# CONSTRUCTION AND PERFORMANCE TEST OF SOLAR PV SYSTEM

A Thesis
by


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Department Of Mechanical Engineering
SONARGAON UNIVERSITY (SU)

MAY 2025

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Submitted to the

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SONARGAON UNIVERSITY (SU)

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of

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# ABSTRACT

Renewable energy is crucial for sustainable development and addressing global challenges such as climate change, energy security, and environmental degradation. Solar energy is one of the important source of renewable energy and plays significant roles to produce electricity. This study focuses on the construction and performance evaluation of a solar panel system for generating a specific amount of electricity. In addition, we have demonstrate the calculation of the full solar panel system during the construction process. Solar irradiance depends on location of the Earth. The research was conducted in Bangladesh, leveraging the PV syst simulation software to determine the optimal tilt angle and azimuth angle for maximizing yearly energy generation. We evaluate the system's efficiency under real-world conditions. Through advanced materials and technology, solar energy systems will become more capable of sustainably meeting energy demands.

We conducted tests on our solar panel over three consecutive sunny days and typically achieved around 75% efficiency. Thus, we believe that in our location, a solar panel with 25% higher capacity than the user's requirement should be installed for fixed tilt and azimuth configurations. Otherwise, the system will not function properly.

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# CHAPTER 1

# Introduction

## 1.1 Significance of Renewable Energy

Renewable energy is crucial for sustainable development and addressing global challenges such as climate change, energy security, and environmental degradation. Renewable energy sources, such as solar, wind, hydro, and geothermal, produce little to no greenhouse gas emissions, helping to mitigate climate change and reduce air and water pollution. By relying on indigenous resources like sunlight and wind, countries can reduce dependence on imported fossil fuels, improving energy security and reducing geopolitical tensions. The renewable energy sector creates jobs in manufacturing, installation, maintenance, and research, contributing to economic development and supporting local economies. Reduced air and water pollution from renewable energy leads to better public health outcomes, decreasing healthcare costs associated with respiratory and cardiovascular diseases. Unlike fossil fuels, renewable energy sources are abundant and inexhaustible. This ensures long-term energy availability for future generations. Renewable energy technologies, such as solar panels, can be deployed in remote or underdeveloped areas, improving energy access and fostering socio-economic development in off-grid communities. Decentralized renewable energy systems are often more resilient to climate impacts, such as natural disasters, compared to centralized fossil fuel-based energy systems. Advances in technology and economies of scale have significantly reduced the costs of renewable energy, making it increasingly competitive with fossil fuels. By transitioning to renewable energy, societies can achieve sustainable development while addressing pressing global challenges.

## 1.2 Objectives

The objective of this thesis study includes the following steps

- To Study Solar PV System.
- To Construct Solar PV System.
- To Analyze the Performance of Solar PV System.

### 1.3 Previous Works on Solar Technology

Many research works are going for the solar technologies. This is one of the major components of the green technology. Improvements are obviously needed in every part of solar technology in order to get the best out of it. This does not leave our country Bangladesh in the dust. Indeed our country is also improving in this specific region to improve and to be a part of the green family of the world as well. As the world is progressing towards a greener future with the solar systems, there are more than 35[1] companies those who are doing business around the globe in improving and implementing the ideas about solar technologies.

Not only that, university students around the globe are also interested about the solar technologies as well. The university students of AUST (Ahsanullah University of Science and Technology) also designed a solar system for their own university.

In addition, the university students of the Rajamangala University of Technology Thanyaburi of Thailand had installed a photovoltaic system in their university to promote solar energy as a project work.

The scientists of Korea and California had developed a different way in order to boost the efficiency of the solar systems by introducing plastic solar panels [2]. Nowadays, people are installing solar systems on the commercial buildings, houses, offices and factories just to obtain the green energy.

Solar energy is mainly a site based energy-harnessing project. Therefore, there are many key factors, which actually determines where the best outcome of the energy is.

**Site and load based:**

The solar system is mostly location based. This means the best outcome comes in a specific region where the solar system is put, mainly the photovoltaic panel. For houses and apartments, the PV panels can be used on the roof top, garden, lawn in order to get the best outcome. Besides that, the solar panels are designed for a particular maximum load or maximum power output. This can be said for Sarnia Photo-Voltaic power plant of Canada, which delivers 80MW of power [3], Olmedilla Photovoltaic Park of Spain delivers 60MW of power [4].

## 1.4 In bangladesh perspective

- **Solar Home Systems (SHS)**

- The Infrastructure Development Company Limited (IDCOL) is a government-owned entity that launched the Solar Home Systems (SHS) program in 2003.
- Over **6 million systems** have been installed, benefiting approximately **20 million people**.
- The program focused on providing electricity to off-grid rural areas where conventional grid electricity was not available.

- **Solar Irrigation Systems**

- Solar irrigation pumps have been implemented as a sustainable alternative to diesel-powered pumps.
- The Bangladesh Agricultural Development Corporation (BADC) and private sector companies, with support from IDCOL, have installed over **3,000 solar irrigation systems**, helping to reduce dependency on fossil fuels.

- **Grid-Connected Solar Power Plants**

Several solar power plants have been established to supplement the national grid:

- **Rangpur Solar Plant**: A 50 MW capacity solar power plant was inaugurated in 2018.
- **Mymensingh Solar Plant**: Another notable project with a capacity of 73 MW, operational since 2021.

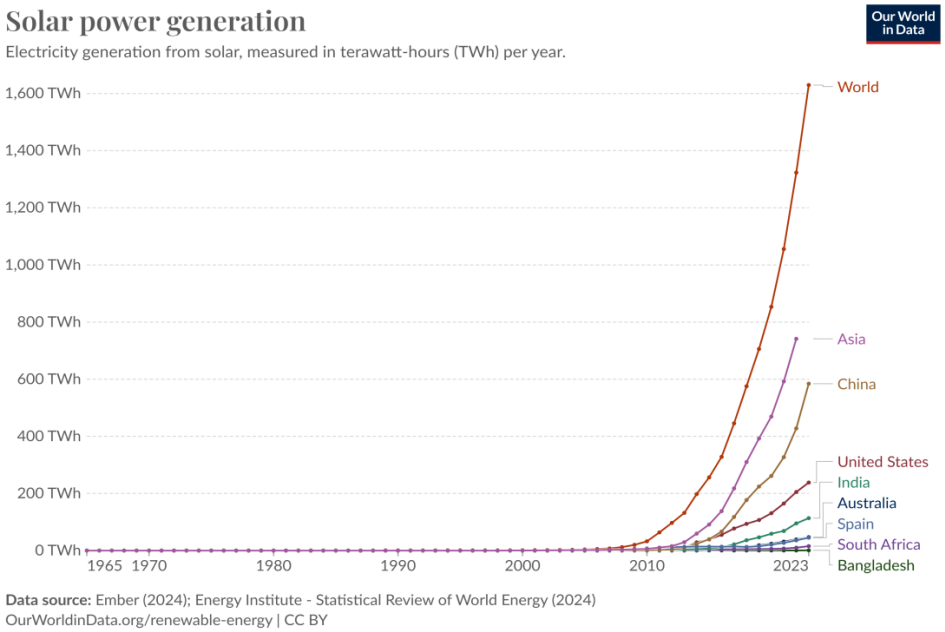



Figure 1.1: Generation of solar energy around the world

### 1.5 Importance of Renewable Energy in Bangladesh

Expanding capacity in the electricity sector can be achieved cost-effectively through clean energy options (renewables and energy efficiency), which not only reduce greenhouse gas emissions, but also increase jobs and improve human health by reducing air pollution. According to a report from the Low Emission Development Strategies Global Partnership (LEDS GP) and based on detailed modeling analysis, the benefits of increasing clean energy in Bangladesh's power generation mix relative to ‘business-as-usual’ could generate the following cumulative results by 2030:

1. reduce greenhouse gas emissions by up to 20%
2. generate domestic employment of up to 55,000 full-time equivalent jobs
3. Potential to produce additional electricity of 30 GW[5] from the utilization of solar PV and 53 Giga watt (GW)[6] of electricity potential from all solar sources.
4. save up to 27,000 lives, and over US$5 billion (BDT 420 billion).[7]

As of June 2023, renewable energy constitutes 4.5 percent of the total installed power capacity in Bangladesh, with 1,183 MW out of 22,215 MW coming from renewable sources, predominantly solar power.[8]

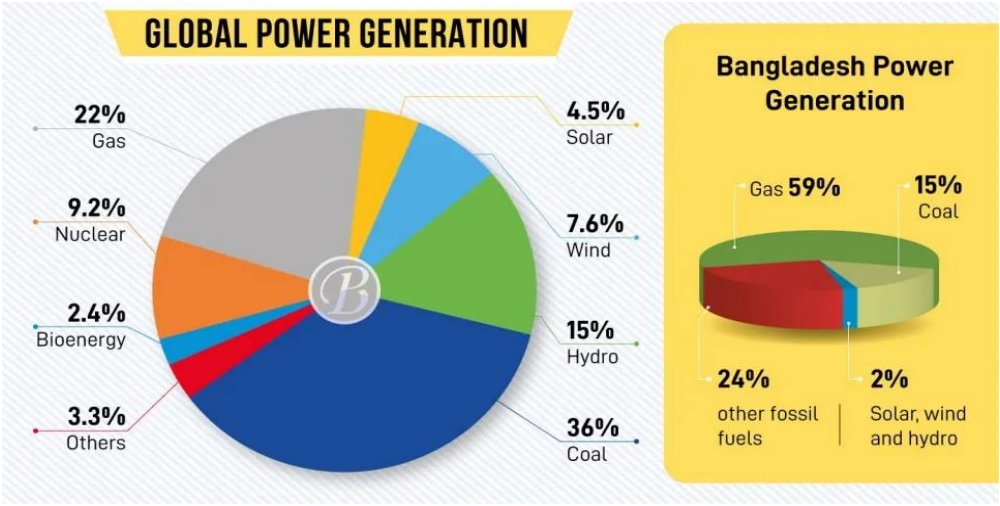



Figure 1.2: The Scenario Between Global And Bangladesh Power Generation in 2022.

### 1.6 Usage of Solar Home System and Solar Energy

1. Affluence of solar energy is worldwide. It is one of the important renewable energy after wind and hydro, which makes it third most reliable renewable energy. In this system, conversion of solar energy done by a solar PV panel to supply power. Solar Home System (SHS) is a standalone system.
2. This system supplies power to the load in a cost effective method. As this system can supply power without grid connection, it can also be called off-grid photovoltaic system. People living in remote rural areas where there is no grid connection, gets advantage from this system.This system is a great blessing for them to get electricity with the benefit of having low maintenance cost.
3. This system can work at rated voltage of 12V DC (direct current) and can supply electricity to low power DC applications. It can also provide power to large appliances having 240VAC rating. This can be done by cabling. Mounting, switching, power conditioner or inverters.
4. However, not every place is appropriate for solar PV panel. It is because of solar incentive. The countries where sun shines brightly are the privileged ones. Incentives can make solar power reasonable.
5. It is not necessary to have higher insolation for PV panel installation. There are many countries around the world does not have sophisticated amount solar insolation yet installed a good number solar power system and using it.
6. According to a survey solar photovoltaic panel having more than 100GW was installed in 2012. These photovoltaic powers has the ability to produce 110TWh electricity. [9]

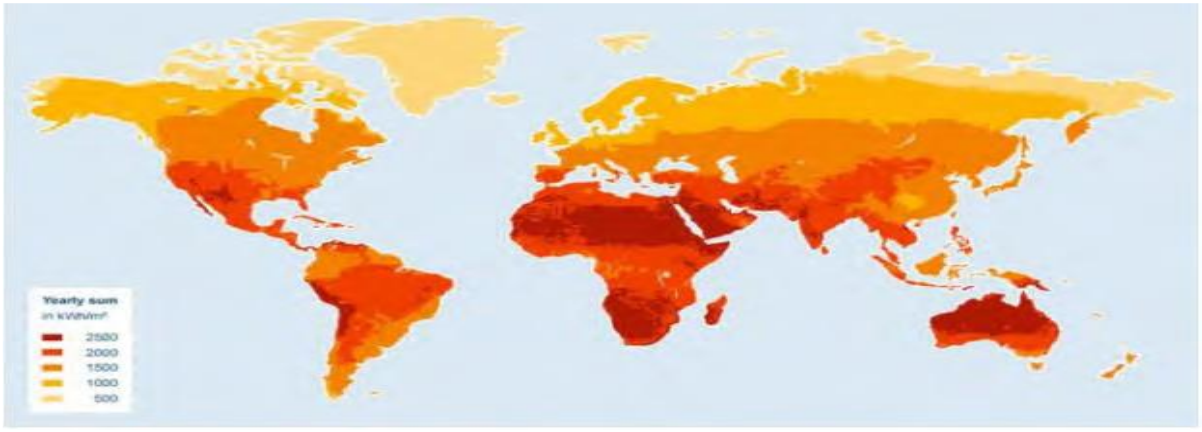



Figure 1.3: Openness and density of solar energy around the world

6. The picture in above shows the availability solar energy around the world. Different colors are indicating the variation of solar energy density in different regions. The warmer the color higher density of solar energy (insolation, solar radiation, sunlight).
7. From the map, it is noticeable that insolation gets higher when we get closer to the equator and in equator it is higher than other places. It is because sun incidents fall directly to the surface of earth in the regions of equator.
8. Germany has installed highest PV power in the world. The capacity of their solar power is 32,411MW, which is almost 31%. In the year 2012, more PV panels were connected and the capacity of power became 76GW for year 2012. In the same year Germany produced electricity of 23TWh (terra watt-hour) by only using solar panels.
9. After that, it only enclosed 3% of country's total consumption. Some market experts hope that by 2050 solar power will cover the 25% of the total consumption in Germany. Although Germany is not blessed with extents of solar energy, it has a great setting effort for solar power to compete in the market.
10. Many European countries have started implement and use solar power. Italy is the second highest capacity of solar power country in the world. In 2012, it added 3.4 GW solar power capacity.
11. Other countries of Europe such as France, UK, Greece and Bulgaria are also implementing solar technologies. With a capacity of 1GW, Spain became world leader in solar thermal power (CSP) in the year 2012, which exemplified 65% of total installed CSP.
12. US has capacity of 7.8GW solar PV. China 8.3 GW solar PV. California has solar power of 1.6 GW. New Jersey, New Mexico and Arizona are not lagging behind. [10]

| Ranking | Country | Installed PV (MW) |
|---|---|---|
| 1 | Germany | 32,411 |
| 2 | Italy | 16,361 |
| 3 | China | 8,300 |
| 4 | USA | 7,777 |
| 5 | Japan | 6,914 |
| 6 | Spain | 5,166 |
| 7 | France | 4,003 |
| 8 | Belgium | 2,650 |
| 9 | Australia | 2,650 |
| 10 | Czech republic | 2072 |

Table 1.1: EPIA's annual Global Market Outlook [11]

### 1.7 Site Selection

This thesis project is performed under Sonargaon University(SU). We chose the rooftop of Sonnargaon University for thesis work. Main building 0f SU University is east facing and it has 6 levels including the rooftop.

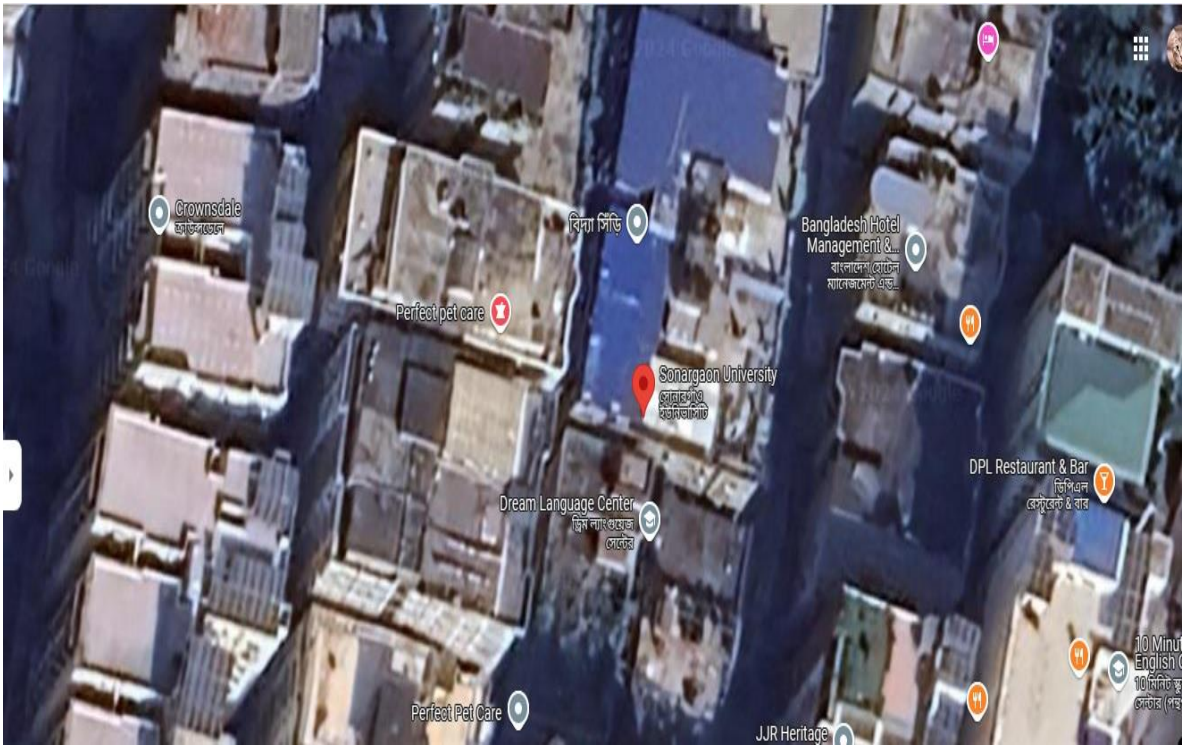



Figure1.4: Site location Sonargaon University (147/I, Green Road, Panthapath, Dhaka)

# CHAPTER 2

# Literature Reviews

## 2.1 Introduction

A literature review on solar energy should introduce the topic by highlighting the significance of solar energy as a renewable and sustainable energy source, emphasizing its role in addressing climate change and energy demand. It should then outline the scope of the review, focusing on specific aspects of solar energy technology, applications, or challenges. Finally, the review should provide a brief overview of the key research areas and advancements in solar energy, setting the stage for a deeper exploration of the topic.

## 2.2 Solar Energy

We know that heat and light are one kind of energy. In addition, solar energy is the energy that is radiated from the sun and arrives at the earth in form of light and heat energy. Solar energy is one of the important source of renewable energy and plays significant roles to produce electricity. The electricity we get or generate by using the solar radiation is called solar power. There are two types of technology for solar energy. These technologies are active solar technology and passive solar technology. In passive solar process, the energy of sun is used by not converting it. Moreover, in active solar system the energy of sun is converted into electricity by using outside sources. The active solar technology is a great renewable energy as it reduces the uses of fossil fuels to produce electricity. [12]

The potential of solar energy is very huge, huge enough to fulfill the requirements of the world. The total energy consumption of the whole world back in 2008 was around 474 exajoules (1EJ=10^18 joules) or approximately 15TW(1.504* 10^13Watts)[13]. Almost 80-90% of this energy came from the fossil fuels [14].

The amount of energy that the earth receives from the sun is about 3850000 EJ[15], which is more over equivalent to 174 peta watts (1PW=10^15W). The earth does not hold all of the energy as it reflects it back to outer space. The remaining power after the reflection is about 89PW. Of this huge amount of energy, only 0.02% of it is enough to replace the fossil fuels and nuclear power supply in the world. Considering all the greenhouse gas effects, and environmental effects we can certainly say that solar systems has the greatest source of energy for the betterment of the earth.

## 2.3 Solar Cells, Modules and Arrays

A photovoltaic solar system is a system, which includes silicon solar panel. The solar panel is made of photovoltaic solar cells. It produces higher voltages, currents and power points if we attach them in series or parallel circuit. A photovoltaic cell is in genuine made of semiconductor material, specifically silicon made. By arranging these cells in series or parallel, a photovoltaic module is created. Again, by attaching photovoltaic modules in series or parallel connection solar arrays are designed. Inside a photovoltaic module, the photovoltaic cells are kept in such a way so that no harm can cause by environment; for example, it is watertight with shielding laminate. Photovoltaic panels may have one or modules. These modules are assembled by a pre-wiring field installable unit[17].

The performance of solar PV module and array depends on their rated condition. This rating is done according to the Standard Test Condition (STC). The STC temperature of a PV module is 25o C and in Fahrenheit it is 77o F. The air mass is 1.5 spectral and the solar irradiance is 1000 W/m^2 as per to the STC rating.Nowadays, photovoltaic modules are reliable source of power generation having low failure rates with a lifetime expansion of 20 to 30 years.

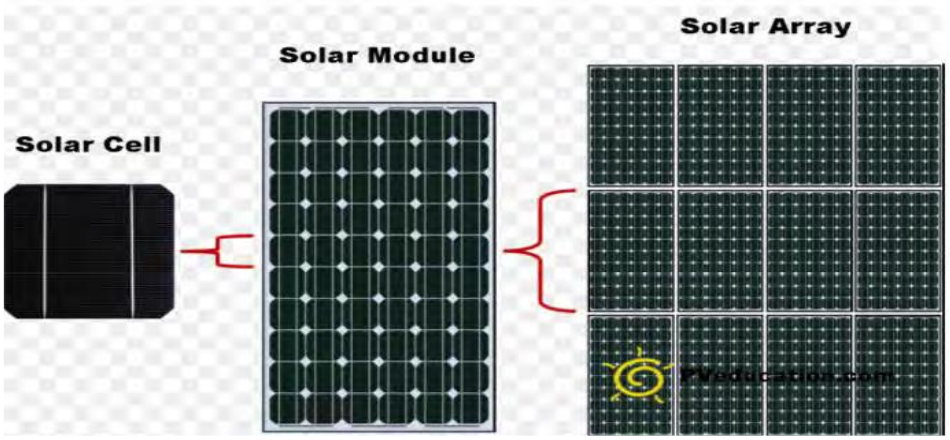



Figure 2.1: Solar cell, module and array

## 2.4 Photovoltaic System

The device, which converts light into electricity, is known as solar panel and the process or system through which light is converted into electricity is known as photovoltaic system. Photovoltaic means light-electricity. Solar panels of photovoltaic system has small cells on it known as solar photovoltaic cells. These photovoltaic cells can be arranged in two ways in a solar panel. One way to connect it is in series and the other way is in parallel. A Solar Photovoltaic cell converts solar energy into electricity. A photovoltaic cell is a semiconducting material composed of silicon. When the sunrays fall on it, it interacts with photons and generates small current.

The semiconducting material or semiconductor of solar cells have minimum two layers, known as wafer. These semiconductors are doped with boron and phosphorus. One of the layer of the material is positively charged and the other one is negatively charged. Thus, the positive layer is P-type or works as a hole and the negative layer is N-type. The silicon layer that is doped with Boron is P-type and the other one that is doped with Phosphorus is N-type. As two different type of charge (positive charge & negative charge) is present in a solar cell, an electric filed is created. This electric field is called P-N junction. Semiconductors absorb photon from light and separate the electrons. The P-N junction make available direction to the separated electrons. These released electrons flow to the negative layer to positive layer and a loop of hole is created. Therefore, a one directional current is created which in actual is a DC current.

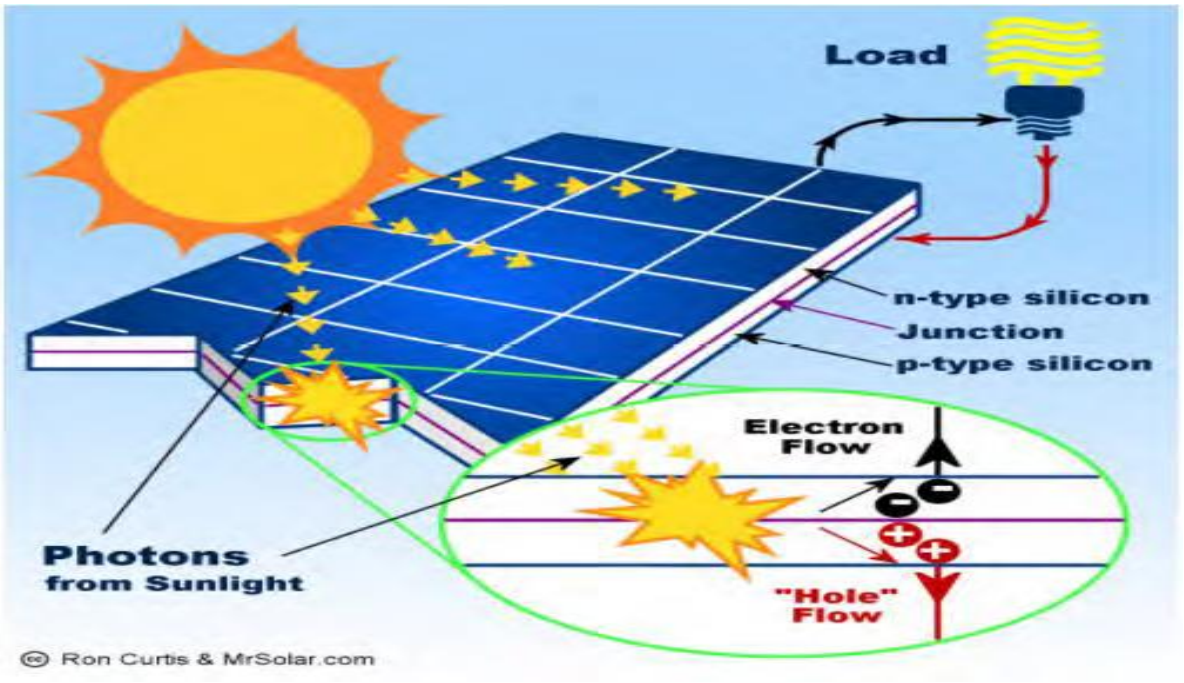



Figure 2.2: Conversion of electricity from sunlight

## 2.5 Solar PV Technology

Many studies and analysis have done to meet the demand of electrical current through solar PV technology. The existing technologies are developing with time. Hence, the solar system we have at the present can generate more electricity than the previous one. Four types of solar PV technology subsists. They are-

1. Single crystalline or mono crystalline
2. Multi crystalline or poly crystalline
3. Thin film
4. Amorphous silicon

### Single Crystalline or Mono Crystalline :

Mono crystalline silicon cells are the most efficient solar cells than the other cells. It can be found easily. If we calculate the power generation per square foot of module, it generates the supreme power. In a mono crystalline PV cell, a single crystal of silicon is cut from each cell. In a solar panel the number of cells are increased by cutting the wafers in a rectangular shape.

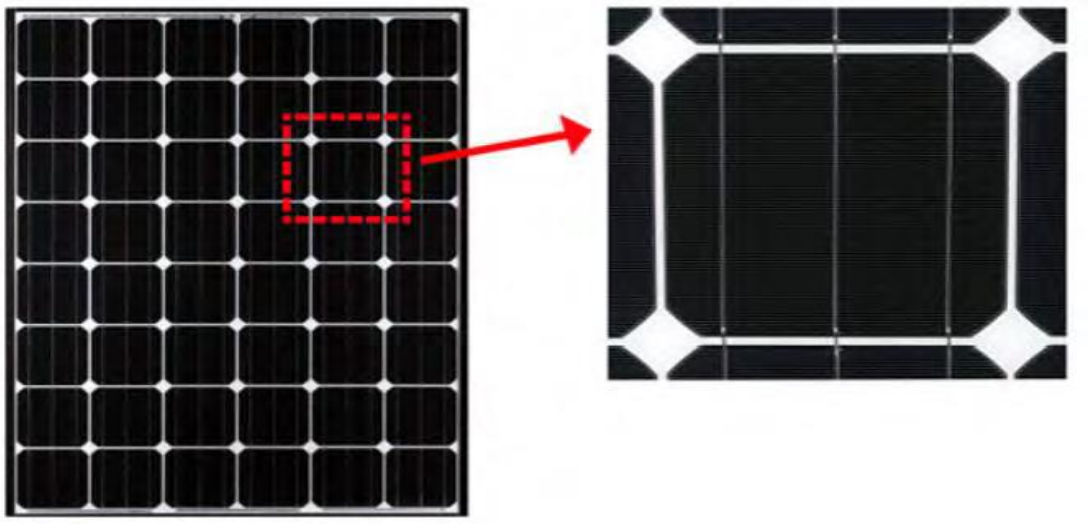


Figure 2.3 : Mono Crystalline Photovoltaic Solar Cell

**Multi Crystalline or Poly Crystalline :**

Polycrystalline cells are made in the same manner; just the difference is that they need go through the melting procedure and then transferred into a mold. Hence, the formation of single crystalline does not take place. In this technology, the mold takes form of square blocks which then turns into square wafers. One advantages of this system is that it wastes fewer materials than mono crystalline technology

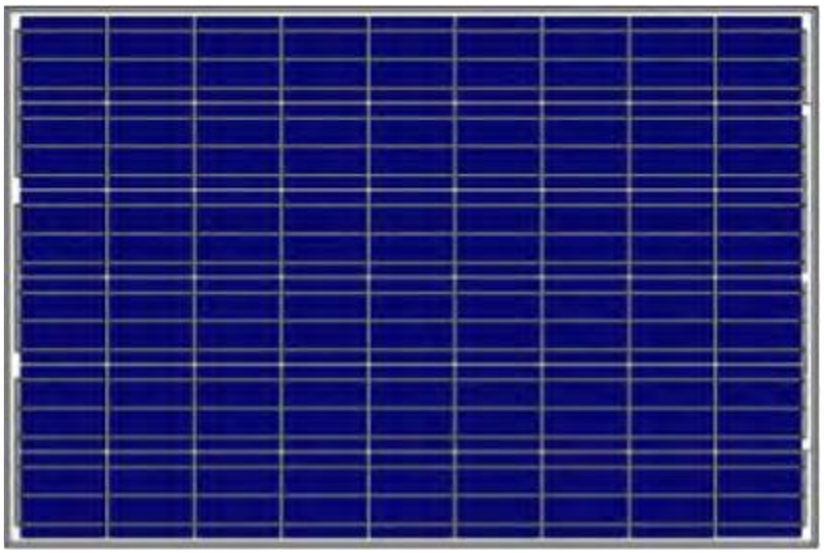


Figure 2.4: Poly Crystalline Photovoltaic Solar Cell

**Thin Film Panel**

Thin film technology is new in the solar cell technology. It is very thin. To be specific, it is of a few micrometer or less than that. This technology includes thin film supplies or materials of Copper Indium, Cadmium Telluride and Gallium Arsenide. They are all accumulated together on glass, stainless steel or in other materials to make a substrate. Few of them can give better performance where there is less light compare to the crystalline silicon.



Figure 2.5: Thin Film Solar Cell

**Amorphous Silicon**

Amorphous silicon is a thin film technology. Nevertheless, it is the very latest solar thin film technology. Amorphous silicon is nothing but a silicon in non-crystal form. This technology includes vaporization of amorphous silicon. The silicon vapor is gathered or deposited on thick amorphous films, which I couple of micrometer and after that, accumulated on stainless steel rolls in this technology only 1% material is used.

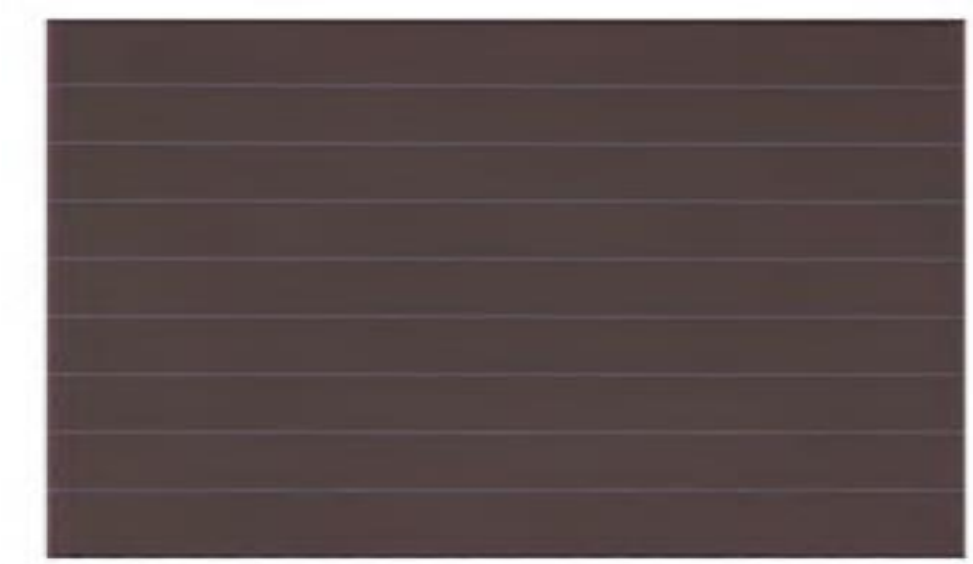


Figure 2.6: Thin Film Solar Panels -3.8V 30μA Amorphous Silicon Solar Cell

| Property | Monocrystalline | Polycrystalline | Thin-Film | Amorphous |
|---|---|---|---|---|
| **Structure** | Single crystal lattice | Multiple smaller crystals | Thin layers of material | Non-crystalline (random atomic order) |
| **Efficiency** | High (18-22%) | Moderate (15-18%) | Low to Medium (10-15%) | Low (6-10%) |
| **Cost** | High (expensive to produce) | Moderate (less costly than mono) | Low (cost-effective) | Very Low (simplest manufacturing) |
| **Durability** | Very High | High | Moderate | Low (degrades faster over time) |
| **Thickness** | Thick (bulk material) | Thick (bulk material) | Thin (micrometers thick) | Very Thin (micrometers thick) |
| **Material Usage** | High | High | Low | Very Low |
| **Manufacturing** | Complex (Czochralski process) | Simpler than mono | Scalable and fast (vapor deposition or sputtering) | Simple (plasma deposition) |
| **Performance in Low Light** | High | Moderate | Good (depending on material) | Moderate |
| **Temperature Coefficient** | Low (better performance in heat) | Moderate | Better than crystalline types | Moderate to Poor |
| **Applications** | High-end solar panels, electronics | Mid-range solar panels | Portable devices, BIPV | Small-scale devices (e.g., calculators) |

| | | | | |
|---|---|---|---|---|
| **Appearance** | Uniform dark black | Bluish, fragmented texture | Smooth and uniform (dark or black) | Uniform, glassy |
| **Environmental Impact** | High material waste | Moderate | Low | Very Low |
| **Weight** | Heaviest | Heavy | Lightweight | Very Lightweight |
| **Lifespan** | 25+ years | 20-25 years | 10-20 years | 5-10 years (prone to degradation) |

**Table 2.1** : Difference among Four types of solar PV technology

## 2.6 Components of PV System

The arrangement of Solar Photovoltaic system has several components such as:

1. **Solar Panel (PV) Module:** Solar panel is the most important component of Solar Home System. This is the device, which converts light energy to electrical energy. A solar panel is an array of solar cells arranged in a series or parallel way.

2. **Charge Controller:** Charge controllers ensures when to charge or discharge the batteries. It is mainly a voltage or current controller. It protects the battery so that it does not get damaged because of overcharging or discharging for a long period. The solar charge controllers can be of different sizes and have features and cost. Charge Controllers have ranges of 4.5A (ampere) and up to 60 A to 80 A.

3. **Battery:** Battery, another mandatory component of solar home system. The solar home system can only convert the solar energy into electricity in day light. However, at night when there is no sunlight, it produces electricity with the help of battery. In case of solar irradiation and over cast weather loads takes power from battery. A better solar system requires a good battery with longevity.

4. **Cables & Accessories:** Solar Home System is an outdoor application. Hence, we need cables, which does not get damaged easily and can ensure low voltage drop along with low power losses.

5. **Inverter:** Inverter plays a great role where solar home system supplies electricity along with the grid connection. We get DC current through photovoltaic system. We might need AC current for some rare case. Under those circumstances, the inverter converts the DC (direct current) to AC (alternative current).

## 2.7 Types of Solar Panel Design

A solar system can be implemented in various ways. Thus, it can be varied according to its functional and operational configuration. Generally, it has three basic design-

1. Grid tied
2. Standalone system
3. Hybrid system

### 1. Grid tied PV system

In grid tied system a simple solar installation is needed which uses a standard inverter. It does not require any battery storage. This system is perfect for those who already using grid supply or want to use grid power and solar power both. Grid tied PV system design is very simple than other and cost effective as it does not require many components. The main goal of this system is to lower the electricity bill and proper use of solar energy. Here, the PV array operates in parallel with the grid. In day the loads takes power from the PV system. At night and in overcast weather the load energies by using grid power. One disadvantage of this system is that the power and system goes out together as they are parallel connected.

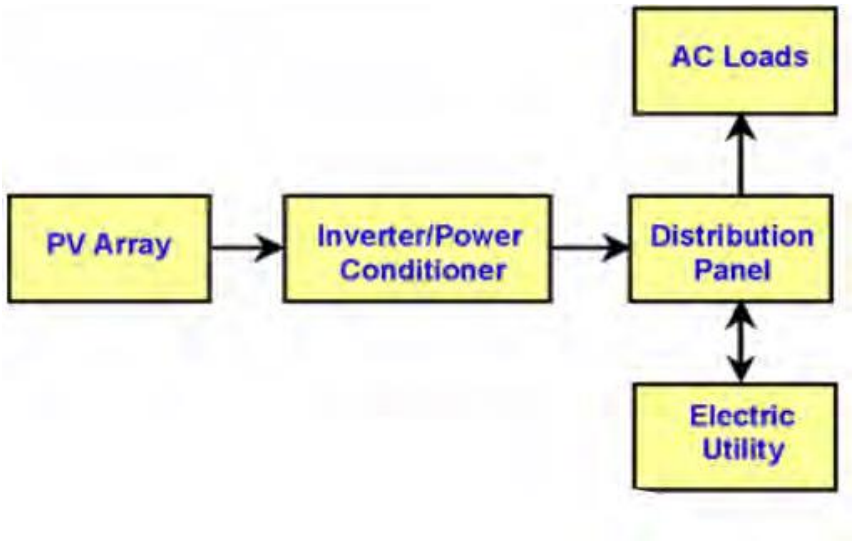



Figure 2.7: Block diagram grid tied solar PV system

## 2. Standalone PV System

Standalone PV system does not require electrical utility grid, it can operate independently without a utility gird. Generally, it takes power from solar module or array. A standalone PV system supply power to the DC or AC load or can supply power to both DC and AC loads. It uses battery to supply power to the loads at night and during rainy day or when there is not enough sun light to produce electrical current. This system also includes a charge controller to protect the battery from damage. In rural areas or in the areas where there is no grid connection, this system plays a vital role to electricity. Common uses of standalone PV system include electrical fan, lights, water-pumping system etc.

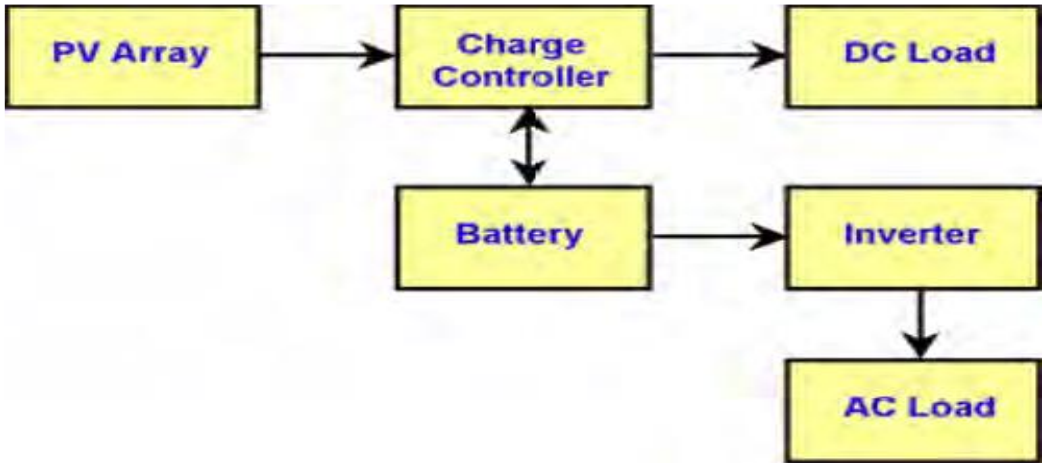



Figure 2.8: Block diagram of standalone PV system

There is another type of standalone PV system where a DC load can directly be connected with the DC output of a PV module or array. It is known as direct-coupled system and this sort of standalone PV system is the simplest one. In direct coupled system there is no battery to store energy. Hence, the load only work during the daylight when the sun shines.

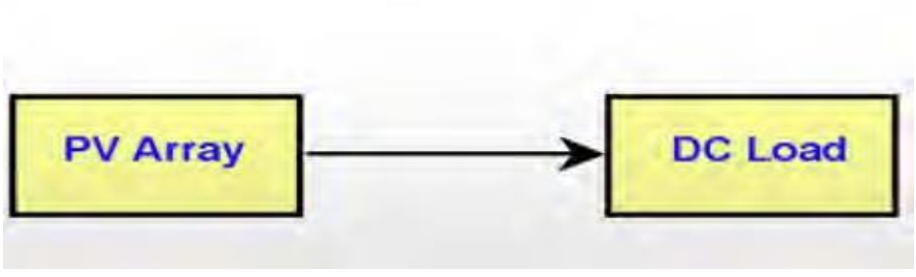



Figure 2.9: Direct-coupled PV system

## 3. Hybrid System:

It is same as grid tie solar PV system but includes batteries to store energy. As this system stores energies, it is also used during blackouts like a UPS (uninterruptible power supply). Generally, the word hybrid refers to the combination of two source. The combination of hybrid system includes solar and battery storage connected to the grid electricity as an auxiliary power source. Wind, engine generator can also be used as an auxiliary power source




Figure 2.10: A typical hybrid solar system

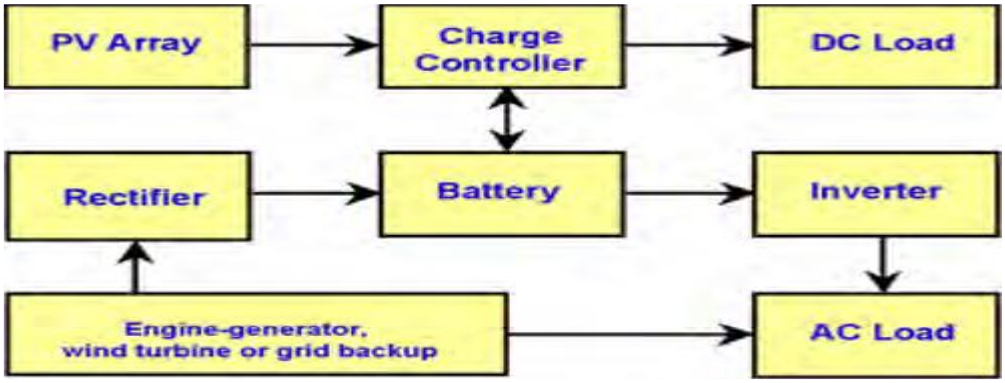



Figure 2.11: Block diagram of a hybrid solar system

## 2.8 Solar Radiation

The energy we get from sun is solar energy. Solar energy is a short wavelength. The ultra-violate rays, radio frequency and visible waves are different form of solar radiation. These radiations are great solar resource. It is a resource, which is easily available, and no cost is needed for it. Every day earth receives a huge amount of solar rays. This ray is the main base to solar panel. Not every sphere of earth gets same amount of solar radiation. It is because-

1. Geographic position
2. Solar rays varying with time
3. Different season caused by annual rotation
4. Changes of weather

The earth, being imperfectly round, has elliptical shape. Therefore, sunrays radiates at different angle. These angles can vary between $0^0$ to $90^0$ [18]. When the sun radiates over the horizon then angle is 00. Again, when the sunshine perpendicularly over the panel then it is 900. Earth's surface gets most of the energy emits from sun as soon as it is in vertical position. In addition, the region where slanted sunrays fall gets less amount of solar energy. It is because slanted rays diffuse and gets scattered. Solar panel is the technology, which converts solar radiation into electrical current. As a result, it is very important to set a suitable location for installing solar PV panel so that maximum sun rays. Not only that, the setting of solar panel also required some necessary measurement such as angle, altitude, mounting etc. The installment of a PV solar panel needs to be positioned by means of two angles known as azimuth angle and zenith angle. Another important parameter for the installment is the tilt angle. These parameters are part of solar geometry

## 2.9 Solar Geometry

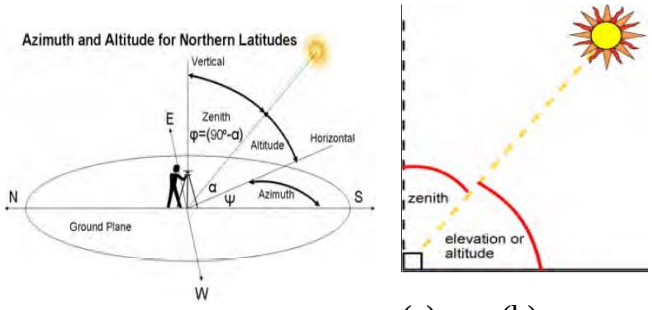
The position of sun has effects on the enactment of solar panel. A brief description of solar geometry is given is below:

**Azimuth Angle**

Azimuth angle can be defined as a horizontal angle. The angular distance of an object horizontally with the location of the object. It is generally measured from north to east by means of horizon. It is denoted with α.

**Zenith Angle**

The zenith angle is the angle which is measured vertically amid with sun. Zenith angle is a 90o angle as it is measured with vertical axi




(a) (b)

Figure 2.12: (a) Picture of azimuth angle along with sun
(b) Difference between zenith angle and elevation angle

**Solar elevation angle**

Elevation angle is also known as altitude angle. It is 00 when the sun rises and 900 when the sun shines in equator [19].

Tilt angle:

The angle, which is measured by using solar panel and horizontal plane, is known as tilt angle. A solar panel is set according to its tilt angle. Tilt angle is very important. Because tilt angle is the angle where the panel can get most of the sunshine. Tilt angles may vary with sides. A south facing building have different tilt angle than a north facing building.

**Air Mass**

Air mass is a body of air having contents of temperature, humidity and pressure. Air masses cover many hundreds or thousands square of miles. Sunrays have to pass through this air mass. Air mass defines what amount sunrays the surface will receive. Air mass has a relation with zenith angle. If the zenith angle increases, air mass increases. It is because the height and path get longer. Nevertheless, it decreases if the elevation angle increases. Because the thickness of the decreases.

Table 2.2: Air mass for some values of solar elevation angle

| Elevation angle along with Sea | Air Mass |
|---|---|
| $90^0$ | 1 |
| $45^0$ | 1.15 |
| $30^0$ | 1.41 |
| $20^0$ | 2 |
| 15 | 2.92 |

# CHAPTER-3

# METHODOLOGY

## 3.1 Methodology

Our project starts with complete observation of solar photovoltaic system. Our system begins with the enumeration of the type and synopses of elements required for installing the system, after that with a general analysis to conclude an idea how much energy the system will be generate.




Figure 3.1: Solar Home System.

**To determine system specification, construction and components we will follow the steps given below:**

1. In this part of the construction, the place where the system will be placed is where the sunlight reaches well. It is very important because the entire value of the system will depend on it. PVsyst software what will help us to calculate the amount of solar radiation we will get on our site.

2. Our initial target was to build a home system that will give enough energy to power two AC LED light and a AC fan

3. Finding the correct place on building roof that can be utilized for the project based on a minimum roof area, roof orientation, slope /pitch.

4. We collected additional information from local dealers. Our information includes, cost, size, weight, etc.

5. Initially, we construction the layout of the system for the selected target load.

### 3.2 Site Selection

In this part of the construction, the location where the system can be built, the availability of sunlight, these issues are well reviewed. Because the entire value of the system will depend on sunlight. Depending on the size of the panel, how much space it will need is decided. The performance of the system is always good for the PV panel in which the sunlight is readily available throughout the year, it cannot be constrained by any obstacle. Considering these factors and visiting the site properly, the solar panel orientation and position is selected.

### 3.2 Calculation of load

Table 4.1: Table for Load

| **Equipment** | **Quantity** | **Rated power (watt)** | **Operating hour** | **Watt-Hour** |
|---|---|---|---|---|
| AC Light | 2 | 5×2=10 | 4 | 10×4=40 |
| AC Fan | 1 | 20×1=20 | 4 | 20×4=80 |
| **Total** | 3 | 30 | 8 | 120 |

### 3.3 Energy Requirement

- The daily energy requirement is calculated based on the usage time of each load. Assuming the lights operate for 4 hours and the fan for 4 hours: Lights: 10W x 4h = 40Wh
- Fan: 20W x 4h = 80Wh
- Total Energy Requirement: 40Wh + 80Wh = 120Wh.

### 3.4 System Sizing

- **Solar Panel : 40W(10W+10W+10W+10W)**
- **Battery: A 12V, 15Ah**
- **Inverter : 150W**
- **Charge Controller: 12V,10A**
- **Wire Gauge: 18AWG**

# CHAPTER-4

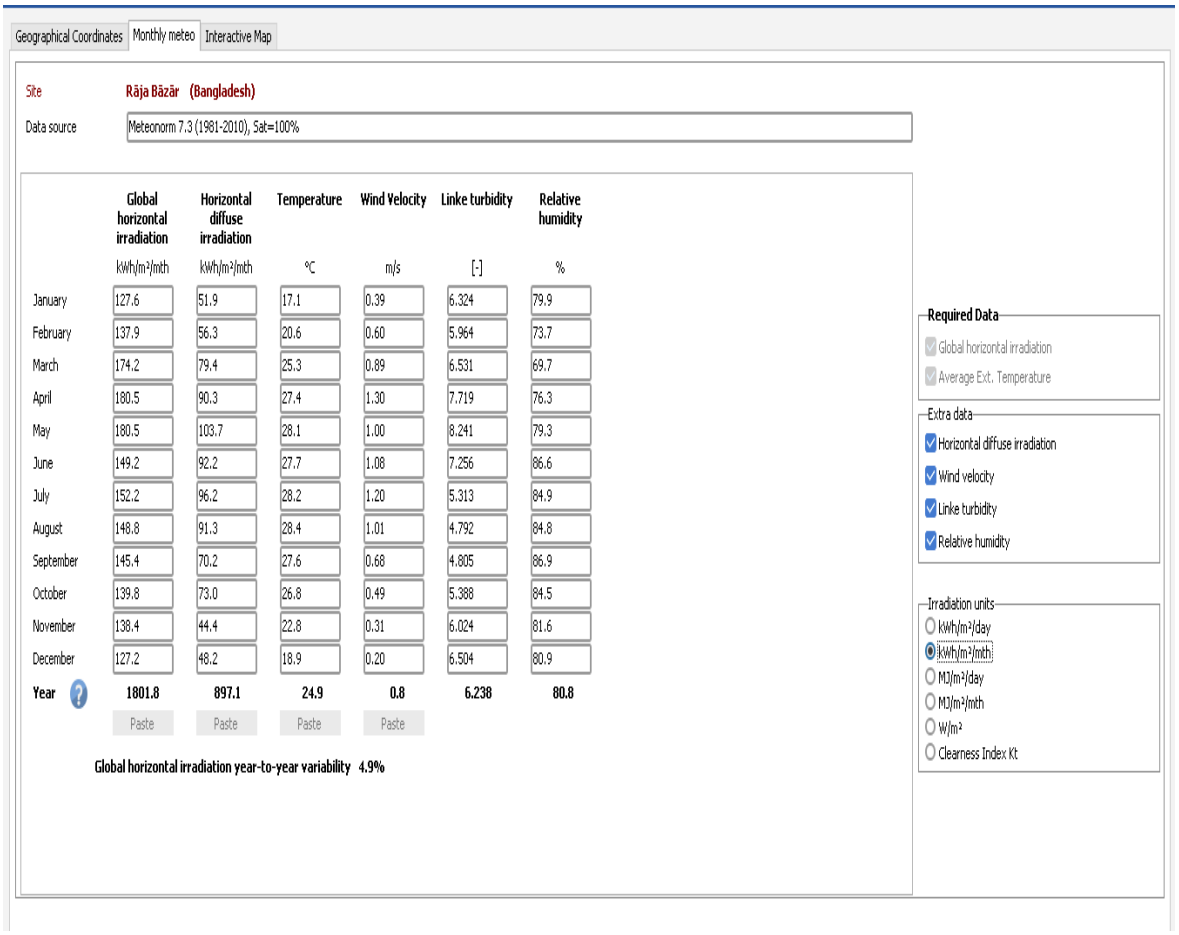
# IMPLEMENTATION

## 4.1 SIMULATION RESULTS

### Acquisition of Site and Meteo Data

The system was implemented on the rooftop of **Sonargoan University,147/l, Green Road,Panthapath, Dhaka**. Tha site latitude and longitude is $23.75^0$North and $90.39^0$East respectively with an altitude of 25 meters.The average annual Horizontal Global Irradiance for the building is 4.94 kWh/$m^2$ per day.

Table 4.1: Meteo and incident energy data for project site obtained from PVSyst



Geographical Coordinates | Monthly meteo | Interactive Map

Site: Rāja Bāzār (Bangladesh)

Data source: Meteonorm 7.3 (1981-2010), Sat=100%

| | Global horizontal irradiation | Horizontal diffuse irradiation | Temperature | Wind Velocity | Linke turbidity | Relative humidity |
|---|---|---|---|---|---|---|
| | kWh/m²/mth | kWh/m²/mth | °C | m/s | [-] | % |
| January | 127.6 | 51.9 | 17.1 | 0.39 | 6.324 | 79.9 |
| February | 137.9 | 56.3 | 20.6 | 0.60 | 5.964 | 73.7 |
| March | 174.2 | 79.4 | 25.3 | 0.89 | 6.531 | 69.7 |
| April | 180.5 | 90.3 | 27.4 | 1.30 | 7.719 | 76.3 |
| May | 180.5 | 103.7 | 28.1 | 1.00 | 8.241 | 79.3 |
| June | 149.2 | 92.2 | 27.7 | 1.08 | 7.256 | 86.6 |
| July | 152.2 | 96.2 | 28.2 | 1.20 | 5.313 | 84.9 |
| August | 148.8 | 91.3 | 28.4 | 1.01 | 4.792 | 84.8 |
| September | 145.4 | 70.2 | 27.6 | 0.68 | 4.805 | 86.9 |
| October | 139.8 | 73.0 | 26.8 | 0.49 | 5.388 | 84.5 |
| November | 138.4 | 44.4 | 22.8 | 0.31 | 6.024 | 81.6 |
| December | 127.2 | 48.2 | 18.9 | 0.20 | 6.504 | 80.9 |
| Year | 1801.8 | 897.1 | 24.9 | 0.8 | 6.238 | 80.8 |
| | Paste | Paste | Paste | Paste | | |

Global horizontal irradiation year-to-year variability 4.9%

Required Data: Global horizontal irradiation; Average Ext. Temperature

Extra data: Horizontal diffuse irradiation; Wind velocity; Linke turbidity; Relative humidity

Irradiation units: kWh/m²/day; kWh/m²/mth; MJ/m²/day; MJ/m²/mth; W/m²; Clearness Index Kt

**Orientation and Horizon**

For our site, the best panel tilt angle on a yearly basis was chosen $27^0$ fixed tilt position with an azimuth of $0^0$ as the Transposition Factor is 1.06 (Highest) and Loss by respect to optimum is -0.1% (Lowest) in this setup. Transposition Factor is the ratio of the incident irradiation on the plane, to the horizontal irradiation. This determines how much energy is gained or lose by tilting the panel meaning the highest is better. Whereas, Loss by respect to optimum means how much solar irradiance are not used or lost by a fixed plane orientation, which elaborates lower values, are better. The tilt angle and the azimuth angle are chosen by the optimization data for the selected meteo site as shown below in the snapshot of the software.

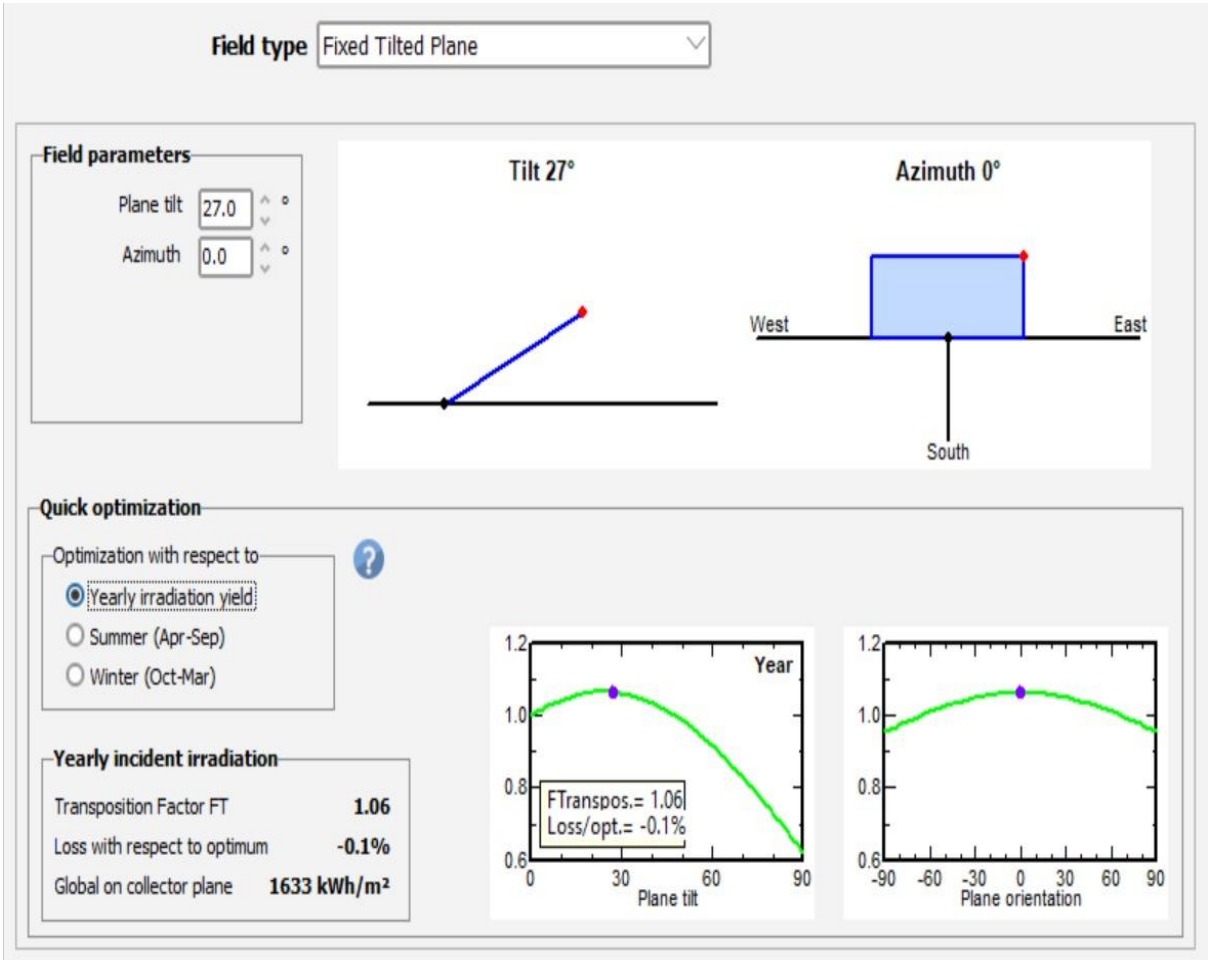



Figure 4.1: Panle orientation and tilt angle[22]

The horizon diagram for the proposed site that was obtaioned in the software is given below:

PVsyst V7.4.8

**Horizon**

**Horizon line at Rāja Bāzār**

| **Geographical Site** | | **Situation** | | | |
|---|---|---|---|---|---|
| **Rāja Bāzār** | | Latitude | 23.75 °N | Average Height | 0.0 ° |
| Bangladesh | | Longitude | 90.39 °E | Diffuse Factor | 1.00 |
| | | Altitude | 25 m | | |
| | | Time zone | UTC+6 | | |

| | |
|---|---|
| Albedo Factor | 1.00 |
| Albedo Fraction | 100 % |

**Horizon profile**

| Azimuth [°] | -120 | -40 | 40 | 120 |
|---|---|---|---|---|
| Height [°] | 0.0 | 0.0 | 0.0 | 0.0 |

**Sun Paths (Height / Azimuth diagram)**

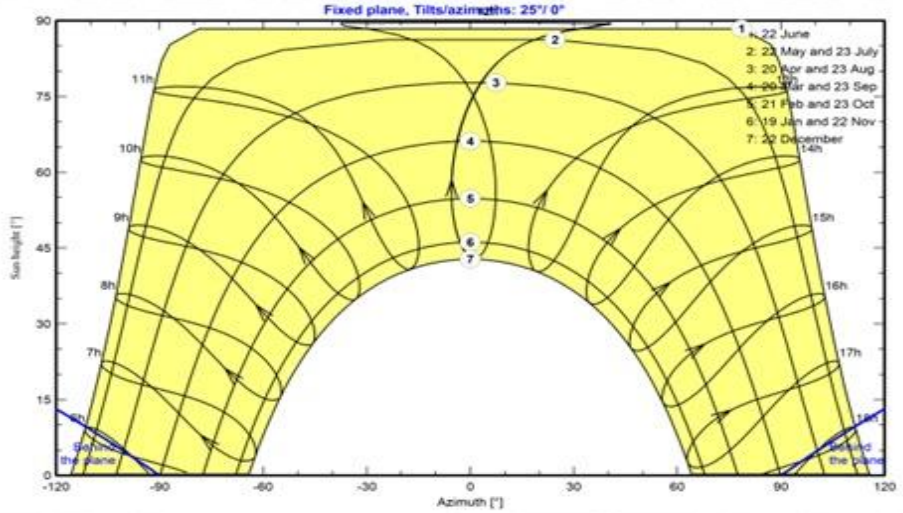





Figure 4.2: Horizon of our site location

**4.2 Solar Panel Setup :** In this project,we use four solar panel in parallel connection Model –SPC-10P(10Wp),. The panel is setup at a tilt angle of $27^0$ and azimuth of $0^0$ according to PVsyst software simulation



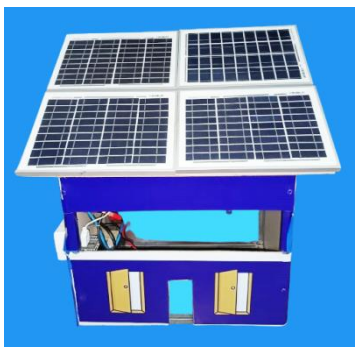
Figure 4.3: Photograph of Solar Panel setup

**4.3 Installation of Charge Controller, Battery, Inverter and load** :To connect a solar power system, First connect the battery to the charge controller by linking the positive and negative terminals securely. Then, connect the solar panel to the charge controller using the solar input terminals, ensuring correct polarity. Next, connect the battery to the inverter, matching the positive and negative terminals. Optionally, small DC loads can be connected to the charge controller's load output. Ensure all connections are tight and use fuses or breakers for safety. Finally, turn on the components in sequence: charge controller, battery, and inverter, and verify the system's operation.



Figure 4.4:Basic system diagram

**Final Project :**







# CHAPTER-5

# RESULT & DISCUSSION

## 5.1 Result

## 5.1 Introduction

We have used Mono crystalline solar panel for our project due to higher efficiency ,long durability and compact size. A typical mono crystalline solar panel have 18-22% efficiency. But there is no efficiency mentioned anywhere on our solar panel. We know that the efficiency of solar panel is measured under Standard Test Condition (STC). So, first of all we have to find out its efficiency under STC condition by given specification.

## 5.2 STC Parameters

1. Irradiance: 1000 watts per square meter ($W/m^2$)

   Represents the sunlight's power at noon on a clear day.

2. Cell Temperature: 25°C (77°F)

   The temperature of the solar panel cells during the test.

3. Air Mass (AM): 1.5

   Refers to the path length of sunlight through the Earth's atmosphere

   (typical of mid-latitude locations).




Figure 5.1: Photograph 0f 10W solar module

### 5.3 Our module efficiency

our module contains 36 cells

area of each cell = 75mm×20mm

$= 1500mm^2$

36 cells area = 1500×36

$= 54000mm^2$

$= 0.054m^2$

solar irradiance of this effective area $= 1000W/m^2 \times 0.054m^2$

$= 54W$

∴ efficiency 0f our solar module, 54x% = 10W

=18.52% (at STC condition)

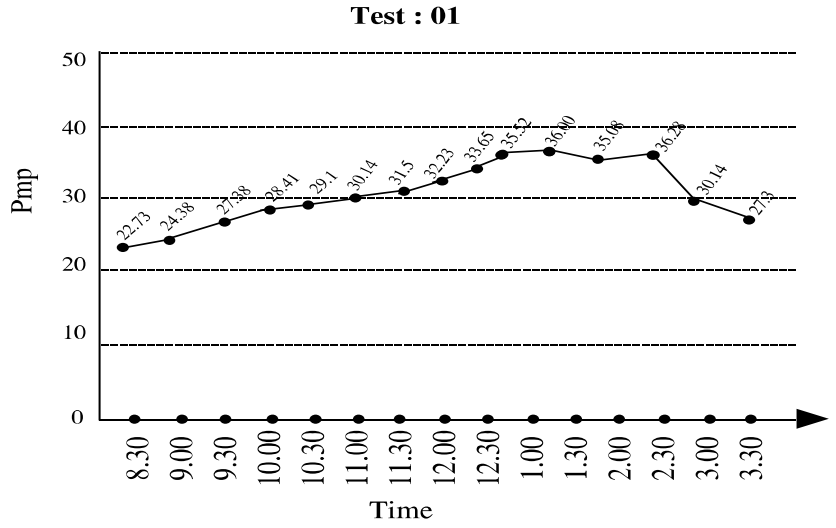
But real world condition is not always match with STC condition. So efficiency is varying with weather condition. We conducted tests on our 40W Array for three consecutive days in varying weather condition and observed the maximum and average efficiency we could achieve. The data and graph for the three days are provided bellow.

## 5.4 Performance Data And Graph

- **1st Test** : 10/05/2025

| Time | Voc | Vmp | Isc | Imp | Pmp |
|---|---|---|---|---|---|
| 8.30 | 16.8 | 14.3 | 1.60 | 1.59 | 22.73 |
| 9.00 | 17.1 | 14.6 | 1.72 | 1.67 | 24.38 |
| 9.30 | 17.5 | 14.7 | 1.92 | 1.89 | 27.78 |
| 10.00 | 18.0 | 14.8 | 1.94 | 1.92 | 28.41 |
| 10.30 | 18.6 | 15.0 | 1.98 | 1.94 | 29.1 |
| 11.00 | 19.4 | 15.3 | 2.1 | 1.97 | 30.14 |
| 11.30 | 18.8 | 15.0 | 2.12 | 2.1 | 31.5 |
| 12.00 | 19.6 | 15.8 | 2.19 | 2.04 | 32.23 |
| 12.30 | 18.8 | 15.8 | 2.22 | 2.13 | 33.65 |
| 1.00 | 19.7 | 16.6 | 2.23 | 2.14 | 35.52 |
| 1.30 | 20.2 | 17.5 | 2.27 | 2.06 | 36.05 |
| 2.00 | 19.8 | 17.2 | 2.25 | 2.04 | 35.08 |
| 2.30 | 19.4 | 16.8 | 2.12 | 2.16 | 36.28 |
| 3.00 | 19.9 | 15.7 | 1.92 | 1.92 | 30.14 |
| 3.30 | 17.6 | 15.0 | 1.85 | 1.82 | 27.3 |

Table 1 : Data For Performance Test

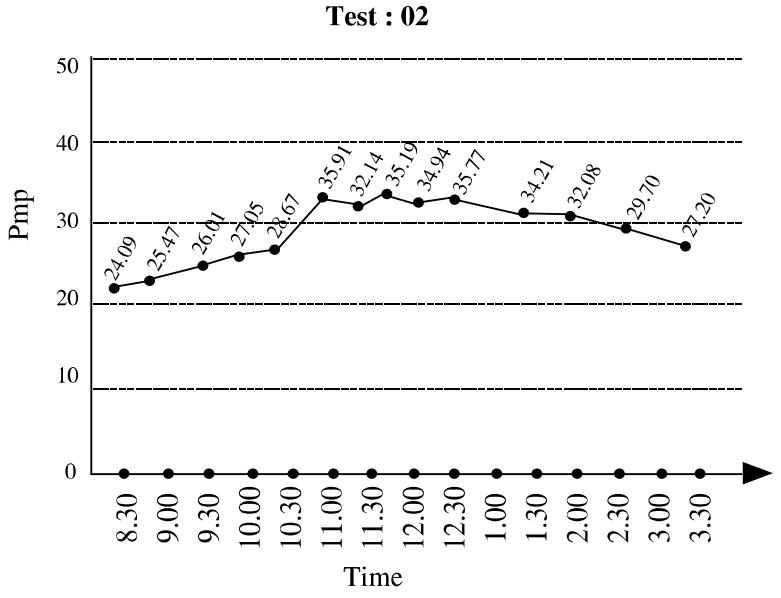



Graph : Variation of Pmp with time

2nd Test : 11/05/2025

| Time | Voc | Vmp | Isc | Imp | Pmp |
|---|---|---|---|---|---|
| 8.30 | 17.5 | 14.6 | 1.70 | 1.65 | 24.09 |
| 9.00 | 17.9 | 14.9 | 1.77 | 1.71 | 25.47 |
| 9.30 | 18.0 | 15.0 | 1.83 | 1.74 | 26.1 |
| 10.00 | 18.12 | 15.2 | 1.90 | 1.78 | 27.05 |
| 10.30 | 18.52 | 15.1 | 1.89 | 1.82 | 27.48 |
| 11.00 | 18.92 | 15.5 | 1.93 | 1.85 | 28.67 |
| 11.30 | 19.3 | 18.9 | 1.99 | 1.90 | 35.91 |
| 12.00 | 19.6 | 16.4 | 2.05 | 1.96 | 32.14 |
| 12.30 | 20.0 | 17.0 | 2.14 | 2.07 | 35.19 |
| 1.00 | 19.9 | 17.3 | 2.23 | 2.02 | 34.94 |
| 1.30 | 19.7 | 17.2 | 2.20 | 2.08 | 35.77 |
| 2.00 | 18.2 | 17.0 | 2.15 | 2.03 | 34.1 |
| 2.30 | 18.8 | 16.4 | 2.06 | 2.00 | 32.8 |
| 3.00 | 18.1 | 15.8 | 1.91 | 1.88 | 29.70 |
| 3.30 | 17.7 | 15.2 | 1.83 | 1.79 | 27.20 |

Table 2 : Data For Performance Test

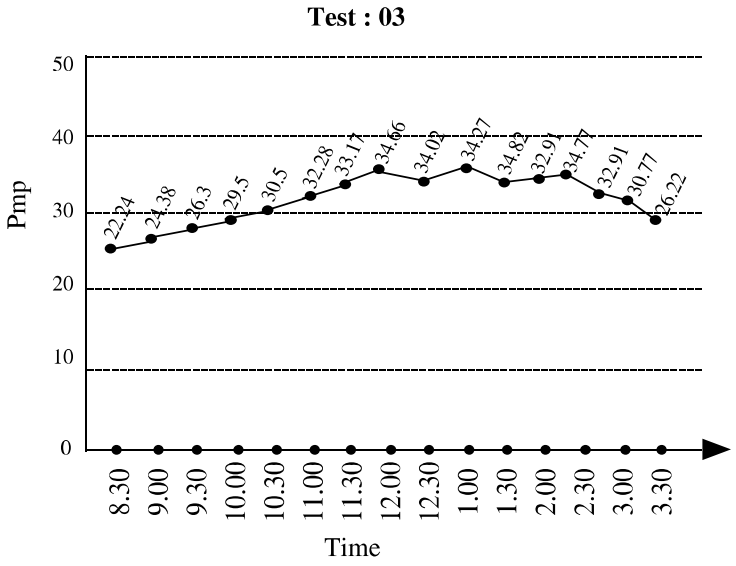



Graph : Variation of Pmp with time

3rd Test : 12/05/2025

| Time | Voc | Vmp | Isc | Imp | Pmp |
|---|---|---|---|---|---|
| 8.30 | 16.3 | 13.9 | 1.59 | 1.60 | 22.24 |
| 9.00 | 16.9 | 14.6 | 1.70 | 1.67 | 24.38 |
| 9.30 | 17.2 | 14.8 | 1.91 | 1.78 | 26.34 |
| 10.00 | 17.6 | 15.0 | 2.0 | 1.95 | 29.25 |
| 10.30 | 18.0 | 15.1 | 2.09 | 2.02 | 30.50 |
| 11.00 | 18.3 | 15.3 | 2.16 | 2.11 | 32.28 |
| 11.30 | 18.2 | 15.5 | 2.17 | 2.14 | 33.17 |
| 12.00 | 18.9 | 15.4 | 2.20 | 2.15 | 33.11 |
| 12.30 | 19.3 | 15.9 | 2.22 | 2.18 | 34.66 |
| 1.00 | 19.7 | 16.2 | 2.26 | 2.10 | 34.02 |
| 1.30 | 20.3 | 16.8 | 2.20 | 2.04 | 34.27 |
| 2.00 | 20.2 | 17.5 | 2.13 | 1.99 | 34.82 |
| 2.30 | 19.8 | 17.6 | 2.04 | 1.87 | 32.91 |
| 3.00 | 18.7 | 17.0 | 2.1 | 1.81 | 30.77 |
| 3.30 | 17.9 | 15.8 | 1.90 | 1.66 | 26.22 |

Table 3 : Data For Performance Test




Graph : Variation of Pmp with time

**5.5: Efficiency**

- 1st Test

- Lowest Pmp = 22.73w
- Lowest Efficiency = 58.28%
- Highest Pmp = 36.28w
- Highest Efficiency = 93.02%
- Average Pmp = 29.50w
- Average Efficiency = 75.64%

- 2nd Test

- Lowest Pmp = 24.09w
- Lowest Efficiency = 61.76%
- Highest Pmp = 35.91w
- Highest Efficiency = 92.07%
- Average Pmp = 30w
- Average Efficiency = 76.92%

- 3rd Test

- Lowest Pmp = 22.24w
- Lowest Efficiency = 57.02%
- Highest Pmp = 34.82w
- Highest Efficiency = 89.28%
- Average Pmp = 28.53w
- Average Efficiency = 73.15%

Total average efficiency for consecutive three days = 75.24%

## 5.2 Discussion

A Solar Photovoltaic (PV) Panel System is a renewable energy technology that converts sunlight directly into electricity using photovoltaic cells. The capacity of our solar panel is 40 watts under STC (Standard Test Conditions), but we have never achieved 40 watts because STC conditions are not always present. Due to various environmental effects, efficiency decreases. We conducted tests on our solar panel over three consecutive sunny days and typically achieved around 75% efficiency. Thus, we believe that in our location, a solar panel with 25% higher capacity than the user's requirement should be installed for fixed tilt and azimuth configurations. Otherwise, the system will not function properly.

# CHAPTER-6

# CONCLUSION AND RECOMMANDATION

## 6.1 Conclusion

A PV solar system is a sustainable, renewable energy solution that converts sunlight directly into electricity using solar panels. It offers a clean and environmentally friendly alternative to fossil fuels, significantly reducing greenhouse gas emissions and dependence on non-renewable resources. PV systems can lower electricity bills, provide energy independence, and offer long-term financial benefits with minimal maintenance. As technology advances and costs decrease, solar energy continues to be a viable and increasingly popular choice for both residential and commercial energy needs. The system, optimized using PV syst software, performed with an average efficiency of 75 % during testing.

## 6.2 Application

1. Residential Power Supply
2. Commercial and Industrial Use
3. Utility-Scale Power Generation
4. Agriculture and Water Management
5. Transportation and Mobility
6. Public Infrastructure

Portable and Consumer Electronics

## 6.3 Advantages

1. Renewable Energy Source
2. Environmental Benefits
3. Reduction in Electricity Bills
4. Low Operating and Maintenance Costs
5. Energy Independence

## 6.4 Disadvantages

1. Weather Dependency
2. High Initial Costs
3. Space Requirement
4. Efficiency Depends on Location
5. Maintenance of Efficiency

### 6.5 Future scope

1. The future of solar panel systems for generating electricity and performance testing looks incredibly promising.
2. As technology continues to advance, solar panels will become more efficient, cost-effective, and widely adopted.
3. With innovations such as energy storage solutions, smart grid integration, and building-integrated photovoltaic, solar energy will play a critical role in meeting global energy demands sustainably.
4. Through ongoing research, development, and collaboration, solar power will continue to be an essential component of the transition toward a renewable and resilient energy future.

### 6.6 Recommendations

1. Seasonal Tilt Adjustments: Implementing seasonal adjustments to the tilt angle may further optimize the system's performance throughout the year.
2. Shading Mitigation: Shading from nearby structures should be minimized by careful placement of panels or the use of tracking systems.
3. Advanced Panel Technology: Research into panels with a lower temperature coefficient could further enhance performance in hot climates.
4. Long-Term Monitoring: Further long-term monitoring and analysis of performance across different seasons will provide a more comprehensive understanding of the system's potential.
5. Integration with Energy Storage: Incorporating energy storage systems (e.g., batteries) could ensure a more reliable power supply, especially for off-grid applications.

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# Appendix

```
lude <LiquidCrystal_I2C.h>
#include <SoftwareSerial.h>

LiquidCrystal_I2C lcd(0x27, 16, 2);
SoftwareSerial mySerial(A1, A0);

#define redLed 2
#define greenLed 4
#define Buzzer 12
#define lpg 8
#define fire 7

void setup() {
  lcd.begin();
  lcd.backlight();
  pinMode(redLed, OUTPUT);
  pinMode(greenLed, OUTPUT);
  pinMode(Buzzer, OUTPUT);
  pinMode(lpg, INPUT);
  pinMode(fire, INPUT);
}

void loop() {
  int lpgStatus = digitalRead(lpg);
  int fireStatus = digitalRead(fire);

  if (lpgStatus == HIGH || fireStatus == HIGH) {
    digitalWrite(redLed, HIGH);
    digitalWrite(Buzzer, HIGH);
    lcd.setCursor(0,0);
```

```
    lcd.print("ALERT: Danger!");
  } else {
    digitalWrite(redLed, LOW);
    digitalWrite(Buzzer, LOW);
    digitalWrite(greenLed, HIGH);
    lcd.setCursor(0,0);
    lcd.print("System Normal ");
  }

  delay(1000);
}
```