International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020

Design of Photovoltaic System with Different Power Point Tracking Techniques for on-Grid Applications

Shaik Rafi kiran, Thirupataiah N., M. V. Bramhananda Reddy

Abstract - In India, solar energy meets consumer energy demand and majority of the plants are grid connected. Solar power is mainly depending on two factors, which are sun ray's incident angle and change of environment conditions. The Maximum Power Point Tracking (MPPT) of photovoltaic (PV) module is necessary to maximize the extraction of PV power under partial shading conditions. The main aim of this paper is to highlight the design and implementation of 5MW solar plant with different power tracking techniques. In addition, the detailed explanation of various materials used to design the PV module is illustrated. This paper also describes the two types of solar rating panels that are used to get high power conversion efficiency as well as continuous power supply along with that the plant cost, monthly and yearly power production and corresponding efficiency is calculated.

Keywords- Design of different rating PV modules, evaluation of energy demand, types of PV array axis tracking.

NOMENCLATURE

Parameters	*Formula*	*Value*
Panel data at standard test condition		
Each module peak power	P_{Max}	Watts
Open circuit voltage	V_{OC}	Volts
Short circuit current	I_{SC}	Amp
Voltage at peak power	V_{MP}	Volts
Current at peak power	I_{MP}	Amp
Maximum system voltage	V_{MSYS}	Volts
By pass diode current	I_{BPS}	Amp
Irradiance (STC)	I_{STC}	1000 W/m^2
Temperature (STC)	T_{STC}	25^{0}C
Air mass (STC)	AM	1.5
Life time of panel	t	30Years
Designed parameters		
Array capture loss (L_{AC})	$Y_{Ar}+Y_{PVA}$	KWh/(KWh-day)
Reference array yield	Y_{Ar}	-
PV-Array yield	Y_{PVA}	-
PV-Thermal losses (L_{th})	Y_{Ar}-Y_{CR}	Kelvin
Cross yield	Y_{CR}	KWh/(KWh-day)
Array final yield	Y_{AF}	KWh/(KWh-day)
System performance ratio	$Y_{AF/}$ Y_{Ar}	%
Array energy	E_{PA}	KWh
Time interval	T	Sec
Noting time	T_n	Sec
PV system losses (L_{SI})	Y_{PVA}- Y_{AF}	KWh/(KWh-day)
Array energy (E_{PA})	$T_n * \sum_T P_A$	KWh
Grid energy (E_g)	$T_r * \sum_T P_g$	KWh
PV-Daily energy ($E_{p,d}$)	$T_r * \sum P_{P,A}$	KWh
Grid daily energy ($E_{g,d}$)	$T_r * \sum_{day} P_g$	KWh
Utilization energy ($E_{u,d}$)	$E_{p,d+}$ $E_{g,d}$	KWh

Manuscript received on February 10, 2020.
Revised Manuscript received on February 20, 2020.
Manuscript published on March 30, 2020.

* Correspondence Author
Dr. Shaik Rafi Kiran, Department of EEE, S. V. Engineering College, Tirupati, India. E-mail: rafikiran@gmail.com
N. Thirupataiah, Department of EEE, S. V. Engineering College, Tirupati , India. E-mail thirupataiah.n@svcolleges.edu.in
M. V. Bramhananda Reddy, Department of EEE, S. V. Engineering College, Tirupati, India. E-mail: bramha.mv@svcolleges.edu.in

I. INTRODUCTION

In the past few decades, the usage of solar electricity keeps on increasing for household, industries, vehicles, satellite systems, solar updraft tower, fuel production and water pumping systems etc. [1-3]. The incident of solar radiation in the form of heat is used to generate the electrical energy. PV effect is the phenomenon used to convert sun light energy to direct current. When solar energy falls over the active surfaces of the PV panel, it starts absorbing heat energy and further resulting in the recombination of electrons and holes. Solar technology is one of the most useful and popular technology because of no additional sources such as water, fuel, transportation is required as well as it is not consisting of any rotating parts [4-6].

The major advantage of solar power plant is it requires less operating and maitainence cost, but the cost of installation is more. The installation cost of plant is minimized by using different PV technologies. The major consequence we are facing is a discontinuous power supply from central grid. During this situation to overcome this discontinuity diesel generator were used for backup supply.

However, it produces hazardous inflammable gases and is having a direct effect on environment. Moreover, the cost of generation is also more [7-8]. Therefore, the most popular renewable and eco-friendly source is solar.

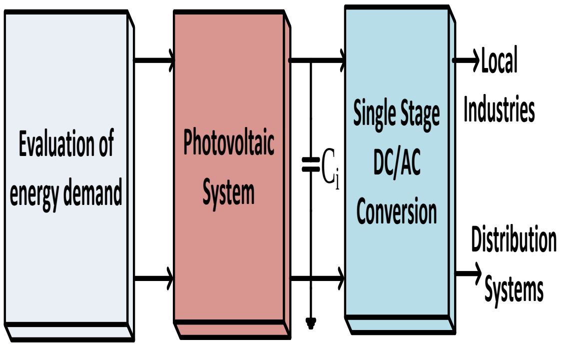

Fig.1. Block diagram of 5MWP solar plant

A general analysis has been conducted to find installation of solar power plant in gulf countries and the analysis of various reports revealed that at present PV technology is not economical for gulf countries due to less efficiency, electricity tariff and higher cost. Globally many researchers have focused on solar systems and they concluded that solar power generation is the best solution for increasing population and electrical usage appliances [7]. In India, national action plan on climate change planned to install an overall eight solar plants all over the country. Among those eight plants, Jawaharlal Nehru plant is consisting the higher rating of 20,000.00MWp for grid-connected applications. In India, state electricity boards and private manufacturing companies are concurring to buy 4%-8% of total required electricity from renewable energy is considered as a major step in the implementation of solar power plants [2], [9].

My study is focusing on the Coimbatore district in Tamilnadu, where a 5MWp solar power plant is used to supply electrical energy for electrical manufacturing company. There the solar energy used for manufacturing and utilizing the products such as boilers, air pre-heaters, control relays, electrostatic precipitators, steam generators, gas turbines, piping systems and fabric filters etc. The remaining energy obtained from these solar power plants are supplied to the local substations. The installation and performance parameters are evaluated in detail on "Table 2". This paper also aimed on 5MWp plant working under different seasonal variation conditions and its power production. In addition to that, efficiency of the plant is evaluated over the time from 2014 to 2016. Here we are using three types of tracking technologies for enhancing and maximizing the power under partial shading conditions and this plant is carrying five incomings sources and two outgoing sources that were explained in detail in the upcoming section.

II. ENERGY DEMAND IN COIMBATORE ZONE

A basic survey was done in peelamedu, the northern most part of Coimbatore city in the state of Tamil Nadu from 2011 to 2013 for meeting the energy demand of local industries and substation. After the survey, monthly energy demand for each industry for different types of equipment's usage and their energy absorption was calculated. After the completion of survey estimation, a 5MWp power plant is installed near to the industry and rural areas. The energy demand evaluation diagram of 5MWp solar plant is shown in the below "Fig.1".

III. DESIGN OF PROPOSED PV-PLANT

Considering all the requirements a 5MWp power plant was installed for giving continuous power supply and to meet the rapidly increasing consumer needs. The newly installed plant was covering an area of 182,109sqmm, in that panel installation area is nearly 101,171sqmm and the remaining area is used for power handling room and storage application. The ambient temperature variation is from 260 0C to 43.7 0C. The 5MWP solar plant consist of ten panels and the rating of each panel is 500KW. The installation layout of the solar plant is shown in "Fig.2".

A. PV-Array design

The entire PV panels are divided in to 10 panels and each panel rating is 500KW.Based on PV materials usage and array tracking techniques these plants are classified as three types, first one is single axis tracking, second is seasonal tracking and the third most is fixed axis tracking plants [10]. The parameters of PV array are evaluated and is shown in detail in "Table 1".

Table 1. Basic speciation's of solar PV at standard conditions

Parameters	2M-Fixed	1M-Fixed	1M-Seasonal	1M-Single axis
Peak Power (Pmax)	230Wp	280Wp	280Wp	280Wp
Open circuit voltage (Voc)	36V	41.2V	42V	42V
Short circuit Current(Isc)	8.3A	8.7A	8.4A	9A
Voltage at peak power point(Vmp)	29V	35V	35V	35V
Current at peak power point(Imp)	7.6A	8A	7.72A	7.72A
Fuse current rating	15A	7.5A	7.5A	7.5A
Max system voltage	1000V	800V	800V	800V
By pass diode current rating	15A	7.5A	7.5A	7.5A
Insolation	1000w/m^2	1000w/m^2	1000w/m^2	1000w/m^2
Temp	250C	250C	250C	250C
AM	1.5	1.5	1.5	1.5
PV-Technology	mono	poly	mono	Mono
Life time	25 years	20 years	25 years	25 years

B. One MWp single axis tracking array solar plant

Generally, auto tracking is classified as single axis and dual axis tracking. In this solar plant single axis tracking, mono crystalline (pure) silicon cells are used. Depending on the time and the varying solar radiation intensity every day the array is rotated automatically [11]. From morning 6am to 9am it is 450, afternoon from 9am to 3pm follows sun ray's incident angel and evening 3pm to 6pm it is -450. After 6pm it starts back tracking and comes to initial position.

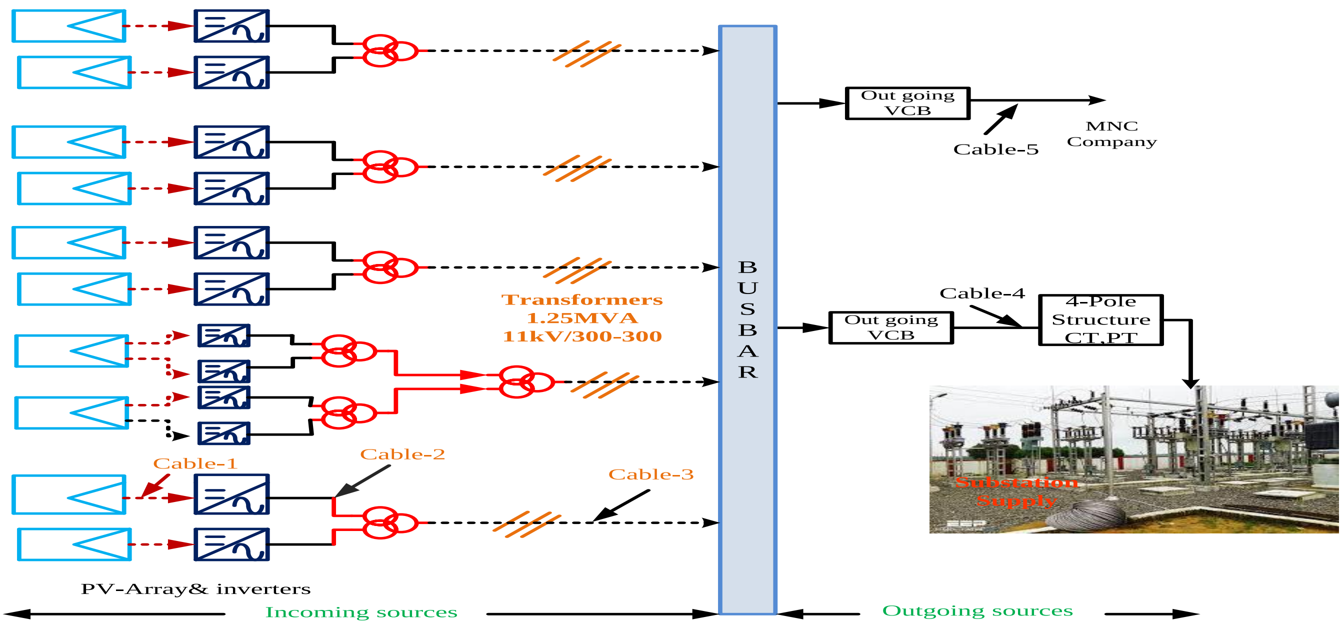

Fig. 2 Different Maximum Power Point Tracking Techniques

The array consists of 3600 number of panels, each single panel is consisting of 72 cells and 20 panels are equal to 1 string and two strings are equal to one structure. Each module is supplying 280watts DC power. Voltage at peak power point (Vmp) is 35V and a maximum peak current of 7.72A, with an overall lifespan of 25years. In this 1MWp single axis tracking array solar plant eight 0.5HP variable frequencies drive induction machines are used for giving supply to the grid.

C. Auto axis tracking

Solar collector and array tracker should be in north-south direction tube supporting of flat rectangular shape solar panels and in that one pier is supported to earth. A linear actuator is mounting on footing separate from the pier footing and it is supported from earth. The actuator may be installed in horizontally or vertically. A torsion tube inserted in between the solar sections joints and its shape is square. All the sections of solar panels joined with single swaged. In this tracking, the position of the sun is determined by using three light dependent resistors. One is used for collector position with respect to sun, second one is used to detect cloud condition and third one is used to detect day or night. The resultant error signal is given to electronic controller, which operates horizontal single axis tracking drive [12-13]. Based on sun ray's incident angel, the single axis horizontal drive is used to move sections of solar panel and this controller gives acceptable accuracy. The accuracy of this controller is depending on magnitude of sun radiations [6]. The principle operation of single axis tracker and axis representation is shown in below "Fig. 3(a), (b)".
The life span of the plant is 20 years and it is 130 fixed north-east. If any damage in cells, the entire array will get shunt down.

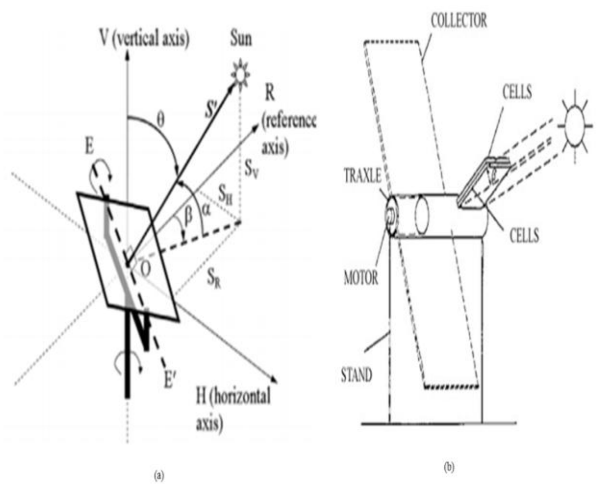

Fig. 3. Single axis array tracking, [6]

D. 1Mw Seasonal tracking array

In this each module rating is 230W, number of modules consist of 3600 and number of structures 180. The peak voltage and current ratings are 35V, 7.72A. The technology using in this array is mono crystalline. Each panel consist of 72cells and one string is equal to 20 panels. Here four months once manual tracking is applied. The life span of this 1MWp plant is 25 years. Based on the season the solar panels are moves from north to south. This process is carried out by four months once and mechanism is done with different panel tilt angel. The seasonal tilt has four slots in the direction of north-south. The slots are divided as (Jan-April, May-Aug, and Sep-Dec). Based on season the solar panels tilted in first season 280, second season 130 and third season 20. This is the best tracking compare to fixed axis array tracking and it improves plant efficiency and power generation without additional plant installation.

E. 2Mw fixed tilt array

This array is designed based on mono crystalline and life span of this array is 25 years. Each panel consist of 60cells and each sting consists of 24 panels. Rating of each module is 230W and number of modules 8832.

IV. INVERTER DESIGN AND ITS COMPONENTS

The rating of each inverter for 5MWp plant is 500KW, number of inverters required for 5MWp is 12. Input DC-voltage of the inverter is 800V and output AC-Voltage of the inverter is 300V. The inverter output voltage is given to the three-phase transformer to step up the inverter output voltage. The conversion efficiency of each inverter is 37.5% and total no of power conditioning units are required for 5MWP plant is12.

a. Air circuit breaker

This circuit breaker is used in between the inverter and transformer. This breaker protects the transformer from over and short circuit currents. The main advantages of this circuit breaker are no chance of fire caused by fluids, Arc quenching is faster than the air blast circuit breaker. The arc quenching time is same for low as well as high current ratings. The cost and maintenance of air circuit breaker is less compare to other circuit breakers. The voltage rating of air circuit breaker is less than 450V, operated current rating is 1250A.The no of air circuit breakers used in 5MWP are 10 and this air circuit breaker arc contacts materials are made with carbon and breaker operating time period is 1 to 3 cycles.

b. Vacuum circuit breakers

In 5MWp plant the vacuum circuit breaker is used in middle of the incoming and outgoing sources of the bus bar and it is shown in “Fig.2”. The arc quenching time period is more compare to air circuit breaker. This circuit breaker is consisting of fast, repeated operation and it is maintenance free. Vacuum circuit breakers are light weight and compact in size. Generally vacuum means ‘0’ torque or ‘0’ mm of Hg pressure. The incoming vacuum circuit breakers are 5 and outgoing vacuum circuit breakers are 2. The voltage and current rating of vacuum circuit breaker is 11kV, 630A.

c. Designing of transformers and cables

The 3- incoming transformers required 5(same rating) and the type of transformer is central tapped. The rating of the transformers is 1.25MVA, Primary and secondary voltages are 300/11KV. The type of connection is used is Dyn11yn11. The remaining current transformers (CT’S) and potential transformers (PT’S) deign details are given in “Table 2”. Based on incoming and outgoing voltage sources, there are three types of cables are used. Cable-1 and cable-2 are used in between PV-Panels and inverters [8-9]. Cable-3 is used in between the incoming transformer and bus bar and cable-4, 5 is used in between the bus bar and substation. The rating of each cable mentioned in below Table.3. The armoured cables are designed by using aluminum or cupper material and it is abbreviated as aluminum wired armoured cables. It is a hard-

covered power cable and using for power supply mains. These cables are used for 11kV and 33kV rating applications. XLPE (cross linked polyethylene) is used as insulation for all power rating cables and it is well suited for medium voltage applications [14]. It is a most popular polymeric insulation for underground cables and 3-runs per phase armoured cable is shown in “Fig.4”. A cable without outer covering steel wire armour is called unarmoured cables. The ratings of unarmoured cables are 300V and it does not consist of cross-linked polyethylene insulation material [15-17]. The designs of armoured and unarmoured cables are shown in “Fig.4”.

Table 2. Design details of CT’S and PT’S

Transformers	CT’S	PT’S
Voltage rating=11kV/415V	Incoming CT’s=5	Incoming PT’s =5
	Outgoing t/f’s=3	Outgoing t/f’s =3
Apparent power=100kVA	Total CT’s=8 (same rating)	Total no of PT’s=13
connection=Dyn11	Type of CT= CT-75/1-1A	-
Total=1	Core one=CL: 0.2, 5VA	Core 1; CL; 0.2, 100VA
	Second core= CL: SP10, 75VA	Core 2; CL; 3P, 100VA

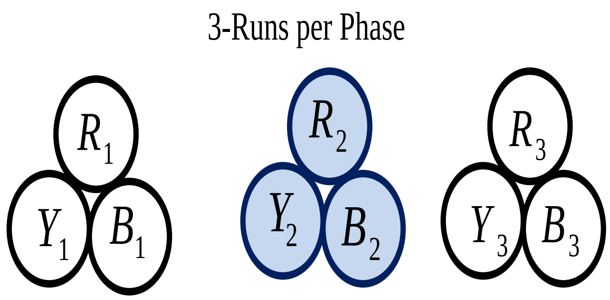

Fig. 4. 3-Runs per phase unarmoured cables [10]

d. String monitoring box

The major component of solar power system is string-monitoring box. It is used to high level of system monitoring purpose, it combines the multiple no of DC sources coming from the solar arrays, and it converts single DC source. The output of string monitoring box is connected to inverter through an air circuit breaker. For different rating solar panels, the technical data of string monitoring box is shown in “Table.4”. The basic features of string monitoring box are, based on functionality, it consists of standard and intelligent combiner box. For with standing all environmental conditions the SMB is manufactured by using polycarbonate. SMB is an anti-reflected UV-ray, acids, alcohols etc.

Retrieval Number: F6988038620/2020©BEIESP
DOI:10.35940/ijrte.F6988.038620
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Table 3. Design of cables for 5MWp solar plant

	In between	Area of cable	Cable material	Type of cable	Rating of cable	No of cables
Incoming Cables	PV-Inverter	1C*120sqmm	Copper	Armoured	800DC	10
	Inverter-ACB	1C*300sqmm	Copper	Un armoured	300AC	12
	ACB-Transformer	1C*300sqmm	Copper	Un armoured	300AC	10
	Transformer-Bus bar	1C*185sqmm	Aluminium	Armoured, XLPE	11kV	5
Outgoing cables	Busbar-Load1	1C*400sqmm	Aluminium	Armoured, XLPE	11kV	1
	Busbar-Load2	1C*400sqmm	Aluminium	Armoured, XLPE	11kV	1

Table 4. Parameters of string monitoring box

16-inputs and 1-output string monitoring box	
Number of strings in each SMB	16
Rating of switch monitoring box	1000V, 40kA
Isolator switch rating	400A, 1000V
SMB Enclosure box	Polyester
Monitoring connection type	Shunt
Current measuring capacity	25A
Voltage measuring capacity	1000V
Auxiliary voltage supply	10-60V
Withstand temperature	20-700C

V. ANALYSIS OF SYSTEM PERFORMANCE

Based on plant power generation data, reporting time interval (τ) on daily, monthly and yearly basis, noting time period (τ_n) in between one minute to ten minutes as per IEC STD 61724 are recorded. From the reporting time interval, PV-Array output energy is calculated as,

$$E_{PA} = T_n * \sum_T P_A \quad \text{KWh} \tag{1}$$

In recorded time interval energy fed in to the grid is calculated as,

$$E_g = T_r * \sum_T P_g \quad \text{KWh} \tag{2}$$

Daily DC-energy output of the photovoltaic array, energy fed in to the grid and useful energy is calculated as,

$$E_{p,d} = T_r * \sum P_{P,A} \quad \text{KWh} \tag{3}$$

$$E_{g,d} = T_r * \sum P_g \quad \text{KWh} \tag{4}$$

$$E_{U,A} = E_{p,d} + E_{g,d} \quad \text{KWh} \tag{5}$$

Based on above calculation, the monthly and yearly energy is calculated and it is shown in Fig.6. Plant load factor is calculated from each individual plant and its comparative performance for different PV-arrays with different orientations is shown in Table.5. In PV-array, yield is used to compare the present operation of plant with respect to rated capacity. At specified time period, the yield of the PV-array is calculated as,

$$Y_{PVA,T} = \int_T \frac{I_i}{I_{STC}} * dt \quad \text{KWh/ (KWh-day)} \tag{6}$$

$$Y_{PVA,T} = \int \frac{T_r * \left(\sum_{day} I_i\right)}{I_{STC}} \quad \text{KWh/ (KWh-day)} \tag{7}$$

For different PV-array tracking panels yield is calculated as daily output energy of the PV-array with respect to the array installed capacity.

$$Y_{PVA,d} = \frac{E_{PVA,d}}{P_{OUT,A}} \quad \text{KWh/ (KWh- day)} \tag{8}$$

Final yield of PV-array is defined as useful energy of the array with respect to the installed capacity and is calculated as,

$$Y_{PVf,d} = \frac{E_{USE,day}}{P_{PV,I}} \quad \text{KWh/ (KWh-day)} \tag{9}$$

VI. PERFORMANCE RESULTS OF 5MWP SOLAR PLANT

Based on the availability solar energy the monthly wise analysis from January to June of a 5MWp plant power generation for different solar panels under partial shading and full sunny condition is calculated experimentally and is shown in “Fig.6”. The 5MWp solar plant is broadly classified into five individual plants. The first plant is 1MW fixed array plant and is again classified in to two plants, with each plant rating is 500kW and it gives 491kW and 470Kw output power. Load factor of this 1MW fixed array individual plants are 0.982, 0.94 and it consists of up to 184 strings. All strings are serially connected and are having 11 string monitoring boxes. The detailed parameters such as load factors and number of strings are given in “Table. 4” along with the other major 4 plants.

The maximum useful power generation and no of units generated (low as well as high) on daily basis are recorded and shown in the below “Table 6”. Based on total energy generation year wise efficiency is calculated.

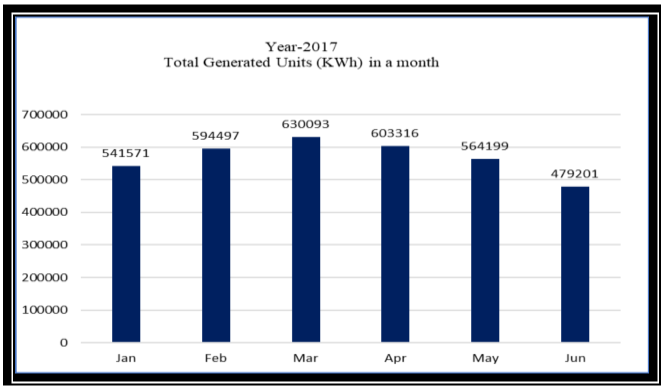

Fig. 6. Monthly energy production

Table 5. Individual plant load performance

S. No	Plant type	Rating of the plant	String number	No of String s in a box	Plant Load factor
1	1st MW FIXED	(491+470) kW	1-184	49-60	0.982,0. 9
2	2nd MW FIXED	(507+475) kW	185-368	37-48	1.04,0.9 5
3	3rd MW SEASONAL TILT	(470+508) kW	369-548	25-36	0.94,1.1 0
4	4th MW FIXED	(538+470) kW	549-728	13-24	1.076,0. 9
5	5th MW AUTO TRACKING	(475+497) kW	729-908	1-12	0.95,0.9 9

Table 6. Day, year wise 5MWp no of units generated and its efficiency

Year	Maximum generation in (MW)	Maximum units generated in (KWH)	Lowest generation in (KWH)	Total units generated in the year (KWH)	Yearly Efficiency (%)
201 4	4.663 Date: 14/11/201 4	26,912 Date: 02/10/201 4	3863 Date: 29/10/201 4	5828668 07/0/2014 To 31/12/201 4	93.26
201 5	4.685 Date: 13/08/201 5	26,963 Date: 26/09/201 5	495 Date: 15/11/201 5	674357 01/01/201 5 To 31/12/201 5	93.7
201 6	4.688 Date: 22/09/201 6	25,963 Date: 26/09/201 6	748 Date: 12/12/201 6	7021047 01/01/201 6 To 31/12/201 6	93.36

VII. CONCLUSION

This study was conducted to unravel the coimbatore power demand and to found design and implementation of different types array tracking techniques and rating of solar panels are explained. The monthly and yearly solar power generation is calculated and its corresponding efficiency is evaluated experimentally. The power system components are inverters, cables, transformers and circuit breakers analyzed theoretically as well as practically. Moreover, from the survey, multiple solar array axis tracking technique gives maximum sun irradiations observing and it generates maximum power with 93.8% efficiency.

REFERENCES

1. Padmavathi.K, and Arul Daniel.S, "Performance analysis of a 3MW p grid connected solar photovoltaic power plant in India." Energy for Sustainable Development 17.6 (2013): 615-625.
2. Mevin. chandel, et al, "Techno-economic analysis of solar photovoltaic power plant for garment zone of Jaipur city." Case Studies in Thermal Engineering 2 (2014): 1-7.
3. Mondal Hossain, and AKM Sadrul Islam, "Potential and viability of grid-connected solar PV system in Bangladesh." Renewable energy 36.6 (2011): 1869-1874.
4. Zahedi. A, "Maximizing solar PV energy penetration using energy storage technology." Renewable and Sustainable Energy Reviews 15.1 (2011): 866-870.
5. Salmi, Tarak, "Matlab/simulink based modeling of photovoltaic cell." International Journal of Renewable Energy Research (IJRER) 2.2 (2012): 213-218.
6. Ratnam. S, Elizabeth. L,Steven. R. Weller, and Christopher M. Kellet, "An optimization-based approach to scheduling residential battery storage with solar PV: Assessing customer benefit." Renewable Energy 75 (2015): 123-134.
7. Nyholm, Emil, Mikael Odenberger, "An economic assessment of distributed solar PV generation in Sweden from a consumer perspective–The impact of demand response." Renewable Energy 108 (2017): 169-178.
8. Qureshi, Tahir Masood. "Factors responsible for solar PV adoption at household level: A case of Lahore, Pakistan." Renewable and Sustainable Energy Reviews 78 (2017): 754-763.
9. Jousse, Jérémie. "Power line communication management of battery energy storage in a small-scale autonomous photovoltaic system." IEEE Transactions on Smart Grid 8.5 (2017): 2129-2137.
10. Shingleton, Jefferson, "Solar collector and tracker arrangement." U.S. Patent No. 6,058,930. 9 May 2000.
11. Kalogirou.A, Soteris, “Design and construction of a one-axis sun-tracking system." Solar Energy 57.6 (1996): 465-469.
12. Chong. K. K, and Wong. C.W, "General formula for on-axis sun-tracking system and its application in improving tracking accuracy of solar collector." Solar Energy 83.3 (2009): 298-305.
13. Mousazadeh, Hossein, et al, "A review of principle and sun-tracking methods for maximizing solar systems output." Renewable and sustainable energy reviews 13.8 (2009): 1800-1818.
14. Walter, and Jeffrey R. Edgerly. W, "Armored electrical cable connector." U.S. Patent No. 6,162,995. 19 Dec. 2000.
15. Akagi, Hirofumi, Edson Hirokazu Watanabe, Instantaneous power theory and applications to power conditioning. John Wiley & Sons, 2017.
16. Zhang and Lin, "Design, testing, and implementation of a linear state estimator in a real power system." IEEE transactions on Smart Grid (2017).
17. Kumar, Deepak. S, Samantaray. R, and Innocent Kamwa. "MOSOA-based multiobjective design of power distribution systems." IEEE Systems Journal 11.2 (2017): 1182-1195.

AUTHORS PROFILE

Dr. Shaik Rafi Kiran , M.Tech, PhD from Jawaharlal Nehru Technological University Anantapur, Ananthapuramu, A.P, India. He has 19 years of teaching experience. At Present Dr. Shaik Rafi Kiran serving as a Professor and Head of the department of Electrical and Electronics Engineering in Sri Venkateswara Engineering College (SVEC),Tirupathi, Andhra Pradesh. He is a Life Member of F.I.E & ISTE. He has presented 40 research papers in reputed International Journals and Conferences .His research areas includes System Identification, Control Systems, Optimization Techniques and Power Systems. He is a ratified Professor under Jawaharlal Nehru Technological University Anantapur, Ananthapuramu, A.P. At present he is guiding one PhD scholar under Jawaharlal Nehru Technological University Anantapur, Ananthapuramu, A.P & one under Annamalai University.

Mr. N. Thirupataiah is currently working as an Assistant Professor in EEE department, SV ENGINEERING COLLEGE, Tirupati. He has received his bachelor of Technology from Narasaraopeta Engineering College,Narasaraoprta, AP, India in 2007 and M.Tech degree in Digital systems and computer electronics, from JNTUA, University Anantapuram, AP, India in 2010.

Mr.M. V. Bramhananda Reddy is currently working as an Assistant Professor in EEE department, SV ENGINEERING COLLEGE, Tirupati. He has received his bachelor of Technology from Sree Vidyanikethan Engineering College, Tirupati, Chittoor, AP, India in 2008 and M.Tech degree in Power Electronics, RGMCET, Nandyal, AP, India in 2011. His areas of interest include Electric Vehicles and received Silver medal in NPTEL Examination.