltaic (PV) panels with their large surface on flat roofs. Examples include warehouses, industrial buildings, universities, factories, etc. This potential is largely unexploited today. Secondly, EVs provide a clean, energy efficient and noise-free means for commuting when compared with gasoline vehicles. The current forecast is that in the World there will be 200,000 EV in 2020 [2].

This report examines the possibility of creating an electric vehicle charging infrastructure using PV panels as shown in Fig. 1. The system is designed for use in workplaces to charge electric cars of the employees as they are parked during the day. The motive is to maximize the use of PV energy for EV charging with minimal energy exchange with the grid. The advantages of such an EV–PV charger will be:

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The EV-PV project aims at combining the two technologies by creating an electric vehicle charging infrastructure using PV panels. The focus is to reduce the energy demand on the

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grid due to electric vehicles by locally producing the charging power in a 'green' manner through solar panels. The EV battery doubles up as an energy storage mechanism for the PV system. A power converter will connect the EV, the solar panels and the electricity grid providing both normal and fast charging for the customers in a safe and reliable manner. Smart charging algorithms will ensure that the EVs are optimally charged based on EV user requirements, distribution network constraints, energy prices, demand for ancillary services and solar forecast information.

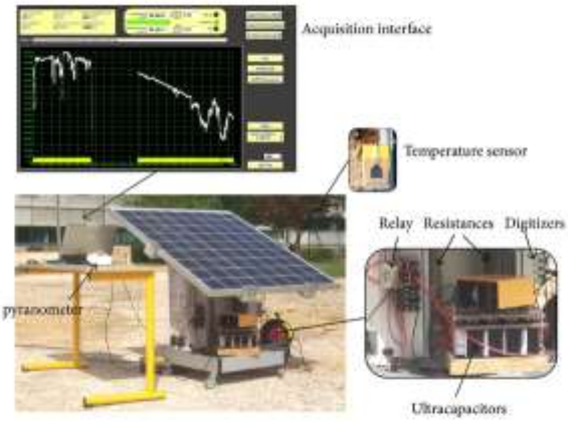

Figure 1: Instrumented setup of photovoltaic energy storage by supercapacitors

Firstly, the use of renewable energy sources such as solar energy is accessible to a wider audience because of the falling cost of PV panels [1]. Industrial sites and office buildings in the World harbor a great potential for photovoltaic (PV) panels with their large surface on flat roofs. Examples include warehouses, industrial buildings, universities, factories, etc. This potential is largely unexploited today. Secondly, EVs provide a clean, energy efficient and noise-free means for commuting when compared with gasoline vehicles. The current forecast is that in the World there will be 200,000 EV in 2020 [2].

This report examines the possibility of creating an electric vehicle charging infrastructure using PV panels as shown in Fig. 2. The system is designed for use in workplaces to charge electric cars of the employees as they are parked during the day. The motive is to maximize the use of PV energy for EV charging with minimal energy exchange with the grid. The advantages of such an EV–PV charger will be:

Fig. 2. Design of solar powered EV charging station

1. Reduced energy demand on the grid due to EV charging as the charging power is locally generated in a 'green' manner through solar panels.
2. EV battery doubles up as an energy storage for the PV and reduces negative impact of large scale PV integration in distribution network [3].
3. Long parking time of EV paves way for implementation of Vehicle-to-grid (V2G) technology where the EV acts as a controllable spinning reserve for the smart grid [4–7].

Several earlier works have analyzed the design of an EV charging station based on PV [8–17]. The mutual benefit of charging EV from solar energy has been highlighted in [18,19] where the potential to charge EV from solar allows for higher penetration of both technologies. In [20], the negative effects of excess solar generation from PV on a national level has been shown to be mitigated by using it for charging EVs. This is especially applicable for charging at workplace as shown in [19]. In [21,22], for the case of Columbus and Los Angeles, USA, the economic incentive and CO2 offsets for PV charging have been shown to be greater than charging the EV from grid.

A major disadvantage of charging EV from PV is the variability in the PV production. Smart charging provides for flexibility of EV charging in order to closely match the PV production. [23] has shown that smart charging combined with V2G has the dual benefit of increasing PV self-consumption and reducing peak demand on grid. In [24], the EV charging profile is varied with time so that maximum PV utilization occurs. In can be seen that the excess PV energy reduces with higher EV penetration [25,26]. Alternately, the total number of vehicles that are charging at a constant power can be dynamically varied so that the net charging power follows the PV generation, as seen in [27]. This type of sequential charging shows great benefit than simultaneous EV charging, which is proved in [28] by considering 9000 different cases. A time shift scheduling is used in [29] to manage the charging of e-scooters so that the net charging power follows the PV profile. This method is further improved with the use of weather forecast data [30].

A second method to overcome the PV variation is to use a local storage in the PV powered EV charging station, like in [26]. The storage is typically charged when there is excess solar energy and is then used to charge the EV when solar generation is insufficient [26]. In [16], three different algorithms for (dis)charging the local storage are compared and it was shown that a sigmoid function based discharging of the storage and charging during night and solar excess was the best strategy. Since storage is an expensive component, optimally sizing the storage is vital. This aspect has been neglected by the papers mentioned above. Secondly, research works that analyzed the use of smart charging have not considered the use of local storage and vice versa. The two methods are investigated together in this work for a solar powered EV charging station. Thirdly, in case of workplace charging it is important to distinguish the effects of weekday and weekend EV charging load. This is because rooftop PV installed in workplace will produce energy even in the weekends even though the EVs of the employee are not present on Saturday-Sunday. This paper analyses the PV system design and EV charging in a holistic manner considering the above aspects.

Objective

The new contributions of the work compared to earlier works are as follows:

1. Determination of the optimal orientation of PV panels for maximizing energy yield in world and comparing it with the use of tracking systems.
2. Possibility of oversizing the PV array power rating with respect to the power converter size based on metrological conditions of the location.
3. Dynamic charging of EV using Gaussian charging profile and EV prioritization, which is superior to constant power charging.
4. Determination of grid impact of two different types of workplace/ commercial charging scenario considering 5 days/week and 7 days/week EV load by running round-the-year simulation.

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5. Optimal sizing of local storage considering both meteorological data and smart charging of EV.

The optimal orientation of PV panels in the World for maximum yield is determined. In the third section, different dynamic charging strategies for EV are analyzed, such that EV charging can closely follow the PV generation. In the fourth section, the benefits of having local battery storage in the EV–PV charger are investigated and the optimal storage size is determined.

II. LITERATURE REVIEW

Related Work

Xiujuan, et al [1] explained the advantage of electric vehicle is that the electric vehicle has zero discharge, low noise and wide source for energy supplement the transformation efficiency of the photovoltaic cell plate is very low (i.e.) 14% because of strong maneuverability the working environment of the solar car changes frequently algorithm of max power point tracking should be increased to get high transformation efficiency condition At present, the common maximum power point tracking methods are the constant voltages tracking method, the perturbation and observation control and the conductance increment method. The tracking accuracy of the conductance increment method is the best among them. It achieves the tracking of the maximum power point. It is obvious that the output power varying different area when we change the working voltage in the area of constant current source the sensitivity is low and in constant voltage load the sensitivity is obvious so the tracking method should be improved In order to improve the accuracy of the maximum power point tracking, when the temperature and the light intensity are definite, and the output power of the photovoltaic cell is close to the maximum power which is the most at the current condition same extent, the tracking step length will be properly lessened , in order that the maximum power point can be tracked more accurately

Rattankumar, V, and N. P. Gopinath[2] Keeping the fact that there is no future fossil fuel we had think of using non conventional energy in effective manner. we have overcome many disadvantage of normal car such as minimizing Coupling losses, BLDC minimizes field losses, smooth handling of speed and fuel cost is minimized .The major parts used while manufacturing a solar car are Photovoltaic module, Solar tubular batteries, BLDC, Ackerman steering, Mechanical structure and MCB .Some of the accessories of solar car are Ackerman steering, Mechanical structure, Miniature Circuit Breaker. At present, the designed solar car runs at a speed of 30Km/Hr for one charging which takes approximately 18 hours and successfully tested for 100Km per charge. Further work is in process to develop the vehicle with Reluctance motor as now it is run by BLDC. It is also proposes to use solar panels of higher efficiency with minimal size. Various drawbacks of the vehicles are studied and steps are in process to eliminate them, hoping that a successful commercial model of solar car will be developed in the future.

Alnunu, Nasser, et al.[3] Since the awareness about sustainability, environment and limitation of conventional sources of energy are being getting supported Research and development in the area of renewable energy is growing fast. Realizing the potential of renewable energy by oil and gas companies and have been supporting the developing technologies and expertise for this field. Shell is one of these car races have started in the mid-80s, and have been very successful ever since. Races such as the World Solar Challenge, the Shell Eco-marathon, the North American Solar Challenge, the South African Solar Challenge and the World Solar Rally are now well established and attract participation of university student teams from all over the world SHELL ECO-MARATHON RACE. Annually in three continents: Americas, Europe and Asia the shell ecomarathon race are held. There are two categories of participation: prototype and urban concept cars. There are number of subcategories under each category on the energy basis. Prototype participant must complete eight laps and a total distance of 25.485 km and a maximum time of 51min. Each team is limited to four official attempts, and the best result is retained. The track is reasonably safety and technical tests to be allowed to race. There are some generic principles for designing and modeling solar cars.

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Typically, the design is of two main phases, namely, mechanical and electrical. Technical as well as soft skills of the engineering student can be improved by solar car races. The experience of QU students' first participation in Shell Eco-marathon race, and has paved the way for future regular participations. The team managed to design from scratch, locally-manufacture and test a solar car in the space of just few months. This car met all the technical and safety inspections tests and participated in the race along with hundreds of entries from all over the world; the goal is achieved. The next participation will be in Shell Eco-marathon Asia in Malaysia 2012, and the team aims to be in the top ten of their category. Work is already under way to design generation 2 of the car.

Qian, Jia, and Song Jie.[4] Because of zero pollution there is the development of "future car" called solar car . In solar car there is no engine, gear box and other component. It is composed of battery board, storage appliances and motor. Aerodynamic drag will be the largest driving resistance replacing the other resistance for the normal car when its speed is more than 60-70 km/h. For the small power solar car, body design with less aerodynamic drag coefficient will be the focus Traditional method of automotive aerodynamics study is wind tunnel testing which requires higher quality facilities, longer research cycle and higher funds. With the development of computer technology, computational fluid dynamics (CFD) method in the automotive aerodynamic research is increasingly important. CFD method has a short cycle, low cost, no real vehicle models and other characteristics. Build geometry of the flow area, border type, and mesh generation using pre-processing software GAMBIT and output the format for the FLUENT solver two kinds of discrete format of first-order upwind and second-order upwind, first first-order upwind is used, after a certain number of iterations, second-order upwind scheme is used to improve the accuracy and convergence of the calculation and to reduce the computation time but it is difficult to converge final alteration therefore it is made by first-order upwind scheme. The resulting aerodynamic drag coefficient and the aerodynamic lift coefficient are relatively small.

Yesil, Engin, et al.[5] The employment of Big Bang – Big Crunch optimization method in World Solar Challenge is proposed in 2013. Renewable energy resources it is important to optimally utilize them in an efficient way Istanbul Technical University (ITU) Solar Car Team was founded in 2004 not only to practically design solar powered cars, but also to demonstrate how efficient an electric car could be and to promote the importance of clean energy. In order for a solar team to come in first place, solar car motor with a durable structural design and realistic estimation the optimization task. Low speed profile in case of cloudy weather, high in case of sunny conditions High speed profile in case of cloudy weather, low in case of sunny conditions, Constant speed throughout the race. The aim of the study is to determine an optimal strategy to minimize the race duration while supplying the race regulations and the constraints imposed by the environmental conditions.

Vincent, Vineeth V., and S. Kamalakkannan[6] A three-input hybrid system for solar car is designed . the are two storage element, one unidirectional input power port and two bidirectional power ports .Three different power operation modes are defied for the converter, Depending on utilization state of the battery. Battery charging in the system is carried out from the amorphous solar panel mounted on the body. The efficiency of the system will improve since the solar energy is directly given to the DC load. The capacitor which is connected to the lead acid battery will charge at off peak hours and discharge during the acceleration time of the car. In this proposed system energy wasted in the brakes are also recovered and used to charge the lead acid battery. Hence competent Hybrid Electric Vehicle was developed by using super capacitor and regenerative braking scheme. The simulation results of the proposed systems show that the performance of the vehicle was improved by providing better working conditions for the battery and increase its operating life, Source of energy extended up to the, regenerative braking scheme along with solar source, will increase the system reliability. Since the super capacitors have the ability to provide a large current in short time acceleration, performance of the vehicle will improve.

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Kawamura, Noritaka, and Mitsuharu Muta[7] first initiative towards low-carbon society by Japan government for eco model society from 2008. Toyota is the one of the 13 municipalities selected for the program .solar car charging system is located 20 km radius from Toyota city hall we have supported the reduction of CO2 emissions at charging station PHEVs is the changing station and to charge we need to use pure natural energy provided by the sun therefore it is charged by the electricity generated by the solar cell The solar cell is capable of producing approximately 1,400kWh per year, reducing CO2 emissions by 440 kg. The power conditioner converts DC power from solar generation or the power storage unit to AC power, and serves as the system's control center. When the electricity generated is not used for charging then it is stored in the power storage unit for future charging of PHEVs and EVs the solar charging system operates under four main modes depending on whether it is being used to charge PHEVs/EVs. There are four modes System is charging PHEVs/EVs, and power storage unit can provide electricity, System is charging PHEVs/EVs, and power storage unit cannot provide electricity, System is not charging PHEVs/EVs, and electricity can be charged to power storage unit and System is not charging PHEVs/EVs, and electricity cannot be charged to power storage unit.

Menasce, Daniel, Marthie Grobler, and Pieter Janse van Rensburg[8] The design of a solar car have a rules and this rules are regulated are contained in Technical Regulations for Alternative Energy Vehicles. The maximum area of the solar array is 6 m2 for an array built from silicon photovoltaic cells. This limits teams to approximately 1kW of energy generation. Furthermore the car may not be more than 4m long and 1.8m wide. There is a mass limit to the size of the battery pack based on the chemistry or type of cells. A team member of the 2003 World Solar Challenge winning team Nuna 2, analysed the difference between the first and second place teams in the 2011 World Solar Challenge. According to his calculations, a 10kg lighter car consumed 1.5% less energy, whilst 1% more efficiency in the electrical systems resulted in 1% more energy available to drive the vehicle.

The main parameter used in the selection or design of component for solar car are the Electric Drive , The Battery Pack and Photovoltaic System .The design of solar car by student will help in developing the student engineering skill ,team work, leadership and ownership.

Ahmed, Shehab, Ahmed Hosne Zenan, and Mosaddequr Rahman[9] The shape of the car is steam line to reduce the air drag and it is designed as two seats to improve the compactness of the car .the solar pannel is mounted on the roof of the car to collect the energy from the sun and convert it into usable electrical energy which is stored in the battery through the charge controller. In order to find the performance the present worth of all component .present worth of any item is the amount of money that need to be invested. The solar car with 2 seats contain 700 w motorwith 48 v battery with a capacity of 40 hp and 200w solar panel will be required to supply the necessary power

Ashrafee, Farin, Sayidul Morsalin, and Asif Rezwan[10] At present time, energy crisis has turned into a bulk throughout the world. Besides resources are decreasing with population increase .At present in 2012 world averaged energy demand is 17TW and 85% of this comes from fossil fuel but in 2050 the demand will be 30TW.As there lies shortage of electric power in Southeast Asian country, it has become a vital issue to initiate the use of renewable energy in developing countries like Bangladesh for reducing the demand of electricity. The design of a car main component include solar panel, wiper motor, wheels, shaft, battery, wood for frame, steel pipe for steering, tin plate for seat, washers, screws, clamps, pins Insulated wire etc. To invest in a project, an investor first has to think how much time it would need to recover his investments. The speed of the car can be increased by changing the car shape to airfoil. Because the value of drag coefficient is very small and this reduces the drag force. When the solar panel is charging the batteries, power tracker will help to protect the batteries being damaged by overcharging.

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III. RESULTS AND DISCUSSION

Initially, in order to evaluate the controller and converter performance, a transient circuit model implementing the P&O algorithm is developed. The steady state operation with the appropriate input and output values of flyback converter has already analyzed and illustrated in paragraph V. In a second step, step variation in solar irradiance is imposed, in order to evaluate the controller operation.

Considering a solar irradiance drop by 50% at time 0.5s, the output voltage of the PV system is shown in Figure 8. Controller duty cycle at MPP is equal to 0.45 and varies between two adjacent values, approving a satisfying performance as illustrated in Figure 8. The experimental voltage for a solar irradiation drop from 750W/m2 to 420W/m2 at time 0.6sec is depicted in Figure 9. From Figure 9 it can be observed that the control response adequately, reducing slightly the voltage of the PV array, at about 9%, in order to follow the MPP. The controller, for this worst case scenario of abrupt reduction of solar radiation, stabilizes after 1.5sec approximately.

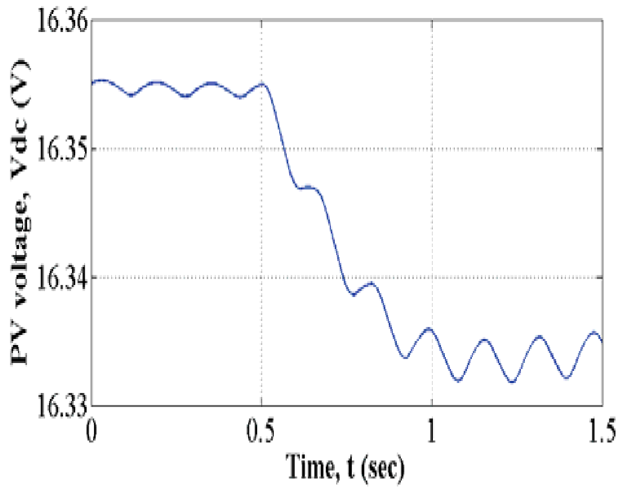

Figure 3. Simulated PV system output voltage under solar radiation drop by 50%

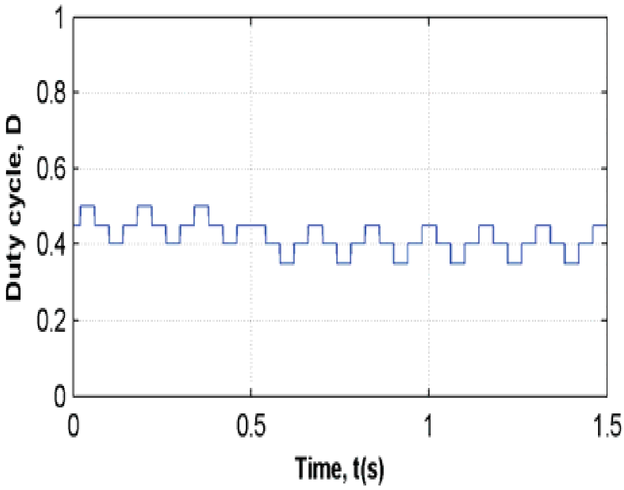

Figure 4. Applied duty cycle during irradiance variation

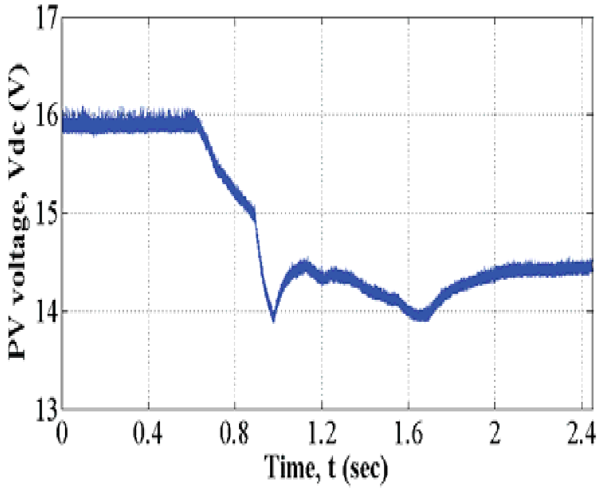

Figure 5. Measured PV array voltage for step variation of solar irradiance at t=0.6sec from 750W/m2 to 420W/m2

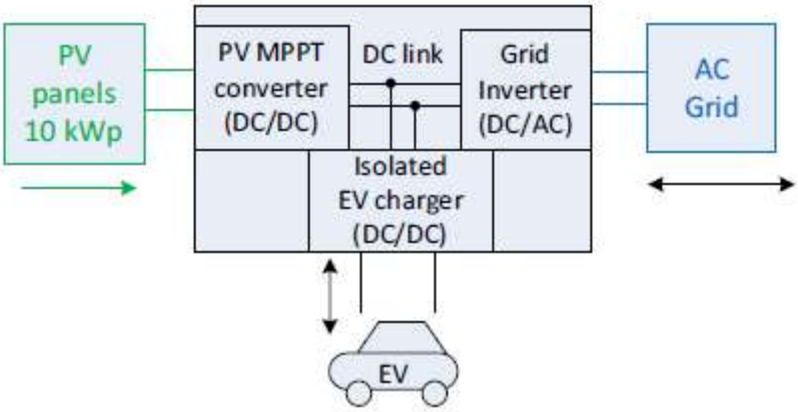

Fig. 6. System architecture of the grid connected 10 kW three-port EV–PV charger

Fig. 7 shows the state diagram for the operation of the EV–PV charger with local storage. Power is exchanged with the grid only when the storage is full/empty or if the maximum power limit of the storage is reached due to C-rate limitations. If there is a surplus of PV power above the EV demand, it is first used to charge the local storage, while a power deficit is first extracted from the local storage.

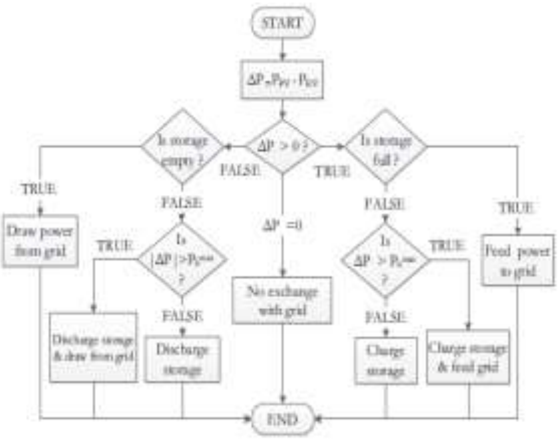

Fig. 7. State diagram for operation of EV–PV charger with local storage

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Fig. 8 shows the power exchanged with the grid and the stored energy in local battery bank for 2017 (1 min resolution), considering EV loads for both 7 days/week and only on weekdays using profile G4. For 7 days/week load, it can be clearly observed that the battery is eternally empty in the winter months due to lack of excess PV power for charging it. Similarly the battery is full in the summer months (Day 80 to Day 270) due to high PV generation.

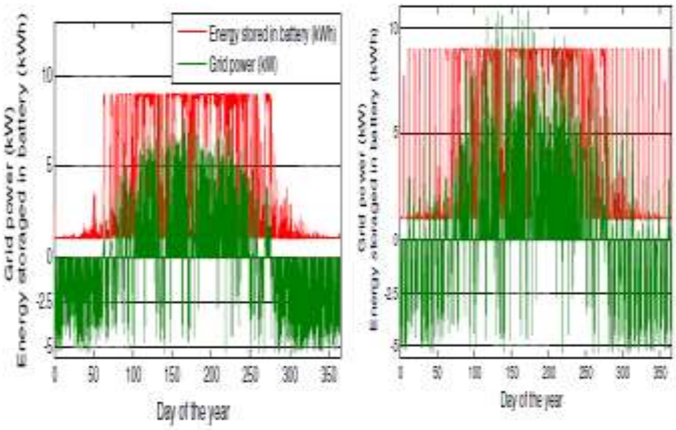

Fig. 8. Power exchanged with the grid (kW) and the stored energy in local storage (kW h) for the EV–PV charger for the year 2013 considering EV loads for 7 days/week (left) and only on weekdays (right)

IV. CONCLUSION

A photovoltaic (PV) charging station for electrical vehicles (EV) has been designed and is operating since one year in Madrid, Spain. The installation, named VELSOL, is able to recharge the daily operation of five EVs. It has a demonstrative character with the objective of promote the use of EVs in urban areas and its recharge with clean energy. Cars, and automotion sector in general, consume almost half of the world petroleum production and are one of the main direct cause of the urban pollution. With the objective of reducing this problem various options are being addressed over the world: reduction of the use of private vehicles in urban areas, increase its efficiency to reduce its consumption and use of new energy systems as fuel cells or EVs. The use of EVs can contribute significantly to the reduction of the environmental pollution in XX] century. Despite the history of EV is as old as the internal combustion engines, the recent technological evolution can make the electric transport competitive with the conventional one. Nevertheless, an effort should be made by the industry and governments to protect the environment. through economical incentives to develop and acquire EV. Cars manufacturers are developing new EVs that use high capacity batteries decreasing weight and volume and increasing autonomy. Despite some EVs models are available in the market; their implementation is mainly at demonstration level. Some expeflences in Florida (USA) and in some UE cities. 8 can be referenced as the most active around the world.

Workplace charging of EV from solar energy provides a sustainable gateway for transportation in the future. It provides a direct utilization of the PV power during the day and exploits the solar potential rooftops of buildings. In this paper, the PV system design and dynamic charging for a solar energy powered EV charging station for World is investigated.

Using data from KNMI, it was seen that the optimal tilt for PV panels in the World to get maximum yield is 28. The annual yield of a 10 kW PV system using Sunpower modules was 10,890 kW h. Using a 2-axis solar tracker increases the yield by 17%, but this gain is concentrated in summer. Solar tracking was thus found to be ineffective in increasing the winter yield, which is the bottleneck of the system. The average daily PV energy production exhibits a difference of five times between summer and winter. This necessitates a grid connection for the EV–PV charger to supply power in winter and to absorb the excess PV power in summer.

Since high intensity insolation occurs rarely in the World, the PV power converter can be undersized with respect to the PV array by 30%, resulting in a loss of only 3.2% of the energy. Such a technique can be used for different metrological conditions in the world for optimally sizing the power converter with respect to the peak power array for the array.
Dynamic charging of EV facilitates the variation of EV charging power so as to closely follow the solar generation. Since solar generation exhibits a Gaussian variation with time over a 24 h period, Gaussian EV charging profile with a peak at 1200 h and a peak lesser than the installed peak power of the solar panels would be most ideal. The exact value of the Gaussian peak and width are location dependent. EV charging using Gaussian charging profile G3 and G4 with peak power of 5 kW and 4 kW were found to closely follow the PV generation curve of World. They delivered 30 kW h energy to the EV for both 5 days/week and 7 days/week EV load and resulted in minimum energy exchange with the grid. For charging multiple EV at workplace, a priority mechanism was proposed that will decide the order of precedence for EV charging, based on stored energy and parking time of EV.
It was proved that a local battery storage does not eliminate the grid dependence of the EV–PV charger in World, especially due to seasonal variations in insolation. However small sized storage in the order of 10 kW h helped in mitigating the day–day solar variations and reduced the grid energy exchange by 25%. The storage remains empty in winter for 7 days/week load and gets periodically full in weekends for 5 days/week load. The storage sizing is site specific and methodology presented here can be used for different locations to determine the optimal storage size.

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