STUDY OF PHOTOVOLTAIC IRRADIATION PATTERN FOR ELECTRICITY GENERATION OF BANGLADESH

This thesis submitted in partial fulfillment of the requirements for the Award Degree of Bachelor of Science in Electrical and Electronic Engineering

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Certification

This is to certify that this thesis entitled "**STUDY OF PHOTOVOLTAIC IRRADIATION PATTERN FOR ELECTRICITY GENERATION OF BANGLADESH**" is done by the following students under my direct supervision and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on April and May 2019.

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Dedicated to

Our Parents

And

Our Teachers

CONTENTS

LIST OF FIGURES

LIST OF TABLES

List of Abbreviations

AC	Alternating Current
DC	Direct current
PV	Photovoltaic
SP	Solar Panel
GS	Grameen Shakti
UV	Ultra Violet
FF	Fill Factor
MW	Mega Watts
KW	Kilowatts
IV	Instrument Measuring
RF	Ripple Factor
SHS	Solar Home System
GDP	Gross Domestic Product
NGO	Non-Governmental Organization
IDCOL	Infrastructure Development Company Limited
PDB	Power Development Board
REB	Rural Electrification Board
LGED	Local Government Engineering Direction
BPDB	Bangladesh Power Development Board
BOS	Balance of System.
STC	Standard Test Condition.
OPC	Operational Condition
PVT	Polyvinyl Fluoride
BUET	Bangladesh University of Engineering and Technology
IRE	Institute of Renewable Energy
EVA	Ethylene Vinyl Acetate
AGM	Absorbed Glass Mat
CIGS	Copper Indium Gallium Selenide

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ABSTRACT

Now a days, the increasing demand of electric power and shortage of present energy resources lead today's engineers and scientists to think about the alternative sources of energy. The sunlight is a potential source for producing electric power. In recent years, this solar system gains its popularity more and more. In home system applications, the use of solar energy is also attractive. Moreover, solar home systems require very little maintenance and need no fuel. Other advantages of a PV system are reliable power, free source of power, flexibility and quick installation. For socio-economic development a reliable, affordable and secure supply of energy is significant. The following research paper is based on analyzing the solar irradiation pattern of Bangladesh for electricity generation. Irradiation and power are discussed with their optimum capacity. Power is one of the most important factors in developing country and for sustainable economy. Like the rest of the countries of the planet, in Bangladesh the demand for power is increasing day by day. The main aim of our research is to find out the irradiation of sun in Dhaka city in the month of May and June so that the power production by the solar panel can be estimated and, we collect the solar irradiation and the maximum power data in Dhaka for (April and May) two months and analyze the data to get average irradiation and find the relationship between solar irradiation and power and by using this data we can easily understand the electricity production by solar home system and create a standard form of power production of solar home system in 2019.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Bangladesh is one of the world's most dense and poorest countries. 17% of the population may be called "very poor" due to low income [1]. This is due to less access to modern energy Services. Its infrastructure is small, inadequate and poorly managed. So, today's power crisis is growing. Because of this crisis, a huge gap was created through poor management of power. This gap in demand and production is now a huge problem in this country. The lack of supply of electricity and energy was the main reason for this growing demand. Demand for electricity has increased due to increasing population and increasing economic activity. Trying to meet the demand for natural gas, coal, fuel, peat and other non-renewable energy production. Renewable energy is also served in various ways. In absolute terms, the number of renewable energy has increased significantly due to population growth. Compared to past years, this problem has been selected in various ways about the current state of energy and some useful solutions have been given to the future energy sector of this country. The purpose of this study is to analyze current and past energy conditions and to analyze their resources in Bangladesh, identify problems. They need their solutions and are willing to take this path to meet the future potential of the country.

1.2 Current State of Electricity In Bangladesh

As a developing country, Bangladesh has the potential to go ahead with increasing demand for electricity. But now Bangladesh is in energy crisis at this age. About 70% of the population lives in lack of electricity and 40% in most villages live below the poverty line [2]. Here we are going to describe the overall current situation in Bangladesh where we can improve the deficit which should be improved.

1.2.1 Gas Sector

Natural gas is the main source of energy in Bangladesh, which contributes 75% of the country's commercial electricity [3]. So far, 24 gas fields have been searched, two of which are located in the operator area. Currently gas is produced from 18 gas fields (79 gas wells)

[4]. Two gas fields (Sylhet and Kailashitola) were tested. Alternative fuels or scientific solutions should be explored to reduce the reliability of natural gas. Despite the current government's efforts to generate electricity, the country's economic development and energy production will continue to be affected by natural gas for many years and will continue. There is a lot of progress in advance of the government. Recently, gas production has been 1750 to 2250 mmcfd and is currently producing 79 wells in 18 gas fields [5]. At present, the country's total and reliable power generation capacity is 6887 MW and 5091 MW, resulting in a loss of 1674 MW every day [6]. It will be possible to supply 880 million cubic feet of gas to the national gas grid every December, and another 2800 million cubic feet will be provided after the implementation of the long-term plan. The national gas grid supplies more than 2000 million cubic feet per day [7]. Data related to gas production are shown in Table 1.1

Table 1.1 Bangladesh Gas Sector 2010-2011 [7]

Content	Amount
Total No of Gas	24
Total Recoverable Reserve	20.605 Trillion Cubic Feet (TCF)
Total Gas Consumption up to June	9.788 Trillion Cubic Feet
Total Remaining Reserve	10.817 Trillion Cubic Feet
Daily Gas Production	2000 MMCF
Daily Demand of Gas	2500+ MMCF
Daily Shortage of Gas Supply	500+ MMCF

1.2.2 Sector of Coal Side

Coal is an important force in Bangladesh. The existence and development of the coal industry is crucial for national economic security. As of 2009-10, the share of gas for electricity generation was 89%, while the share of oil and coal was 5% and 3.5% respectively [8]. If coal can replace gas, it can be a good alternative to the above conditions. However, this did not happen because coal was suffering from a serious management crisis. In the last few decades, no one has considered coal mining as logical. Due to short supply, the country was not ready for the crisis. Coal supplies 28% of our primary energy [9]. But thanks to the formal progress of coal-based power plants, this may change in a short time. It has been able to contribute more than what has been done so far. Power generation will be 2020 MW in

2020, of which 50% will be coal based [10]. Coal reserves in the five regions of Bangladesh is 3.0 billion tones equivalent to 67 billion tons of gas, which can provide electricity for 50 years [11]. The recovery rate varies depending on the choice of technology and mining methods. With the adoption of modern mining technology, about 85% of the coal can be recovered from Barapukuria, Phulbari and Dighipara. This will ensure regular monitoring and monitor supervision. Khalsipir Qualcomm may be the ideal candidate for salt, though we can wait year after year for the technical development of Jamaalganj coal mining [12].

1.2.3 Current Situation in Renewable Energy

Innovative technologies are widely used in developing countries, but they are still very small in Bangladesh. In order to achieve a sustainable solution, the amount of investment and the potential terms of the technology are necessary. Despite the reliability of natural resources, the government of Bangladesh is trying to promote renewable energy system. The government brings a lot of revenue to renewable energy projects. Bangladesh Bank, IDCL and some private commercial banks are moving forward to provide financial assistance. Accordingly, the government has increased its revenues with deductions on new renewable energy products such e.g. solar panels, solar panel production accessories, LED lighting, solar powered lighting and wind power plants [16]. In table 1.2 shown how many power generate from renewable energy.

Table 1.2 National Capacity of Renewable Energy Based power in 2014 [14]

Type	Achievements
SHS	100 MW
Solar Irrigation	1 MW
Roof top solar PV at Government, Power sector office buildings and at newly constructed buildings	14 MW
Wind Energy	2 MW
Biomass based electricity	< 1 MW
Biogas based electricity	5 MW
Hydro power	230 MW
Total	**403 MW**

1.3 Potential upcoming of energy region in Bangladesh

Bangladesh has been in trouble for almost a decade due to acute power crisis. Drought Natural gas is the primary source of coal and commercial fuels, however, they are limited to the country's development supply. About something Creativity and precisely government driven, Bangladesh is likely to be this is a first-time energy demand.

1.3.1 Natural Gas

The demand for gas in Bangladesh has always increased. Natural gas often provides electricity generation and according to the forecast by the Petro Bangla Production and Marketing Department, the demand for gas has increased by 25 and demand will reach 4162 MMCFD [15].

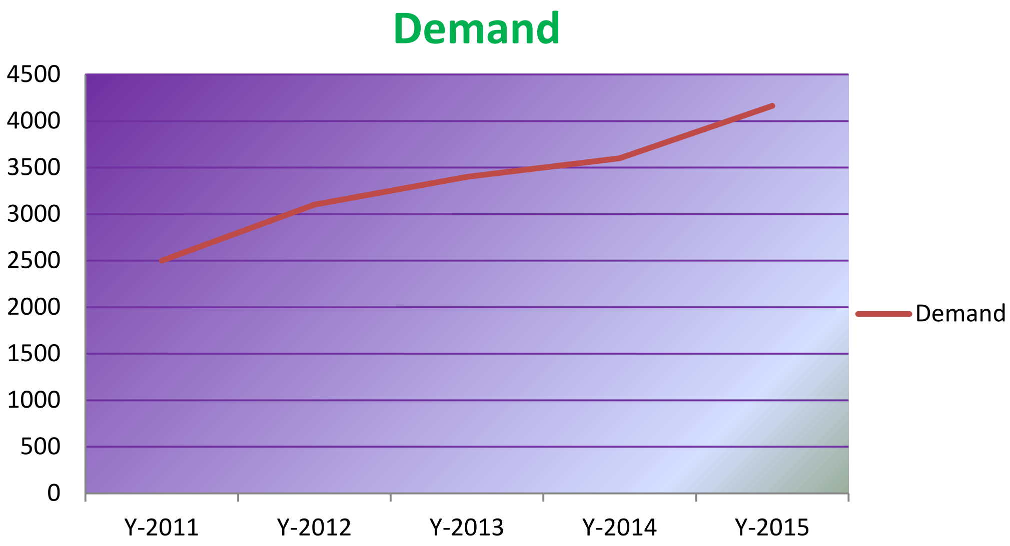

Figure: 1.1 Demanded Plans of Gas (2011-2015) [13]

In 2013, there was a shortage of 470 MMCFD [13], with production of 2270 mmcfd to reduce dependence on natural gas in the future. In Bangladesh, it is essential to reduce the use of natural gas to maintain a stable or moderately stable energy project. As there are multiple studies on the reliability of natural gas, it has finally attracted the consideration of the Bangladesh administration. Straightforward society is focused on reducing natural gas erosion. Later, in Figure 1.1 there is a possibility of raising the mandate for newly introduced companies such as energy, coal, renewables and nuclear power. This dependency deprivation is exacerbated by any economic flaw because if it does, gas may seem like a low-cost way to meet national fuel demand.

1.3.2 Coal and Fuel

Coal can thus fund more than what the outgoing has done. After 2005, the upcoming coal system could make significant changes to the energy structure through the rewards of natural gas. Ignorance about setting up a coal-based power plant may be completely unable to meet the demand for natural gas [17, 18]. In 2025, if coal-fired power plants provide 32,837 MW to 41,899 MW, the situation will improve. About 449.44 metric tons (450 megawatts) of coal will be used in the power sector, according to estimates of high GDP growth by 2025[16]. These are considered by the government for national coal policy considerations. According to coal power and forecast data, if the annual demand for this year is 32,837 MW, the power for the next ten years will be 375 (5x75) million tons and an additional 750 (extra 750) 10x75 million years in the next 5 years. The tune will be needed. There will be a demand for a total of 120 million tons of coal from 2005 to 2035 years. Therefore, conservation of coal is not enough to meet the need for more than 25 years. The economic situation of the country will depend on the import of energy. In the future, if the State Plan of Coal is implemented then some of the energy emergency issues will be resolved at that time. If conservative measures are used to pollute the pollution caused by the coal drainage process, the power system will be smart and adequate. Once a good amount of money is ready to invest in the country's coal policy, it will be easier to get sustainable energy. For the moment, humble resource organizations will essentially import fuel from afar, which hinders the country's economic growth.

1.3.3 Renewable Energy

By 2015, the government of Bangladesh has planned to produce 5% of renewable energy and 10% in 2020. Biomass and biogas can in turn generate 400 MW and 800 MW of power plants. By 2020, our government will get 20 MW of electricity by 2020 by setting up micro (<100 kW) and mini (1000 person) hydroelectric power plants.

1.4 Problems

Neither method is a careful model. One of the major problems is the distribution of fuel in the country Imbalances and therefore will be responsible for most of the natural gas production Power. There is a problem in Bangladesh's energy sector that needs to be addressed.

1.4.1 Problems of Natural Gas

Although Bangladesh is doing impressively in natural gas, it is not satisfying due to lack of progress in the sector and lack of balanced power planning. Increased fuel efficiency is pushing for a path to unstable energy, with lack of funding for the development of natural gas assets and some concerns over increased energy efficiency.

1.4.2 Problems of Coal

Coal is another energy resource in our country. This is a significant reserve, unused lying. Bangladesh does not have long-term energy security, but if resources are used properly, it will be better positioned to supply electricity. The current crisis is high in coal and not a viable solution to the crisis. The government plans to produce large quantities of electricity through imported coal, but it can reduce targets due to catastrophic economic conditions and infrastructure shortages.

1.4.3 Problems of Fuel

Bangladesh is a fuel importer, so if CNG-powered vehicles are shut down it could be an economic burden for Bangladesh as it will put pressure on high volume imports Fuel. Furthermore, the demand for fuel and diesel is increasing due to natural gas shortages, Electricity will turn into an expensive oil-powered power plant. To our government Focus on the best plan for consuming more fuel and making it work for everyone.

1.4.4 Problems of Renewable Energy

The renewable energy system is still unused in Bangladesh. Countries like Australia, India, Canada have launched a revolutionary renewable strategy to improve their power systems. While other countries are integrating renewable electricity, implementation of renewable energy-based power plants in Bangladesh and the implementation of SHS in villages is underway. Also, the current cost of renewable energy systems is very new to it and the capital is very high. Due to the dependence of renewable energy and uncertainty about energy requirements, it is difficult to produce another climate.

1.5 Photovoltaic (PV) Cells

PV cells produce electricity from sunlight. The panel has a computer chip this system is similar to the materials used. They absorb sunlight and are generated Electricity. The electricity produced is DC. So convert and supply DC to AC. A photovoltaic system employs solar modules, each containing several solar cells that produce electrical energy. PV installations can be mount-mounted, roof-mounted, wall-mounted or floating. The mount can be fixed, or use a solar tracker to follow the sun across the sky. Solar tracking can be based on a single axis (e.g. following the sun during the day), or two axes (adjusting the time of year for the tiller too).

1.6 Objectives of The Thesis

- To col1ect the solar irradiation and the maximum power data in Dhaka for (April & May) two months.
- To analyze the data for getting the average irradiation and find the relationship between solar irradiance and power.

1.7 Scopes

We work in our university's roof top. Here we maser off grid solar power, efficiency, voltage, current etc. by IV-400 meter. It is a Germany project. Bangladesh has a lot of demand for energy. The country commonly experiences the unconquerable demand supply gap of electricity basically during summer. The energy gap is one of the largest losses in Bangladesh and hamper for growth economic. In this time the solar system is develop of our country. This is a good solution of electricity. SHS can variation the lives of people in rural and city area. Solar power may be a way of development providing solar electricity solutions for households, healthcare, education, telecommunication, agriculture, rural streets and market places. Government and various private sectors are initiative good steps on the solar system. SHS is social and economically development in Bangladesh.

1.8 Thesis Outline

Chapter 1: Introduction.

Chapter 2 Literature Reviews

Chapter 3: Solar System.

Chapter 4: Methodology.

Chapter 5: Data Analysis.

Chapter 6: Conclusion.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

Renewable energy is the fuel that is collected from renewable resources and which naturally replenishes in human time such as wind, tides, waves, sunlight, rain and geothermal heat. There are four key areas that provide renewable energy air and water heating / cooling, electricity generation, rural energy services and transportation. Almost all used energy was renewed in the mid of 19th century, which preceded the development of coal. The use of biomass for fires has not become commonplace for many millions of years, doubtless the oldest use of renewable energy, dating back to about 800,000 years, in the form of traditional timber biomass for lighting. Strengthening the air to ship over water is probably the second oldest use of renewable energy. The Persian Gulf and the Nile Ships are where this practice is to be found in 7010 years. The primary sources of renewable energy are animal energy, human labor, water power, fire wood, grain grinding air. The United States until the 1900 natural gas and oil showed almost the same importance as wind and solar.

2.2. Energy

Energy is the amount of a physical system. It defines the efficiency of change and processes, which took place in the universe, starting with movement and ending with thinking.

2.2.1 Solar Energy

Solar energy is the sun's illumination and heat that uses various development technologies, for example photovoltaic, solar architecture, solar heating, solar thermal energy, molten salt energy plants and artificial photosynthesis. It is an important source of renewable energy and its technologies are widely characterized as passive solar or active solar, depending on how solar energy is received and distributed or converted to solar power. Active solar techniques include the use of photovoltaic systems, the use of central solar power and heating energy by solar power. Passive solar techniques include focusing a building on the sun, selecting the optimum heat mass or light-dispersive properties, and designing natural circulation spaces.

2.3 Renewable Energy Technology Preferable in Bangladesh

Renewable energy is energy that is collected from renewable resources that is naturally fulfilled during the human period for rain, tide, sunlight, wind, waves and geothermal heat. Renewable energy often provides energy in 4 important areas: electricity generation, transportation, heating or cooling of air and water, and rural (off-grid) energy services. Renewable energy is constantly replenished from natural processes. In its various forms it is derived directly from the sun or the heat generated by the depths of the earth. There are applications suitable for different types of renewable energy systems (RES) explain the title of the hierarchy to Bangladesh –

- Solar Photovoltaic
- Waste Energy
- Biomass
- Wind Power
- Tidal Power
- Biogas Energy

2.4 Present scenario of renewable energy and conventional energy (Electric Power) generation of Bangladesh

The current situation in our country is 10213 MW of total generation. Given a Table 2.1 When sectors and what kind of fuel it uses [20]. And the table 2.2 the total generates of off grid electricity is 22.5 and whose sector come it. We see the table 2.2 the most electricity come to solar and minimum come in micro hydro. [21] Total Power Generation Capacity = 21,306.62 MW (Including Off-Grid RE) Renewable Energy Share = 2.84%.

Table2.1: Renewable energy shear in Bangladesh [22]

Technology	Off-Grid (MW)	On-Grid (MW)	Total (MW)
Solar	297.64	73.05	370.69
Wind	2.000000	0.90	2.90
Hydro	-	230.000000	230
Biogas to Electricity	0.63	-	0.63
Biomass to Electricity	0.40	-	0.40
Total	**300.67**	**303.95**	**604.62**

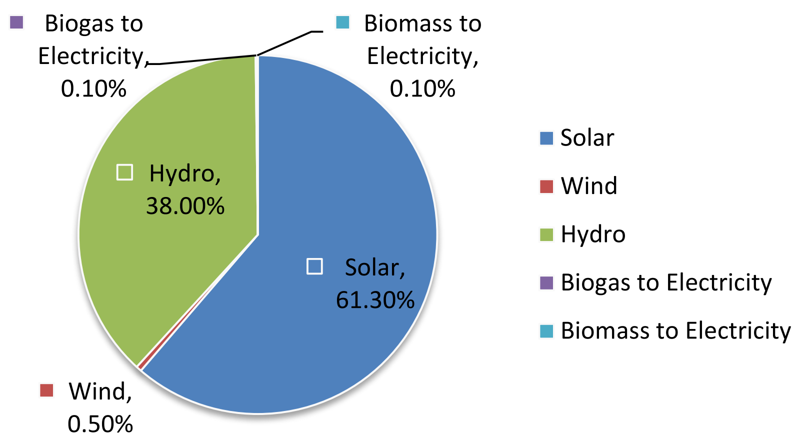

Figure 2.1: Renewable energy shear in Bangladesh [22]

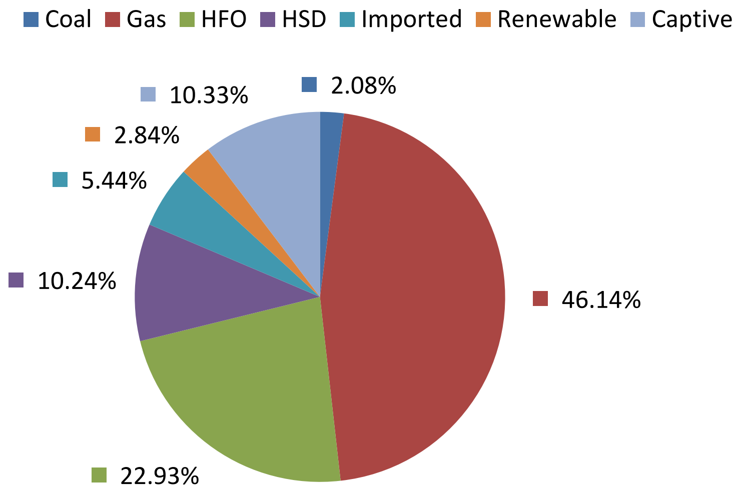

Figure 2.2: Electricity Generation Mix [22]

Table2.2: Total insulated power in grid [20]

Total insulated power in grid electricity is 10213MW	
Gas	**6587**
Coal	**250**
Diesel	**683**
Furnace oil	**1963**
Hydro	**230**
Import	**500**

Table2.3: Total insulated power off grid electricity [21]

Total off grid insulated electric power is 22.5MW	
Wind	**2.5MW**
Solar	**18.55MW**
Biomass/Biogas	**0.5MW**
Micro Hydro	**0.1MW**

2.5 Government helps in Renewable Energy Department in Bangladesh

Our government is very supportive of generating electricity in the renewable energy sector. Show a table below 2.4 GOVT It helps.

Table2.4: Government helps in RE sector in Bangladesh

Sector	Responsibility
Duty & Vat	Government wipe out all short of duty for the Renewable Energy commodities
Government Policy	The government has a vision that at least 5% electricity in 2015 and 10% in 2020 will be generated by RE
Tax Free(According to RE policy)	The RE policy declared that, Renewable Energy company will 5 years tax holiday from its supply but actual budget doesn't agree with it.
Manufacturing Plant for PV module	Assembling of PV module is example of duty of capital machinery.

2.6 Bangladesh background and Government situate

Today greenhouse gases are the most dangerous to the environment. The weather is directly affected by the rise in temperature by greenhouse gases. Our country is one of the top 48 weather sensitive countries. It is facing the effects of climate change such as rising sea levels, increasing salinity, floods, heavy rainfall and groundwater. As an unprotected country, both the public and private sectors of our country have taken many plantations to move towards renewable energy production to save the environment and improved living conditions. Given a figure 2.3 to show solar home system in town are.

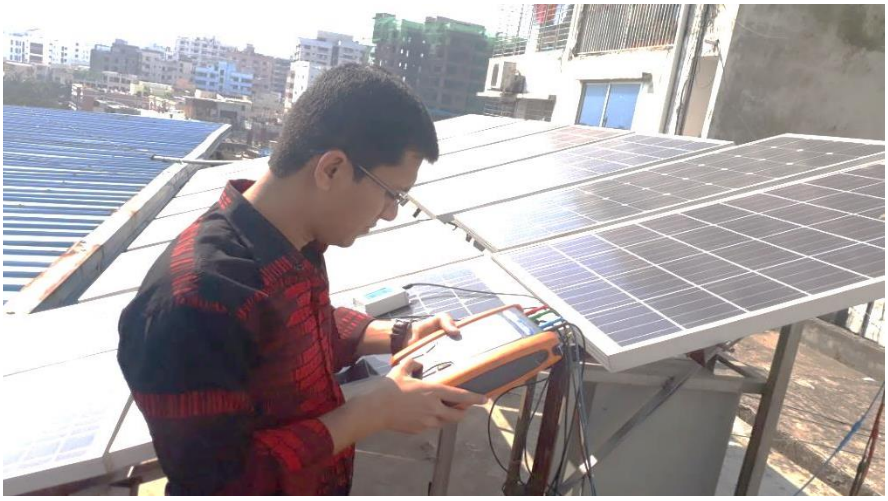

Figure 2.3: Solar home system in town are

The government has established SRED to provide policy support and guidance for the sustainable growth of renewable energy. They are different steps for the development of our country and electricity. Now, our government will take steps to improve the rural and town areas. The town is located on the roof top solar panel. No photovoltaic cell is required to stand in Dhaka city DPDC building in Bangladesh capital, so there is no new line in their consumer without solar.

Figure 2.4: Solar home system in rural are

2.7 Solar System in Bangladesh

From the sun we get light and heat. Light gives us vision and helps plants grow, so food is supplied, heat helps us survive. The most interesting thing is the light and by using this heat we can create the electricity. The solar system is the gravitation-ally bound system of the sun and the objects that orbit it directly or indirectly.

2.8 Wind Power

Wind power is the conversion force used to manipulate wind speed. For example, the use of windmills to generate electricity, windmills for mechanical power, air pumps for water or drainage, sail for ships. Electrical or mechanical energy is the conversion of wind energy from wind power into a useful wind power by wind turbines. Where the velocity of the air is directly proportional to the energy. Particularly in the islands of Bangladesh and the southern maritime facial where long winds are flowing, so that Bangladesh declares that the average wind speed in April to September is from 3 to 4.5 m/s and for the rest of the period are 1.6 to 2.2 m/s. Of the year. The application of air calls for pumping and electrification in the islands and coastal areas is very high. Wind battery hybrid power project in the islands of Kutubdia where the Bangladesh Electricity Development Board has completed a 1000 kW power system [13]. Installing window turbines that are power alone type. The total energy produced by all wind turbines is stored in a battery.

Figure 2.5: Wind Power

The BPDB project completed their 0.90 MW capacity grid connected to wind power in the Muhuri Dam area of Feni district in 2007[14]. The BPDB has allocated that wind power can contribute 10% of the energy produced. The main advantage of wind turbines is that they do not require any fuel to generate electricity. The potential of wind conditions for generating electricity under different conditions in Bangladesh and illuminates that the maximum annual average wind speed is 2.42 m / s in Cox's Bazar and 2.08 m / s in Hatia Island [15]. Wind energy is a very important part of renewable energy. For the first time in our country, this energy is produced by the muhuri dam. It is located in Feni district and 0.9 MW of this capacity. The other is on the island of Kutubia. This capacity is 20KW. Airfield levels have been created in Patenga, Cox's Bazar, Kuakata, Maheshkhali and Nuakhali, with this area standing [12]. The figure 2.6 to show that a wind power plant at Muhuri Dam in Feni, Bangladesh.

Figure 2.6: Wind Power Plant in Bangladesh

2.9 Hydropower

Hydropower is produced from 16% -18% of electricity. In the Kaptai region a large hydroelectric power station was built in the 1960s using the Karnafuli River. This capacity is 230 MW and supports our country's electricity. Generation costs are very low compared to other fuels in our country. Bhutan This field has the capacity to produce 25000 MW. Now the country will produce 1500 MW and the project of their implementation will produce 6300 MW of Indian subsidiary. Our public and private sectors will jointly invest in Nepal for hydropower to facilitate electricity generation. These are very useful in our country.

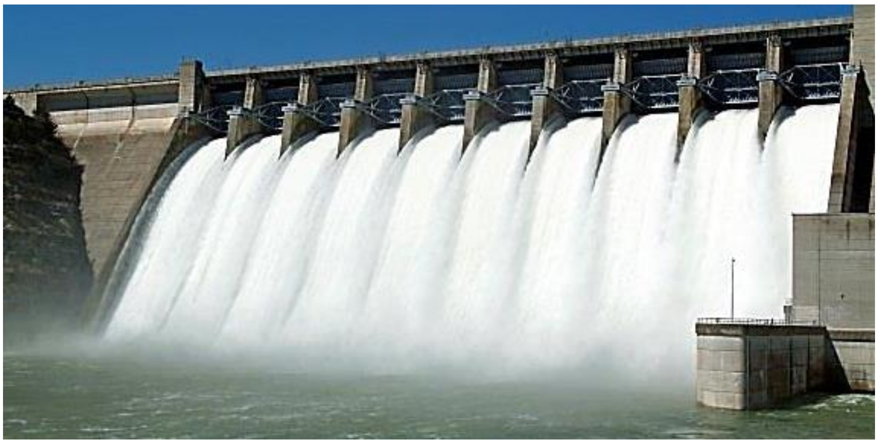

Figure 2.7: Hydropower

2.10 Biomass Energy

As an agricultural country, it has the potential to generate electricity from biomass sources. Biomass is available for power generation, livestock, agricultural exploitation, poultry, water harvesting, rice flame etc. Biomass fuels come from things that once survived: wood products, dried plants, crop residues, aquatic plants, and even waste. This is known as the 'natural element'. Plants use a lot of sun energy to create their own food (photosynthetic). They store foods in plants in the form of chemical energy. As the plants die, the energy is trapped in the residue. This trapping energy is usually emitted by burning and can be converted into biomass energy. There are currently 25,000 biogas plants across the country and 0.20 million ovens have been set up to store biomass fuel. Over 900 braking machines are operating commercially on a commercial basis [16]. The power of paddy cultivation is about 16 MW / kg. Potential results of the biomass plant temperature of 13,648 Btu / kW are shown in Table 5 [17].

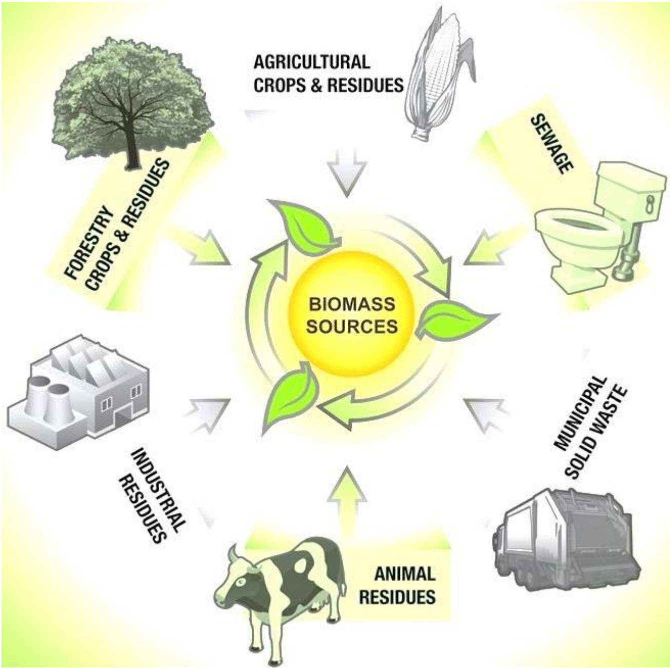

Figure 2.8: Biomass Energy Sources

CHAPTER 3

SOLAR SYSTEM

3.1 Introduction

International energy agency sources say that by the end of the calendar of 2015, the capacity to install solar PV has reached about 277 GW. Capacity has increased tenfold since 2008 years, producing more than 1.3% of all global electricity needs. In addition to some of policy, regulatory and market projects which have been taken by many governments throughout the globe, the cost economics of poly-silicon has additionally been a key motive force of this progress in sun PV. As can be visible in Figure 15, the charge of poly-silicon isn't without delay proportional to potential accompaniments in sun PV (after 2008). Historically, solar PV was now not measured to be a mainstream power source, and become characterized by way of very low mobile efficiencies and high expenses of poly-silicon. Most of the poly-silicon produced earlier than 2005 changed into used by the IT enterprise and subsequently, there was a deliver constraint. Policy goals to fight weather alternate and addition of substantial potential of solar PV by way of many advanced international locations consisting of Germany, the USA and Japan driven investments in poly-silicon step by step and by way of 2008-09 there was a glut in poly-silicon marketplace. This led to intense fall in poly-silicon charges and consequently usual sun PV expenses, attracting large investments within the quarter. In fact, the glut in marketplace became so massive that many massive industry gamers had to close down their poly-silicon manufacturing conveniences, due to disappearing profit margins and struggles to be price-aggressive with Chinese output. A complete solar PV system is a unified package of different components. These components are separated and integrated through a lot of hard work by different players across a very large supply chain comprising several large components, including a solar module and system balance (BOS) - inverters, mounting structures, electrical infrastructure and (in some cases) some energy savings [25]. It is likewise very critical to consult that development in cellular efficiencies currently has also performed a crucial function in qualifying solar PV as a critical source of electricity.

3.2 Solar System

The function of the solar system is to generate electricity from sunlight. This method is generally of two types.

1. On-grade Solar System
2. Off-grid Solar System

3.2.1 On-grade Solar System

On-grid systems are solar photovoltaic systems that produce energy only when a utility power grid is available. In order to function, they must connect to the grid. They can transmit the extra energy you generate to the grid when you produce extra so you credit it for later use. These are the simplest method and the most expensive to install. These systems will pay for themselves by offsetting utility bills in 3-4 years. These are effective in the long run and save money in the long run to pay for themselves. It can reduce its own electronic bills and carbon footprint so is a good choice [23].

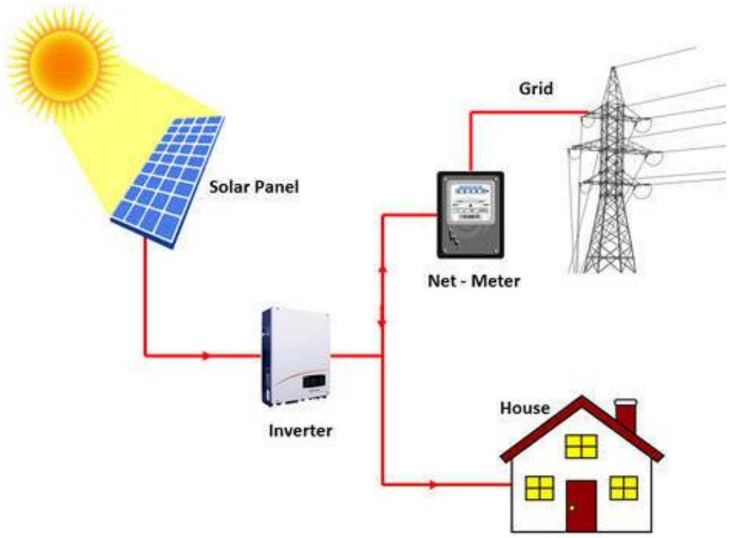

Figure 3.1: On-grade Solar System

3.2.2 Off-grade Solar System

Off-grid is the name of the method used to store solar electricity through batteries during night or load shedding. These systems allow the use of solar power to be stored in batteries for use when the power grid is down or not on the grid. Hybrid systems provide the power to offset grid power whenever the sun shines, and transmit excess power to the grid for later use [23]. Equipment's required for off-grid solar systems:

a) Solar panels
b) Charge controller

c) Inverter and

d) Battery

The solar panel converts sunlight to DC power to charge the battery. This DC power is fed to the battery through a solar controller that ensures that the battery is properly charged and not damaged. DC applications can be operated directly from the battery, but AC appliances require an inverter to convert DC power to 240 volts of AC power.

3.3 Solar panels

Photovoltaic solar panels ingest sunlight as a source of energy for power generation. A Photovoltaic (PV) module is usually a packaged, connected assembly of 6x10 photovoltaic solar cells. Photovoltaic modules constitute a photovoltaic array of photovoltaic systems that produce and deliver solar and commercial applications to commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC) and is usually 100 to 365 W (W). The efficiency of a module determines the output of the same rating of a module - an 8% efficient 230W module will double the area of 16% efficient 230W module 24% [1] [2]. Without cells, there is no electricity generation in this case. We work with three solar panels in blue and there are 45, 60 and 100 watts.

Figure 3.2: Solar panel

3.4 Charge Controller

The solar controller is used to control the photovoltaic panel to operate the battery and to provide load control voltage for voltage sensitive devices. It controls and controls the charging and discharge conditions of the battery, and controls the power output of the load's solar cell module and battery, which is the main control part of the complete photovoltaic power supply. It controls the battery charge. Once the battery is full of charge, it will stop charging and disconnect the load from the battery when the charge is finished. Thus protecting the battery. Most "12 volts" panels remove 16 to 20 volts, so if not Control, the battery will be damaged by additional charge. Most batteries require about 14 to 14.5 volts to fully charge. Generally, little maintenance, or trickle charge panels need no charge controller with about 1 to 5-watt panels. The overall system is that if the panel holds 2 watts or less for every 50 battery amphores, we don't need one.

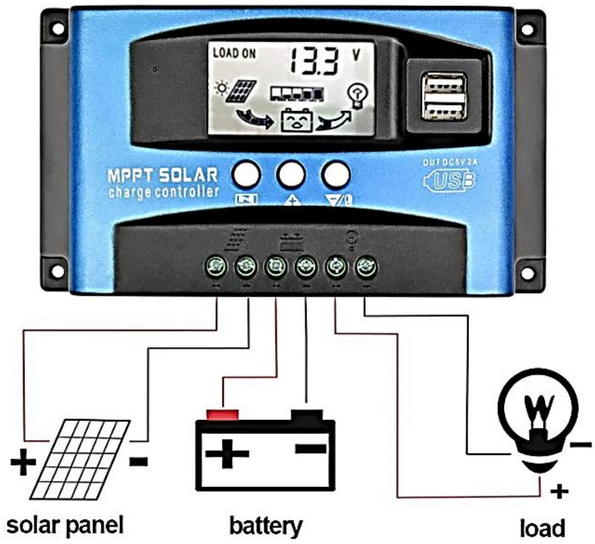

Figure 3.3: Charge Controller

3.4.1 Parallel or shunt controller

In this system the charge controller is in parallel with the battery and the load. When the battery is fully charged, the solar panel is shortened by the controller. This system requires a blocking diode. So that's not the reverse current panel battery. When the battery is charged through this block diode it heats up. Some of the disadvantages of a shunt controller are:

- Power loss,
- When the panel is summarized, a large amount of short circuit current (Isc) switches (FETs) flow,
- The shunt controller is warmer than the series controller.

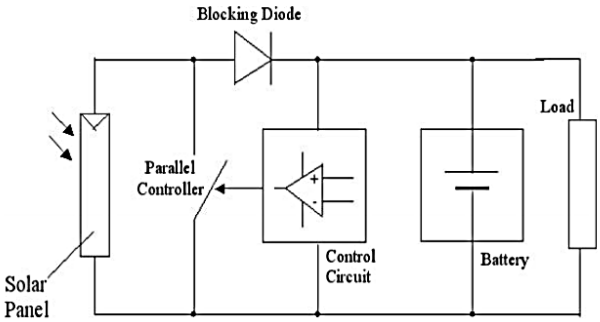

Figure 3.4: Parallel Controller in Solar Home System

3.4.2 Series controller

In this system the charge controller is connected between the solar panel and the battery. The series controller should be off of the battery to stop the power flow to the battery. There is no need to block the diode in this system, but it is used to stop the discharge system for several reasons. To minimize power loss, it must maintain as little resistance as possible. Advantages of Series Controller:

- Blocking diode is not required.
- The series controller switch is operated with a lower voltage than the shunt controller.
- Low switching sound.
- This is made possible by the precise charge of the battery and the PWM technique.

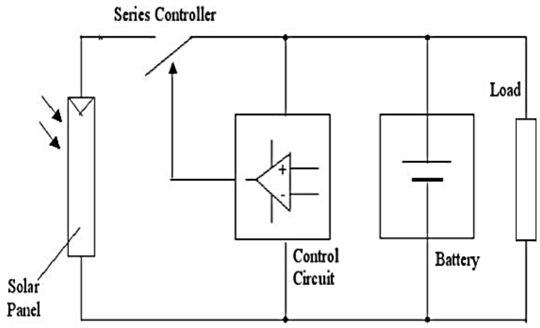

Figure 3.5: Series Controller in Solar Home System

3.5 Inverter

The electricity generated by the solar panel from the sun is usually DC. This DC power charge starts to accumulate in the battery through the controller. But we usually use AC loads in our homes so this DC current needs to be converted to AC which we can do with the inverter. Most AC devices will work fine on a modified sine wave inverter, but there are some exceptions. Devices like laser printers can be damaged if modified sine wave power is powered on. However, modified sine wave inverters make the transition from DC to AC very efficiently and they are relatively inexpensive.

Figure 3.6: Inverter

3.6 Battery

An electron, or electric cell, refers to a component that contains one or more electrochemical cells, and which has a connecting mechanism on the outside. When connected, electrons can provide the electrical power needed to operate a variety of electrical devices such as flashlights, mobile phones, or even electric cars. When an electron provides electrical power, its electrically positive end is called a cathode electron and the negative end is anode electron. Batteries can be connected in series or in parallel when using multiple batteries. If you want to increase the voltage, you need to connect the batteries to the series and if you want to increase the current, you need to connect the batteries to the parallel.

Figure 3.7: Battery

3.7 Photovoltaic Solar Power

Solar energy is an energy that is present in sunlight. For thousands of years it has been used by people around the world in various ways. As well as its common human uses in heating, cooking and drying, such as other power supplies are missing today, such as those used in power generation, such as in remote places and in space. Generating electricity from solar energy is becoming cheaper and in many cases it is now competitive with energy from coal or oil. The most common type of solar energy is the photovoltaic cells shown in fig 3.2, which converts light directly into electricity. Photovoltaic (PV) cells develop semiconductor technology to translate solar radiation directly into electric current that can be used immediately or stored for future use. PV cells are often grouped in the form of "modules" to produce arrays that have the ability to produce energy for orbiting satellites and other spacecraft.

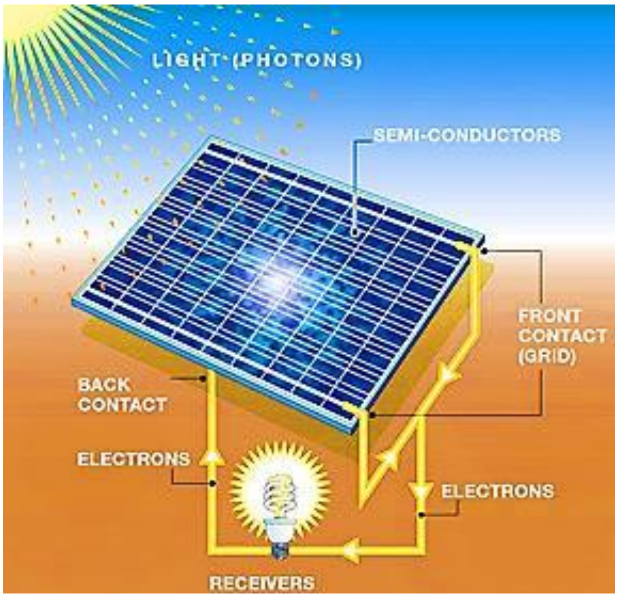

Figure 3.8: Photovoltaic Solar Power

Recently, with the continuous rejection of manufacturing expenditures (from 3% to 5% per year in recent years), the use of PV technology has included home electricity generation, and grid-connected power generation. Deployment of PV systems is growing exponentially due to extensive incentive programs that help limit the cost of these systems and allow users to advertise overload electricity on the public grid. With the increasing need for solar power, new technologies are being introduced and accessible technologies are increasing. There are 4 types of solar PV cells.

1. Poly Crystalline [Cell color blue]
2. Mono Crystalline [Cell color black]
3. Thin film
4. CIGS [Coffee color]

3.7.1 Poly Crystalline

Polycrystalline solar panels are made of similar silicon material so instead of following the slower and more expensive process of making single crystals, the molten silicon is simply put in one and cooled with a seed crystal. Using the casting method, the crystal around the seed is not uniform and many, smaller crystals have branches, thus the term "polycrystalline". The surface has a shaking appearance, with various variations of blue. Amesisola manufactures various types of polycrystalline solar modules.

3.7.2 Mono Crystalline

Mono Crystalline silicon is the base material for silicon-based discrete components and integrated circuits used in virtually all modern electronic equipment. Mono-Si also acts as a photovoltaic, light-absorbing element in the production of solar cells. Many small crystals make room for them. This is more than the low cost of mono Crystal cells have this efficiency rate of 15-17%. The color of this cell is black.

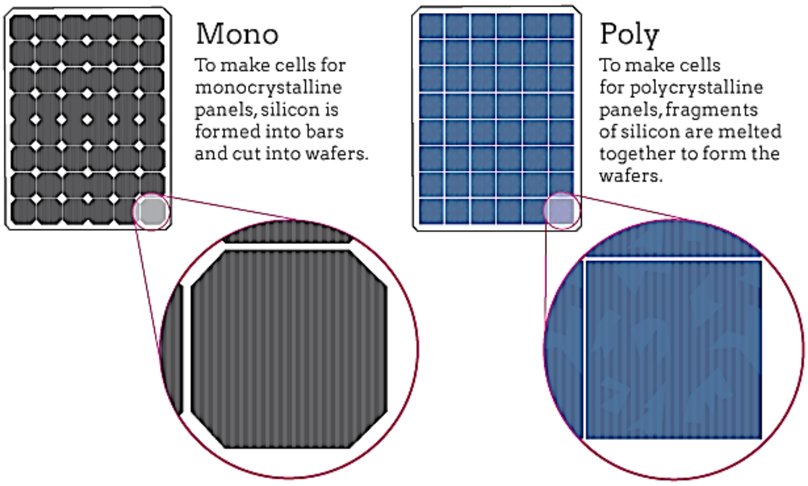

Figure 3.9: Characteristics of poly and mono crystalline solar panel

3.7.3 Thin Film

A thin film is a layer of material from a fraction of a monolayer to several micrometers in thickness. Controlled synthesis of materials such as thin films is a fundamental step in many applications. A familiar example is a household mirror, which usually has a thin metal coating on the back of the glass sheet to form the reflection interface. Solar panels are a type of device that is equipped to convert light energy into electrical energy. It is an updated cell and its weight is very low. It is made of plastic, metal or glass. The thin film is very flexible in other panels.

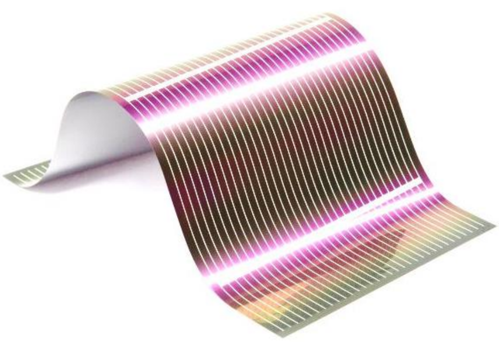

Figure 3.10: Thin Film solar panel

3.7.4 CIGS

CIGS (Copper Indium Gallium Selenide) is another thin film. The cell is producing gallium, indium, copper and a small layer of plastic or glass. A copper indium gallium selenide solar cell, which is a solar cell used to convert fine light into electrical energy. Since the material has a high absorption coefficient and absorbs sunlight vigorously, much thinner film is required than other semiconductor elements. Since the material has a high absorption coefficient and absorbs sunlight vigorously, much thinner film is required than other semiconductor elements.

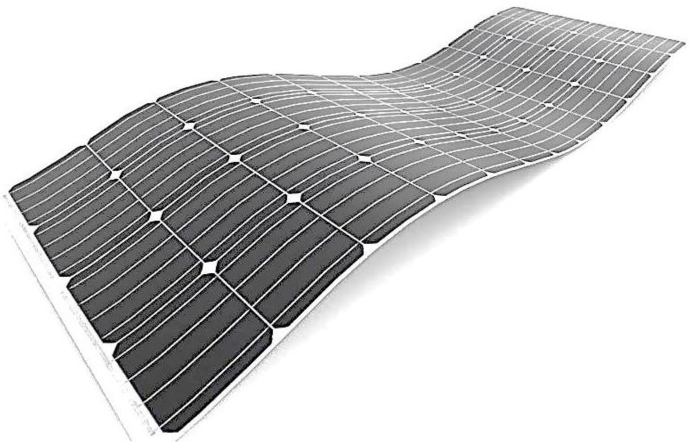

Figure 3.11: CIGS solar panel

3.8 Components of a Solar PV System

A common solar PV system includes solar panels, charge controllers, batteries, inverters and load. Figure 3.12 shows the block diagram of the national system.

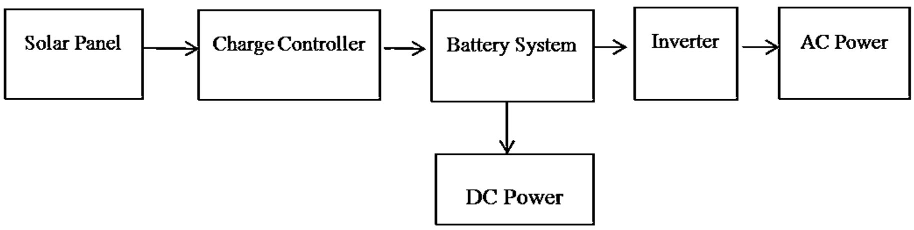

Figure 3.12: Block diagram of a typical solar PV system

3.9 Tracking Systems

Tracking systems are hardware devices that are frequently used in pole-mounted solar arrays that allow for solar panel location to follow the movement of the sun. This helps ensure that the solar cells have the highest exposure. A tracking system can increase the output of your PV system by 30% in summer and 15% in winter in non-track systems. Tracking systems are usually confidential as passive or active. In a passive system the tracker follows the sun from east to west without using any type of electric motor in kinetic energy. Instead, the system is rotated by the arrangement of heat and gravity. Since electricity does not require any external basis such systems are ideal for off-the-grid situations in the grid or for use with water pumping systems where peak command is at its peak in the summer. Tracking systems are sometimes also privy to the number of axes they track against. Normal an axis system simply rotates left to right rather than an arch. A two axis tracking system will track from left to right and both top and bottom. This allows the original arch of the sun to follow more accurately during the day. Passive tracking systems have some limitations. First, they are at risk in a bit of high air that can drop the tracker in the right direction. They can also be a bit lazy to operate in cooler temperatures because they are electrically driven and mechanically powered. Active tracking systems are powered by small electric motors and require a kind of organized module to operate them.

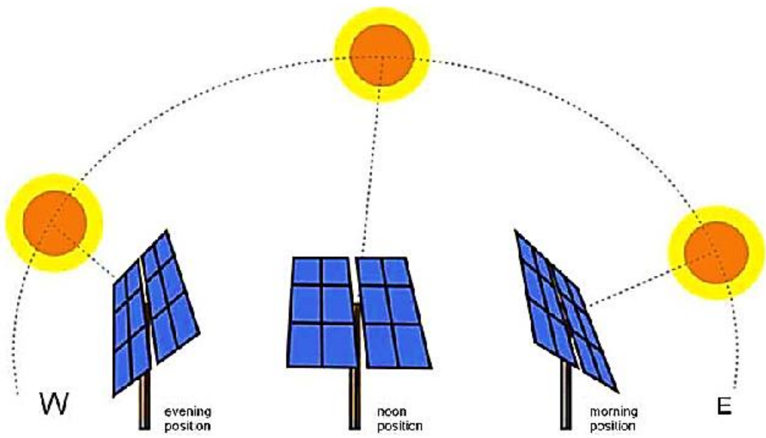

Figure 3.13: Solar PV Tracking System

They are comparable to systems that support giant TV dishes. Active systems require some electrical power, which can come from an external source or from a solar panel depending on the model [49]. The big question with the trackers is whether the supplementary costs of the first tracking system, both the initial cost and the maintenance cost, are justified by the extra electrical power they generate. Tracking systems need to be saved and simply adds a great deal of complexity to the system.

3.10 Photovoltaic Modules

The PV modules are completed from the solar cells connected to the series and are parallelized to achieve the desired current and voltage levels. Solar cells are weatherproof because they have to be weather resistant and electrical allies have to be rigid and corrosion free. The general production of the PV module is shown in Figure 3.14. Because the cells are fragile, they are bound to the polymer ventilated layer of ethylene vinyl acetate (EVA), so the cells are cushioned and restricted to transport and handling in that way. The upper cover is a tempered glass that is treated with an antireflection coating so most of the light is transmitted to the cell. At the bottom is a sheet of polyvinyl fluoride (PVF), also known as Tedler, a synthetic polymer (CH2CFF) N that inhibits moisture and protects cells from chemical attack.

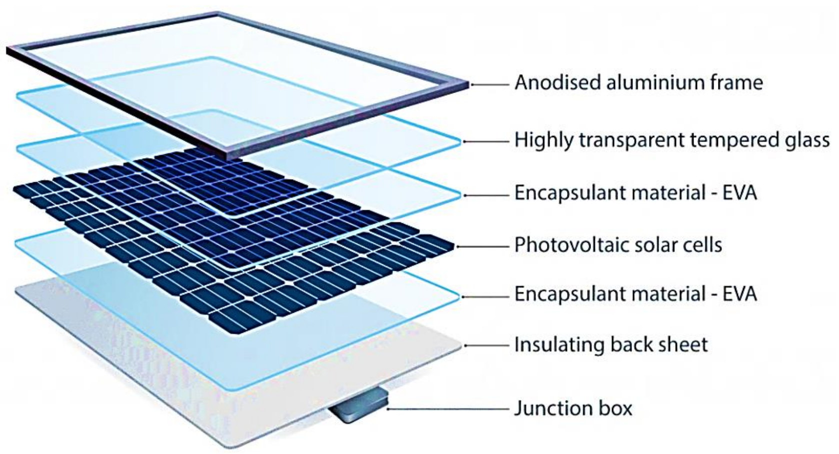

Figure 3.14: PV Module typical construction

The aluminum frame is used for easy mounting and handling and extra protection. Frameless modules are sometimes used in fax for aesthetic reasons. This general construction is used because the PV module has to "survive" for at least 20-25 years, sometimes extreme, in different weather conditions. This construction assures the least lifetime of the PV modules. In fact, PV panel manufacturers offer a guarantee of at least 20 years, for example, BP Solar assures 85% of the minimum amount of warranted power output after 25 years of service, 93% of the minimum warranted power output of 12 years and a five-year warranty of materials and workmanship. This national long guarantee is extremely long compared to most products and due to the special construction of PV modules.

3.11 Solar Cell

A solar cell or a photovoltaic cell is an electrical device that converts the energy of light into a power unaffected by photovoltaic effects. It is a form of photoelectric cell that is guaranteed as a device, whose electrical properties, such as current, voltage or resistance, change when exposed to light. Solar cells are the building blocks of photovoltaic modules, otherwise known as solar panels. Source the solar cells are described as photovoltaic, regardless of sunlight or artificial light. They are used as photo detectors (for example, infrared detectors), detecting light or other electromagnetic radiation near a symptomatic range or measuring the intensity of light. Operation of a photovoltaic (PV) cell requires three basic features [29]:

1. The combination of light produces either an electronic-hole pair or an extension.
2. Reverse type of charge carrier separation.
3. Individual withdrawal of these carriers in the external circuit.

Figure 3.15: Solar Cell

The basic steps in the procedure of a solar cell are as in figure 3.16 and figure 3.17:

- The generation of light-generated carriers;
- The collection of the light-generated carries to generate a current;
- The generation of a large voltage across the solar cell; and
- The indulgence of power in the load and in parasitic resistances.

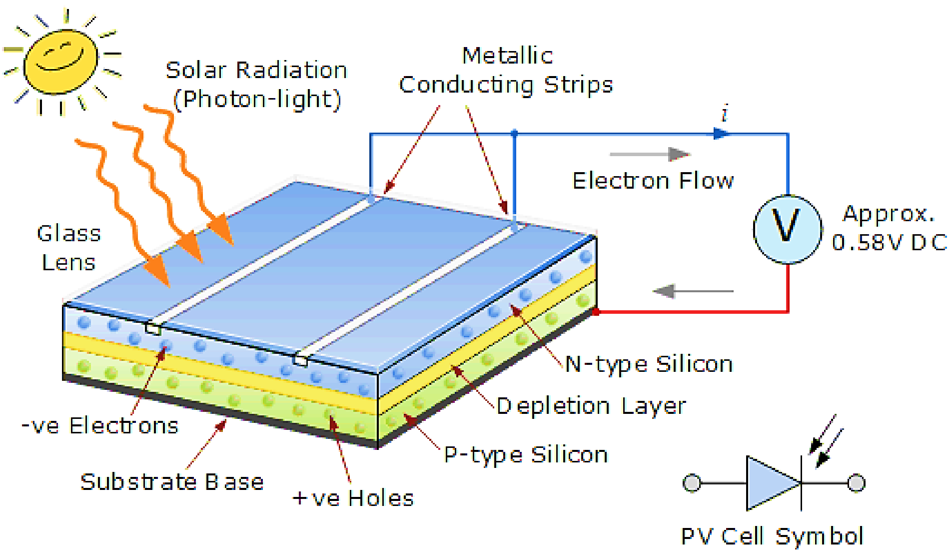

Figure 3.16: Structure of Solar cell

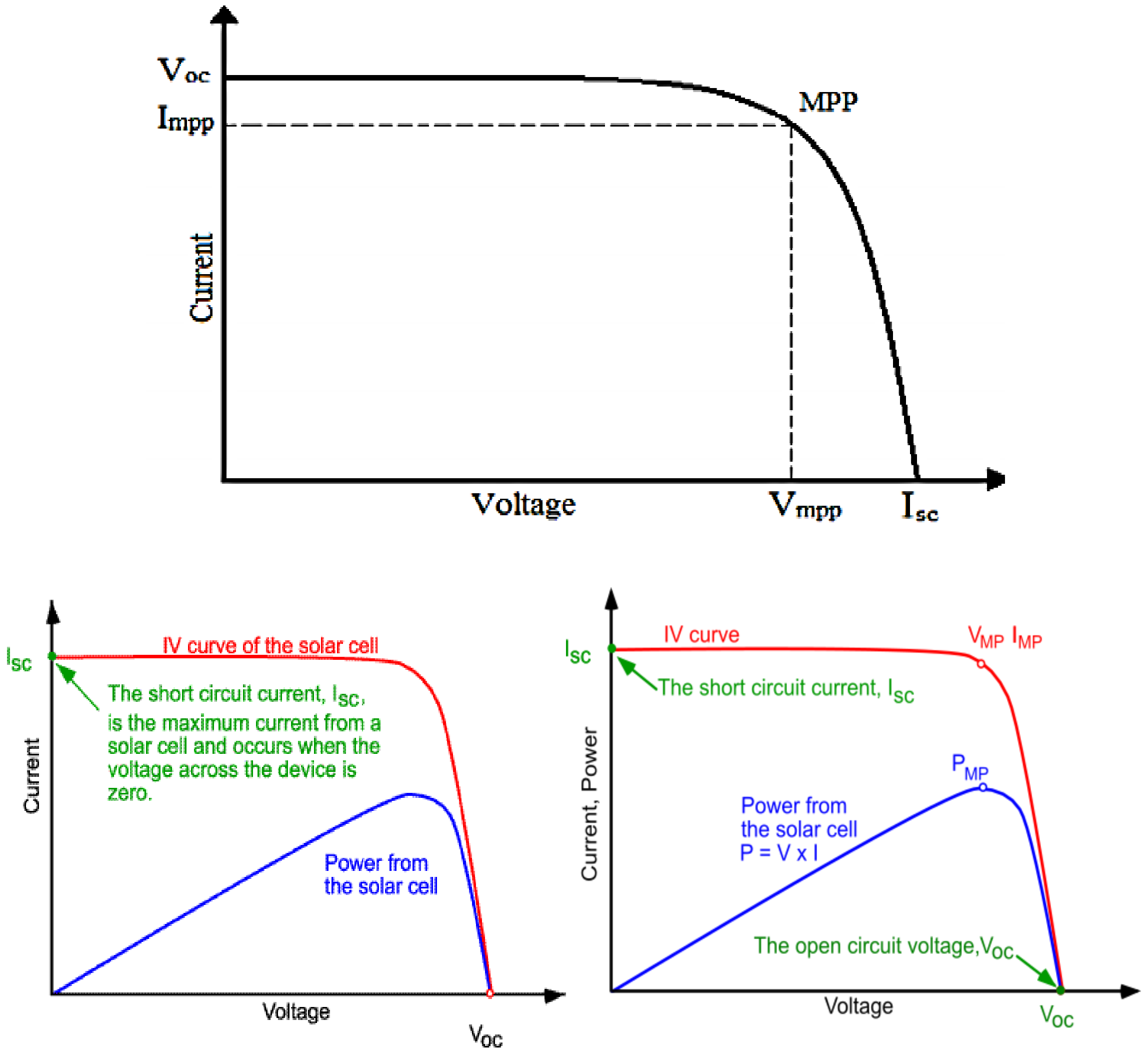

Figure 3.17: I-V characteristics of the PV cell

CHAPTER 4

METHODOLOGY

4.1 Introduction

Bangladesh is a suitable country for Solar. We take sunlight 6 to 8 months a year. Four to six months of sunlight is very good for generating electricity. There is no current in our country's grid area, but this area is suitable for photovoltaic cells, so the government attached the place and suggested located for the solar home system. There are a lot of buildings in Dhaka city, this height is very good. The roof top of this building is connected to a solar panel and grid, which means it, is connected to the main switch in this building. The medium-sized solar panel reduces costs and reduces electricity bills by about ten thousand per year.

4.2 Description of Study Area

Our field of study has been established on the roof of the administrative building of Daffodil International University. It is located in Dhanmondi, Dhaka, Bangladesh. Its inception began as the residential area of the city in 1 and for decades it has become a small town with malls, schools, banks, offices and universities. The field of study (Figure 4.1) is a place where we collect data for our work. Different types of solar panels are installed there like 45W, 60W and 100W. We study the performance analysis of 45W off the grid solar panel.

Figure 4.1 Steady area (DIU AB Building)

4.3 Satellite View

Figure 4.2: Satellite View

4.4 System Design

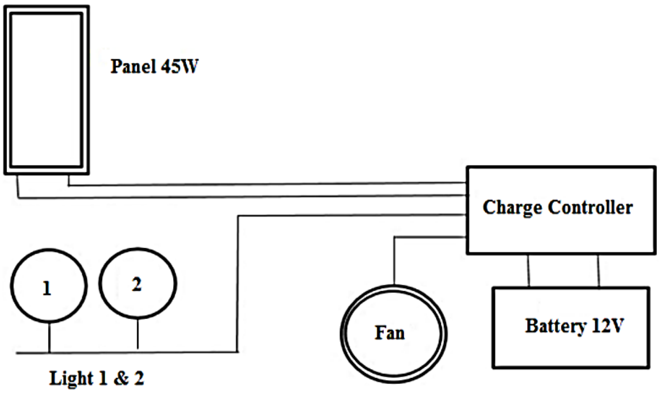

Figure 4.3: System Design (45W)

4.5 Solar Panel

Devices that convert solar panels to light. These are called "solar" panels because most of the time the sun is called the most powerful source of astronomers. Some scientists call them photovoltaic, which is basically "light energy." Solar panel compilation of solar cells. Large solar cells scattered throughout a large area can work together to achieve a greater volume. To illuminate one more house, which produces electricity, spaceships are usually created with solar panels, which can always be directed toward the sun, while the remainder of the spacecraft remains almost constant, since the tank is moving independently of the tank, the target. There are three types of solar panels in our workplace. Power is produced when solar modules are illuminated on their front surface, if the DC voltage can exceed 30V, then the voltage equal to the total voltage of the individual module is connected to the module. If the module is connected in parallel, the total current is equal to the current currents. There are:

1. 45watt solar panel
2. 60watt solar panel
3. 100watt solar panel

During the first ten years, cells can produce no less than 90% of their initial minimum energy and not less than 80% of their initial minimum stated energy for 25 years.

4.6 45W Solar Panel

This is a small solar panel where we work. This area is 0.32 m ^ 2. The solar cell always sets 23 degrees to the south for Bangladesh. So this solar panel is shining directly into the sun. Germany's solar cells are made in Germany. The room temperature is 25 degrees Celsius for measuring energy in standard test conditions (STC). The efficiency of this solar cell and 45W panel made in Germany is 14%.

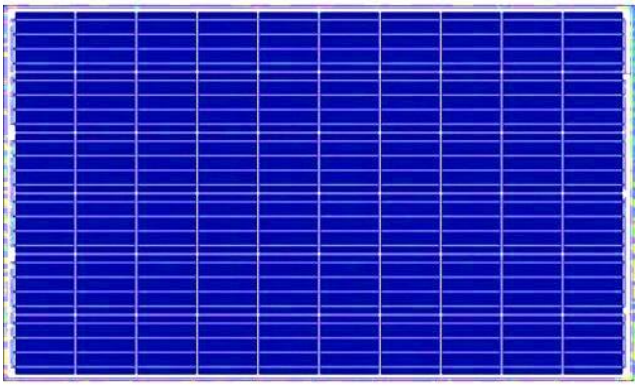

Figure 4.4: 45W Solar Panel

4.6.1 Electrical Specifications

1. Maximum Power(PmP) 60wp
2. Open Circuit Voltage(Voc) 21.5v
3. Short Circuit Current(Isc) 3.76A
4. Voltage at Maximum Power(Vmp) 17.5v
5. Current at Maximum Power(Imp) 3.46A
6. Module Dimension 805*550*35mm
7. Module Weight 5.9+-3%

4.7 Measurement Equipment

We measure different data in this work. There are open circuit voltage, short circuit current, voltage at maximum power, current at maximum power, maximum power, fill factor, irradiance and temperature. There are three measuring tools in our work. There are:

1. Photovoltaic Meter
2. Irradiance Sensor
3. Temperature Sensor

4.7.1 Photovoltaic Meter

The photovoltaic meter is the most important meter in our work. These are different data measurements. Solar meters allow the display of real-time PV energy production data. Photo: Solar-log solar meters can refer to pyrometers, which are used to measure solar radiation flux density (W/m2), or devices used to measure KWH production from PV systems. Photovoltaic meters are very useful for planning and maintaining photovoltaic parks. Photovoltaic meters are commonly used to test photovoltaic modules for better location detection and efficiency. Solar power is one of the most important alternatives of the day because it will be attractive to invest in this sector for long-term benefits. Photovoltaic installation uses solar radiation heat to generate energy from solar light. A good plan is essential before installing a photovoltaic park. Our photovoltaic meters allow users to record direct sunlight over extended periods of time. For further analysis of the radiation value, the meter is stored in the internal memory.

Figure 4.5: Photovoltaic Meter

4.7.2 Irradiation Sensor

When we measurement our data we connected the irradiance meter is connected to the photovoltaic meter. Then the meter show the irradiance of photovoltaic meter. Evolution is defined as a measure of solar energy and it is declining solar energy onto a surface. Power unit w (brief briefly w). In the case of solar immersion we typically measure the strength of each unit area, so the separation is usually quoted as w / m ^{2}- it is per square meters per watts. The amount of solar energy that falls within the given period is called the irony. A measure of the power of taunts. It is added to the power of the sun during some time. Now here comes the confusing part. If the sun is illuminated in constant 1000 watts / m for an hour, we say it supplies power of 1 kilowatt / m ^{2} The power amount of power (1000 Watts / m ^{2}) is the length of the bar (1 hour) and the power unit is none. Disorder (measured in KWA) is not the same as the measurement (measured in KOD), which is not miles miles per hour. Another commonly used term is the "peak sun hour" that reflects the energy received during the daily hours, which is determined by the equal number of hours reaching the solar energy valued at 1000 watts / m^2 of the total energy value. This term is interchangeable with kWh / m^2 / day.

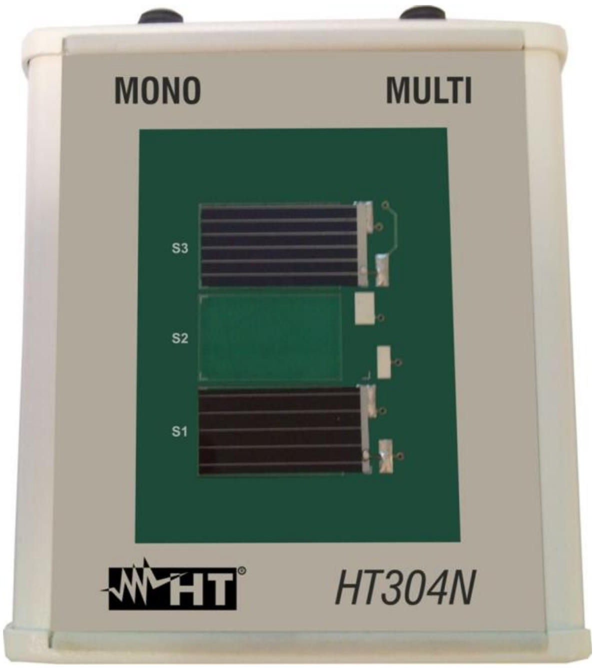

Figure 4.6: Irradiation Sensor

4.7.3 Temperature Sensor

A temperature sensor, a thermocouple or RTD (resistance temperature detector) is required to measure the temperature through an electrical signal. Thermocouples are made of two separate metals, resulting in the proportional production of atomic voltage for temperature change. Temperature sensor measures the warmth or cooling of an object. The function of the sensors is to read the voltage across the base diode. If the voltage increases, the temperature increases, and the transistor terminal of the base and emitter have a voltage drop, they are recorded by the sensor. If the voltage difference is increased then the device produces an analog signal and is directly proportional to the temperature.

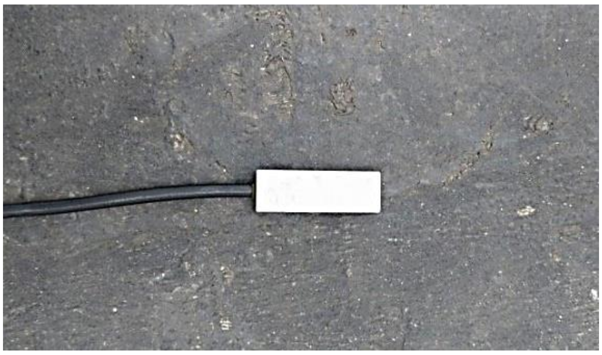

Figure 4.7: Temperature Sensor

4.8 Flow Chart

The variant is a type of image that represents a workflow or process. The flanked arrows show numerous types of boxes and steps as their order boxes. We use flowcharts to analyze, document or manage processes or programs in various fields.

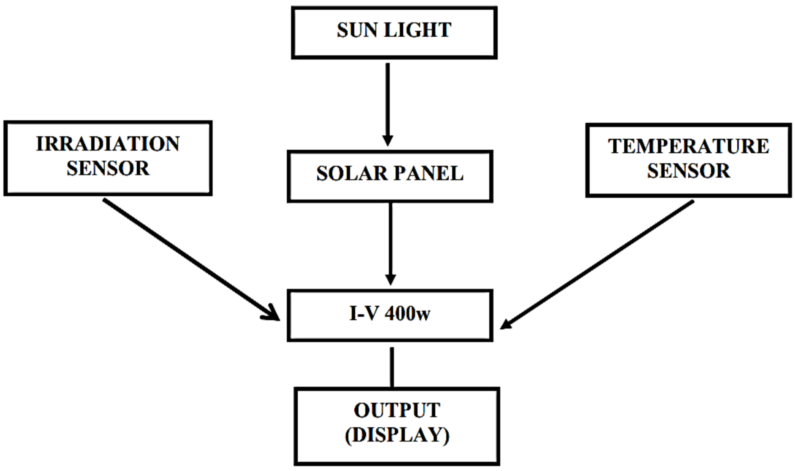

Figure 4.8: Flow Chart

4.9 I-V 400 W Calibration

Before starting the measurements, we must calibrate the I-V400W. The I-V400W calibration parameters are given below Table 4.1.

Table-4.1: I-V 400 W Calibration

Pmax	50W
Voc	21.42 V
Vmpp	17.10 V
Isc	3.20 A
Impp	2.92 A
Toll-	1.0 W
Toll+	1.0 W
Alpha	0.033%/ ℃
Beta	-0.034%/ ℃
Gamma	-0.042%/ ℃
Noct	45 ℃
Tech.	STD
Rs	1Ω
Degr	0.0%/yr

4.10 Data Measurement Technique

Our data collection process was very lengthy. We work to a few month of the year. We collect the data in the day time. If sunny day we measure our data. We assume data in day time start 6AM to 6PM. It depends on the irradiance and sun light. Sun light here then measure the data. Total ten to twelve times metering in the data in every hour. The Figure 4.9 shows our work time and place when our data is measured.

1. First we go to the roof top the work building.
2. Then we start our work. We connect the solar panel to the photovoltaic meter and the irradiance meter.

3. It is also connected to the temperature sensor.
4. Then we have the data dimension at 45 watts
5. The data here is the photovoltaic meter when the solar panel is connected to the whole meter. We take a picture of all the data.
6. Then we connected the 60 watt solar to the photovoltaic meter and the temperature sensor. Again we snap all the data from the 60 watt solar panel to my mobile phone.
7. Lastly we joined the photovoltaic meter and temperature sensor from 100 W cells. Collect all the data and take a picture on our phone.

Figure 4.9: Data Measuring

It is perfect for a sunny day. These days we measure all the data we collect. On a rainy day and Low light sun radiation is low so there is no data on this day.

4.11 Put the Data in Lab Sheet

We collected data ten or more times in one day. We collect and put up in the Google Sheets or Lab Sheets. All data set is maximum power, open circuit voltage, short circuit current, voltage at maximum power, current in maximum power, fill factor and irradiance. Table 4.3 provides all the elements that a panel measures.

Efficiency = Output/Input

Output = Power of solar panel

Input = Irradiance*Panel area

Suppose,

P max = 1.47w

Input = 54 w/m^2*0.32m^2

Then efficiency = 8.5%

Table 4.2: Represents parameter-wise data of 45 watt solar panel of a single day (17-May-2019) starting from sunrise to sunset.

Irradiane (W/m2)	Voltage (V)	Current (I)	Vmpp (V)	Impp (I)	Fill factor	Pmax (W)	Area of Panel (m2)	Efficiency (%)
90	19.3	0.24	12.8	0.14	0.44	1.792	0.32	6.24%
225	20.1	0.8	18.3	0.41	0.48	7.503		10.45%
348	20.9	1.95	7.3	1.74	0.32	12.702		11.44%
351	20	0.68	16.4	0.52	0.7	11.54		10.31%
302	20.1	0.85	16.5	0.74	0.71	12.21		12.67%
482	20.1	0.89	16.4	0.98	0.72	16.072		10.45%
488	19.8	0.84	17.6	1.12	0.73	19.712		12.66%
381	19.9	1.05	15.6	0.95	0.71	14.82		12.19%
524	20.1	1.34	14.8	1.21	0.66	17.908		10.71%
480	19.8	0.84	18.1	1.5	0.74	27.15		17.73%
325	19.5	0.65	8.5	0.5	0.34	4.25		4.10%

Where,

Voc =, Open circuit voltage

Isc =, Short circuit current

Vmpp =, Maximum power at voltage

Impp =, Current at Maximum power

Fill factor =, Vmpp*Impp/ Voc*Ioc

Pmax =, Vmpp*Impp

Efficiency = Pmax/ Irradiance* panel area

CHAPTER 5

DATA ANALYSIS

5.1 Introduction

In order to use solar power more efficiently, we need to measure irradiation in our country for its importance, along with changes in radiation over time. In this thesis our main strength was to find the sun's radiation in our Dhaka city. The latitude and longitude of Dhaka are 23.70 ° and 90.37 °, respectively. Solar panels and our used data we can easily understand solar power generation by solar, and in April and May, the city of Dhaka can create a standard form of solar power generation. Our focus of this thesis is the magnitude of the solar irradiation and the continuous energy produced by the 45 W panel. There are some parameters like as irradiance, Pmax. Equivalent strength is the coefficient between the irradiance and panel region. Also, the equivalent power is the input power (45 W) of the total solar panel and the output power is Pmax. We measured the data with an I-V 400W Photovoltaic Panel Analyzer (operational condition).

5.2 Irradiance:

Solar irradiation (SI) is the force per unit area of the Sun to be recognized in the form of electromagnetic radiation in the wavelength range of a calculation device. Solar Irradiance integrated with time is called solar irradiation. Total solar irradiance (TSI) is a measure of solar power over all wave lengths per unit field. SI unit of irradiance per square meter watt (W/m^2).

5.2.1 Irradiance of April 2019 for 45W panel

The April 2019 solar irradiance data for the 45W panel are recharged. Here we can see that the highest value of solar irradiance we measured was on April 29^{th} and it was about 767 W/m^2 it is indicated here with a Green color and the lowest irradiance value was found on April, 20^{th} which is about 275 W/m^2 It is indicated here with a purple color & and the reason behind this scenario was weather change.

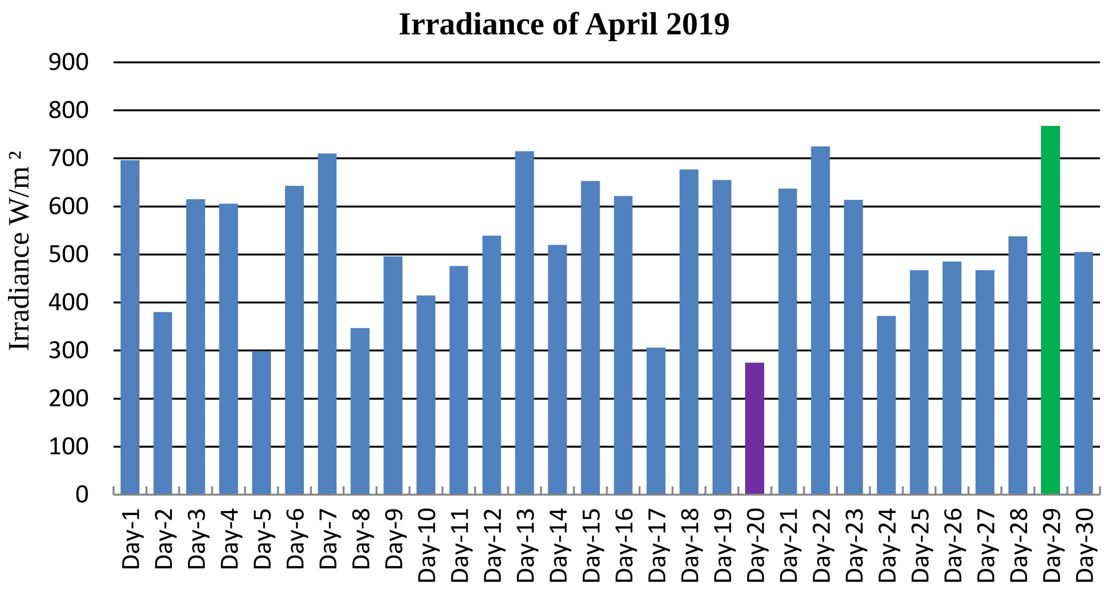

Figure 5.1: Daily irradiance for April

5.2.2 Irradiance of May 2019 for 45 W Panel

May 2019 solar radiation data for 60 watt panels. The highest value of solar radiation here was May 15th, and it was about 623 W / m ^{2} it is indicated here with a Green color and the lowest value of solar radiation was May 29th, which was about 156 W / m ^{2}it is indicated here with a purple color, and the reason behind this scenario was weather change.

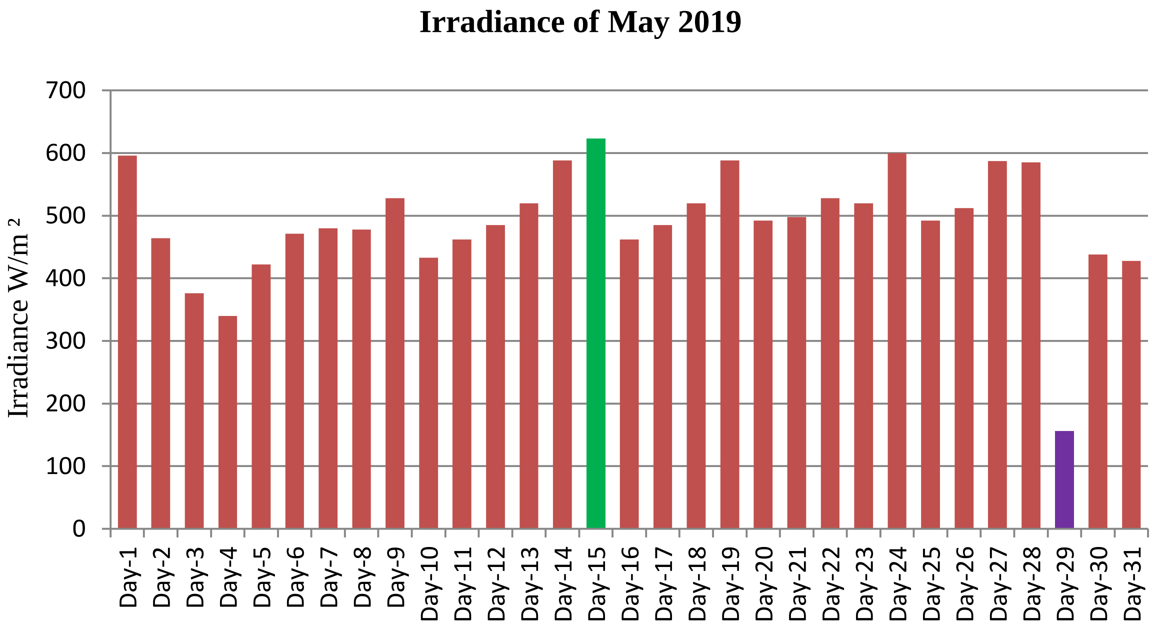

Figure 5.2: Daily irradiance for May

5.2.3 Irradiance comparison between April and May 2019 for 45 W Panel

Figure 5.3 presents the comparison of solar Irradiance between April and May of 2019 for the 45 W solar panel. The maximum values were 767 W/m ²on 29th April and 623 W / m ²on 15th May it is indicated here with a Green color, where the lowest values for solar Irradiance were approximately 275 W / m ²on 20th April and 156 W / m ²on 29th May it is indicated here with a purple color.

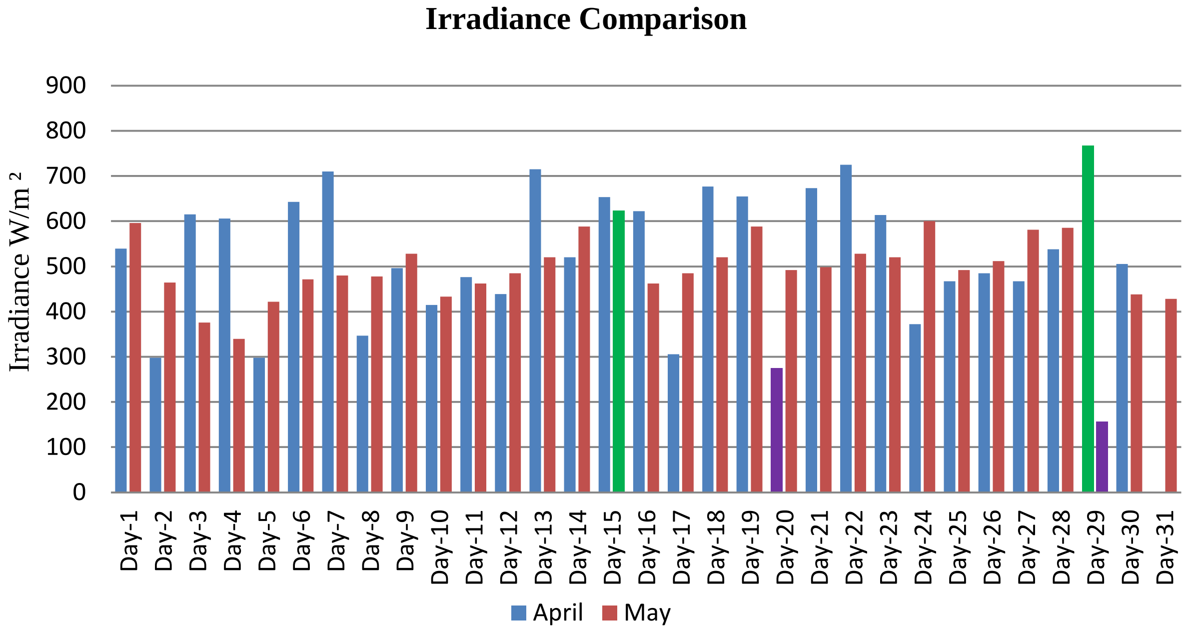

Figure 5.3: Irradiance comparison between April and May for 45 W Panel

5.3 Power

Solar energy is the cleanest, most reliable form of renewable energy and can be used in various forms to strengthen our home or business. Solar-powered photovoltaic (PV) panels convert sunlight into electricity through attractive electrons using photons of light from the sun in silicon cells. This electricity can then be used to supply renewable energy to our home or business. Power's SI unit is watt. The power equation, $P = V \times I$.

5.3.1 Power of April 2019 for 45 W Panel

Figure 5.4 represents the maximum power generation curve of the 45 W solar Panel in April 2019. On 1st April we got the highest value of maximum power 25.34 W it is indicated here with a Green color and the lowest value of maximum power 5th April that was about 9.62 W it is indicated here with a purple color.

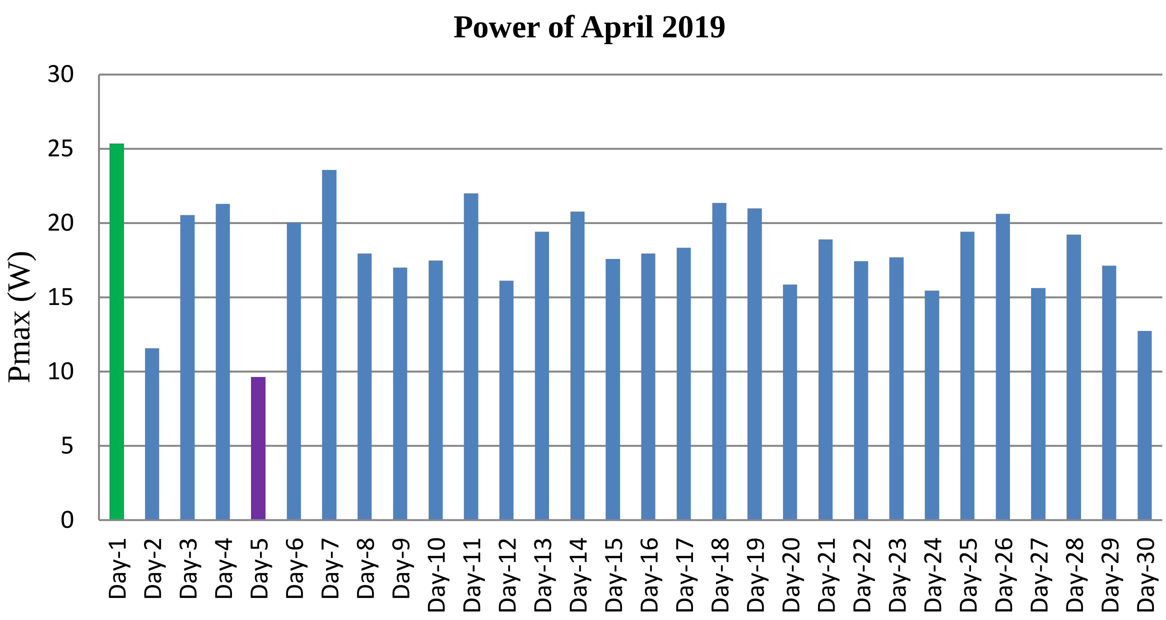

Figure 5.4: Power of April 2019 for 45 W Panel

5.3.2 Power of May 2019 for 45 W Panel

Figure 5.5 represents the maximum power generation curve of the 45 W solar Panel in May 2019. On 21st April we got the highest value of maximum power 24.44 W it is indicated here with a Green color and the lowest value of maximum power 25th April that was about 8.85 W it is indicated here with a purple color.

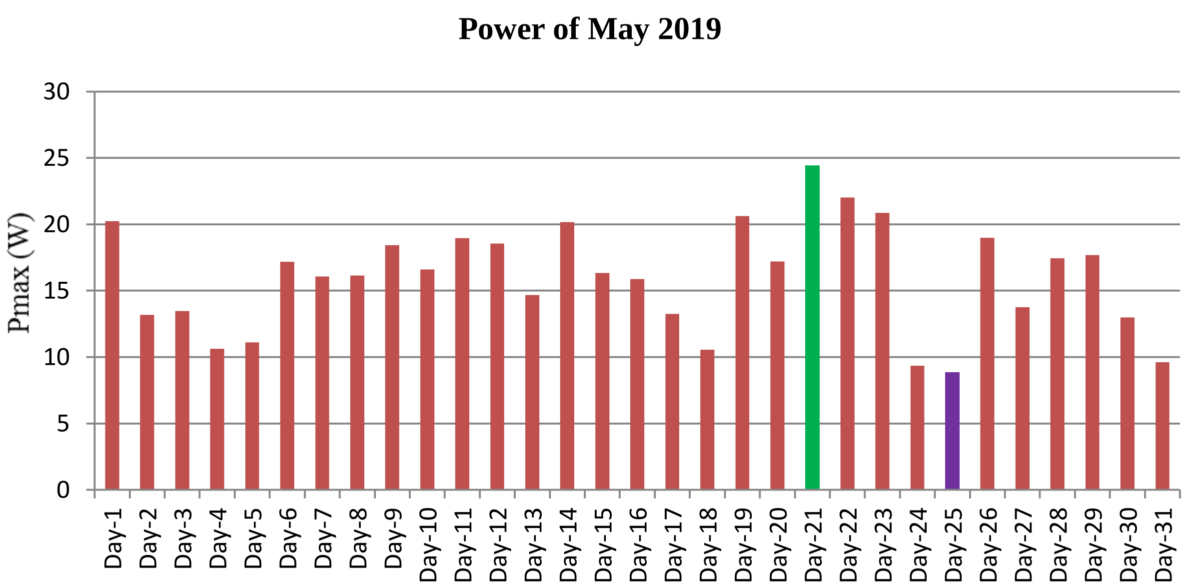

Figure 5.5: Power of May 2019 for 45 W Panel

5.3.3 Power Comparison between April and May 2019 for 45W Panel

Figure 5.6 presents a comparison of the maximum power generation curve between April and May of 2019 for the 45 W solar panel. The highest values show that the maximum power generation curve was 1st April 25.34 W and 21st May 24.44 W it is indicated here with a Green color where the minimum values were approximately 9.62 W on 5th April and 8.85 W on 25th May.

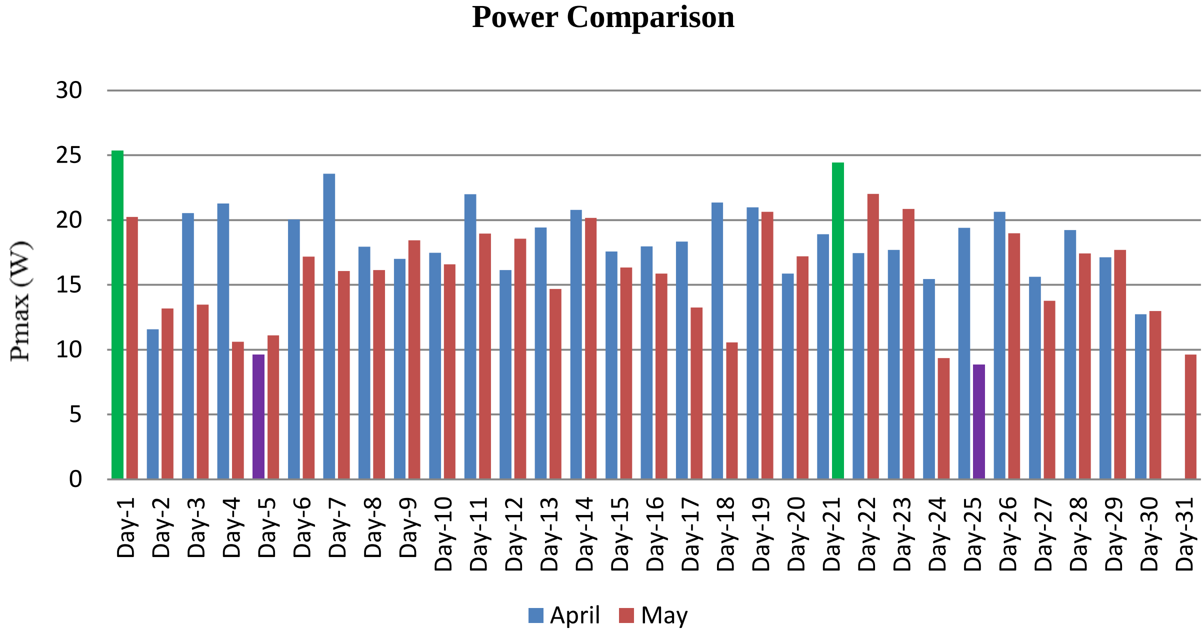

Figure 5.6: Power comparison between April and May for 45 W Panel

5.4 Efficiency

The efficiency of the solar cell is currently from about 20% to about 40% in the height range, while it is improving. The remaining sunlight on the panel is wasted as heat. More efficient photovoltaic cells have been identified (up to 43% efficient) but they are newly discovered and artistically expensive [30].

5.4.1 Efficiency of April 2019 for 45 W Panel

Here,

Irradiance (avg) of April = 540.7 W/m ^{2}

Pmax (avg) of April = 18.30 W

Area of panel for 45 W = 0.32 m ^{2}

So the average efficiency of April = Pmax (avg) of April/ (Irradiance (avg) of April * Area of panel for 45 W)

Panel Efficiency of April (average) = 10.57%

5.4.2 Efficiency of May 2019 for 45 W Panel

Again,

Irradiance (avg) of May = 488.93 W/m ^{2}

Pmax (avg) of May = 15.97 W

Area of panel for 45 W = 0.32 m ^{2}

So the average efficiency of May = Pmax (avg) of April/ (Irradiance (avg) of April * Area of panel for 45 W)

Panel Efficiency of May (average) = 10.2%

5.4.3 Efficiency Comparison between April and May 2019 for 45W Panel

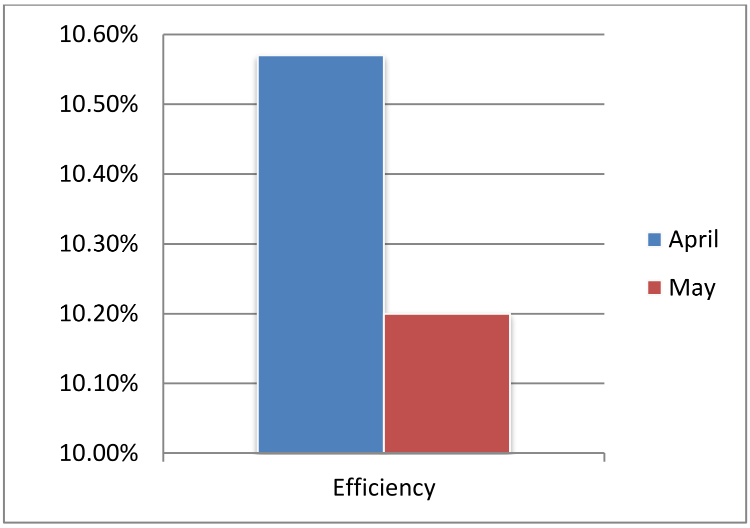

Figure 5.7: Efficiency comparison between April and May for 45 W Panel

5.5 Comparison of Solar Radiation Data Among Different Years

This is the monthly average solar irradiance data for 2008, 2009 and 2010. At 2008, the average annual solar irradiation was 5.01 kW / m ² / day and the radiation value decreased at 2009 and was 4.73 kW / m ² / day. The declining trend of solar irradiation quality was also observed between 2009 and 2010 because in 2010 only 4.50 kWh / m ²/ day irradiation was measured as described in Table 5.1.

Table 5.1: Data of Monthly Average Solar Irradiance in 2008, 2009 & 2010 [31]

Month	**Solar Irradiance (w/m^2) 2008**	**Solar Irradiance (w/m^2) 2009**	**Solar Irradiance (w/m^2) 2010**
January	164.9	165.6	151.5
February	209.8	219.1	186.7
March	225.7	228.3	238.2
April	283	273.1	236.7
May	261.1	235.1	225.8
June	212.4	210.3	176
July	176.2	197	201.6
August	174.1	177.5	166.3
September	189.6	166.8	165.5
October	179.7	189.1	175.2
November	208.1	164	168
December	123.7	142.5	159.2
Annual Average Irradiance (w/m^2)	209.05	197.36	187.55
Annual Average $kWh/m^2/day$	5.01	4.73	4.50

Solar radiation data was collected from the Center for Renewable Energy Research (University of Dhaka), National Renewable Energy Laboratory and Development and Research is given in Table 5.2. Most of the solar radiation data was collected from different cities of Bangladesh. In 1985-1991, the annual average solar radiation was 4.59 kWh / m ²/ day and in 1987-89 it increased to 4.64 kWh / m ² / day. However in 2000-03, the annual average radiation was 4.52 kWh / m ²/ day, which decreased to 4.2 kWh / m ² / day in 2003-05. At 2006 the radiation was increasing, and the value was 4.45 kWh / m ²/ day.

Table 5.2: Collected Solar Irradiance Data of Bangladesh from 1985-2006 were Presented Below [32].

Month	NREL (1985-91)	RERC (1987-89)	RERC (1992)	DLR (2003-05)	RERC (2003-05)	RERC (2006)
January	4.18	4.29	3.34	4.58	3.16	3.4
February	4.68	4.86	4.05	4.81	4.46	3.79
March	5.55	5.53	5.24	5.31	4.88	5.04
April	5.65	5.23	6.02	5.84	5.28	5.06
May	5.58	5.67	5.76	5.21	5.46	5.09
June	4.88	5.13	5.39	3.85	4.22	4.8
July	3.9	3.87	4.2	3.76	4.48	3.84
August	4.12	3.92	4.87	4.11	4.12	4.73
September	3.96	4.5	5.38	3.76	3.78	5.15
October	4.7	4.61	4.93	4.19	3.57	3.18
November	4.25	4.22	3.72	4.47	3.92	3.35
December	4.04	3.89	3.39	4.34	3.19	2.84
Annual Average (kWh/m^2-day)	4.59	4.64	4.69	4.52	4.21	4.45

Table 5.3: Collected Data from 1985-2005, 2008-2010, 2018 and 2019 Compare Irradiance Among them were Presented Below

Year	Month	Irradiance kWh /m ^{2}/day
1985-1991	April	5.67
	May	4.89
2001-2004	April	5.82
	May	5.62
2005-20010	April	4.87
	May	5.23
2011-2014	April	4.41
	May	5.12

2015-2017	April	5.98
	May	4.82
2018	April	5.76
	May	5.63
2019	April	6.54
	May	5.87

Table 5.3 after analysis, we can say that in April we received the highest amount of irradiation than May. In 1985-1991, April and May average solar radiation was 5.67 and 4.89 kWh / m ^{2} / day and it was promoted in 2001-2004 5.82 and 5.62 kWh / m ^{2} / day. However, the average radiation was 4.87 and 5.23 kWh / m ^{2} / day in 2005-10, April and May which were reduced to 4.41 and 5.12 kWh / m ^{2} / day in 2011-14. At 2018, the radiation was cumulative and the values were 6.54 and 5.57 kWh / m ^{2} / day. Additionally, in 2019, irradiation is higher than any other year, for that reason we can Of course, say that global warming is increasing day by day.

CHAPTER 6

CONCLUSION

6.1 Conclusion

Bangladesh is a small country with the largest population in the world. Bangladesh is the most densely populated country in which 79% of the population lives in rural areas. The main problem is the development of the energy crisis. Countries generally feel the supply of unmet demand for electricity. Fossil fuels depend on both the private sector and state-owned power plants. Natural gas supply is not enough to meet the demand. More importantly, existing oil and gas will be exhausted once a day. So we have to think about other energy sources. Solar energy can be an alternative source of energy.

The overall enthusiasm for the essentials will be more than double that of the mid-century and the end of the triplet consecutively. Dealing with this interest is the driving test of society. The progress of maintainable energy sources on existing unnecessary advances can overcome any barriers between the current creation and the needs of tomorrow. The vast unknown affordability of the obsolete sun is a delightful opportunity to meet the needs of our future needs. This unfamiliar source has traveled extensively through the open door to hold the booster for use.

East of India in Bengal Nero, Bangladesh is a beautiful green and numerous pirate country in South Asia. It is located between 20.87 °N and 26.48 °N scopes and 88.35 °E and 92.3 °E longitude. In Bangladesh, about 147,570 square km, the perfect area is connected to various waterways. Bangladesh is a tropical country, experiences dry weather from September to May and experiences rainfall from June to August. It consists of eight divisions - Dhaka, Chittagong, Khulna, Rajshahi, Barisal, Sylhet, Rangpur and Mymensingh. Virtually all locale energy is experiencing an emergency. Power supply is insufficient in the provincial regions, which rarely addresses problems where electricity has not yet arrived, especially in some regions. Parts of the new power plant are still gaining interest. Taking care of the total demand for electricity, hiring a sun-based vitality can be a great opportunity and helps to measure the sun's vitality over Bangladesh. Al though Sunflower Home Framework is very famous in Bangladesh. Establishing strong, reliable, clean, and naturally life-sustaining systems by setting up sun-based home frameworks, provides a helpful and effective method for energy, and it impacts the lives of people in the Matrix region of Bangladesh by equipping them with incredibly immediate and backhanded finances. However, due to high costs, lack of adequate back up support by the battery, excessive inspection of the battery due to high DOD rates, absence of good quality sunlight based boards, reduced yield due to shedding and residue development, inconsistent work such as certain unclear arsons and shady weather. Looking to use a wider scale of SHS within and in the future Contains threats. Families of closed network countries have not yet decided to use SHS as an accessibility call for electricity, suggesting that the age of any PV-based focal power will change the general situation of using individual sunflower home structures. To use solar energy more effectively, measuring the radiation of that country from time to time is very important because the sun's radiation changes over time. In this thesis, our main goal was to find the radiation of the city of Dhaka in April and May so that electricity generation can be estimated by solar panels and using this information we can easily understand the power generation of SHS and create a standard form of SHS power generation in 2019. Here we can see that average irradiation of April 540.7 W/m^2, average Pmax of April 18.30 W and average irradiation of May 488.93 W/m^2, average Pmax of May 15.97W.

6.2 Future Scopes of the Work

In this research, we try to clarify how much energy can be generated from the solar system in April and May of 2019. We only worked for two months but in the future we can analyze the panel efficiency as well as measure the energy and irradiation throughout the year. We only worked for two months but in the future we can analyze the panel's efficiency as well as measure energy and radiation throughout the year. Future scopes make this work very bright. We work on solar irradiation and power. In the future, the task is to determine the standard of solar power, impact of dust and loss of battery.

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