STUDY OF THE SOLAR IRRADIATION PATTERN OF BANGLADESH FOR ELECTRICITY GENERATION

This thesis submitted in partial fulfillment of the requirements for the Award
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Submitted by

Md. Suman Babu

ID: 162-33-3380

Md. Shihab Ahmed

ID: 162-33-3422

Supervised by

Dr. M. Shamsul Alam

Professor

FACULTY OF ENGINEERING

DAFFODIL INTERNATIONAL UNIVERSITY

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Certification

This is to certify that this project and thesis entitled "**STUDY OF THE SOLAR IRRADIATION PATTERN OF BANGLADESH FOR ELECTRICITY GENERATION**" 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 December 2019.

Supervised by:

Dr. M. Shamsul Alam
Professor
Faculty of Engineering
Daffodil International University

Signature of the candidates

Md. Suman Babu

ID: 162-33-3380

Md. Shihab Ahmed

ID: 162-33-3422

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Dedicated to

Our Parents
And
Our Teachers

ABSTRACT

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 a developing country and for a 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 November and December so that the power production by the solar panel can be estimated and, we collect the solar irradiation and the average power data in Dhaka for (December & November) 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 2018.

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List of Abbreviations

FF	Fill Factor
SP	Solar Panel
PDB	Power Development Board
REB	Rural Electrification Board
LGED	Local Government Engineering Direction
IDCOL	Infrastructure Development Company Limited
NGO	Non-Government Organization
SHS	Solar Home System
RE	Renewable Energy
PV	Photovoltaic
MW	Megawatt
SEGS	Solar Energy Generating System/Station
AC	Alternating Current
DC	Direct Current
IV	Instrument Measuring
SREDA	Sustainable And Renewable Energy Development Authority
DPDC	Dhaka Power Distribution Company
IAU	International Astronomy Union
STC	Standard Test Conditions
CIGS	Copper Indium Gallium Selenide
BCSIR	Bangladesh Council of Scientific and Industrial Research
LGED	Local Government Engineering Department
BPDB	Bangladesh Power Development Board
TMSS	Thengamara Mohila Sabuj Sangha
CMES	Centre For Mass Education In Science
KUET	Khulna University of Engineering & Technology
IDCON	Infrastructure Development Company Limited
BCAS	Bangladesh Centre for Advanced Studies
PC	Personal Computer
RF	Ripple Factor
USB	Universal Serial Bus
RTD	Resistance Temperature Identifier

Chapter 1

Introduction

1.1 Introduction

Bangladesh is a developing country. In the electricity sector, day by day develops so renewable energy is developing. Our work is performance testing and analysis of rooftop solar panels. It is suitable for our country and start renewable energy. It supports that the non-renewable energy in our country. The solar rooftop also helps in our electricity cost minimization, supports the load shedding time and many other help. In this local area there is no electricity there is no reach grid area, this helps the rooftop solar system. But the solar system is the most important problem, low light, rainy season in rainy day, there is not work a solar system. Our work is performance and analysis of the rooftop solar system in the capital of Bangladesh, this name is Dhaka. We work to see the performance of the three solar panels. There are 45 watts, 60 watts, and 100 watts. We see their performance, efficiency, short circuit current, short circuit voltage, peak circuit, and voltage and the fill factor (FF). Our country is a six season's country. There are the summer, rainy, winter, autumn, spring and late autumn. Each season comprises two months, but some seasons flow into other seasons, while others are short. Actually, Bangladesh has three distinct seasons from March through May this time the solar irradiance is very high, so this time out solar panel output is high, we take a good electricity in the solar panel. The Rainy monsoon season which lasts from June through October, this time the Rainy season is not comfortable to a solar panel. The majority day the sky is cloudy and rain at any time of the day and night. So, this time the solar system is not working. In that time we pick our current is discontinuously and a cool dry winter season from November through February. This time solar irradiance is middle level. The sun flows the day 3 or 4 hours, the highest 5 hours. So this time we take middle electricity.

In the present situation of our country, we generated seventeen thousand-megawatt electricity. It is not enough for our country so we produce a new installation side. These are the solar system on-grid and rooftop SP off-grid. The other energy installation is wind, Biomass, Biogas, Hydro, etc. These are very helpful and supportive of our electricity.

1.2 Statement of the problem

Bangladesh depends on fossil fuels in the power sector. In public and private sector generates electricity this fuel. About 89% of installed power comes from carbon-emitting liquid fuel, natural gas, coal, and hydropower. From natural gas we get a big amount of electric power, it's a big help for our power sector. The supply of natural gas is not adequate to meet the demand. The present situation gas production capacity in Bangladesh cannot support our needs and as well as the wider electricity generation for our country. The existing reserve of gas and oil will be ended very soon. This time our country is facing big trouble and to fall down to generate our electricity. So we should take various steps to run our projects.at the time world-wide there are big steps for clean and sustainable energy. These times both are developing renewable sources like solar, wind, biomass, biogas, hydro, tidal power and geothermal, etc. Bangladesh is very good for renewable energy. This topology our country is suitable for solar energy. In this time solar energy is a preferable reliable and good secure energy of the country. But the present time Bangladesh share of RE for electricity generation is only 3.05% of total major people are lives in rural areas. These areas of electricity distribution is not good. So they take solar energy to reduce the grid electricity. This time their cost is minimized. Solar energy types the rural electrification begun in the country 1988 at Norshingdi Power Development Board (PDB), Rural Electrification Board (REB), Local Government Engineering Direction (LGED), Infrastructure Development Company Limited (IDCOL) and a significant number of private-sector agencies including Non-Government Organization (NGO) are involved in solar electricity development. In the city area, this time SHS is increasing day by day. The majority of building owners has there solar panel on the rooftop of the building. Here these places generate the electricity of on-grid in this building so their electricity bill decreases.

The renewable energy is the most important worldwide. Many countries produce energy to help this. These are helping the energy generation's own country. The RE is generated from natural resources- these are sunlight, wind, rain, tides, geothermal, biomass, biogas-which are renewable.

In 2006 all most 18%-20% of global energy final consumption came to the renewable energy which cost are very low. The 13% comes from traditional biomass, such that wood-burning. Hydroelectricity was the second stage of the biggest renewable energy source providing 3%-5% of the world energy consumption and 15% of the global electricity generation. The yearly 30 percent rate is growing the wind power. It is very important and we produce a lot of energy from this field. The solar system also helps us to generation in our RE. The Photovoltaic (PV) system depends on the sun. The PV energy annually manufacturing output of the photovoltaic industry reached 6900MW, in 2008. These stations are very popular USA, Germany, Spain, and France. There is the biggest plant is 354Megawatt. SEGS power plant in the Mojave Desert. The world's largest geothermal power generation is Geysers in California. This capacity with rated of 750MW. Our government is also various steps to develop our renewable energy. These are

The SHS system is compulsory to the Dhaka and all other cities. The government office, private office, home building, school and colleges, hospital are situated are rooftop solar panel is necessary and this connection is connected to on-grid. It is very helpful for our daily energy consumption and cost minimize our electricity bill. The pi-chart shows the whole renewable energy in the world. Then we see the chart biomass is half and all the others are. Hydroelectric power is 35% and 5 percent is geothermal.

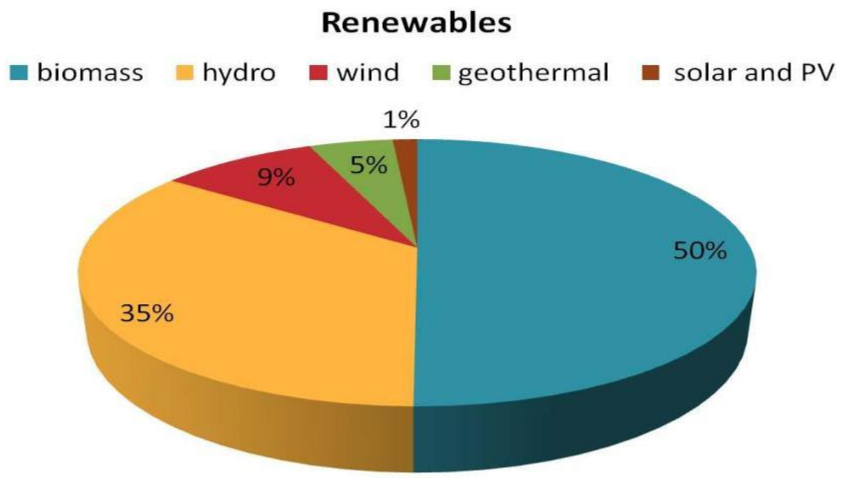

Figure 1.1: A pie-chart of RE in the world

Our country's situation is not good enough for renewable energy. There are 8% is here. These are wind 11, solar 1, biomass 53, geothermal 3 and hydroelectric is 31%.

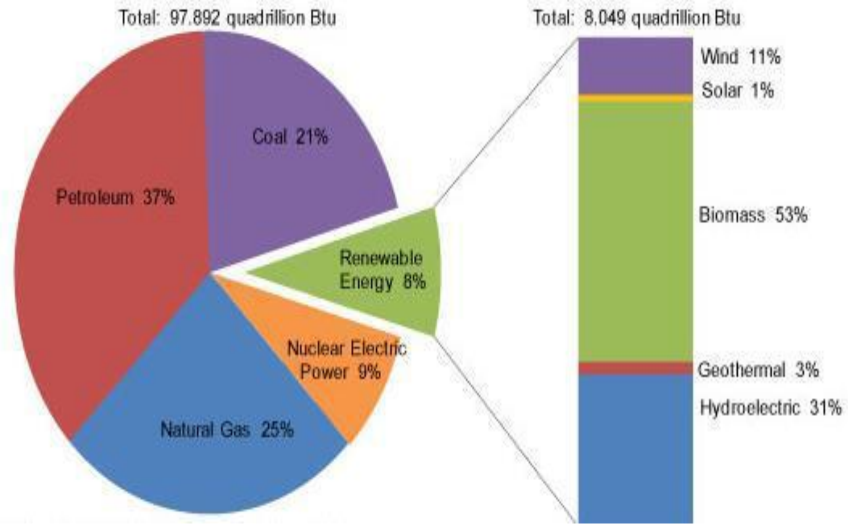

Figure 1.2: A pie-chart of RE in Bangladesh

1.3 Current State of Electricity In Bangladesh

As a developing country, there is a possibility of Bangladesh going forward to increase electricity demand. But now in this era, Bangladesh is facing the energy crisis. About 70% of people are lacking in electricity and most of the villagers live in, 40% of them living below the poverty line [2]. Here we are going to describe the overall current situation of Bangladesh where we can define the deficit which should be improved.

1.4 Renewable Energy

By 2015, the government of Bangladesh plans to generate 5% from renewable energy and in 2020 is 10%. Biomass and Biogas can be bases of 400 MW and 800 MW power generation in turn. By 2020, our government will get 20 megawatts of electricity by 2020 by installing micro (<100 kW) and mini (<1000 person) hydropower plants. [21] Bangladesh is technically backward matched to other established nation-state. Renewable energy is nothing but new technology and it is tired to make Bangladesh as a corrupt and economically unstable country within a few years renewable. After acquiring balanced resources in India, the smart grid system can be infiltrated. Meanwhile, NGO awareness campaigns have encouraged residents to start with the elementary energy effective process and the system will be extended in a few years.

1.5 Photovoltaic (PV) Cells

Solar System:

The PV cells produce electricity from the sunlight. The panel has computer chips are similar to materials used in this system. These absorb the sunlight and generate electricity. They produce electricity are DC. So the DC current converts to AC and supply.

Figure 1.3: Solar Panel System Rooftop

1.6 Objectives

- To col1ect solar irradiation and maximum power data in Dhaka for (May & June) two months.
- To analyze data to get average irradiation and find the relationship between solar irradiance and power.
- To study the solar PV system of Bangladesh.
- To assess the role of SHS on socio-economic development in Bangladesh.
- To introduce Renewable Energy (RE) as an alternative solution for power generation.

1.7 Scopes

We work in our university's rooftop. 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 developing in our country. This is a good solution for electricity. SHS can variation the lives of people in rural and city areas. 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 a social and economic development in Bangladesh.

1.8 Thesis Outline

This thesis is organized as follows:

Chapter -1	**Introduction**
Chapter -2	**Literature Reviews**
Chapter -3	**Methodology**
Chapter -4	**Data analysis**
Chapter -5	**Conclusions**

Chapter 2

Literature Reviews

2.1 Introduction

Renewable energy in which energy is collected from renewable resources and which are naturally replenished on a human timescale, such as wind, tides, waves, sunlight, rain, and geothermal heat. There are four important areas that provide renewable energy which is air and water heating/cooling, electricity generation, rural energy services, and transportation. Almost all energy used was renewable in the mid-century of 19th which was prior to the development of coal. In the form of traditional biomass to fuel fires, dates from near 800,000 years ago, without a doubt the oldest known use of renewable energy, until many hundreds of thousands of years later, Use of biomass for fire did not become commonplace. Harnessing the wind in order to drive ships over water which probably the second oldest usage of renewable energy. The ships in the Persian Gulf and on the Nile where this practice can be traced back some in 7010 years. The primary sources of traditional renewable energy were animal power, human labor, water power, firewood, in grain crushing windmills and wind a traditional biomass which was recorded history into the moving time. The United States up until 1900 shows natural gas and oil with about the same importance as wind and solar.

2.2 Definition of energy

2.2.1 Energy:

The energy is the quantity of a physical system. It defines the ability of the changes and processes, which take place in the Universe, starting with movement and finishing with the thinking.

2.2.1 Solar Energy:

The solar energy is the heat of the sun and radiant. It converts sunlight to energy. They directly use the PV system and indirectly use concreted solar power or alternatively. The energy is very helpful off-grid area in our country.

2.3 Renewable Energy Technology Preferable in Bangladesh

There are various types of renewable energy systems (RES) application fit for Bangladesh are explained is the sequential heading-

- Solar Photovoltaic
- Waste Energy
- Biomass
- Wind Power
- Tidal Power
- Geothermal Energy
- Ocean Wave energy
- Biogas Energy

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

The present situation of our country the total generation is 10213MW. Given a table 2.1 when sector and what types of fuel use it. And the table 2.2 the total generate of off-grid electricity is 22.5 and whose sector comes it. We see table 2.2 the highest electricity comes to solar and the lowest come in micro-hydro.

Table 2.1: Total insulated power in grid

Total Insulated Power in Grid Electricity is 10213 MW	
Gas	6587
Coal	250
Diesel	683
Furnace Oil	1963
Hydro	230
Import	500

Table 2.2: Total insulated power off-grid electricity

Total Off-Grid Insulated Electric Power is 22.5 MW	
Wind	2.5 MW
Solar	18.55 MW
Biomass/Biogas	0.5 MW
Micro Hydro	0.1 MW

2.5 Bangladesh background and Government situate

Today Greenhouse gas is the most dangerous for the environment. The weather is directly affected because of increasing the temperature by greenhouse gas. Our country is one of the top weather vulnerable countries in 48 countries. It is facing the impact of weather change as increasing sea levels, rising of salinity, floods, heavy rainfall, and land sides. As a vulnerable 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 better living situations. The government has

founded SREDA to give policy support and guidelines for the sustainable growth of renewable energy. They are various step to develop our country and electricity.

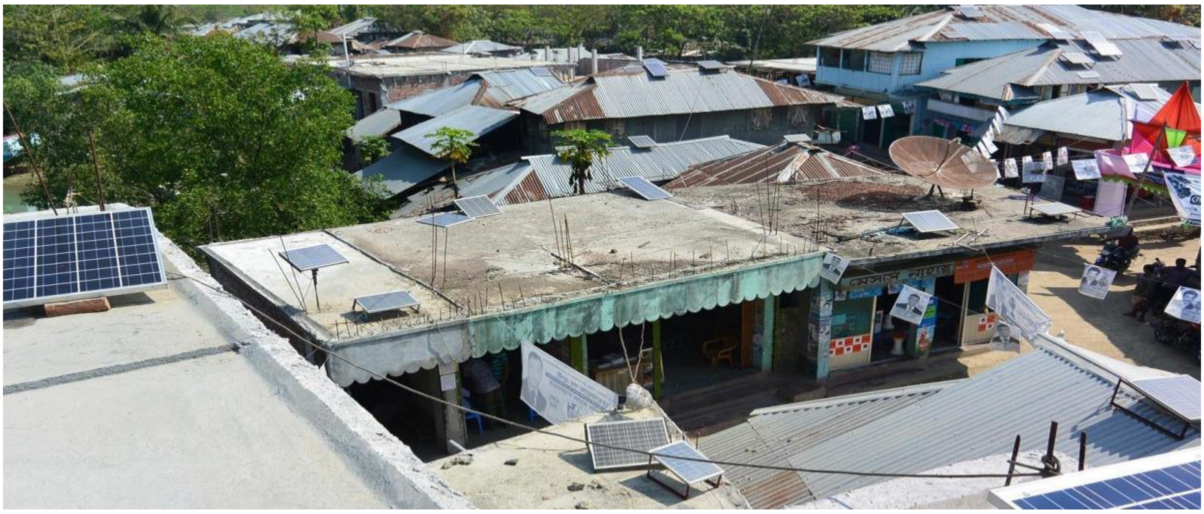

Figure 2.1: Solar home system in village are

Now our government to step village and town area to develop. The town area rooftop solar panel situated. In the capital of Bangladesh, the Dhaka city DPDC is compulsory to stand a photovoltaic cell in the building so there is no newline in their consumer without solar.

Figure 2.2: The SHS system in town area

2.6 Solar System

The Sun and the objects that are directly or indirectly focused on orbits, orbits, eighteen planets from Solar system gravitationally bound technique which determined by the International Astronomy Union (IAU) and five dwarf planets. Among the objects that light the Sun directly, eight planets exist in eight planets, the other little objects, like dwarf planets and little solar system bodies. In the indirectly illuminated sun-moon-two small planets, larger than Mercury. Solar power was formed from the gravitational collapse of the molecular cloud of a giant interstellar 4.6 billion years ago. Given a figure 2.3 shows the whole mechanism of the solar system.

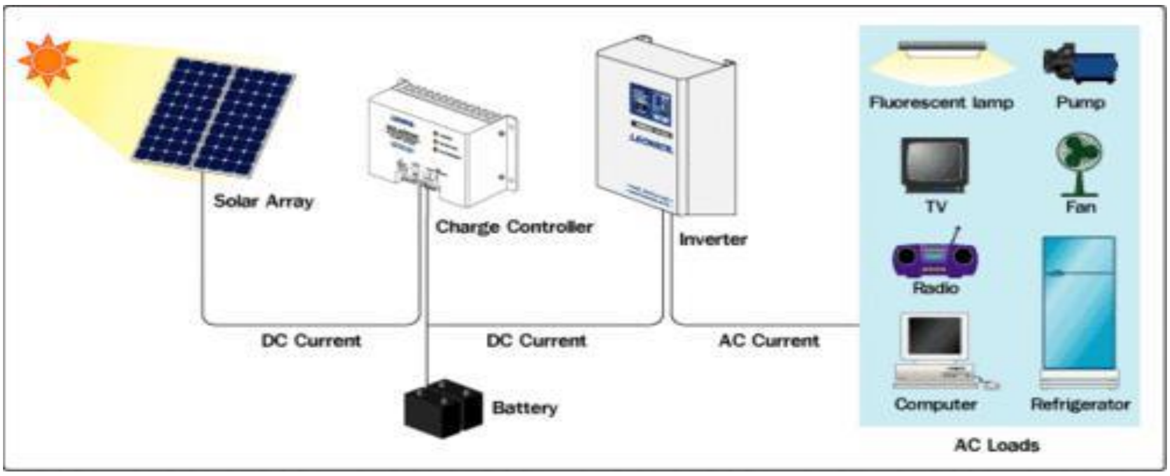

Figure2.3: The solar home system mechanism

A large number of system masses are in the sun, the remainder is in Jupiter. The four small inner planets, Mercury, Venus, Earth the terrestrial planets, are initially formed of rock and metal. Four outer planets are giant planet, being massive enough than terrestrials On Thursday and Saturday two large gas giant, which is mainly made of hydrogen and helium; Two outer planets, Euripus and Neptune, the monster of snow, which makes most of the substances with high melting points compared to hydrogen and helium, such as water, ammonia and methane. There are about eight orbital orbits that are located in plain discs, which are called circular. There are four things need to run a solar system:

(i) Panel (ii) Battery(iii) Charge Controller (iv) Inverter

2.6.1 Panel

Photovoltaic solar panels imbibe sunlight as a source of energy for the production of electricity. A photovoltaic (PV) module is usually a packaged, connected assembly of 6x10 photovoltaic solar cells. Photovoltaic modules form photovoltaic arrays of a photovoltaic system that produces and supplies solar and commercial applications in commercial and residential applications. Each module is rated by its DC output power under the Standard Test Conditions (STC) and usually ranges from 100 to 365 W (W). A module efficiency determines the output of the same rating of a module - an 8% efficient 230 wad module will double the area of a 16% efficient 230 wad module 24% [1] [2]. There are several commercially available solar modules that exceed the efficiency. A solar panel is very necessary and useful. Without the cells, there is no electricity production in this field. We work three solar panels this panel blue color and there are 45, 60 and 100 watts. Given a figure2.4 to show the solar panel.

Figure 2.4: Solar panel

2.6.2 Battery

Batteries are very useful in the solar system. In day time sunlight is here the panel absorbs the heat and produce electricity and this time the energy charge to the battery. Then the night-time battery is a help to give to flow bulb, fan, light, television, etc. There are three elements of liquid lead-acid, lithium-ion and saltwater.

Figure 2.5: Battery

2.6.2.1 Lead-acid

Lead-acid batteries are a tested technology used in off-grid energy processes for decades. While they have a relatively small life and lower than other kinds of batteries, they are also one of the minimum costly options currently on the market in the home energy storage sector. For homeowners, lead-acid can be a good option, who wants to go off the grid and want to install lots of energy storage.

2.6.2.2 Lithium ion

Most of the new home energy storage systems, like them, use some form of lithium-ion chemical composition. Lithium-ion batteries are lighter and over compact than lead-acid batteries. They have a higher and longer lifespan when compared to lead-acid batteries. However, lithium-ion batteries are over costly than their lead-acid counterparts.

Saltwater:

The saltwater battery is a newcomer in the home energy storage industry. Since saltwater batteries don't contain heavy metals, that's why other home energy storage options, relying instead on saltwater electrolytes. We have to be disposed of with special systems, a saltwater battery can be easily recycled. Since, batteries that use heavy metals, including lead-acid and lithium-ion batteries, so it will be a new process saltwater batteries that are relatively not tested, and the one company that makes solar batteries for home use filed for bankruptcy in 2017.

2.6.3 Charge Controller

Charge Controller or Charge Controller is basically a voltage and/or current controller for keeping battery from additional charging. It's going to battery going voltage and current control from the solar panel. Most "12 volt" panels remove 16 to 20 volts, so if there is no control, the batteries will be damaged by additional charging. Most of the batteries require about 14 to 14.5 volts to fully charge not ever, but generally. Usually, there is no necessity for a charge controller with the little maintenance, or trickle charge panels, about 1 to 5-watt panels.

A rough system is that if the panel puts out such as 2 watts or less for each 50 battery amp-hours, then we don't need one.

Figure 2.6: Charge controller

2.6.4 Inverter

An inverter or power inverter is a device of electronic or circuitry that changes direct current to alternating current. The input and output voltage and frequency, and overall power handling depend on the specific device or circuitry design. Given a figure 2.6 to show an inverter.

Figure 2.7: An inverter

The variable direct current output of a photovoltaic solar panel into a utility frequency alternating current which converts by a solar inverter or PV inverter is a type of electrical converter. That can be fed into a commercial electrical grid or used by a local, off-grid electrical network. Solar inverters may be classified into three broad types.

2.6.4.1 Stand-alone inverters

The inverter draws its DC energy from batteries charged by photovoltaic arrays. Where used in isolated technique by Stand-alone inverters. An AC source when available, many stand-alone inverters also incorporate integral battery chargers to replenish the battery. Normally these do not interface in any way with the utility grid, and as like, are not required to have anti-islanding protection.

2.6.4.2 Grid-tie inverters

Grid-tie inverters, which match phase with a utility-supplied sine wave. Grid-tie inverters are designed for shut down auto upon loss of utility supply, because of safety. They do not provide backup power during utility outages.

2.6.4.3 Battery backup inverters

Battery backup inverters are exceptional inverters that are designed to draw energy from a battery, handle the battery charge via an onboard charger, and export excess energy to the utility grid. The inverters are able to supply AC energy to selected loads during a utility outage and are required to have anti-islanding protection.

2.7 Types of Panel

(ii) Poly Crystalline [Cell color blue]

(iii) Mono-Crystalline [Cell color black]

(iv) Thin film

(v) CIGS [Copper Indium Gallium Selenide] Coffee color

2.7.1 Poly Crystalline

The polycrystalline cell is better than the other cell. The color is blue. The cells are very good to absorb the sunlight. It is the highest efficiency for the other solar panel. The panel is very costly. It is made are cut from a silicon ingot.

2.7.2 Mono-Crystalline

The cells are made for many smaller crystals. It is more than a low cost by the monocrystalline cell. This efficiency rate is 15-17% [3]. This cell color is black.

The given a figure 2.7 to show the characteristics of poly and monocrystal solar panel.

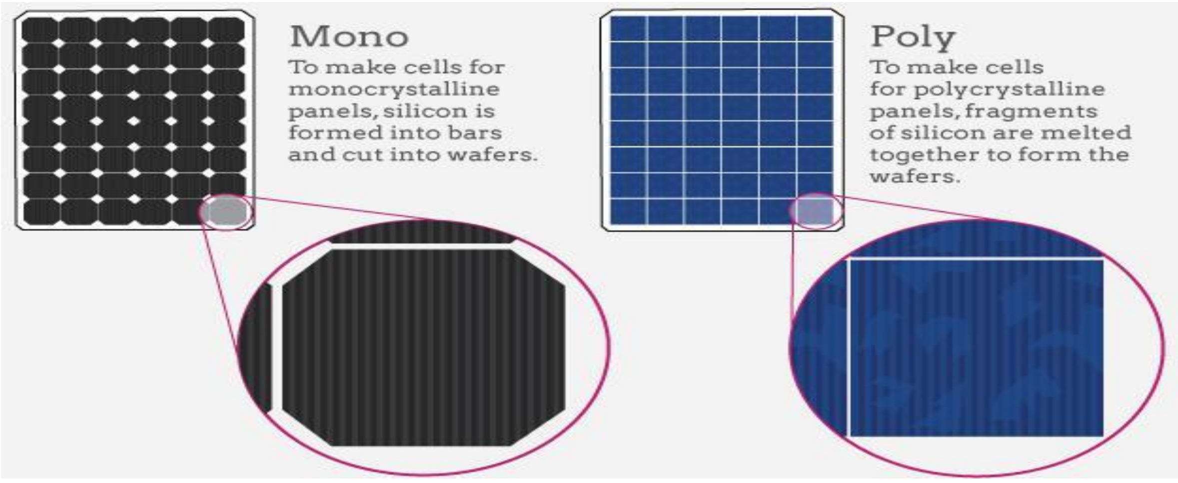

Figure 2.8: Characteristics of poly and mono crystalline solar panel [4]

2.7.3 Thin Film

The solar panel is a type of device that is decorated to convert light energy to electrical energy. It is the updated cell and its weight is very low. It is made such as plastic, metal or glass. The thin film is very flexible to the other panel. To below a figure 2.8 to see a thin film.

Figure 2.9: Thin-film

2.7.4 CIGS

This is the other thin film. The cell is manufacturing by deposited a small layer of gallium, indium, copper and plastic or glass. This is significant it opens up to the possibility of the holy grail in solar, silicon kind of efficiencies at low thin film [5]. The CIGS full meaning copper indium gallium selenide and is also multipurpose. The given a figure 2.9 a CIGS thin film

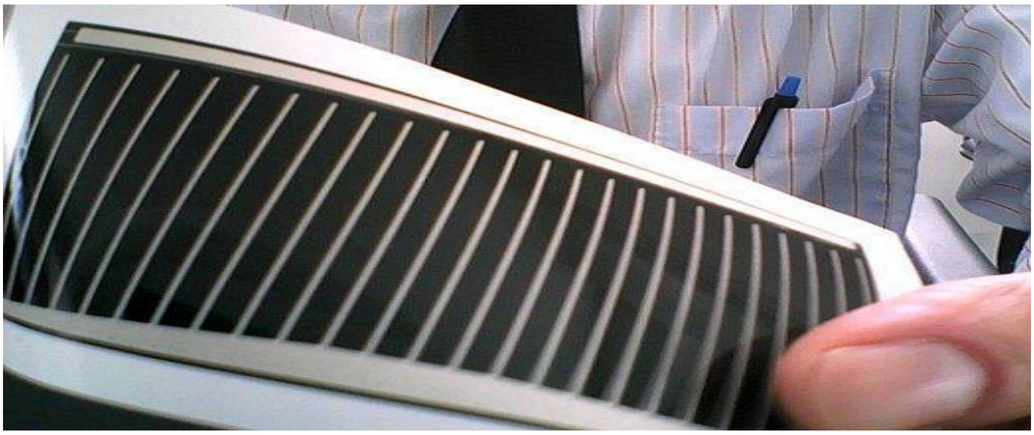

Figure 2.10: A CIGS solar panel

2.8 Others going project RET project in Bangladesh

- Biomass plants-**BCSIR, BRAC**
- Micro hydropower plant-**LGED**
- Windmill water pumping led
- Hybrid system – Grameen Sakti, **BRAC**
- Wind power generation – **BPDB**
- SHS project – **TMSS**
- RET feasibility study – **BCSIR**
- CHT SHS project – **BPDB**
- RET in Asia – **CMES/KUET**
- Biogas pilot project- **LGED**
- GTZ funded project –**REB**
- PREGA – **REB/BPDB**
- Renewable energy development project – **REB/IDCON**
- Sustainable rural energy – **LGED**

2.9 Wind Power Project

From electrical or mechanical energy by wind turbines into a useful wind energy from wind power is the conversion of wind energy. Where the velocity of the wind is directly proportional to the power. Particularly the islands and southern maritime facial of Bangladesh where lengthy period wind flux, so that Bangladesh declares that the average wind speed remains between 3 and 4.5 m/s in the months of April to September and 1.6 to 2.2 m/s for the residual period of the year. The appeal of windmills for pumping and electrification is very high in islands and coastal areas. Wind battery hybrid power project in Kutubdia islands where Bangladesh Power Development Board completed the 1000 kW capacity system [6]. Wind turbines are being installed which capacity stand-alone type. The total power generated by all the wind turbines is stored in a battery bank.

Figure 2.11: Wind power

The project of BPDB has completed its 0.90 MW capacity grid-connected to wind energy at the Muhuri Dam area in the Feni district in 2004 [7]. The BPDB has allotted that wind energy can contribute up to 10% of the energy generated. The major benefit of wind turbines is that for electricity generation they do not need any fuel. The feasibility of wind situation for generation of electricity at different situations in Bangladesh and illuminates that maximum annual average wind speed is 2.42 m/s in Cox's Bazaar and minimum 2.08m/s in Hatia Island [8].

The wind power is a very important part of the renewable energy. In our country, this energy first-ever production of wind is at Muhuri Dam. It is situated in the district of the Feni and this capacity of 0.9MW. The other is at Kutubia island. This capacity is 20KW. Wind force has been the dimension in Patenga, Cox’s Bazar, Kuakata, Moheskhali and Nuakhali by the stand this field [9].

Figure 2.11 shows that a wind pump set up by BCAS at Patenga, Chittagong.

Figure 2.12: Wind power in Bangladesh

2.10 Hydropower

The hydropower is generated to 16%-18% electricity. A large hydroelectric plant was stand in the Kaptai region using the Karnaphuli river during the 1960s. This capacity is 230MW and helps us with our country's electricity. The generation power cost is very low than other fuel in our country. Bhutan is in this field their capacity to produce 25000megawatt. Now this country generated 1500MW and their implement project 6300MW of production down Indian assistant.

Our government and private sector will to jointly investment in Nepal for the hydroe-lectricity to advantages to electricity production. These are very useful in our country. To show figure 2.12 the world's largest hydropower plant in China. It situated in the Three Gorges Dam. This installed capacity is 22500MW in 2014.

Figure 2.13: The world largest hydropower in China [10]

2.11 Micro/Mini Hydro

The mine hydro contributes to distributed generation in a local electricity grid and to the improvement of hydroelectric power on a scale worthy for the local community and industry. The common generation capacity of 1 to 20 megawatts where a small hydro project varies.

Given a figure 2.13 to a mini/macro hydropower plant to show that

Figure 2.14: Micro/Mini Hydropower plant

2.12 Biomass Energy

As an agricultural country, Bangladesh has the potential to produce electricity from bio-mass sources. For the production of biomass electricity, cattle, agricultural exploitation, poultry, water heist, rice flame, etc. are found in Bangladesh. The common biomass resources are rice, the residue of crops, wood, jute stick, animal waste, municipal waste, sugarcane biogas, etc. Currently, there are 25,000 biogas plants throughout the country and 0.20 million ovens have been set up for the conservation of biomass fuel. More than 900

Braking machines are working commercially on a commercial basis [11]. The strength of rice cultivation is approximately 16 megawatts/kg. The biomass plant's temperature is 13,648 BTU / kW Possible results are shown in Table 5 [12]. Given a table 2.4 to show the technical potential for biomass.

Table 2.3: Technical Potential for Biogas

Annual Rice Husk Crop (tons)	HHV (MJ/kg)	Gross Energy Potential (mmBTU)	Gross Electricity Potential (MWh)	Net Electricity Potential (MWh)	Potential Capacity (MW)
10,130,000	16	139,363,715	4,084,514	2,042,258	274

2.13 Energy Efficiency Measures

For energy saving purposes and encourage the use of CFLs by consumers, free CFL (Compact Fluorescent Lamp) Distribution Program in different offices of BPDB along with headquarter has been conducted. CFLs, T-5 tube light instead of incandescent bulb will be installed in all offices of BPDB in different phases. For the efficient use of energy, steps have been taken to encourage/promote the use of heat reflective glasses for Passive Cooling of commercial buildings, Solar Powered Security Lighting in urban buildings and replacement of Diesel/Electric Pumps by Solar Irrigation Pumps, replacement of Electric/Gas Dryer by Solar Dryer, replacement of Electric/Gas Heater by Solar Water Heater among the consumers of distribution zones of BPDB. In addition to that energy efficiency measures, alternative and renewable energy subjects have been introduced in the national Text Book Curriculum of schools, madrasas, and colleges. The Energy Star labeling program has been started by BSTI to motivate users to use energy-efficient appliances. Electricity Week Program has already been launched since 2010 with a view to promote energy savings campaigns at consumer and school levels. This program is nationally observed on 7th December each year

2.14 Research Activities

Development is continuing its own research works in various renewable energy sectors and these projects Directorate of Renewable Energy & Research alongside. In this situation, the engineers of the directorate are constructing a fully operational prototype-based Wind Turbine System, Hydro Emulator Set, Solar Power Converter. Three different types of turbine technology including horizontal axis and vertical axis turbine are consist of the wind power system. Depending on wind velocity the total capacity of the system is hope to be 200 W. the respective engineers who complete the design, assembly, and installation of the turbine system. The Hydro Emulator Set is a small prototype-based which consists of two different types of turbine technology are Pelton wheel and Kaplan turbine. From a small water reservoir tank will run the turbine system. I hope that 20 W will generation capacity from the two turbines. The engineers trying to design Solar Power Converter with innovative ideas and new concepts that are more preferable to us.

2.15 Summary

This chapter shows all other things in RE and solar home system all elements. First, start the definition of energy and solar energy the RE technology preferable and the present scenario in renewable energy of Bangladesh. The government helps and situate the background of Bangladesh. There is a whole solar system element describes this chapter and different types of solar panel also. There are many ongoing projects in Bangladesh this is shows also. The renewable energy wind power, hydropower, micro/mini hydropower, biomass energy are also described and the Bangladesh situation of this energy. This present time government should take responsibility for this energy efficiency measure and research activities.

Chapter 3

Methodology

3.1 Introduction

Bangladesh is a suitable country for solar. We take sunlight in six to eight-month of a year. There are four to six months the sunlight is very good to produce electricity. In the off-grid area of our country, there is no current but this area is suitable for photovoltaic cells, so the government advises this place to connect and situated for a solar home system. In Dhaka city there is a lot of building, this high is very good. This building rooftop stands the solar panel and connected to on-grid which means these are connected to the main switch in this building. Medium type solar panels are cost minimization and about ten thousand taka decreases in electricity bills per year.

3.2 Description of Study Area

Our work in the Dhanmondi area. It is the ridden area of our country. The place is situated in Dhaka City, Bangladesh. Its invention started as a residential area for the city in the year 1950, and for decades it has become a small town in malls, schools, banks, offices, and universities. After the War of Liberation, it initially consisted of two search chamber. Dhanmondi is located in the Dhaka district of Bangladesh. It has 33451 houses and a 4.34 km² area. Apart from schools, universities, hospitals, restaurants and shopping centers, apart from Dhanmondi's original double-decker rooms, there are apartment complexes [13].

A study area (Figure3.1) is a place where we collect data for our necessary work. Our study area has established in Daffodil International University Administrative Building rooftop. It is situated in Dhaka 1215, Bangladesh. Different types of solar panels have installed them as 45W, 60W, and 100W.

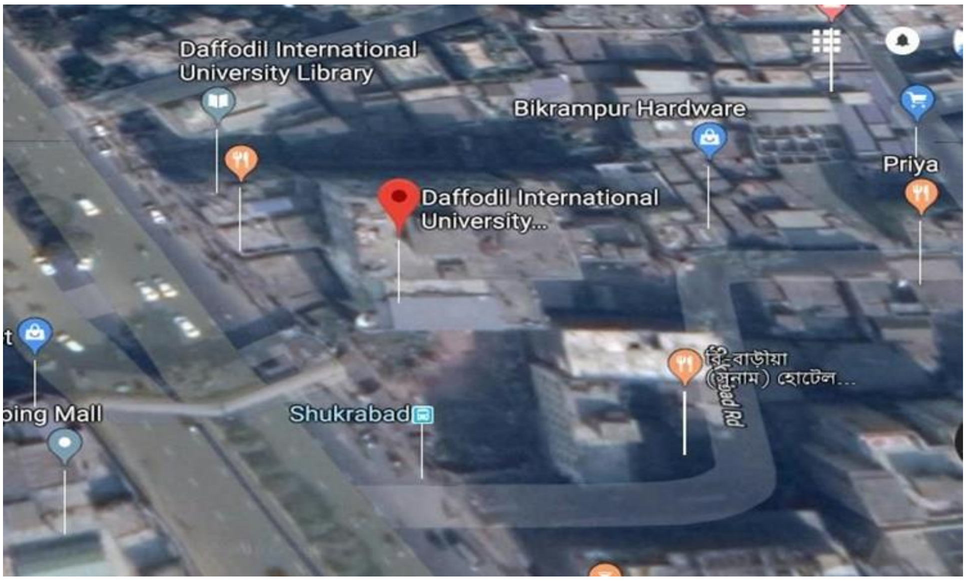

Figure 3.1: Satellite View

3.3 System Design

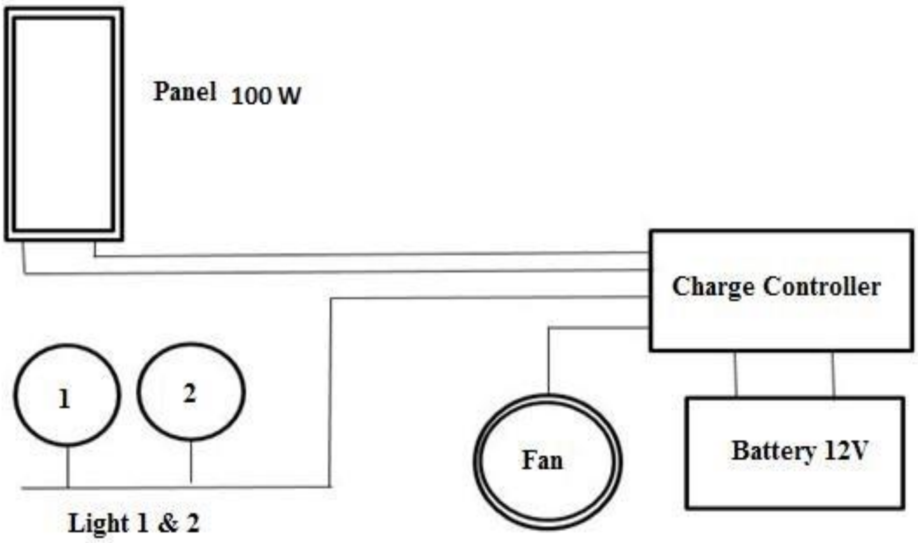

Figure 3.2: System Design (100 W)

3.4 Solar Panel

Devices that convert solar panels into light. They are called "solar" panels because most of the time the Sun is called the most powerful source of astronomers. Some scientists call them photovoltaics, which is basically "light-energy". A collection of solar cells in a solar panel. Large solar cells spread across a large area can work together to gain immensely. Lightening a cell more, which generates electricity, the spaceships are usually designed with solar panels, which can always be directed towards the sun, while the remaining part of the spacecraft continues almost, as the tank burgeon tank is going independently, the goal. Our workplace has three types of solar panels here. Electricity is generated when the solar modules are enlightened on their front surface

If the DC voltage can be exceeded 30V, the total voltage equal voltage component of the individual module is connected to the module. If the module parallel is connected then the total currents are equal. There are:

(i) 45watt solar panel

(ii) 60watt solar panel

(iii) 100watt solar panel

The cells are no less than 90% of their initial minimum stated power in the first 10 years, and also to produce no less than80% of their initial minimum stated power for a period of 25 years.

3.4.1 100 watt Solar Panel

This is the small solar panel where we work. This area is 0.32m^2. The solar cell always set 23 degrees in the south part for Bangladesh. So the sunshine is directly shining this solar panel. The cells of the solar made in Germany. To measure power in Standard Test Condition (STC) cell temperature is 25°C

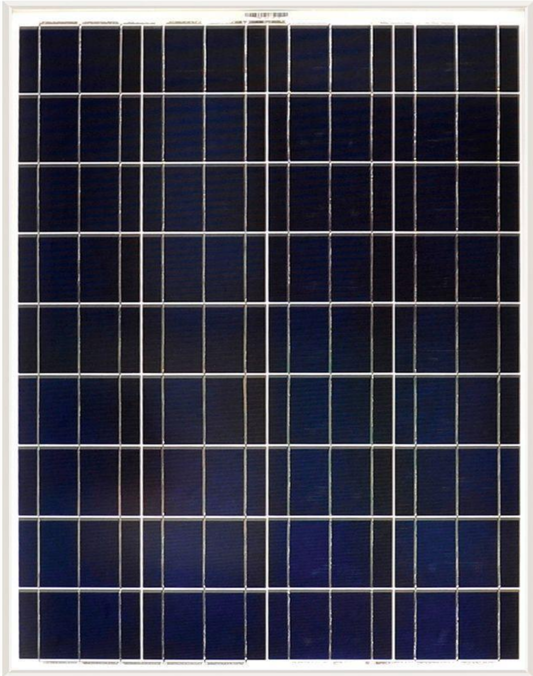

Figure 3.3: 100 Watt solar panel

3.4.1.1 Electrical Specifications

I.	Maximum Power(PmP)	100 W
II.	Open Circuit Voltage(Voc)	22.4 V
III.	Short Circuit Current(Isc)	5.92 A
IV.	Maximum Power at Voltage(Vmp)	17.8 V
V.	Current at Maximum Power(Imp)	5.62 A
VI.	Module Dimension	39.7x26.7x1.4 inches
VII.	Module Weight	16.5 Ibs

3.5 Measurement Equipment

We measure the various data in this work. There are the open-circuit voltage, short circuit current, voltage at maximum power, current at maximum power, maximum power, fill factor, irradiance and the temperature. There are three measurement equipment in our work. There are

(i) Photovoltaic Meter
(ii) II. Irradiance meter
(iii) III. Temperature Sensor

3.5.1 Photovoltaic Meter

The photovoltaic meter is the most important meter in our work. These are various data measurements. Solar meters allow for 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 the kWh production from a PV system. Photovoltaic meters are very useful for the planning and maintenance of photovoltaic parks. Photovoltaic meters are generally used to check photovoltaic modules for the best position search and expertise. Solar energy 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 produce energy from solar light. A good plan is essential before installing a photovoltaic park. Our photovoltaic meter allows users to record direct sunlight over an extended period. For further analysis of the radiation value, the meter is stored in internal memory. Given a figure 3.6 to show a photovoltaic meter.

Figure 3.4: Photovoltaic Meter

3.5.1.1 Electrical Specifications

Table-3.1: Range, resolution, and accuracy

Parameter	Range (V)	Accuracy
VDC Voltage @ OPC	5.0 - 999.9	(1.0%
IDC Current @ OPC	0.10 - 10.00	1.0
Max Power @ OPC (Vmpp>30V, Impp>2A)	50 - 9999	1.0%
VDC Voltage (@ STC and OPC), IVCK	5.0 - 999.9	4.0
IDC Current (@ STC and OPC), IVCK	0.10 - 10.00	4.0
Max Power @ STC (Vmpp>30V, Impp>2A)	50 - 9999	5.0%
Irradiance (with reference cell)	1.0 - 100.0	1.0
Temperature of module (with auxiliary PT1000 probe)	-20.0 - 100.0	1.0

3.5.1.2 General Specifications

DISPLAY AND MEMORY:

Features: 128x128pxl custom LCD with backlight

Memory capacity: 256kbytes

Saved data: 249 Inflect (I-V curve examination), 999 IVCK

POWER SUPPLY:

SOLAR I-V internal power supply: 6x1.5V alkaline batteries type LR6, AA, AM3, and MN 1500

Autonomy of SOLAR I-V: > 249 curve (I-V curve test), 999 IVCK test

Approx 120 hours (yield test)

SOLAR-02 power supply: 4x1.5V alkaline batteries type AAA LR03

SOLAR-02 max recording time (@ IP=5s): approx 1.5h

OUTPUT INTERFACE

PC communication port: optical/USB

Interface with SOLAR-02: wireless RF communication (max distance 1m)

MECHANICAL FEATURES

Dimensions (L x W x H): 235 x 165 x 75mm

Weight (batteries included): 1.2kg

ENVIRONMENTAL CONDITIONS:

Reference temperature: 23°C - 5°C

Working temperature: 0° - 40°C

Working humidity: <80%HR

Storage temperature (batt. not included): -10 - 60°C

Storage humidity: <80%HR

GENERAL REFERENCE STANDARDS:

Safety: IEC/EN61010-1

Safety of measurement accessories: IEC/EN61010-031

I-V curve measurement: IEC/EN60891 (I-V curve test)

IEC/EN60904-5 (Temperature measurement)

Insulation: double insulation

Pollution degree: 2

Overvoltage category: CAT II 1000V DC, CAT III 300V AC to ground

Max 1000V among inputs P1, P2, C1, c2

Max altitude of use: 2000m

3.5.2 Irradiance Meter

When we measurement our data we connected the irradiance meter is connected to the photovoltaic meter. Then the meter shows 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 / m² - it is per square meters per watts. The amount of solar energy that falls within the given period is called irony. A measure of the power of taunts. It is added to the power of the sun for 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 / m². The power amount of power (1000 Watts / m²) 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 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 / m2 of the total energy value. This term is interchangeable with kWh / m2 / day

Figure 3.5: Irradiation Meter

3.5.2.1 Technical Specifications

Table-3.2: Range & accuracy

Parameter	**Range [W/m^2]**	**Accuracy**
Irradiation	50 - 1400	±3.0% of readings

3.5.3 Temperature Sensor

The temperature sensor requires a thermocouple or RTD (resistance temperature identifier) to measure the temperature through an instrument, an electrical signal. The thermocouple is made by two different metals, which in turn produces proportional to the atomic voltage to change the temperature.

The temperature sensor measures the warmth or coolness of an object. The work of the sensors is the voltage read across the base diode. If the voltage increases, then the temperature increases and the base and emitter's transistor terminals have a voltage drops, they are recorded by the sensor. If the voltage difference is increased, then the analog signal is generated by the device and it is directly proportional to temperature.

Figure 3.6: Temperature Sensor

3.6 Flow Chart

A variant is a type of image that represents a workflow or process. Flanked arrows show boxes of numerous types and steps as their order box. We use flowcharts in a process or program analysis, documentation or management in different fields.

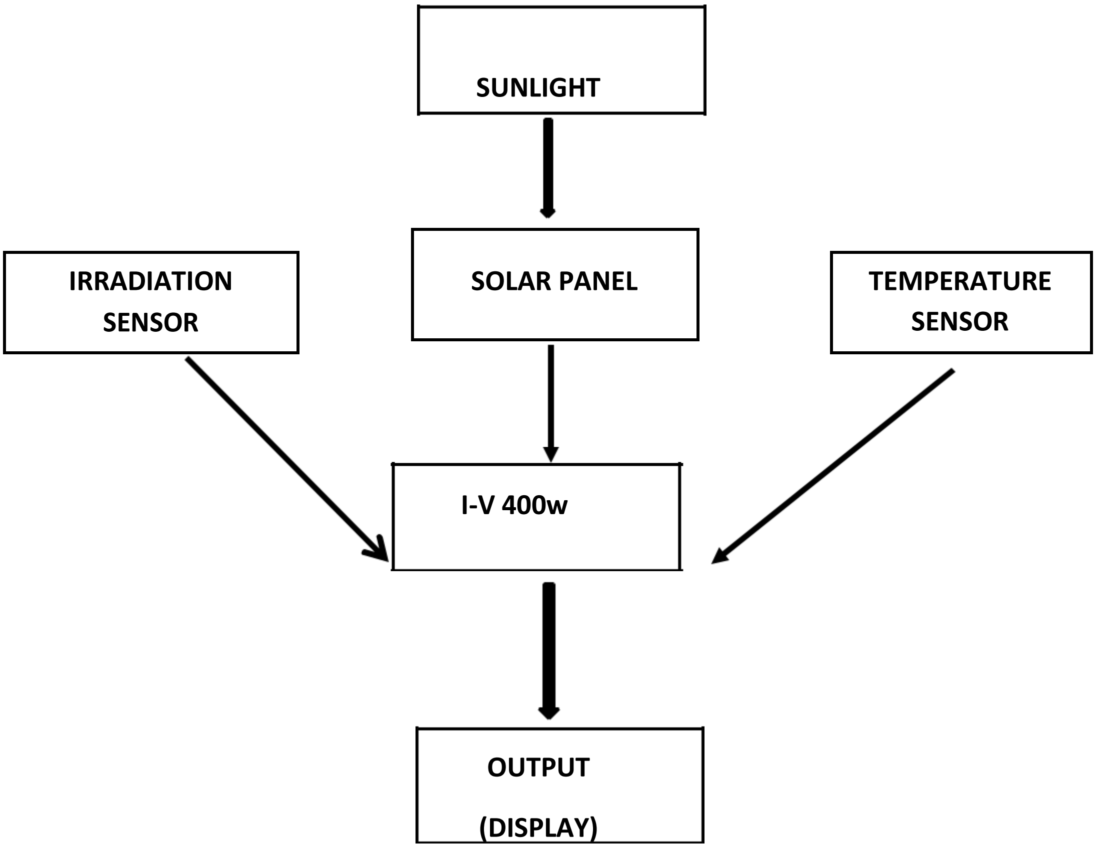

Figure 3.7: Flow Chart

3.7 I-V 400 W Calibration

Before starting the measurement, we must have to calibrate I-V 400 W. For I-V 400 W calibration parameters has given below Table-4

Table-3.3: I-V 400 W Calibration.

Pmax	50 W
Voc	21.42 V
Vmpp	17.10 V
Isc	3.20 A
Impp	2.92 A
Toll-	1.0 W
Toll+	1.0W
Alpha	0.033 %/°C
Beta	-0.34 %/°C
Gamma	-0.42 %/°C
Noct	45 °C
Tech.	STD
Rs	1 Ω
Degr	0.0 %/yr

3.8 Process of Data Collection

Our data collection process was very lengthy. We work for a few months of the year. We collect the data in the day time. If a sunny day, we measure our data. We assume data in day time start from 6 AM to 6 PM. It depends on the irradiance and sunlight. Sunlight here then measure the data. Total ten to twelve times metering in the data every hour. To show figure 3.10 our work time and place when we measure the data.

Figure 3.8: Working Place (To measure data)

1. First, we go to the rooftop the work building
2. Then we start our work. We connect the solar panel to the photovoltaic meter and irradiance meter.
3. It is also connected to the temperature sensor.
4. The solar panel connected the Whole meter then the data is here the photovoltaic meter. We take a picture of all the data.
5. Then we connected the 60watt solar to photovoltaic meter and temperature sensor.
6. Again we snap in my mobile phone all data the 60watt solar panel.

Last we join the 100watt cell to photovoltaic meter and the temperature sensor. Al data collection and take a picture on our phone. It is suitable for a sunny day. On this day we measure all data collected. On a rainy day and low light, the solar irradiance is low so there is no data on this day.

3.9 Put the Data in the Lab Sheet

We collected the data in a day ten or twelve times. We collect and put up in the google sheet or lab sheet. The set all data these are maximum power, open-circuit voltage, short circuit current, the voltage at maximum power, current in maximum power, fill factor and irradiance. Given the table 3.4 all elements which measure a panel and put them.

Efficiency= Output/Input

Output= Power of solar panel

Input= Irradiance*Panel area

Suppose,

Pmax= 1.47w

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

Then efficiency= 8.5%

Table-3.4 Represents parameter-wise data of 100-watt solar panel of a single day (1st November 2018) starting from sunrise to sunset.

SL	Time (Sunrise to Sunset)	Irradiance (W/m2)	Voltage (V)	Current (I)	Vmpp(V)	Impp (I)	Fill factor	Pmax (W)	Area of Panel (m2)	Efficiency (%)	Avarage Efficiency	Average Fill Factor (%)
1	6:03	0							0.75	0.00%	9.15%	67.71%
2	7:03	0								0.00%		
3	8:03	652	19.9	3.7	15.6	3.49	0.7	54.44		11.16%		
4	9:03	745	20	4.66	15.5	4.22	0.7	65.41		11.74%		
5	10:03	854	19.6	5.12	14.9	4.63	0.68	68.98		10.80%		
6	11:03	866	19.4	5.5	14.6	5.09	0.7	74.31		11.47%		
7	12:03	688	20.1	3.81	17.2	2.64	0.59	45.4		8.82%		
8	13:03	632	20	3.67	16.1	3.12	0.68	50.23		10.63%		
9	14:03	527	19.9	3.35	16.3	2.82	0.7	45.96		11.66%		
10	15:03	589	19.8	1.76	16.2	1.65	0.69	26.73		6.07%		
11	16:03	0								0.00%		
	17:19	0								0.00%		

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

3.10 summary

This chapter name is methodology so we describe this chapter all working procedures and work elements like photovoltaic meter, Irradiation meter, temperature sensor. This is very important in the work. We show the technical, electrical specification, I-V 400W calibration, and a flow chart this is how to work sunlight to a solar panel. The solar panel 100, 60, 45W is all specification given this chapter. We work the all procedure on how to work, which are necessary and which meter is connected is all things describe this chapter. At last, which element are measure and this data is put up the lab sheet.

Chapter 4

Data Analysis

4.1 Introduction

The grounding, opinion, policy and present situation of solar electrification dissemination for bringing socio-economic development in town and rural areas been discussed. This is observed in the previous discussion that energy plays a key role in development. The solar home system is suitable for Bangladesh. There is a huge electricity generation is the future of this sector we should want. Bangladesh is a solar energy-rich country. Solar energy can play a vital role in play a secure energy source for sustainable development. The main reason for this study is to access solar energy is given the output of our country in Dhaka city. The survey results are analyzed as follows in the following sections.

4.2 Result:

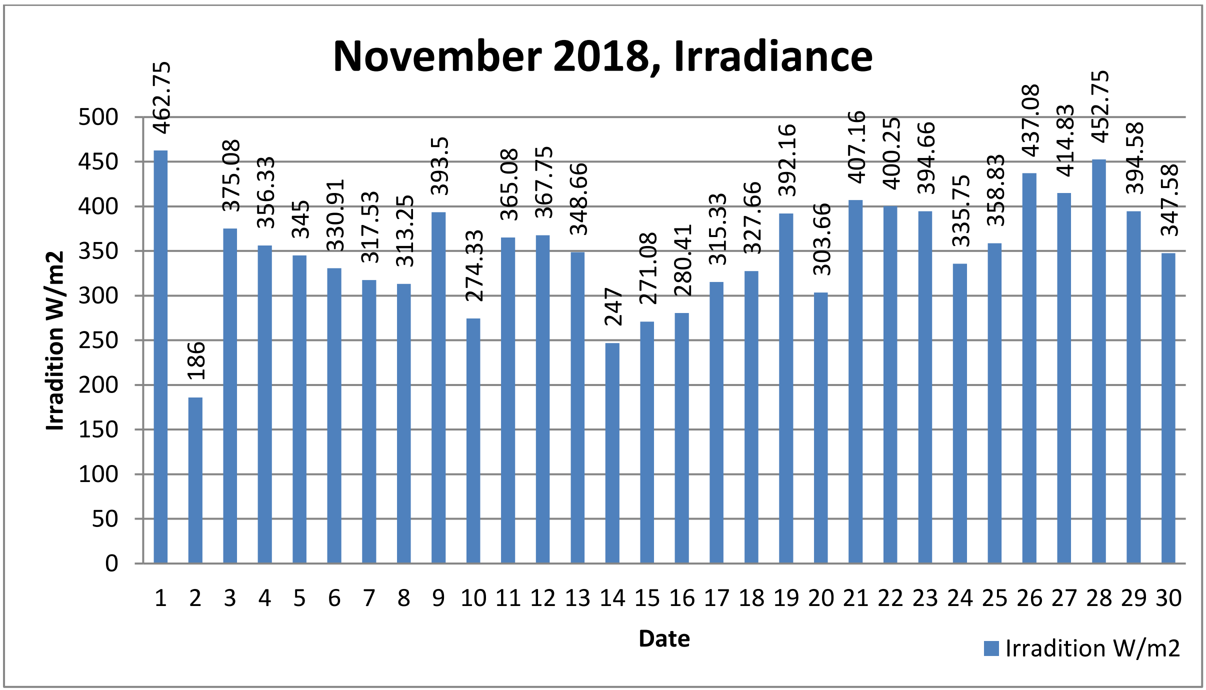

Figure 4.1: Irradiance for November 2018

Figure-4.1 shows the data of the solar irradiation of November 2018. From 01 to 30 November 2018, the highest value of solar irradiance was measured that was 462.75 W/m2 and the lowest value of the solar irradiance was measured that 186 W/m2, the main reason behind this situation was a sunny day and rainy day. During the sunny day, we have gotten the highest value and for the rainy day, we have gotten the lowest value.

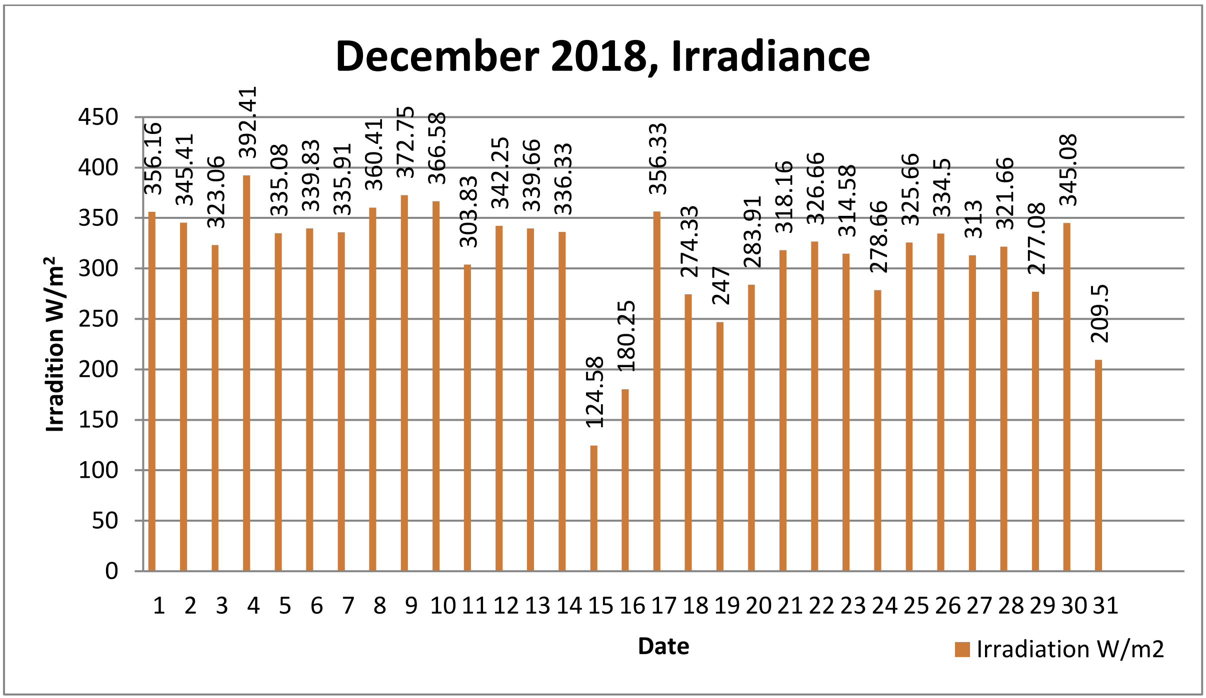

Figure 4.2: Irradiance for December 2018

Figure-4.2 shows the data of the solar irradiation of December 2018. From 01 to 31 December 2018, the highest value of solar irradiance was measured that was 392.41 W/m2 and the lowest value of the solar irradiance was measured that 124.58 W/m2, the main reason behind this situation was a sunny day and rainy day. During the sunny day, we have gotten the highest value and for the rainy day, we have gotten the lowest value.

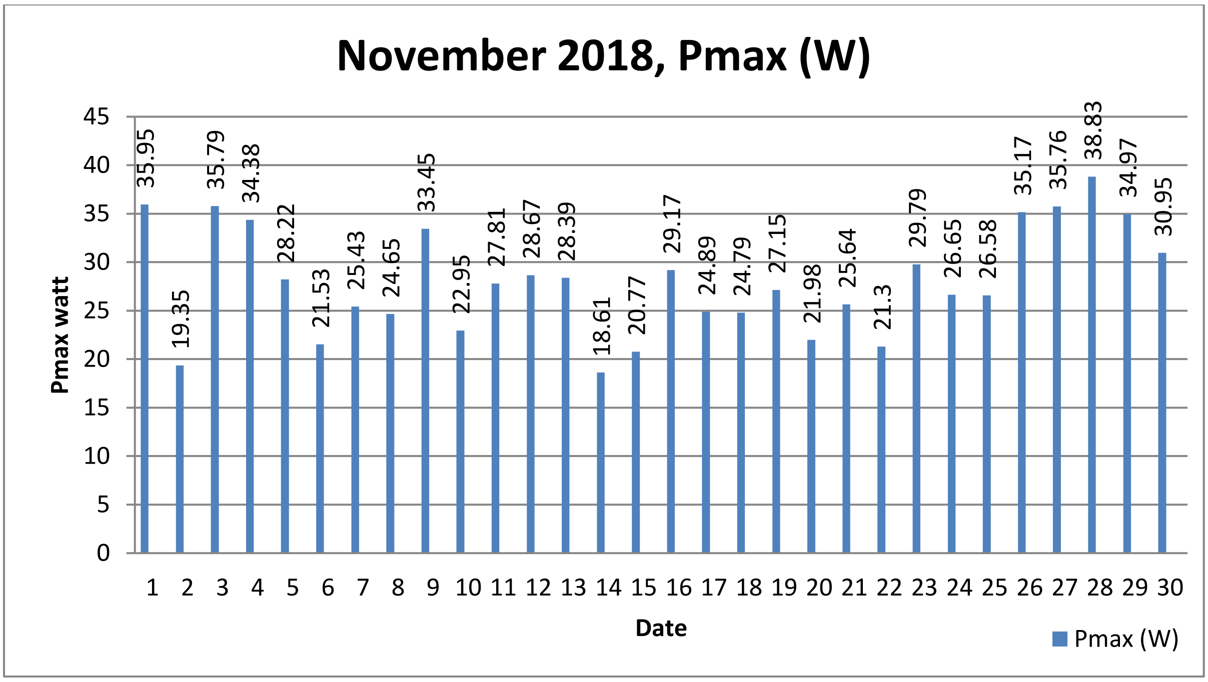

Figure 4.3: Pmax for November 2018

Figure-4.3 represents the power generation curve of the 100W solar panel in November 2018. From 01 to 30 November 2018, we have found the highest value of maximum power (38.83W) and the lowest value of minimum power (18.61W) in November 2018.

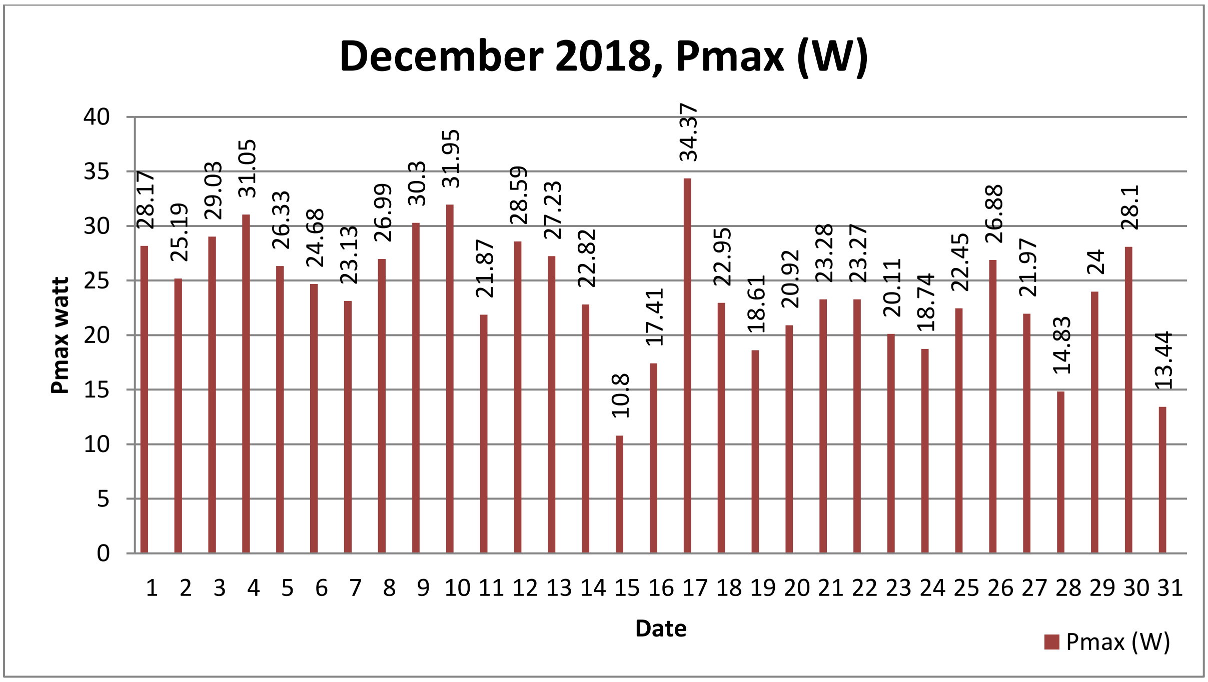

Figure 4.4: Pmax for December 2018

Figure-4.4 Represents the power generation curve of 100 W solar panel in December 2018. From 01 to 31 December 2018, we have found the highest value of maximum power (34.37W) and the lowest value of minimum power (10.8W) in December 2018.

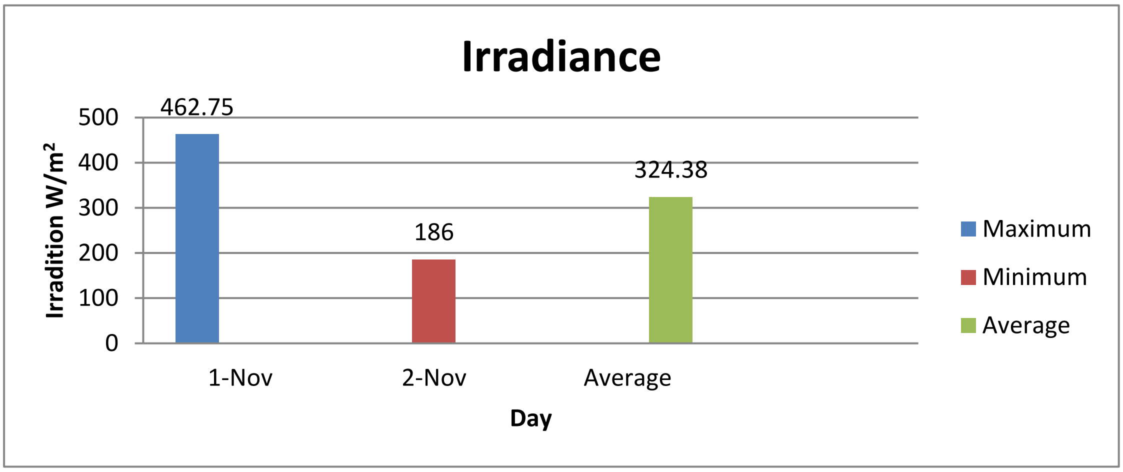

Figure 4.5: Irradiation graph for November (Maximum, Minimum & Average)

Figure-4.5 shows the data of the solar irradiation of November 2018. On 01 November 2018, the highest value of solar irradiance was measured that was 462.75 W/m^2 and on 02 November 2018, the lowest value of irradiance was found that was 186 W/m^2 and the main reason behind this situation was a sunny day and rainy day. During the sunny day, we have gotten the highest value and for the rainy day, we have gotten the lowest value. Moreover, November 2018 monthly average irradiation is 324.38 W/m^2 per day or 7.785 kWh/m^2/day.

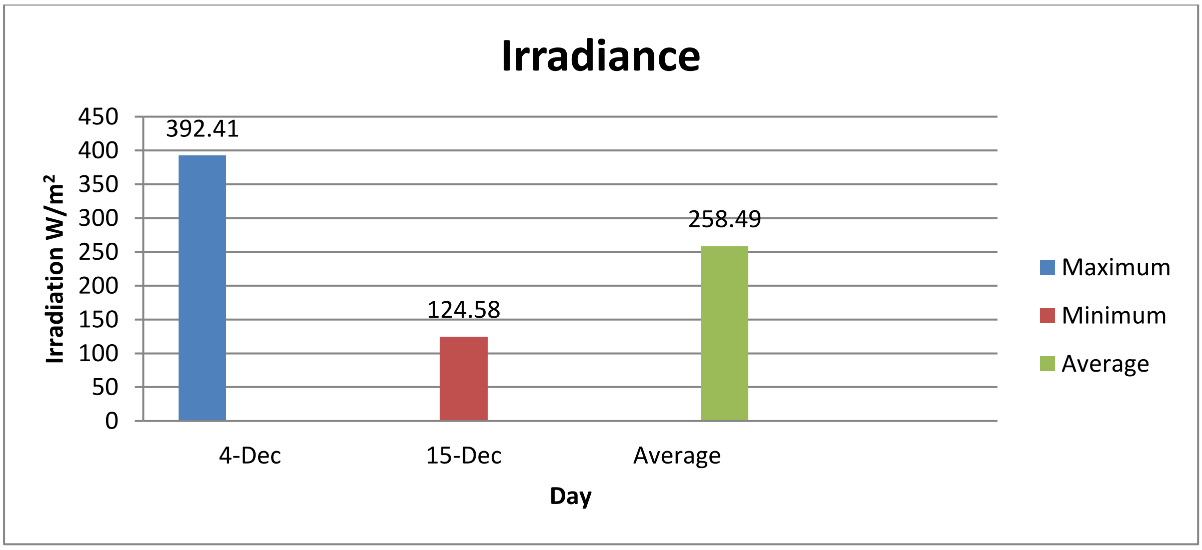

Figure 4.6: Irradiation graph for December (Maximum, Minimum & Average)

Figure-4.6 shows the data of the solar irradiation of December 2018. On 04 December 2018, the highest value of solar irradiance was measured that was 392.41 W/m^2 and on 15 December 2018, the lowest value of irradiance was found that was 124.58 W/m^2 and the main reason behind this situation was a sunny day and rainy day. During the sunny day, we have gotten the highest value and for the rainy day, we have gotten the lowest value. Moreover, December 2018 monthly average irradiation is 258.49 W/m^2 per day or 6.203 kWh/m^2/day.

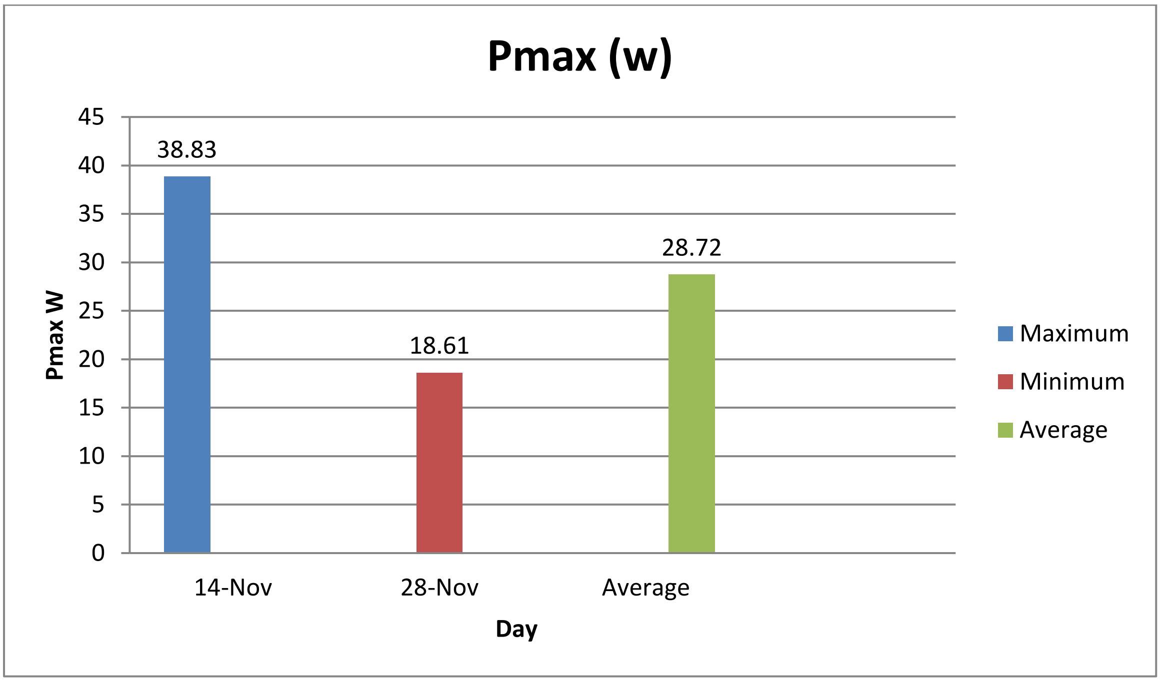

Figure 4.7: Pmax graph for November (Maximum, Minimum & Average)

Figure-4.7 represents the maximum power generation curve of 100 W solar panel in November 2018. On 14 November 2018, we have found the highest value of maximum power (38.83W) and the lowest value of minimum power (18.61W) on 28 November 2018. The monthly average power is 28.72 W.

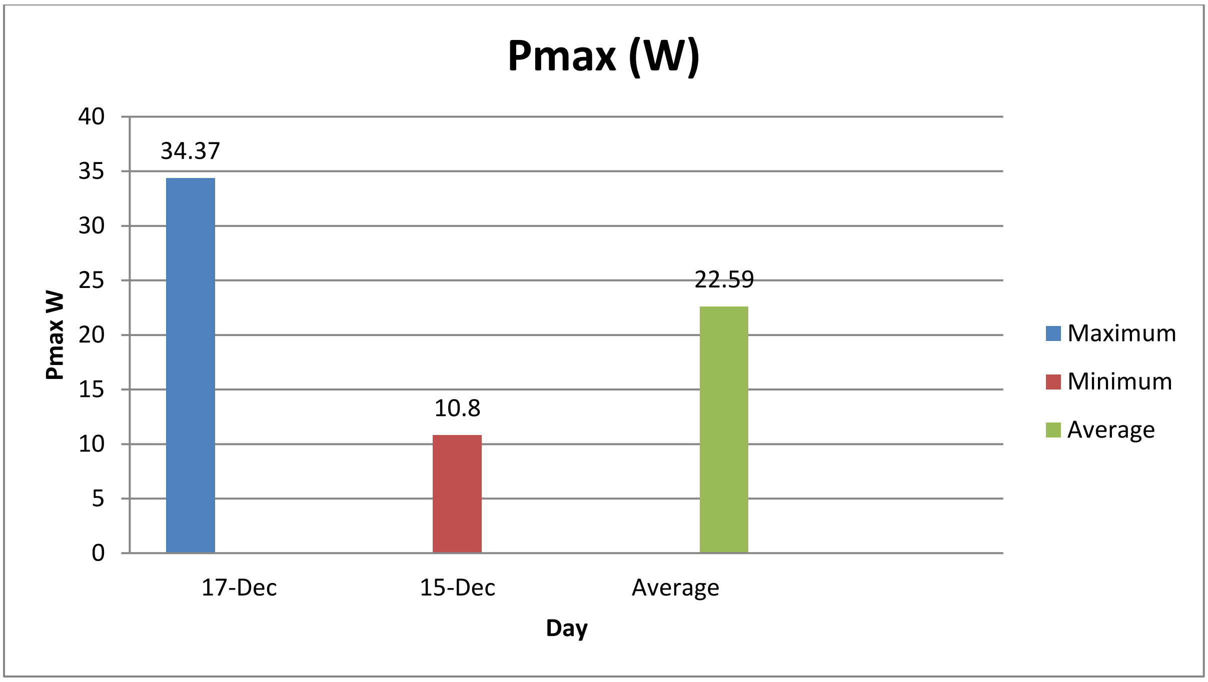

Figure 4.8: Pmax graph for December (Maximum, Minimum & Average)

Figure-4.8 Represents the maximum power generation curve of 100 W solar panel in December 2018. On 17 December 2018, we have found the highest value of maximum power (34.37) and the lowest value of minimum power (10.8 W) on 15 December 2018. The monthly average power is 22.59 W.

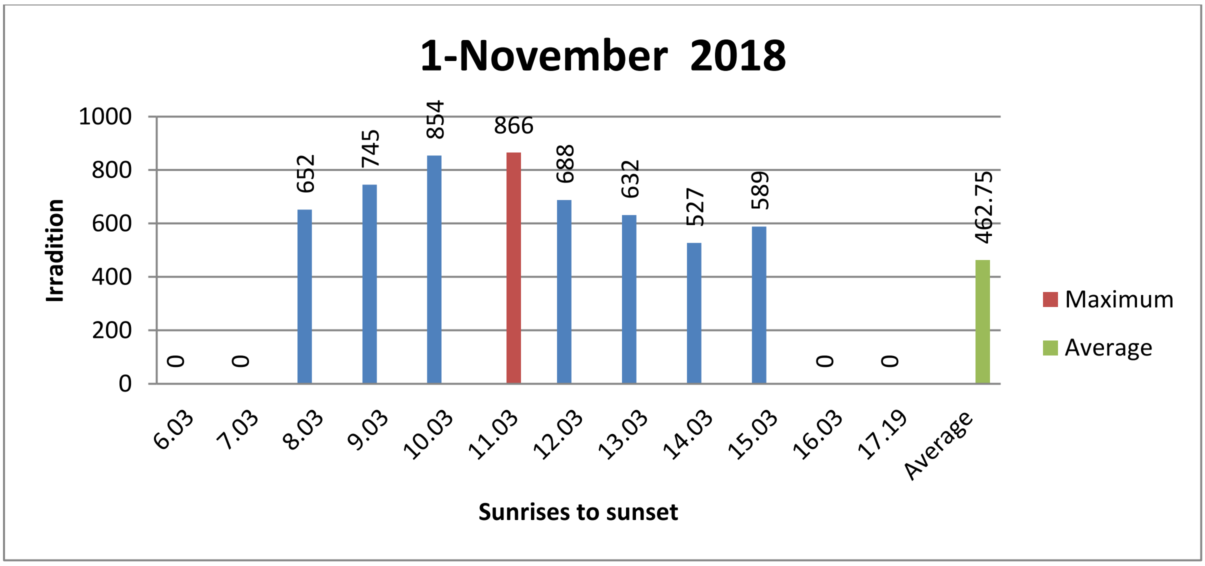

Figure 4.9: Sunny day irradiation for November 2018

Figure-4.9 shows the data regarding the irradiance of a sunny day in November 2018: During a sunny day, we get the highest irradiance 866 W/m^2. On a sunny day, we measured our data every hour. The average irradiance of sunny days is 462.75 W/m^2.

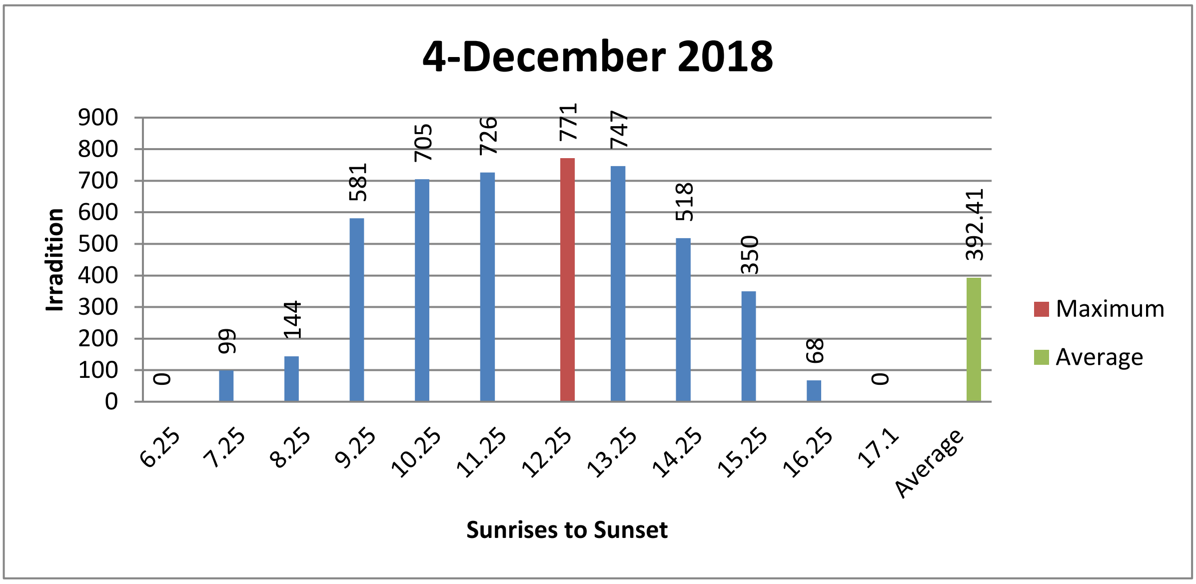

Figure 4.10: Sunny day irradiation for December 2018

Figure-4.10 shows the data regarding the irradiance of a sunny day in December 2018: During a sunny day, we get the highest irradiance 771 W/m^2. On a sunny day, we measured our data every hour. The average irradiance of sunny days is 392.41 W/m^2.

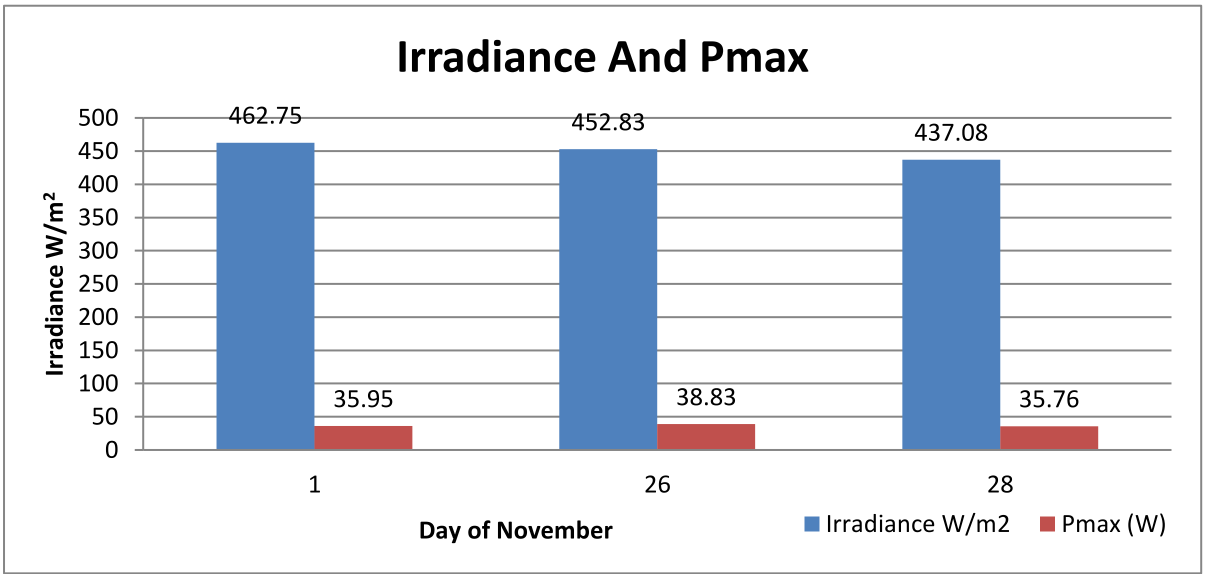

Figure 4.11: Irradiance and Pmax in November

Figure- 4.11 On 01 November 2018, the measured irradiance was 462.75 W/m^2 and the corresponding power produced by that panel was 35.95 W. However, the matter of concern that, on 26 and 28 November 2018, the measured irradiance was 452.83 & 437.08 W/m^2 but the power produced by the panel was 38.83 & 35.76 W which was higher than the previous one. The average power of the sunny day is 28.72 W. This is another finding of this research. Generally, we can see that the power is proportional to the irradiation of the sun. But in this case, the situation is not similar because we get more power in less irradiation and get less power in higher irradiation. Here in this research, we find this main reason behind this problem. This happens because the irradiation measurement tool does not measure the power production of the panel at that moment. We get the total produced power from the solar panel and irradiation from the other toolbox. As we know sun irradiation is not the same in all places. So, when we measured the less power at that moment the fallen irradiation of the sun on that panel was less than the irradiation measured toolbox. So, we get less power in more irradiation. We take data by I-V 400W Photovoltaic Panel Analyzer. Our main purpose is to find out how much dc power we get from a solar panel or how much efficient a solar panel. We take 12 certain times data in a day. The purpose of taking data from the solar panel is to find out how much dc output can deliver a solar panel in a day. So as much time we can take data in a day then the calculation will be more approximate.

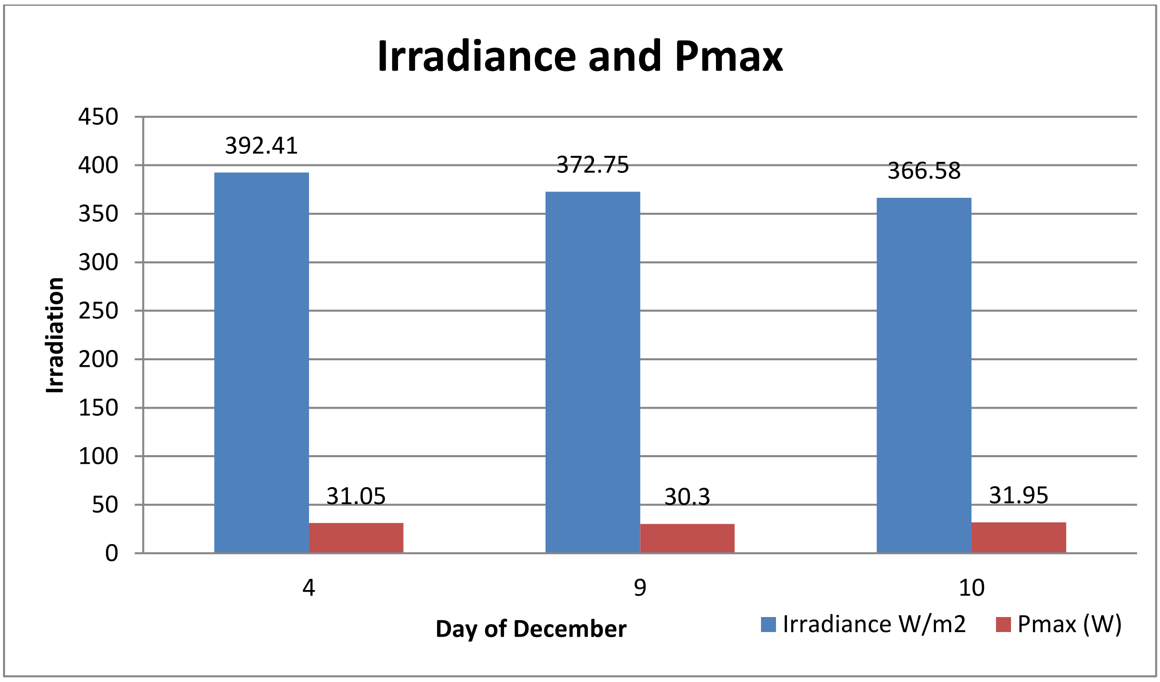

Figure 4.12: Irradiance and Pmax in December

Figure-4.12 On 04 December 2018, the measured irradiance was 392.41 W/m^2 and the corresponding power produced by that panel was 31.05 W. However, the matter of concern that, on 9 and 10 December 2018, the measured irradiance was 372.75 & 366.58 W/m^2 but the power produced by the panel was 30.3 & 31.95 W which was higher than the previous one. The average power of the sunny day is 22.59 W.

Table 4.1: Two months Irradiation and Pmax (November & December)

Date	November 2018		December 2018	
	Irradiance (W/m2)	Pmax (W)	Irradiance (W/m2)	Pmax (W)
1	462.75	35.95	356.16	28.17
2	186	19.35	345.41	25.19
3	375.08	35.79	323.06	29.03
4	356.33	34.38	392.41	31.05
5	345	28.22	335.08	26.33
6	230.91	21.53	339.83	24.68
7	317.33	25.43	335.91	23.13
8	313.25	24.65	360.41	26.99
9	393.5	33.45	372.75	30.30
10	274.33	22.95	366.58	31.95
11	365.08	27.81	303.83	21.87
12	367.75	28.67	342.25	28.59
13	348.67	28.39	339.66	27.23
14	247	18.61	336.33	22.82
15	271.08	20.77	124.58	10.80
16	380.42	29.17	180.25	17.41
17	315.33	24.89	356.33	34.37
18	327.67	24.79	274.33	22.95
19	392.17	27.15	247	18.61
20	303.67	21.98	283.91	20.92
21	407.16	25.64	318.16	23.28
22	400.25	21.30	326.66	23.27
23	394.66	29.79	314.58	20.11
24	335.75	26.56	278.66	18.74
25	358.83	26.58	325.66	22.45
26	437.08	35.17	334.5	26.88
27	414.83	35.76	331.3	21.97
28	452.75	38.83	321.66	14.83
29	394.58	34.97	272.08	24
30	347.58	30.85	345.08	28.10
31			209.5	13.44

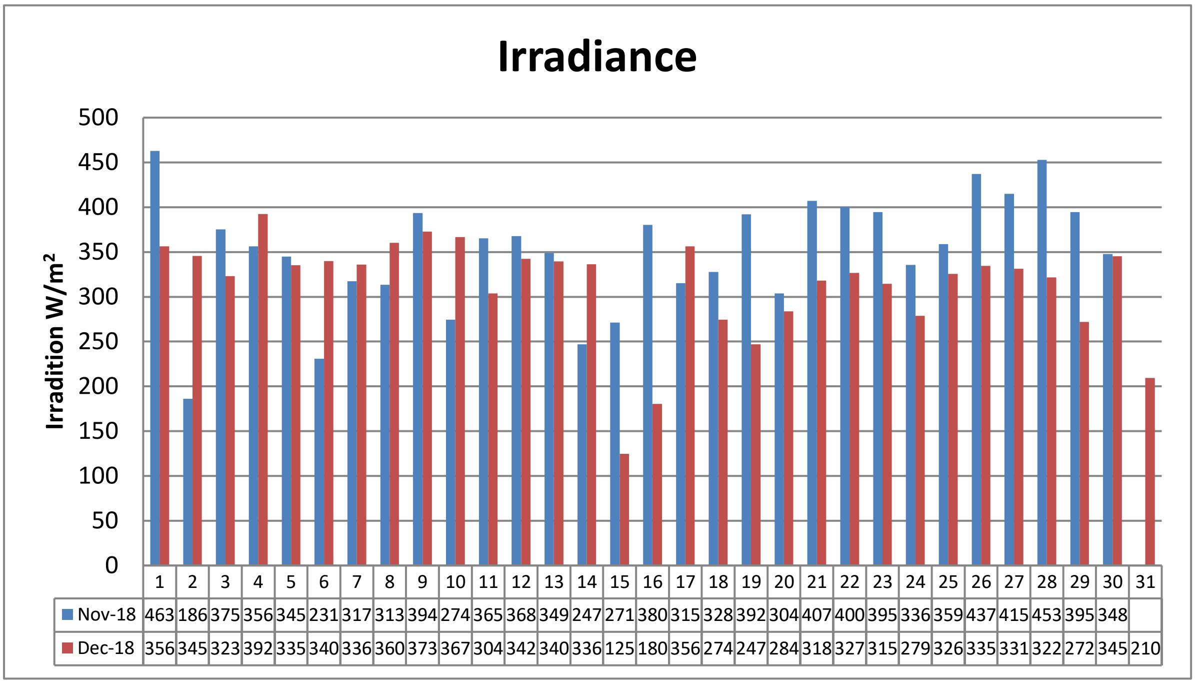

Figure 4.13: Two Months irradiation (November & December)

In figure 4.13 by measuring irradiation for both months November and December we see that the irradiation of November is better than December. Since getting power is depend on irradiation so the irradiation of November gets more power than December. So we can say November is better in both the two months of November and December.

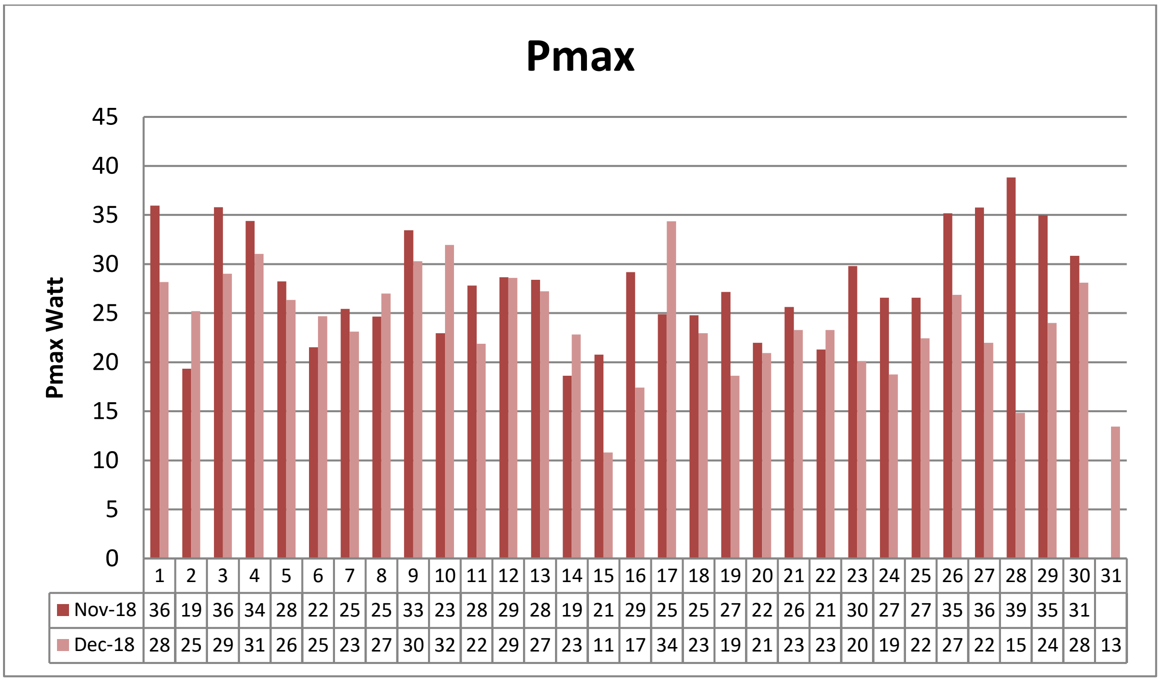

Figure 4.14: Two Months Pmax (November & December)

In figure 4.14 shows that Pmax of the full month both November and December. In the previous figure, we saw that the average Pmax of November is 27.98 and the Pmax of December 23.85. The Pmax of November is good from the Pmax of December.

4.3 Comparison of Solar Radiation Data among Different Years

Table 4.2: Data of Monthly Average Solar Irradiance in 2008, 2009 & 2010 [14].

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	283.3	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

In the year 2008, annual average solar irradiation was 5.01 kWh/m^2/day and the value of irradiation in 2009 was decreased and that was 4.73 kWh/m^2/day. There was also a declining trend in solar irradiation value between 2009 and 2010 because, in 2010, only 4.50 kWh/m^2/day irradiation was measured as shown in Table- 9.

Solar radiation data were collected from the Renewable Energy Research Center (Dhaka University), National Renewable Energy Laboratory and Development and Research is given in Table-7. Most of these solar radiation data were collected from DU for Dhaka with different cities in Bangladesh.

Table 4.3: Collected Solar Irradiance Data of Bangladesh from 1985-2006 were Presented Below [15]

Month	NREL (1985-91)	RERC (1987-89	RERC (1992)	DLR (2000-2003)	RERC (2003-2005)	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	4.48	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	4.06	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

In the year 1985-1991, annual average solar radiation was 4.59 kWh/m^2/day and it was increased into 4.64 kWh/m^2/day in 1987-89. But in 2000-03, annual average radiation was 4.52 kWh/m^2/day which was decreased into 4.2 kWh/m^2/ day in 2003-05. In 2006, radiation was increasing, and the value was 4.45 kWh/m^2/day.

4.4 Summary

In the data analysis chapter, we describe our work. We work on 100 W solar panels in our University in the Dhanmondi area. Here we measure daily irradiation and Pmax for November and December. We got monthly average irradiance for November is 350.56 w/m2 and 312.71 w/m2 for December. And also got monthly average Pmax for November is 27.98 W and 23.58 W for December. We measured separately average irradiation and Pmax for sunny days for both month November and December. We got average irradiation for November is 462.75 and 392.41W/m^2 for December on sunny day. By measuring both November and December we analyze that the average irradiation of November is better than December. So the Pmax of November is also better than December.

Chapter 5
Conclusion

5.1 Conclusion

At present days the impetus, progressive and sustainability of civilization depend on energy. For utilizing solar power more effectively, it is very important to measure the irradiation of that country from time to time because solar radiation is changed over time. In this thesis, our main aim was to find out the irradiation of sun in Dhaka city in the month of November and December so that the power production by the solar panel can be estimated and by using this data we can easily understand the electricity production by SHS and create a standard form of power production of SHS in 2018. Here we find that the average irradiation of November 350.55 and December was 312.71 W/m^2. And corresponding power produced by the 100 W solar panel was 27.98 W and 23.85 W respectively. Although the use of SHS energy implement is more limited, lifestyle has significantly developed due to the availability of solar energy. Family members excerpt households work position develops due to electric lighting and ignore of kerosene-related work. Solar energy lighting enhances the evening hours of family activity. Watching TV, productive activities and the studying of school-going children are common activities advantages from the enhanced evening time. SHS electricity also develops a family situation for education as it provides clear light and fresh air as well as longer studying hours for kids. In the case of health benefit, it is also found that SHS owned households get developed indoor air, availability of information on health issues as well as reduced accidents related to kerosene use. We get many information, education, and entertainment for using TV, Radio and mobile phones. Improve economic growth, quality education, health benefit and access to information can significantly raise the productivity, skill, and livelihood of the rural people. In combination with other wide rural improvement programs, SHS will ensure sustainable socio-economic development in the long run. Our life directly depends on electricity, In Bangladesh electricity generation is mostly dependent on diesel fuel and gas. These resources are limited, why solar energy will be the main source of electricity. Immense prospect of solar electricity in rural areas of Bangladesh Researchers are acknowledged that.

Now researchers are trying to use this technology for rural development and trying how to get more solar energy from this technology and we get more and more benefits from solar energy. Now it is high time to integrate structural set up for using this untapped resource.

5.2 Future Scopes of the Work

In this research, we try to clarify how much power can be produced in the month of November & December 2018 from a solar system. We have worked only for two months but in the future, we can measure power and irradiation throughout the year along with the analysis of panel efficiency. This work is a long time processing. These are a minimum of one year and a maximum of two or three years. The future of scopes of this work is very bright. We work the solar irradiation and power. In the future, this work is to fix up the standardization of solar energy, the effect of dust and to determine the battery losses.

Reference

[1] Ulanoff, Lance (2 October 2015). "Elon Musk and Solar City unveil 'world's most effi-cient' solar panel". Mashable. Retrieved 9 September 2018.

[2] Jump up^ da Silva, Wilson (17 May 2016). "Milestone in solar cell efficiency achieved" ScienceDaily. Retrieved 9 September 2018. A new solar cell configuration developed by engineers at the University of New South Wales has pushed sunlight-to-electricity con-version efficiency to 34.5% -- establishing a new world record for un-focused sunlight and nudging closer to the theoretical limits for such a device.

[3] https://en.wikipedia.org/wiki/Monocrystalline_silicon

[4] https://www.energysage.com/solar/101/monocrystalline-vs-polycrystalline-solar-panels/

[5] https://en.wikipedia.org/wiki/Copper_indium_gallium_selenide_solar_cells

[6] Bangladesh Power Development Board. http://www.bpdb.gov.bd/bpdb/in-dex.php?option=com_content&view=article&id= 26.

[7] Md. Habib Ullah, T. Haque & Md. M. Hasib. “Current Status of Renewable. Energy Sector in Bangladesh and a Proposed Grid-Connected Hybrid Re-newable En-ergy System”.

[8] Khairul Anam and H. A. Bustami. “Power Crisis & Its Solution through Re-newable Energy in Bangladesh”

[9] “Development of Renewable Energy in Bangladesh” http://www.thedailystar.net/development-of-renewable-energy-in-bangladesh-49670.

[10] https://en.wikipedia.org/wiki/Three_Gorges_Dam#/media/File:ThreeGorg es-Dam-China2009.jpg

[11] M. Rofiqul, M. Rabiul, M. R. A. Beg. 2008. “Renewable Energy Resources

[12] SREDA- Sustainable and Renewable Energy Development Authority.2015

[13] https://en.wikipedia.org/wiki/Dhanmondi_Thana

[14] http://en.wikipedia.org/wiki/Solar_panel

[15] Global Environment Facility, Proposal by REB for "Multiple Off-Grid Elec- trify cation Initiatives (Private Sector, Cooperative, and Community Based)", 2001 World", Washington, USA, 2001

[16] "3 Types of Solar Inverters Explained". Do it yourself. Retrieved 15 February 2017.

[17] Md. Saydur Rahman, S.K Saha, Md. R.H Khan, U.H, SMH Chowdhury. 2013. “Present situation of Renewable Energy in Bangladesh: Renewable Energy Re- sources.

[18] Existing in Bangladesh” Global Journals Inc (USA).

[19] Mohammad Hossain. 2015.“Achieving Sustainable Energy Targets in Bangla- desh“The Magazine of the United Nations.

[20] “Power System Master Plan 2016 Summary” Power Division, Ministry of Power, Energy and Mineral Resources Government of the People’s Republic of Bang- ladesh. https://0x9.me/vBlF6.

[21] Md. Alam Hossain Mondal. “Implication of Renewable Energy Technologies in the
Bangladesh Power Sector: Long-Term Planning Strategies”.

[22] “Target to Generate 2,000 MW Renewable Energy in 2021”,http://www.theindependentbd.com/printversion/details/31438.

[23] Md Niaz Murshed Chowdhury. 2015. “Present Scenario of Renewable Energy and Non Renewable Energy Sources in Bangladesh: A Compact Analysis” Business and Economics Journal.

[24] M. Hussain. 1987. “Bangladesh Energy Resources and Renewable Energy Prospects”.

[25] Md. Abu Bakr Siddique and S. M. Rezaul Karim. 2017. “Modeling of Double Diode Solar Photovoltaic Module using Matlab” International Journal of Computer Applications 179(7): 4-10.

[26] Mazharul Islam. 2008. “Renewable Energy Prospect and Trends in Bangla-desh”.

[27] “Bangladesh Power Development Board” http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=26.

[28] Khairul Anam and H. A. Bustami. “Power Crisis & Its Solution through Re-newable
Energy in Bangladesh”.

[29] M. Rofiqul, M. Rabiul, M. R. A. Beg. 2008. “Renewable Energy Resources and
Technologies Practice in Bangladesh”.

[30] U. Rehling, “Small biogas plants, sustainable energy systems and management (SESAM), University of Flensburg, Germany, 2001.

[31] A. K. Azad. 2011. “A Review on Renewable Power Sources: Prospects of Bangladesh and Scotland,” eBook, St. Andrew’s University, Scotland, UK.

[32] I.B. Fridleifsson, R.B, E.H, John. W.L, A.R and L.R. 2008. “The Possible Role and
Contribution of Geothermal Energy to the mitigation of Climate”.

[33] REN21-Renewable Energy Policy Network for the 21st Century.

[34] Md. Abu Bakr Siddique, M.T. Hoque, T.S. Ullah, R.H. Sagor, Md. S. Ullah. 2015. “Study of PV Implementation for Electricity Generation in Bangladesh” Green Energy and Technology (ICGET), 3rd International Conference on, IEEE, pp. 1-5.

[35] http://www.thegreenage.co.uk/article/the-impact-of-temperature-on-solar-panels/

[36] https://www.asme.org/engineering-topics/articles/energy/self-cleaning-solar-panels- maximize-efficiency

[37] http://pveducation.org/pvcdrom/characterisation/measurement-of-solar-cell-efficiency

[38] European Commission (2015) The impacts of large-scale Concentrated Solar Power on the local environment, http://ec.europa.eu/environment/integration/research/newsalert/pdf/environmental_i mpact_of_large_scale_concentrated_solar_power_400na2_en.pdf

[39] http://solarenergy.com/power-panels/latest-solar-news/solar-panel-efficiency-lets- dig- deeper

[40] http://www.yougen.co.uk/blog- en-try/2189/How+important+is+the+efficiency+of+solar+panel'3F/

[41] http://homeguides.sfgate.com/effects-temperature-solar-panel-power-production- 79764.html

[42] Applications of Solar PV

[43] C.D., Urmee, T.P., Kumar, S., & Bhattacharya S. (2001). A photovoltaic solar home system dissemination model. Progress in Photovoltaic Research and Applications, 9, 313–322

[44] http://en.wikipedia.org/wiki/Solar_panel

[45] Global Environment Facility, Proposal by REB for "Multiple Off-Grid Electrification Initiatives (Private Sector, Cooperative and Community Based)", 2001 World",Washington, USA, 2001

[46] "Renewable Energy Policy of Bangladesh", Bangladesh Gazette, 2008

[47] M.J. Haque, M.N. Hyder, M.A. Rashid Sarker and A.M Aziz-Ul Haque, 'Performance Enhancement of PV Modules Using Reflectors' Journal of Energy and Environment Pub-lished by the Centre of Energy Studies, BUET, Volume 1, PP 1-9, November 1999

[48] Global Environment Facility, Project Document of "Solar and Wind Energy Resource Assessment (SWERA) ", May 2001Bangladesh", Dhaka, Bangladesh, 1996

[49] A.K.M Sadrul, M. Islam, and T. Rahman, Effective renewable energy activities in Bangladesh, Renewable Energy, 31(5), 2006, 677-688.

[50] http://homeguides.sfgate.com/effects-temperature-solar-panel-power-production- 79764.html

[51] http://solarenergy.com/power-panels/latest-solar-news/solar-panel-efficiency-lets- dig-deeper