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Analysis of Different Solar Panel Arrangements using PVSYST

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***Abstract*—To maximize the power generation from a limited area is one of the major concern due to increased land cost and unavailability of lands in urban areas. The solar PV module directly converts the incident solar radiations into useful electrical energy. The variation of temperature and solar irradiance are the major factors which affects the performance of the solar PV module. Shading on solar PV modules reduces the life span of the system as well as reduce the performance of the system. Here, three different arrangements of solar PV modules are done on a standalone system. In this work, the maximum generation was obtained from a three layer solar PV system with dual axis tracking system. By this arrangement we can reduce the space requirement to 58% to generate maximum energy.**

***Keywords*—Solar PV Module; PVSYST; Tracking; Shading.**

I. INTRODUCTION

Energy is a vital requirement to sustain and improve the standard of our daily lives. With the exponential growth in population, rapid spread of technology and advancement of globalization, energy consumption in the developing countries like India, is rising at a very fast pace. Like many of the developing countries, India is also facing an immense shortage of energy. The electricity sector in India had an installed capacity of 249.488 GW as of end June 2014[1]. Peak power deficit in the country fell to 5.4% at 7,556 megawatts (MW) in April from 7.4% a year ago due to increased capacity and lower electricity consumption by states. The decline in consumption in certain north Indian states was due to a weak intra-state network for dissemination of electricity. According to the latest data by the Central Electricity Authority (CEA), the total requirement in the country last month was 2,49,998 MW, as against the supply of 2,42,442 MW a peak power deficit of 5.4%[1]. This shortfall necessitates load shedding. Suffering of the common people is nowhere more pronounced than in urban areas where electricity is a necessity in carrying out daily activities. Like most other places, solar energy has the promise and potential to solve the energy crisis of India as it is available throughout the country and does not need a broad technological base. It is projected that by the year 2030, the solar PV electricity will also dominate compared to other sources of energy[1]. From the study growth of photovoltaic, an average about 45% annual increase is noticed during the years 2000 to 2009. From the study of cost economics of a solar photovoltaic power plant, PV modules cost about 45% and the other 55% is due to components, like transformers, cables, inverters, and civil works[2,3]. This work aims at solving this problem by introducing novel approach to arrange the solar panels in a way that minimizes the use of floor space.

In this paper we compare different types of panel arrangement to get a particular Kilowatts of energy and to save the land cost is to adopt a new methodology to get maximum output from the solar power plant in a limited area[5]. Here we were using a single layer panel, a single layer panel with tracking system and a three layer solar PV panel arrangement with solar tracking for comparison. For this purpose, the PVSYST[4] modeling software has been used, and a design with a new concept for the solar PV module is suggested, and its advantages over conventional design were discussed.

The rest of the paper been organized in the following way: Chapter II gives a brief description of the different solar panel structure and its operation. Chapter III deals with the overview different panel arrangements. Chapter IV discussion of results of different arrangements with land cost. Chapter V deals with conclusion.

II. METHODOLOGY

The basic characteristics of a solar parallel will depends up on type of solar cell, temperature of the cell and the radiations incident on it. The conversion efficiency of PV system is important factor to be determined in the power generation technologies. In this paper we used to analysis the performance with the help of PVSYST software[4].

A. PVSYST Software

PVSYST software[4] is used to design different types of solar application systems like DC grid, grid connected, standalone and DC pumping systems. Different solar PV module, battery and converter manufacture database for designing the system as it is included in the software package. Location details for the area of the experiment can be added with the help of software like Meteonorm, RETSCREEN etc[3]. This software helps to design the system with respect to the load and available area. It also helps to analyze the annual, monthly and weekly production and performance of the designed system.

B. Data

For designing a standalone system, the geographical data, solar PV module, battery database and monthly meteorological data for global radiation and temperature are

required. The angle of tilt can be adjusted to get maximum irradiance on the solar PV module Table 1 shows the location details of Thiruvanathapuram for the study. Table 2 shows the meteorological data of the site.

Table 1 Location details

Name of the site	Thiruvanathapuram
Latitude in degrees	8.5^0N
Longitude in degrees	76.9^0E
Altitude	13m
Azimuth	0^0
Tilt	13^0
Yearly irradiation yield	2052 kWh/m^2

C. Standalone System

The standalone system consisting of a solar PV module, a charge controller and a battery. In some cases extra diesel generator back up is used and it will be depends upon the type and behavior of the load[6]. In standalone system, solar PV modules generates the current and it helps to meet the load demand during daytime. At the same time, some generated current is used to charge the battery and it is helpful to meet the load demand during night time. Charge controllers are used to control the flow of charging and discharging current into and from the battery[6]. Figure 1. shows the standalone system of solar PV system.

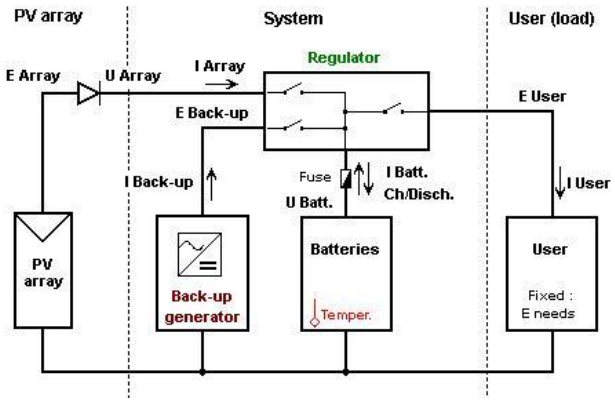

Fig.1 Standalone solar PV system

D. Solar PV Module

Table 3 shows the specification of the solar PV module used for the study.

Table 3 Panel Specification

Name of the manufacturer	Emmvee Photovoltaic Power Pvt. Ltd
Model	ES-190 P48 G
Type	Polycrystalline
Rated power	190Wp
Module efficiency at STC	14.3%
Open circuit voltage V_{OC}	29.49V
Short circuit voltage I_{SC}	8.31A
Rated voltage V_{MPP}	23.78V
Rated current I_{MPP}	7.99A
Dimension (LxBxT)	990x1340x50mm

E. Battery

Table 4 shows the specification of battery used for the study.

Table 3 Panel Specification

Name of the manufacturer	Exide Classic
Model	OPzS Solar 140
Type	Lead Acid, Tubular
Nominal Voltage	12V
Nominal Capacity	103Ah
Internal Resistance	9.3 Ohm
Coulombic Efficiency	97.0%
Dimension (LxBxH)	205x273x385mm

III. Different Panel Arrangements

In order to get maximum performance from the solar PV modules, the panels should be free from partial shading losses. So the arrangement of solar PV modules are a major concern to meet the demand of the consumer.

Table 2 Meteorological data from Meteonorm

Interval	Global Horizontal Radiation kWh/m^2.mth	Diffused Horizontal Radiation kWh/m^2.mth	Beam Horizontal Radiation kWh/m^2.mth	Beam Normal Radiation kWh/m^2.mth	Global Inclination kWh/m^2.mth	Ambient Temperature ^{0}C	Wind Velocity m/s
January	175.5	58.97	116.5	184.1	196.1	27.25	0.892
February	172.4	62.13	110.3	163.6	185.4	27.75	0.899
March	202.7	76.20	126.5	176.2	207.5	28.75	1.095
April	182.2	78.60	103.6	146.7	177.0	28.65	1.085
May	170.1	86.11	84.0	119.3	159.6	28.45	1.502
June	137.0	79.72	57.3	80.3	127.4	26.85	1.591
July	158.6	84.09	74.6	101.9	148.0	26.35	1.995
August	169.5	82.12	87.4	121.6	162.4	26.65	2.103
September	171.5	82.55	88.9	125.7	172.0	26.85	1.594
October	166.1	77.83	88.3	131.1	174.1	26.65	1.100
November	144.6	68.15	76.4	118.7	157.7	26.75	0.710
December	160.7	63.51	97.2	155.4	180.6	26.85	0.808
Year	2011.0	899.98	1111.0	1624.6	2047.7	27.31	1.285

A. *Single layer solar PV system*

Three solar panels are arranged in a single layer with a tilt of 13^0. Each panels are arranged without affecting the partial shading issues. The panels are facing towards the south pole. Fig.2 shows the 3D arrangement of solar PV panels and Fig.3 shows the side view of the solar PV panels.

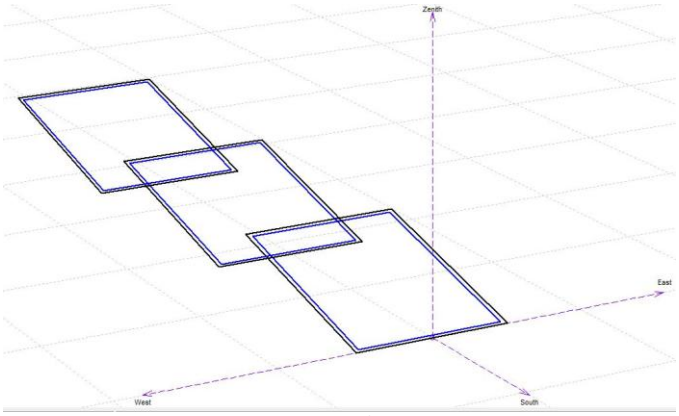

Fig.2 3D arrangement of solar PV panels

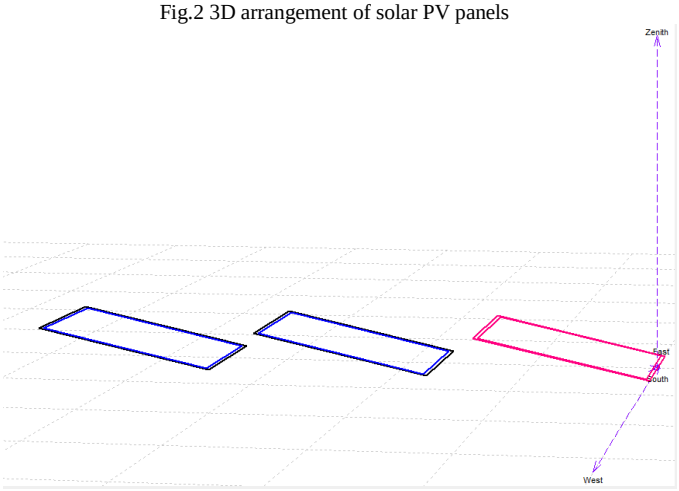

Fig.3 Side view of solar PV panels

B. *Single layer solar PV system with solar tracking system*

In this case, the single layer solar PV panels are connected with solar tracking systems. Panels are facing towards the south pole direction. For tracking, the area required will be higher in order to avoid the partial shading losses. Fig. 4 shows the 3D arrangement of solar PV panels with solar tracking system.

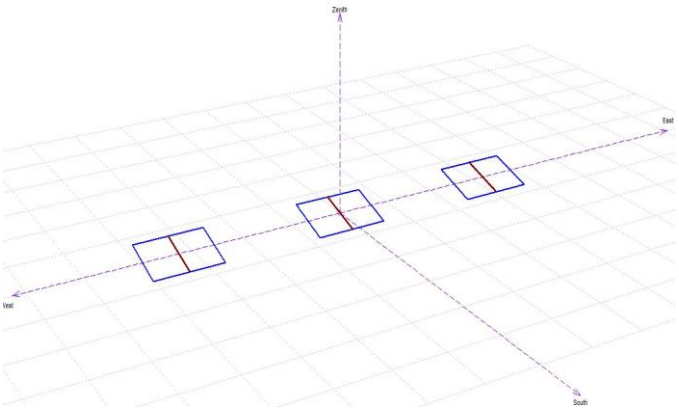

Fig.4 3D arrangement of solar PV panels with solar tracker

C. *Three layer solar PV panels with solar tracking system*

Three solar PV panels are arranged in a step like manner. Each panels are arranged without causing any partial shading with each other. For obtaining maximum energy, panels are separately connected with solar tracking systems. Panels are facing towards the east pole direction. Fig.5 shows the 3D arrangement of a three layer solar PV panels with solar tracking system. Fig.6 shows the front view of a three layer solar PV panel incorporated with solar tracking system.

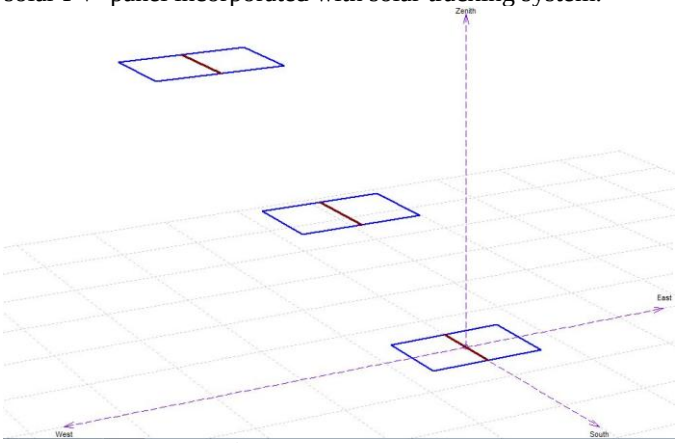

Fig.5 3D arrangement of a three layer solar PV panels with solar tracker

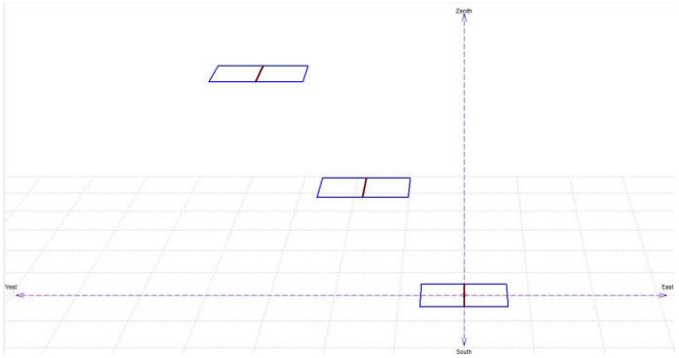

Fig.6 Front view of a three layer solar PV panels with solar tracker

IV. COMPARISON OF DIFFERENT SOLAR PANEL ARRANGEMENT

Although the study clearly demonstrate the maximum energy generation for the multi layer solar panel system as compared to single layer, one should be careful about the cost economics involved for such a system.

A. *Single layer solar PV system*

In the first case we were considered a single layer panel system which have to produce a cumulative energy of 1.5 kWh/day. For that 190W solar panels and placed in the direction facing south with a tilt angle of 13^0. Here three modules of 190W solar PV panels are used to produce an energy of 1.5 kWh/day. We know that as the number of modules increases, both the cost and area required was also increased. The detailed analysis about the performance and cost implication of the solar panel is shown in Table 3.

B. *Single layer solar PV system with solar tracking system*

In the case of single layer solar PV system with solar tracking system the same 190W solar panels are used and

placed in the direction facing south with a tilt angle of 13^0 which was arranged in single layers. In order to produce an energy of 1.5 kWh/day 3 modules of 190W solar PV panel are used. Solar tracking systems are incorporated with each solar modules to extract maximum power available in the atmosphere. The detailed analysis about the performance and cost implication of the solar panel is shown in Table 3.

Table 3 Comparison of different solar PV panel arrangements

	Single Layer	**Single layer with solar tracking system**	**Three layer with solar tracking system**
Area required (m^2)	4.6	7.45	4.13
Land cost* (Rs.)	56,832	92,007	51,191
Technology	Si-Poly	Si-Poly	Si-Poly
Panel Wattage (W)	190	190	190
No. of Modules	3	3	3
Energy generated (kWh/day)	1.5	1.5	1.5
Investment on system (Rs.)	112,200	117,200	115,200
System production (kWh/year)	1036	1360	1357
Total Expenditure (Rs.)	169,032	209,207	166,391

*Cost of 1 cent of land is taken as Rs.500,000/-

C. Three layer solar PV panels with solar tracking system

In the case of three layer solar PV module with solar tracking system, the same 190W solar PV modules and placed in the direction facing east which was arranged in three layers. In order to produce an energy of 1.5kWh/day 3 modules of 190W solar PV modules are used. Here the panels were arranged one above the other without affecting shading losses. The system gives maximum energy from these 30 modules all the time. This arrangement will not cause any partial shading on the second and third layer solar panels. The detailed analysis about the cost implication of the solar panel is shown in Table 3.

V. CONCLUSION

Electricity generation has now become a major challenge for a country like India with rising fuel price and worsening air pollution. Generating electricity using PV panels is a potential solution to the current energy crisis faced by India as it is renewable and climate friendly. In large urban cities there was not enough roof top space for installation of solar PV panels. In this paper, we had compared different panel arrangement that will minimize the floor area and maximize power generation through tracking the sun. In the case of single layer solar PV panel the area required to generate 1.5 kWh/day energy was around 4.6 m^2. So the land cost will be higher as compared with the three layer system. In single layer solar PV module with tracking system, the area required will be more as compared to the single layer solar panel and three layer system. From Table 3, the land cost for the installation of a three layer solar panel is found to be low and the production from the system will be higher. The main disadvantage of the system was shading losses. The area required for the system is comparatively low. In order to get maximum output, less shading losses, less land area requirement, we use solar tracking techniques along with the three layer solar panel system.

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