Designing of Solar Charging Stations for Electric Vehicle

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Abstract - *The transport sector generates more than 35% of total CO2 emissions. As you can see in the current scenario the electric vehicles are the future of every transport system and the demand for electric vehicles are growing tremendously. The government is also supporting the electric vehicle system and big company like Tata is investing huge on electric charging stations across India. The electricity generation in India is still depends on coal, oil and biomass was with the contribution of more than 80%. So, to make the electric vehicle system complete green solution there is a demand to make the solar powered EV charging system. So here in this report the complete design of solar charging station for electric vehicle is done. The parameter considered for designing the charging station are the efficiency of solar panel and its types, with detailed study of charge controller and battery. The complete design of solar panel its type and size are calculated and also the area required for charging the electric vehicle by taking the example of Tata Nexon is done. The various type of losses like conversion losses in solar panel battery inverter and wires are considered, along with the environmental losses and design losses.*

***Key Words*: Solar system, Design, Charging station, electricity, Electric Vehicle.**

1.INTRODUCTION

India is the world's third largest producer and third largest consumer of electricity. Energy use has doubled since 2000, with 80% of demand still being met by coal, oil and solid biomass (Fossil Fuel). Share of Renewable energy is around 20%. According to NITI Aayog's energy policy report, India's demand for energy is expected to double by 2040, and that for electricity to potentially triple as a result of increased ownership of electric vehicles. As electric vehicles are going to increase in future, this will create heavy load on electricity demand in future. There should be development of charging infrastructure for electric vehicles, which should be operated with the help of renewable energy. Solar charging stations is the best option. First, electrification will change our global energy consumption habits from the need for fuels that are burned on site - gasoline, oil, natural gas and others - to the need to use electricity. This means that our country's demand for fossil fuels will decrease, while our overall electricity demand will increase. Solar power generation is very influential in India. The geographical location of the country is favourable for the production of solar energy. The reason is that India is a tropical country and receives solar radiation almost all year round, which amounts to 3,000 hours of sunshine yearly. The use of solar power can reduce our dependency on fossil fuels for electricity generation.

2.PROBLEM DEFINATION

One important goal of the climate commitment is to reduce primary energy demand in the transport sector and increase the use of renewables, since around 33% of primary energy is consumed in this sector. As the world's resources become more and more depleted, so does the government. agencies and NGOs advocate a greener solution through the use of renewable energy sources, as electric power must become less dependent on fossil fuels and transportation must become more electric to reduce carbon emissions and mitigate climate change.

3.AIM AND OBJECTIVES

The main objective of the project is to design the EV charging station for actual available car model in Indian market considering all the parameter like sun light availability, charging area required for solar panel, battery and power calculation and considering each and every parameter about charging and equipment. The design should be such that after referring the document user should be able to install the solar EV station very easily. And also, to avoid local grid overload and guarantee a higher percentage of clean energy, EV charging stations can be supported by a combined system of grid-connected photovoltaic modules and battery storage.

4.SCOPE

The demand for rooftop solar charging stations is expected to increase in the near term as the number of electric vehicles increases. Solar energy can serve as an alternative source of power, and utilized to address excess demand for electricity. India can use solar power for electricity generation and store energy in batteries. Further this can be used to charge the electric vehicles. This will not only fulfill the deficit of power generation but also contribute largely in Green Energy Production to help to reduce the Climatic Changes problems.

5.LITERATURE REVIEW

One Before Elangovan , Deepa , Maheshwari (2015) discuss about the efficient utilization of solar energy using

SLC. The presented SLC is closed loop controlled using FPGA Spartan 6 processor. The suggested SLC influences the quality of DC link voltage and transfer gain. The attained DC link voltage is three times greater than that of the voltage from the PV array. Also, the ripple content in the DC link voltage is less than 1%.

Pavan, Vijayendra, Shashikala (2015) present a proposed charging station microgrid model for off-grid EV charging station with the integration of renewable energies such as solar photovoltaic, wind, Fuel Cell with provision for storage with mainly battery and optional storage with ultra-capacitors has been presented.

Vishal, Vaidya, Kaiwalya. Kulkarni (2015) have done the team's research indicated a benefit to the campus for such a structure and also room for improvement on other existing charging stations. Other stations the team found were quite expensive to build. Additionally, solar designs and innovations are rapidly advancing which could contribute to a more efficient charging station.

Simon Steinschaden and José Baptista (2015) discuss about the tool has been developed to help find solutions for each combination of charging station properties, most efficient combination. It emerges that solar charging stations for private and commercial use can be design. In summary, due to the ease of management and simplicity of the tool compared to alternative computing software, this tool is suitable to suit a wide range of audience groups including professionals and non-professionals. However, all the necessary parameters for the design of a solar charging station are taken into account. The results are comparable with solar power design, self-sufficiency rate, self-expenditure and payback period.

Gheorghe Badea, Raluca-Andreea, Felseghi (2015) examines the possibility of charging electric vehicle batteries with clean energy using solar autochthonous renewable resources. At the charging station of a photovoltaic module and battery-based electric vehicle, an island system was designed, sized, and simulated in operation. The optimal configuration of the photovoltaic system was supplemented with Hybrid Optimization software enhanced by Genetic Algorithm (iHOGA) version 2.4 and we simulated its operation. The solar power system should be designed so that the charging station always has enough electricity to power multiple electric vehicles 24 hours a day.

6. METHODOLOGY

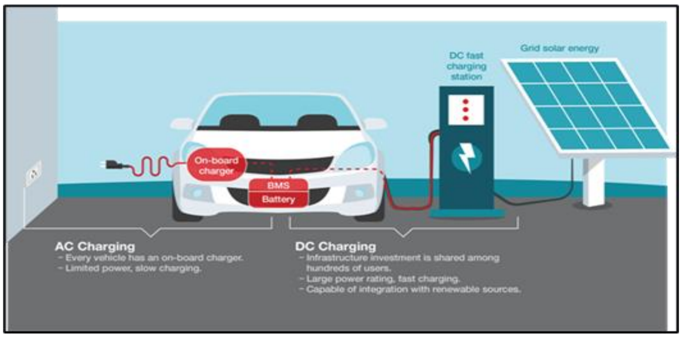

Fig -1: Solar powered E V station

1.1 Components

Before a) Solar Panel: Solar panels are made of several layers of material. The top layer of glass protects the smaller individual units called solar cells. Two layers of semiconductor silicon are there on solar cells. Silicon brings electrons together and allows them to move through positive and negative charges. Each solar cell is connected together to form a solar panel.

b) Charge controller: A solar charge controller works as a regulator for your solar battery that prevents it from overcharging and overheating. Batteries are rated at particular voltage capacity, and exceeding that voltage can lead to permanent damage of the battery and loss of functionality over time.

c) Solar tracker: Using Solar Tracker systems increases the amount of solar power which is received by the solar energy collector and improves the energy output of the electricity which is generated. The solar tracker will boost the output of solar panels by 20-30%, which increase the system economics of the solar panel project.

d) Batteries: Batteries in photovoltaic systems are subject to frequent charging and discharging. Lithium-ion batteries with deep discharge technology is commonly used for automobiles and for PV applications.

e) Ev Charger: EV Chargers depending upon their rated capacity can charge your EV at much faster rates (multiple times) compared to 13A plug point. EV chargers come with multiple built-in protection systems that improve overall safety. EV charger comes with OTP/RFID authorization system. So, you can rest assured that no one can abuse the toll booth in your parking lot without your permission. Most EV chargers come with features like remote control and access, smart charging, and more. which is not available in the 13A socket.

f) Inverter: It is a combined solar inverter and EV charger that can charge from rooftop solar panels directly. Integrating the charger with a solar inverter is a smart solution that eliminates the need for a separate EV charger as well as additional wiring and possible electrical upgrades.

1.2 Calculations

Sample Calculations are done considering Tata Nexon EV car model as an example to understand the complete system

Calculation for solar system [at 1000W/m2 of solar irradiance at 25 0c.]

Consider, 50 KW of solar system [i.e., daily output]

Average sunshine in hours in India = 5 Hours.

(50 KW-hr)/5 hrs = 10 KW

10 KW system will be needed.

∴ 10 KW * 5 hours = 50 KW daily output.

Considering, solar panel with peak power = 385 Watts with, Maximum voltage = 40.3 V.

Maximum current = 9.56 Amp.

P = V * I

∴ No. of panels required for 10 KW system is,

$((10 * 10)^3$ Watts)/385 Watts = 25.97 = 26 panels.

Panels are connected in series to increase voltage output & connected in parallel to increase current output.

Solar panel dimensions are:

Length = 197.6 cm,

Width = 99.1 cm,

Thickness = 3.5 cm.

∴ Area of Solar Panel = Length * Width

= 19582.16 cm2.

= 1.95 m2.

∴ Area for 26 panels = 26 * 1.95

= 51 m2.

Calculation for solar panel - area

Dimensions of Tata Nexon EV are:

Length = 3.99 m,

Width = 1.811 m,

∴ Area of Tata Nexon EV = Length * Width

= 3.99 * 1.811

= 7.233 m2.

∴ Total Plant Area = Area for 26 panels + Area of Tata Nexon EV.

= 51 + 7.22

=58.23 m2.

∴ Minimum Area required for Solar Charging Station is 60m2

Calculation for batteries

The nominal voltage of Lithium-ion battery is 3.60V/cell and current is 2600mah.

P = V * I

P = 3.60 * 2.6

P = 9.36 Watt [For one cell]

We considered the Lithium polymer battery of Tata Nexon EV with following specifications:

Capacity: - 30.2 KW-hr & 320 V Lithium polymer battery.

To get the no. of cells in a battery pack,

Total output power = 30.2 KW

Output power of one cell = 9.36 Watts

∴ No. of cells = $((30.2 * 10)^3$ Watts)/9.36 Watts

= 3226.49 cells

No. of cells ≈ 3227 cells.

Battery of Tata Nexon EV: -

Calculating ampere output of battery

P = V * I = $(30.2 * 10)^3$ = 320 * I

∴ I = 94.375 Amps.

∴ To calculate no. of cells in series / parallel.

(P(Battery))/(P(cell)) = (V(Battery))/(V(Cell)) (I(Battery))/(I(Cell))

$(30.2 * 10)^3/9.36$ = 320/3.6 * 94.375/2.6

3227 = 88.88 * 36.29

3227 = 89 * 36

∴ 89 cells are connected in series & 36 cells are connected in parallel to meet the battery capacity.

Operating voltage for batteries

∴ Lithium-ion will operate safely within the designed operating voltages.

Normal cell voltage = 3.6 V

Typical end of discharge = 2.8V – 3.0V

Maximum Charge Voltage = 4.2 V.

As 89 cells are connected in series,

∴ [89 * 4.2 = 373.8 Volt] is the maximum charge voltage of a battery pack.

Voltage should not exceed this value; it may lead to temperature rise & battery damage.

∴ [89 * 2.8 = 249.2 Volt]

i.e., when voltage reaches 249.2 Volt hence, battery will be in discharged state.

1.3 The major losses in the solar power generation

During the conversion of solar energy into electrical energy there are multiple process involved. Due to complex system, there are many losses involved during conversion. The solar energy received by the PV panel is much higher than the electrical energy we get as an output. Due to multiple components involved in the PV System most of the energy in the solar power system is either lost as the conversion loss within the components or as a transfer loss through wires. As we know we cannot fully convert one form of energy into another due to the number of system complexity and due to the presence of losses. We cannot convert an equal amount of one form into the equal amount of the other form. For example, Conversion loss.

As we know that no system on the planet is fully efficient, i.e., it cannot convert a certain fraction of the energy as we gave as input into the useful energy and the remaining energy is lost in the environment.

1) Solar panel: The basic function of the solar PV panel is to convert the solar irradiation into the DC electrical energy. Not all the sunrays falling on the panels is converted into the DC electrical energy, some amount of percentage of it is been reflected back or gets dissipated as heat into the environment. In the afternoon and the clear sky, a solar (PV) panel of 1 m^2, keeps flat on the earth's surface receives around 1,000 watts of solar energy. It is used to convert a small percentage, at about 18%, efficiency of solar panel, of the solar energy into electrical energy. The remaining 82% of the power is either reflected back or dissipated as heat into the environment. This is known as the conversion loss of the energy. The function of the solar charge controller is to protect the battery from getting overcharged.

2) Battery: When the energy is not being used from the PV panels to charge the vehicle, then that energy is used to store in the solar batteries in the form of chemical energy which later that energy can be used to charge the vehicle, when there is insufficient number of sunrays or during late night. The main function of solar batteries is by converting chemical energy into DC energy and during these electrical conversion losses may occur. If for example battery is 80% efficient then the battery will convert 80 % of stored chemical energy into DC electrical energy.

3) Inverter: The energy after getting converted into DC electrical energy by the solar panels is passed through the inverter. The main function of the inverter is to convert a DC electrical energy into AC electrical energy. It is the conversion of energy from one form to another. For example, an inverter is 95 % efficient, means that it is able to convert 95 % of the input DC electrical energy into AC electrical energy. It will convert those 380 watts of DC electrical energy into 95 % of 380 or 361 watts of AC electrical energy. Those 19 watts are lost as conversion loss into the system.

4) Wires: To transfer the electrical energy from one component to another we need some medium, wires do the best role of it. Copper wires are mostly used in electrical systems due to its low resistance to electrical flow. Different components present in the solar power station are connected through copper wires. When the electricity passes through the wire, some of the energy gets lost as a heat into the environment. The distance between the equipment's used in the solar system should be within a specific range. If the distance increases the wiring size will increase and will lead to waste of energy. Therefore, minimum or optimum distance should be kept and the correct sizing of the wires between the various components and the electrical load should be selected. For example, If the wire losses are 2% inside the solar power plant so, the DC electrical energy that is 2% of 380 watts that is equal to 7.6 watts are lost as heat.

5) Design loss: The panels give maximum efficiency when the sunrays angle falling on the surface of the solar panel is perpendicular. But due to relative motion between sun and the earth the sun rays cannot be every time normal to the solar panel surface. As we know solar trackers helps the panel to move from east to west in line with the sun's motion to get the maximum sunrays, but as the solar trackers are very costly so it is not feasible to fit the solar trackers for small units. Therefore, the optimum way to tackle the cost and to limit the use of solar tracker, is to find optimum tilt and orientation of the panels relative to the sunrays so that panels get maximum sunlight in the day. The tilt and the orientation depend on the region where the panels are installed.

6) Loss due to ageing: Solar PV panels usually degrades with time and produce less DC current and becomes less efficient. The output power of the solar panels reduces nearly to 80% of their rated power in the 25th year. For example, a solar panel of 380 watts will produce 80% of 380 = 304 watts after 25 years due to degradation with time.

7. CONCLUSION

As we know 21 cities amongst world's 30 most polluted cities are from India and India stands 5th in the most polluted countries list. The electricity generation sector is currently the greatest carbon emitter in India. Also, carbon particulates emissions from the automobile sector are rapidly increasing due to increase in the number of gasolines powered vehicles. The effective control of pollution from these two emerging sectors is related to the greatest achievement of pollution control objectives. Thus, this paper tries to develop a model that combines solar powered charging stations for Electric Vehicles and use of EV's to simultaneously reduce pollution from the power generation sector and automobile sector.

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