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Implementing the solar PV system in a pharmaceutical industry

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ABSTRACT

Solar Energy a clean renewable resource with zero emission, has got the tremendous potential for energy which can be harnessed using a variety of devices. With recent developments in the solar energy field, solar energy systems are easily available for industrial and domestic use with the added advantage of minimum maintenance and cost. Solar energy could be made financially viable with incentives and rebates offered by the government. Most of the developed countries, as well as developing countries, are switching over to solar energy as one of the prime renewable energy sources. It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power so as to minimize cost. Active solar techniques focus on the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy and use it efficiently. Passive solar techniques mainly focus on orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. This paper analyses the economic feasibility of investments in industrial PV systems. On Implementing the Solar PV system, highly encouraging results have been obtained.

Keywords— *Solar PV system, Renewable energy, System requirement*

1. INTRODUCTION

1.1 The Photovoltaic process

The Photovoltaic (PV) process comes into existence when photovoltaic systems are exposed to sunlight, resulting in the production of electricity. The sun's rays are composed of particles of energy called photons which serves as the ignition process of generating electricity. Thus when the sun’s radiation affects an area of the PV material, photons cross the surface of the PV material and may either be reflected or absorbed by the material. If a photon is absorbed, its corresponding energy gets transferred onto an electron in an atom located in the PV material. After receiving the necessary energy, the electron is able to leave its usual position in the orbit of its host atom and jump to the higher energy level. Thus increases the current of an electrical circuit, and in this manner, the phenomenon is called the "Photovoltaic" effect.

Solar energy is in the form of radiant light and heat from the Sun that is harnessed using a range of technologies such as solar heating, photovoltaic, solar thermal energy, solar architecture. It is an important source of renewable energy and its technologies are broadly classified as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power for further use. Active solar techniques include the use of photovoltaic systems, concentrated solar power, and solar water heating to harness the energy. Solar power in India is a growing industry.

Solar PV cell is the basic building block of a typical PV system. It consists of semiconductor material that absorbs sunlight in the form of photons to generate electricity through a phenomenon called “photoelectric effect”. Only sunlight of a certain range of wavelength is able to effectively generate electricity. Although a solar PV can generate electricity on a cloudy day i.e. on a low intensity of solar radiation, it is not as effective as it is on a sunny day.

A basic PV cell produces a very small amount of electricity and multiple of them are connected together to form a Solar PV module that can generate 10W to 300W output [8]. If more amount of electricity is required, then multiple such PV modules have to be installed in an order i.e. in form of an array. Multiple kinds of materials are used to create an effective solar cell and the efficiency of a solar cell depends on the same. The efficiency of a solar cell can be defined as its capability to convert a certain amount of solar radiation i.e. sunlight into electricity. Solar cells available in the market are of various efficiencies: 4%, 8%, 12%, 14% and 16% [10].

Table 1: Panel Efficiency of Different Panels [10]

S. No.	Panel Capacity (Wp)	Panel Efficiency [Wp/(1000*m^2)]
1	200	12.42%
2	225	13.98%
3	250	15.53%

There are many reasons to install the solar photovoltaic system, from reducing the carbon footprint as well as the annual electricity bills to minimizing the impact of ever-increasing energy costs year by year and generating a tax-free income. Solar PV panels and systems are easy to install, guaranteed to last for a long time and require minimal maintenance.

The main reasons for using Solar PV panels over the conventional electricity generation are:

- The high rate of Electricity
- Non-continuous supply of Electricity
- High Carbon Footprints

1.2 Components of A solar rooftop PV system [11]

1.2.1 Solar Modules

A typical Solar PV System is available in the form of a module. There are two kinds of modules: Thin-film, and Crystalline. Rooftop solar plants predominantly use crystalline panels because they are more efficient and therefore better suited to installations like rooftops where space is a constraint. There are two important parameters about solar panels:

1.2.2 Panel efficiency

It should be noted that the efficiency of a solar panel is calculated with reference to the area it occupies. For example, two 250 Wp (watt peak) panels of different efficiency rating will generate the same amount of power, but occupy different amounts of space on your rooftop as per the effectiveness of the two panels.

1.2.3 Capacity rating

The capacity of a solar panel is denoted in terms of watts as Wp (watt peak). Example, 250 Wp. This is the power output of the plant at 25°C. The capacity of the plant reduces at temperatures above 25°C and increases at temperatures below 25°C.

2. INVERTERS

Inverters are a very crucial component of a rooftop solar PV plant because they determine the quality of AC power you get, and also the kind of loads that can be powered with solar PV system – different inverters support different levels of starting current requirements which affect the kind of machinery that can run on solar power. Inverters are also the only major component of your solar plant that is replaced during the lifetime of the plant.

2.1 Types of inverters

Based on the explanation above, inverters can be classified into 3 types:

2.1.1Grid-tied

These inverters are primarily designed to supply the generated power to the grid and also power the load while grid power is available. This inverter will not generate power during a power failure, not only because it needs grid power as a reference voltage, but also because the inverter shuts down the system to stop sending power into the grid and avoids the risk of electrocuting utility personnel who are working to repair the grid (known as Anti Islanding)

2.1.2 Off-grid

These inverters do not work with the grid and are designed to work only with a battery backup or diesel generator in off-grid applications. They are suitable for applications where grid power is not available at all but are not the right choice if you need your solar plant to work in conjunction with grid supply. So they are not reliable in the areas where the sun does not shines over the year that is on a cloudy day, the intensity of solar radiations are less.

2.1.3 Grid-interactive

These inverters work both with the grid supply and with either a battery backup or diesel generator to support the load even during a power failure.

3. SOLAR PANEL MOUNTING STRUCTURES

Solar panels are mounted on iron fixtures so that they can withstand wind and weight of panels. The panels are mounted to face south in the Northern Hemisphere and north in the Southern Hemisphere for maximum power tracking. The tilt of the panels is at an angle equal to the latitude of that location.

The proper design of mounting structures is important to power plant performance as the power output from the PV plant will not be maximized if the mountings buckle and the panels are not optimally oriented towards the sun. In addition, improperly mounted panels present a ragged appearance that is not pleasing to the eye. Allowing sufficient air circulation to cool the PV panels is also an important factor that mounting structures should be designed for because, as mentioned above, rooftop PV plant output falls as temperatures rise above 25°C.

3.1 Solar trackers

Tracking is a way of mounting the panels through a mechanism that allows the panels to follow the sun as it moves across the sky that is with the help of external equipment. Single-axis trackers follow the sun as it moves from East to West during the day, while dual-axis trackers also follow the sun on its North-South journey over the course of a year so that maximum amount of solar radiation falls on the surface of the solar PV panels. Trackers can increase the power output from the PV plant but add significantly to both the initial cost of the plant and maintenance expenditure; utilization of trackers should be decided on a case-to-case basis after performing a cost-benefit analysis over the lifetime of the rooftop plant. Also, this type of system can be used in the areas where space is a constraint.

4. BATTERIES

A battery pack can add about 25-30% to the initial system cost of a rooftop PV solar system for one-day autonomy (storing an entire day's output). Charge controllers that are integrated into the inverter are preferred as the inverter directs either grid power or solar power, based on availability and demand, to charge the batteries. This extends the battery life compared with using stand-alone charge controllers that allow parallel charging between the grid and solar power at different power levels, damaging the battery

4.1 Reasons to use batteries

(i) Make power available when the sun isn't shining

This can be particularly useful for applications where electrical consumption is greater during the night than in the day, such as BPOs that work on night shifts, or even residential apartments where most people are away during the day and at home during the night

(ii) Smoothen power delivery during the day

Clouds moving across the sun can suddenly reduce the output from your rooftop plant. A battery backup can ensure that the load gets sufficient power during such dips in plant output

(iii) Immediately cut-in during power failures

If space isn't available for a large rooftop plant, solar panels with batteries can be used to support the load until a diesel generator can be turned on

(iv) Optimize time-of-use billing

If the utility charges different tariffs based on time of day, power from the batteries can be used to reduce consumption at those times when utility power is very expensive

4.2 Drawbacks to using batteries

(i) Charge/discharge efficiency

Batteries and their charging equipment are not 100% efficient. There is a loss of energy both while charging and discharging the battery. Different models of batteries can have different charge/discharge efficiencies. If we lose 15% of the energy while charging and another 15% while discharging, we get back only about 72% of the power that was sent to the battery.

(ii) Maintenance

Battery packs require careful maintenance. Maintenance isn't limited to the physical condition of the battery (amount of electrolyte, cleaning of terminals) but also extends to the way we charge and discharge the battery. Repeatedly deep discharging the batteries, discharging before the battery has reached a full charge, etc., are ways in which the life of the battery can be significantly reduced. Batteries can last as long as 10 years or give trouble within a few days, depending on how they are used.

(iii) Maintenance of rooftop solar PV systems

The basic rooftop solar PV system has no moving parts and therefore requires very little maintenance. Additional components, such as trackers and batteries, can significantly increase the maintenance effort and expenditure.

5. LITERATURE REVIEW

Some important reported research studies related to lean are mentioned in the tabular form in Table 2.

Table 2: Summary of Research Paper Studied

S. No.	Research Paper	Author	Summary of the Work
1	Investigating the option of installing small-scale PVs on facility rooftops in a green supply chain.	Tarek Abdallah, Ali Diabat, Jasper Rigter	This paper presents a case study of checking the feasibility of roof whether it is economical to install the PV system on the rooftop or not.
2	Effectiveness Evaluation for a Commercialized PV-Assisted Charging Station.	Nian Liu and Minyang Cheng	In this paper, the operation mode and profitability of a commercialized PVCS are analyzed under the energy policy of China.
3	A Feasibility Assessment of Photovoltaic Power Systems in Ireland; a Case Study for the Dublin Region.	Fionnuala Murphy and Kevin McDonnell	This paper evaluates potential energy generation by PV in Dublin and determines the technically feasible size of installation relative to existing roof space.
4	Models for Deployment of Solar PV Lighting Applications in Rural India.	Anand Saumya and Rao Anand B.	This paper focuses on Implementing the off-grid Solar PV system in a village for developing the power to run general lighting appliances.
5	Grid-connected PV systems installed on institutional buildings.	A. Allouhi, R.Saadani, T. Kousksou, R. Saidur, A. Jamil, M. Rahmoune	The purpose of this research is to set up a Grid Connected PV system in an institutional building and checking the performance of the system.
6	Design and cost analysis of 1 kW photovoltaic system based on actual performance in Indian scenario.	Shahzad Ahsan, Kashif Javed, Ankur Singh Rana, Mohammad Zeeshan	The study is based on the design of a solar PV system and a case study based on a cost analysis of 1.0 kW off-grid photovoltaic energy system installed at Jamia Millia Islamia, New Delhi.

7	Performance analysis of an 11.2 kWp rooftop grid-connected PV system in Eastern India.	Sharma Renu, Goel Sonali	From the study it was found that the System efficiency was found to be 12.05%, Performance Ratio is 0.78.
8	Performance Assessment of 100 kW Solar Power Plant Installed at Mar Baselios College of Engineering and Technology.	Prakash Thomas Francis, Aida Anna Oommen, Abhijith A.A, Ruby Rajan and Varun S. Muraleedharan	The objective of this project work is to analyze the performance of a 230Wp capacity solar panel installed in Mar Baselios College of Engineering and Technology

6. METHODOLOGY ADOPTED

In case of industry ***Parsh Pharmaceuticals, Ujjain, Madhya Pradesh***, ayurvedic medicines are manufactured. In the present study, an attempt has been made to implement a 3KWp Rooftop Solar PV system in the case industry. The purpose of this test is to determine the estimate to implement the Solar PV system on the roof.

1) Estimate the amount of energy required from the solar plant rooftop. The amount of energy needed is determined based on the load that needs to be supported. The load represented by the equipment can be calculated as:

Total energy requirement/day (Wh) = Wattage of appliance (Watt) * No. of appliances * No. of working hours (Hrs)

This should be divided by 1,000 to be converted into kWh/day.

At this point, the plant designer might wish to identify large/variable loads that need not be supported by solar power or that can be operated through some other power source to reduce the investment in the solar system.

2) Now we know that in India, Sun shines almost 8 hours in a day. So to calculate the system requirements to fulfill energy requirements, the following formula can be used:

Total solar PV system requirement = Total wattage requirement in a day (Watt)/No. of hours of solar power generation (Hrs)

7. RESULTS AND DISCUSSION

Before applying the above methodology, it is very necessary to calculate the initial requirements to implement the above methodology.

Table 3: The Wattage of the different lighting appliances

S. No.	Name of Appliance	Wattage (Watt)	No. Of Appliance	Total Wattage (Watt)	Working Hours (Hrs)	Total Wattage* Hrs
1.	18 W CFL	18	22	396	11	4356
2.	T-12 And T-8 Tube Light	40	42	1680	11	18480
3.	9*2 W CFL	18	6	108	11	1188
4.	18*2 W CFL	36	11	396	11	4356
5.	300 W Metal Halide Lamp	300	4	1200	10	12000
6.	Total Wattage			3780		40380

1. Total Energy Requirements = Total Wattage (Watt) * No. Of Working Hours (Hr)
= 40380Whr
= 40.38KWhr

2. The inverter should be 25% greater than the total load= 3780 * 1.25
= 4725 Watts
= 5000 Watts (approx.)

This is the rating for UPS (Inverter)

Now the required Backup Time in hours is 3 hours.
Suppose we are going to install 100Ah, 12V Batteries= 24 * 100 * 0.91 (Battery Efficiency taken as 91%)
= 2184 Wh

Now for one battery (That is the backup time for one battery) = 2184 / 3780
= 0.5777

But our requirement time is 3 hours, so =3 / 0.5777
=5.19= 6 (approximately)

So we will require approximately 6 batteries each of 100Ah and 24 V.
And all the batteries should be connected in parallel.

We will connect 6 Batteries in parallel (each of 100Ah and 24 V) and there are 6 Batteries, 600Ah, 24 V

Now required charging current for these 6 batteries
(Charging current should be 1/10 of batteries Ah) = 600 * (1/10)
= 60A

Now the required number of solar panel of 250W per panel of efficiency 15%,
Therefore, actual power output of a 250W Panel is = 250 * 0.85
= 212.5 W

Power generated by 250W solar panel in 8 Hours = 212.5 * 8 = 1700W

Now total number of panels required is= Total energy required per day / Power output of a 250W panel per day
=40380 / 1700
=23.75
=24 (Approx.)
So, total number of solar panels required will be 24.

This will be the requirement of total setup to run the **M/s Parsh Pharmaceutical** on Solar Power so that the cost of electricity can be minimized as well as an alternate source of power can also be utilized.

8. CONCLUSION

So from the above discussion, it has been shown that after Implementing the Solar PV system in the case industry, highly encouraging results were obtained. The dependency on the Conventional source can be very much reduced by implementing the above method.

As the tariff for electricity is increasing year by year, so the switching on the other, as well as cheap and efficient sources of electricity, has been increasing day by day.

As for implementing this method, highly encouraging results have been obtained as follows:
1. Total Inverter capacity to bear 3780 W of the load is found to be 5000 W.
2. 6 Batteries (each of 24 V and 100 Ah) should be installed to bear the load for 3 hours backup.
3. 24 Solar Panels of 250 W capacity should be installed and connected in parallel to bear the load.

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