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INTERPRETATION OF CELL TECHNOLOGY AND ASSORTMENT OF PV MODULE

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ABSTRACT

In modern years the consumption of electrical energy is increased. The energy produced by non-renewable energy sources not getting full-fill the present demand of electrical energy. So, by using the present technology we have an alternative renewable energy sources like Solar energy, Wind energy, Tidal energy, Geothermal energy, Biomass energy. In all of these renewable energy sources solar energy maintains life on earth and it is an infinite source of clean energy. The solar energy is converted to electrical energy by using the cells. Solar cells are devices that use the photovoltaic effect to convert the light energy to electrical energy, producing the electrical charges to move freely in semiconductor. The first generation of solar cell is produced by using the silicon wafers either by using monocrystalline or polycrystalline. Solar module or PV module is a single photovoltaic panel which is formed by connecting the solar cells in series.

Although there are three different type of PV modules like Monocrystalline, Polycrystalline and Bifacial (Thin film). In our Industry oriented mini project, we used the PVsyst software for different output voltages we observed the technical parameters.

Keywords: SolarCells,PVmodule,PVsyst,Monocrystalline,Polycrystalline,Bifacial

I. INTRODUCTION

In 1883, American inventor Charles fritts made the first solar cell from selenium. Solar cells are also called as “Photovoltaic cells”. Solar cells is a specialized semiconductor converts sunlight directly into electricity. The photovoltaics gets its name from the process of converting light (Photons)to electricity (Voltage). The term Photovoltaic conveys from the Greek word “Phos” meaning light and word “volt”, named by Italian physicist Alessandro volta and volt refers to electricity. Photovoltaic modules commonly none as solar panels, are web that captures solar power to transform it into sustainable energy. A semiconductor material usually silicon, is basis of each individual solar cell. A Solar cell panel or Solar electric panel, Photovoltaic module, PV Panel or Solar panel is an convention of photovoltaic cell mounted in a free and a neatly organized collection of PV panels is called a photovoltaic system or solar array. The module consist of three type monocrystalline, polycrystalline and Bifacial. The solar panels are usually able to process 15-22% of solar energy into usable energy depending upon factors like weather conditions etc.

II. METHODOLOGY

EVALUTION OF SOLAR CELL

Solar cell technology became more efficient now a days. In upcoming years the cost of solar cell module will decreases and the solar cell module uses become more widely.

First Generation Cells:

First generation of cell manufacturing used conventional wafers. The first generation cells are based on crystalline silicon, which is dominated the market. The structure of the cells is Mono or Polycrystalline. The monocrystalline solar cell is constructed from silicon crystals. These cells are 25% efficient. In the manufacturing process of polycrystalline solar cell number of different crystals, grouped together to form a single cell.

Second Generation Cells:

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Second generation cells are installed in structure and standalone system. These cells are used Thin Film technology and more economical than the wafer-based cell of first generation. The absorption layer of light in silicon wafer based cells is around 300µm of thickness, while thin film cells around 1µm.

There are three common types of second generation cells:

1. Amorphous silicon (a-Si)
2. Cadmium telluride (CdTe)
3. Copper indium gallium di-selenide (CIGS)

Third Generation Cells:

Latest technology used in third generation cells. The aim of third generation cells is to surpass the Shockley-Queisser (SQ) limit. Currently, the most popular, state of sculpture developing solar cell technologies include:

1. Quantum dot solar cells
2. Dye-sensitized solar cells
3. Polymer based solar cells
4. Perovskite based solar cells

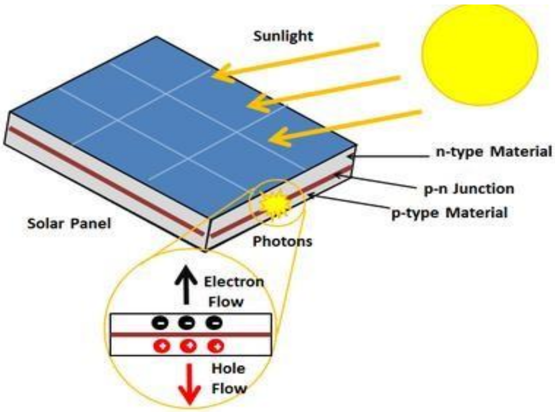

Fig. 1: Photo voltaic cells

SILICON SOLAR CELL MANUFACTURING

Step 01: Pre-check and Pretreatment:

The raw silicon wafer disks first experience a precheck during which they are inspected on their geometric shape and thickness conformity and on damages such as cracks, breakages, scratches, or other anomalies.

Step 02: Texturing/Texturization:

For monocrystalline silicon wafers, the most common technique is the random pyramid texturing which involves the coverage of the surface with aligned upward-filling pyramid structures.

This is achieved by etching pointing upwards from the front surface. The proper arrangement of the pyramids etched out is a result of the steady, neat atomic structure of monocrystalline silicon

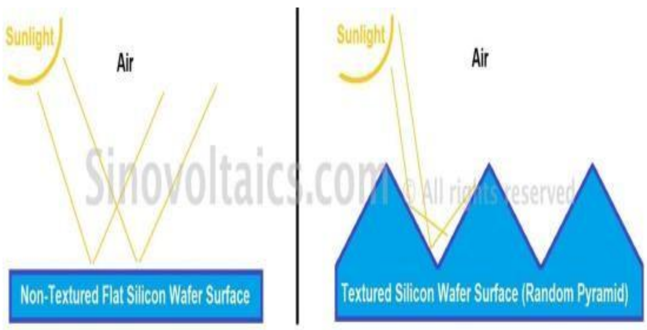

Fig.2: Texturing & Non- Texturing Surface

Step 03: Acid Cleaning:

After texturing, the wafers experience acidic rinsing (or: acid cleaning). Using hydrogen fluoride (HF) vapor, oxidized silicon layers on the substrate can be fixed away from the wafer surface.

Step 04: Diffusion (or) p-n Junction Formation:

While the previous method basically involves the already mentioned uniform doping of the wafers with the p-type and n-type materials. Wafers has benn already been pre-doped with p-type boron during the casting process are the diffusion process given to a negative (n-type) surface which is diffused with a phosphorous source such as Phosphorous Oxychloride ($POCl_{3)}$ at a high temperature, creating the positive-negative (p-n) junction. **Step 05: Etching & Edge Isolation:**

During diffusion, the n-type phosphorous diffuses not only into in the desired wafer surface but also around the edges of wafer as well as on the backside, to creating an electrical path between the front and backside and in this way also preventing electrical isolation between the two sides.

Step 06: Anti Reflective Coating Deposition:

This anti reflective coating is very much needed as the reflection of a bare silicon solar cells is over 30%. Silicon nitride (Si3N4) or titanium oxide (TiO2) are used for thin AR Coating. By varying the thickness of anti-reflecting coating the solar cell color will be changed.

There are three basically methods of depose layers. They are:

- Atmospheric Pressure Chemical Vapor Deposition (APCVD), it is used for only few application and it requires high temperature.
- Low-Pressure Chemical Vapor Deposition (LPCVD), it is also required high temperature.
- Plasma Enhanced Chemical Vapor Deposition (PECVD), it’s common method foe AR Coating.

Step 07: Contact Printing & Drying:

As the next step, metal in lines are printed on the wafer with the objective to create ohmic contacts. These metal in lines are printed on the hindmost side of the wafer, which is called backside printing. This is achieved by printing the metal pastes with special screen- printing devices that place this metal in lines onto the backside. After completion of printing, the wafer undergoes a drying process.

Fig.3: Printing

Step 08: Testing & Cell Sorting:

In this final process, under sunlight condition the solar cells are tested and according to the efficiency the are sorted. The process of testing and cell sorting are done by solar cell testing device. The factory workers then only need to take out the cells from the respective efficiency repository to which the machine assorted the cells.

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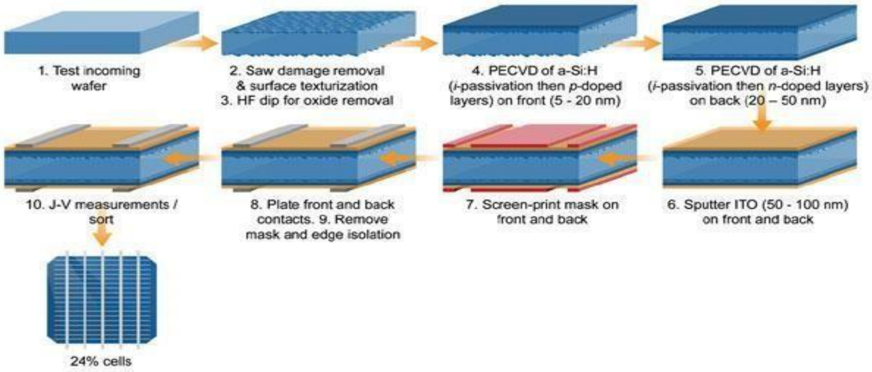

Fig.4: Process Summary Flowchart

PV MODULE MANUFACTURING

Step 01: Cell Cutting:

The cells are cutting out using laser cutting machine. The size of a cell is determined, depending upon the wattage of the panels you want.

Step 02: Stringing Process:

Cut/Full Solar Cells are looped together using automatic stringers. The bottom white side is positive while the upper Sun facing Side (Blue / Black side) is the negative part.

Step 03: Glass-EVA Loading:

Once the cells are strung together, the machine transfers it onto the tempered glass, which already has ethylene vinyl acetate (EVA) encapsulation layer over it.

Step 04: Visual Inspection:

The cells are inspected by a technician whether the string has any fault.

Step 05: Taping:

During taping, a technician tapes the cell strings into a matrix alignment.

Step 06: Connection:

Interconnects are then joined together. Any extra material is cut out.

Step 07: Insulate Module Connection:

Insulating the connections are done by using back sheet, also called Tedlar – Poly Vinyl Flouride (PVF) and EVA encapsulation. From any dust and moisture this process is protected

Step 08: Mirror Observation:

The module is visually checked once again for any dust particle, color mismatch, etc.

Step 09: Electroluminescence (EL) Testing:

EL Testing or Electroluminescence test is a testing process, Using EL machine the module is scanned. The EL machine making it easy to spot dead or low power cell/s, short circuit cells, cracks, etc. if any defect are detected, the module is sent back for defect rectification.

Step 10: Lamination Process:

At 140-degree Celsius the module get laminated. This takes approximately 20 mins to complete the process. After lamination, the modules are left to cool down to ambient temp for 10-15 mins.

Step 11: Backsheet/Tedlar Trimming:

To make perfectly shaped modules, the excess material is cutting of in this step.

Step 12: Frame Cutting:

In this step, for providing structural integrity to the assembled panels, frames of different sizes are cut out.

Step 13: Frame Punching:

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For mounting and grounding the panels, holes are punched in the frames.

Step 14: Sealant Filling / Framing:

A sealant is provided to protects the panels from air, dust, and moisture and helps the module to firmly attach on the frame.

Step 15: Junction Box Fixing:

Using a sealant to firmly attach it to the structure, a junction box is fixed to the back of the module. Connections are then linked and left for 10-12 hours for curing, so that the structures become perfectly dry and attached properly.

Step 16: Module Cleaning:

The front surface of the module is then wiped remove any traces of dust, foreign particles or extra sealant.

Step 17: Module Testing:

The module is tested for its output current, voltage, power, etc. For each module report is generated. A label (with all details) is pasted behind the module for the benefit of the users. Finally, the module is sent to the Quality and check in lab where it is tested for insulation resistance. For a min 3000v DC passes through it.

Step 18: Packing:

After (FQA), this is the last step in the module manufacturing process, where the modules are safely packed into large boxes for transportation and storage.

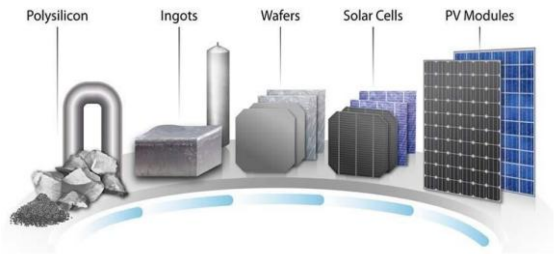

fig.5: Construction of PV Module

III. MODELING AND ANALYSIS

Algorithm:

Step1: Open PV Syst Software

Step2: Select grid connected

Step3: Select the New Project and Plant Location

Step4: Save the project

Step5: Now, come to variant part Configure the Orientation

Step6: Configure the system and enter the plant output Voltage, select PV module, select inverter

Step7: Then, Run Simulation

Step8: The output Waveform is generated.

Circuit:

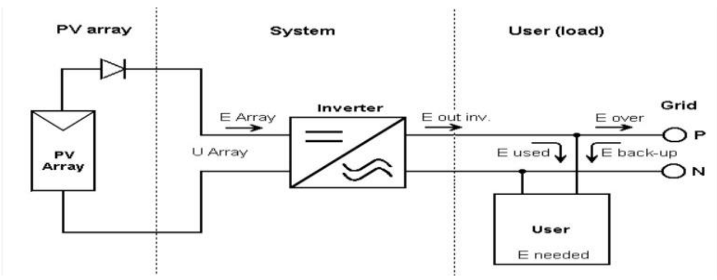

Fig.6: PV Syst Schematic Diagram of system

The above circuit diagram is the PV Syst Schematic Diagram of system.

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IV. RESULTS AND DISCUSSION

Case Study:

Fig.6 is same circuit for 20KW and 500KW case study. We done the case study on three different type PV modules. They are:MonoCrystalline, PolyCrystalline and Bifacial. By using the PVSyst Software we obtained the graphs and Some parameters.

20KW Load:

Monocrystalline:

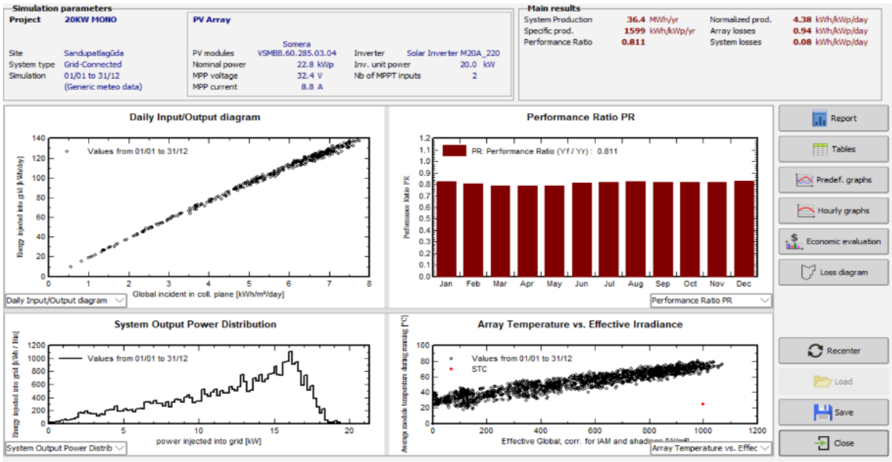

Fig.7: Graphical representation of monocrystalline

Polycrystalline:

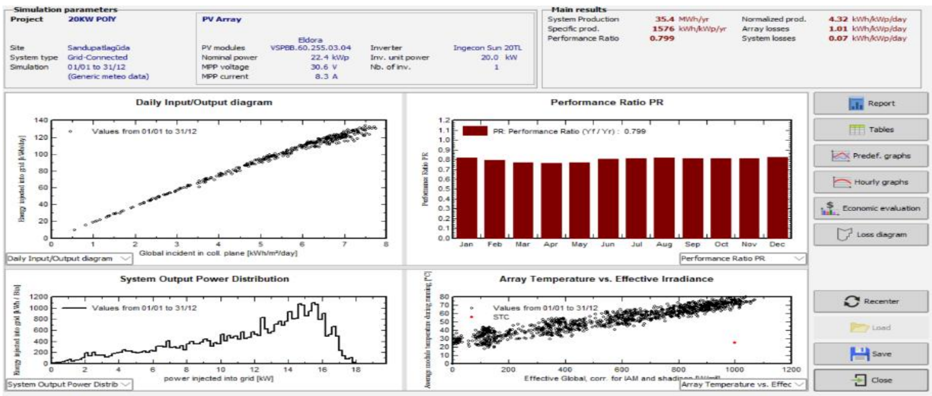

Fig.8: Graphical representation of polycrystalline

Bifacial:

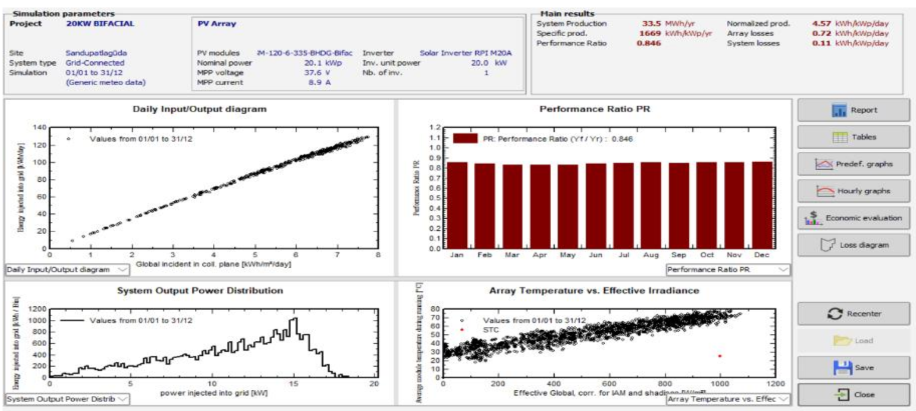

Fig.9: Graphical representation of Bifacial

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Daily Input and Output Diagram, Performance Ratio, System Output Power Distribute and Array Temperature vs Effective Irradiance graphs of Monocrystalline, Polycrystalline and Bifacial PV Modules for 20kw load were shown in fig.7,8,9 respectively.

500KW Load:

Monocrystalline:

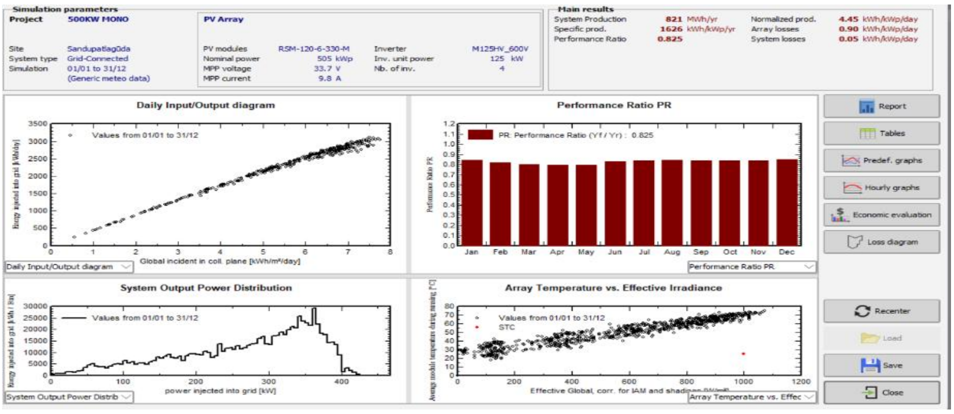

Fig.10: Graphical representation of monocrystalline

Polycrystalline:

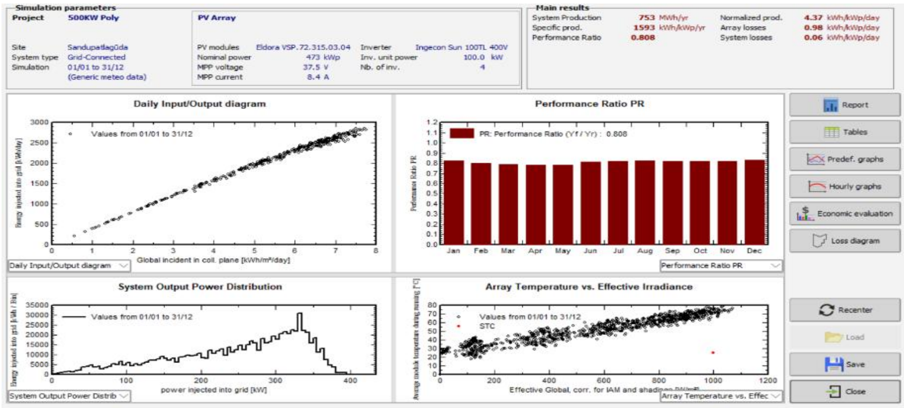

Fig.11: Graphical representation of polycrystalline

Bifacial:

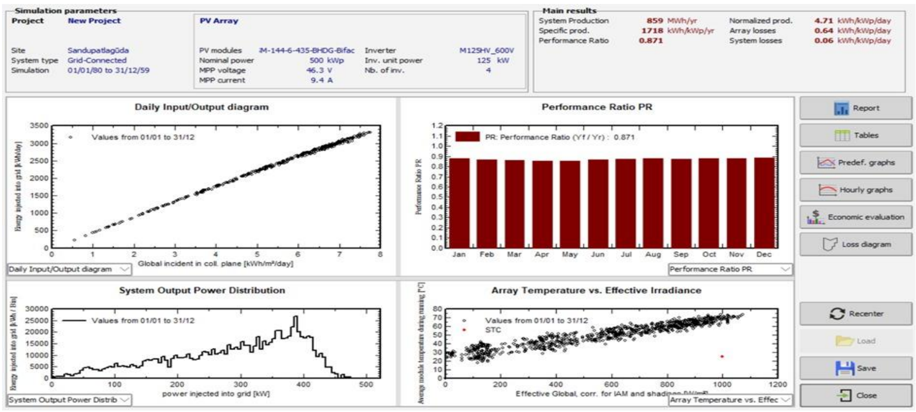

Fig.12: Graphical representation of Bifacial

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Daily Input and Output Diagram, Performance Ratio, System Output Power Distribute and Array Temperature vs Effective Irradiance graphs of Monocrystalline, Polycrystalline and Bifacial PV Modules for 20kw load were shown in fig.10,11,12 respectively.

Result:

For 20KW Load:

For the considered 20kw load, the parameters like module in series, number of strings, number of modules, module area and number of inverters are compared in following table.1 for monocrystalline, polycrystalline and bificial

Parameters	Monocrystalline	Polycrystalline	Bifacial
Module in series	**20**	**22**	**20**
No. of strings	**4**	**4**	**3**
No. of modules	**80**	**88**	**60**
Module area	**130m^2**	**143m^2**	**102m^2**
No. of inverters	**1**	**1**	**1**

Table:1 Comparison of monocrystalline, polycrystalline and bificial parameters

For 500kw Load:

For the considered 500kw load, the parameters like module in series, number of strings, number of modules, module area and number of inverters are compared in following table.2 for monocrystalline, polycrystalline and bificial .

Parameters	Monocrystalline	Polycrystalline	Bifacial
Module in series	**30**	**19**	**18**
No. of strings	**51**	**79**	**57**
No. of modules	**1530**	**1501**	**1026**
Module area	**2574m^2**	**2912m^2**	**2087m^2**
No. of inverters	**4**	**4**	**4**

Table:2 Comparison of monocrystalline, polycrystalline and bificial parameters

V. CONCLUSION

In this work we came to understand the cell technology and when we installing a solar plant, the selection PV module will play a key role. While selecting the PV module, we have to consider some technical parameters.

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