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STUDY AND IMPLEMENTATION OF OFF-GRID SOLAR SYSTEM FOR RESIDENTIAL LOAD

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***Abstract*—Solar energy is the cleanest and most developed form of renewable energy. In order to be completely independent of the grid source we need to study an off grid solar system. In this paper we have study on off grid solar system. We have used 1 Lithium Ion Battery, 1 ULT solar inverter (MPPT) and 1005W solar panels to make a DC system that would be sufficient enough to provide 1 classroom with load of 700 kWh/day.**

This paper will focus on how methodology of off-grid solar system/stand alone system can reduce the dependency of grid and allow us to live in self-sufficient manners without reliance on one or more students/public utilities.

Keywords*— *(Off-Grid, Solar Power, Classrooms, Residential Load)

I. INTRODUCTION

As of November 2015, the installed generation capacity of India is 281 GW of which, the thermal, hydro, nuclear, and renewable capacities are about 195GW, 43GW, 6GW and 37GW respectively. The renewable installed capacity is at 13.2%, whereas the thermal installed capacity is 69.3 %, which is a major source of carbon dioxide emissions in India. For reducing the CO2 emissions fuel substitution by the way of increased use of renewable energy sources is an attractive option. Solar power is the one of the cleanest form of renewable energy available, and it can be converted and used in different forms, such as heat and electricity to help power homes and business. Solar panels, also known as PV modules, contain photovoltaic (PV) cells made from silicon that transform incoming sunlight into electricity. "Photovoltaic" means electricity from light (photo = light, voltaic = electricity). The conventional view that the solar photovoltaic electricity is more expensive compared with the grid provided electricity at retail level is being challenged by the continuous trend of reducing the cost of solar technologies and raising cost of fossil fuels.

In this scenario, some consumers may want to explore and shift to alternate sources for meeting their demand. However, shifting to solar power requires upfront investment. The economic benefit has to be justified in order to convince the consumer to make the initial investment. A normal consumer may not have the technical and commercial knowledge to install and operate the solar equipment. Consumer has to get expert advice from third party companies which may not be reliable and customized to specific requirements. The concept of rooftop PV has been successfully demonstrated in a project under the PV rooftop programme. In this project, the architectural system, data acquisition system has been presented, along with the calculation of payback time and economic profitability of the project.

II. LITERATURE REVIEW

A. Description of System

One of the most used renewable energy technologies used is Photovoltaic (PV) system. It uses the solar insolation from sun rays that incident on the PV module to generate electricity for the consumers. There are numerous PV technologies which include:

1) Multi-crystalline (or Polycrystalline) silicon contains multiple plates and silicon's crystals grains that form the polycrystalline cells when arranged together. The lifespan is (>25 years), it is durable and cheap to manufacture. They are about 12% less efficient than the monocrystalline silicon cell. It is a mechanical brittle and has low conversion efficiency.

2) Monocrystalline silicon: they are produced from pure crystal silicon. It has a conversion efficiency of around 15%, and it is durable (>25%). It is, however, expensive due to the thickness reduction of the cell.

3) Thin-film (Amorphous silicon): This type of solar cell is produced using less silicon film on a substrate glass. The lesser silicon film is used than in polycrystalline silicon and monocrystalline silicon. It has a low efficiency of about 6%. The advantages of thin-film silicon include; it can be produced in diverse shapes, flexible, has cell efficiency of 5-7%, and does not experience overheating that decreases solar cell performance.

4) Thin-film (Cadmium Telluride CdTe): it has an efficiency of around 165%. It is well-known because it has a cheaper cost per kW/hr. However, it does not absorb the longer wavelength of light like the silicon cells. It also has a toxic effect on the environment when disposed.

5) Copper Indium Gallium Selenide (CIGS): The efficiency of CIGS is around 20%, which makes it a better option than the thin-film PV cell. Also, it does not contain the toxic (Cd), and it has good resistance to heating.

B. Inverter

An inverter is a device that can convert a direct current (DC) to an alternating current (AC) that most home appliances use. For example, the output of solar PV panels is direct current, and an inverter converts this direct current to alternating current, which most household appliances run on. Therefore, there is a need to consider the inverters ability to handle surge electric demand from the load when choosing an inverter for an off-grid design.

C. Battery energy storage system

The battery stores electrical energy as chemical energy and converts the chemical energy to electrical energy when supplying the load. Batteries are rated according to their power and energy capacity. The needed current and voltage required by a specific photovoltaic system design is obtained when batteries are connected in series and parallel. Deep cycle batteries are mostly used for renewable energy systems, and they usually range from 18 to 40 MWh. Some of the batteries used for PV systems are:

1) Lithium-ion (Li-ion): The positive electrode (cathode) consists of litigated metal oxides (phosphates) and contains the lithium titanate (carbon) in the negative electrode. It has a high energy density and has a cell voltage of around 3.6V to 3.7V.

2) Lead-acid battery: A porous material that is dipped in a sulfuric acid electrolyte separates the positive electrode and negative electrode of the lead-acid battery. The positive electrode is made of lead dioxide, and the negative electrode is made of sponge lead.

3) Nickel Cadmium (Ni-Cd) battery: Ni-Cd provides reliable services; they have a long life span and are easy to manage.

4) Sodium sulphur (NaS) battery: each cell has a positive electrode of molten sulphur and a negative electrode of molten sodium. It has an efficiency of 90%.

D. System Configuration:

Fig.1 shows the system configuration of an off-grid system which comprises of solar panel that produces DC electrical power from direct sunlight. Batteries stores the excess DC power produced by the PV panels and supply to the load when there is no sunshine. A charge controller regulates, monitors and controls the energy flowing from the PV array to the inverter and the charge flowing from the battery to the load. An off-grid PV system supplies electricity directly for domestic usage; this system is designed to provide alternating current or direct current to power the classroom appliances.

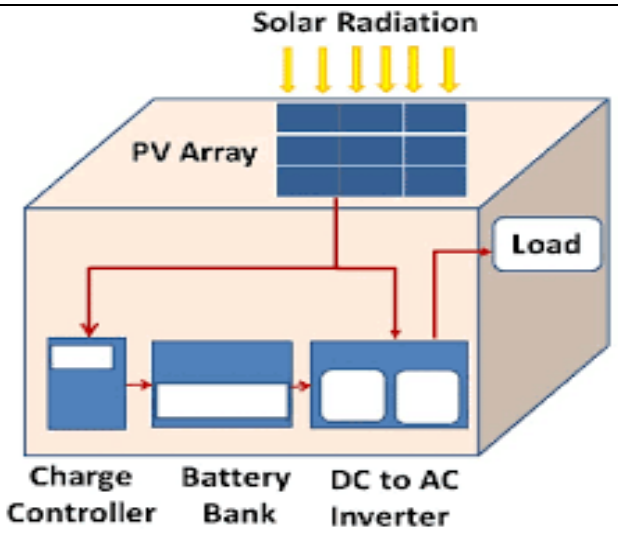

Fig 1. Off Grid Solar System

III. METHOLOGY

The methodology presented in this paper studies the classroom energy demand in residential load, which does not require a large electrical load. Firstly, the power rating of the electrical devices and the hours of use per day are listed.

A. Estimation of Load: Estimation of the load of a typical classroom of residential is determined. The detailed analysis of the appliances used in a typical household is shown in table I.

B. System Voltage Selection: It is required that the system voltage is adequate to supply the load demand. The system voltage usually increases with the increase in load. The system voltage of a standalone PV system is selected based on the characteristics of the inverter available. The total AC load power is less than 650W, system voltage is selected.

C. PV Module Selection: The PV module, the characteristics, the efficiency and the case of replacing the module are the major factors considered when selecting a PV module. The solar is used for this system, considering the factors mentioned below.

Table II. Ccharacteristics Of Solar PV module

Model	NS335011502456
Types of Technology	Polycrystalline
Power	1005W
Short Circuit Current	9.58 A
Open Circuit Voltage	45.4 V
Efficiency	51.78%
STC	25^0C

Table I. Load Of Classroom

D. Inverter Selection: The total AC load power is required to determine the exact capacity of the inverter for the off grid system. This has a total AC load of 585W, therefore, an inverter of 1000VA, 12V/24V is selected. Inverter capacity of 1000VA is chosen because it is higher than the total AC load power.

A 1000VA, 12V/24V inverter with a built-in Maximum Power Point Tracking (MPPT) is selected for this system.

E. Charge controller: The function of a charge controller in a standalone PV system is to protect the battery from over-charging by the array, it keeps the battery at the maximum state of charge, it also protects the battery from over-discharging by the load. The charge controller prevents severe discharging from the battery, which reduces its life span.

SR.NO	ELECTRIC APPLIANCE	LOAD POWER	QUANTITY	WATTAGE RATING
1	FAN	40W	9 SET	360Wh
2	LED TUBELIGHTS	15 W	5 SET	75Wh
3	SWITCHES	50 W	3 SET	150Wh
	TOTAL			**585Wh**

F. Battery Bank: we used lithium-ion battery because it is high energy density, faster rate of current, self-discharge, low maintenance, cell voltage. The load characteristics of a lithium-ion cell or battery are reasonably constant 3.6 volts per cell before falling off as the last charge is used. The battery capacity of 12V,80Ah is selected for this system. The oxides (phosphates) and contains the lithium titanate (carbon) in the negative electrode.

MAIN (volt)	Main (frequency)	SPV (volt)	SPV (kwh)	SPV (amp)	BATTERY (volt)	BATTERY (amp)	UPS (volt)	UPS (frequency)	LOAD (%)
0.00V	0.00HZ	26.2V	15.2W	17.8A	14.2 V	0.0A	219V	50HZ	72%
0.00V	0.00 HZ	25.9V	14.0W	18.4A	13.5V	0.0 A	219V	50HZ	64%
0.00V	0.00 HZ	26.7V	15.6W	17.7A	12.0V	0.0 A	219V	50 HZ	73%
0.00V	0.00 HZ	0 V	13.7W	0.0A	12.7V	0.0 A	219V	50 HZ	73%

Table III. Load reading table of classroom.

Conclusion

The quantity of solar radiation received by Nagpur city is high, it is estimated at average monthly radiation of about 4-6 kWh/m2 /day. This city has a great potential for the off-grid PV system, especially in the residential houses located in the rural areas which are not situated closely to the conventional power grid. The components and guidelines for designing and studying a cost-beneficial off-grid PV system is presented in this paper.

The 1KW array obtained from the result consists of 3 PV array modules, 1 (12V,80Ah) batteries and 12V/24V, 1000VA inverter, which has a built-in charge controller. The above listed components will adequately supply the classroom in the residential load if the load demand is within the capacity sated in this paper. The guideline stated in this paper can be adopted by the classroom in residential load.

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