Reduction in Electricity Consumption by Applying Solar Electric System or Photovoltaic (PV) System at Residential Apartment

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Abstract— Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. For engineers, sustainable development is the design of man-made systems to ensure the current uses of natural resources without affecting the quality of life of future generations. One of the natural resource that we can use is Sun which gives us solar energy. Solar energy can be converted into solar power. Solar power is produced by collecting sunlight and converting it into electricity. Solar energy is completely non-polluting, green energy, throughout its life free and also it does not emit any greenhouse gases into the atmosphere. The objective of this paper is to save electricity consumption used for common purpose at residential apartment. This paper presents the proposed idea of implementing solar electric system also called as photovoltaic (PV) system at Akshat Palms apartment , Solapur. Photovoltaic (PV) systems convert sunlight directly to electricity. They work any time the sun is shining, but more electricity is produced when the sunlight is more intense and strikes the PV modules directly. Solar power system provides safe and reliable power generation without the need and expense of installing utility power. This paper gives the description about how much electricity is currently used by the apartment for common purpose like lift, parking area, porch light etc and how this electricity consumption can be reduce by applying solar panels at this apartment. The study involves determining the size of PV system required for the apartment. Then comparison of the electricity generated by this PV system per year with the usage of current annual electricity. It is based on the electricity usage measured in kilowatt-hours for apartment over the past few months. This electricity bills shows usage of near about 4500 units per month. The goal of this study is to reduce this electricity consumption which will automatically reduce carbon emission. We can also assume that Solar Photovoltaic will play an important role in the overall energy supply for residential apartment. By applying solar PV system at residential apartment will automatically reduce the monthly maintenance cost which each flat owner have to pay.

Key words: Sustainable development, Solar electric system, photovoltaic (PV) system, Residential apartment, electricity consumption

I. INTRODUCTION

Solapur City has been shortlisted by the Minister of Urban Development as one of the smart city of India. The definition of smart city is towards sustainable development. Solar electric systems have a number of benefits that include electric bill savings, reductions in greenhouse gas emissions and other toxic air contaminants. Solar electric system is part of sustainable development. As these system make use of a renewable source of energy—the sun, these are more affordable for homes , apartments and businesses. Solar electric power is free and it is feasible to extract power out of the solar energy falling on the earth. Hence, a Solar PV System has become an important part of our life. The objective of this study is, i) to facilitate the reduction in consumption of diesel for power generation and dependency on grid power, ii) to establish the effectiveness of solar systems for residential apartments. Solar power system has the characteristics of self-control, self-protection, needing no attention, compact structure, and convenience. Keeping all these things in mind, the proposed idea for installing Solar electric system at the residential apartment is discussed here.

II. RELATED WORK

S. Ramanan, R. Sridharan described the need for India to switch towards using the renewable energy. A brief status and statistical analysis of the rising need of power generation is given. The employment scenario of Indian engineers in the Information Technology (IT) sector irrespective of their specialization is discussed. To use the full potential of Indian engineers, solar photo voltaic is portrayed to be the next major area. There is a discussion on the need for inclusion of solar photo-voltaic coursework in the Undergraduate curriculum. A brief introduction and conceptual discussion of solar photo-voltaic is given as a motivation to the undergraduate students. In this paper, the authors infer that solar energy has a great potential in the future of India in both energy as well as employment sectors [2].

Dolf Gielen, paper aims to serve the need of renewable energy and it contains a set of five reports on solar pholtovoltaics, wind, biomass, hydropower and concentrating solar power that address the current costs of these key renewable power technology options. The reports provide valuable insights into the current state of deployment, types of technologies available and their costs and performance. The analysis is based on a range of data sources with the objective of developing a uniform dataset that supports comparison across technologies of different cost indicators - equipment, project and levelised cost of electricity – and allows for technology and cost trends, as well as their variability to be assessed [5].

III. METHODOLOGY

Photovoltaic Systems make use of the ‘photovoltaic effect’ (photo=light and voltaic=electricity), the basic process discovered by Edmund Becquerel, a French physicist in 1839. He discovered the PV effect while experimenting with an electrolytic cell made up of two metal electrodes; finding that certain materials would produce small amounts of electric current when exposed to light. Sunlight is composed of photons, or ‘packets’ of energy. These photons have various amounts of energy corresponding to different wavelengths of light. When photons strike a PV cell, they may be reflected or absorbed, or they may pass right through

the surface (causing heat only). When a photon is absorbed, the energy of the photon is transferred to an electron in an atom of the cell, a semiconductor based material (such as silicon). With its newfound energy, the electron is able to escape from its normal position associated with that atom, to become part of the current in an electrical circuit. By leaving this position, the electron leaves a hole behind. While the electron is negatively charged, the hole is recognized as a positive charge carrier and contributes to current. The PV cell has a built-in electric field, providing the voltage needed to drive the current through an external load, such as a light bulb [4].

There are different types of Photovoltaic systems like, grid connected PV system, Direct-coupled PV system, stand-alone PV system with battery backup and without battery backup. The best suited PV system for residential apartments is stand-alone PV with battery backup. Figure 1 shows the block diagram of stand-alone PV system with battery backup powering DC and AC loads.

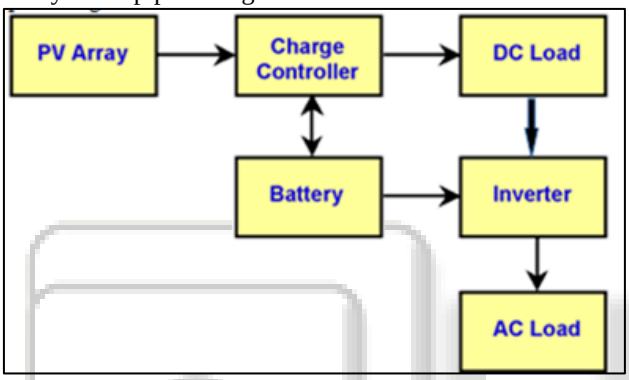

Fig. 1: Block diagram of Stand-Alone PV system (source: http://www.fsec.ucf.edu/en/consumer/solar_electricity/basics/types_of_pv.htm)

The standalone PV system without battery backup work in days till sun gives light so these can be use only for common appliances like, fan light, pumps etc only in day. As in residential apartments the common light should be on at night also in parking area, entrance etc. Along with this the elevator should also be in working condition at night. So that batteries are an important element of any standalone solar power system.

The function of the battery is to convert the electrical energy into stored chemical energy for use when the solar array is not producing power. During the day when sun shines, the PV system is directly fed to the load, with excess electrical energy being stored in the batteries for later use. During the night, or during a period of low solar irradiance, such as a cloudy, rainy days, energy is supplied to the load from the battery. So battery storage allows a stand alone PV system to be run when the solar panels are not producing enough energy on their own.

A. Calculation of Electricity Usage for Common Purpose in Apartment:

The common purpose electricity usage contains 10 tube lights of parking area, 3 tube lights at each floor for common passage. As building has 7 floors, total 21 tube lights are used for common passage at night. Common usage also contains one elevator. To calculate the daily electricity usage the electricity bill for the past year were collected and average monthly electricity usage was calculated. This is shown in below given table.

Sr. No.	Month	Unit (Kwh)	Bill (Rs.)
1	Aug 2016	1378	17,980/-
2	July 2016	812	10,474/-
3	June 2016	810	10,449/-
4	May 2016	668	8,612/-
5	April 2016	1188	15,325/-
6	March 2016	904	11,661/-
7	February 2016	758	9,778/-
8	January 2016	662	8,540/-
9	December 2015	1648	21,259/-
10	November 2015	1538	19,840/-
11	October 2015	1113	14,357/-
12	September 2015	700	9,030 /-
Total		12179 Kwh	1,57,305 /-

Table 1:

Average Monthly Electricity Consumption = Total kWh / 12
= 12179 kWh /12
= 1015 kWh

Daily Electricity Consumption = Average Monthly Electricity Consumption / 30

Daily Electricity Consumption = 1015 kWh / 30

Daily Electricity Consumption = 34 kWh

As 1kWh = 1000 wh, we can say that daily electricity consumption is 34000wh.

To get the total Watt-hours per day we need to multiply above Watt-hours per day by 1.3 (the energy lost in the system) which must be provided by the panels.

So Total PV panel energy needed = 34,000 * 1.3
= 44,200 wh/day

B. Size the PV module

Different size of PV modules will produce different amount of power. To find out the sizing of PV module, the total peak watt produced needs. The peak watt (Wp) produced depends on size of the PV module and climate of site location. We have to consider "panel generation factor" which is different in each site location. For Maharashtra, the panel generation factor is 5.25. To determine the sizing of PV modules, calculate as follows:

Total Watt-peak (wp) PV panels capacity = Pv panel Energy needed / panel generation factor

Total wp of PV panel capacity = 44,200 / 5.25 =8419 wp

Number of Pv Panels Needed = 8419 wp / 110= 76.5 modules

Actual requirement = 77 modules

So this system should be powered by at least 77 modules of 110 wp Pv module.

C. Inverter

The input rating of the inverter should never be lower than the total watt. The inverter must have the same nominal voltage as a battery. As we are going to use stand-alone systems, the inverter must be large enough to handle the total amount of Watts which we will be using at one time. The inverter size should be 25-30% bigger than total Watts.

D. Battery Sizing

The battery type recommended for using in solar PV system is deep cycle battery. Deep cycle battery is specifically designed for to be discharged to low energy level and rapid

recharged or cycle charged and discharged day after day for years. The battery should be large enough to store sufficient energy to operate the appliances at night and cloudy days. To find out the size of battery, calculate as follows:
Consider,
Total Watt per day, Per day battery loss (0.85), depth of discharge (0.6) and nominal battery usage (12V)
Size of Battery = Total Watt per day / (Per day battery loss * depth of discharge * nominal battery voltage)
Total Watt per day = 34000 w/ (0.85 * 0.6 * 12)
Total Watt per day = 34000 w/ 6.12
Total Watt per day = 5555.5 Ah
So the total Ampere-hour required is 5556 Ah per day. [6]

IV. CONCLUSION

Solar power capacity has increased rapidly in the past 10 years. Solar power is a practical solution to climate change. While many people may think solar power is too costly, but if we see it can actually be cheaper than energy from fossil fuels if we make the right investments.

As per the calculation if we invest 10 to 12 lacs for solar panel installation, we can save 12,000/- to 15,000/- electricity bill for every month. It requires only little maintenance. Once the solar panels have been installed and are working at maximum efficiency there is only a small amount of maintenance required each year to ensure they are in working order. This will automatically reduce the carbon emission require to generate 44,200 Watt-hours per day for our need. Also fossil fuel is limited resource, it creates volatile market in which energy prices increases in short period of time, so by using solar energy we can automatically reduce dependency on fossil fuel.

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