Residential Electricity Consumption and Load Pattern Analysis

A Project and Thesis submitted in partial fulfillment of the requirements for the Award of Degree of
Bachelor of Science in Electrical and Electronic Engineering

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DECLARATION

We hereby declare that the work presented in this Thesis, is the outcome of the research work performed by us under the supervision of **Md Mahbub-Ud-Jaman**. Lecturer Department of Electrical & Electronic Engineering, Daffodil International University Bangladesh.

We also declare that no part of this thesis and there of has been or is being submitted elsewhere for the award of any degree or Diploma Countersigned.

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ABSTRACT

This study presents energy resources, availability of solar energy for power generation and development of solar energy in Bangladesh. Main aim of this study is to find the growth of solar energy, solar energy development challenges and prospects. Access to power is one of the most important influences influencing a country's socioeconomic maturity. Bangladesh is now suffering from a severe power outage. About 65 percent of people do not have access to electricity, and the bulk of them live in villages. The provided energy was unable to Assemble the market, resulting in load shedding of up to 1500MW. In this case, "Solar Home Systems" technologies might be a good way to tackle the problem by harnessing electricity from the country's free-flowing natural supply, such as sunlight. Solar energy forms and technologies can be learned from this study. Solar Home System installation has risen dramatically over the last 20 years, and its applications are expanding on a daily basis. So the time has come to assess the effects of SHS in our world. This outcome will help us to more successfully tackle our energy crisis. This study represent the conversation of sunlight into electricity and the advantages of solar energy.

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Dedicated to

Our Parents

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CHAPTER 1
Introduction

1.1 Introduction

Load control for electricity is an urgent need for the sector's long-term growth. Only it will help our people and the world more. It is possible for us to harness the sun's electricity. This is a golden chance for developed nations to seize. Solar power is becoming more common in more developed countries, which can gain from lower electricity costs over time It is also beneficial to the environment because it replaces the traditional, and in effect harmful, methods of energy production. There are other renewable energy sources besides solar, but it is especially practical for sunny are as which have limited access to wind and water Solar panels are becoming more effective than ever before as a result of extensive research in this area. Because of the increased rivalry among suppliers, costs may be reduced.

The growing number of initiatives undertaken by numerous organizations and governments further clearly demonstrates the benefits of using solar energy. This energy supply has a wide range of applications. houses and massive power grids to automobiles, demonstrating a mobility that is ideal for the needs of a developing country. Bangladesh's current energy demand is growing day by day for a variety of reasons, including the population, aspirations for a better standard of life, and general economic and industrial growth. Bangladesh's current energy demand is emerging day by day due to a variety of factors such as rising population, aspirations for a better standard of life, and general economic and industrial growth. If consumption continues at its current pace, reversed natural gas and coal will be depleted by the years 2020 to 2030. To minimize reliance on imported fuel and the demand on natural gas, the current power generation system must be diversified while remaining effective. Indigenous energy resources must be investigated and established at this period. It should be noted that environmental concern is now a universal problem, and conventional energy contributes to greenhouse gas emissions. gases with negative health and environment implications In these views, harnessing renewable energy and developing related technology is a critical strategic choice. Communities in Bangladesh's rural and, in particular, remote areas have few opportunities to invest in the national energy supply. As a result, and in the light of environmental conservation, renewable energy may make a significant contribution to the supply of Some of the main challenges that decide the need for technical inventions in solving energy challenges in rural areas include: renewable energy to consumers, etc.

1.2 Objective

1. To learn about the advantage of Solar energy.
2. To know about the present situation of solar energy in Bangladesh.
3. To learn about how to calculate total load for a building and finding the load curve by using MATLAB.
4. To make some recommendation about development of solar energy in Bangladesh.
5. To learn about the conversion of sunlight into electricity.

1.3 PROJECTED ELECTRICITY DEMAND

1.3.1 Power System Master Plan, 2005

Energy consumption should preferably be projected in light of the development of particular end-user industries. The prediction is focused on an outstanding historical correlation of energy production. Demand with GDP and three GDP growth projections through 2025 The base case employs GDP numbers with a cumulative annual growth rate of 5.2 percent. The estimated annual rate of the low case GDP figures is 4.5 per cent The worst-case scenario is based on a GOB estimate with an annual average pace of 8.0 percent. These GDP growth rates result in net energy demand growth rates of 7.9 percent in the base case, 6.7 percent in the low case, and 12.0 percent in the high case to 2025. It is in all three of these situations. It is also expected that transmission and delivery losses will begin to decrease. By 2018, they will have dropped to 3.0 percent for transmission. By 2019, distribution losses will be reduced to 10%.

1.3.2 Estimated Electricity Demand (Base Case)

	2005	**2010**	**2015**	**2020**	**2025**
GDP (million Taka)	2634409	3525434	4607601	5880596	7328292
Growth Rate (%)	5.3	6.0	5.5	5.0	4.5
Total GWh	21964	33828	50306	72222	100083
Net Peak Load (MW)	4308	6608	9786	13993	19312
Load Factor	58.2	58.4	58.7	58.9	59.2

Table 1.1: Estimated Electricity Demand

1.3.3 Estimated Electricity Demand (High Case)

	2005	2010	2015	2020	2025
GDP (million Taka)	2664431	3525434	4607601	5880596	7328292
Growth Rate (%)	6.5	6.0	5.5	5.0	4.5
Total GWh	22336	37652	68924	126172	217137
Net Peak Load (MW)	4381	7355	13408	24445	41899
Load Factor	58.2	58.4	58.7	58.9	59.3

Table 1.2: Estimated Electricity Demand (High Case)

1.3.4 Projected Demand for Electricity (Low Case)

	2005	2010	2015	2020	2025
GDP (million Taka)	263409	3362248	4189972	5221468	6352714
Growth Rate (%)	5.3	5.0	4.5	4.5	4.0
Total GWh	21964	31533	43697	60553	80982
Net Peak Load (MW)	4308	6160	8501	11732	15626
Load Factor	58.2	58.4	58.7	58.9	59.2

Table 1.3: Projected Demand for Electricity (Low Case)

Source: Power System Master Plan (PSMP) of Bangladesh, 2005

1.3.5 The Current Government's Prospective Energy Plan

The Planning Commission of the government of Bangladesh has proposed an energy mix to produce 20,000 MW generation by 2021 in its Perspective Plan for the term 2010-2021. Goals of Electricity generation is expected to reach 7,000 MW in 2013 and 8000 MW in 2015. The energy balance for power generation is as follows, according to the Perspective Plan. The Perspective Plan's energy mix Energy production from 2010 to 2025.

Energy Sources	Target Period		
	Current	**2021**	**2030**
Gas	88%	30%	28%
Coal	3.7%	53%	38%
Oil	6%	3%	5%
Hydro	2.7%	1%	4%
Nuclear	0%	10%	19%
Renewable	0%	3%	6%

Table 1.4: Current Government's Prospective Energy Plan

1.4 Energy Definition

The power to do work is the scientific concept of electricity. It can also be described as force that can be transformed into motion or that can lead to resistance being overcome. Kinetic and future energy are the two primary types of energy.

1.5 Renewable Energy

Any energy supply that is naturally regenerated on a limited time scale that is obtained directly from the sun (such as thermal, solar, and geothermal energy) photochemical, and photoelectric), indirectly from the solar (such as wind, hydropower, and photosynthetic energy contained in biomass), or from other normal environmental movements and mechanisms (For example, geothermal and tidal energy). Renewable energy excludes energy supplies derived from fossil fuels, waste products derived from fossil fuels, and waste products derived from inorganic sources.

1.5.1 Types of Renewable Energy

- Biomass
- Geothermal Energy
- Wind Energy
- Photovoltaic (PV) Cells
- Hydropower

1.5.2 Main forms/sources of renewable energy

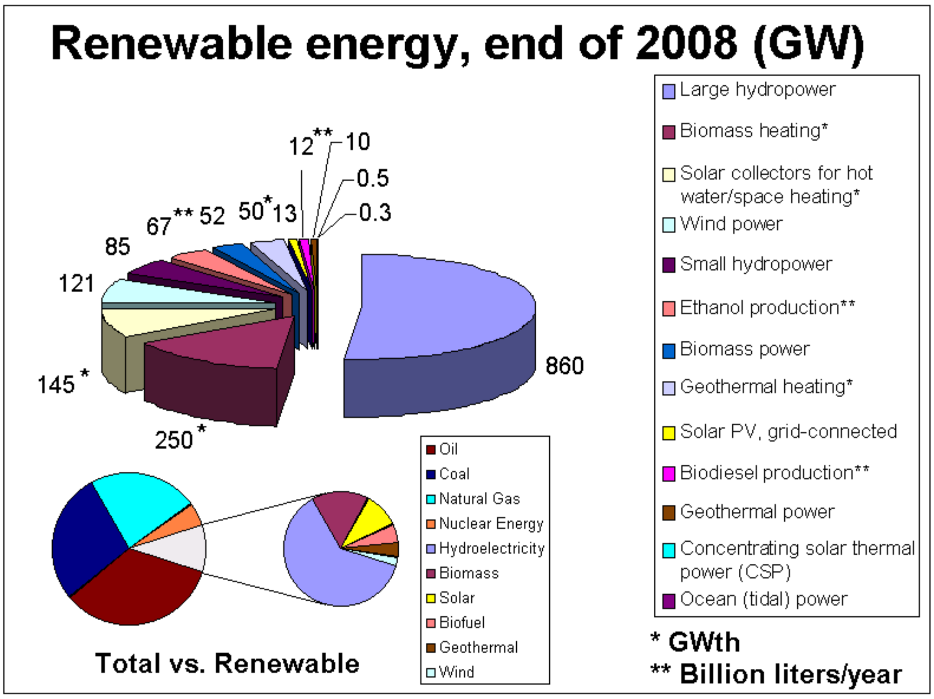


Figure1.1: Source of Renewable energy

1.6 The Benefits of Renewable Energy

- It is strongly renewable since it is produced from inexhaustible sources.
- It produces no greenhouse gases or hazardous waste, leaving the environment cleaner and healthy.
- It is extremely cost efficient since no fuel is needed to run the power plant.
- It is also cost efficient because renewable energy stations need less labour and need less upkeep.
- Since many renewable energy plants are located outside of major cities, they can provide economic benefits to rural communities.

- Renewable energy generators, such as solar power, may be retrofitted into existing structures to make them more eco sustainable and energy efficient.
- Some types of renewable energy, such as geothermal steam plants, need less space than larger traditional power plants and can operate at any time of day or night.
- Hydroelectric power plants can be programmed to deliver
- more control during peak hours and be idle during power lulls utilization
- Biomass energy contributes to a reduction in the volume of garbage shipped to landfills.

In most cases, if a person has a green energy source connected to their home or company, such as solar power, they can sell the surplus power back to the grid, reducing the total number of homes or businesses generated by fossil fuel plants.

1.7 Renewable Energy Technology in Use (RET)

- Renewable energy development project- REB/IDCON.
- Sustainable rural energy- LGED
- Solar & Wind resource assessment project- RERC, DU
- SHS project- Grameen Sakti.
- PREGA- REB/BPDB
- GTZ funded project – REB.
- Biogas pilot project – LGED.
- SHS project- BRAC.
- CHT SHS project- BPDB.
- RET feasibility study- BCSIR.
- SHS project-TMSS.
- Solar home lighting system- Centre for mass education in
- science (CMES)
- Solar home system- Integrated Development Foundation (IDF)
- Wind power generation- BPDB

- Hybrid system- Grameen Sakti, BRAC.
- Wind mill water pumping-LGED.
- Micro hydro power plant- LGED.
- Biogas plants- BCSIR, BRAC.

CHAPTER 2
Literature Reviews

2.1 introduction

Renewable energy is energy derived from renewable supplies that replenish themselves on a human timescale, such as sunshine, wind, rain, oceans, waves, and geothermal heat. Biogas, hydropower, solar, and wind are the current sources of renewable energy. Bangladesh is a developing world with many clean energy choices and prospects. sources of energy for producing electricity There are numerous natural resources in Bangladesh, including coal, gas, and petroleum. Bangladesh's primary energy supply (24 percent) is natural gas, which is expected to be exhausted by 2020. In February 2000, the government released its prospect and strategy assertion, with the aim of providing energy to the whole world by 2020. As of February 2017 (ES in Bangladesh), the potential of electricity generation was 15,351 MW, and this energy field is growing by the day. Coal, gas, diesel, and other fuel-based power generation systems are used to satisfy the combined demand for electricity. This, however, is insufficient. The government and non-governmental organizations are both operating independently and collaboratively to Promote renewable energy technology (RET) throughout the country, as stated in the existing literature. As a result, long-term preparation and systematic knowledge of this diverse area necessitate ongoing evaluation. Furthermore, the sector's growth, as well as its setbacks, should be closely monitored. The current situation of power generation and renewable energy is discussed in this article.

2.2 Present Electricity Generation Situation in Bangladesh

The capacity of power generation has risen from 4,942 MW in 2009 to 13,883 MW in 2015.

Table 1 The table below lists the nation's power sector capacities and delivery.

Item	September, 2016
Power Generation Capacity	15,755MW
Transmission Line	10,436 circuit km
Distribution Lion	341,000 km
Access to Electricity	77%
Per Capita Power Generation	371 kWh
NOS. of consumers	25,26,594
Average System Loss	14%

Table 2.1: Power Sector Details in Bangladesh

A Power System Master Plan was developed in 2010 as part of this policy to improve electricity supply, with the following targets summarized in table 2.

Year	MW
2016	16,000
1021	24,000
2030	40,000

Table 2.2: Power System Master Plan

Total electricity consumption is projected to increase to 132 TWh by 2035 in Bangladesh.
The government has set a target to generate 2000, MW of electrical power from renewable energy by 2021. Currently, the total electricity generation from such sources is 404 MW. The new target of renewable energy would be 10% of the total electricity generation in 2021 and would rise to 20 percent by 2030. Initiatives have been taken to generate 30 MW of electricity from green energy in Dhaka, 60 MW in Rangunia, 3 MW in Sharishabari, 55 MW in Gangachhara, 200 MW in Mymensingh, 20 MW in Cox's Bazar, and 200 MW in Teknaf

from the Sun Edition Solar plant. Furthermore, plans are in the works to install Solar Home Systems (SHSs) in Kaptai, Hatia, Thakurgaon, and Ishwardi and Sirajganj.

2.3 Renewable Energy Prospects in Bangladesh

In recent years, there has been notable success in the clean energy market. Currently, 404 MW is produced from renewable energy sources. Solar home systems are a success story in Bangladesh, and their popularity is growing in rural areas, especially in off-grid areas. Table 3 displays the gains made in the clean energy market so far Bangladesh.

Table 3. Progress in The Renewable Energy Sector

Methods	**MW**
Installation of Solar Home System (3.5 million)	150.00
Installation of Rooftop Photovoltaic (PV) at Government/Semi-Government offices	3.00
Installation of PVs on commercial buildings and shopping centers	1.00
Installation of PVs by consumer during new electricity connections	11.00
Installation of Wind-based power plants	2.00
Installation of Biomass-based power plants	1.00
Installation of Biogas-based power plants	5.00
Solar Irrigation	1.00
Hydro Electric power generation	230.00
Total	**404.00**

Table 2.3: Renewable Energy Prospects in Bangladesh

2.4 Renewable Energy Source in Bangladesh

The future of renewable energy in Bangladesh looks bright, especially in the case of solar energy. However, renewable energy will remain annexed to the current energy genesis through non-renewable traditional means for the foreseeable future. Nonetheless, solar technology can play an important role in serving customers who live outside of the national grid or where grid access is delayed.

2.5 Global Scenario of Renewable Energy

According to the Green Energy Policy Network for the Twenty-First Century, renewable energy contributed 19.2 percent to humanity's global energy demand and 23.7 percent of power supply in 2014 and 2015, respectively [19]. This energy use is split as follows: 8.9 percent is from conventional biomass, 4.2 percent is heat energy, 3.9 percent is hydroelectricity, and 2.2 percent is power from solar panels. Wind, solar, geothermal, and biomass are all examples of renewable energy sources. In 2015, global investments in green energies totaled more than US$ 286 billion, with countries such as China and the United States actively invested in wind, hydro, solar, and biofuels. Globally, there are an estimated 7.7 million jobs associated with clean energy sectors, with solar accounting for the majority of these The biggest solar employer is photovoltaic . Solar PV is a vital technology for reaping the advantages of providing no waste, no moving parts, no pollution, lower transportation costs, no need for water during power generation, and no negative environmental impacts.

Renewable power generation capability increased by the most in a single year in 2016, with an estimated 161 gigawatt (GW) installed. Every year, the planet added more renewable power energy than it added (net) capacity from all fossil fuels combined. Renewables is responsible for an unprecedented 62 percent of net adds to global power generation capacity in 2016.

2.6 Summary

The current scenario of clean energy sources in Bangladesh is depicted very simply and coherently in this article. The compilation of this paper shows that Bangladesh has a significant potential to fulfill its total power demand by adequately leveraging its existing renewable resources. It is feasible if it can make the most use of its existing clean energy options. to remove the country's load-shedding crisis As a consequence, now is the time to look ahead and collaborate with green energy fields to generate power rather than relying solely on traditional methods. Bangladesh's government has also begun efforts to address the country's electricity crisis. Renewable energy sources, such as solar, should be prioritized. energy is a growing clean energy market in Bangladesh that has the ability to meet the bulk of the country's energy and power demand. Other green energy options will also play an important role in meeting our everyday energy needs. Bangladesh would benefit from these opportunities. will produce electricity and will be able to meet future power demands To address Bangladesh's power crisis, the government and private sector should collaborate to place a greater emphasis on renewable energy sources. The paper also has a short overview of the global green energy situation. When the supply of fossil fuels depletes, As fossil fuels becoming less abundant, more focus should be placed on renewable energy sources to satisfy global power demand. This paper is the first step toward creating a truly uninterrupted power supply on a national and global scale by making the best use of available renewable energy sources to harness clean energy for electricity while also protecting the environment.

CHAPTER 3
Sun and Energy

3.1 The Sun

The sun is a celestial body. It is the most massive planet in our solar system and one of the most massive stars of our galaxy. The Sun's supply of energy is at its core, where hydrogen is the molecular transformed to helium. This energy flows from the Sun's center to the surface and is mainly emitted into space as light. The Sun is the most prominent. Our solar system has a notable feature. It is the largest object in the solar system, accounting for about 98 percent of the overall mass. The sun has been there for 4.6 billion years. It is also made up of hydrogen and helium.

The sun is about 110 times larger than the Earth. To fit across the Sun's surface, one hundred and nine Earths will be needed. The interior could contain more than 1.3 million Earths. The photosphere is the Sun's outer visible sheet, and it has a temperature of 6,000°C (11,000°F).

3.2 Temperature on the Surface of the Sun

It has a density that ranges from one millionth to one ten millionth that of water. The photosphere radiates the sun's energy as heat and light. The majority of the light we see comes from its pebbly surface. The photosphere is 340 miles high, with temperatures ranging from 5,500 to 6,000 degrees Celsius. It has dark spots called sunspots, which are the only visible solar activity. The temperature is about 4,000 °C above the photosphere; above that, the temperature increases to 27,800 °C. The region is made up of hot gases.

The chromospheres are a form of violent motion. It has blazing gas fountains. The convection zone is the area under the photosphere. It is 60,000 miles deep and has a temperature that can reach 0 degrees Celsius. 2 million degrees Celsius The radiation zone is situated just under the convection zone. Energy from the center rebounds for years before surfacing, and it is 300,000 miles deep and up to 6.5 million degrees Celsius hot. The sun's center is subjected to 200 billion times the weight of the Earth's surface. It is 60,000 miles thick and has a diameter of temperature that does not exceed 15 million degrees Celsius The temperature is so high that hydrogen is fused into helium.

3.3 The Extraterrestrial Radiation

It is therefore important to understand the spectral spectrum of extraterrestrial radiation, or radiation that will be received in the absence of an atmosphere. At mean earth sun wavelength, the extraterrestrial solar spectrum can be separated into three major zones, which are normally divided into wave bands (1 micron = 1m = 10-6, mm = 10-6 meter).

- Ultraviolet region (l < 0.38 mm). Percentage of solar radiation 7%.
- Visible region (0.38 < l < 0.78 mm) Percentage radiation 47.3%.
- Infrared region (l > 0.78mm) percentage ration 45.7%

Extraterrestrial radiation is provided at all times of the year by

$$Ion = Isc\,\{1 + (360\text{nm}/0.033cos)\}$$

where Isc is the solar constant and Ion is extraterrestrial radiation measured on a plane normal to the radiation on the n‘th day of the year, n=1.

The solar constant is defined as the amount of energy obtained from the sun on a unit area of surface perpendicular to radiation at mean earth sun wavelength. WRC settled on a value of 1367W/m2.

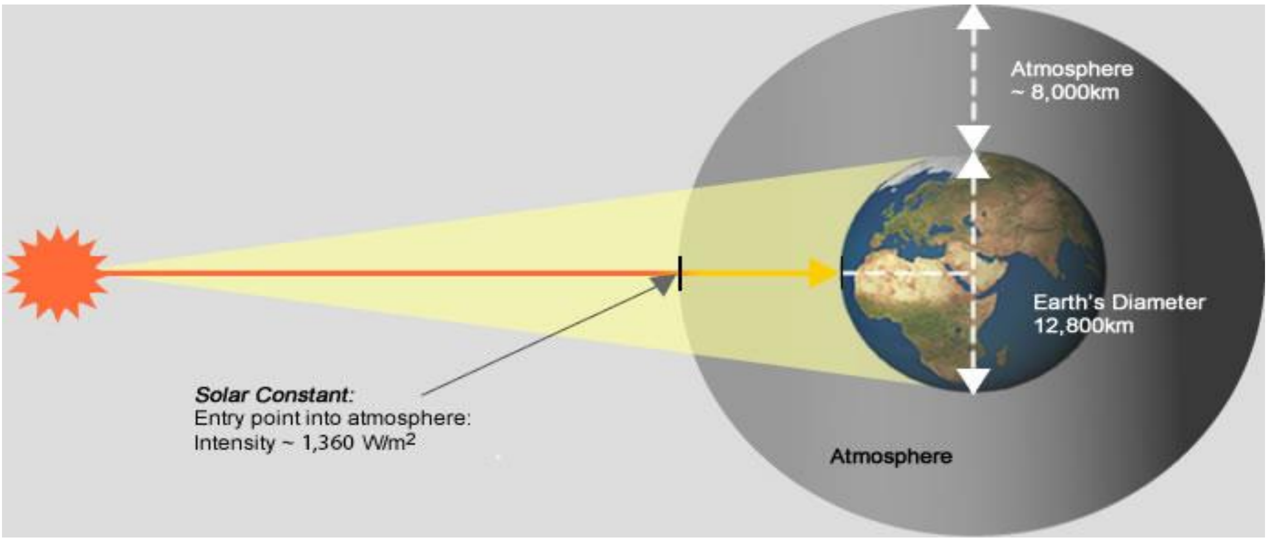


Figure 3.1: Extraterrestrial radiation

3.4 Equation of time

E = 229.2(0.000075+0.001868 B- 0.032077 sin B - 0.014615 cos 2B- 0.04089sin2B)
Where, B = (n-1)360/365 and n is the day of the year.

Monthly averaged daily global radiation (kWh/m2/day)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
4.02	4.64	5.01	5.37	4.83	4.22	4.00	4.13	4.15	4.23	4.04	3.80	4.37

Table 3.1: Equation of time

3.5 Conversion of Sunlight into Electricity

As light strikes a silicon semiconductor, electrons flow, resulting in electricity. This property is used by solar power generation systems to turn sunlight directly into electrical energy.

Solar panels (also known as solar modules E) generate direct current (DC), which is converted by a power inverter into alternating current (AC) — energy that we can use in our homes or offices. derived from a utility power firm Solar power generation systems are classified into two types: grid-connected systems, which are linked to the commercial power infrastructure, and stand-alone systems, which feed electricity to a facility for immediate use or to a battery for storage. Grid-connected networks are found in residences. Schools and hospitals are examples of public buildings, as are offices and shopping malls. Energy produced during the day can be used immediately, and excess electricity can be sold to the utility power provider in some situations. If the machine does not produce enough energy, or produces none at all, Electricity is obtained from the utility power provider (for example, on a cloudy or snowy day, or at night). Power output trends and surplus sale can be monitored in real time on a computer, providing an accurate estimate of daily energy usage. Stand-alone networks are used in a range of uses, such as emergency power supply and remote power where conventional technology is unavailable.

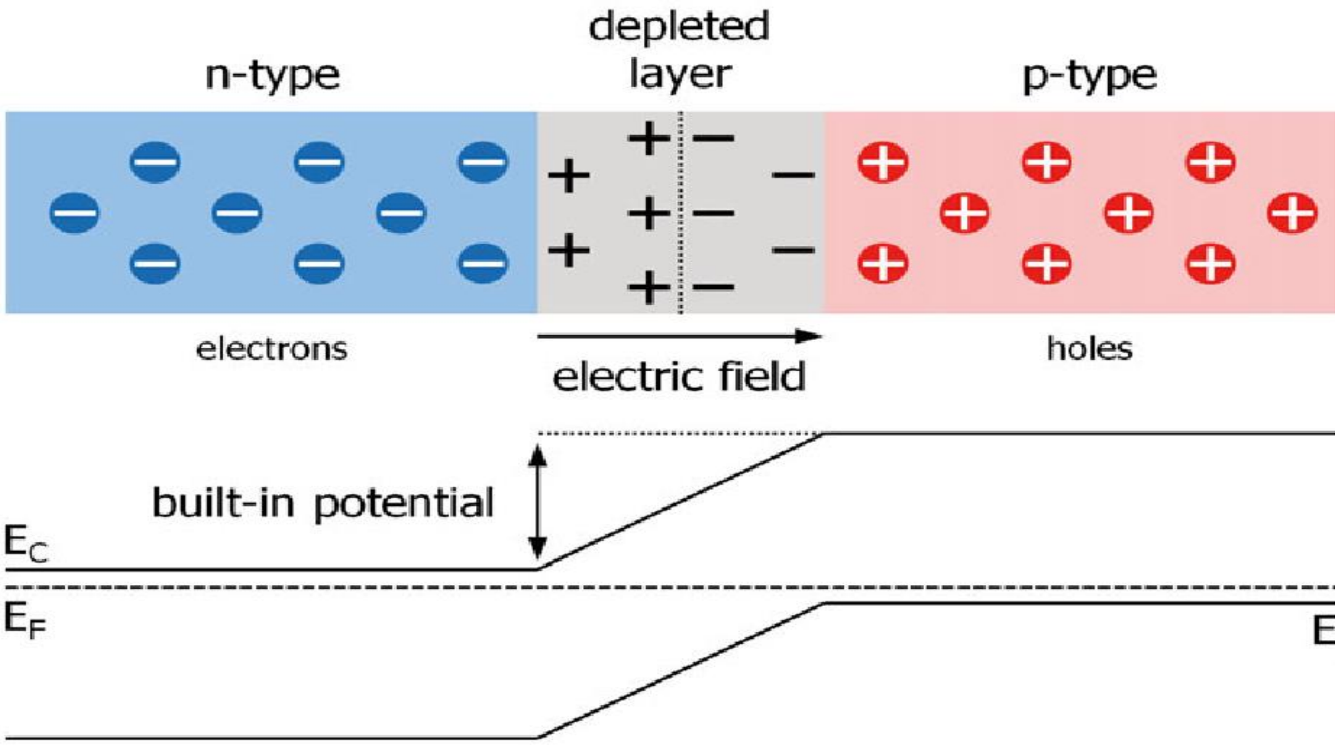


Figure 3.2: Conversion of sunlight into electricity

When sunlight strikes the semiconductor in figure 2-2, an electron leaps up and is drawn to the n-type semiconductor. This causes more negative electrons in the n- type semiconductor and more positive electrons in the p-type, resulting in an electric current flow in a mechanism known as the photovoltaic effect.

3.5.1 Sun -Earth relation-1

Figure 3.3: Sun Earth Relation-1

3.5.2 Sun -Earth relation-2

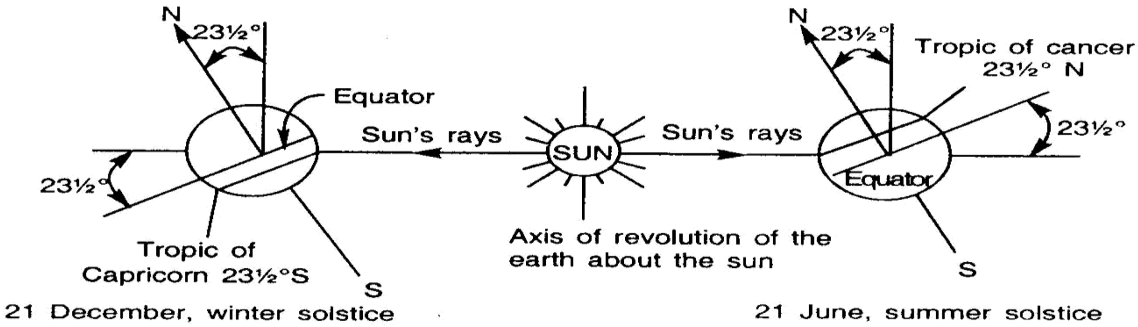


Figure 3.4: Sun Earth Relation-2

3.6 Energy

The energy that enters the Earth takes two forms: heat and light.

Enough solar energy leaves the Earth every hour to satisfy the world's energy demand for an entire year. The sum of solar energy that leaves the Earth per year is 4 x 1018 Joules. 4 x 1018 Joules per Year 365 Days per Year = 1 x 1016 Joules per Day 1016 x 1. Joules/ Year ÷ 365 Days/ Year = 1 x 1016 Joules/ Day. 1 x 1016 Joules/ Day ÷ 24 Hours/ Day = 4 x 1014 Joules/ Hour. The amount of energy consumed annually by the world's population is about 3 x 1014 Joules.

3.7 Forms of Energy

Energy comes in two basic forms:

1. Potential Energy
2. Kinetic Energy

Potential Energy: It is any type of stored energy; it isn‘t shown through movement. Potential energy can be:

(a) Chemical

(b) Nuclear

(c) Gravitational or Mechanical

Kinetic Energy: It is the energy of movements:

(a) Motion

(b) Thermal energy and Temperature

(c) Sound

(d) Electromagnetic Radiation

(e) Electric

3.7.1 Forms of Potential Energy

Chemical

Chemical energy is contained in the chains that hold atoms together. As bonds are broken and new bonds are formed – chemical reactions – this accumulated energy is released and absorbed. Chemical reactions alter the arrangement of atoms. Atoms, like letters of the alphabet, may be rearranged to create new words with somewhat different meanings. to be reorganized chemically to form new compounds with dramatically different properties Each compound has its own chemical energy that is correlated with the bonds between the atoms that make up the compound.

When we exercise, the components of sugar (a compound composed of hydrogen, oxygen, and carbon) are reorganized into water (H2O) and carbon dioxide (CO2). These reactions consume and release energy in equal measure, but the net reaction releases energy.

Nuclear

Nuclear energy is the latent potential of an atom's nucleus, or core. On Earth, most atoms are stable; they maintain their identity as specific elements, such as hydrogen, helium, iron, and carbon, as described in the Periodic Table of Elements. The basic identity of atoms is altered by nuclear reactions. Atoms break apart or come together to form new types of atoms in nuclear reactions, which are referred to as fission and fusion, respectively.

Gravitational

As mass travels away from the core of the Earth or other objects large enough to produce significant gravity, systems may accumulate gravitational energy (the sun, other planets and stars)

For eg, the greater the potential energy gained by lifting an anvil away from the base.

3.7.2 Forms of Kinetic Energy

Motion

Kinetic energy exists in a moving entity. A basketball moved between players demonstrates translational energy in the motion of getting the ball from player A to player B. The kinetic energy of the ball is proportional to its mass and the square of its velocity. A player expends four times the energy to throw the same ball half as far.

When a player shoots a basketball with backspin or topspin, the ball has rotational energy as it spins in the air.The rotational energy of a ball is proportional to how much it revolves, as well as its mass, height, and form. To rotate at the same speed, a hollow ball needs more energy than a solid ball of equal density. esteem Since its mass is further from its core, the hollow ball takes more energy.

Thermal Energy and Temperature

Temperature is specifically related to heat and thermal energy. Specific atoms cannot be seen vibrating, but their kinetic energies can be felt as temperature, which is a measure of the frequency with which atoms vibrate. When there is a temperature differential between the atmosphere and a device within it, thermal energy is exchanged as heat between them. As heat flows from the tea to the atmosphere, a hot cup of tea in a cold room loses some of its thermal energy. If the tea loses heat, the atoms in the tea delay their vibrating, and the tea cools to the same temperature as the room for a few hours. At the same time, the room absorbs the tea's wasted thermal energy, but since the room is small, Even bigger than the tea, the temperature of the room rises so slowly that no one notices.

Sound

Sound waves are generated by the emitted vibration of atoms in bulk — while atoms can also vibrate due to heat — and sound can propagate by the motion of atoms regardless of whether they are liquid, solid, or gaseous. Since there are no atoms to convey vibrations in a vacuum, sound cannot fly.

Sounds are transmitted as waves by solids, liquids, and gases, but the atoms that move along the signal do not travel (unlike the photons in light). The sound wave flows through atoms like crowds in a sports stadium passing along a tube. Different sounds have different pitches, wavelengths (related to pitch), and magnitudes (related to how loud).

Even though radio waves can relay sound information, they are an entirely different type of energy known as electromagnetic.

Electromagnetic Radiation

Radiation and light energy are also examples of electromagnetic energy. This type of kinetic energy can manifest as visible light waves, such as the light from a candle or a light bulb, or as unseen waves, such as radio waves, microwaves, x-rays, and gamma rays. Radiation can fly in a vacuum, whether it comes from a candle or nuclear fission of uranium. Electromagnetic radiation, according to scientists, is broken into tiny energy packets called photons. Each photon has its own frequency, wavelength, and energy, but they all propagate at the same distance, the speed of light, or approximately 1 billion feet per second.

Electric

The kinetic energy of traveling electrons, the negatively charged ions in atoms, is referred to as electric energy. Basics of Electricity is a good place to start if you want to learn more about electricity.

CHAPTER-4
Solar Power System

4.1 Solar System

The Solar System is made up of the Sun and its eight planets, as well as their moons and other non-stellar elements. It was created by the gravitational collapse of a massive molecular cloud 4.6 billion years ago. The Sun holds the vast majority of the system's mass, with Jupiter holding the majority of the remaining mass. Mercury, Venus, Earth, and Mars, also known as the terrestrial planets, are mostly made of rock and metal. The four outer planets, known as gas giants, are much larger than the terrestrial planets. Jupiter and Saturn, the two largest planets, are mostly hydrogen and helium; the two outermost planets, Uranus and Neptune, are mostly hydrogen and helium. Uranus and Neptune are often referred to as "ice giants" because they are often made up of ices with relatively high melting points (compared to hydrogen and helium), such as water, ammonia, and methane. All planets have nearly circular orbits that lie inside the ecliptic plane, which is a nearly flat disk.

A variety of regions in the Solar System are inhabited by life. smaller things Around Mars and Jupiter is the asteroid belt. Jupiter is similar to the terrestrial planets in that it is mostly made up of gas. Objects made of metal and rock. The Kuiper belt and scattered disk, which are related populations of trans-Neptunian objects made mostly of ices, lie outside Neptune's orbit. There are several hundred to over ten thousand artifacts in these populations that are wide enough to have been rounded by gravity. Dwarf planets are the name given to such objects. The asteroid Ceres, as well as the trans-Neptunian objects Pluto, Eris, Haumea, and make, have all been identified as dwarf planets. Multiple small-body regions exist in addition to these two. Comets, centaurs, and interplanetary dust, for example, freely pass between regions. Natural satellites orbit six of the planets, at least three of the dwarf planets, and many of the smaller bodies, which are commonly referred to as "moons" after Earth's Moon. Planetary rings of dust and other small objects encircle each of the outer planets.

4.2 Solar Power System

The conversion of sunlight into electricity is known as solar power. It consists of the Sun, eight planets, their moons, and other non-stellar objects, as well as the Sun's solar system. Concentrated solar power systems concentrate a wide area of sunlight through a narrow beam using lenses or mirrors and tracking systems. Concentrated solar power plants were first installed commercially in the 1980s.

4.2.1 Applications of Solar Power System

The conversion of sunlight into electricity is known as solar power. Sunlight can be converted directly into electricity using photovoltaics (PV) or indirectly using concentrated solar power (CSP), which uses the sun's energy to boil water and then use it to generate electricity. Stirling engine dishes, which use a Stirling cycle engine to power a generator, are an example of other technologies. From a calculator powered by a single solar cell to off-grid homes powered by a photovoltaic array, photovoltaics were and still are used to power small and medium-sized applications. Where grid power is inconvenient, they are an effective and relatively inexpensive source of electrical energy. Connecting is either prohibitively costly or completely unavailable.

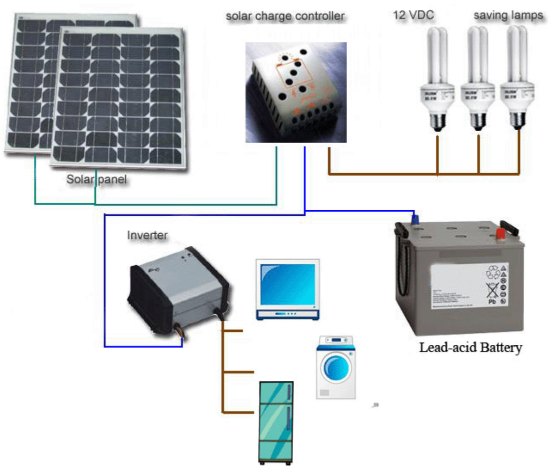


Figure 4.1: Application of solar Power system

4.3 Photovoltaic system

Solar panels transform sunlight into electricity in photovoltaic systems (PV systems). One or more photovoltaic (PV) panels, a DC/AC power converter (also known as an inverter), a monitoring device to keep the solar panels in place, electrical interconnections, and mounting for other components make up a system. The term "photovoltaic" is derived from the Greek word "camera" and "volt," the unit of electromotive energy, which is derived from the last name of Italian physicist Alessandro Volta, the inventor of the battery (electrochemical cell). Solar cells, also known as photovoltaic cells, are made of semiconducting materials that can directly transform sunlight into electricity. When sunlight enters the cells, it displaces and liberates electrons, which then pass to create a direct electrical current (DC). A maximum power point tracker (MPPT), battery system and charger, solar tracker, energy management software, solar concentrators, or other equipment can be included as options. A small PV system can power a single user or a single isolated unit, such as a lamp or a weather station. Large grid-connected PV systems can meet the energy needs of a large number of customers.

Figure 4.2: Solar park or PV farm

4.3.1 Advantage Photovoltaic System

Photovoltaic systems have a number of advantages over traditional energy sources:

- Dependability. Photovoltaic systems have proved their dependability in extreme conditions. PV arrays protect businesses from expensive power outages in cases where uptime is crucial.
- Longevity. After ten years of use, the majority of PV modules on the market today show no signs of deterioration. Future modules are expected to generate power for at least 25 years.
- Low-cost maintenance. It is costly to transport supplies and workers to remote areas for equipment repair or service work. PV systems are usually less expensive than conventionally fueled systems because they only require periodic testing and occasional maintenance.
- There are no fuel costs. There are no costs associated with buying, storing, or transporting fuel because no fuel source is needed.
- There is less noise pollution. Photovoltaic devices are completely silent and move very little.
- Photovoltaic Modularity is a term used to describe the modularity of solar panels. PV systems are less expensive than traditional, bulky systems. A photovoltaic system's usable power can be increased by adding modules one at a time.
- Security. When properly designed and installed, PV systems do not require the use of combustible fuels and are extremely safe.
- Self-reliance. The primary motivation for many residential PV users to adopt the new technology is energy independence from utilities.
- Decentralization of the electrical grid Small-scale decentralized power plants minimize the likelihood of electric grid outages.
- Ability to perform at high altitudes. The use of photovoltaics is beneficial at high altitudes due to increased insulation and optimized power output. A diesel generator, on the other hand, must be de-rated at higher altitudes due to losses in efficiency and power output.

4.4 Photovoltaic Module

Due to the low voltage of a single solar cell (typically about 0.5V), a "laminate" is made by wiring multiple cells in series (see Copper in Photovoltaic Power Systems). A photovoltaic module or solar panel is created by assembling the laminate into a protective weatherproof enclosure. The modules can then be connected to form a photovoltaic array.

4.5 Photovoltaic Array

A photovoltaic array (also known as a solar array) is a series of solar panels that are connected together. Since one module's power is rarely sufficient to meet the needs of a home or company, the modules are connected together to form an array. An inverter converts the DC power produced by the modules into alternating current, which can power lights, motors, and other loads in most PV arrays. In a PV array, the modules are normally connected in series to achieve the desired voltage before being connected in parallel to allow the device to generate more current. In most cases, solar panels are measured in watts under STC (standard test conditions) or PTC (PVUSA test conditions). Panel ratings usually vary from less than 100 watts to more than 400 watts. The array rating is made up of the panel ratings, which are measured in watts, kilowatts, or megawatts.

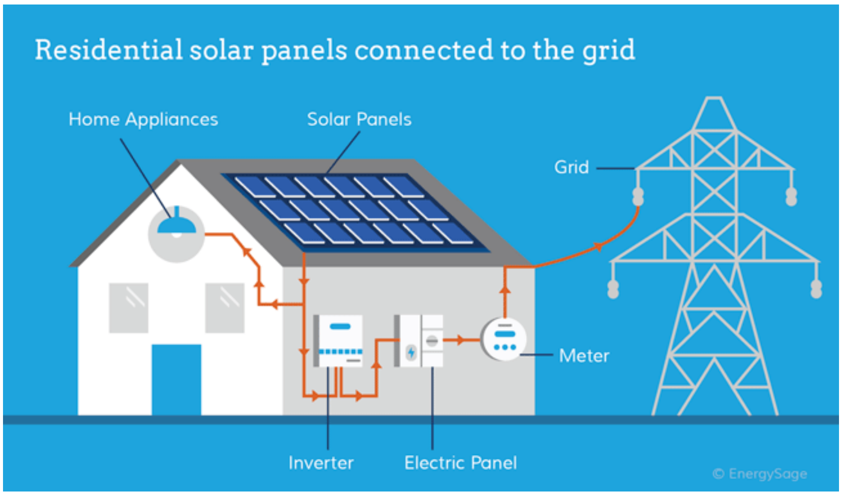


Figure 4.3: Basic Photovoltaic Components Used to Capture Solar Energy

4.6 Module Circuit Design

A PV module's voltage is usually chosen to be compatible with a 12V battery.

Under 25 °C and AM1.5 illumination, a single silicon solar cell has a voltage of just under 0.6V. Most modules have 36 solar cells in series to account for the expected reduction in PV module voltage due to temperature and the fact that a battery may require voltages of 15V or higher to charge.

Under normal test conditions, this results in an open-circuit voltage of about 21V and an operating voltage of about 17 or 18V at full power and operating temperature.

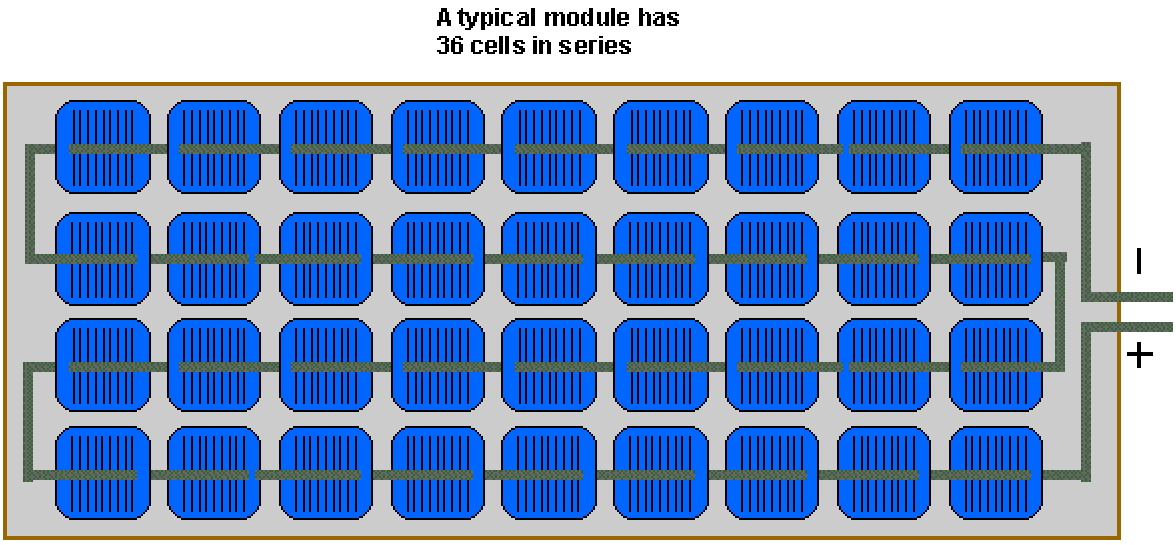


Figure 4.4: In a typical module, 36 cells are connected in series to produce a voltage sufficient to charge a 12V battery.

- While the number of solar cells determines the voltage of the PV module, the current depends primarily on the size of the solar cells as well as their performance.
- Single crystal solar cells provide a total current of about 3.5 A from a module at AM1.5 and under ideal tilt conditions. Since multi crystalline modules have larger individual solar cells but a lower current density, their short-circuit current is typically about 4A.
- If all of the solar cells in a module have the same electrical characteristics and are exposed to the same isolation and temperature, they will all operate at the same current and voltage.
- In this case, the PV module's I-V curve is similar to that of individual cells, with the exception that the voltage and current are higher.

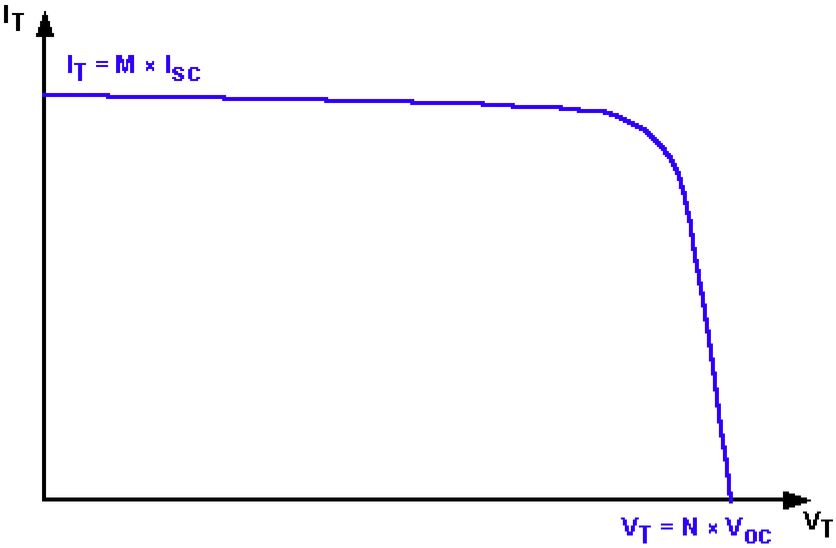


Figure 4.5: The overall IV curve of a set of identical connected solar cells.

4.7 Mismatch of PV cells

- PV cells or modules that are mismatched do not have the same properties or are exposed to different conditions.
- When one solar cell in a module is shaded while the others are not, the power provided by the "healthy" solar cells can be dissipated by the lower performing cell instead of being used to power the load.
- Mismatch may cause localized power dissipation (hot spot), and the resulting local heating can harm the module irreversibly.
- Mismatch in PV modules is often caused by the shading of one area of a module compared to another.
- When the electrical parameters of one solar cell differ greatly from those of the other devices in a PV module, this is known as mismatch. The impact and power loss caused by mismatch are determined by the following factors:

The PV module's operating point

the layout of the circuit; and The parameter (or parameters) that set the solar cells apart from the rest.

4.7.1 Mismatch for Cells Connected in Series

- Series mismatches are the most common form of mismatch encountered since most PV modules are connected in series.

- There are two basic forms of mismatch.
  - mismatch in short-circuit current
  - mismatch in open-circuit voltage

A short-circuit current mismatch is more common, as shading part of the module can easily trigger it. This is the most serious form of mismatch.

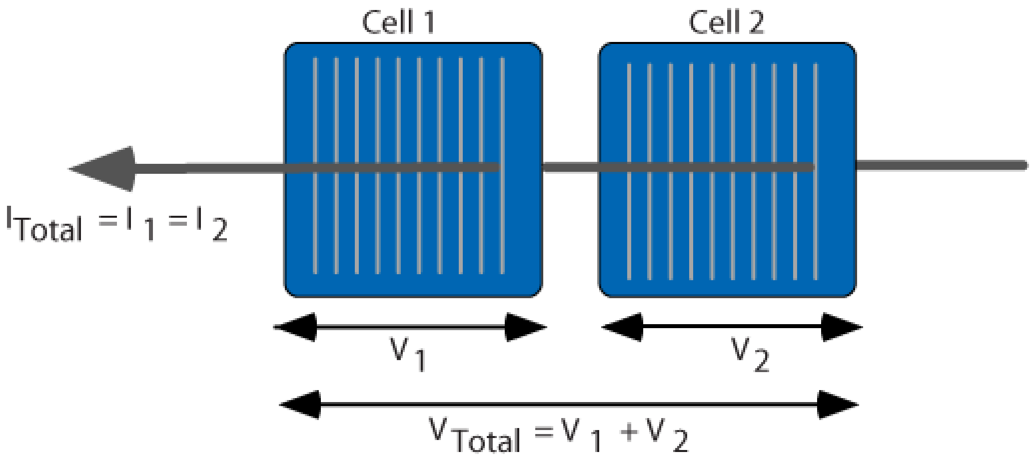


Figure 4.6: Mismatch for Cells Connected in Series

A mismatch in current means that the total current from the configuration is equal to the lowest current since the current must be the same.

4.7.2 Open Circuit Voltage Mismatch for Cells Connected in Series

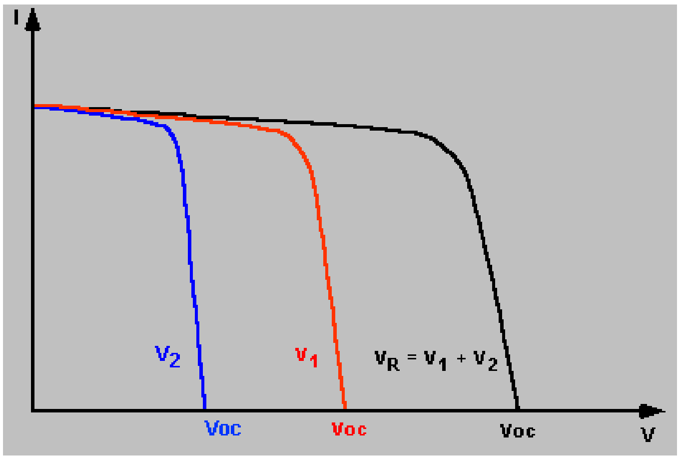


Figure 4.7: Graph of Open Circuit Voltage

Since the weak cell generates less power at the highest power point, the total power is decreased. The current through the two solar cells is the same since they are connected in sequence, and the total voltage is calculated by adding the two voltages at a given current.

4.7.3 Short-Circuit Current Mismatch for Cells Connected in Series

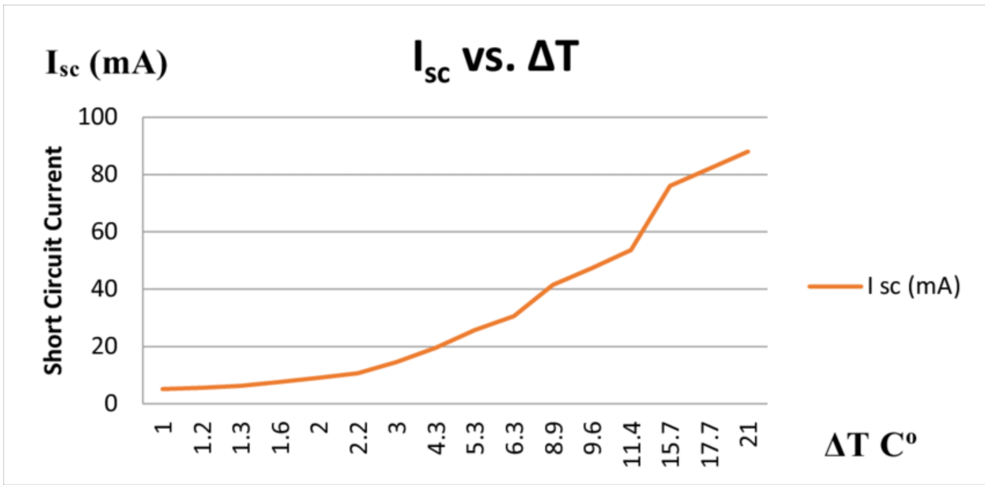


Figure 4.8: Graph of Short Circuit Current

For two cells in sequence, current mismatch can be quite serious and quite popular. The combination's Isc is limited to the lowest cell's Isc. Reduced short-circuit current has a negligible effect at open-circuit voltage. The current from the combination cannot surpass the weak cell's short circuit current.

The extra current-generating capacity of the good cells is not dissipated in each individual cell at low voltages where this condition is likely to occur, but rather in the weak cell. 3.8 Hot-Spot Heating

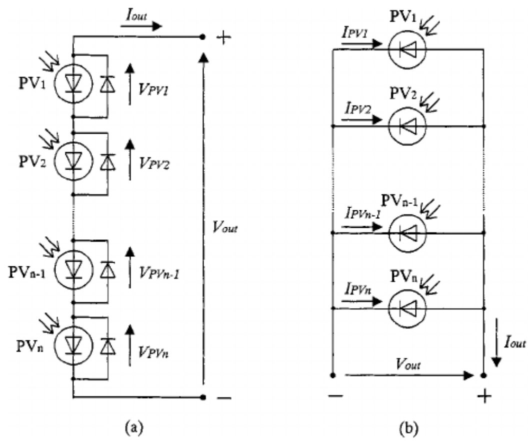


Figure 4.9: Module Connected to Series

When one low current solar cell is present in a string of at least many high short-circuit current solar cells, hotspot heating occurs. the current through the good cells is reduced by one shaded cell in a series, causing the good cells to generate higher voltages, which can also reverse bias the bad cell.

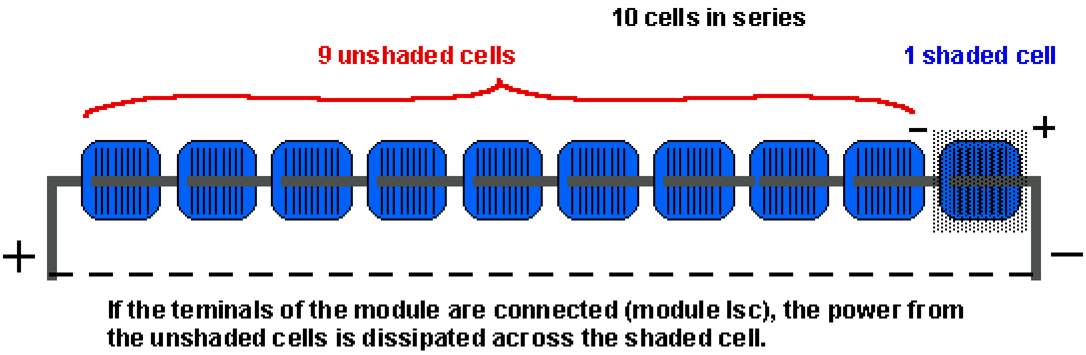


Figure 4.10: Module Connected To Series

When a large number of series linked cells cause a large reverse bias across the shaded cell, a large amount of power is dissipated in the weak cell.

In the weak cell, the entire generating power of all the healthy cells is dissipated. The massive power dissipation in a small area causes localized overheating, or "hotspots," which can result in damaging effects like cell or glass cracking, solder melting, or solar cell degradation.

4.8 Heating in Specific Areas

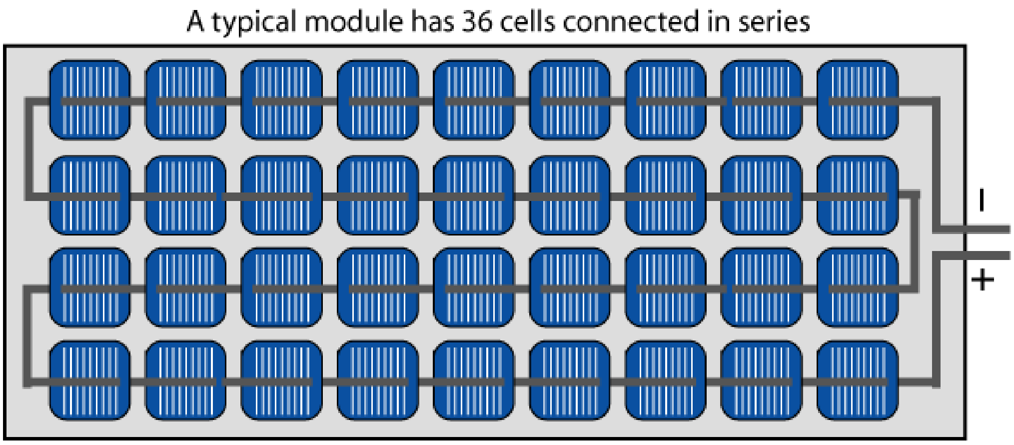


Figure 4.11: Module Connected To Series

- When there is one low current solar cell in a series of at least many high short-circuit current solar cells, hot-spot heating occurs.
- One shaded cell in a string decreases the current flowing through the good cells, allowing the good cells to emit higher voltages, and will frequently reverse bias the poor cell.
- The weak cell effectively dissipates the full generation power of all the healthy cells. The massive power dissipation in a small area causes local overheating, or "hotspots,"

which causes destructive effects such as cell or glass shattering, solder melting, or solar cell degradation.

4.9 Protection of PV Module

4.9.1 Bypass Diodes

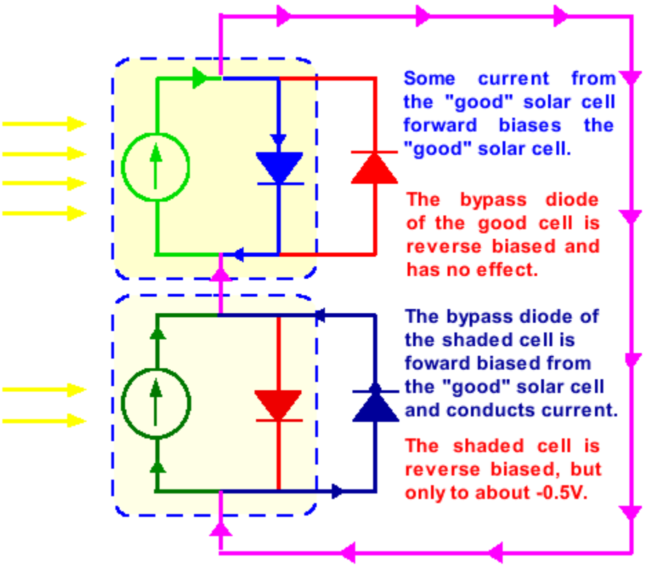


Figure 4.12: Bypass Diodes

The bypass diode conducts when a solar cell is reverse biased due to a short circuit current mismatch between several series connected cells, allowing the current from the good solar cells to flow in the external circuit rather than forward biasing each good cell.

The maximum reverse bias across the bad cell is reduced to about a single diode drop, which limits current and prevents hotspot heating.

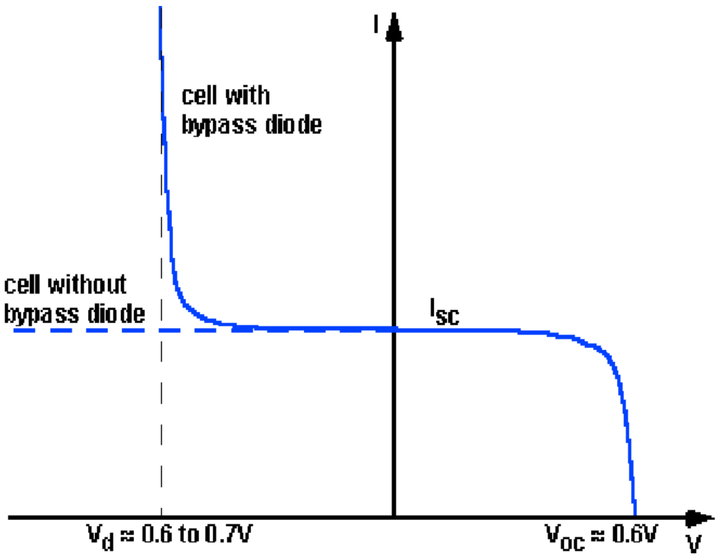


Figure 4.13: IV curve of solar cell with bypass diode

The shaded cell's overall power dissipation is roughly equal to the group's total generating capacity.

For silicon cells, the maximum group size per diode that can be used without causing damage is around 15 cells/bypass diode. Two bypass diodes are used in a typical 36-cell module to ensure that the module is not susceptible to "hot-spot" damage.

4.9.2 Blocking diode

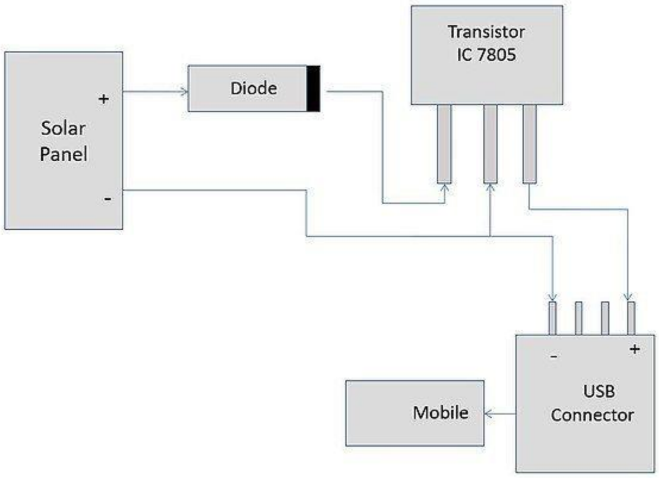


Figure 4.14: Circuit Diagram of Blocking Diode

A blocking diode prevents current flow from the battery to the PV array, preventing the module from charging the battery at night.

Each string to be connected in parallel should have its own blocking diode when using parallel connected modules. This not only decreases the blocking diode's required current carrying capacity, but also prevents current from flowing from one parallel string into a lower-current string, reducing mismatch losses in parallel linked arrays.

4.10 Solar Cell

A solar cell (also known as a photovoltaic cell) is an electrical system that uses the photovoltaic effect to transform light energy directly into electricity. It is a type of photoelectric cell that, when exposed to light, can produce and sustain an electric current without being connected to any external voltage source (its electrical characteristics—e.g. current, voltage, or resistance—variate when light is incident upon it). Though it is also used explicitly to refer to the production of electricity from sunlight, photovoltaic is the field of technology and research related to the practical application of photovoltaic cells in generating electricity from light. And when the light source is not actually sunlight, cells may be classified as photovoltaic (lamplight, artificial light, etc.). In such situations, the cell may be used as a photo detector (for example, infrared detectors) to detect light or other electromagnetic radiation in the visible range or to measure light intensity.

A photovoltaic (PV) cell must have three basic characteristics in order to function:

1. Light absorption that results in electron-hole pairs or exactions.
2. The isolation of opposite-type charge carriers.
3. Separate carriers are extracted and routed to an external circuit

4.10.1 Solar Cell Manufacture

Solar cells are semiconductors, and they use some of the same processing and manufacturing methods as other semiconductors like computer and memory chips. Solar cells, on the other hand, have less stringent criteria for cleanliness and quality control than semiconductor fabrication. The majority of large-scale commercial solar cell factories currently produce polycrystalline or single-crystalline silicon solar cells with screen printing.

Wire-sawing block-cast silicon ingots into very thin (180 to 350 micrometer) slices or wafers produces poly-crystalline silicon wafers. Typically, the wafers are lightly p-type doped. A surface diffusion of n-type do pants is performed on the front side of the wafer to create a solar cell. A few hundred nanometers below the surface, a p–n junction is formed.

Anti-reflection coatings are usually added next to maximize the amount of light coupled into the solar cell. Because of its excellent surface passivation properties, silicon nitride has increasingly replaced titanium dioxide as the anti-reflection coating. At the solar cell's surface, it prevents carrier recombination. Using plasma-enhanced chemical vapor deposition, it is usually applied in a layer several hundred nanometers thick (PECVD). Textured front surfaces on certain solar cells, similar to anti-reflection coatings, help to increase the amount of light coupled into the cell. Normally, such surfaces can only be formed on single-crystal silicon, but methods for forming them on multi crystalline silicon have been established in recent years.

A full-area metal contact is then made on the back surface of the wafer, and a grid-like metal contact consisting of fine "fingers" and larger "bus bars" is screen-printed onto the front surface using silver paste. A metal paste, typically aluminum, is screen-printed on the back touch as well. This touch usually covers the entire back side of the cell, though it may be written in a grid pattern in certain cell designs. The paste is then fired at high temperatures to

create metal electrodes in ohmic contact with the silicon. To improve cell performance, some companies use an additional electroplating step.
The solar cells are interconnected by flat wires or metal ribbons and assembled into modules or "solar panels" after the metal contacts are made. On the front, tempered glass is used, and on the back, a polymer encapsulation is used.

4.10.2 Solar Cell Materials

Different materials have changing degrees of productivity and cost. Materials for viable sun based cells should have properties that are viable with the range of light accessible. A few cells are intended to change sun oriented light frequencies that enter the Earth's surface productively. Some sunlight base cells, then again, are intended to ingest light external the Earth's climate. Light-engrossing materials can be utilized in an assortment of actual settings to profit with different light assimilation and charge partition instruments. Monocrystalline silicon, polycrystalline silicon, undefined silicon, cadmium telluride, and copper indium selenide/sulfide are at present utilized in photovoltaic sun oriented cells. Numerous right now accessible sun based cells are produced using mass materials that are cut into wafers going in thickness from 180 to 240 micrometers thick and afterward treated also to different semiconductors. Such materials are saved on supporting substrates as meager film layers, natural colors, and natural polymers. A third kind is quantum spots, which are made of nanocrystals (electron-restricted nanoparticles). Silicon is likewise the solitary material that has been completely concentrated in both mass and flimsy film applications.

4.10.3 Solar Cell Theory

Three measures are involved in the operation of a solar cell:

1. Sunlight photons strike the sun light based board and are consumed by semiconducting materials like silicon.
2. Negatively charged electrons are catapulted from their molecules, bringing about an electric likely contrast. To drop the potential, flow starts to course through the material, and this power is caught. The electrons in sunlight based cells are just permitted to go one way because of their novel construction.
3. Solar energy is converted into a usable amount of direct current (DC) electricity by a solar cell array.

4.11 Solar Energy from The Sun

The beginning is the sun and its energy. They can be thought of as the driving force behind the weather and environment. The sun provides about 178,000 terawatts of energy to the planet per year. Simply put, this is 15,000 times more energy than the entire planet consumes today. The earth absorbs half of this energy, while the atmosphere reflects the other half back into space. The remaining 20% powers the hydrological cycle, with just 0.6 percent of this volume going into photosynthesis. Photosynthesis is the foundation of all life on Earth and is responsible for the formation of fossil fuel reserves. It is well understood that these reserves are finite, and the decreasing supply of fossil fuel supplies indicates that fossil fuel protection is now in jeopardy. When confronted with this impending issue, a complete switch to renewable energy resources as a source of cheap, safe, and silent energy should become inevitable. This has a lot of potential for reducing global warming and halting climate change's consequences.

4.11.1 Solar Energy Uses

Solar energy uses in various respects. Such as:

- To create energy, photovoltaic sun cells are employed.
- Generate energy utilizing centered sun power.
- To create energy, heat trapped air is used to spin turbines in a solar updraft tower.
- Buildings might be warmed straightforwardly utilizing detached sunlight based structure plan.
- Solar ovens are used to cook food.
- For private boiling water and space warming, sun oriented warm boards heat water or air.
- Solar chimney stacks are utilized to warmth and cool the air.
- Solar power satellites are used to generate electricity in geosynchronous orbit.
- Air conditioning powered by the sun.

4.11.2 Solar Energy Advantages

The sun is a completely free energy source.

- Solar energy does not pollute the environment.
- Solar energy systems have become highly cost efficient thanks to technical advances.
- The majority of systems do not need any maintenance during their lifetime, so you will never have to spend money on them.
- Most devices have a 30- to 40-year lifespan.
- The majority of systems come with a complete warranty that lasts for 20 to 30 years or longer.
- Many new systems, such as Uni-Solar rolls that lie directly on the roof like standard roofing materials, are sleeker than conventional monstrous panel systems.
- Solar energy can be fed back to the utilities in 35 states, obviating the need for a storage facility and drastically lowering or eliminating your electric bills.
- Solar energy systems are now tailored to specific requirements. You can, for example, convert your outdoor lighting to solar power. The solar cells are mounted directly on the lights and are not visible to the naked eye. At the same time, you get rid of all the costs of maintaining your outdoor lighting.

4.11.3 Solar Energy Spectrum

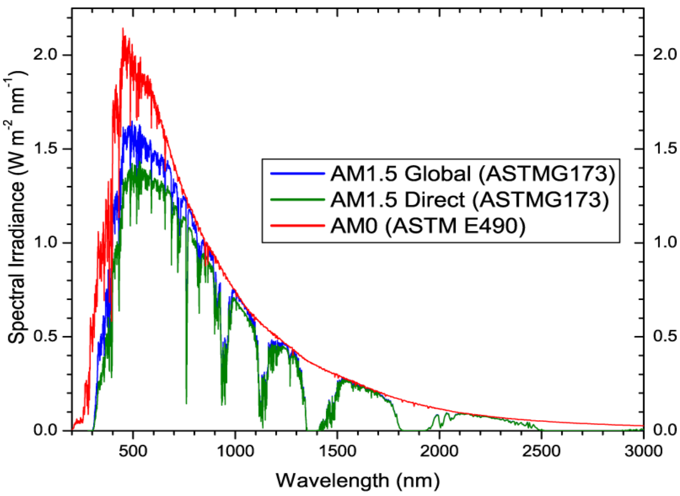


Figure 4.15: Solar Energy Spectrum-1

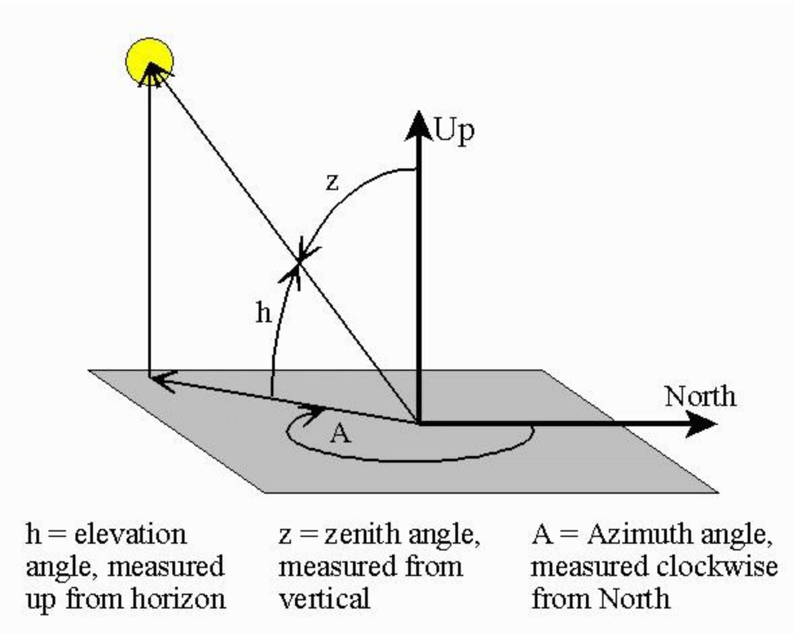


Figure 4.15: Solar Energy Spectrum-1

4.12 Solar Radiation

The sun provides this green energy. Radiant energy is emitted by the sun as a result of nuclear fusion within it. Direct radiation is the radiant energy that is not absorbed or reflected by clouds, ozone, or dust and is perceived as daylight and heat. The sum of this type of energy varies depending on altitude and location. It also depends on the sun's location, which is affected by the season, time of day, and geographical latitude. Global radiation, on the other hand, is still a combination of direct and diffuse sky radiation. It encompasses all solar electromagnetic radiation wavelengths, not only visible light. Just about half of this light is visible (wavelengths between 380 and 789 nm), with the other half consisting of infrared and ultraviolet radiation. Although this part is not visible to the naked eye, it is critical for photovoltaic and thermal solar gain. Light is made up of photons, which are the smallest particles in the universe. A photon is the carrier of all wavelengths of electromagnetic radiation, such as gamma rays, X-rays, ultraviolet light, visible light, infrared light, microwaves, and radio waves. 5 Sunlight can achieve a maximum of 1 kW (kilowatt) per square meter depending on the conditions. The Auckland area, for example, has around 2060 hours of sunshine per year, according to the New Zealand National Institute of Water and Atmospheric Research (NIWA) database. Global radiation is estimated to be around 1530 kWh/a (kilowatt hours per year). Palmerston North (1734 sunshine hours, 1280 kWh/a) and Wellington (2065 sunshine hours per year, 1420 kWh/a) have slightly lower sunshine hours.

CHAPTER-5
Aspects of Solar Energy in Bangladesh

5.1 Crisis of Power in Bangladesh

Electricity has brought the world a more modern and sophisticated way of life. It's difficult to imagine a civilized world without electricity. Power crises are a frequent occurrence in Bangladesh. It has now evolved into a major issue. The reasons for the reduced availability are as follows:

- Some plants are shut down for repairs, reconstruction, and overhaul.
- Some plants' capacity has been reduced as a result of their age.
- There is a gas shortage.

Transmission losses (both technological and non-technical), equipment losses, distribution losses, and corrupt management all contribute to the power crisis. Consumption loss, billing loss, and collections loss are non-technical losses. If the demand for electricity grows, it is necessary to build new power plants to meet the increased demand. However, due to a lack of funds, it is unlikely that new power plants will be built in our country. The old power plants, on the other hand, have reached the end of their useful lives. Occasionally, any of the units or the whole station will fail in this situation. As a result, the national grid goes down and the whole country goes dark.

5.1.1 Data on power crisis in Bangladesh

Year	Installed capacity (MW)	Generation capability (MW)	Demand forecast (MW)	Load shedding (MW)
2003-04	4680	3592	4259	694
2004-05	4685	3782	4375	800
2005-06	4690	3810	4490	1312
2006-07	4693	3849	4550	1212
2007-08	5466	4415	4800	385

Table 5.1: Data on power crisis in Bangladesh

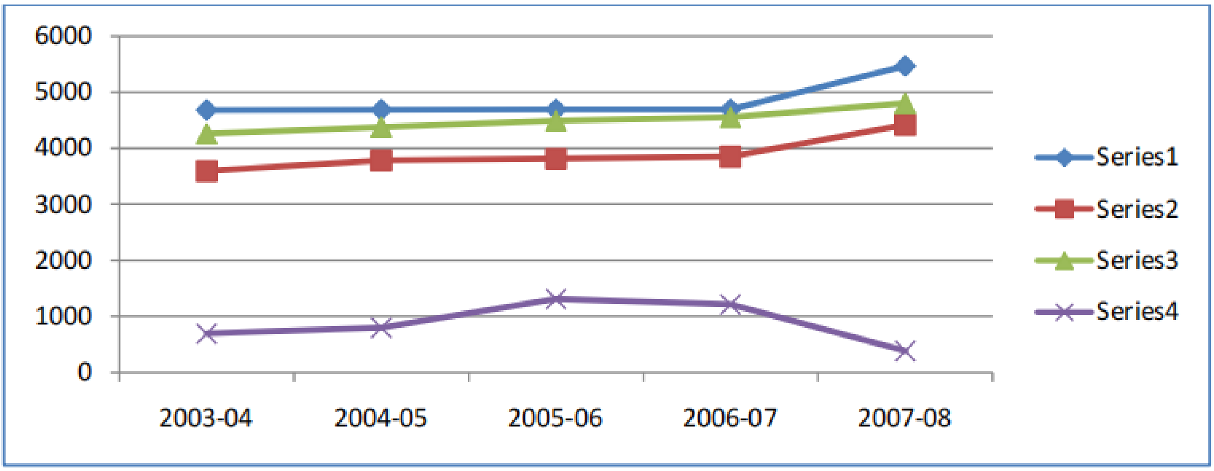


Figure 5.1: Graph of Power Crisis

5.2 Solar Energy in Bangladesh

Bangladesh is a subtropical country with 70% of the year's daylight falling on it. Therefore, sun powered boards can be utilized to produce a lot of power. In Bangladesh, sun powered radiation differs from one season to another. Bangladesh gets a normal of 4-6.5 kWh/m2 of sun based radiation each day. Figure 1 shows the greatest and least sums for November, December, and January. Dhaka College's Environmentally friendly power Exploration Center (RERC) is the solitary source with long haul determined information of Dhaka Sunlight based Energy, which could be an extraordinary hotspot for settling Bangladesh's force emergency. Bangladesh is situated somewhere in the range of 20.30 and 26.38 degree north scope and 88.04 and 92.44 degrees east longitude, making it a brilliant area for sun

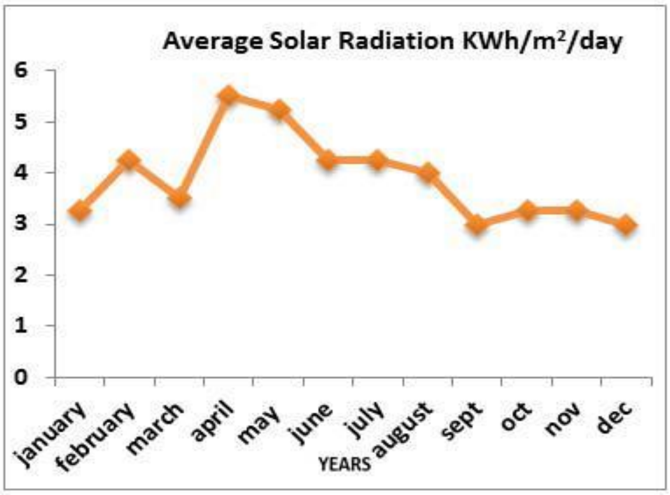


Figure 5.2: Graph of Monthly average solar radiation profile in Bangladesh

The most noteworthy and least force of direct radiation in W/m2 at this area are additionally displayed in the accompanying figure2. Subsequently, Bangladesh is in an optimal position.

As a general rule, the public authority of Bangladesh has as of late taken various measures to urge individuals to utilize sun based energy. Pretty much every recently developed high rise currently remembers sun based boards for expansion to a framework connect to assist with load shedding. Likewise in provincial regions, a few non-legislative associations have been attempting to give minimal expense sun oriented boards to townspeople. Figure 4-2. Shows the assessed establishment of SHSs by division. The dissemination of SHSs is most noteworthy in Dhaka and least in Sylhet, as indicated by the information.

The accompanying condition would now be able to be utilized to quantify sun based force:
Solar power, Psolar = (Area per sq- ft × watts per sq-ft).

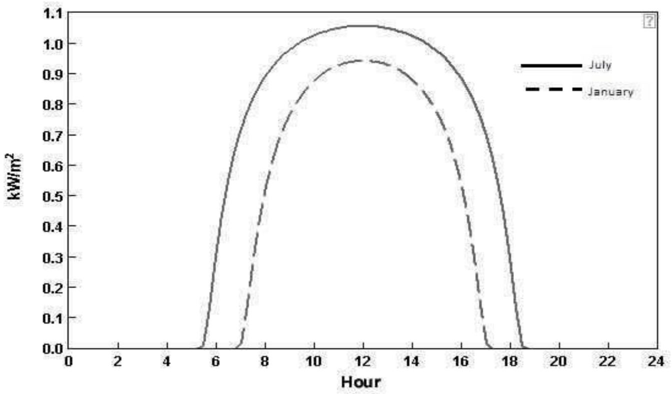


Figure 5.3: The highest and lowest intensity of direct radiation in W/m²

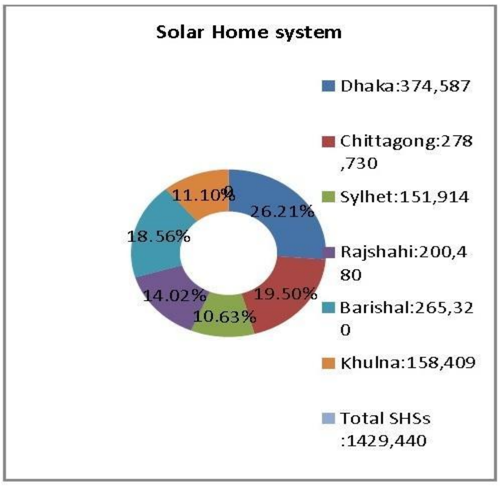


Figure 5.4: Distribution of solar HOME system in six divisions of Bangladesh to January2013

5.3 Solar Energy Project

Solar Home Systems (SHSs) are promoted by Infrastructure Development Company Ltd. (IDCOL) as part of the Rural Electrification and Renewable Energy Development Project (REREDP). In the Chittagong hill tracts, the government has launched a solar energy production initiative. One of the two projects in Rangamati's Juraichhri area has been completed successfully. Approximately 600 homes have been electrified as a result of this program. The second step has begun in the Rangamati district's Thanchi Upozila. This project includes 600 SHSs with 120 WP each, 20 sets of 75 WP solar photovoltaic (PV) street light systems, 2 sets of 1800 WP solar PV submersible water pumps with 50,000 liters per day lifting power, and 6 sets of 360 WP solar PV vaccine refrigerators for health care centers. For the electrification, one set of 10 KW centralized AC market electrification systems is needed. The Rural Electrification Board (REB) has taken on three solar PV projects in various parts of Bangladesh:

(1) The first project, in the Narshingdi Sadar Thana (Karimpur & Nazarpur) by the river Meghna, began in 1994 and ended in 1998. Approximately 1000 people from different categories benefited from the initiative.
(2) Project two focused on the Bay of Bangal (Cox's Bazar) islands of Austragram (Kishoreganj), Shingra (Natore), Kotalipara (Gopalganj), Moheskhali, Kutubdia, and St. Martine. The project's main goal is to provide 6000 PV Solar Home Systems to rural areas that are remote and isolated.
(3) Sirajganj, Natore, Pabna, Barisal, Cox's bazar, and Sunamganj are the project's three main goals. The project's main goal is to construct 16000 SHSs in rural areas, benefiting approximately 80,000 people.

In the case of solar energy, however, IPPs and private organizations such as Brac Bangladesh, Summit Power, Grameen Shakti, Rahim Afroaz, and ENERGYPAC play a key role.

5.4 Development in Solar Energy Program

There are few renewable energy centers in the country, and those that do exist are not well-established in comparison to other countries. As a result, experts aren't coming out of the woodwork. Bangladesh imports solar cells from abroad due to a lack of large funds and skilled manpower, and only makes panels here. As a result, it is expensive and difficult to use, and as a result, consumers are not interested in using solar panels. In Bangladesh, however, the solar energy program has tremendous potential. The government has In the Chittagong hill tracts district, a solar energy development program has already been implemented. This initiative should be expanded to the country's rural areas. To improve the solar energy program, at least ten modern renewable energy research centers must be built, from which skilled experts will come and train others. A public-private partnership program for large funds could be developed. Encourage IPP to continue to develop their software. Champaign should be required to educate the public about the benefits of solar panels, and the government should provide subsidies for solar cell imports.

5.5 Solar Home Systems in Rural Bangladesh

Bangladesh is verged on the east, west, and north by India, and on the south by the Inlet of Bengal. On the south-eastern tip, there is likewise a slight line with Myanmar. Bangladesh covers a space of 147,570 square kilometers. kilometer With a populace of 158,570,535 individuals (as of July 2011), (The World Factbook, 2011). Provincial regions are home to over 75% of the populace (Bangladesh Department of Measurements, 2009a). Bangladesh was positioned 146 out of 177 nations in the Human Improvement Report (2009), with a Human Advancement Record (HDI) score of 0.543. Bangladesh, for instance, is an agricultural nation with no public network augmentation. PV cells are utilized to build sunlight based home frameworks since they are both practical and in fact doable (SHSs). PV innovation is utilized in the SHSs to light country homes and force other essential home machines including lights, radios, and little highly contrasting TVs. A sunlight based board, battery, and charge regulator are the key parts, which can all be worked with negligible preparing (Islam and Infield 2001, pp. 50). Sun powered photovoltaic frameworks are a kind of innovation that changes over daylight (one sort of energy) into power (another sort of energy) without the utilization of moving parts. Figure 2.1 shows that utilizing sun oriented innovation to create power doesn't involve the utilization of petroleum products since daylight is the essential crude material. Daylight is a promptly accessible, savvy, and reliable fuel source. Moreover, with legitimate gear upkeep, a sun oriented home framework can work easily and produce power for quite a long time.

5.6 Overview on Villages and Household Characteristics

Before focusing on energy issues and their socioeconomic consequences, it's important to get a broad picture of the situation and conditions in the villages and households under investigation. In the following paragraphs, some basic details about the socioeconomic background, problems, and aspirations of rural Bangladeshi households will be presented.

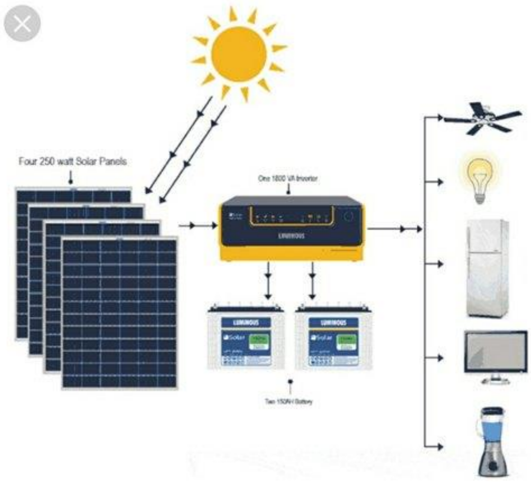


Figure 5.5: Solar Home Systems to Produce Light

5.6.1 Household Income Group

The average monthly household income in Bangladesh was 7100 BDT. As a result, the villages were neither exceedingly wealthy nor impoverished, and thus accurately reflected the economic condition of a typical rural community. Income distribution must be considered in order to get a clearer picture of income reality for rural households.

5.6.2 Households by Occupation Groups

Rural people are active in all phases of agricultural operations, both directly and indirectly, with a focus on post-harvest activities, homestead gardening, food and nutrition issues, and so on. Agriculture accounted for the highest number of respondents (36%) and industry accounted for around 32% of all respondents.

5.7 Owners Decided to Purchase a Solar Home System

We asked owners to list up to three reasons why they purchased the item. The 100-fold increase in light from a kerosene lamp to a SHS is linked to the top two answers, improved light quality and increased ease of studying. Personal use of television was the third most popular answer.

5.8 BRAC Social Enterprise

Background

In December 1998, the BRAC Solar Energy Program for Sustainable Development was launched. An integrated and multipurpose program, its projects spread across the country in a wide variety of settings including households, BRAC and other NGO offices, training centres, schools, health clinics, cyclone shelters, a weather monitoring station, Carpentry, tailoring shops, fabric dyeing and printing shops, leather factories, restaurants, and grocery stores are among the income-generating centers. The project's goal was to improve the overall socio-economic status of rural residents in the project areas by creating new jobs, increasing education hours, and assisting the vulnerable in pursuing income-generating activities. BRAC installed capacity 1.38 Mw with WB/GEF/GTZ/Kfw support.
Standalone Solar Home System to provide electricity in rural off-grid areas, which supported 56,444 beneficiaries as of March 31, 2010.

BRAC Solar Today:

BRAC Sun oriented is one of BRAC's three Green Endeavors, and it has created energy-proficient and savvy sun-based arrangements. BRAC Green Endeavors partakes in naturally supportable drives to guarantee that its cycles, products, and offices appropriately resolve existing ecological issues, as a feature of its continuous commitment to natural qualities in its business tasks. BRAC Green Ventures is an aggregate of three organizations that cooperate to give green answers for the corporate metropolitan market. BRAC Sunlight based Undertaking represents considerable authority in sun-based energy arrangements, while BRAC Nursery has some expertise in finishing and plant rental, and BRAC Reused Paper has practical experience in office writing material. This group of green organizations is cooperating to make earth practical products, and accordingly, they are aiding the social uprising of green drives in both provincial and metropolitan regions. This drive is special in that numerous organizations in the environmentally friendly power area sell existing merchandise in existing business sectors, yet BRAC Green Endeavors has carried out a thorough office arrangement that, if generally received, will rush the way toward greening the professional workplace in our country.

CHAPTER-6
Solar Home System

6.1 Solar Home System Design

- Basic Components:
- Module
- Battery
- Charge Controller
- Load

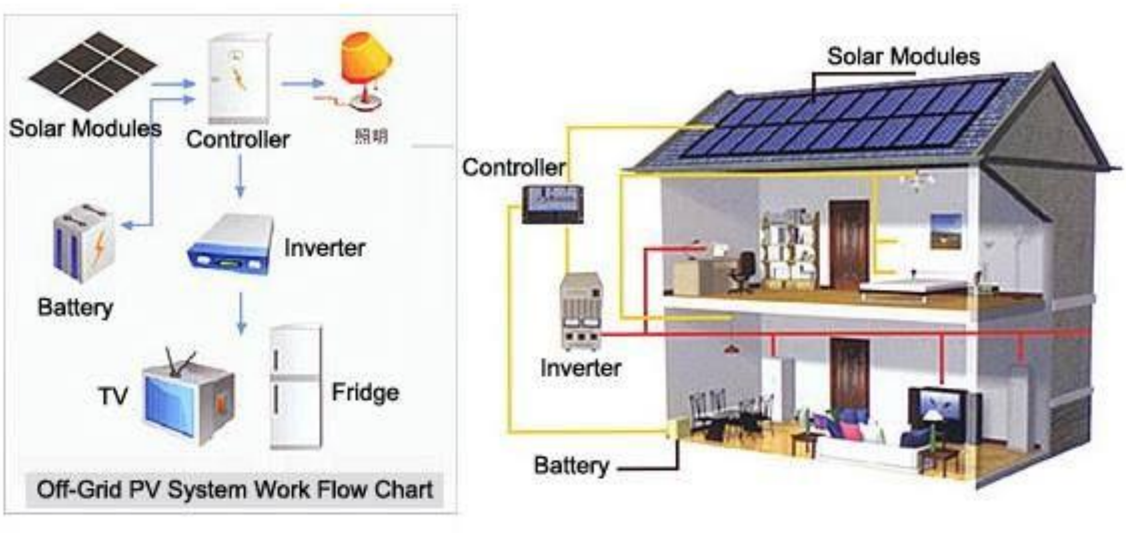
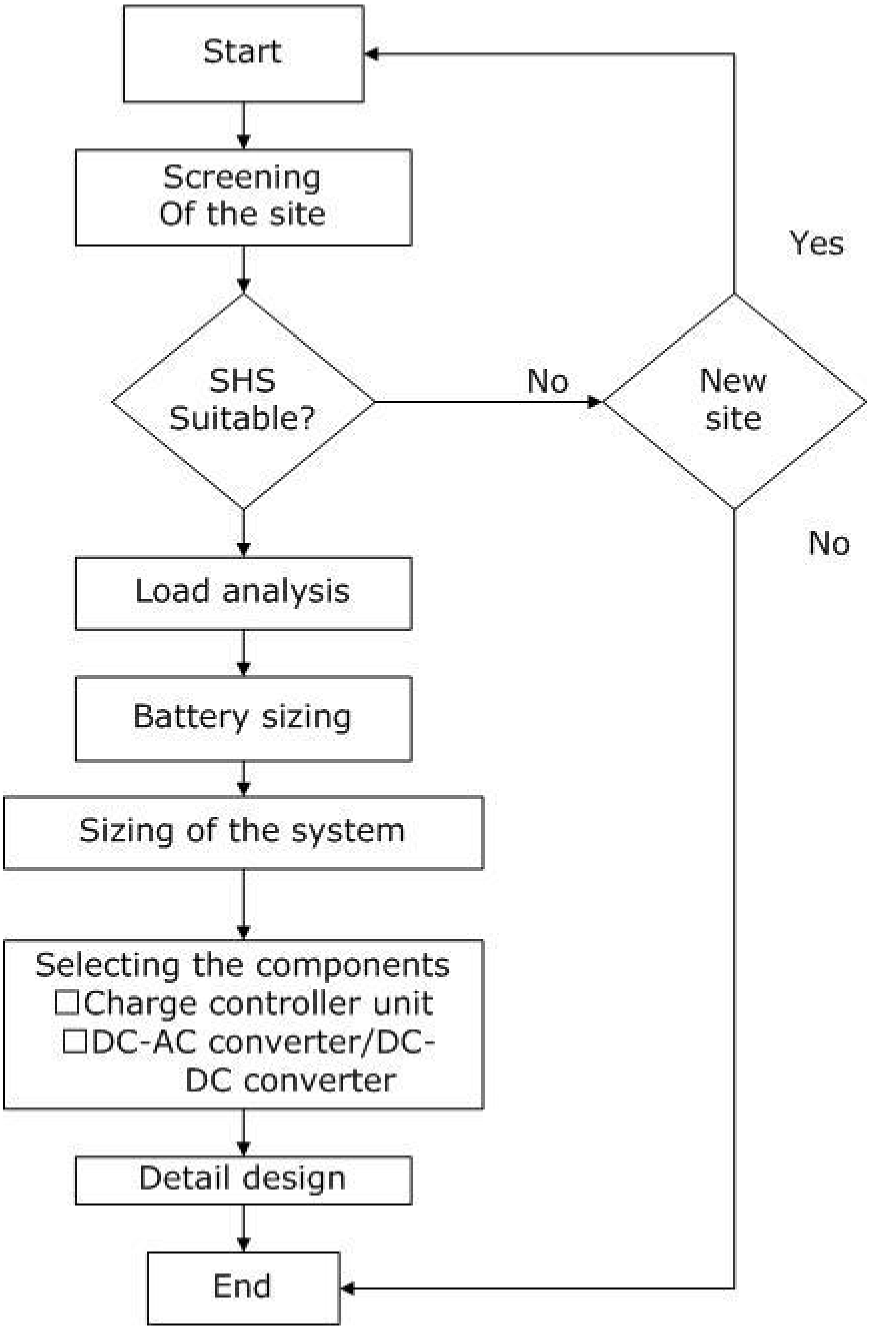


Figure 6.1: Design of Solar Home systems

6.2 Block Diagram of solar home system design process



The above Block Diagram depicts the method of designing a solar home system. The scanning of the site is the first step in the process. This ensures that it must be placed in an area with enough sunshine. The first stage is load calculation, followed by battery scaling. Then there are other components of the device components, such as the charge controller unit and voltage converter (if required), are chosen. The whole device architecture is processed in this manner.

6.3 Circuit Diagram of Solar Home System

Figure 6.2: Circuit of Solar Home system

6.4 Site Screening

In this section of the design, we will first analyze the position of the solar system installation where there is available sunlight. As we all know, not all sites get the same amount of sunlight, but this is a critical component. And the cost of the whole device is dependent on it.

6.5 Load Determination

Bachelor Paradise (DIU)

A Stage of love for non-residential Students

Sr. No	**Name of the Appliance**	**Watts (W)**	**No**	**Total Watts (W*N)**
1	Tube Light	20	10	200(w)
2	Fan	45	45	2025(w)
3	LED	18	45	810 (w)
4	Laptop	65	90	5850(w)
5	Mobile	25	90	2250(w)
6	Air Exhaust	25	10	250(w)
7	Water Filter	25	5	125(w)
9	Refrigerator	150	1	150(w)
10	Water Pump 5hp	746	1	3730(w)
		Total Load = 15410/1000 watt **Total Load = 15.41 Kilowatt**		

Table 6.1: Load Determination

Summer Season

Summer	Tube Light	Fan	LED	Laptop	Mobile	Air Exhaust	Water Filter	Refrigerator	Water Pump 5HP	Hourly Consumptio
5:00AM						700	1200	3600		5500
6:00AM						700	1200	3600		5500
7:00AM					2250	700	1200	3600	7460	15210
8:00AM				5850	2250		1200	3600	7460	20360
9:00AM		2025				700	1200	3600		7525
10:00AM		2025				700	1200	3600		7525
11:00AM		2025				700	1200	3600		7525
12:00AM		2025				700	1200	3600		7525
1:00PM		2025				700	1200	3600		7525
2:00PM		2025				700	1200	3600		7525
3:00PM		2025					1200	3600		6825
4:00PM		2025					1200	3600		6825
5:00PM		2025	810				1200	3600		7635
6:00PM	200	2025	810			700	1200	3600		8535
7:00PM	200	2025	810			700	1200	3600		8535
8:00PM	200	2025	810			700	1200	3600		8535
9:00PM	200	2025	810	5850			1200	3600		13685
10:00PM	200	2025	810	5850			1200	3600		13685
11:00PM	200	2025	810				1200	3600		7835
12:00PM	200	2025	810				1200	3600		7835
1:00PM	200	2025	810				1200	3600		7835
2:00PM	200	2025	810				1200	3600		7835
3:00PM	200	2025				700	1200	3600		7725
4:00PM	200					700	1200	3600		5700
Total	**2200**	**38475**	**8100**	**17550**	**4500**	**9800**	**28800**	**86400**	**14920**	**210745**

Table 6.2: Summer Season

Solution:

The daily energy needed for the given family = 15410/1000 watt
= 15.41 KW

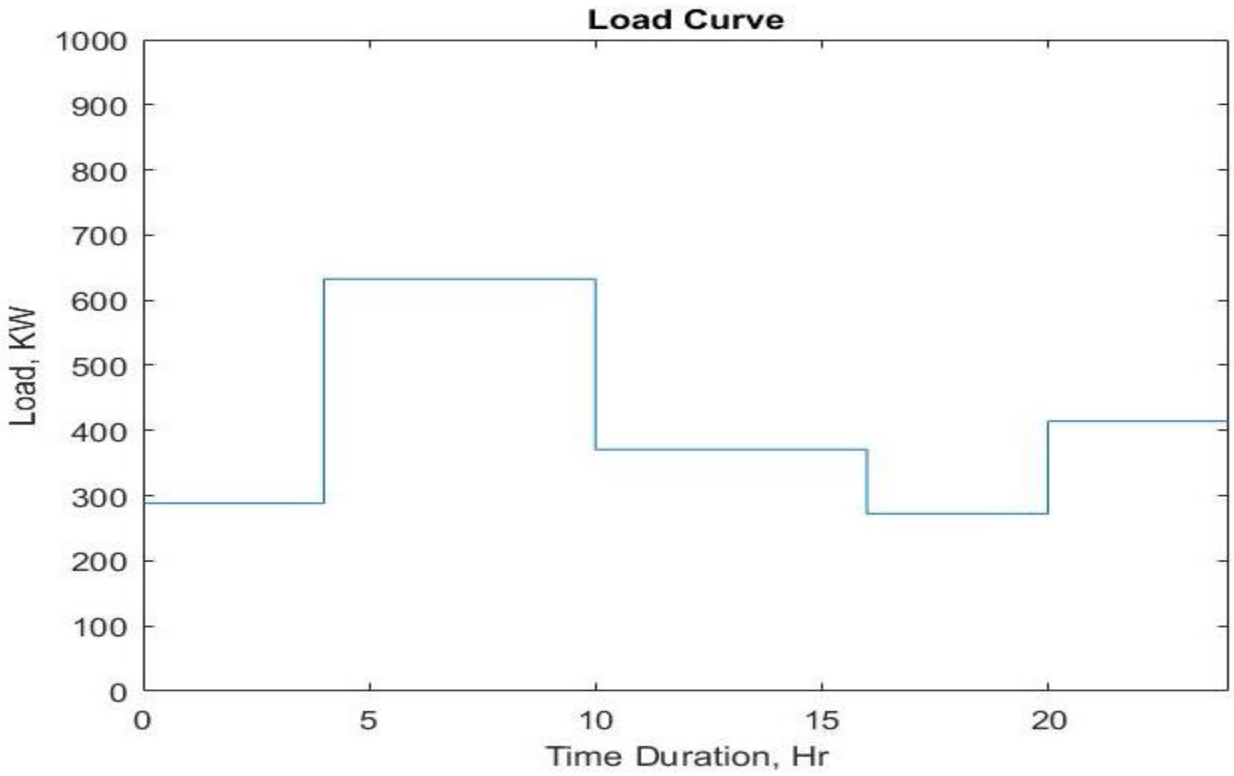


Fig 6.3: Load Curve (Summer)

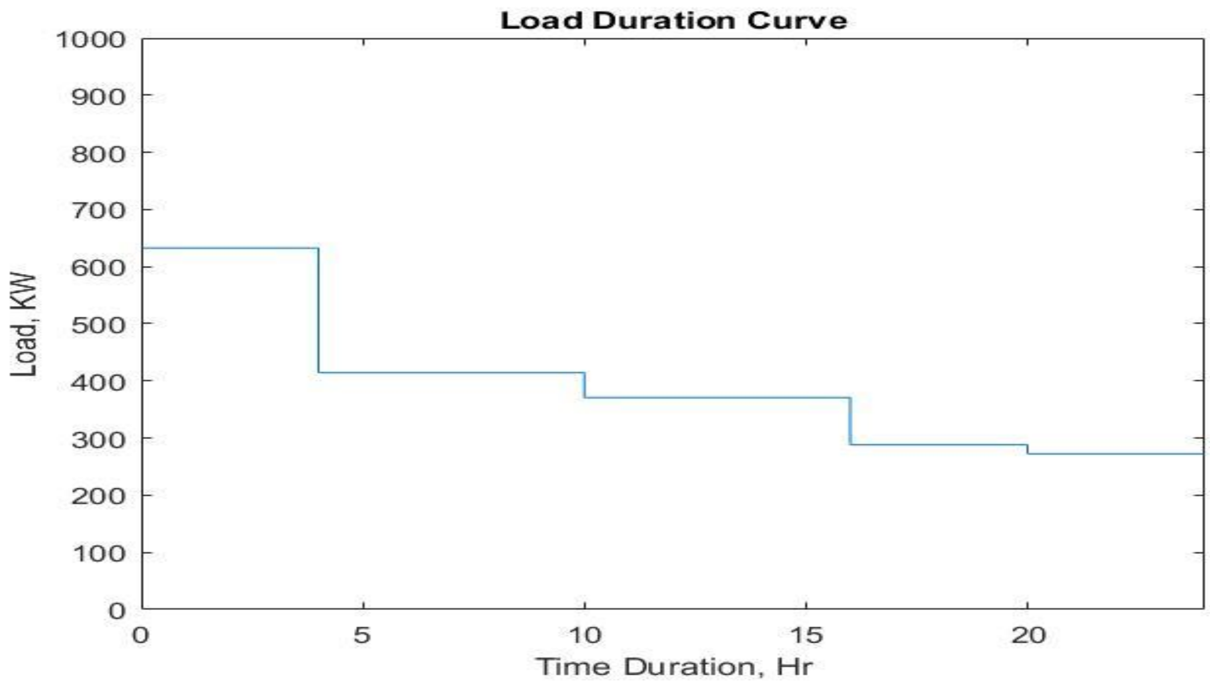


Fig 6.4: Load Curve Duration (Summer)

Winter Season

Winter	Tube Light	LED	Laptop	Mobile	Air Exhaust	Water Filter	Refrigerator	Water Pump 5HP	Hourly Consumption
5:00AM					700	1200	3600		5500
6:00AM					700	1200	3600		5500
7:00AM				2250	700	1200	3600	7460	15210
8:00AM			5850	2250		1200	3600	7460	20360
9:00AM					700	1200	3600		5500
10:00AM					700	1200	3600		5500
11:00AM					700	1200	3600		5500
12:00AM					700	1200	3600		5500
1:00PM					700	1200	3600		5500
2:00PM					700	1200	3600		5500
3:00PM						1200	3600		4800
4:00PM						1200	3600		4800
5:00PM		810				1200	3600		5610
6:00PM	200	810			700	1200	3600		6510
7:00PM	200	810			700	1200	3600		6510
8:00PM	200	810			700	1200	3600		6510
9:00PM	200	810	5850			1200	3600		11660
10:00PM	200	810	5850			1200	3600		11660
11:00PM	200	810				1200	3600		5810
12:00PM	200	810				1200	3600		5810
1:00PM	200	810				1200	3600		5810
2:00PM	200	810				1200	3600		5810
3:00PM	200				700	1200	3600		5700
4:00PM	200				700	1200	3600		5700
Total	**2200**	**8100**	**17550**	**4500**	**9800**	**28800**	**86400**	**14920**	**172270**

Table 6.3: Winter Season

Solution:

The daily energy needed for the given family = 172270/1000 watt
= 17.22 KW

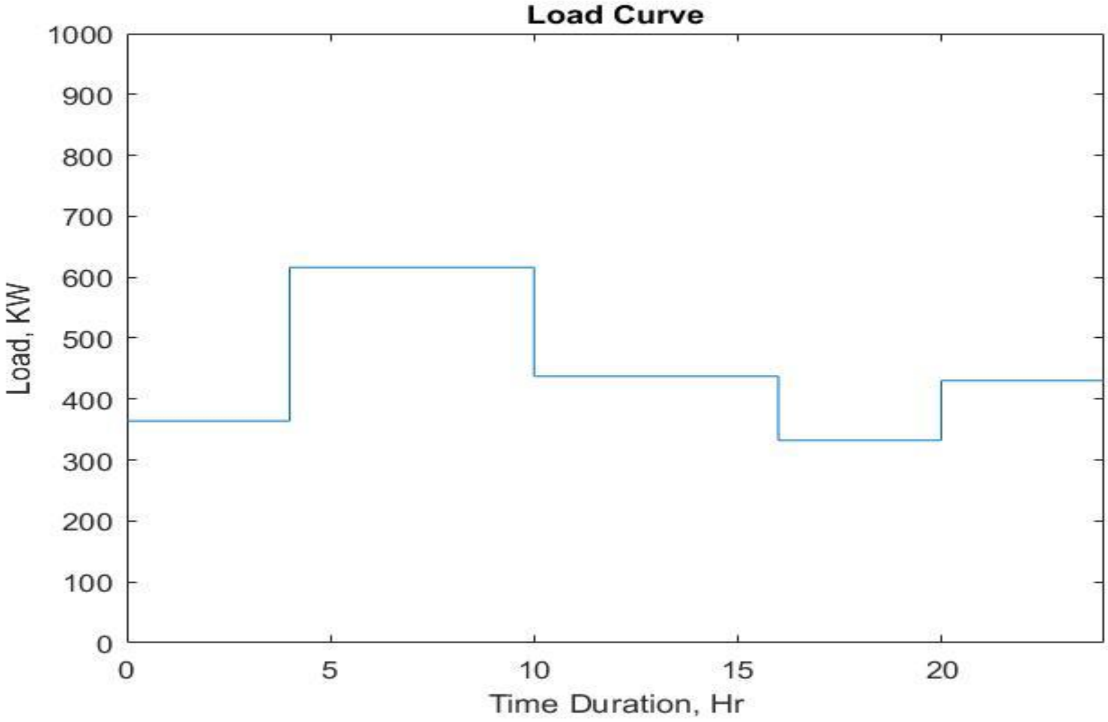


Fig 6.7: Load Curve (Winter)

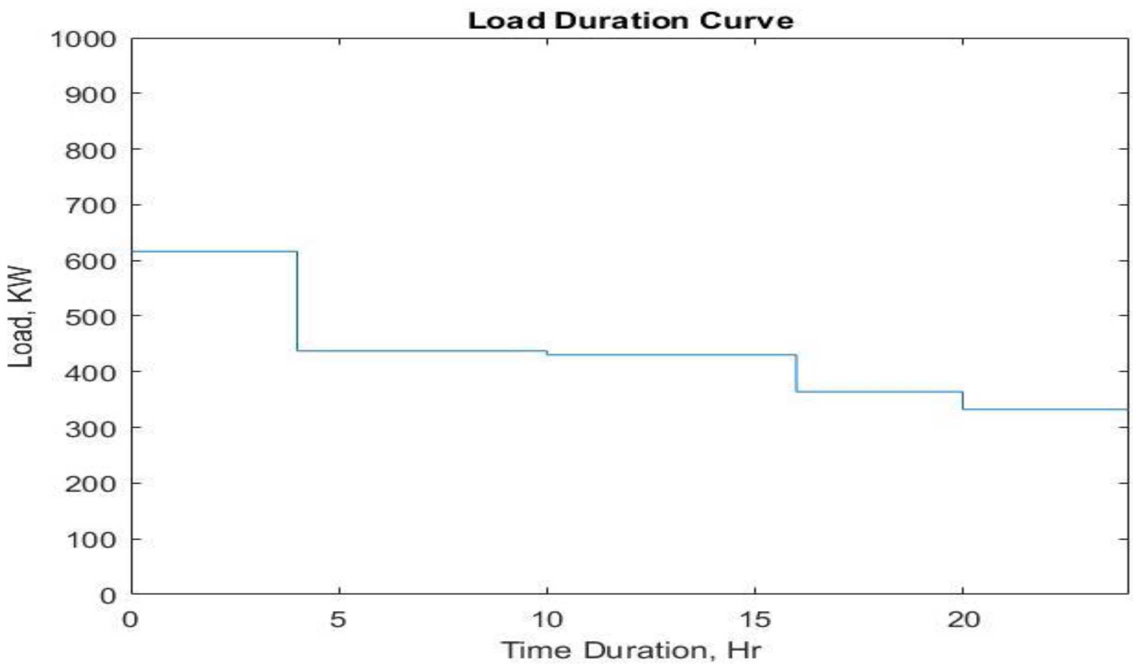


Fig 6.8: Load Curve Duration (Winter)

6.6 Battery Measuring

The accompanying qualities are required for a sun-based home framework battery:

- For profound cycle, long lifetime
- Low support
- High charging limit
- The capacity of totally release
- Low inside releasing rate
- Reliability
- Minimum change under inordinate temperature

6.7 Array Sizing

The estimation of the number of PV modules in a PV configuration is known as array scaling.

6.8 Charge Regulator Choice

Utilitarian boundary of sun-oriented home framework charge regulator

- Maximum current Get from PV board
- Ability of greatest force supply on the heap
- Mark It low voltage level
- Mark it high voltage level
- Electric insurance from thunder
- Good guideline
- Protection from turn around extremity
- Adjust with framework voltage

6.9 Choice of Converter

A solar home system uses alternating current (AC) and direct current (DC) voltage to power appliances. Since the output voltage of the solar module is dc, a dc-dc or dc-ac converter is required for this system. Any of the load is attached to the appropriate converter.

6.10 System Wiring

Electric wiring is required from the PV module to the device component. Voltage drop happens due to the wire's intrinsic resistance. This voltage decrease in the solar home system should be kept to a minimum. Wire cost is critical, and wire length must be kept to a minimum. The solar aspect under dement must be linked.

- The system must be safe.
- These wires do not degrade the output of device components.
- Each component performs to the best of its ability.
- If at all necessary, use a centralized 12volt dc setup.
- If at all necessary, use a centralized 24volt dc setup.

6.11 Wire Standard Size

Cross sectional area(mm^2)	**Wire Gauge (AWG or SWG)**	**Current Rating (A)**
1.0	18	10
1.5	16	15
2.5	14	20
4.0	12	30
6.0	10	35
10.0	8	50
16.0	6	70
25.0	4	90

Table 6.4: Wire Standard Size

6.11.1 Maximum length of wire for 0.6 volt drop in12 volt System

Cable size(mm²)	**Maximum cable Length (m) for various load Requirement**							
	Load power(w)	24	36	48	60	72	96	120
	Current at 12 v (A)	2	3	4	5	6	8	10
1.5		12	8	7	5	5	4	3
2.5		20	13	10	8	7	6	5
4.0		31	21	16	13	11	8	7
6.0		46	31	23	19	16	12	10
10		76	51	38	31	26	20	16

Table 6.5: Maximum length of wire for 0.6 volt drop in12 volt System

6.11.2 Maximum length of wire for 1.2 volt drop in 12volt System

Cable size(mm²)	**Maximum cable Length (m) for various load Requirement**							
	Load power(w)	48	72	96	120	144	192	240
	Current at 12 v (A)	2	3	4	5	6	8	10
1.5		23	16	12	10	8	7	5
2.5		38	26	20	16	13	10	8
4.0		61	41	31	25	21	16	13
6.0		91	61	46	37	31	23	19
10		151	101	76	61	51	38	31

Table 6.7: Maximum length of wire for 1.2 volt drop in 12volt System

6.12 A small size 12volt Home System Design

Let's build a 12volt solar home system with a load determination of 15410Wh/Day. Here, an 85Wp module (Isc = 7.9A, Imp = 7.00A, and nominal voltage=12) and a 660 Ah battery (DOD = 60%, Efficiency = 80%) will be used.

- Cabal voltage drop maximum 5%
- Maximum power loss 5%
- Inverter efficiency 90%

Battery Size

DC Wh/day =15410÷ (0.9*0.95) = 18023 Wh

Daily load = 18023 Wh ÷ 12V = 1501.94 Ah

Battery efficiency = 80%

DOD (Depth of Discharge) = 60%

If autonomy of battery 3 day

So Amp-hour for battery = (= 1501.94 *3) ÷ (0.6*0.8) = 9387.125 Ah

Number of battery required = 9387.125 ÷ 660 = 14.22 ≈ 4

So 4 batteries are needed.

Each one is 660Ah.

Array sizing

Every day PV module yield = 12*7.00*6 = 506Wh/day

Module ostensible voltage = 12V

Every day avg. pick protection = 6 hours

Summing up 15% misfortune PV Cluster Sizing= 506*0.15 = 75.6Wh

DC watt-hours Accessible = 506-75.60Wh = 430.4Wh

So no. of module = 3546/430.4 = 8.24 ≈ 9

Inverter size

Size of the inverter = 355/ (.9) *1.25 = 493.06W ≈ 500W

So 500W inverter is needed

6.13 Cost of Solar Power System (3.546 kw-h)

Sl. No	Description of items	BDT
1	Solar Panel(13)	114833
2	Battery(4)	36000
3	Charge Controller	3000
4	Wire	4200
5	Panel Mounting	6500
6	Miscellaneous	2500
7	Maintenance Cost(Labor & Others)	27000
Total		1,94,000

Table 6.8: Cost of Solar Power System (3.546 kw-h)

6.13.1 Cost of Power from DESCO (3.546 kw-h)

Per Unit Cost of power from DESCO ≈ BDT 7

Per year cost of power from DESCO= BDT 9060

Total cost for 20 Years (without considering any maintenance cost)

= BDT 9060×20

= BDT 181200

6.14 Comparison Between Solar Home System and Power From DESCO

Comparison	Solar Home System	Powered From DESCO
Cost	Total cost for 20 Years = BDT 1,94,000	Total cost for 20 Years (without considering any maintenance cost) = BDT 9060×20 = BDT 181200
Load Shedding	No	Yes
Cost Variation Due time	No	Yes
Utility Bills	Low	High
Back up Capability	Around 4 day	No
Source of Production	Sunlight (No green house gases)	Coil, Burning, Gas, Water, Garbage etc.

Table 6.9: Home System and Power From DESCO

6.15 Identifying Direct Costs

Direct costs items are usually classified into two types:

1. Capital costs
2. Operating and maintenance Costs

6.15.1 Capital costs

- Land and other natural resources that are not being used in other ways
- Technology and architecture in great detail
- Work in preparation for installation
- Cost of building vehicles, raw materials, and components
- Building and auxiliary installation costs
- During building, engineering and operating costs will be incurred.

- Organizational expenses
- Expenses associated with working in cycles
- unforeseen circumstances

6.15.2 Operating and maintenance Cost

- Inventive and non-creative products
- Fuels and Energy
- Workforce
- Insurance and rent
- Natural resource depletion
- unforeseen circumstances
- The above-mentioned objects were discovered during the technical research.
- should be expressed in the financial analysis as well
- Sunk Price
- This are the expenses that have already been accrued on the project.
- its evaluation
- Prices in the shadows
- What are the ideals of o.

6.16 Benefits of a Solar Home System

1. Immediately save money on the electric bills

- Installing a home solar panel will greatly reduce the energy bills. Many homeowners save up to 30% on their power bills, and some even remove their energy bill entirely.
- The average Bangladeshi household consumes 3.546 kWh of electricity every day. Renewable Energy Corporation's residential solar array of 840 kWh a month will almost completely cover the energy costs.
- Your exact savings will be determined by your home's electricity demands, available space for a photovoltaic device, and the direction of your PV system. For an overview and estimation, contact Renewable Energy Corporation.

2. Protect Yourself from Rising Energy Prices

- Over the last five years, electricity prices have risen by more than 21%.

- Rates increased by 10.3 percent in 2006.
- Fossil fuel reserves are declining, resulting in higher electricity prices.
- Solar energy secures the electrical bills and saves you from can utility costs.

3. Reduce Your Carbon Footprint

- The average American household generates 7.4 tons of carbon dioxide (CO2) per year through electrical use.
- This equates to 185 tons of CO2 over the course of 25 years. The output of Solar World solar panels is assured.
- Carbon dioxide contributes to global warming, which has a significant impact. Our climate is causing glacier melt, shoreline erosion, and endangering wildlife. many animals around the world.

4. Protect Our Natural Resources

Each hour, enough sunlight strikes the earth to fuel the entire planet for a year.

- That is 400 trillion gigawatt per second, or 400 quintillion houses.
- Putting the sun to work limits the use of coal and nuclear power.
- Energy expected to control your home which helps save the world's stockpile of non-environmentally friendly power.
- Water is used extensively in the manufacture of coal and nuclear resources.
- As a result, installing solar on your home will save over 16,000 gallons of water per year.

5. Strive for Energy Independence

We will reduce our dependence on non-renewable and non-renewable energy sources by harnessing the sun.

6. Increase the Value of Your Home

- According to studies, solar systems will increase the worth of your house by 20 times the annual energy savings.
- Furthermore, homes with solar panels sell 15 percent quicker than homes without solar, according to some reports.

7. Lower The Utility Bill

When you start generating your own solar electricity, you will see a big reduction in your electric bill. The amount you will save will be determined by the scale of the your solar system, as well as your family's electricity consumption You will still draw some power from the utility grid, but at a lower-priced rate tier. Solar City. will build a solution that is appropriate for your home and decide the best utility rate structure for your remaining energy requirements.

8. Minimal Environmental Impact

Since the manufacture of solar panels necessitates the use of some raw materials, Solar power has a low environmental footprint due to the use of materials and resources. The technology emits no gas, nitrogen, or particulate matter. emissions the fossil fuels produce, and it does not necessitate large-scale mining. as well as fracking activities Since panel arrays may be installed on rooftops or in buildings, Solar power's physical footprint is manageable in remote desert areas since okay.

6.17 Limitation of Solar Home System

- Due to a scarcity of suppliers and a lack of expertise in the solar energy industry, the price of SHS is very high. As a result, it is important to expand the technology market.
- During the rainy season, sunshine is not always available.
- Initial costing is high that‘s why some middle-class family can‘t afford it.
- If a solar panel is damaged, it must be replaced.

CHAPTER-7
Conclusion

7.1 Conclusion

The photovoltaic effect, which is the creation of a potential difference at the junction of two distinct materials in response to electromagnetic radiation, is the basis for solar cells' operation. The sun's energy can be regarded the primary source of all energies. It may be utilized in a variety of ways, including directly generating electricity from sunlight or using the sun's heat as a source of thermal energy. In the solar energy industry, photovoltaic (PV) cells are often used. The main goal of this paper research is to assist anyone who is new to the solar energy sector by introducing current advances in the industry. This review, which is part of a series that evaluates the performance of PV technologies, can help and save time while writing a literature review about PV. A comparative survey is provided in this article, which looks at the three generations of PV cells with the most recent features.

Appendix
Solar Power–Related Definitions

The words relating to solar power that are used in this report and/or are widely used in relation to the subject matter related to this report are as follows.

In certain instances, several meanings can be found in the popular literature. Where different definitions exist, priority is given to federal or state publications, as well as broadly accepted consensus-developed codes and standards. In certain instances, different meanings of the same word are given.

Absorber. A component of a solar collector that absorbs radiant energy and transfers it as heat into a fluid.

Aperture. The gap in the solar collector from which unconcentrated solar radiation is admitted.

Array. A precisely collected get together of modules or plates, alongside an emotionally supportive network and base, tracker, and other important parts, to shape an immediate current force delivering unit. Likewise see Photovoltaic.

Building Integrated Photovoltaic. Photovoltaic cells, systems, components, or modular materials that are built into a building's exterior surface or framework and act as the building's outer protective surface.

Charge Controller. To charge a battery, equipment that regulates dc voltage or dc current, or both, is used.

Concentrating Collector. Reflectors, mirrors, or other optical components are used in solar collectors to focus and concentrate solar radiation passing through the aperture onto an absorber. Often see Solar Collector.

Electrical Production and Distribution Network. A power generation, distribution, and consumption mechanism that is not operated by the photovoltaic power system, such as an energy system and attached loads.

Heat Transfer Fluid. A fluid that is used to transfer thermal energy between device components.

Hybrid System. A device of many power sources. Photovoltaic, wind, micro-hydro generators, engine-driven generators, and other power sources may be included, but electrical generation and delivery network networks are not included. For the purposes of this concept, energy storage devices such as batteries do not qualify as a power source.

Interactive System. A photovoltaic solar system that operates in parallel with and may supply power to an electrical production and distribution network. For the purposes of this definition, an energy is defined as A storage subsystem of a solar photovoltaic device, such as a battery, is not another form of electricity.

Inverter. Equipment used to alter the voltage frequency, waveform, or both of electrical energy. An inverter [also known as a power conditioning unit (PCU) or power conversion system (PCS)] is a computer that converts dc input to alternating current (AC). Inverters can also be used to charge batteries by using alternating current. another source and turn it to direct current for battery charging Electric energy converter that converts direct current to single-phase or multi-phase alternating currents.

Module. A full, ecologically secured gadget, restrictive of the tracker, comprising of sun Oriented cells, optics, and different segments intended to create dc power when presented to daylight. Likewise see Photovoltaic Module.

Panel. A series of mechanically fastened, wired modules designed to provide a field-installable unit. Also see Photovoltaic Panel.

Photovoltaic Array. PV module assembly and service system comprised of mechanically assembled and electrically linked PV modules, PV plates, or PV sub-arrays. It should be noted that a PV array does not include its foundation, monitoring apparatus, thermal power, and other elements. Also see Array.

Photovoltaic Assembly. PV components assembled outdoors and away from loads, such as modules, support systems, base, plumbing, monitoring apparatus, and thermal control (where specified), as well as junction boxes, charge controls, and inverters, depending on the assembly's installed configuration.

Photovoltaic Cell. The most basic photovoltaic system. Often see Solar Cell.

Photovoltaic Module. Full and environmentally safe interconnected photovoltaic cell assembly. Also see Module.

Photovoltaic Panel. PV modules that have been mechanically integrated, preassembled, and electrically attached. Also see Panel.

Photovoltaic System. Components that generate and provide electricity by the conversion of solar energy.

Photovoltaic System Voltage. Any photovoltaic source or photovoltaic output circuit's direct current (dc) voltage. The photovoltaic device voltage is the peak voltage for any two dc conductors in a multi-wire installation.

Solar Cell. When exposed to light, a photovoltaic battery produces electricity. Also see Photovoltaic Cell.

Solar Collector. A device designed to absorb solar radiation and transfer the resulting thermal energy to a fluid flowing through it. Also see Concentrating Collector.

Solar Energy. The sun emits electromagnetic radiation as part of its energy. It should be noted that the term "solar energy" is commonly used to refer to any energy generated by the capture and conversion of solar radiation.

Solar Heating System. Thermal energy is provided by solar collectors and other components in a device.

Solar Photovoltaic. Concerning photovoltaic (PV) systems that operate under the influence of sunlight.

Solar Photovoltaic System. The whole set of components and subsystems that, when combined, transform solar energy into electric energy suitable for connection to a load.

References

[1] https://globaljournals.org/item/1570-present-situation-of-renewable-energy-in-bangladesh-renewable-energy-resources-existing-in-bangladesh

[2] https://www.banglajol.info/index.php/BJSIR/article/view/5714

[3] https://zantworldpress.com/journals/?j=global-science-technology-journal

[4] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=5&Itemid=6

[5] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=5&Itemid=6

[7] Power System Master Plan (PSMP) of Bangladesh, https://powerdivision.gov.bd/site/page/f68eb32d-cc0b-483e-b047-13eb81da6820/Power-System-Master-Plan-2016

[8] International Science Panel on Renewable Energies (ISPRE) https://council.science/publications/proposal-for-an-international-science-panel-on-renewable-energies/

[9] Power Grid Company of Bangladesh Ltd. (PGCB) http://pgcb.gov.bd/

[10] Bangladesh Power Development Board (BPDB). https://www.bpdb.gov.bd/

[11] Rural Electrification Board, Bangladesh. (REB). http://www.reb.gov.bd/

[12] Energy Statistics, Bangladesh Energy Regulatory Commission. (BERC) http://www.berc.org.bd/

[13] Local Government Engineering Department (LGED) https://www.lged.gov.bd/ 15. Bangladesh (www.reein.org)

[14] http://www.powercell.gov.bd/site/page/d730f98d-8912-47a2-8a35-382c4935eddc/Power-Sector-at-a-Glance

[15] https://www.researchgate.net/publication/316371662_A_Review_of_Energy_Sector_of_Bangladesh

[16] https://energypedia.info/wiki/Portal:Solar

[17] https://www.researchgate.net/publication/285371220_Bangladesh_Country_Profile