DESIGN AND IMPLEMENTATION OF AN OFF GRID 2KWp PV SYSTEM WITH MPPT FOR ILLUMINATION OF LED LIGHTS

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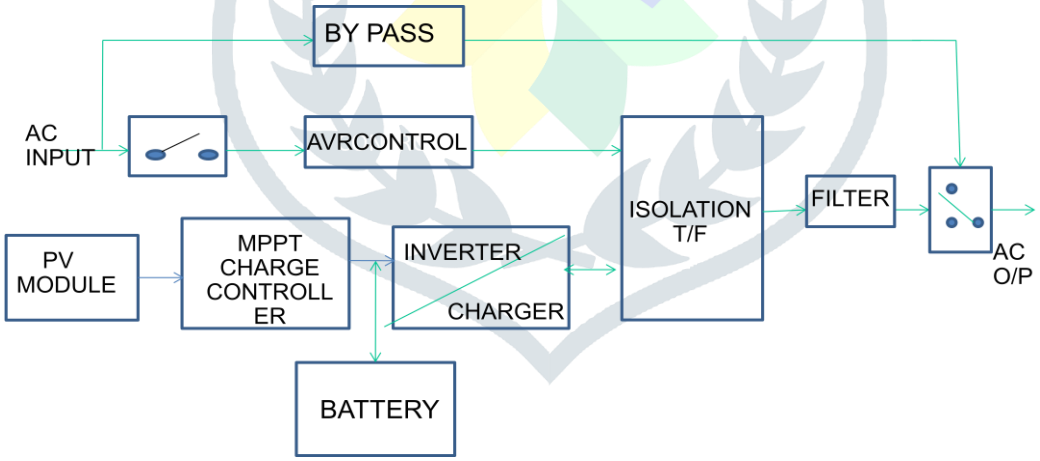
Abstract: An off-grid 2 KWp solar system is designed and implemented for illumination of LED Street lights in college campus. This paper mainly focused on various design aspects like PV sizing, Battery sizing and MPPT based Inverter sizing also required protection like DC and AC side earthing along with Lightening arrester followed by cable sizing. In this computation the shortest day of the year has been assumed. Although the total design is acceptable from engineering point of view, from economical view the total Cost of system is higher than the case that has been designed for summer days. Also presents various steps to be followed while installation and testing of off grid solar system.

Index Terms: **PV Sizing, Inverter Sizing, MPPT, Battery Storage**

1. INTRODUCTION

As the non renewable sources are decreasing, use of renewable sources for producing electricity is increasing. Solar panels are becoming more popular day by day. Solar panels absorbs energy from sun and converts into electricity by photovoltaic effect which can be stored in the batteries up to some extent that can be utilized when ever required. To increase the system efficiency the solar panels should absorb the maximum energy to a maximum extent. The solar is the more efficient renewable resource compared to other renewable resources like tidal energy, wind energy, bio-mass energy, geo-thermal energy etc. The solar energy give having efficiency around 15-18% and the life time is 25 -30 years.



Functional Block Diagram.

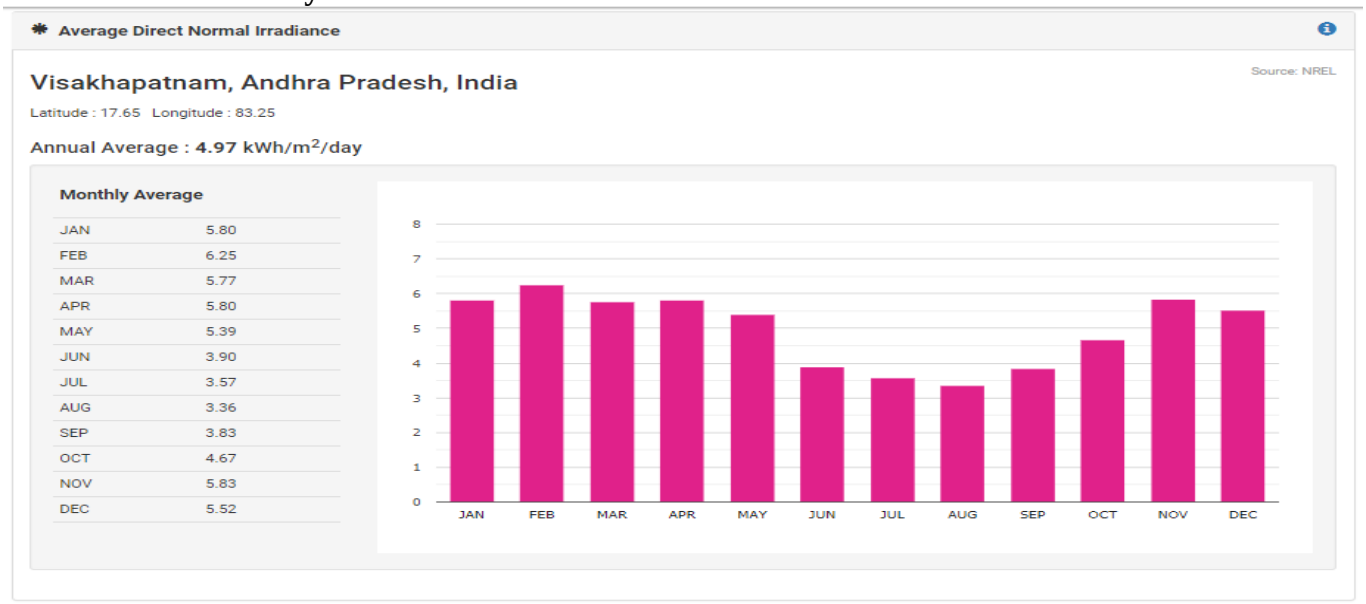
In order to compute the off-grid solar system components, solar data for Visakhapatnam district is obtained from NREL web site. The design was done based on the shortest day of the year. This paper also describes grid sharing facility in order to improve the life of batteries and to provide continuous power to loads during bad atmospheric conditions. Maximum power point tracking technology used in order to extract maximum possible energy at any irradiation level by operating PV modules at Vmpp. Loads are smoothly transferred on to grid while solar generation low and SOC of battery bank falls bellow preset value.

The rest of the paper is organized as follows: Section II briefly presents Design factors to be considered for solar photovoltaic system. Section III shows various steps of installation process along with safety rules to be followed. Section IV deals with results and discussions

II DESIGN METHODOLOGY

Design of solar system includes following steps wise Solar data analysis, Load Estimation, Battery Sizing, PV sizing followed by Inverter sizing.

A. Solar data analysis



B. Load Estimation

Sr. No	Equipment Name	No of Units	Watt/Unit	Wattage	Usage Hr/Day	Watt Hr./Day
1	LED LAMPS	6	80	480	12	5760.0
2	LED LAMPS	2	40	80	12	960.0
3	LED LAMPS	1	40	40	12	480.0
				600	12	7200.0

C. Battery Sizing: Required battery bank for above estimated load is designed by using following parameters

Amp Hour removed = Energy required/operating voltage
Batter Bank Required = Amp Hour Removed/DOD
Series Batteries = Operating voltage/Each Battery Voltage
Parallel Batteries = Total Amp Hour/Each Battery Ah

Battery Bank Details

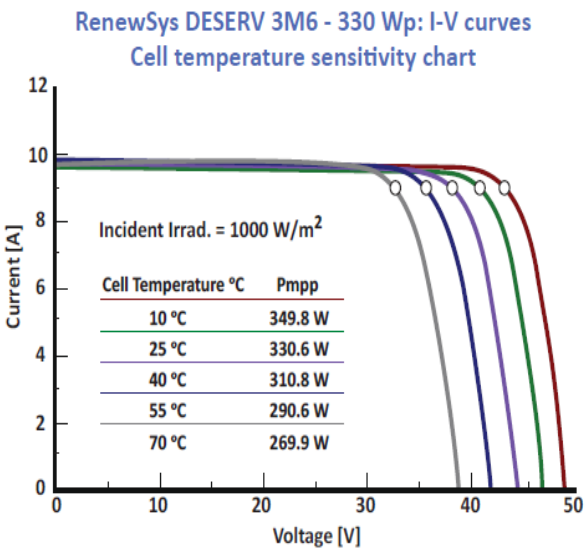
Battery Bank's Voltage	48	Volts DC		
Reserve Day: (How many days of capacity you want your batteries to Give you Current)	1	Days		
Battery Efficiency	100	%	1	
Depth of Discharge:(DOD)	50	%	0.5	
Battery Operating Temp:	80			
Amp Hour Removed	150			
The Battery Bank Required:	300.0	Amp.Hr		
Enter Each Battery Rating	150.0	Amp.Hr @	12	Volts
No of Battery required In series	4.0			
No of Battery required In parallel	2.0			
Total no of Batteries required	8			

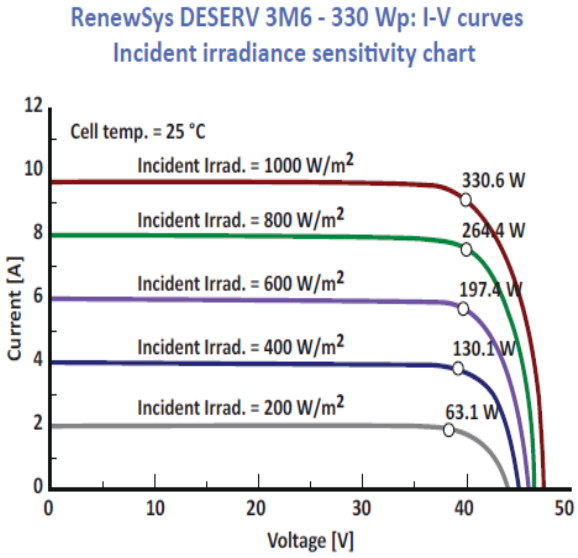
D. PV Sizing

RenewSys DESERV 3M6 – 320 Solar PV Module
Performance of Under stander test conditions
(1000 W/m2 ,25 degree Celsius)

Parameter	Value
Rated power(Pmax),Wp	320
Maximum Power Volatge (mp),V	37.20
Maximum Power Current(Imp),A	8.61
Open Circuit Voltage (Voc),V	46.21
Short Circuit Current(Isc),A	9.06
Module Efficiency	16.51

Cable	12AWG,4 sqmm
No of Cells	72
Module Dimensions,mm	1957 X 987
Module Weight	21.5 Kg





Charge Rate Tq	Amp hr removed*1.15/Avg Sunshine Hours
Total PV array Wattage	PV volatge*Tq

Solar Panel Detail

Solar System Voltage	74	Volts DC
In Winter	6	Hrs.
In Summer	8	Hrs.
In Monsoon	6	Hrs.
Average Daily Sunshine Hours	6.7	Hrs.
Charge rate	26	Amps
Solar PV wattage required	1915	Watts
Considered PV Rating	2KWp	
Total no of panels required		6
No of panels to be connected in series		2
No of panels to be connected in parallel		3

E. INVERTER

As per PV rating 2KWP, System requires minimum 2KVA Inverter at nominal Input voltage 48V DC and output 230V AC at 50HZ.

Following Table illustrates functioning of power conditioning unit.

Battery State of charge	Priority setting	Availability of source		Load < Solar		Load > Solar	
		Solar	Grid	Load works with	Battery charges with	Load works with	Battery charges with
>60% or Voltage Set Value	Solar			Solar	Solar	Solar+Battery	X
		X		Battery	X	Battery	X
			X	Solar	Solar	Solar+Battery	X
		X	X	Battery	X	Battery	X
	Grid			Grid	Solar	Grid	Solar
		X		Grid	Grid	Grid	Grid
			X	Solar	Solar	Solar+Battery	X
		X	X	Battery	X	Battery	X
<60% or Voltage Set Value	Solar			Solar	Solar	Solar+Battery	X
		X		Grid	X	Grid	X
			X	Solar	Solar	Solar+Battery	X
		X	X	Battery	X	Battery	X
	Grid			Grid	Solar	Grid	Solar
		X		Grid	Grid	Grid	Grid
			X	Solar	Solar	Solar+Battery	X
		X	X	Battery	X	Battery	X

III. INSTALLATION STEPS

Various steps to be followed in installation off grid PV system is discussed in section as follows

Mounting structure fixing

Placing of pv panels on structures

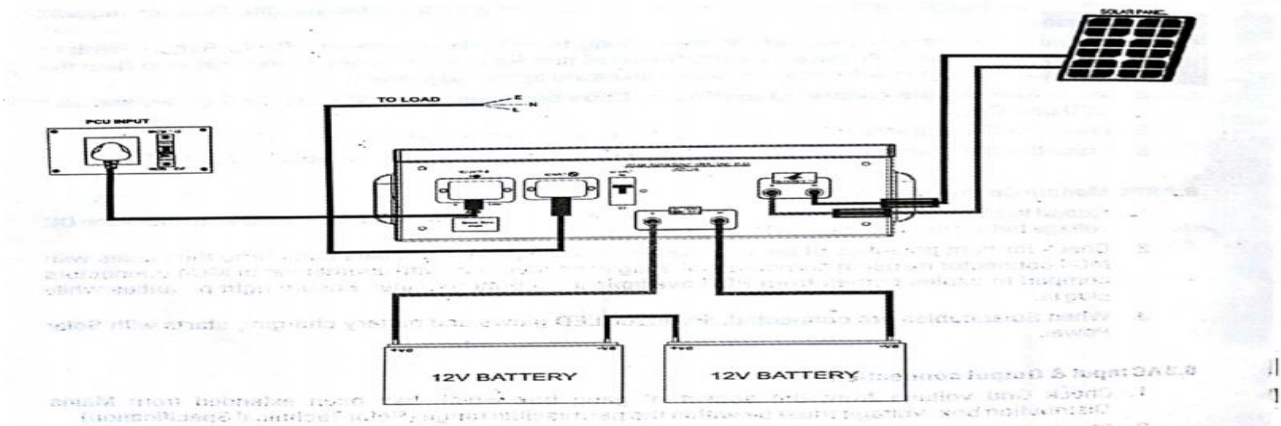
PCU mounting on wall

Battery banks installation

Digging of earth and lightening arrester pits

Following earthing standards

Wiring of entire system to PCU including loads



PCU Integration Diagram

Note: 4nos of 12V batteries shall be connected in series for PCU.

The PCU (Power controlling Unit) must be fixed in right place on wall with good ventilation at least 150mm ambient space around the vent and fan has to be maintained. The height of PCU must be 4.5 feet (1.37 meters) distance from the ground for better visibility. The mounting has to be fixed on the wall & PCU has to be hanged gentle in the mounting plate. Check both (left & right sides) sides of the PCU to ensure that is correctly seated on bracket. Mount the PCU only vertically never mount in with a reverse/side way tilt / horizontally. Separate this PCU from both the PV Array & grid before commencing any installation or maintenance /repair work. Do not install in a sealed enclosure as it will lead to overheating

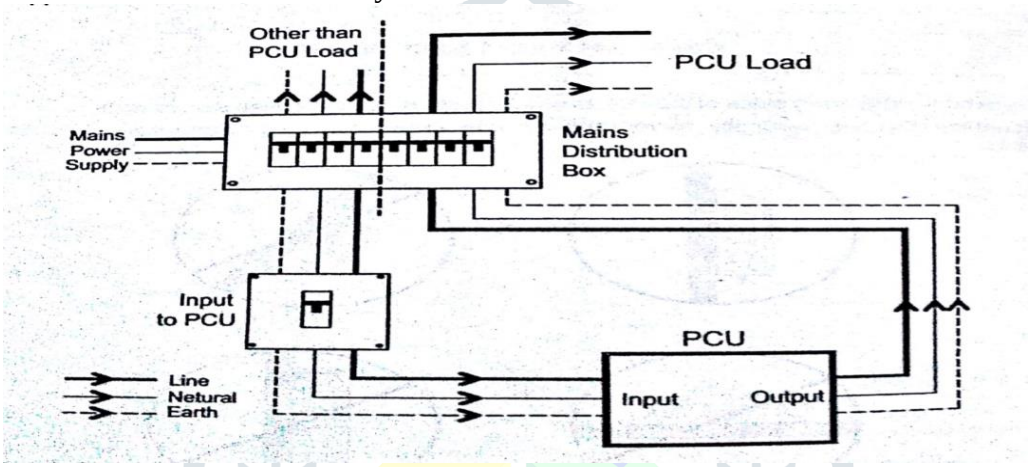
and decrease product life time to avoid this provide sufficient cooling space around the PCU.Do not install the PCU near flammable items. Keep explosive vapours away from the PCU do not install & Battery in a location where people can accidentally come in to contact with the front of the PCU

While working with metal tools be careful on or around PV Panels or Batteries. A possible risk exists to drop a tool to spark or short circuit PV Panel/ Batteries or other electrical parts and could cause an explosion. If mounted bracket is weakened, such as rusted , replace them with new ones, otherwise it may fall down and cause injury. Use tools with insulated handles during installation and maintenance to avoid personnel injure.

Input AC power supply to PCU: Install gang box near to selected location for installing PCU and extend input power cables of line, neutral and earth from mains distribution box recommended to use equivalent sixe of MCB which is available in PCU if using additional at input supply side.

Output AC power supply from PCU : Identify the appliances (loads) that to be used with PCU and separate its line , neutral and earth (L-N-E) cables of appliances from mains power supply at mains distribution box and extend the cables to near to PCU. amps Connect the extended cables to 16 amps AC 3pin top.

It is recommended to use for loads for safety.

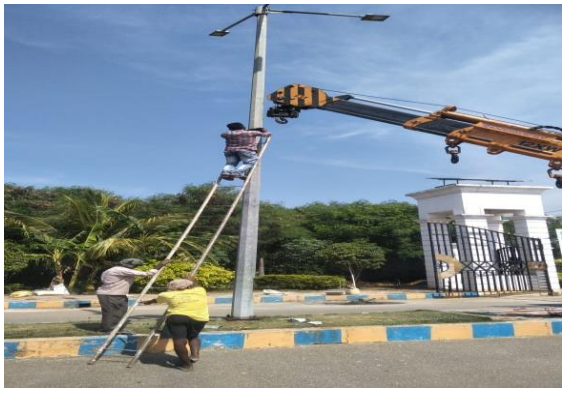


IV. RESULTS AND DISCUSSIONS

Energy Required for Load	7.2	KWh	
Average Production from PV array	6	KWh	Aprox
Energy Shortage	1.2	KWh	
PV operating Voltage	65	Volts	DC
PCU Output Voltage	230	Volts	AC
PCU Output frequency	50	Hertz	
Current Varies based on irradiation level			
Preset SOC	60	%	
DOD	40	%	
Amp Hours Removing Daily	120	Ah	
No of Hours Can Supply 600 Watt Load	9.6	Hours	
Minimum Production	200	Watt	Aprox
Maximum Production	1600	Watt	Aprox

By changing Preset Value to 50% we can supply 600 Watt Load up to 12 Hrs

For 800 Watt we require two more panels and four batteries which increases cost of the system.


CONCLUSION: In this paper basic design practices of off grid solar system is discussed in order minimize dependency of utilities on electricity supply boards. There will be net saving in tariff as most of the loads are supplying with renewable energy which is free of cost and also PCU transmits loads on to grid when ever produced energy is not enough.

V.REFERENCES

1. Adithya Rajeev ; K. Shanmukha Sundar., 'Design of an off-grid PV system for the rural community' 2013 International Conference on Emerging Trends in Communication, Control, Signal Processing and Computing Applications (C2SPCA)
2. Hugo Andres Macias Ferro ; Yuri Ulianov Lopez., 'Low cost off-grid solar PV and led lightning system' 2014 IEEE ANDESCON
3. NREL WEBSITE., https://www.nrel.gov/
4. Neha Beniwal ; Ikhlaq Hussain ; Bhim Singh., 'Control and operation of a solar PV-battery-grid-tied system in fixed and variable power mode' IET Generation, Transmission & Distribution Year: 2018 , Volume: 12 , Issue: 11 Page s: 2633 - 2641
5. NPTEL Video lectures