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Solar Installation for Lighting Load

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Abstract:- Solar energy can be harvested to generate electric power by photovoltaic (PV) panels. In applications where electricity is required, it can be a legitimate consideration. Solar PV system that provides Energy supply to an energy demand installation/building. Furthermore, solar PV energy systems have provided the versatility solution for many sectors in all over the world especially in rural areas where outage of utility connection is the case. Also depending on the availability of the solar resources at the location where the system is to be installed.

Hence, the potential of the off-grid solar PV systems stands out so clearly to compensate the outage of the utility connection. It is now possible to set up several system configurations for designing solar off-grid PV systems. Energy requirements needed to be supplied and the availability of the solar resources in the location where the solar off-grid PV system is being installed. The goal of the off-grid PV system design is to optimize the most suitable design in order to collect all the available solar energy to satisfy the need for the energy demand at an economically feasible price.

1. INTRODUCTION

The sun gives the energy to manage continuity of life in our solar system. In 60 minutes, the earth gets enough energy from the sun to meet its energy requirement for about a year .Harnessing solar energy to control electrical machines begins by altering the energy from the sun to power. Solar PV is the direct transformation of solar energy into power. PV systems can be utilized to utilize the solar energy in all applications and with fossil fuel assets and the truth that they are going to be depleted this century. Today, more than 1.4 billion individuals everywhere throughout the world need access to power. To enhance access to power to the next level in the rural areas on the planet, a decentralized off-grid installations are considered in type of solar PV. An Off-grid PV Systems are systems which utilize photo-voltaic innovation. The systems utilize the DC yield of the PV modules to power DC loads, while a battery bank is utilized to store energy when there is demand. Solar energy is the solar radiation that reaches the earth which is then being converted to electrical Power through several strategies. Solar buildings generally utilize solar PV panels to produce electricity. Solar PV panels produce DC electric power when exposed to sun light, and a DC-AC inverter normally converts this to AC power, which is the conventional form of the electric power in a typical building. Using DC electric power directly from solar PV panels is a bit challenging as most of the electric appliances are functioning using an AC power.

2. AIM & OBJECTIVE

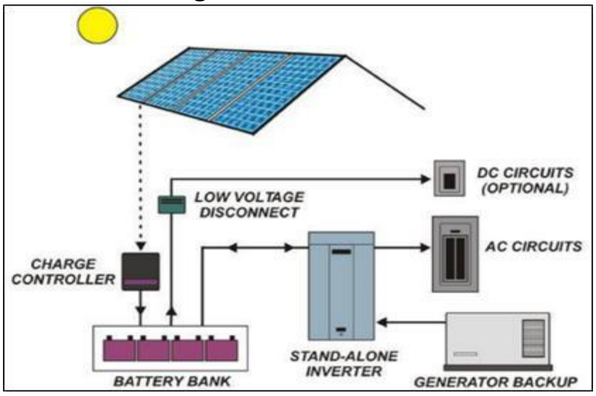
AIM

The aim of our project is to install an off grid solar system for lighting load of our electrical lab and replacing conventional luminaries by energy efficient ones.

OBJECTIVES

- The objective of this project is to design an off- grid PV solar system that is capable of providing a 100% of Electricity demand
- Reduce the energy bill of our college with the help of solar energy
- To serve the college by adopting alternate source of energy
- To conserve the fossil fuels and environment by reducing the consumption of electricity
- To inspire others to adopt another alternate source of energy source

3. Block Diagram



Principle of solar energy: The Photovoltaic effect

Photovoltaic (PV) effect is the conversion of sunlight energy into electricity.

In a PV system, the PV cells exercise this effect. Semi-conducting materials in the PV cell are doped to form P- N structure as an internal electric field. The p-type (positive) silicon has the tendency to give up electrons and acquire holes while the n-type (negative) silicon accepts electrons. When sunlight hit the cell, the photons in light excite some of the electrons in the semiconductors to become electron-hole (negative- positive) pairs. Since there is an internal electric field, these pairs are induced to separate. As a consequence, the electrons move to the negative electrode while the holes move to the positive electrode. A conducting wire connects the negative electrode, the load, and the positive electrode in series to form a circuit. As a result, an electric current is generated to supply the external load. This is how PV effect works in a solar cell.

Components of Off-grid PV System

- Solar PV Modules
- Dc-Ac inverter
- Battery Bank
- Load

4. System Design Methodology

- **Planning and Site Survey**

The PV solar array output is majorly dependent on the geographical locations and timing. It is quite crucial to select proper site based on solar natural resources. Thus, in planning a solar PV system installation, appropriate selection of site with consideration of nearby high-rise objects is necessary.

- **Assessments of Energy Requirements**

In an off-grid solar PV system, evaluating the energy demand and surveying the exact abundant solar natural resource availability are the most essential undertakings/tasks which must be done appropriately.

- **Load Assessment**

In arranging, regular and day by day load alterations are required. It is critical to evaluate the sorts and use of loads with their electric profiles. A system engineer needs to consider the energy necessities with load profiles in conference with the consumers

- **Energy Audit**

We began our project with energy audit and in this we did lighting load assessment of our lab to understand the actual energy consumption and how we can reduce the energy consumption with the help of our solar panels. (PHS= Peak Sun Hour)

Load	Rated power (watts)	Quantity	Hours used per day	Watts	Wh/day
FTL	40	35	7	1400	**9800**
FAN	60	15	7	900	**6300**
		Total		**2300**	**16100**

Daily Energy Use (kWh)	16100Wh
Monthly Energy Use (kWh)	483kWh
Annual Energy Use (kWh)	5876.5kWh
PSH	4.5

Tariff rates as per BEST for Educational institutes

Consumption Slab (kWh)	Fixed/ Demand Charge	Variable Charges (Rs/kWh)	
		Energy Charge (Rs./kWh)	Transport Division Loss Recovery Charge (Rs/kWh)
All Units	Rs. 200 per kVA per month	6.60	1.51
TOD Tariffs (in addition to above base tariffs)			
0600 to 0900 hours		0.00	
0900 to 1200 hours		0.50	
1200 to 1800 hours		0.00	
1800 to 2200 hours		1.00	
2200 to 0600 hours		-0.75	

Energy consumption = No. Of lamps*Watt *Hour + No. of fans * watt* hour
Per day. = (35*40*7) + (15*60*7)
= 16100Wh/day

Energy consumption =Energy consumed per day * no of days in month
Per month. =16100Wh * 30days
=483000Wh = 483kWh

Energy consumption = Energy consumed per day * no of days in a year
Per Year = 16100Wh * 365 days
= 5876500Wh = 5876.5kWh

Energy bill Calculation

- **1 unit=** 1000 Wh
- **Units consumed per month=** energy consumed per month / 1000
  = 483000 / 1000 = 483 units
- **Units consumed per year =** energy consumed per month / 1000
  = 58765000 / 1000 = 5876.5 units
- **Cost of energy consumption=**units per month × (Tariff + Tax)
  In one month =483 × (6.60 + 1.51) =3918 /-
- **Cost of energy consumption =** units per year × (Tariff + Tax)
  In one year = 5876.5 × (6.60 + 1.51) =47658.415/-

After doing the lighting load assessment we realized that there are total 7 sub-circuits in our lab and each sub circuit is operated by a separate MCB. As our first idea was to give solar energy to all the FTL but each tube-light is connected to different sub circuit. If we want to give supply all the FTL we must make single switch board for all the FTL which will required extra wiring and it will increase cost of our project. As to avoid this problem and as an alternate we calculated the load on each sub circuit and try to reduce is to match it with our solar panel output. After doing calculation we got to know that 20 FTL and 6 fans were working on 4^{TH} no of MCB sub circuit which had a total load of 1100 watts and after replacing it by LED it will be reduce to 760watts. This requirement can be easily fulfilled by our solar panels.

After replacing all the FTL with 20-watt LED tubes and with 6 fans of 60 watts our load on selected sub circuit reduced to 760 watts.

Replacement of FTL with LED Tubes

Load	Rated power (watts)	Quantity	Hours used per day	Watts	Wh/day
FAN	60	6	7	360	**2520**
LED	20	20	7	400	**2800**
Total				760	**5320**

1 unit= 1000 h

Units consumed per month= energy consumed per month / 1000
= 159600/ 1000 = 159.6 units

Units consumed per year = energy consumed per year / 1000
= 1941800 / 1000 = 1941.8 units

Cost of energy consumption in one month =units per month × (Tariff + Tax)
=159.6units × (6.60 + 1.51) =1294.35/-

Cost of energy consumption in one year = units per year × (Tariff + Tax)
= 1941.8 × (6.60 + 1.51) = 15747.98/-

Since the LED and FAN's are running on solar so these 15747.98 rupees will be deducted from Actual energy bill.

Actual energy bill cost = energy cost by the actual load – energy saved by the solar
= 47658.41 – 15747.98
= 31910.43/-

Selection of PV module

In this part, the PV module was selected due to few reasons that are worth to Mention; its performance, warranty and high efficiency. Thus, Suva Solar is monocrystalline 260watts is chosen.

- **Rated peak power**=260w
- **Total Wh/day** =5320Wh/day
- **System efficiency**=invertor+batteries +losses
  =85%+85%+75%
- **Average efficiency of system** = 81.66%
- **Actual power used at the end**
  =260W* 0.8166= 212.33 W
- **Energy produced by the panel in a day**
  =212.33 * 8hours = 1699Wh
- **No. of solar panel required**
  = total energy required/ energy produced
  = 5320/1699= 3.11 ~ 3 panel
- **3 panels are required of 260W each**

Inverter Design and Selection

In this part we have chosen an inverter that can handle the maximum electric wattage that must be drawn by all the electric appliances when they are all turned on at the same time. Total daily wattage needed = 760 kW+ (20% SF) =1kW and this number still valid as it is in the recommended region of the electric Inverter.

- Now the required Back up Time of batteries in Hours = 2 Hours

Product Description

- Rated AC power: 1100VA, 24V
- Operating Voltage 100-290V
- Max supported panel power: 24V up to 1000 WFP
- Charge Controller Rating - 20 Amp/12V, with 98% efficiency for fast charging

Battery Design and Selection

As our working time is 9 to 10 hours in day time and in Mumbai region there is no load shading, it rarely in happens in due to some fault or maintenance purpose we don't required much battery backup. As a precaution we had provided the battery backup for 2 hours to run the load if solar energy or main supply is not available.

Required No of Batteries

- Suppose we are going to install **100Ah, 12 V batteries**,
- 12V x 100Ah = 1200 Wh
- Now for one Battery (i.e. the Backup time of one battery)
- 1200 Wh / 760 W = 1.8 ~ 2 Hours
- 2 Batteries are connected in series and it will give 100Ah 24V back up supply to our system

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Market survey

After designing the system and system components we did the market survey. We did online survey and went to different markets and shops to get the idea about the rating of components, cost, and details about the solar system.

Different Suppliers:

1. Sky Services : 92,000 /-
2. Unique electro systems : 75,000/-
3. Yash technologies : 95,000/-

After getting the quotation we finalized the three suppliers and asked them for site visit and for the further discussion about the project. Due to higher budget we didn't go for sky services and Yash technologies and finalized the unique electro system.

6. WORKING OF THE SYSTEM

Case1: We have installed the solar panel having a capacity of 780watts and if our load requirement is 700 watts then invertor with the help of inbuilt charge controller extract the maximum power available power from the solar power. It checks the output of PV module, compares it to battery voltage then fixes what is the best power that PV module can produce to charge the battery and converts it to the best voltage to get maximum current into battery. It can also supply power to a DC load, which is connected directly to the battery. In this way solar panels fulfilled the load requirement.

Case2: In case our load requirement is above 700 or 800 watts and power extracted from the solar panel is not sufficient to fulfil the load requirement then inverter gives first priority to batteries. Batteries will help to give the remaining power to load. Charge control will compare the battery voltage and solar panel voltage and supply the best power that both can produce together. This is how continuity maintained b solar inverter.

Case3: In rainy seasons due to clouds solar may not produce require power to run the load and to charge the batteries. In this case solar will give priority to main supply to charge the batteries and as well as to supply the remaining power to load with solar panel and maintain the continuity of the supply.

In this way solar installation system works in different cases and will maintained the continuity of supply.

7. PROJECT COST ANALYSIS

Cost of energy consumption by solar connected load
= units per year × (Tariff Tax)
= 1941.8 × (6.60 + 1.51) = 15747.8/-

Since the LED and FAN's are running on solar so these 15747.98 rupees will be deducted from Actual energy bill which is nothing but our savings.

Cost of the panels 800watts: 27,500/-
Cost of the 1800va inverter: 14,000/-
Cost of the batteries 12V 100Ah= 16,000/-
Mounting structure: 11,000/-
LED tube lights of 20W:
3800/- **Cost of the cable:**
1300/-
Other expenses: 10,400/-
Total cost of the project: 84,000/-

Accordingly, the payback period can be calculated using Equation**:**

Simple Payback year
= total cost of the project + maintenance charges/savings
= 84000 + 1000 / 15747.8 = 5.5 years

8. CONCLUSION

If users replace their existing system with rooftop solar home system, then within 5.5 years they can recover their initial cost; that means the payback period is 5.5 years. Therefore, by adopting this proposed system users can save 15747.98 rupees annually and improve their economic conditions.

9. REFERENCE

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