CASE STUDY FOR THE IMPLEMENTATION OF STANDALONE PV SYSTEM IN ADMIN BUILDING (DMIETR), WARDHA

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Abstract
A photovoltaic system, also solar PV power system, or PV system, is a power system designed to supply usable solar power by means of photovoltaics. This paper gives detailed study of a standalone photovoltaic system for regular power supply of institutional building in DMIETR is presented. This paper gives complete procedure for specifying each components of the standalone PV system and an institution in Wardha, India is selected for case study. The process of obtaining power from PV panels involves design, selection and determination of specifications of different components that are used in the system conforming the load estimation. Completion of this process depends on a different factors such as geographical location of institution, weather condition and solar irradiance at location, and load consumption. Complete cost analysis which also includes installation and maintenance cost of a solar photovoltaic system has been carried out also it has been observed from the analysis that capital investment is high but payback period is less and after that it will gain consequential profit.
Keywords: photovoltaic system, inverter, charge controller, battery, payback period

I. INTRODUCTION

Energy is the primary and most universal measure of all kinds of work by human being and nature. The degree of development and civilization of a country is determined by the amount of energy utilized by its human being. Energy demand is increasing day by day due to increase in population, urbanization and industrialization. While fossil fuels will be the main fuels for thermal power, there is a fear that they will get exhausted eventually in the next century. Therefore other system based on non-conventional and renewable sources are being tried by many countries. These are solar energy, wind energy, sea, geothermal and biomass are clean, inexhaustible and environment- friendly resources [1].

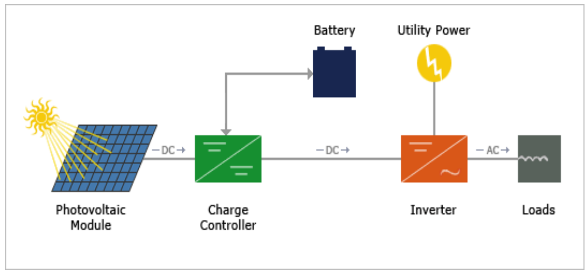
Solar energy has the greatest potential of all the sources of renewable energy and if only a small amount of this form of energy could be used, it will be one of the most important supplies of energy especially when other sources in country have depleted. The sun gives us 1000 times more power than we need if we can use 5% of this energy, it will be 50 times what the world will require. However on account of large space required, uncertainty of availability of energy at constant rate, due to clouds, winds, haze, etc. there is limited application of this source in the generation of electric power.At the off- time extra energy storage device are required to meet the demand. In this context, standalone solar power system are now being contemplated.

Different places on the globe experience different climatic condition [2]. Variation of total solar irradiance that reaches the surface of earth depends on time of day, season, location and weather condition. Therefore, design of the standalone solar system cannot have only one standard. Location is a major angle that will affects photovoltaic power system design and it varies from place to place. India is blessed with enough sun shine which can meet our energy demand without any compromise and it is also pollution free. Standalone PV system is a popular concept in rural areas of India where national electricity grid connection is easily available, it is not a common practice to use solar power. There is a general impression that grid energy from conventional source is much less costly compared to solar and other alternate energy source.

Equipment specification givenare based on availability of the best components in market. In addition to design considerations, we have done a detailed cost analysis of the system in this paper. As expected initial cost of solar power plant installation has been found to be very high and so, the cost of solar energy consumption unit is much more than conventional energy unit. And this is quite discoursing for general public to go for solar power plant. However, more interestingly, our estimation of the long term cost and area requirement of a standalone SPV power plant installation establishes our other objective that, contrary to general perception, it is very much economical and cost effective system [2].One of the objective of this paper is to calculate the potential of solar photovoltaic power system in rural area. For this purpose, a DMIETR college building in Wardha is taken up for designing and developing a PV system based on its daily load requirement. Before presenting the results and analysis of the case under study, i.e. of a DMIETR College building in Wardha, we have given introduction of different components of a standalone PV system and their functions in brief in the below section.

II. STANDALONE PHOTOVOLTAIC SYSTEM

Wherever a power grid is not or not at reasonable costs available, a stand-alone photovoltaic system can be used to generate the needed electric energy.Since the solar modules only produce electric energy during daytime, it is necessary to store energy for the night or for cloudy days. The components of such a systems are:1) Solar PV array, 2) Charge controller, 3) Inverters, 4) Battery, 5) Cables and 6) Protection devices. Depending upon load requirement and radiation intensity at the location, the components of the system will have to be specified. Figure 1 gives a schematic diagram of interconnection of components of atypical stand-alone photovoltaic power system.



In the following subsections we give a brief review of the functions of the components.

A. Solar Photovoltaic Panel

The solar panel or module is composed of solar cells that are responsible of collecting solar radiation and transforming it into electrical energy. The solar panel arrays are formed by a set of panels connected in series (to increase voltage) and/or parallel (to increase current) so as to provide the necessary energy for the load. The electrical current supplied by an array of solar panels varies proportionally to the solar radiation. It is the main and primary component in a PV system. Current and voltage generated depends on the area of the cell. A 13.5” 13.5” size solar cell can generate voltage of about 0.55 volt and a current density of 30-35mA/cm

B. Solar Battery

Storage battery is the dynamic component a standalone PV system. The battery is the combination of individual cell. A cell is the elemental combination of materials and electrolyte constituting the basic electro-chemical energy. Its function is to store energy during sunshine hours and supply current to load during non-sunshine hours. Lead Acid Battery, VRLA battery, Lithium-ion battery etc. are different types of batteries that can be incorporated in solar PV system [2].

C. Inverter

Inverter (also known as power conditioning unit) is the heart of the system. A direct/alternating (DC/AC) converter, also known as inverter, allows to convert the DC current from your solar panels into AC at the price of losing some energy during the conversion.

D. Charge Controller

A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining ("deep discharging") a battery, or perform controlled discharges, depending on the battery technology, to protect battery life. Two types of charge controllers are available: solar charge controller with PWM based technology and solar charge controller with MPPT based technology. In this paper MPPT design based charge controller is employed [2].

E. Load

An electrical load is an electrical component or portion of a circuit that consumes electric power. This is opposed to a power source, such as a battery or generator, which produces power. In electric power circuits examples of loads are appliances and lights. The term may also refer to the power consumed by a circuit. Power consumption units are load for a PV system to be planned. A proper load estimation is necessary for designing a grid connected PV system. For the purpose of PV system design, electrical loads may be classified broadly as either resistive loads do not necessitates any significant surge current when energized. Like light bulb, electric heater etc. are resistive loads, On the other hand, inductive load requires a large amount of surges current when the first energized which is about three times the normal energy requirement. Fan, electric motor, air conditioner etc. are inductive load. Depending on the load estimation of a building a proper design can be implemented.

F. Balance of the system components

The balance of system (BOS) encompasses all components of a photovoltaic system other than the photovoltaic panels.This includes wiring, switches, a mounting system, one or many solar inverters, a battery bank and battery charger. These components are required to protect the system in an efficient way. Cable size should be chosen in such a way that voltage drop or cable loss is minimized.

III. PROBLEM STATEMENT

1. In recent years, alternative energy systems have become an area of intense focus.
2. DMIETR campus currently does not have any solar energy installations.
3. Solar energy is uniquely suited for peak load conditions because solar power is maximized in midday when energy needs are the greatest.
4. Supply by MSEDCL is irregular as the college campus belongs to rural area.
5. Have to pay cost to the MSEDCL for using the electricity.
6. Need to depend on MSEDCL supply.

IV. METHODOLOGY FOR PV SYSTEM DESIGN

PV system design is a process of determining capacity (in terms of power, voltage and current) of each component of a standalone photovoltaic power system with the view to meeting the load requirement of the residence for which the design is made. The designing is done following the steps given below.

Step 1: Site inspection and determination of sun hours available per day.
Step 2: determination of power consumption demand of building
Step 3: Choice of system voltage and components
Step 4: Determine capacity of Inverter.
Step 5: Determine capacity of battery.
Step 6: Charge controller specification.
Step 7: DC cable Sizing.
Step 8: Solar PV array Specification and Design Layout.
Step 9: PV module orientation and land require for solar panels.
Step 10: Cost estimation.

A. Site Selection

- The site selection for a Solar Power Plant is pre-dominantly determined by solar irradiation.
- Availability. Equally important are other essential factors / considerations such as:
- Availability of adequate roof top space for Power Plant and green belt development
- Availability of water and power during construction
- Availability of labour force.
- Availability of load centres (towns) within vicinity
- Easy accessibility of the site
- The proposed site where Power Plant located in Wardha city of Maharashtra state and is found favouring all the above factors to a reasonable extent.

About Wardha District

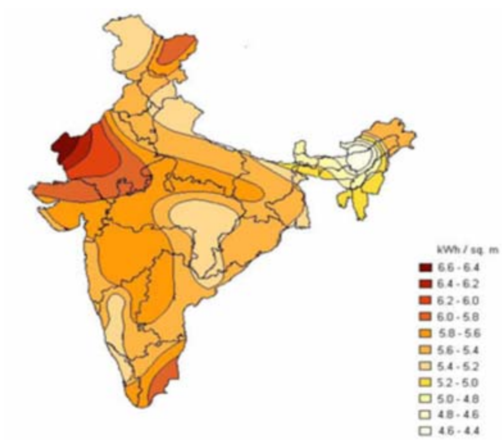
Wardha district is located on the north-eastern side of the state of Maharashtra .Wardha district lies between 20 degrees 18 minutes north and 21 degrees 21 minutes north latitudes and 78 degrees 4 minutes east to 79 degrees 15 minutes east longitudes. The maximum temperature in the district reaches 46 degree Celsius whereas the minimum temperatures hit around 9.4 degree Celsius.

Table: Monthly average radiation data of the site of the year 2016.

- **Proposed Location and Land Availability**
- **City= Wardha**
- **Topographical & Geological Conditions**
- **Location of place on Earth**
  (i) Latitude: 20.8049,^{0}N
  (ii) Longitude: 78.5661,^{0}E
- **Altitude** = 234m
- **Average annual solar isolation**

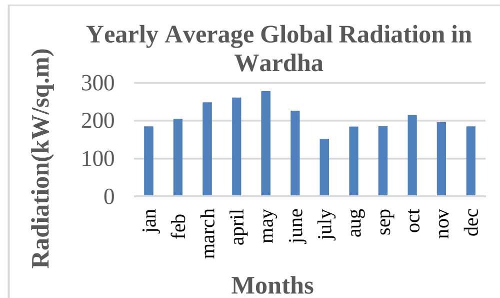
a) Average direct normal radiation5.38 kWh/m^2/day

b) Average global horizontal radiation5.64 kWh/m^2/day



Mean Global Solar Radiant Exposure at Wardha.

Months	**Daily solar radiation-Horizontal kWh/m²/d**
January	1.85062
February	2.05013
March	2.48481
April	2.61393
May	2.78232
June	2.26261
July	1.52094
August	1.84741
September	1.85228
October	2.15214
November	1.96209
December	1.85030
Annual	(2.102 **Kwh/m²/d**)



B. Choice of system DC voltage and components

Once the building load is calculated, Dc voltage other PV system require to be to be fixed. Generally, it should be taken as high as possible so that less current will be required to meet the high energy requirement. Lower the current through cables lower will be the electric energy loss, because cable has resistivity and high current will cause joule heating of cable. Otherwise, much thicker wires are required which will increase cost of the system. In a typical standalone system, in addition to PV panels, other subsidiary components required are battery, inverter, charge controller, cables and mounting structure [2].

C. Calculated Load of Administration Building

1. Library (no. x hours x wattage)

	Fan	Tube Light	Computers	Exhaust Fan	Ac	TV	Ducting
Library Hall	4x2x80 =640 wh	7x2x18 =252 wh				3x7x60 =1260 wh	2x4x2238 =17904 wh
Book Hall	4x7x80 =2240wh	14x7x18 =1764 Wh	4x7x100 =2800 wh		1x0.5x1650 =810wh		
Bath room		4x7x18 =504wh		2x0.5x60 =60 Wh			

Ground floor

Admin block

	Fan	Tube Light	Computer	Exhaust fan	Ac	TV	CFL	Xerox m/c
Xerox room	1x6x80 =480 wh	1x7x18 =126 wh						1x6x1250 =7500 wh
Principle room	4x4x80 =1280 wh	4x40x4=640 wh 4x5x1 =300 wh	1x3x100 =300 wh		1x3x1650 =4950 wh			
Board room	6x1x80 =480 wh				3x0.5x1650 =2475 wh		12x15x2 =360 12x2x40=960 wh	
Office room	20x7x80 =11200 wh	34x7x18 =4284 wh	18x7x100 =12600 wh	2x0.5x60 =60 wh				

2. Total electrical load (watt hour per day)

Library

- Library hall=20056 watt hour per day
- Book hall=6614 watt hour per day
- Bathroom=504 watt hour per day

Ground floor

- Xerox m/c room=8106 watt hour per day
- Principle room 7470 watt hour per day
- Board room=3315 watt hour per day
- Office room=22144 watt hour per day

Total electrical load= 68209 watt hour per day

3. Calculate solar system size

- Average Sunshine Hours = Daily Sunshine Hour in Summer+ Winter+ Monsoon /3
- **Required Size of Solar System = (Electrical Load / Avg. Sunshine) X Correction Factor**

4. Calculate No. of Solar Panel / Array of Solar Panel

If we Use 250 Watt, 24V Solar Panel in Series-Parallel Type Connection

- In Series-Parallel Connection Both Capacity (watt) and Volt are increases
- **No of String of Solar Panel (Watt) = Size of Solar Panel / Capacity of Each Panel**
- **No of Solar Panel in Each String= Solar System Volt / Each Solar Panel Volt**

Calculate Electrical Load

- Load for Computer = No x Watt
- Load for Computer = 23×100 =**2300 Watt**
- Load for Fan = No x Watt
- Load for Fan = 39×80 = **3120 Watt**
- Load for CFL Light = No x Watt
- Load for CFL Light = (16x15)+(16x40) = **880 Watt**
- **Load for tube light =62x18=1116 watts**
- **Load for exhaust = 2x60 =120 watts**
- **Load for AC = 5x1650=8250 watts**
- **Ducting = 2x2238=4476**

- Total Electrical Load = 2300+3120+880+1116+120+8250 =**20262Watt**

Calculate Size of Inverter

- Total Electrical Load in Watt = **20262Watt**
- **Total Electrical Load in VA= Watt /P.F**
- **Size of Inverter =Total Load x Correction Factor / Efficiency**

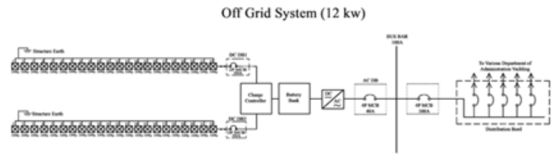
D. Costing of plant

Equipments	Quantity	Price (Rs)
Vikram solar panel (250 W)	44 x7,500	3,41,000
Inverter (30 kW)	1 x 2,54,000	2,54,000
Batteries	48 X 17,000	8,16,000
(Cable, MCB, WIRES)		25,000
Infrastructure		35,000
Service charge	1441000 x 0.15	2,16,150
Travelling expenses	60,000	60,000
Total		17,38,150

E. Payback Period for off grid system

Total cost of Plant = 1699150Rs.
Plant Capacity = 12 kW
Generation per Day = 12 x 8 (operating hours)
= 96 kWh /day
Annual Generation = 96 x 365
= 35040 kWh/annum
Annual Saving = 35040 x 8(Per unit charge)
= 280320 Rs
Subsidy = (30/100) x Total Cost
= 0.3 x 16991500
= 509745Rs
Payback Period= (Total cost- Subsidy) / Annual saving = (1699150-509745)/280320 = 4.24Years

V. DESIGN OF THE 12 KW STANDALONE PHOTOVOLTAIC SYSTEM



VI. CONCLUSION

The objective of this paper was to design a standalone photovoltaic system on radiation data (available for the location) to optimize the space requirement and the cost of installation. A standalone photovoltaic system for meeting the electrical energy and for the energy requirement for Data Meghe institute of engineering technology and research is presented as a case study for explaining the methodology adopted.

From the work presented, it can be concluded that the design based on monthly average daily energy generated gives 44 panels. Total cost required for establishment of plant is about 17,38,150 Rs and payback period estimated is about 4.24 years, considering the subsidy provided by the government on PV system installation.

The initial investment is very high, the rate of return is less. Assuming the life span of the panel to be 20 years as claimed by the industry, the remaining 50% of the life, electrical energy generate will be at a very small cost because of batteries and the maintenance.

Keeping in view, the present power shortage and also frequently interruption of power supply particularly for institution in rural areas to which DMIETR campus belongs, it is economical to utilize solar energy for meeting electrical energy requirement. This will improve reliability of power supply at a reasonably low cost which benefits the organization.

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