Design and Implementation PV Energy System for Electrification Rural Areas.

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Abstract: ***Solar energy generation utilizes solar cell or photovoltaic cell devices to convert the energy of light directly into electricity. There are two main types of solar energy technology: Photovoltaic and solar thermal. In recent it has proved that the population increased and the need for energy and its related services to satisfy human social and economic development and healthy is increasing .Fossil fuel are limited in supply and will one day depleted also cause global warming and air or water pollution so renewable energy such as solar, wind, Biomass, geothermal, hydropower energy are required to satisfy our needs. Most of developing countries are poor in conventional fossil fuel resources and have to import them so, a decentralized system of solar equipment installed at the village level is one among technically feasible solutions. Solar power offers many advantages in the generation of electricity. it is zero raw fuel cost and no environmental issues such as rejection of carbon dioxide(CO_2) in atmosphere like conventional energy source. The factors influencing power generation from solar panel are irradiance and temperature. The components of standalone power generation system are: Solar cells, solar charge controller, solar battery, inverter and load. This paper focused on design and implementation photovoltaic energy system installed near the clients. It has many applications such as: powering rural health clinic, health post, health center, Radio Base station in Telecom industries, water pumping, refrigeration and electrification household in rural areas.***

In this study we have done:

- ***Design standalone solar energy system to supply power to a single family having load of 8006W***
- ***Experiment of implementation solar energy system to supply a load of 180 watts as sample.***

Thus thanks to the result of the experiment realized making it possible to confirm the hypothesis, the reality and future utility of our study and to draw conclusions and recommendations.

Keywords: implementation, photovoltaic system, stand-alone, infinite source energy, low cost energy, clean energy.

I. INTRODUCTION

Various points to be discussed within this introduction are the general introduction of the study, problem statement, general and specific objectives, research questions and hypothesis of the study.

A. General Introduction

Conversional energy source reject the carbon dioxide in atmosphere which in turn causes Global warming and air or water pollution.

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They are non renewable and one day will be depleted so in order to meet energy demand of future generation, we need to return to renewable energy source such Sources such as solar power, wind power, water power, wave energy, biomass, geothermal energy and tidal. The opportunities associated with renewable energy sources include: Energy Security, Energy Access, Social and Economic development, Climate Change Mitigation, and reduction of environmental and health impacts.[1][2] Solar cells produce electricity through a natural reaction called photovoltaic effect .Power generated from solar modules has the following advantages over the power generation of traditional sources:

a)A solar module produce energy passively when exposed to sunlight without any moving parts .This makes them maintenance free and therefore long lasting.

b) The fuel required for them to operate is free sunshine

C) They are harmless to the environment.

Therefore an increase in size of a decentralised photovoltaic installation is one of feasible solution of our demand energy. The photovoltaic power systems are generally classified according to their functional and operational requirements, their component configurations and how the equipment is connected to other sources and electrical loads. The principal classifications are grid-connected system, standalone systems and hybrid systems. [3]; [4]. In our project we focussed on stand-alone system.

B. General Objectives

The main objective of the study is design and implementation solar energy system for electrification rural areas.

C. Specific Objectives

The specific objectives of the study are to:

- Design standalone PV system to supply single family having a load of 8006Watts.
- Doing experiment of Implementation a stand-alone PV system that can supply a room using 2 CFL bulbs, 1 mobile phone charger, one radio and one laptop,

D. Problem Statement

Most of developing countries are poor in conventional fossil fuel source and have to import them and conventional source of energy are not renewable one day will be depleted.

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The reserve of fossil fuel remains is very few this implies that the cost of energy will increase. In additional, many traditional energies are located in the area where electricity supply is costly due to the higher transportation cost, transmission loss etc. we should also remember that air or water pollution are the measure issues surrounding the use of fossil in energy generation.[5]

Again the world's population increases daily which also increase the need for energy and its related services to satisfy human social and economic development. At our rate of consumption, this fossil fuel can't meet our current or future energy need demands. The question is how we will get the energy to satisfy our needs without environment degradation and at low cost?

E. Research Question

Thus, study is based in the following questions:

.How we will get the energy to satisfy our needs without environment degradation at low cost?

With the experiment of implementation standalone PV system how we can get out energy to supply a room using 2 VFL bulbs, 1 mobile phone charger, 1 laptop and one radio.

What are the basic elements required for designing stand-alone PV system?

F. Research Hypotheses

The provisional answers is conformed or rejected through observations or experimentations. It is a guess of what the researcher will reveal. This study is based on the following hypothesis:

- ➢ The basics components required to design a stand-alone solar energy system are: load, solar PV modules, batteries, inverter and solar charge controller.
- ➢ Decentralized solar power plant is one of solution of our future demand energy and is at low cost..
- ➢ 1 panel 70Wp PV module is enough to supply power at a room using a room using 2 VFL bulbs, 1 mobile phone charger, 1 laptop and one radio which are working one hour per day.

II. METHODOLOGY

According to S.M Goldfield a method is a procedures set of rules and principles of intellectual operations to do the analysis in order achieve result using scientific analysis. It is a set of principles leading all organized research, allowed to select and coordinate research.

A. Electronic sources

In this research the electronic sources was used by visiting websites. Here internet was a good instrument to get information we needed. Through electronics sources we accessed different Journal and online books which played a greater role to improve the idea we had related to our study.

B. Design method

According to Wikipedia access on 14/03/2019 design methods are procedures, techniques, aids or tools for designing. They offer a number of different kinds of activities that a designer might use within an overall design process. In this study we showed all the steps involved for designing a stand-alone PV system.

PV system design is the process of determining the size of each component of standalone photovoltaic power system with the purpose of meeting the load requirement. The designing is done through the following steps:

Step 1 site inspection
Step 2 determining load requirements
Step 3 PV module sizing
Step4 charge controller sizing
Step5 battery bank sizing
Step 6 inverter Sizing
Step 7 cable size
Step 8 cost estimation

- ➢ **Step 1 site inspection** is the most important of the design because it helps to determine whether a stand-alone system is viable or not. The factors influencing power generation from the PV system are irradiation and temperature .At constant temperature power generation from PV System increases with increasing irradiation so site location should be inspected in order to know the number of sun day per year.
- ➢ **Step 2 determining load requirements:** this is also important point in designing PV system because it helps to know how powerful PV system required for satisfying clients' demand. The load is determined by listing all appliances with their power ratings and operation hours then summing it to obtain the total average energy demand in watt-hours or kilowatt-hours.Table1gives ideas of how to estimate the load.
- ➢ **Step 3 PV module sizing:** hence the load has been determined the following step is to know the number of PV module required for reliability of our system. In this step we need to calculate the following: a) Total power use per day=Total appliances use power in watt per day b) Total energy consumption per day=Total appliances use in watt-hours per day c) The total energy required from panel=total energy consumption per day×1.3 where 1.3 is the factor of energy lost in the system. The minimum of PV module required is equal to the total of energy required from PV module divided the product of power fact generation and watt-peak of PV module available for you .The equation (1) to (7) explain this step with example of calculation.
- ➢ **Step 4 charge controller** in this step we select the appropriate charge controller to match the voltage of PV array and the battery. The charge controller rating is equal to the product of number of battery in parallel, the short circuit current of PV module available for you and safety factor. where safety factor 1.3.
- ➢ **Step 5 battery sizing**: This step is also very important for reliability of our system because during night and cloud days' sufficient energy are required to operate the appliances. The equation (9) has been used to determine the battery capacity of our system.
- ➢ **Step 6 inverter sizing**: Inverter is required to converter direct current to alternating current. If the power rating of inverter is less than the total power of electrical load our system will be overloaded so the inverter rating should be 25%-30% greater than the power of appliances. The equation (8) has been used to determine the inverter rating.

➢ **Step 7 cable sizing**: the purpose of this step is to match the type of wire you need to use with the current which will pass through it in order to maintain the reliability and the performance of our system. The equation (15) has been used to determine the cross section of cable.

➢ **Step 8 cost estimation:** Hence you have a project you need also to calculate the money required to run your project. In our PV system the cost estimation equal to the sum of cost of components, cost of balance of system component and the maintenance cost of the PV system per year. Table III and table VII show the results of cost estimation of the proposed system.

C. Experimental Method

Experiment is the process of examining the truth of a statistical (numerical) hypothesis, relating to some research problem. [6] In our case we were examining our study hypothesis. See figure 6 experiment of implementation PV system done. From this experiment PV module is connected to solar charge then solar charge is connected to the battery also battery is connected to inverter which is finally connected to the load (3 lamps, one radio, one computer, 2 phones).

III. DESIGN STANDALONE PV SYSTEM FOR SUPPLYING POWER TO A SINGLE RESIDENTIAL HOUSEHOLD

In this section we presented a design for a stand-alone photovoltaic system to provide the required electricity for single family in rural area in developing countries. Based on appliances we determined the client needs, Size of the PV modules, inverter sizing, battery bank sizing, solar charger controller sizing, cost estimation and payback period based on the cost of 1kwh.

A. Reference System Specification Rating

For our PV system design we chosen from the market the solar panel, solar charge controller, solar battery and solar inverter as reference which used in sizing our system.

a) Solar PV specification rating
LUMINIOUS MONOCRYSTALLINE SOLAR 335 WATT-24 VOLTS

Wattage (wp) =335w

Short circuit current=8,96A
Performance warranty=25years
Price of each piece=14500 rupees [7]

b) Solar charge controller rating
60A MPPT solar charge controller
DC 12V24V48V
Price 14446 Rupees [8]

c) Solar battery specifications:
Lead acid battery solar energy
Storage system 12V200AH solar
Price US dollars 10-180/piece [9]

d) solar inverter rating
In this system the following inverter has been used:
Microtek 11k M-sun solar grid tie system GT
Price 106 000 rupees [10]
Notice: the nominal voltage used here or system voltage=48V as the load is greater than 5000W [11]

B Determination Of Power Consumption Demands

The first step in designing a solar system PV system is to find out the total power and energy consumption of all loads that needs to be supplied by the solar PV system. **So here** we determined:

. Total appliances energy in watt-hours per day

. Total energy in watt-hours per day required from Panel

Total appliances power

This is the first step for designing a solar PV system and which find out the total power and energy consumption per day of all loads that need to be supplied.

Total power use per day=Total appliances use power in watt per day.

Total energy consumption per day=Total appliances use in watt-hours per day.

Now the total PV panels energy required=Total energy consumption per day x1.3 (1)

Where 1.3 is loss factor of the system.[12]

Table i. Estimated energy demand for load per day

load	Power rating (watt)	quantity	Hour Used per day	Power in watt	Energy per day (wh)
Mobile phone charger	10	5	2	50	100

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Laptop	100	1	8	100	800
Desktop computer	100	1	8	100	800
Television	120	1	6	120	720
Printer	50	1	2	50	100
Radio	40	2	8	80	640
Electrical iron	750	1	1/3	750	250
Vacuum cleaner	500	1	1/4	500	125
Room A/c 1TON	1400	1	8	1400	11200
Water pump 0.5 HP	375	1	1/3	375	125
Electrical cattle	1500	1	1/3	1500	500
Fridge 310lts	400	1	8	400	3200
Ceiling fan	75	5	8	375	3000
Tube light	52	3	5	156	780
CFL bulbs	15	10	5	150	750
Induction cooker	1200	1	1	1200	1200
Microwave	700	1	1	700	700
Total				8006	24990

The power needed by the load in single family=8006w
Energy consumption in one day=24990wh/day
Total Energy needed from the PV modules to operate the appliance=24990wh/day x1.3
Total energy needed =32487wh/day

C. Size of Pv Modules

To find the size of PV module we need to calculate the total watt-peak rating needed from the PV panel to operate the appliance and also one has to know the panel generation factor for the site location. In India panel generation factor is 4.32

Number of PV modules for the system=Total watt-peak rating require to operate the appliance divided by watt-peak of the PV module available for you.

$$Nm = 1module \times \frac{watt-peak\ rating}{rated\ output\ peak\ of\ the\ PV\ available} \quad (2)$$

[12]; [18]

N_m =number of PV modules

The total watt-peak rating required to operate the appliances is equal to the total PV energy required from panel divided by panel generation factor

The total watt- peak rating= $\frac{total\ energy\ required}{module\ generation\ factor}$ (3)

Panel generation factor is used while calculating the size of solar photovoltaic cells. it is a varying factor depending upon the climate of the site location.

For example, in Thailand it is 3.43, in Europeans countries it is 2.93 and in Indian it is 4.32. [13]; [14]

The total watt-peak rating required to operate the appliance=32487wh/day/ 4.32
Total watt=7520.2Wp

Our PV module available=335Wp see reference solar panel in section 4.1 a)

The number of Minimum of PV modules for the system=7520.2Wp/335Wp
= 22.448 panels
=23 Panels

The minimum number of PV panels required is 23 PV panels. If more PV modules are installed, the system will perform better and battery life will be increase

So this system should be powered by at least 23 modules of 335Wp PV module

$N_{ms}= V_{system} \div V_{module}$ (4) [15], [16], [17]
= 1 module x 48V÷24V
=2 PV modules

$N_{mt} = N_{ms} \times N_{mp}$ (5) [15], [16], [117]

$N_{mp} = N_{mt} \div N_{ms}$ (6) [15], [16], [17]
=1 module X23/2
=11.5Panels
=12 Panels required in parallel

$P_{array} = N_{ms} \times N_{mp} \times P_{module}$ (7) [15];[17]
=2 x 12 x 335 w
=8040W

Where:
N_{mt} =number of total PV modules
N_{mp}=Number of PV module in parallel
N_{ms}= Number of PV modules in series

D. Inverter sizing

The input rating of the inverter should never be lower than the total watt of the appliances. The inverter must have the same nominal voltage as your battery. The input rating of the inverter should be 25-30% bigger than the watt of your appliances.

For grid tie systems or grid connected systems, the input rating of the inverter should be same as PV array rating to allow for safe and efficiency operation. [12]

The total watt of our appliances =8006w

Inverter size= $\frac{total\ watt \times 130}{100}$ (8) [12]

So inverter size= 8006/130%
=10 407.8w

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So the required inverter size equal 10500 W or little bit greater than 10500W

Number of inverter required= 1 inverter having 11kw from our reference inverter in section 4.1 d)

E. Battery Sizing

Solar battery sizing is the one of the most important considerations when choosing the basics components of your stand-alone solar electric system. The main objectives when sizing a battery bank is to get one energy that can handle the load coming from your PV panel array and provide enough stored power for your needs when there is no sunshine. The battery bank system voltage can be 12volts, 24 volts, 48 volts or 96 volts depends on the amount of voltage your solar system produces. If you buy battery for your solar system that is 12 volts and 105 amp-hours (storage capacity) the energy this battery will store =12V*105 AH

=1260wh

This means is that you can power 100 watt appliance for 1260wh/100W=12.6 hours on fully charged battery.

The battery capacity should be large enough to store sufficient energy to operate the appliances at night and cloud day.

$$\text{Size of battery} = \frac{C*n}{0.85*0.6*\text{Vsystem}} \quad (9)\ [12]$$

Where;

0.85= battery loss

0.6=depth of discharge

Our V system voltage=48V

C=battery bank capacity or energy required per day in wh

n=autonomy days

Autonomy is the number of days that you need the system to operate when there is no power produced by PV panel.

$$\text{Battery size with autonomy 3 days} = \frac{\frac{24990\text{wh}}{\text{day}}*3\text{days}}{0.85 \times 0.6 \times 48\text{v}}$$

$$= 3062.5\text{Ah}$$

As our reference battery capacity =200A

$$N_{bt} = 1\ battery \times \frac{\text{battery bank capacity}}{\text{capacity of selected battery}} \quad (10)[15],[16],[17]$$

Number of battery required=1battery x3062.5AH/200AH

=15.3215 batteries

=16 batteries

So our system requires 16 batteries

$$N_{bs} = \frac{Vsystem}{Vbattery} \quad (11)\ [15], [16], [17]$$

= 1 battery x 48V/12V

= 4 batteries

$$N_{bp} = 1\ battery \times \frac{Nbt}{Nbs} \quad (12)\ [15], [16], [17]$$

N_{bp}=1 battery x 16 /4

= 4 batteries

$N_{bt} = N_{bs} \times N_{bp}$. (13) [15], [16], [17]

N_{bt} =number of total battery

N_{bs} = number of battery in series

N_{bp} = number of batteries in parallel

E. Solar Charge Controller Sizing

The function of a charge controller is to regulate the charge going into your batteries bank from your solar panel array and prevent overcharging and reverse current flow at the night. Most used charge controller are Pulse width modulation(PWM) or Maximum power point tracing (MPPT).when a MPPT solar charge controller notices a difference in voltage, it will automatically and efficiently convert the lower voltage so your panels, battery bank and PV charge can all be equal in voltage.
For the series charge controller type, the sizing of controller depends on the total PV input current which delivered to the controller and also depends on PV panel configuration (series or parallel configuration).
In our case PV module specification the short circuit current=8.96A

I_{rated}= (N_{bp} x I_{sc}) x1.3 (14) [15], [16,[17]

= 4x 8.96 x 1.3A

= 46.592A

= 47A

Where:

I_{rated} =solar charge controller rating

I_{sc}=short circuit current

N_{bp}= number of parallel battery

1.3 is safety factor

So that the charger controller should be rated 47 A or little bit greater

The reference solar charge controller in our system is 60A in section 4.1 b)

Number of charge controller= 1

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F. Cable Sizing

When the size and type of wire are well selected this improves reliability and performance of PV system that is why cable sizing is a very important step .In this system we used copper wire.

The cables cross sectional are determined by the following equation:

A=$\frac{p\times L\times I}{Vd}\times 2$ (15) [15], [16]

Where:
p=resistivity of wire
For copper p=1.724 x $10^{-8}\Omega\cdot$m
L=length of wire
A= cross sectional area of cable
I =the rated current of regulator
V_d=Voltage drop
In both AC and dc wiring for standalone photovoltaic system the voltage drop is taken not to exceed 4 % value.[15];[16]

a) **Determination cables size between PV modules and Batteries**

Maximum voltage Drop; $V_d = \frac{4}{100}\times Vmodule$ (16) [15];[18]
Vd= $\frac{4}{100}\times 24V$
=0.96v
Let the length of the cable is 1m

Now A= $\frac{p\times l\times I}{Vd}\times 2$
$=\frac{1.724\times 10^{-8}\times 1\times 47}{0.96}\times 2m^2$
=168.80 $x10^{-8}m^2$
=1.688mm^2

This means that any copper cable of cross sectional area 1.688 mm^2, 47 A and resistivity 1.724 x$10^{-8}\Omega\cdot$m can be used for the wiring between PV module and batteries through the charge controller.

b. **Determination of cable between the battery bank and the inverter**

The maximum voltage drop, V_d= $\frac{4\times Vsystem}{100}$ (17) [15], [16]
At full load, batteries maximum current I_{max} is given by

$I_{max} = \frac{inverterkva}{efficiency\ of\ inverter\times Vsystem}$ (18) [15], [16]
System voltage=48V
Let length of the cable be 8m
I_{max}= $\frac{11kva}{0.972\times 48V}$
=235.768A
=236A
Maximum voltage drop V_d= $\frac{4\times 48}{100}V$
$= 1.92V$
$A = \frac{1.724\times 10^{-8}\times 8\times 236}{1.92}\times 2m^2$
=33.90 mm^2
=34mm^2

This means that any copper cable of cross sectional area of 34mm^2, 236A, and resistivity1.724 x $10^{-88}\Omega\cdot$m can be used for the wiring between the battery bank and inverter.

c. Determination of cable sizes between the inverter and load

The maximum voltage Drop, V_d= $\frac{4}{100}\times system\ voltage$ (19) [15]
Here system voltage=220V

$I_{phase} = \frac{Inverterkva}{Vout\times\sqrt{3}}$ (20) [15]; [16]

$= \frac{11kva}{220\times\sqrt{3}\,A}$

=28.87A

=29A

Vd= $\frac{4}{100}\times 220V$
= 8.8V
Where: Vout=220V
A= $\frac{p\times l\times I}{Vd}$
Let the maximum length of cable be 24m

A=$\frac{1.72410^{-8}\times 24\times 29}{8.8}\times 2m^2$

A =2.727mm^2
A=3mm^2
This means that any copper of cross sectional area 3mm^2, 29A, and resistivity 1.724 x 10^{-8} Ω-m can be used for the wiring between the inverter and load

Table ii..results obtained from the sizing of the proposed standalone pv system

Component	Description of Component	result
Load estimation	Total estimated load	24990Wh
PV array	Array capacity	8040 W
	Number of modules in series	2
	Number of modules in parallel	12
	Total number of module	24
Battery bank	Battery bank capacity	3062.5 W
	Number of batteries in series	4
	Number of Battery in parallel	4
	Total number of battery required	16
	Capacity of voltage regulators required	47A

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Voltage regulator	Number of voltage regulators required	1
Inverter	Capacity of inverter	11kva
Wire	Between PV module and batteries through voltage regulator	47A 1.688mm^2
	Between battery bank and inverter	236A 34mm^2
	Between inverter and load	29A 3mm^2

From here it is easily seen that the basics elements required to design a stand-alone PV system are:

- **Load**
- **Battery bank**
- **Voltage regulator**
- **Inverter**

G. Cost Estimation

The cost estimate is the approximation of the cost of a program, project or operation. The cost estimate of the system's components summarized in table III .

Table iii. Cost estimated of the proposed system's components

Device	Model	Qty	Unit Price (Rupees)	Cost of Devices (Rupees)
Module	335W-24volts	24	14500	348000
batteries	Lead-acid 12V200AH	16	12450.6	199209.6 =199210
Voltage regulator	60 A MPPT dc12V24V48V	1	14446	14446
inverter	Microtek 11K M-sun	1	106000	106000
subtotal				667656
Other BOS costs(wires, fuses, circuit breakers, etc)				133531.2
Total capital				801187.2
Annual maintenance cost of PV system				8011.872
Overall cost of the System				809201.072

Cost of component=quantity x unit price

Other balance of system component (BOS) cost =20% of subtotal. (21) [15], [17]

The operating costs for Solar PV installations are negligible, but the annual maintenance cost may amount to 0.5% to 1% of total capital of the system. Maintenance cost of the PV system=1% of the total cost (22). [15], [17]

Overall cost of the system =capital cost of the system + Maintenance cost. (23) [15], [17]

produced based on price of 1 kwh to make sure if PV system is really highly cost.

H. Estimation Cost Based on Price Of 1kwh In Indian

Estimated energy produced per day= 24.990 Kwh

In 30 days of one month energy consumption =24.990Kwh/day x 30days
=749.7Kwh

Energy can be consumed in 12 months=749.7Kwh x12
=8996.4Kwh

The price of 1 Kwh is 5 rupees therefore the cost estimation of energy consumed during one year
= 8996.4Kwh x 5 rupees/kwh
=44982 rupees

Overall cost of PV system=809201.072 rupees

The payback
$$=\frac{\textit{overall cost of PV system}}{\textit{total estimed cost of energy consumed per year}} \quad (24)$$

The payback period= (1 year × 809201.072) ÷ 44982
=17.989years
=18years

PV system guaranty is 25 years this implies that there will be a saving money of 7 years as well as the initial cost of

From Table3 it is well seen that the initial cost of our system is high so let us compared it with the cost of energy traditional system.From here it is well seen that decentralized solar power system is one of solution of our future demand energy without environment degradation and it will be at lower cost.

IV IMPLEMENTATION STANDALONE PV SYSTEM FOR SUPPLYING POWER A LOAD OF 180 WATTS

In this section we presented a design for a stand-alone solar system to provide the required electricity for supplying a load of 180 watts. The results from this experiment of implementation helped to confirm the reality and the future utility of our study.

A. Component Description

In the experiment of implementation, we used the following components:

a) Solar panel: convert sun light into Dc electricity. Our solar panel specifications are shown here bellow:

SWSS Model type 70W-12

Rated Maximum Power (P_{max}) = 70W

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Short-circuit current(I_{sc}) = 4.34A

See figure below:

Figure1: 70W-12V Solar panel

b) **Solar charge controller**: regulates the voltage and current coming from the solar panel going to battery and prevents battery overcharging and prolongs the battery life.
Charge controller specifications:
LOG JOTHI
INTEGRATED SOLAR SOLUTION
Current rating=10 A
See figure below:

Figure2: 10 A integrated charge controllers

c) **Battery**: stores the energy for supplying to electrical appliances when no-sun-day or dark day also when the sun is not providing enough radiation.
Battery specifications:
Manufacture: Amara Raja Batteries limited
Type: Powerzone-PZ3WMF
Capacity: 30AH see figure below:

Figure3: 30 Ah battery

d) Inverter: Convert DC output of PV Panels into a clean AC current for AC appliances or fed back into grid line.

Inverter specification:

Solar power Inverter

12 V DC- 230V
300 Watts (selected one) see figure below:

Figure 5:300 W inverter

e) **Load** is electrical appliances that connected to solar PV system such as lights, radio, phone and laptop.

Notice: Nominal voltage or system voltage =12V

B DETERMINATION OF POWER CONSUMPTION DEMANDS

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TABLE IV. POWER ESTIMATION IN STUDY EXPERIMENT OF IMPLEMENTATION

APPLIANCE	POWER RATING IN WATT	No OF APPLIANCE	Working hours per day	POWER USED IN WATTS	Energy consumed in Wh/day
CFL BULB	15	2	1	30	30
MOBILE CHARGER	10	1	1	10	10
RADIO	40	1	1	40	40
laptop	100	1	1	100	100
Total load				180	180

Total power required for sample load per day=180w
Total energy consumption by load per day =180wh
The total energy required from PV panel to operate the system=180wh x1.3

=234wh

C. Size of Pv Modules

a) The total energy peak required from panel to operate the appliance is equal to the total energy per day needed from PV module divided by power generation factor.[12][18]

Now the watt-peak rating needed for PV module =234wh/4.32

=54.166Wp

b) Number panel for the system= the watt-peak rating needed for the PV module divided the rated output watt peak of the PV modules available to you. In our case output watt peak of the PV module=70Wp (PV module available).

$$N_m = \frac{watt-peak\ rating}{rated\ output\ watt\ peak\ of\ the\ PV\ available} \quad [12]$$

$$= 1\ panel \frac{\times 54.166Wp}{70Wp}$$

= 0.7738 panel

= 1 panel required

D. INVERTER SIZING

From equation (8)

the inverter size=180w x 130/100

=234 watt or little bit bigger

E. BATTERY SIZING

From equation (9) the battery capacity can be calculated as:

$$\text{Battery capacity} = \frac{180\text{wh}\times 1\text{day}}{0.85\times 0.6\times 12\text{V}}$$

=29.41AH

=30AH

V system=12V

F. SOLAR CHARGE CONTROLLER SIZING

For our system short circuit current =4.34A Number of battery =1

From equation (14) we calculated charge controller rating (I)

I=4.34A x1 x1.3

=5.642A

I = 6A or little bit greater

G. *SIZE OF CABLE*

When the size and type of wire are well selected this improves reliability and performance of PV system that is why cable sizing is a very important step .In this system we also used copper wire.
The cables cross sectional area is determined by the equation (15)
In both AC and dc wiring for standalone photovoltaic system the voltage drop is taken not to exceed 4 % value.[15]

a) **Determination cables size between PV modules and Batteries**

From equation (16) we calculated $Vd = \frac{4}{100} \times 12V$
=0.48v

Let the length of the cable is 2m

$$\text{Now } A = \frac{p \times l \times I}{Vd} \times 2 \qquad (15)$$
$$= \frac{1.724\times 10^{-8} \times 2 \times 6}{0.48} \times 2m^2$$
$= 86.2 \times 10^{-8} m^2$
$= 0.862 mm^2$
$= 1mm^2$

This means that any copper cable of cross sectional area 1 mm^2 , 6 A and resistivity 1.724 $\times 10^{-8}\Omega\cdot m$ can be used for the wiring between PV module and batteries through the charge controller.

b. **Determination of cable between the battery bank and the inverter**

The maximum voltage drop, $V_d = \frac{4\times Vsystem}{100}$

At full load, batteries maximum current I_{max} is given by

$$I_{max} = \frac{inverter\ kva}{efficiency\ of\ inverter \times Vsystem} \quad (18)$$

System voltage=12V

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Let length of the cable be 0.8m

$I_{max} = \frac{300W}{0.85 \times 12V}$

$=29.76A$

$=30A$

Maximum voltage drop $V_d = \frac{4 \times 12}{100} V$

$= 0.48V$

$A = \frac{1.724 \times 10^{-8} \times 0.8 \times 30A}{0.48} \times 2m^2$

$=1.724\ mm^2$

$=1.724mm^2$

$=2mm^2$

This means that any copper cable of cross sectional area of $2mm^2$,30A, and resistivity$1.724 \times 10^{-8}\Omega m$ can be used for the wiring between the battery bank and inverter.

c) Determination of cable sizes between the inverter and load

$A=0.026234\ mm^2$

The maximum voltage Drop, $V_d = \frac{4}{100} \times system\ voltage$ (19)

Here system voltage=230V

$I_{phase} = \frac{Inverterkva}{Vout \times \sqrt{3}}$ (20) where Vout =230V

$= \frac{300W}{230 \times \sqrt{3}\ A}$

$=0.75A$

$=1A$

$Vd = \frac{4}{100} \times 230V$

$= 9.2V$

$A = \frac{p \times l \times I}{Vd}$

Let the maximum length of cable be 7m

$A = \frac{1.724\ x10^{-8} \times 7 \times 1A}{9.2}$

This means that any copper of cross sectional area $0.026234mm^2$, 1A, and resistivity $1.724 \times 10^{-8}\Omega$-m can be used for the wiring between the inverter and load

TABLE V. RESULTS OBTAINED FROM SIZING OF STANDALONE PV SYSTEM OF 180 WATTS

Component	**Description of component**	**Result**
Load estimation	Total load estimation	**180wh**
PV array	Array capacity	**70 Watts**
	Total number of modules	**1**
Battery bank	Battery bank capacity	**30Ah**
	Total number of batteries	**1**
Voltage regulator	Capacity of voltage regulator	**6A**
	Number of voltage regulator required	**1**
Inverter	**Capacity of inverter**	**234 w or little bit bigger**
Wire	**Between PV modules and batteries through voltage regulators**	**6A** **$1mm^2$**
	Between battery bank and inverter	**30A** **$2mm^2$**
	Between inverter and load	**1A** **$0.026234mm^2$**

H. Experiment Of Implementation

For feasibility of our study we did experiment see figure bellow:

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Figure6: Experiment of implementation stand-alone PV system with 180W load

From experiment it is easily seen that a solar modules produce energy passively when exposed to sunlight without any moving part , no fuel required to operate them therefore it does not reject carbon dioxide(CO_2) in atmosphere and the basic components required to design stand-alone P V system are:

Load

PV modules

Charge controller

Battery bank and

Inverter

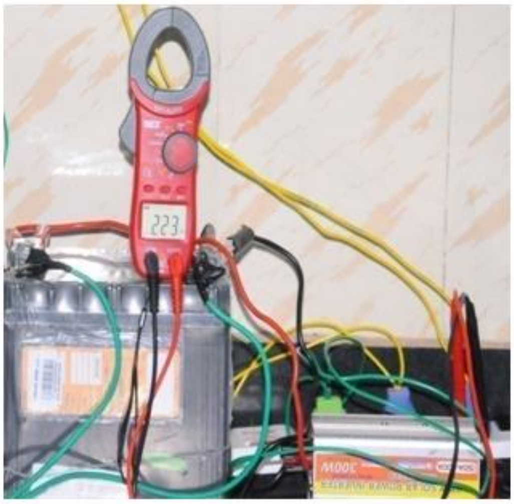

Figure7: clamp meter measuring output of inverter

Table VI. experiment results

Date	System working hours per day	Load Connected in watt	Load Working Hours per day	Energy Consumed per day in kwh	Autonomy of battery
27/03/2019	8h (8h30-16h30)	180w	3h20	600kwh	1h40
28/03/2019	8h (8h30-16h30)	180w	3h00	540kwh	1h40
29/03/2019	8h (8h30-16h30)	180w	3h20	600kwh	1h40
30/03/2019	8h (8h30-16h30)	180w	2h46	500kwh	1h40
31/03/2019	8h (8h30-16h30)	180w	3h00	540kwh	1h40

Notice: Any time clamp meter showed battery voltage equal to 12V we disconnected the load from the system.

The proposed experiment system was designed to supply power to the load during one hour and battery autonomy was designed be one hour. According to the experiment results table VI it can be easily seen that battery autonomy is 1h40 and the minimum hours the load can be connected is 2h46, this means that the designed system is reliable to meet load demand in all condition of irradiation and temperature (enough irradiation or less irradiation even for high temperature).

I. COST ESTIMATION OF EXPERIMENT OF IMPLEMENTATION 'S COMPONENTS

The cost estimate is the approximation of the cost of a program, project or operation. The cost estimate of the system's components results summarized in table VII.

Table vii. Cost estimated of the experiment system's components

Device	Model	Qty	Unit Price (Rupees)	Cost per Device (Rupees)
Module	SWSS 70W-12v	1	5000	5000
batteries	Powerzone-PZ3WMF	1	2000	2000
Voltage regulator	Integrated Solar solution 10A	1	600	600
inverter	12VDC-230-300W	1	4000	4000
subtotal				11600
Wires and lamps,				200
Total cost of the system				11800

K. COST ESTIMATION AND PAYBACK BASED ON PR ICE OF 1KWH IN INDIA FOR OUR EXPERIMENT PV SYSTEM

From the experiment results table6 we have seen that the minimum energy can be produced by our PV system is 0.5 KW/day. In 30days it can produce 0.5Kw/day x 30days which is equal to 15kw.In one year our system can produce 15Kw x 12=180kw.

The cost estimation of energy consumed per year = 5 rupees/KW x 180 KW

= 900 rupees

The payback period= $\frac{Total\ cost\ of\ the\ system}{the\ estimated\ cost\ of\ energy\ consumed\ per\ year}$ (24)

The pay back= 1 year x 11800rupees÷ 900 $rupees$

=13.1 year

=13 year

PV system guaranty is 25 year this means that our system will save money during 12 year when compared to the traditional or conventional energy system.

From here it is easily seen that solar energy system is a future of our energy demands at the low cost.

V. CONCLUSION AND RECOMMENDATION

A. Conclusions

The methods and techniques we used are scientifically recognized and results match with literature review that is why we consider the findings of this research reliable. The design results showed that a load estimation of 24990wh per day requires 8040 W array capacity of 24 PV modules,60A voltage regulator ,16 (12V,200Ah) batteries,11KVA,48V inverter and copper wire of cross-sectional area (1.688mm^2,24mm^2 and 3mm^2) for installation. The cost estimation is 809201 rupees which is relatively high but based on the energy produced by the system per day, the cost of 1 kwh here in India and the guarantee of the system of 25 years so the payback period of the system was found to be 18 years which means there will a save of money during 7 years compared to the conventional energy. The design and implementation experiment results showed that the load estimation of 180 wh per day used 70W array capacity of 1 PV module,10A, 1(12V,30Ah) battery,300W-12V inverter and copper wire of cross sectional(1mm^2,2mm^2 and 0,0262mm^2) for the installation. The cost of experiment of implementation done was found to be 11800 Rupees and the observation showed that the minimum energy that can be supplied by the system per day is 500 watts then based on the cost of 1kw here in India and the guarantee of the system of 25 years so the payback period of the system was found to be 13 years which implies a save of money during 12years compared to the conventional energy.

Generally this research work was aimed to design standalone PV system for supplying power to a single family based on its load and make experiment of implementation standalone PV system for supplying a load of 180 watts. The objectives cited within this study have been achieved and the hypothesis has been confirmed.

This type of solar energy system can be modeled near the clients, which reduces the transmission cost, losses and transportation cost. Therefore the decentralized PV energy system is the solution of our energy demand at low cost without environment degradation, it is very important to install PV energy system to generate the electricity in rural areas.

B. Recommendation

Government should encourage and facilitate private investors to increase and expand their investment in solar energy system projects. Government should promote the solar energy system project through education and training in order to be in the position of supplying power produced by the solar power system. Government should install PV system at village level to generate the electricity.

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