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# Analysis and Implementation of Solar Photovoltaic Energy Plants in India

Shiva Kumar Nomula[1], Munna Varma[2]
[1, 2] Dept of Mechanical Engineering, Bhagwant University, Ajmer- 305004, India

***Abstract: Solar Photovoltaic power is a very useful for present global warring effects time, the output of electricity his clean and green power without a doubt, is the cleanest energy in the world by getting the never end resource of sun power . The main object of this paper his to implement the solar photovoltaic power with high efficiency and less cost with the less time period by consideration and analysis of regional wise the exciting power plants in India. Consideration of solar radiation, temperature, wind to design of solar system to performance of module output and difficulties of module performance and stringing of module by connect to combiner box with cabling, to connect the inverter by consideration of grid synchrization and output collecting of grid with availability it's all consider to develop the new plant . Also O&M of plant maintenance with operational difficult by different modules performances***
***Keywords: Generation of solar power, solar design, Plant orientation, Power quality, simulation of renewable energy solar Photovoltaic energy system, solar power plants, generation data simulation .***

## I. INTRODUCTION

Solar Photovoltaic energy is a basic need of human for present global scenario. At Present energy consumption is based on waste from fossil fuels like oil, coal and gas. [1] These sources are not inexhaustible and these can cause environmental degradation. That way, only alternatives that remain are nuclear fusion energy, which still has much to develop, and renewable energies. In front of conventional sources, the renewable energies are clean and inexhaustible resources provided by the nature with practically no impact on the Environment. Within the renewable energies, along with solar thermal and photovoltaic, which are those with higher expectation for the future? In this project we will focus on solar photovoltaic energy. [2] Each year, the sun sheds on the surface of the Earth, four thousand times the energy we use and will continue for several billion of years, World electricity demand is about 17300 TWh. The daily average solar-power-plant generation capacity in India is 0.20 kWh per $m^2$ of used land area, equivalent to 1400–1800 peak (rated) capacity operating hours in a year it is clear that the sun gives us more energy than we can consume, due to the efficiency used to exploit it. Based on current market conditions for renewable energy, the social and cultural benefits that suppose to humanity and the good business opportunity, in this project it will be analyzed a project of [3] 5MW photovoltaic plant located in the Khimsar, Nagaur (D) Rajasthan. [4] 5MW photovoltaic plant located in the Ananthapur Andhra Pradesh. The aim of this paper is review of study the project, technical description of a photovoltaic system, analyzing each of the elements, the presentation of different types of existing plants, and presenting a proposal of such a plant basing on the theoretical considerations, next modeling and proper calculations. Anyway, further evaluation of the current energetic, environmental and economic situation in a real photovoltaic plant ought to be conducted and compared. In this paper the suggested method is based on real data from the existing photovoltaic power plant.

With all radiation and billing data collected from the real plant, [3] there will be developed energetic, environmental and economic balances of the situation. By this analysis, it will be possible to visualize how the equipment works and the contribution exercised by each one of the elements within the plant. Aside of the technical and economical aspects of the proposed solution, the environmental problems are also taken into consideration according to the EU standard andneeds.

Indian states are widely exposed to natural sunshine, especially Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu, Telangana and Rajasthan, during almost the entire year. [5] [6] Precisely, Indian regions harvest 5–6.5 kWh/m2/day as energy yield which leads to the Capacity Factor (CF) of 17–23%. For various parts of India, the GHI (Global Horizontal Irradiance) resource map published by National Renewable Energy Laboratory (NREL) [7] and Ministry of New and Renewable Energy (MNRE) is used. The total installed solar power capacity in India as of 31 March 2019 is 28.18GW

## II. DESIGN OF SOLAR POWER PLANT- ORIENTATION

[8] Photovoltaic power plants, photovoltaic panels (PV) are arranged in series arrays and the output of each array is parallel to connect the common string combiner box. Then, SCB (string combiner box) will be connected to an inverter and then connected to LT panel to step-up transformer and it's connected to HT Panel it's connected to Grid Figure 1. Shows the layout of solar power

plant using 3-phase inverters with output from an inverter connected to a step-up transformer (Star-delta) to step the voltage up from 3- phase 415V Vac to 3-phase 33kV Vac. It is designed such a way that from low voltage DC to High voltage AC conversion is as per the National Electrical code standards.

*A. Earthing*

Involves exposed conductive parts and the live parts of the generation power system. Exposed conductive parts include metal frame of the PV modules and other parts of the power plant that, even though should be isolated, could have current circulating through them by a fault event (e.g. metal racks and structures).

The generation power system refers to live parts of the PV plant. It is important to differentiate between the AC side and the DC side.[9] Two different cases: - PV plants with galvanic insulation of the DC side from the electrical grid can be functionally earthed - PV plants without galvanic isolation of the DC side from the grid cannot be functionally earthed. Based on the inverter design, [10] the earthing of transformers is done. The design of inverter as per the standards of IEEE 1547/UL 1746 with 0.9 lag to unity power factor to meet the reactive power requirement and to bear the surges in voltages.

In photovoltaic power plant mainly earthing and lighting arrestor s system very important for system protection system to get the clean energy of output.

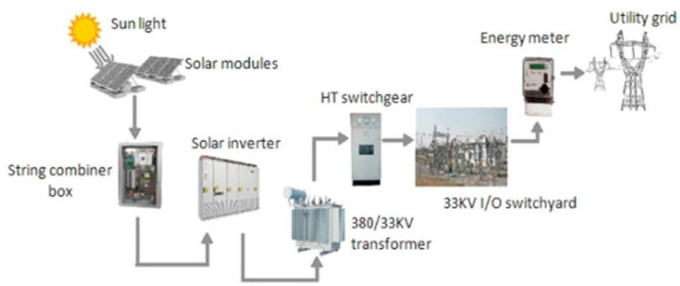



Fig1: Layout of Solar power plant and orientation

## III. STUDY AND ANALYSIS

*A. Our Study and Analysis in 5MW SOLAR POWER PLANT at Khimsar Rajasthan*

1) *Solar Photo Voltaic Arrays:* [11] As maximum possible voltage or optimal voltage from a solar PV cell is limited to its design, irradiance, and temperature. Hence, it is required to connect the required number of cells in series framing an array. Figure 2 shows a model representation of 24 panels in each array and the output voltage of each array will be 36.3V of 250W. Using Simulink software, in each panel. 36 PV cells are designed by using simelectronics blocks. An average solar radiation 1000 W/m$^2$ with 25$^o$C temperature are used as inputs to PV panel to observe optimum voltage

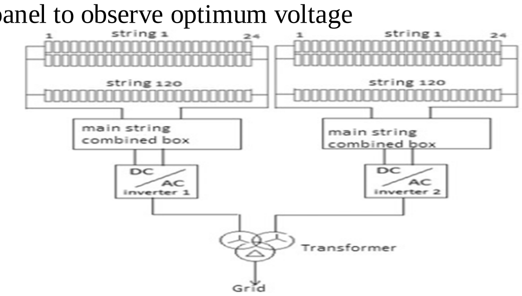


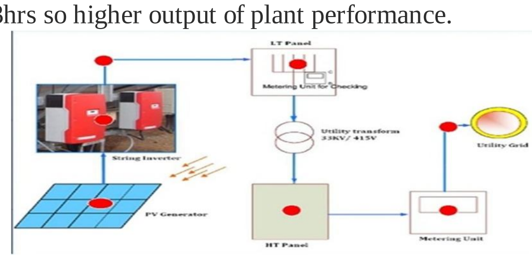

Fig. 2 Output of transformer is connected directly to 33 kV grids.

Stringing of solar power plant design and connecting of plant major steps involve the Fig 2.

[3] 5MW photovoltaic power plant design mainly 200-220Wp modules of 80% multicrystaline module and 8% monocrystalline ,7% thinfilm modules and 5% CPV modules using and its 20 modules string to connect single phase string inverter connecting so DC to AC conversion looses very less and 3Phase connecting with 3 inverter s connecting to 1SPJB and 3 SPJB are connecting to 1MPJB and 16MPJB connecting to 1LTPANEL in the power connecting 3LTPanel are connecting to Power transformer to setup the power to connecting Grid. Fig.3 showing major equipments using the plant execution by optimal system design.

2) *Structural Design:* Voltage regulators are designed as per the standards of IEEE C57.15-2009 [8]. To regulate the input voltage to inverters as it needs a constant DC voltage to invert to 3-phase AC 415 V.
3) *Grid tie Inverter:* 3-Phase inverters are designed as per standards of [10] IEEE 1547/UL 1746. The output voltage from an inverter is 415V. The necessary filters are considered as per standards of IEEE 1547/UL 1746 to avoid harmonics distortion.
4) *3-Phase Transformer:* Design of step up transformer is as per the standards of IEEE C57.12.00.2010 and it is designed as star-delta transformer to step up the voltage to grid level voltage.

5) *Monitoring System:* Monitoring system control of SCADA by consideration data from String array module. Inverter input and output and Grid syncarization data with losses and output performance to control the photovoltaic power plant. These are designed as per the standards of IEEE1547/UL 1746[10].
6) *Operation and Maintenance:* To optimize system performance, there is a need to ensure that the plant components function efficiently throughout the lifetime of the plant. Continuous monitoring of PV systems is essential to maximize the availability and yield of the system. [11] A SCADA system is able to monitor the real-time efficiency of the PV system and continuously compare it with the theoretical efficiency to assess if the system is operating optimally. This information can be used by the O&M contractor to establish the general condition of the system and schedule urgent repair or maintenance activities such as cleaning.
7) *Performance of Photovoltaic plants;* 5MW Photovoltaic power plant at khimsar, Rajasthan Temperatures maintaining remaining good level so output of plant higher values. Annual average value of PR ratio is nearly 85.12%. Sun availability daily nearly 330 – 360 days/ year and day availability 6.3hrs so higher output of plant performance.




5MW Photovoltaic power plant SLD

Fig. 3 5MW Photovoltaic power plant SLD (single line major equipment diagram)

Major line connecting of system in 5MW solar power plant simple understanding design of equipments Showing in the Fig.3 its major operational system in generation process of solar power plant with minimized the process of smart design system with consideration of all the engineer understanding and performance of losses recertification less.

Table .1 5MW Solar power plant monthly generation data.

| Total energy generated during various months | | | | | |
|---|---|---|---|---|---|
| Month | kW h/kWp) | (kWh/kWp) | (GWh) | Eshare (%) | PR (%) |
| Jan | 134.5 | 4.34 | 1.76 | 9.5 | 78.4 |
| Feb | 139.4 | 4.98 | 1.67 | 9 | 79.7 |
| Mar | 182.3 | 5.88 | 1.98 | 9.6 | 84.9 |
| April | 184.2 | 6.14 | 1.93 | 9.4 | 85.8 |
| May | 207.1 | 6.68 | 1.98 | 9.1 | 84.3 |
| June | 194.4 | 6.48 | 1.38 | 6.8 | 81.5 |
| July | 167.7 | 5.41 | 1.19 | 6.1 | 79.1 |
| Aug | 159.7 | 5.15 | 1.28 | 6 | 77.9 |
| Sep | 154.8 | 5.16 | 1.37 | 7.1 | 77.9 |
| Oct | 146.4 | 4.88 | 1.43 | 8.7 | 77.6 |
| Nov | 131.4 | 4.38 | 1.52 | 9.1 | 78.4 |
| Dec | 128.3 | 4.14 | 1.56 | 9.6 | 76 |
| Year | 1930 | 5.30167 | 19.05 | 100 | 80.12 |

5MW solar power plant generation data showing on Table.1 for the performance of monthly generation data with MW solar Power plant generation data of as per performance of the plant its generation data.

Average Performance Ratio in various months and actual performance Ratio in here very good performance in actual output of plants its design, module output and inverter performance and operation & maintenance are very high performance [6].

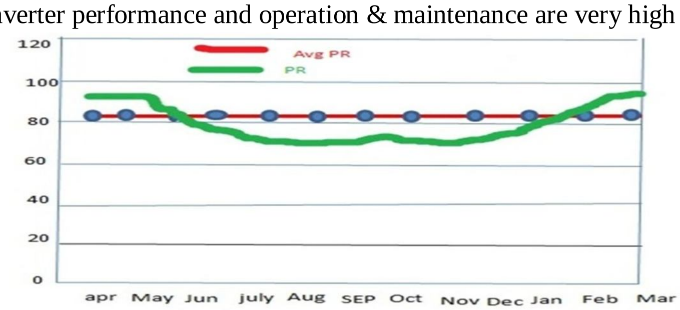



Fig .4 Actual Performance of plant Vs Average Performance of plant output.

Solar power plant generation also consideration of acutal pefromacne and avaerge performance consideration which his showing on Fig .4 as per calculation of average data performance are considered in the comparasion of actual data its performance of present installation of out put energy data its comparasion higher value of output will performance of actual performance data in the solar power plant.


Fig .5 Monthly Performance of Solar power plant data.

Solar Photovoltic power plant performance are consideration of monthly its showing on Fig. 5 per monthly wise data its higher performance are march,apr il,may,june and lower performance months are augest,october ,January.

*B. Our Study & Analysis in 5mw Solar Power Plant at Annatapur AP*

1) *Solar Photo Voltaic Arrays:* As maximum possible voltage or optimal voltage from a solar PV cell is limited to its design, irradiance, and temperature. Hence, it is required to connect the required number of cells in series framing an array. Figure 3 shows a model representation of 8 panels in each array and the output voltage of each array will be 77.3V of 130W. Using Simulink software, in each panel. 76 V cells are designed by using sim electronics blocks. An average solar radiation 1000 W/m$^2$ with 28$^o$C temperature are used as inputs to PV panel to observe optimum voltage [4].

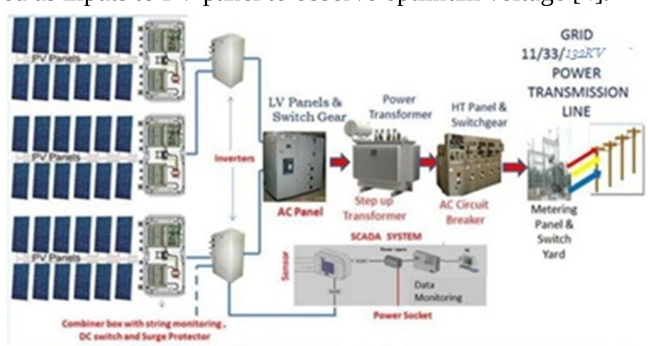



Fig. 6 Solar Power Plant design with equipment details

5MW photovoltaic power plant design mainly 130Wp modules of 41600 no's of modules using in the power plant .all the panels are 100 % thin film modules (CIS) are using and each string his connected 08 of modules .showing on Fig.6 for design of system in the each AJB connecting of 8 to 10 string and its connected to Inverter of capacity 500kw .each inverter connecting of 520strings and total 10nos of inverter are using in the plant. each step up transformer 1.25MVA /11KV connecting to 2nos inverters and 5nos step up transformer are connected to Power transformer of 6.25MVA/33KV its connected to 33KV/132KV substation of power plant

2) *Structural Design:* Using MS galvanized material of single axis structure using each structure 20nos modules using to maintaining structure with withstander the wind of 100km/hr by using 70microns galvanized coated [4] to protect the atmosphere weather condition using the 15degree angle and concerting the RCC foundation .
3) *Grid tie Inverter:* 3-Phase inverters are designed as per standards of [4, 5] IEEE 1547/UL 1746. The output voltage from an inverter is 415V. The necessary filters are considered as per standards of IEEE 1547/UL 1746 to avoid harmonics distortion.
4) *3-Phase Transformer:* Design of step up transformer is as per the standards of [5, 6] IEEE C57.12.00.2010 and it is designed as star-delta transformer to step up the voltage to grid level voltage. Using the step up transformer & Power transfer of design of plant on showing on Fig.6 for transformer connecting of process.
5) *Monitoring System:* These are designed as per the standards of IEEE1547/UL 1746 [4]. Monitoring of central inverters and junction boxes to string level. Measurement & storage of the temperature, irradiation, and string level current values, etc. Transmits the data required for monitoring, such as yields and the system efficiency, to the Internet portal, where the data is converted into straightforward diagrams and stored

_DC side of the power plant

PV modules convert Sun light into DC Power.

PV modules are connected in series & parallel to create necessary voltage & current. The series & parallel connections are done as per the design. [11]

The output of PV array is connected to junction boxes and outputs of the several junction boxes are connected to main combiner box.

This generated DC power is passed through the Inverter to convert DC power into AC power.

AC side of the power plant

The output of the Inverter will be AC power at 415V.

This converted AC power at 415V is connected to LV panel and stepped up to 11kV using a step-up transformer.

From 11 kV the power is stepped up to 33 kV and is connected to HT panel and from HT panel to Double Pole conductor.

AC Power is transmitted through overhead line to the 33/132 kV substation located at about 10 km from the project site.

Both on DC side of generation as well as AC side of conversion, protection and safety devices are provided to ensure safe and reliable operation of the complete Solar Power Generating system.

Monitoring and Analysis system provided with the power plant will record, store and transfer data that are essential for the same purpose.

6) *Operation and Maintenance:*

a) *Mode of Operation:*

The PV system basically consists of the following components:

PV arrays convert Sun light into DC Power.

This generated DC power is passed through the Inverter to convert DC power into AC power.

This converter AC power at 415V is stepped up to 33 kV using a step-up transformer.

AC power at 33 kV is connected to the Grid at the same voltage.

Both on DC side of generation as well as AC side of conversion, protection and safety devices are provided to ensure safe and reliable operation of the complete Solar Power Generating system.

Monitoring and Analysis system provided with the power plant will record, store and transfer data that are essential for the same purpose

b) *Maintenance Requirements:* The following measures will help in reducing the break down maintenance and also help in planning for preventive intendances.

Careful logging of operation data and periodically processing it to determine abnormal or slowly deteriorating conditions.

Careful control and supervision of operating conditions. Wide and rapid variations in voltage and frequency conditions do contribute to increased maintenance.

Regulate routine maintenance work such as keeping equipment clean, cleaning of module, proper maintenance of inverters etc.

Correct operating procedures.

Frequent testing of plant equipment by 'Walk Down' checks to internal condition of equipments such as module performance, inverter efficiency test, monitoring system testing etc.

Close co-ordination with the manufacture to effect improvements in plant layouts and design, use of better material, introduction of such facilities as lightning protection, etc.

7) *Performance of Photovoltaic Plants:* 5MW Photovoltaic power plant at anantapur Andhra Pradesh annual average value of PR ratio is nearly 75.12%. The highest value of PR is found to be 87.5% in the month of December and the lowest PR was 72.88% in the month of April. [11] System malfunction can be deducted based on the PR values. Lower PR is attributed to the incorrect operation of the system and inverter malfunctions.

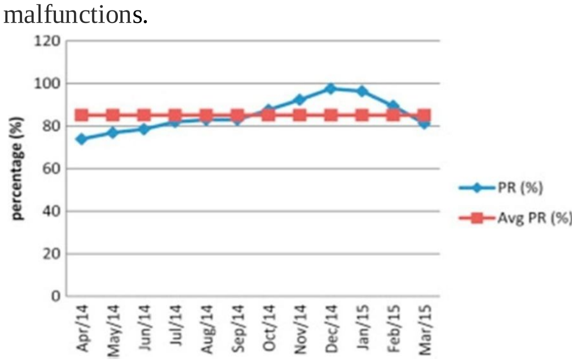
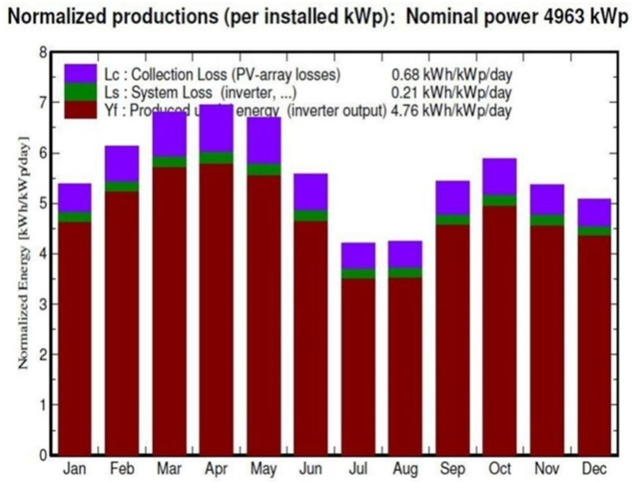



Fig. 7 Actual Performance of plant Vs Average Performance of plant output.

Solar power plant generation also consideration of acutal pefromacne and avaerge performance consideration which his showing on Fig .7 as per calculation of average data performance are considered in the comparasion of actual data its performance of present installation of out put energy data its comparasion higher value of output will performance of actual performance data in the solar power plant.

Fig .8 Monthly Performance of Solar power plant data.




Solar Photovoltic power plant performance are consideration of monthly its showing on Fig. 5 per monthly wise data its higher performance of solar power plant are summer section of march,apr il,may,june & lower performance of month are july, augest,Dec ,January, remaing month are avaerge performance of solar powr plant its actual performance of solar power plant

Table .2 5MW Solar power plant monthly generation data

| Total energy generated during various months -MW | | | | | |
|---|---|---|---|---|---|
| Month | kW h/k W p)M | (kW h/ kW p)Day | (GWh ) | Eshare ( %) | PR (%) |
| Jan | 156.1 | 5.04 | 1.56 | 9.5 | 78.4 |
| Feb | 146. | 5.24 | 1.47 | 9 | 76.7 |
| Mar | 157.6 | 5.58 | 1.58 | 9.6 | 74.9 |
| April | 153 | 5.8 | 1.53 | 9.4 | 73.8 |
| May | 148.3 | 5.78 | 1.48 | 9.1 | 73.3 |
| June | 111.1 | 4.7 | 1.11 | 6.8 | 75.5 |
| July | 99.4 | 4.21 | 0.99 | 6.1 | 77.1 |
| Aug | 97.6 | 4.15 | 0.98 | 6 | 77.9 |
| Sep | 116.8 | 4.89 | 1.17 | 7.1 | 77.9 |
| Oct | 142.7 | 4.6 | 1.43 | 8.7 | 77.6 |
| Nov | 149.4 | 4.98 | 1.49 | 9.1 | 78.4 |
| Dec | 156.3 | 5.04 | 1.56 | 9.6 | 79 |
| Year | 1634.9 | 5.008 | 16.35 | 100 | 76.6 |

5MW solar power plant generation data showing on Table.2 for the performance of monthly generation data with MW solar Power plant generation data of as per performance of the plant its generation data.

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## IV. CONCLUSION

In this paper, a solar photovoltaic power plant review and analysis , performance of plant in the two variable location of India (Rajasthan & Andhra Pradesh ) performance with consideration of system analysis and necessary components consider in the performance of different location power plant system analysis, design, technical performances, operational & maintenances and performance of power plant generation for the consideration of new power plant development by using the existing plants .consideration of design , technical viability projects cost with high performance equipments with less time execution and higher

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performance outputs. Also analysis of the two power plants performance sum of observations are Rajasthan power plant output of power plant very high & sunny days are very long hours available and operationally its very looses are there compare to Andhra Pradesh.

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