World Journal of Advanced Engineering Technology and Sciences

eISSN: 2582-8266

Cross Ref DOI: 10.30574/wjaets

Journal homepage: https://wjaets.com/

(Review Article)

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Designing of charging station by renewable source of energy and by conventional ac system: A case study on electric vehicle

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World Journal of Advanced Engineering Technology and Sciences, 2023, 09(01), 008–016

Publication history: Received on 19 March 2023; revised on 29 April 2023; accepted on 02 May 2023

Article DOI: https://doi.org/10.30574/wjaets.2023.9.1.0128

Abstract

Today it is very necessary to develop different types of system used for storage and energy conversion devices because human population is increasing rapidly and their dependency on energy based gadgets for their survival. So for this purpose there is a greater need of devices which may be operated on either conventional energy sources or non-conventional energy sources but for environment friendly purpose use of solar energy becomes very popular because of diminishing fossil fuels because of concerns of greenhouse emissions.

Keywords: Electric Vehicle; Solar PV cell; SAE J1772 Charger; DC-AC Converter; PWM Controller

1. Introduction

Our Project is based on Electric Car Charging by Solar Energy and by General AC Network.

Today it is very necessary to develop different types of system used for storage and energy conversion devices because human population is increasing rapidly and their dependency on energy based gadgets for their survival. So for this purpose there is a greater need of devices which may be operated on either conventional energy sources or non-conventional energy sources but for environment friendly purpose use of solar energy becomes very popular because of diminishing fossil fuels because of concerns of greenhouse emissions.

A Solar Energy is defined as the energy obtained from the suns radiations which fall on the earth's surface this energy is assumed be environmental friendly and can be obtained from artificial photosynthesis, solar photovoltaic and solar heating. It is Evident that at the core of the sun the solar energy is in the form of nuclear energy due to the collisions of atoms of Helium and Hydrogen a amount of radiation which has a approximate numerical value about $3.8 * 10^{26}$joules per second.

With the abundant option of renewable energy sources only solar energy is found to be effective with the comparison of normal AC voltage supply and will find out reliability, sustainability and efficiency between both of the energy system to access electric car charging because at some places it is very difficult to provide AC systems. Solar energy is found to be effective because of the easy availability and environmental friendly and it is better option to greener community.

2. System design description

Basically a system design helps to the researchers how our model is actually structured and designed which actually a pictorial form of our actual installed system which includes all the steps to achieve our required goals. This design helps

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in many ways to researchers to find a problem and their solution a figure is shown below in which six subsystem which we have discussed earlier includes microcontroller , solar panel , storage battery , AC net , car battery and inverters.

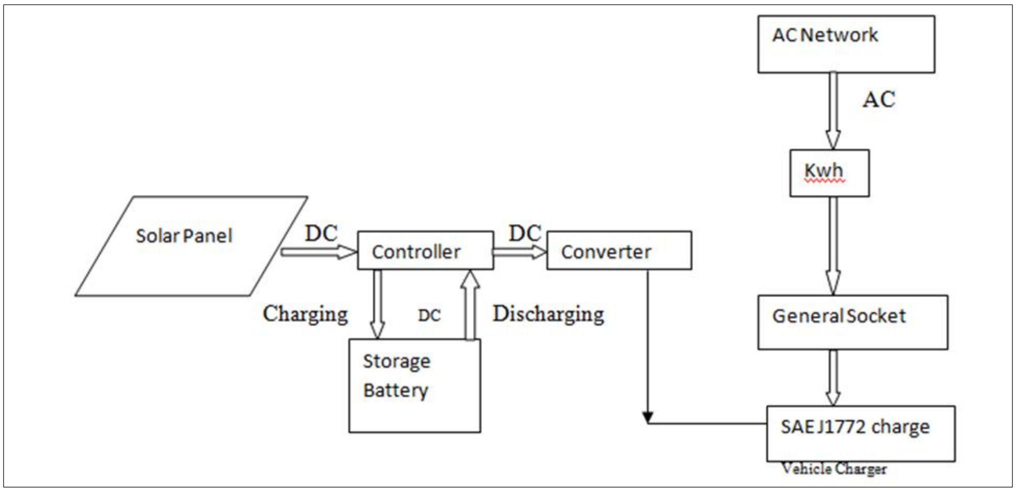

Figure 1 System Structure

3. Controller description

Basically a microcontroller is a part of system which regulates the current/voltage between batteries it is basically a electronic apparatus it monitors complete battery discharging or overcharging. It protects battery and increases their life. It could be referred as standalone apparatus or IC system that is integrated circuit system is attached to a battery system. It consist of mainly three parts

- MPU controller
- PWM controller
- MPPT controller

4. Storage battery connections

So here we are discussing about how batteries are configured for that some specification like controller and photovoltaic module are required and the way they both connected and gives output power.

A formula is shown below which shows the relationship between PV phalanx and the battery storage unit.

$$P_m = Q_L f / KT_m$$

Where
C_w= Battery Unit Capacity in kWh
Q_L= Amount of energy to be delivered to appliances
d = Days when no sunlight is present we assume d=2
f =Charging Quantity / Discharging Quantity = Discharge Coefficient
k=Loss between battery and appliances
D=Battery discharge level Depth it is assumed 80%
P_m = Single PV phalanx Peak Power =350W total 21 PV modules in a single PV phalanx = 7350 W
T_m=Peak Sun Hours assumed 2.8

From above two formula

$$C_w = P_m d T_m / D$$

$$= 7350 \times 2.8 \times 2 / 80\ \% = 51450 \text{ Wh}$$

The voltage for each battery is 12V and the all the batteries are connected in series and the system voltage is 240V so we need

$$240/12= 20 \text{ batteries.}$$

Batteries are connected in series to increase the system voltage as we know the voltage remains in series and divided in parallel connection.

Capacity of each battery is

$$C = C_{w\,/}\ \text{System voltage} = 51450\ \text{Wh} / 240\ \text{V} = 214.38\ \text{Ah Approx.}$$

We selected model number BAT41201080 battery which has a capacity of 220Ah which is higher than what we calculate here. It shows what we select here is giving higher output which satisfy our demand.

Some batteries we showing below with their Ampere Hour and Voltage.

Table 1 Battery Model Number

BATTERY MODEL NUMBER	AMPERE HOUR	VOLTAGE	L × W × H	WEIGHT
BAT412101080	115	12	325x182x220	33
BAT412121080	130	12	410x176x227	38
BAT412151080	167	12	475 × 171 × 240	48
BAT412201080	220	12	522 × 238 × 240	66

The controller that we are using has four electrical circuits and individual circuit is designed for particular voltage and current that is 240 Volt and 5 Ampere same is the input voltage for individual battery.

5. Charging mode selection

All the electric vehicle have different types of charging modes but all the EV supported home electric plug sockets and follows SAE J1772 slandered charging or DC fast charging. In all above modes DC fats charging is latest and common now a days , number of vehicle supports this mode.

Charging rate in DC charging mode is 20 to 30% higher than the AC charging. In one hour they charge 80 % . In INDIA there are two methods are following for charging listed below

- CHAdeMO
- Combined charging slandered

One drawback is they consume high power but its efficiency is higher. If DC charging is implemented in system, CHAdeMO charger provides nearly 40 KW power for that we need 114 solar photo voltaic module each of capacity around 350 WATT then they will provide 40 KW output for one DC charger. Here we have 840 Modules in our system it is assumed.

$$So=350 \times 840 \times 2.8 / 1000$$

$$=823.2 \text{ kwh}$$

350- Each panel capacity
840- Number of modules
2.8 – Assumed maximum sun shine per day

So we get maximum output nearly 823.2 Kwh and it can support DC charger for

= 823.2 Kwh / 40

=20.58 Hour / Day

If we want to use more number of chargers then

=350 × 840 / 1000 × 40

=7 DC fast chargers will provide the required power

Only DC charging is not enough to charge the system we need some extra technology which is fast charging which is now as SAE J1772 standard charging and new vehicle coming supports this technology also house hold charging obviously. So in INDIA there are two standard of charging discussed above. Difference between two is that one is getting power form solar PV module another from GRID as house hold supply. General socket is also available in EV to make the charging efficient whenever necessary this option is also open it makes charging available all the time.

So let us talk about mostly specked charger that is SAE J1772 standard charger.

6. SAE J1772 Standered charger

Figure 2 SAE J1772 STANDERED CHARGER

This charger is based on American standered of electrical safety for electric vehicle and this charger is cared by SAE. SAE is a global association of commercial vehicle industry. This charger follows the protocol of below fields-

- Communication
- Physics
- Electrical

Now we discuss parameters of SAE chargers for our system

6.1. SAE charger specification

Table 2 SAE Charger Specification

	Level of Voltage	Supply Phase	Maximum current	Rating of Power
Level 1 Alternating Current	120 Volt	Single Phase	15 A	1.94 kW
Level 2 Alternating Current	220-240 Volt	Split Phase	80 A	19.31kW

Today most of the electric vehicle employs SAE based charger with the level 2 alternating current so we also employ level 2 for further proceeding.

So to apply this charging technology we adopt a charger named as Clipper Creek HCS 40 Charger specification is listed below

Charging Power = 31.9 Amp Approx.

Product Dimensions = 20L x 9W x 6D

Input current = 40 Amp

Frequency = 50 Hz

Warranty =5 Years

In INDIA general power socket for EV are

7. Charging time and power consuming

Table 3 Charging time and power voltage and current specification

Car Model	Capacity in Kwh	POWER IN Kw	CURRENT IN AMP	CHARGING TIME in hours
TATA TIAGO EV	24 Kwh	5.2	22.3	3.6
KIA EV6	27Kwh	5.6	27.5	4
TATA TIGOR EV	19.2Kwh	4.2	22.3	3.2
HYUNDAI KONA ELECTRIC	39.2Kwh	5.6	15.6	5.5
BMW Ix	22kWh	3.3	13.8	7
BMW i7	22 Kwh	3.3	13.8	7
MAHINDRA XUV 400	39.4Kwh	5.6	16.6	6.5
TATA NEXON EV	19.2Kwh	5.4	24.4	3.1

So from this table we can charge all these with SAE J1772 charging because of average charging power which is nearly about 5.4 kW. However our charger is providing maximum power of 7.7 Kill Watt Hour.

Power consuming by charging is = 4.9kW

Average charge taken by vehicle to get fully charge= 6.2 Hours by the table

8. Arrangement of chargers

As we know

$$P_m x\ T_m = 350 \text{ x } 840 \text{ x } 2.8 = 823.2 \text{ kWh}$$

And

Average Power consuming by charging is = 4.9 kW

Total time for charging is = 823.2 kWh / 4.9kW

= 168 H

Average charge taken by vehicle to get fully charge= 6.2 Hours

So number of chargers will be = 168 / 6.2 = 27 chargers

Each charger is available for separate vehicle so at a time 27 vehicles can charge

9. Results and discussion

In this section we will conclude our study based on this we will find which option for EV charging is suitable although both the systems have shortcomings, but based on our study we will make some graphs for each parameter also we will do the simulation of Photo-voltaic module and battery will show the result of battery charterstics and battery voltage for various loads

9.1. Modeling of solar cell

The equation for solar cell modeling is given below-

$$I = I_{lg} - I_{os} \times \left[\exp\left\{q \times \frac{V+I \times Rs}{A \times k \times T}\right\} - 1\right] - \frac{V+I \times Rs}{Rsh}$$

$$I_{os} = I_{or} \times \left(\frac{T}{Tr}\right)^3 \times \left[\exp\left\{q \times Ego \times \frac{\frac{1}{Tr} - \frac{1}{T}}{A \times k}\right\}\right]$$

$$= I_{lg}\ \{ I_{scr} + K_i \times (T-25)\} \times \boldsymbol{\lambda}$$

$$I = N_p \times I_{lg} - N_p \times Ios \times \left[\exp\left\{q \times \frac{\frac{V}{Ns} + I \times \frac{Rs}{Np}}{A \times k \times T}\right\} - 1\right] - \frac{V \times \left(\frac{Np}{Ns}\right) + I \times Rs}{Rsh}$$

Where

I & V: Photovoltaic cell output current and voltage;
Ios: PV cell reverses saturation current;
T: Solar cell temperature in Celsius;
k: Boltzmann's constant, 1.38 × 10−19 J/K;
q: Electron charge, 1.6 × 10−23 C;
Ki: Short circuit current temperature coefficient at Iscr;
λ : Solar cell irradiation in W/m2 ;
Iscr: Short circuit current at 25 degree Celsius;
Ilg: Light-generated current;
Ego: Band gap for silicon;
A: Ideality factor;
Tr: Reference temperature;

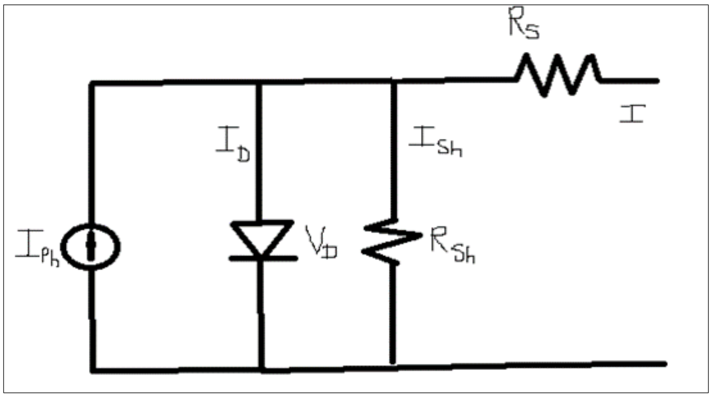

Figure 3 A single solar cell module

Above solar cell works on constant current source with minimal values of working voltage and a constant voltage source with minimal values of working current.

Specification of solar cell being already discussed two parameter to be discussed are $V_{O.C.}$= 32.6 V and $I_{S.C.}$= 8.5 A

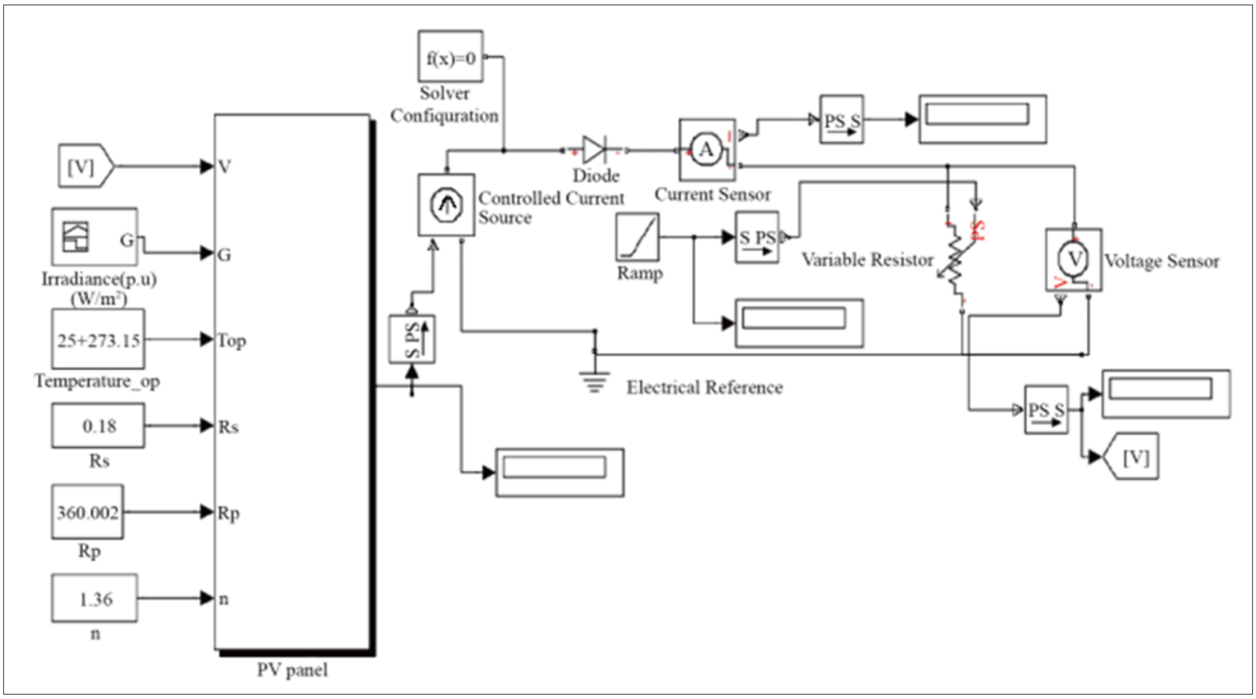

Figure 4 PV Panel Simulink

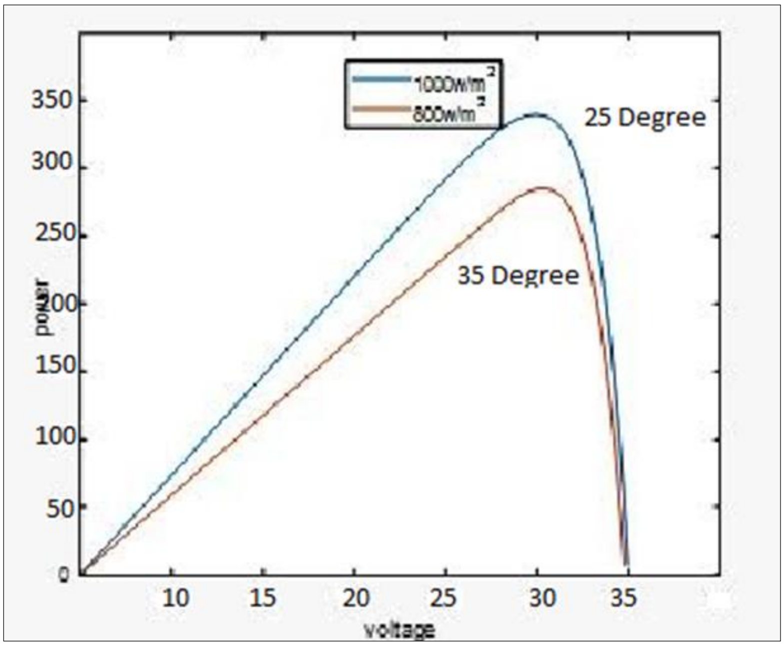

Figure 5 Power Vs Voltage Characteristics of PV Module for Different Temperatures

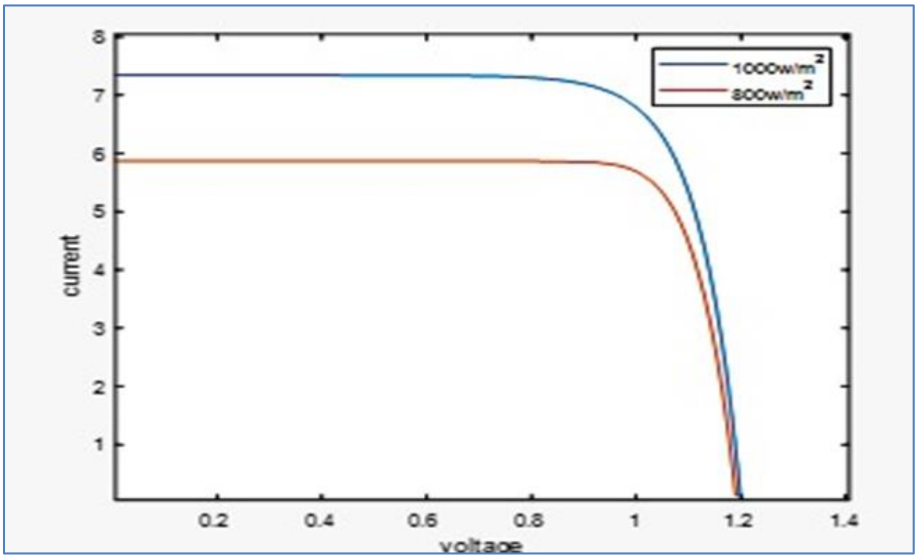

Figure 6 Voltage Vs Current Characteristics of PV Module for Solar Irradiance

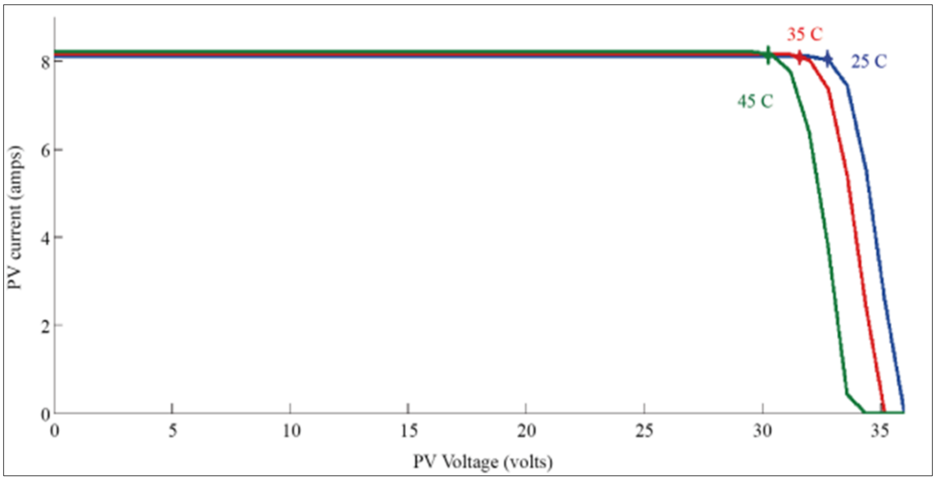

Figure 7 Voltage Vs Current Characteristics of PV Module for Different Temperatures

- Grid system has higher efficiency then the solar system so this aspect belongs to grid system.
- Grid system has higher cost of installation then the solar system so this aspect belongs to solar system.
- Less Charging time and less power consuming by vehicles in grid connected system which is better than the solar system.
- Grid system has reverse powering capacity as it supports V2G operation which belongs to grid system as solar system does not have this capability.
- Cost of electricity production by grid is 8.9Rs/Unit while in solar it is 5.3Rs/Unit , solar system is efficient in context of charges per unit
- Very less carbon emissions CO2 in solar connected vehicles which reduces the global warming.
- There is no need of separate land in solar system as parking itself has rooftop solar
- Power generation is available all the time in grid connected system while it is not possible in solar system.

10. Conclusion

In this project work we have taken two power entities for charging of electric vehicle that is solar powered electric vehicle and grid connected electric vehicle. With the help of experiment we have determine number of parameters. The main purpose of estimation is to find out the best source of power generation in order to reduce cost, environmental aspects and many more.

Compliance with ethical standards

Acknowledgments

I am grateful to all of those with whom I have had the pleasure to work during this and other related projects. Each of the members of my Research Paper Committee has provided me extensive personal and professional guidance and taught me a great deal about both scientific research and life in general.

Disclosure of conflict of interest

All manuscripts for articles, original research reports, editorials, comments, reviews, book reviews, and letters that are submitted to the journal must be accompanied by a conflict of interest disclosure statement or a declaration by the authors that they do not have any conflicts of interest to declare. All articles that are published in the journal must be accompanied by this conflict of interest disclosure statement or a statement that the authors have replied that they have no conflicts of interest to declare. If a journal prints unsigned editorials, they should not have been written by anyone with a conflict of interest.

References

[1] K.W.E. CHENG, Recent development on electric vehicle, 31 (2009): pp. 171–192

[2] http://www.ireda.gov.in

[3] http://mnre.gov.in/prog- biomasspower.htm

[4] Biberacher M. ,Dominguez J and Angelis-Dimakis A., Renewable and Sustainable Energy Reviews, Methods and tools to evaluate the availability of renewable energy sources,15 (2011): pp. 1182-1200

[5] www.iea.org/Textbase/techno/essentials.htm

[6] D. Barapatre., C. Kanfade., A. Bari, Ravindranath,Electric vehicle, 29 (2005): pp. 178–190

[7] Zhu J.Y. and Pan X.J. Bio resource Technology, Woody biomass pre-treatment for cellulosic ethanol production: Technology and energy consumption evaluation, Bio resource Technology, 101 (2010): pp. 4992–5002