

STUDY OF THE SOLAR IRRADIATION PATTERN OF BANGLADESH FOR ELECTRICITY GENERATION

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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 January 2019.

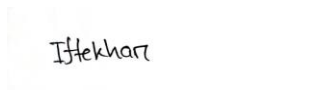
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Dedicated to

Our Parents

And

Our Teachers

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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	Mega Watt
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

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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 (May & June) 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.

Chapter 1

Introduction

1.1 Introduction

Bangladesh is the developing country. In the electricity sector, day by day develop so the renewable energy is develop. Our work is performance testing and analysis of roof top solar panel. It is suitable for our country and start the renewable energy. It support that the non-renewable energy in our country. The solar roof top are also help in our electricity cost minimization, support the load shedding time and many other help. In this local area there is no electricity there is no reach grid area, this are help the roof top solar system. But solar system is most important problem, low light, rainy season in rainy day, there is not work a solar system. Our work is performance and analysis the roof top solar system in the capital of Bangladesh, this name is Dhaka. We work to see performance the three solar panel. There are 45 watt, 60 watt and 100 watt. 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 season from March through May thus time the sun irradiance is very high, so thus 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, thus time the Rainy season is not comfortable to a solar panel. Majority day the sky is cloud and rain in any time of the day and night. So thus time solar system is not work. In that time we pick our current is discontinuously and a cool fry winter season from November through February. This time solar irradiance is middle level. The sun flow the day 3 or 4 hours, highest 5 hours. So this time we take middle electricity.

The present situation of our country we generated seventeen thousand megawatt electricity. It is not enough of our country so we produce new installation side. These are the solar

system on grid and roof top SP off grid. The other energy installation is wind, Biomass, Biogas, Hydro etc. These are very helpful and support in 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 hydro power. 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 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 running our projects. at the time the worldwide there is big steps for clean and sustainable energy. These time both are developing renewable sources like as 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 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. This areas electricity distribution is not good. So they take the solar energy for reduce the grid electricity. This time their cost is minimize. Solar energy type 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 city area this time SHS is increases day by day. Majority of building owners has there solar panel on the roof top of building. Here these place generate the electricity of on grid in this building so their electricity bill is decrease.

The renewable energy is the most important worldwide. Many country produce energy to help this. These are helpful the energy generation own country. The RE is generated from the 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 sources providing 3%-5% of the world energy consumption and 15% 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 of these field. The solar system are also helps us to generation in our RE. The Photovoltaic (PV) system are depends of sun. The PV energy annually manufacturing output of the photovoltaic industry reached 6900MW, in 2008. These station are very popular USA, Germany, Spain and France. There is the biggest plant is 354Megawatt. SEGS power plant in the Mojave Desert. The world largest geothermal power generation is Gaysers in California. This capacity with rated of 750MW. Our government are also various steps to develop our renewable energy. These are

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

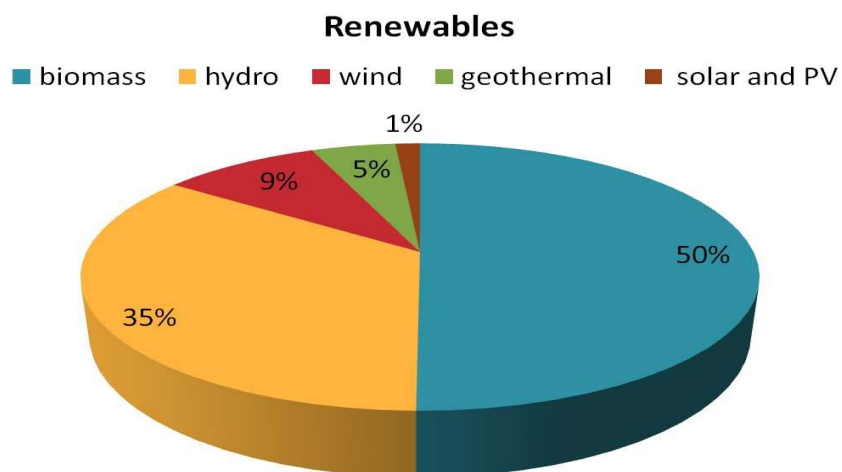


Figure 1.1: A pi-chart of RE in the world

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

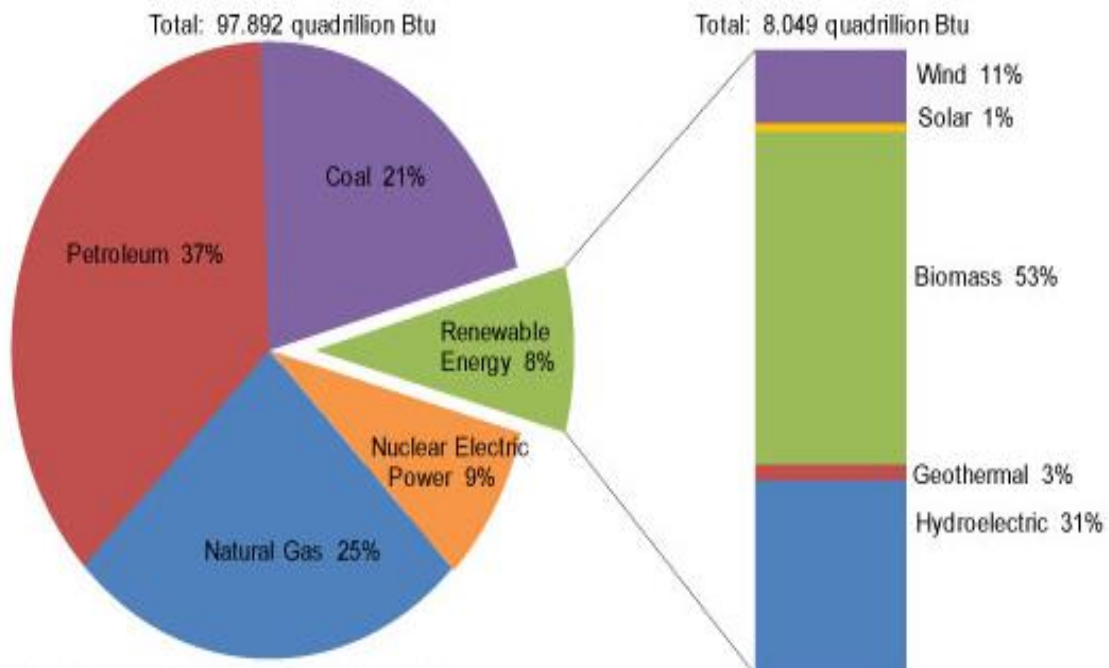


Figure 1.2: A pi-chart of RE in Bangladesh

1.3 Photovoltaic (PV) Cells

Solar System:

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



Figure 1.3: Solar Panel situated the paddy field

1.4 Objectives

- To collect 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 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.

1.5 Scopes

We work in our university's roof top. Here we measure 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.

1.6 Thesis Outline

This thesis is organized as follows:

Chapter 1 Introduction.

Chapter 2 Reviews the literature.

Chapter 3 Methodology.

Chapter 4 Data analysis.

Chapter 5 conclusions.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

Renewable energy is 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 which provides renewable energy which are air and water heating/cooling, electricity generation, rural energy services and transportation. Almost all energy used was renewable in the mid of 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 the 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 is the convert sunlight to energy. The directly use the PV system and indirectly uses concreted the 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 the 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 come it. We see the table 2.2 the highest electricity come to solar and lowest come in micro hydro.

Table2.1: Total insulated power in grid

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

Table2.2: Total insulated power off grid electricity

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 help in Renewable Energy Department in Bangladesh

Our government is very helpful to generate electricity in renewable energy sector. Below show a table 2.3 the GOVT help this.

Table2.3: Government help 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 gas is the most dangerous for environment. The weather is directly affected because of increasing the temperature by greenhouse gas. Our country is one of the top weather vulnerable country among 48 country. 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 public and private sector of our country have taken many plantation 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 sustainable growth of renewable energy. They are various step in develop our country and electricity.

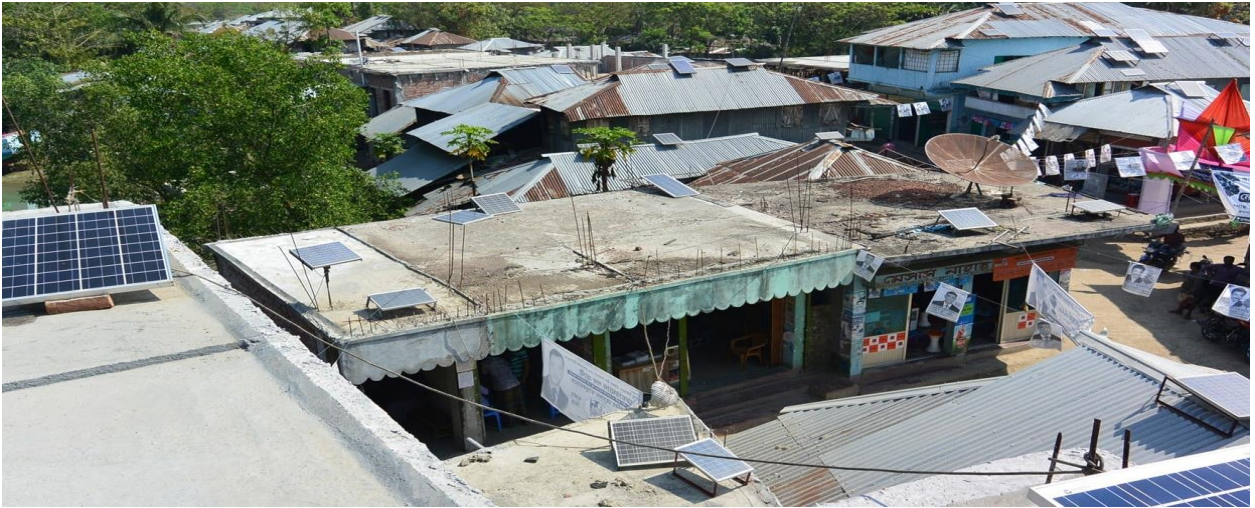


Figure 2.1: Solar home system in village are

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



Figure 2.2: The SHS system in town area

2.7 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 to shows the whole mechanism of solar system.

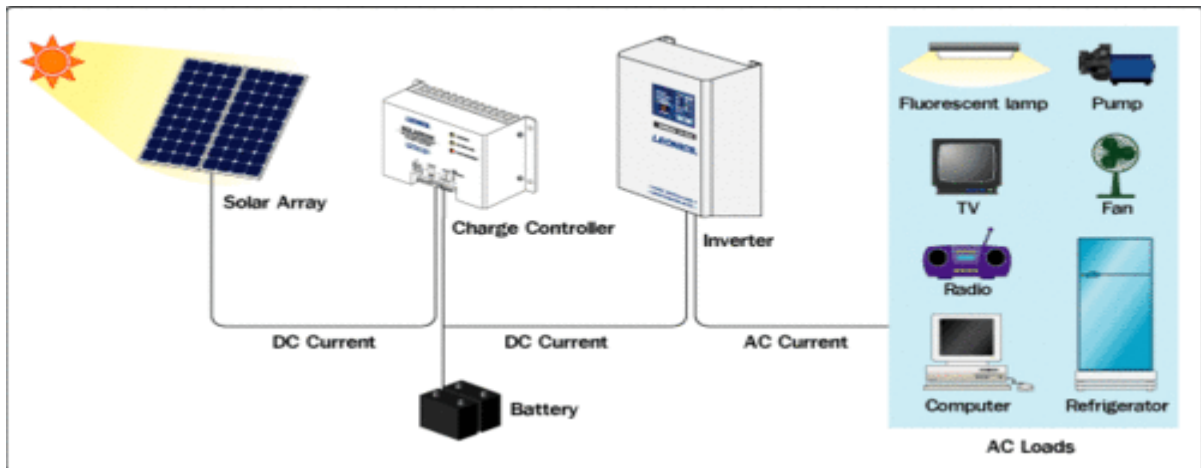


Figure2.3: The solar home system mechanism

The 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:

1. Panel
2. Battery
3. Charge Controller
4. Inverter

2.7.1 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 watt module will double the area of a 16% efficient 230 watt 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 produced in this field. We work three solar panels this panel blue color and there are 45, 60 and 100 watt. Given a figure 2.4 to show the solar panel.



Figure 2.4: Solar panel

2.7.2 Battery

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



Figure 2.5: Battery

2.7.2.1 Lead acid

Lead acid batteries are a tested technology that used in off-grid energy processes for decades. While they have a relatively small life and lower than other kind of battery, 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 want to go off the grid and want to install lots of energy storage.

2.7.2.2 Lithium ion

The most of the new home energy storage systems, like the, use some form of lithium ion chemical composition. Lithium ion batteries which 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 which use heavy metals, including lead acid and lithium ion batteries, so it will be a new process saltwater batteries which are relatively not tested, and the one company that makes solar batteries for home use filed for bankruptcy in 2017.

2.7.3 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 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

2.7.4 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.

2.7.4.1 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.

2.7.4.2 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.

2.7.4.3 Battery backup inverters

Battery backup inverters, are exceptional inverters that is designed for 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 of supplying AC energy to selected loads during a utility outage, and are required to have anti-islanding protection.

2.8 Types of Panel

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

2.8.1 Poly Crystalline

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

2.8.2 Mono Crystalline

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

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

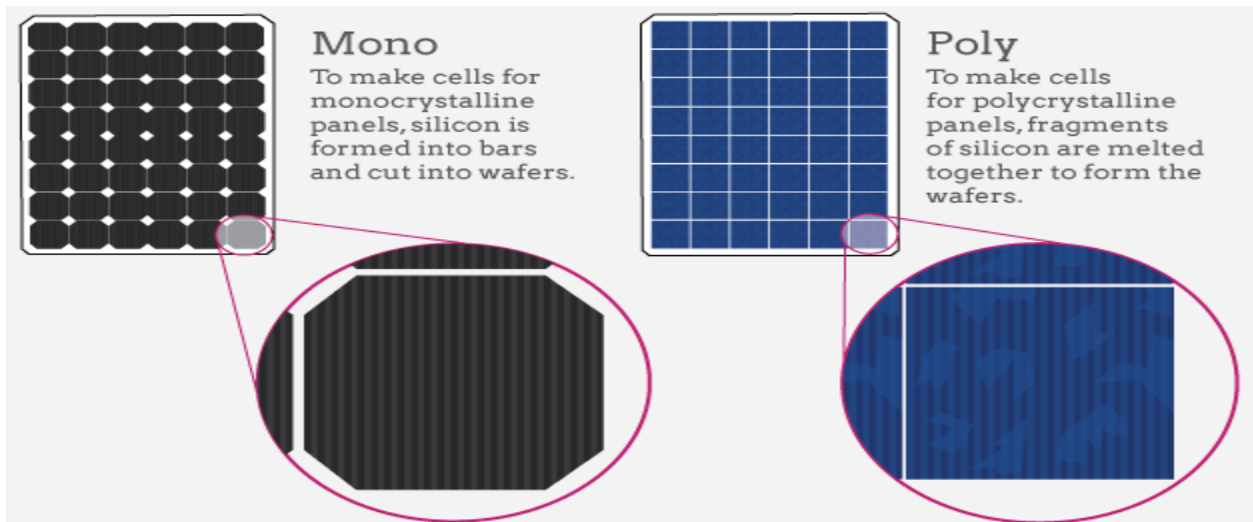


Figure 2.8: Characteristics of poly and mono crystalline solar panel [4]

2.8.3 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 are very flexible to the other panel. To below a figure 2.8 to see a thin film.



Figure 2.9: Thin film

2.8.4 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 the 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

2.9 Others going project RET project in Bangladesh

- Biomass plants-BCSIR, BRAC
- Micro hydro power plant – LGED
- Wind mill water pumping – LGED
- 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

2.10 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 declare 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 wind mills 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 1000 kW capacity system [6]. Wind turbines are being installed which capacity stand-alone type. The total power which generated by all the wind turbines is stored in a battery bank.



Figure 2.11: Wind power

The project of BPDB has completed their 0.90 MW capacity grid connected to wind energy at Muhuri Dam area in 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 the very important part of the renewable energy. In our country this energy first ever produce of wind is at Muhuri Dam. It is situated 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 dimension in Patenga, Cox's Bazar, Kuakata, Moheskhali and Nuakhali by the stand this field [9].

The figure 2.11 to show that a wind pump set up by BCAS at Patenga, Chittagong.



Figure 2.12: Wind power in Bangladesh

2.11 Hydropower

The hydropower is the generated to 16%-18% electricity. A large hydroelectric plant was stand in the Kaptai region using the Karnaphuli river during the 1960s. These capacity is 230MW and help us our country electricity. The generation power cost is very low than other fuel of our country. Bhutan is this field their capacity to produce 25000megawatt. Now this country to 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 hydroelectricity to advantages to electricity produce. These are very useful our country. To show a figure 2.12 the world largest hydro power plant in China. It situated the Three Gorges Dam. This installed capacity is 22500MW in 2014.



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

2.12 Micro/Mini Hydro

The mini hydro contribute to distributed generation in a local electricity grid and to improvement of hydroelectric power on a scale worthy for 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 hydro power plant to show that



Figure 2.14: Micro/Mini Hydro power plant

2.13 Biomass Energy

As an agricultural country, Bangladesh has the potential to produce electricity from biomass 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, 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 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 2.4: 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

2.14 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. Energy Star labeling Program has been started by BSTI to motivate the 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 level. This program is nationally observed on 7th December each year.

2.15 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 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 consists by wind power system. Depending on wind velocity the total capacity of the system is hope to be 200 W. the respective engineers who complete design, assembly and installation of the turbine system. The Hydro Emulator Set is small prototype based which consists of two different type of turbine technology are Pelton wheel and Kaplan turbine. From a small water reservoir tank will run the turbine system. Hope that 20 W will generation capacity from the two turbines. The engineers trying to design Solar Power Converter with innovative ideas and new concept which are more preferable to us.

2.16 Summary

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

Chapter 3

Methodology

3.1 Introduction

Bangladesh is a suitable country of 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 off grid area of our country there is no current but this area are suitable for photovoltaic cells, so the government advice this place connect and situated for solar home system. In Dhaka city there is a lot of building, this high is very good. This building roof top stand the solar panel and connected to on grid that means these is connected to main switch in this building. Medium type solar panel are cost minimization and about ten thousands taka decreases in electricity bill per year.

3.2 Description of Study Area

Our work place in 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 Dhaka district of Bangladesh. It has 33451 houses and 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 Dhaka 1215, Bangladesh. Different types of solar panel have installed their as 45W, 60W and 100W.

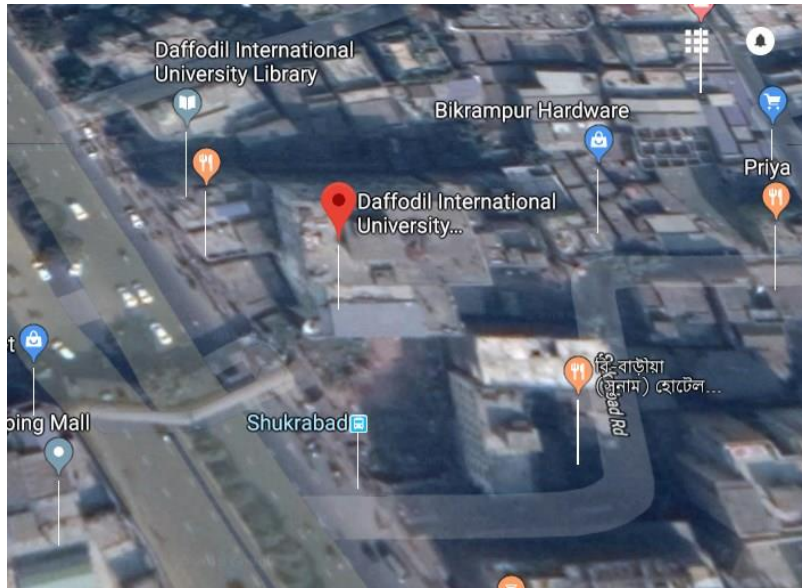


Figure 3.1: Satellite View

3.3 System Design

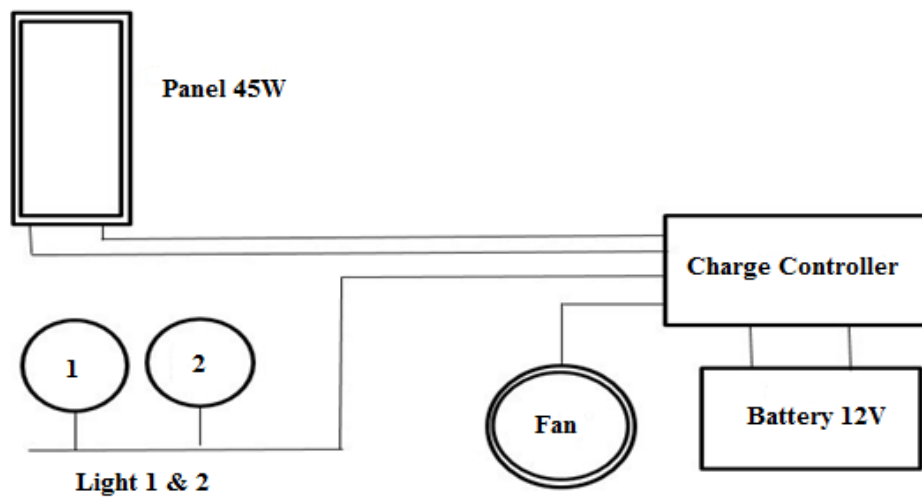


Figure 3.2: System Design (45W)

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 photovoltaic, 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 than 80% of their initial minimum stated power for a period of 25 years.

3.4.1 45 watt Solar Panel

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

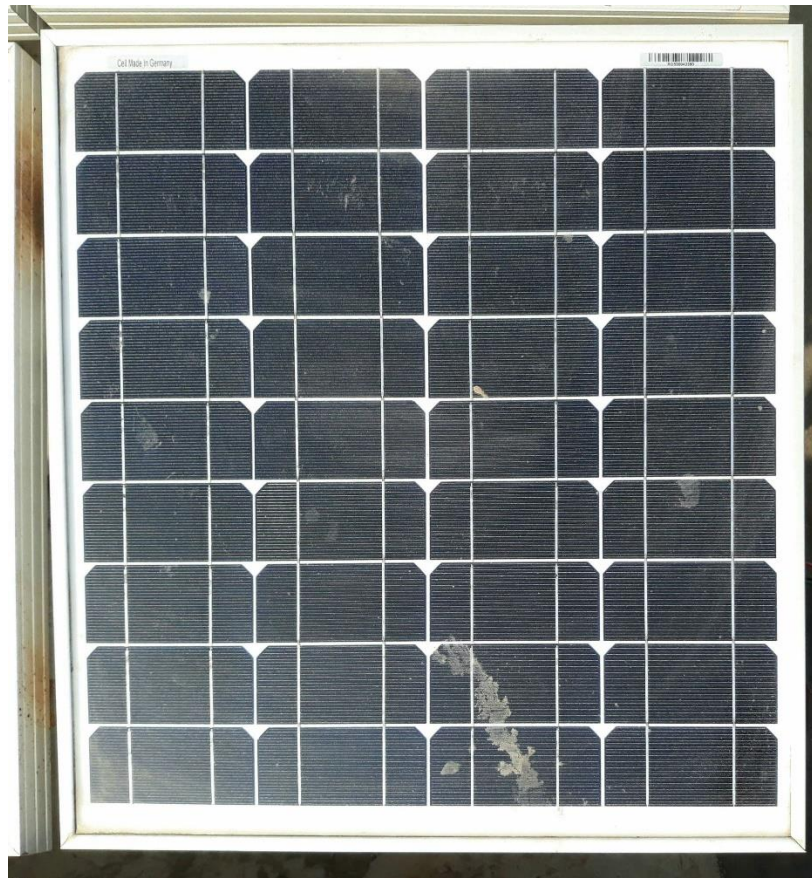


Figure 3.3: 45 Watt solar panel

3.4.1.1 Electrical Specifications

I.	Maximum Power(PmP)	45wp
II.	Open Circuit Voltage(Voc)	21.42v
III.	Short Circuit Current(Isc)	2.72A
IV.	Maximum Power at Voltage(Vmp)	17.10v
V.	Current at Maximum Power(Imp)	2.63A
VI.	Module Dimension	580*550*350mm
VII.	Module Weight	4.16+-3%

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. Irradiance meter
- III. Temperature Sensor

3.5.1 Photovoltaic Meter

The photovoltaic meter is most important meter in our work. These are various data measurement. 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/m^2), 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 (V _{mpp} >30V, I _{mpp} >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 (V _{mpp} >30V, I _{mpp} >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 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 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 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

3.4.2.2 Common Specifications

Available reference cells: MONO Crystalline and MULTI Crystalline Silicon

Guidelines

Safety: IEC/EN 61010-1

Technical literature: IEC/EN 61187

Calibration: IEC/EN 60904-2

Mechanical protection: IP65 in compliance with IEC/EN 60529

Pollution degree: 2

Mechanical characteristics

Dimensions (LxWxH): 120x85x40 mm

Weight: 260g

Environmental conditions

Working temperature: $-20^{\circ}\text{C} \div 50^{\circ}\text{C}$

Storage temperature: $-20^{\circ}\text{C} \div 60^{\circ}\text{C}$

3.5.3 Temperature Sensor

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 about 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.

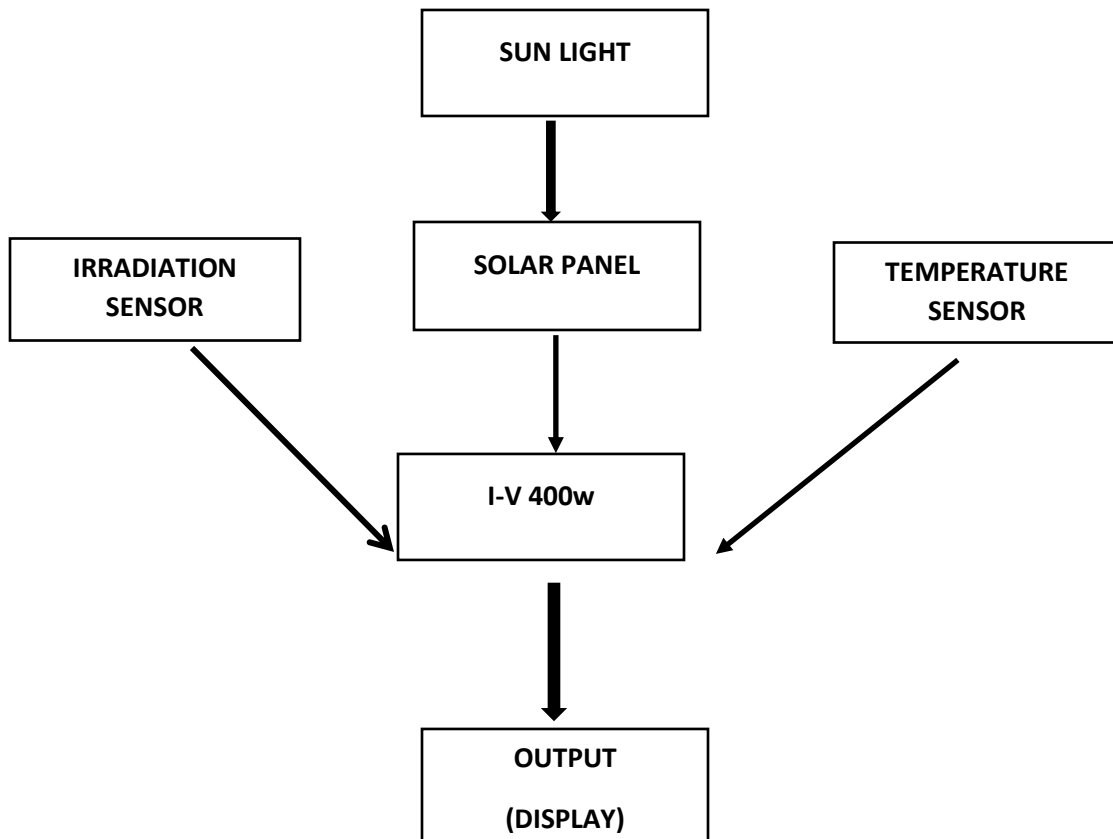


Figure 3.7: Flow Chart

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 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. To show figure 3.10 our work time and place when we measure the data.



Figure 3.8: Work time (To measure data)

- I. First we go to the roof top the work building
- II. Then we start our work. We connect the solar panel to photovoltaic meter and irradiance meter.
- III. It is also connected the temperature sensor.
- IV. Then we dimensions data in 45watts
- V. The solar panel connected the Whole meter then the data is here the photovoltaic meter. We take a picture in all data.
- VI. Then we connected the 60watt solar to photovoltaic meter and temperature sensor. Again we snap in my mobile phone the all data the 60watt solar panel.
- VII. Last we join the 100watt cell to photovoltaic meter and the temperature sensor. All data collection and take a picture in our phone.

It is suitable for a sunny day. In this day we measure all data collected. In rainy day and low light the sun irradiance is low so there is no data in this day.

3.9 Put the Data in 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, voltage at maximum power, current in maximum power, fill factor and irradiance. Given the table 3.4 the all elements which are measure a panel and put them.

Efficiency= Output/Input

Output= Power of solar panel

Input= Irradiance*Panel area

Suppose,

$P_{max} = 1.47\text{w}$

Input= $54\text{ w/m}^2 * 0.32\text{m}^2$

Then efficiency= 8.5%

Table-3.4 represents parameter-wise data of 45 watt solar panel of a single day (3rd June, 2018) starting from sunrise to sunset.

Irradiance (W/m ²)	Voltage (V)	Current (I)	V _{mpp} (V)	I _{mpp} (I)	Fill factor	P _{max} (W)	Area of Panel (m ²)	Efficiency (%)
54	18.9	0.14	16.3	0.09	0.55	1.47	0.32	8.5%
171	19.8	0.42	18.2	0.24	0.53	4.37		7.9%
142	18.8	.33	14.1	0.27	0.59	3.85		8.4%
268	19.5	0.35	17.7	0.29	0.74	5.06		5.95%
485	19.2	0.64	17.3	0.48	0.68	8.30		5.34%
814	20.4	1.57	18.3	1.32	0.75	24.16		9.27%
283	19.4	0.62	18.3	0.38	0.57	6.86		7.57%
327	19.1	0.79	17.2	0.74	0.62	12.64		12.07%
107	18.8	0.25	16.5	0.15	0.53	2.84		8.29%
113	19.3	0.30	16.7	0.17	0.48	2.76		7.63%
43	18.3	0.11	15.3	0.08	0.57	1.15		8.35%

Where,

V_{oc}=, Open circuit voltage

I_{sc}=, Short circuit current

V_{mpp}=, Maximum power at voltage

I_{mpp}=, Current at Maximum power

Fill factor=, $V_{mpp} \cdot I_{mpp} / V_{oc} \cdot I_{oc}$

P_{max}=, $V_{mpp} \cdot I_{mpp}$

Efficiency= $P_{max} / \text{Irradiance} \cdot \text{panel area}$

3.10 summary

This chapter name is methodology so we describe this chapter all working procedure and work elements like as photovoltaic meter, Irradiation meter, temperature sensor. This are very important in the work. We shows the technical, electrical specification, I-V 400W calibration and a flow chart this is how to work sunlight to solar panel. The solar panel 100, 60, 45W is all specification given this chapter. We work the all procedure how to work, which are necessary and which meter is connect 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 the previous discussion that the energy plays the key role for development. The solar home system is suitable for Bangladesh. There is a huge electricity generation in future this sector we should want. Bangladesh is a solar energy rich country. Solar energy can play vital role play secure energy source for sustainable development. The main reason of this study is to access the 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:

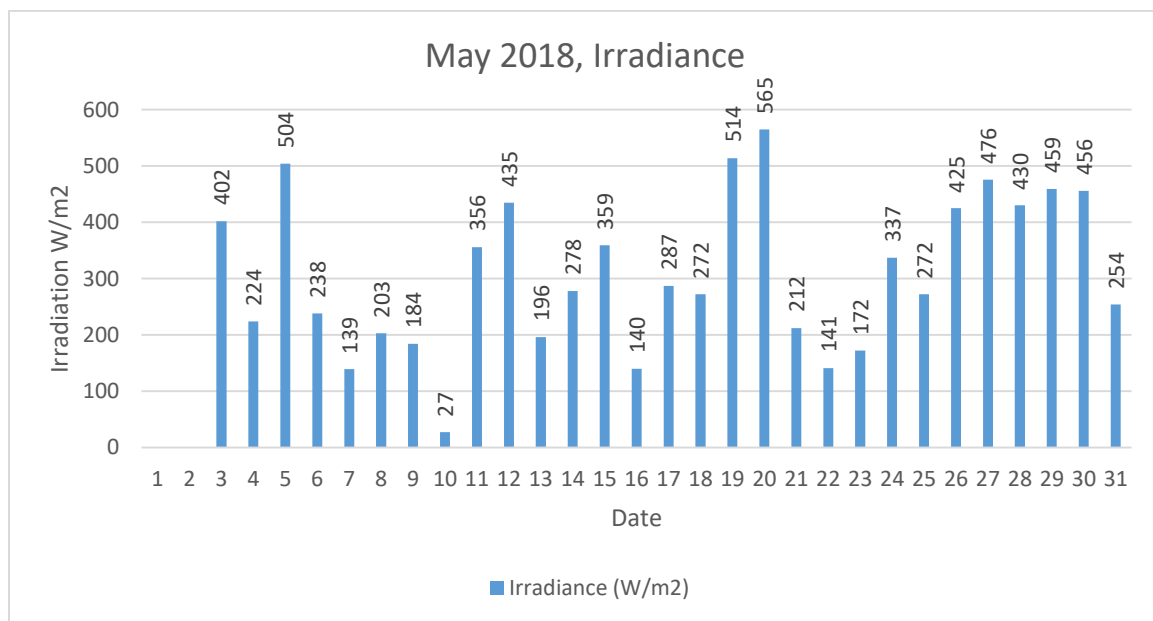


Figure 4.1: Daily irradiance for May

Figure-4.1 shows the data of solar irradiation of May 2018. On 03 to 31 May 2018, the highest value of solar irradiance was measured that was 565 W/m² and the lowest value of the solar irradiance was measured that 27 W/m², the main reason behind this situation was sunny day and rainy day. During the sunny day we have gotten the highest value and for rainy day we have gotten the lowest value.

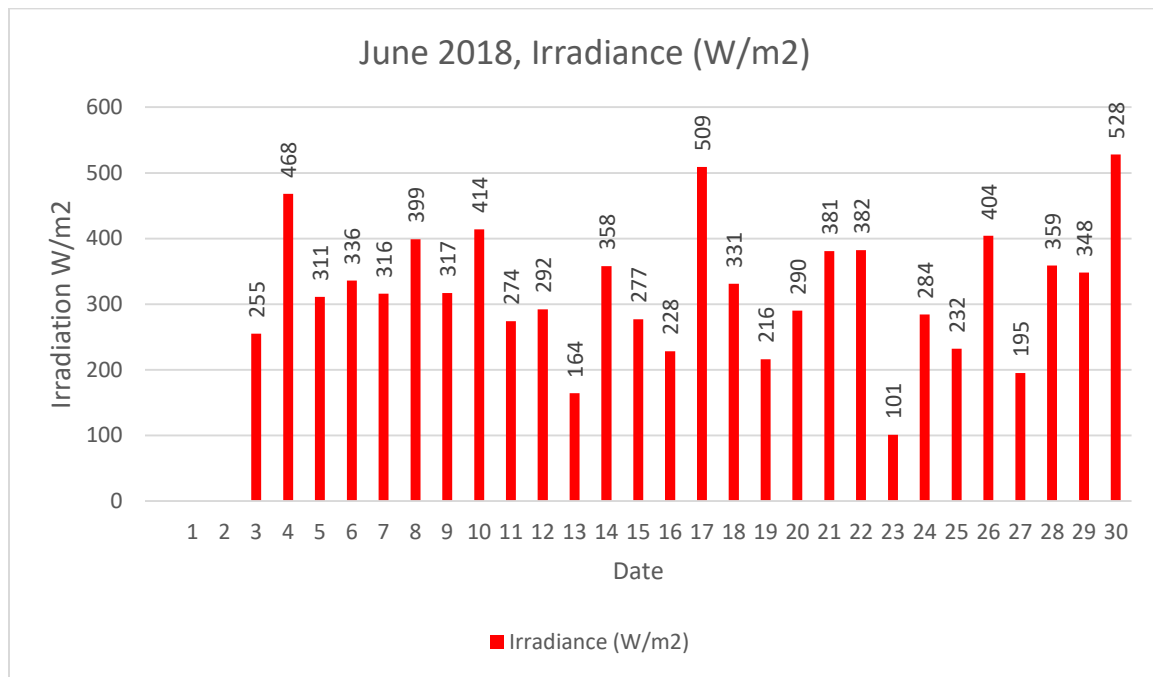


Figure 4.2: Daily irradiance for June

Figure-4.1 shows the data of solar irradiation of May 2018. On 03 to 31 May 2018, the highest value of solar irradiance was measured that was 528 W/m² and the lowest value of the solar irradiance was measured that 101 W/m², the main reason behind this situation was sunny day and rainy day. During the sunny day we have gotten the highest value and for rainy day we have gotten the lowest value.

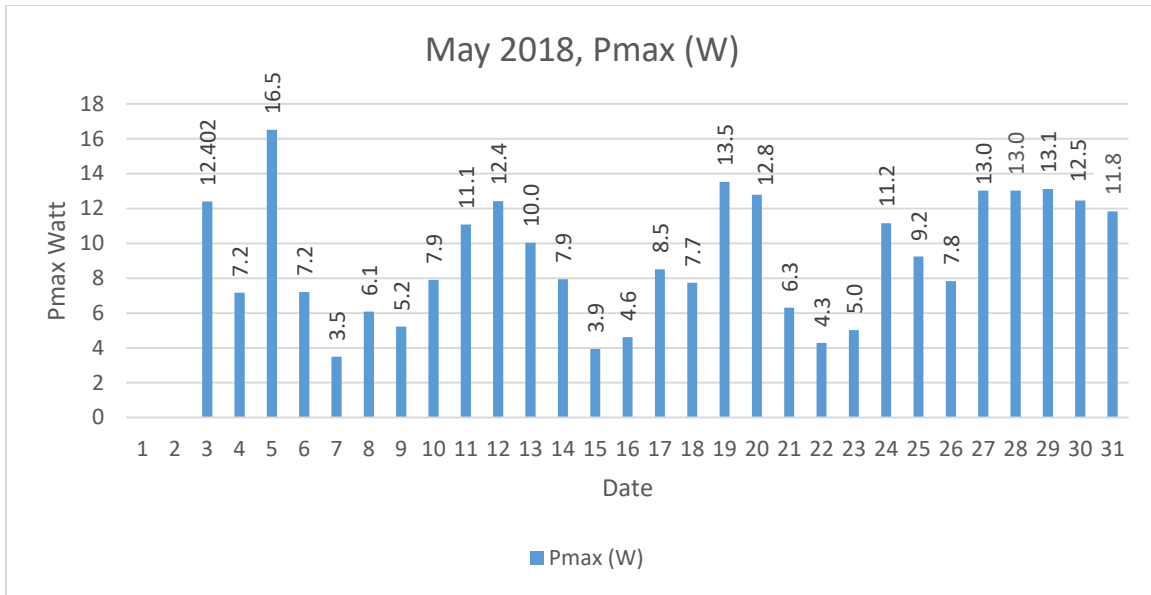


Figure 4.3: Daily pmax for May

Figure-4.3 represents the power generation curve of 45 W solar panel in May 2018. On 03 to 31 May 2018, we have found the highest value of maximum power (16.5W) and the lowest value of minimum power (3.5W) in June 2018

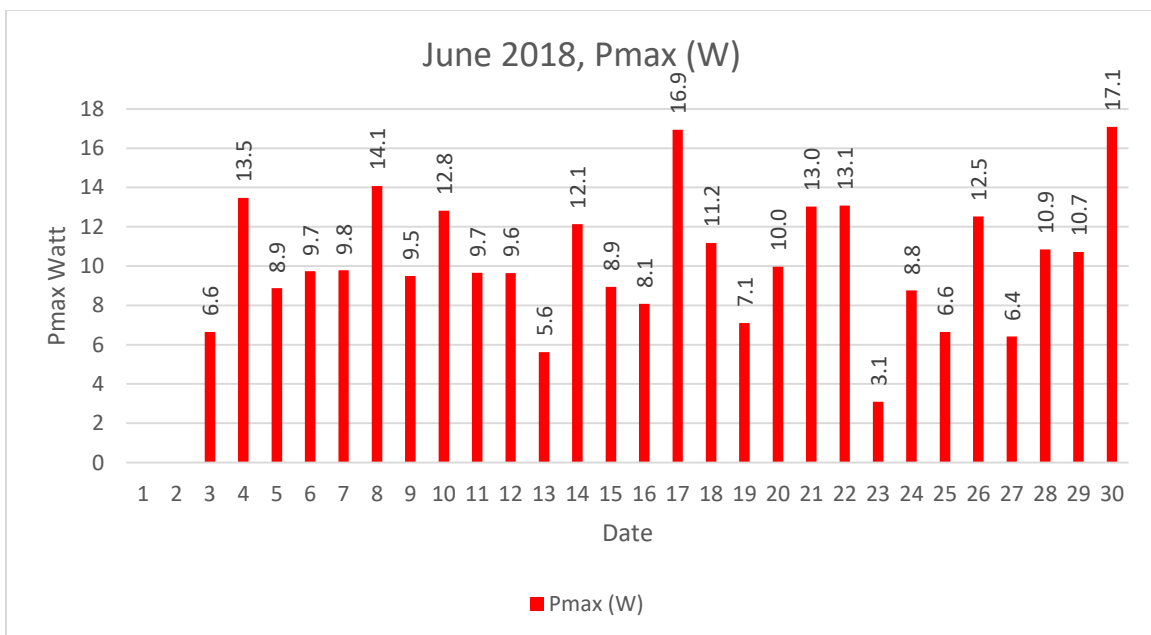


Figure 4.4: Daily pmax for June

Figure-4.3 represents the power generation curve of 45 W solar panel in May 2018. On 03 to 31 May 2018, we have found the highest value of maximum power (17.1W) and the lowest value of minimum power (3.1W) in June 2018

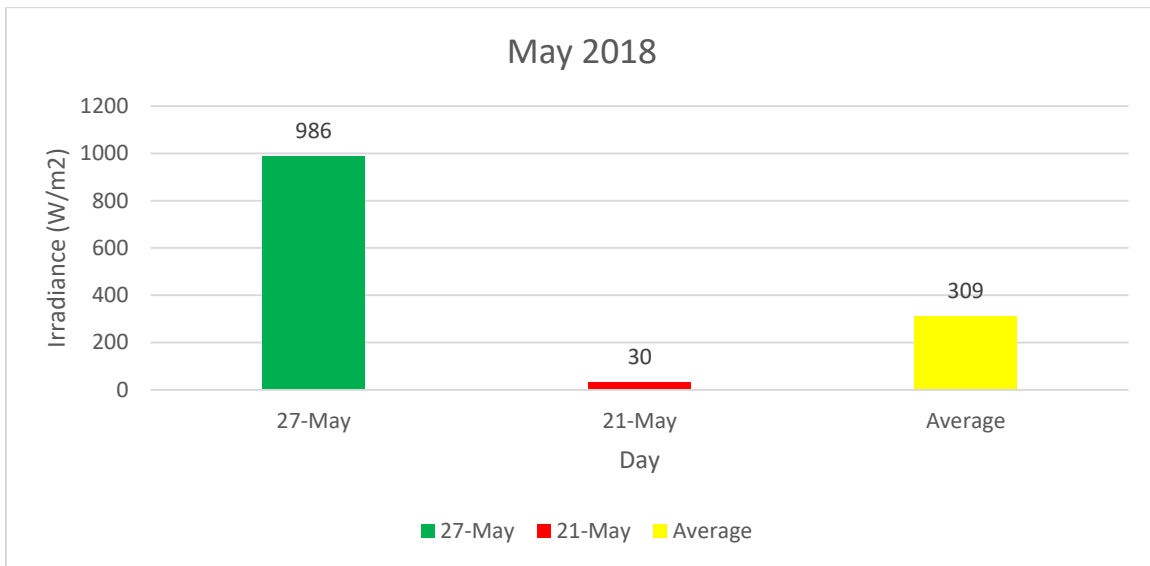


Figure 4.5: Irradiation graph for May (highest, lowest & average)

Figure-4.1 shows the data of solar irradiation of May 2018. On 27 May 2018, the highest value of solar irradiance was measured that was 986W/m^2 and on 21 May 2018, the lowest value of irradiance was found that was 30W/m^2 and the main reason behind this situation was sunny day and rainy day. During the sunny day we have gotten the highest value and for rainy day we have gotten the lowest value. Moreover, May 2018 monthly average irradiation is 309W/m^2 per day or $7.42\text{kWh/m}^2/\text{day}$.

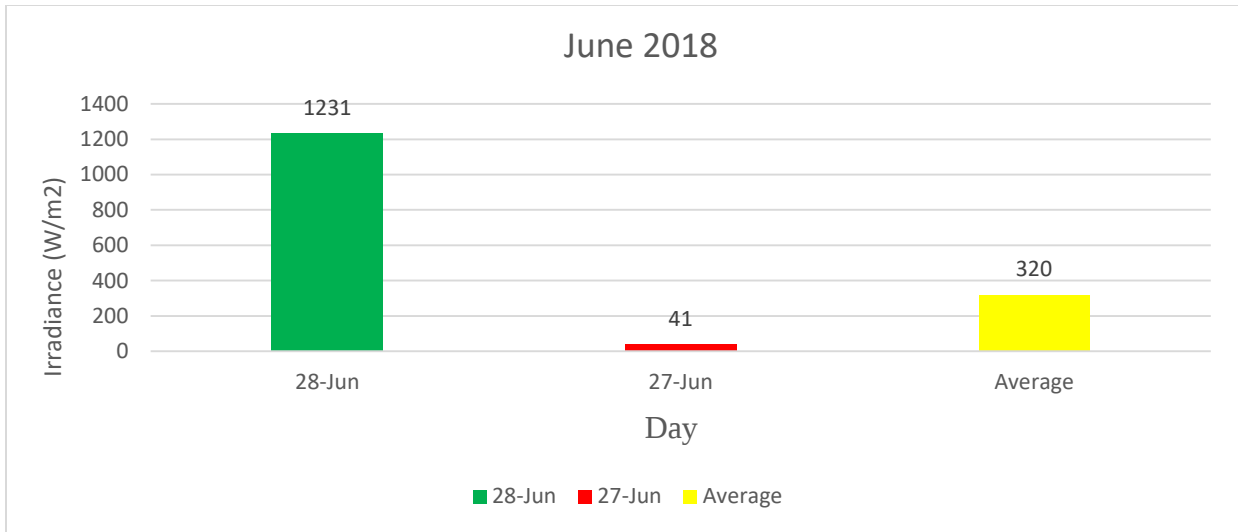


Figure 4.6: Graph Irradiation for June (high, low & average)

Figure-4.2 shows the data of solar irradiation of June 2018. On 28 June 2018, the highest value of solar irradiance was measured that was 1231 W/m^2 and on 27 June 2018, the lowest value of irradiance was found that was 41 W/m^2 and the main reason behind this situation was sunny day and rainy day. During the sunny day we have gotten the highest value and for rainy day we have gotten the lowest value. Moreover, June 2018 monthly average irradiation is 320 W/m^2 per day or $7.68 \text{ kWh/m}^2/\text{day}$.

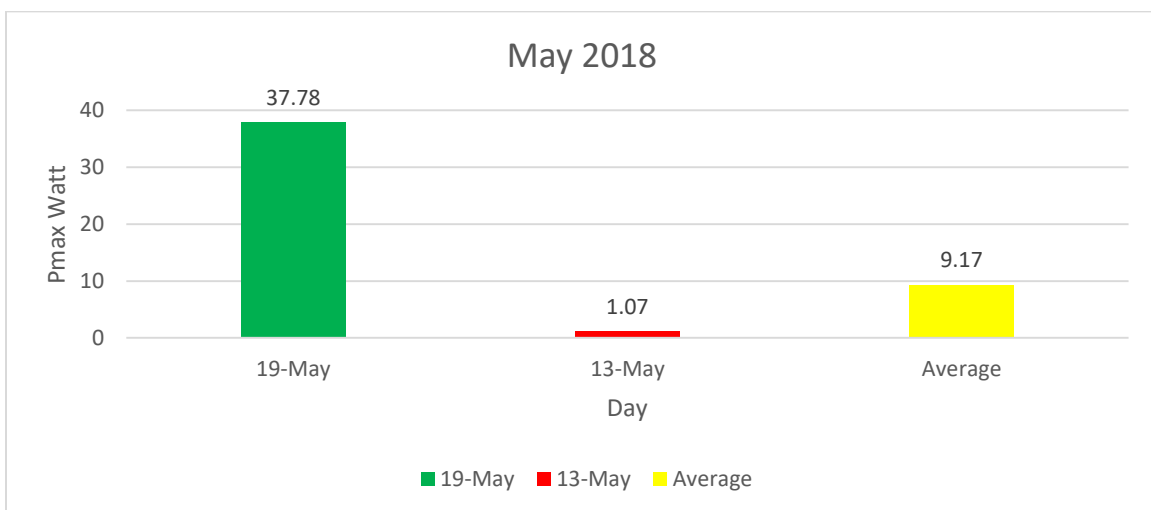


Figure 4.7: Pmax graph for May (high, low & average)

Figure-4.3 represents the maximum power generation curve of 45 W solar panel in May 2018. On 19 May 2018, we have found the highest value of maximum power (37.78W) and the lowest value of minimum power (1.07W) in 13 May 2018. Monthly average power is 9.17 W.

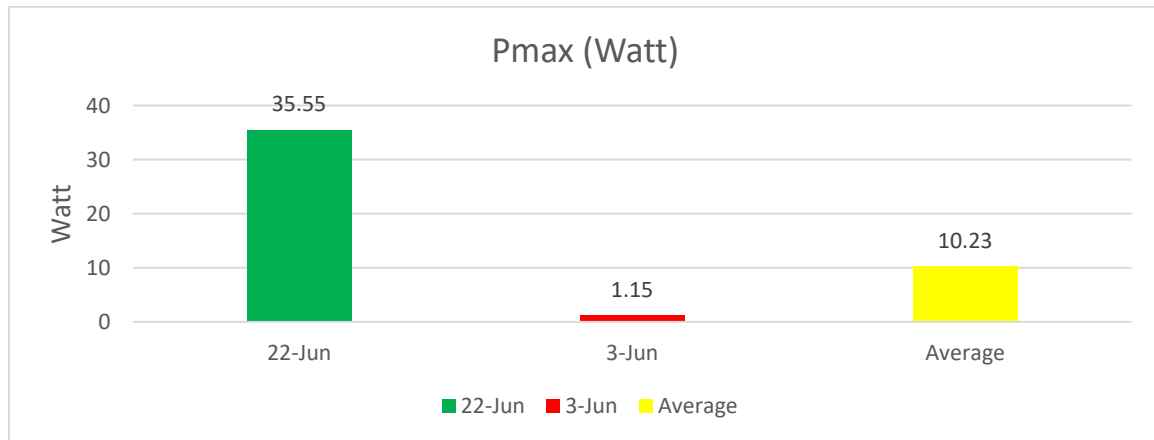


Figure 4.8: Graph Pmax in June (highest, lowest & average)

Figure-4.4 represents the maximum power generation curve of 45 W solar panel in June 2018. On 22 June 2018, we have found the highest value of maximum power (35.55W) and the lowest value of minimum power (1.15W) in 3 Jun 2018. Monthly average power is 10.23 W.

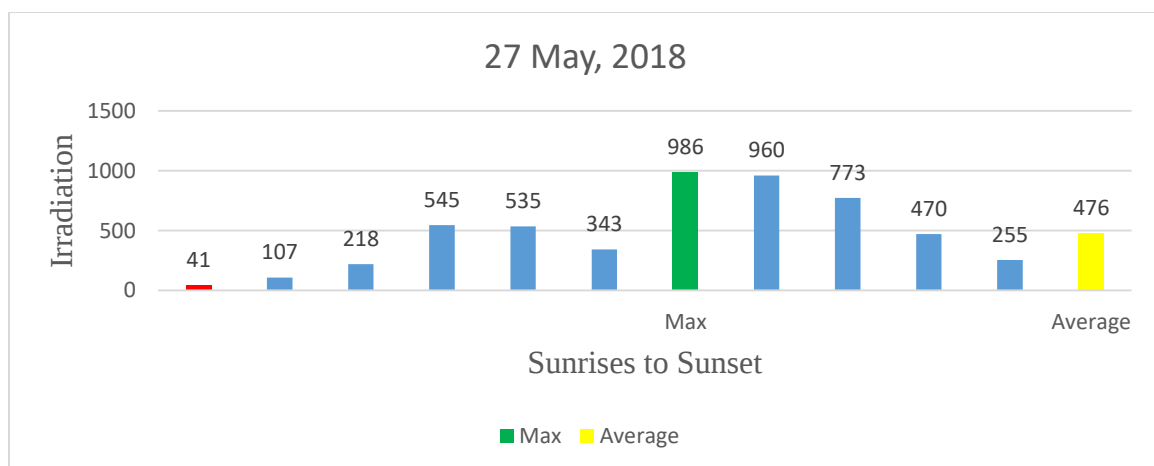


Figure 4.9: Irradiation of Sunny day in May

Figure-4.5 shows the data regarding the irradiance of sunny day in May 2018: During sunny day, we get the highest irradiance 986 W/m². In sunny day, we measured our data every hour. The average irradiance of sunny day is 476 W/m².

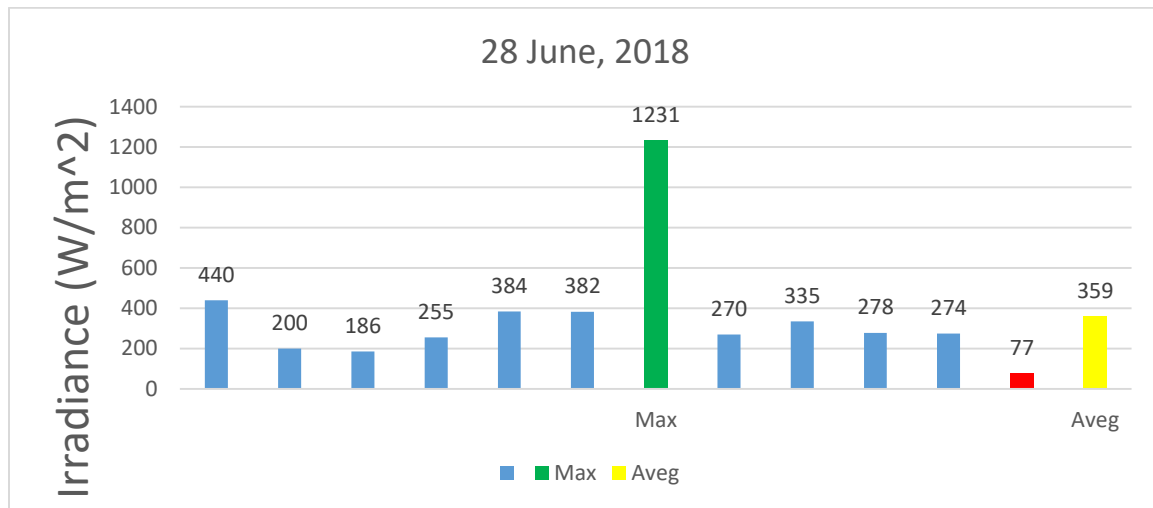


Figure 4.10: Sunny day irradiation for June

Figure-4.6 shows the data regarding the irradiance of sunny day in June 2018: During sunny day, we get the highest irradiance 1231 W/m². In sunny day, we measured our data every hour. The average irradiance of sunny day is 359 W/m².

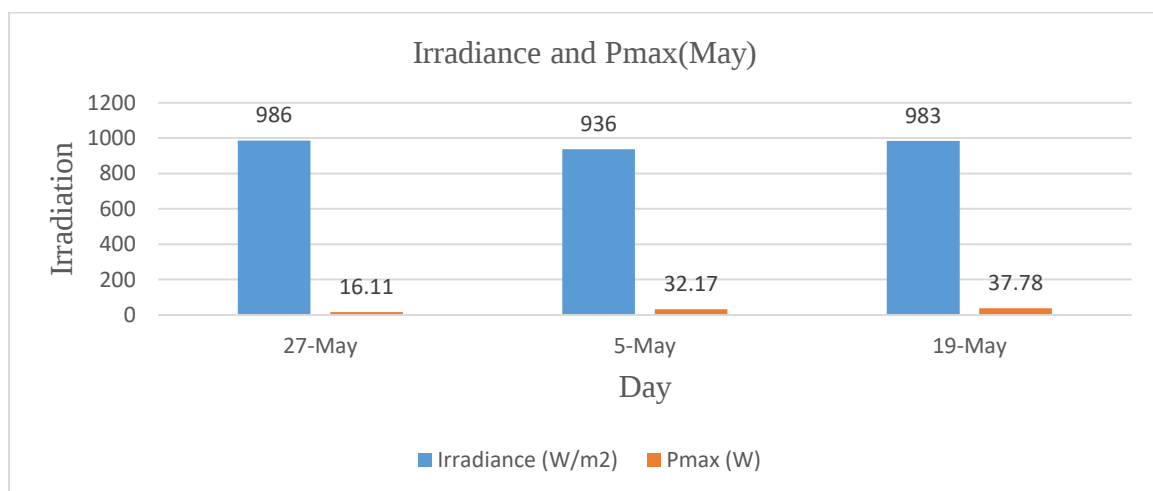


Figure 4.11: Irradiance and Pmax in May

Figure- 4.7 On 27 May 2018, the measured irradiance was 986 W/m^2 and the corresponding power produced by that panel was 16.11 W . However, the matter of concern that, on 5 & 19 May 2018, the measured irradiance was 936 & 983 W/m^2 but the power produced by the panel was 32.17 & 37.78 W which was higher than the previous one. The average power of sunny day is 9.17 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 is happened because the irradiation measurement tool does not measure the power production of the panel in that moment. We get the total produced power from the solar panel and irradiation from the other tool box. As we know sun irradiation is not same in all places. So, when we measured the less power (7.201 W) at that moment the fallen irradiation of the sun on that panel was less than the irradiation measured tool box. 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 14 certain times data in a day. The purpose of taking data from 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.

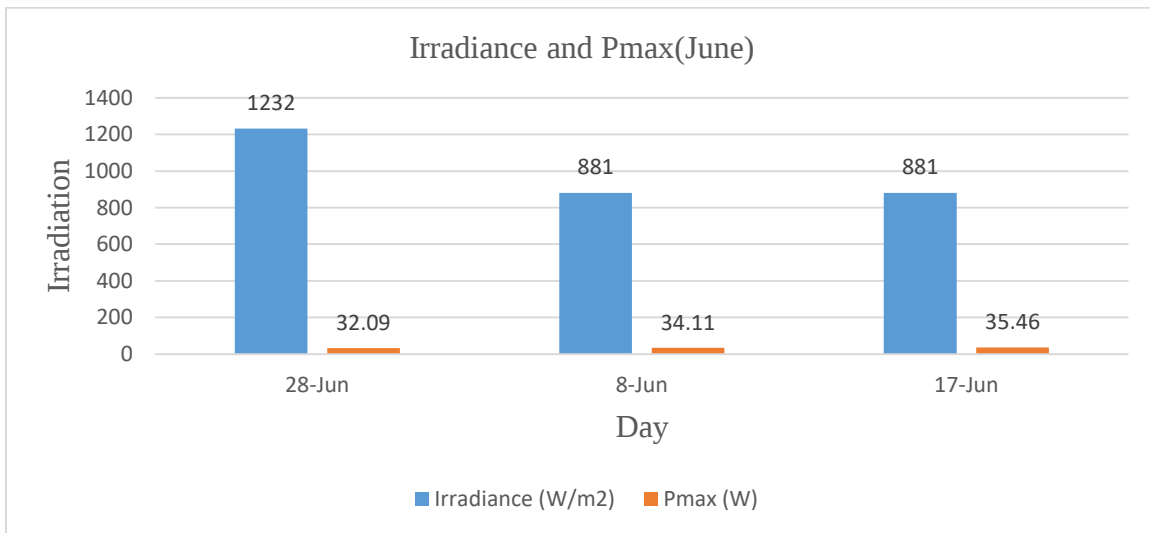


Figure 4.12: Irradiance and Pmax in June

Figure-4.8 On 28 June 2018, the measured irradiance was 1232 W/m^2 and the corresponding power produced by that panel was 32.09 W . However, the matter of concern that, on 8 & 17 June 2018, the measured irradiance was 881 W/m^2 but the power produced by the panel was 34.11 W & 34.56 W which was higher than the previous one. The average power of sunny day is 10.23 W .

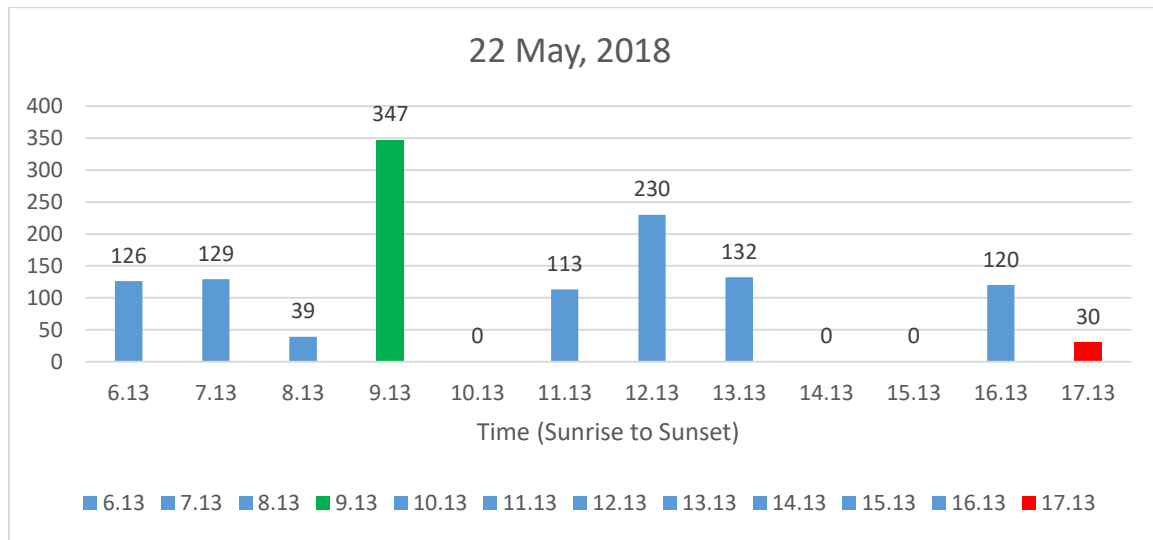


Figure 4.13: A rainy day Irradiance of May

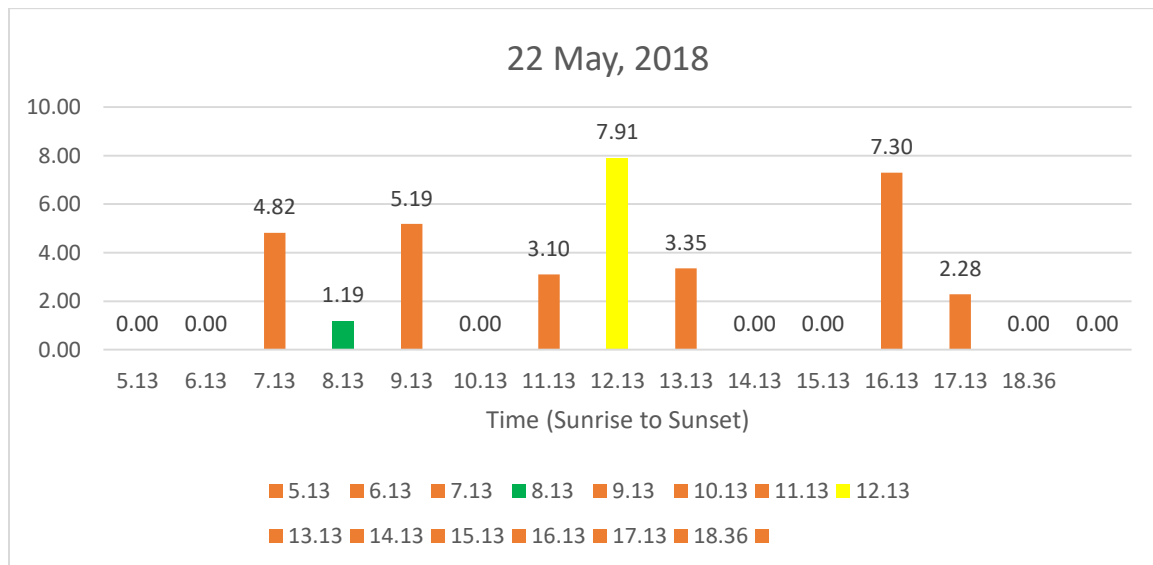


Figure 4.14: Pmax for a rainy day

Figure- 4.9 shows only rainy-day irradiance in May 2018: in rainy day, average irradiance is 141 W/m^2 . We got the highest & lowest irradiance 347 W/m^2 & 30 W/m^2 respectively. In rainy day, maximum time we cannot measure our required data in time. On 22 May 2018, 347 W/m^2 (Fig. 4.9 & Fig. 4.10) solar irradiance was measured whereas the corresponding power was 5.19 W in time 9.13 AM .

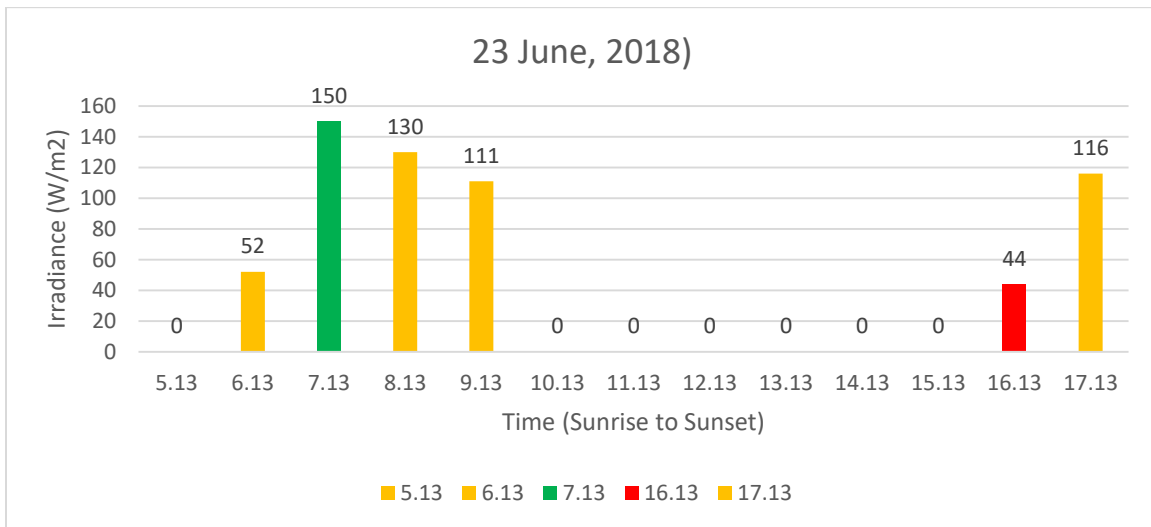


Figure 4.15: Irradiance for a rainy day (June)

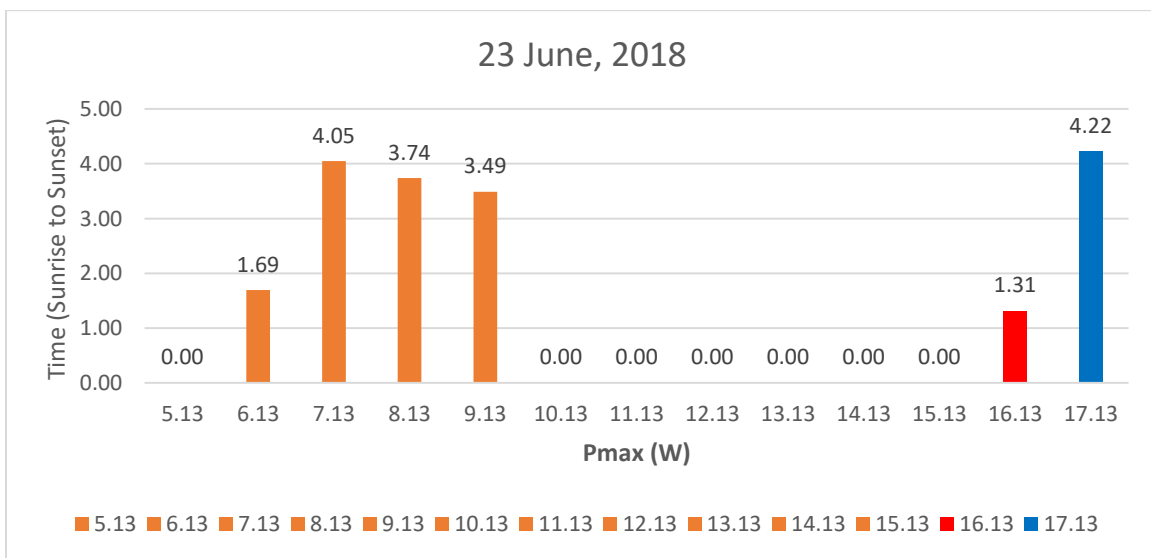


Figure 4.16: Pmax for a rainy day (23rd June)

Figure- 4.11 shows only rainy-day irradiance & Figure 4.12 shows the Pmax in June 2018: in rainy day, average irradiance is 151.33 W/m^2 . We got the highest & lowest irradiance 150 W/m^2 & 44 W/m^2 respectively. In rainy day, maximum time we cannot measure our required data in time. On June 2018, 44 W/m^2 (Fig. 4.11) solar irradiance was measured whereas the corresponding power was 1.31 W and On 23rd June 2018, 150 W/m^2 solar irradiance was measured whereas the corresponding power was 4.05 W .

Table 4.1: Two months irradiation and Pmax (May & June)

Date	May-18		Jun-18	
	Irradiance (W/m2)	Pmax (W)	Irradiance (W/m2)	Pmax (W)
1				
2				
3	402	12.40	255	6.64
4	224	7.17	468	13.47
5	504	16.51	311	8.87
6	238	7.20	336	9.74
7	139	3.50	316	9.79
8	203	6.08	399	14.07
9	184	5.22	317	9.49
10	27	7.90	414	12.81
11	356	11.07	274	9.65
12	435	12.43	292	9.64
13	196	10.03	164	5.62
14	278	7.94	358	12.13
15	359	3.93	277	8.94
16	140	4.62	228	8.08
17	287	8.52	509	16.94
18	272	7.73	331	11.17
19	514	13.52	216	7.1
20	565	12.78	290	9.97
21	212	6.30	381	13.03
22	141	4.29	382	13.08
23	172	5.02	101	3.09
24	337	11.15	284	8.76
25	272	9.23	232	6.64
26	425	7.82	404	12.53
27	476	13.02	195	6.41
28	430	13.03	359	10.85
29	459	13.12	348	10.71
30	456	12.45	528	17.08
31	254	11.83		

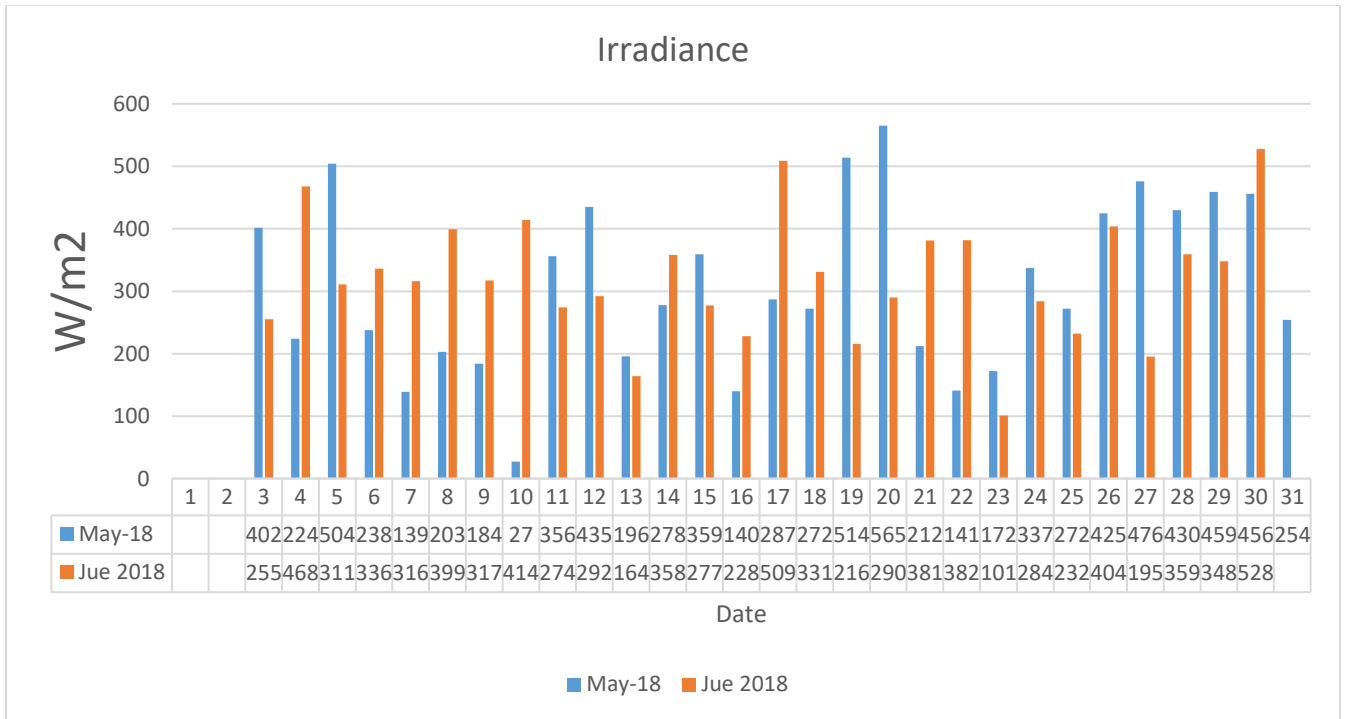


Figure 4.17: Two month irradiation (May & June)

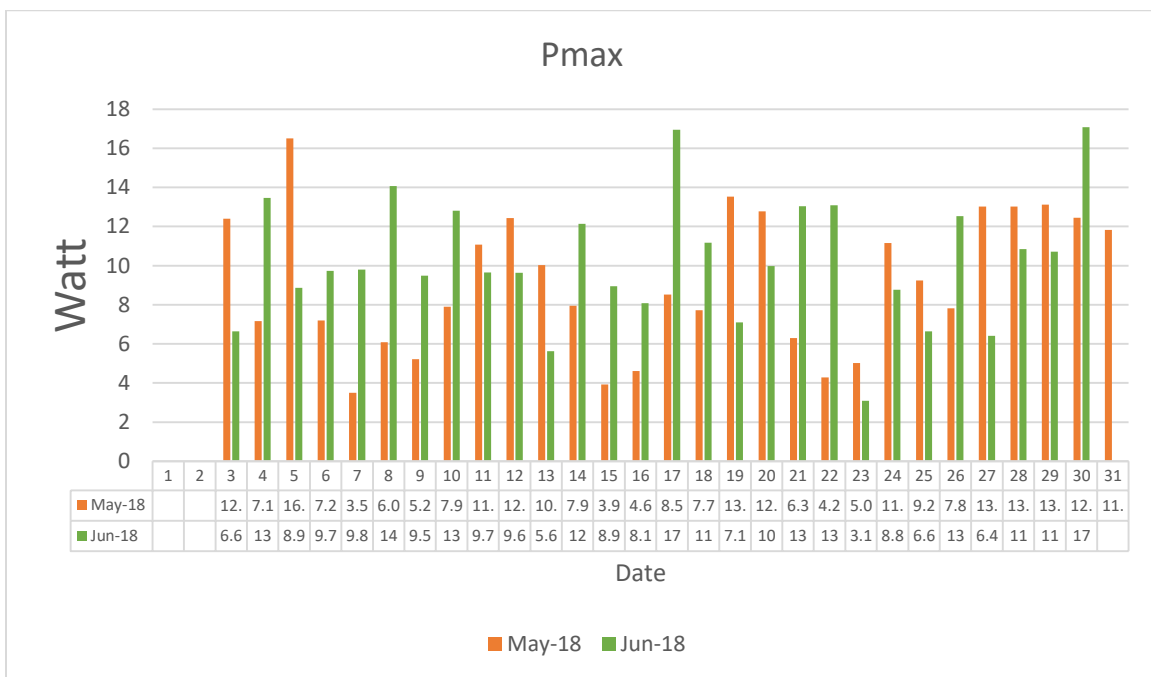


Figure 4.18: Pmax for two month (May & June)

In figure 4.17 by measuring irradiation for both month May and June we see that the irradiation of June is better than May. Since getting power is depend on irradiation so the irradiation of June get more power than May. So we can say June is better in both two month May and June. In figure 4.18 shows that Pmax of the full month both May and June. In previous figure we saw that the average Pmax of May is 9.17 and Pmax of June 10.23. The Pmax of June is good from Pmax of May.

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/m²/day and the value of irradiation in 2009 was decreased and that was 4.73 kWh/m²/day. There was also a declining trend in solar irradiation value in between 2009 and 2010 because in 2010, only 4.50 kWh/m²/day irradiation was measured as shown in Table- 9.

Solar radiation data were collected from 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/m²/day and it was increased into 4.64 kWh/m²/day in 1987-89. But in 2000-03, annual average radiation was 4.52 kWh/m²/day which was decreased into 4.2 kWh/m²/ day in 2003-05. In 2006, radiation was increasing, and the value was 4.45 kWh/m²/day.

Table 4.4: Collected Data from 1985-2005, 2008-2010, 2018 and Compare Irradiance Among them were Presented Below

Year	Month	Irradiance kWh/m ² /day
1985-1991	May	5.58
	June	4.48
1987-89	May	5.67
	June	5.13
1992	May	5.76
	June	5.3
2000-2003	May	5.21
	June	3.85
2003-2005	May	5.46
	June	4.22
2008	May	6.26
	June	5.09
2009	May	5.64
	June	5.04
2010	May	5.4
	June	4.22
2018	May	7.42
	June	7.68

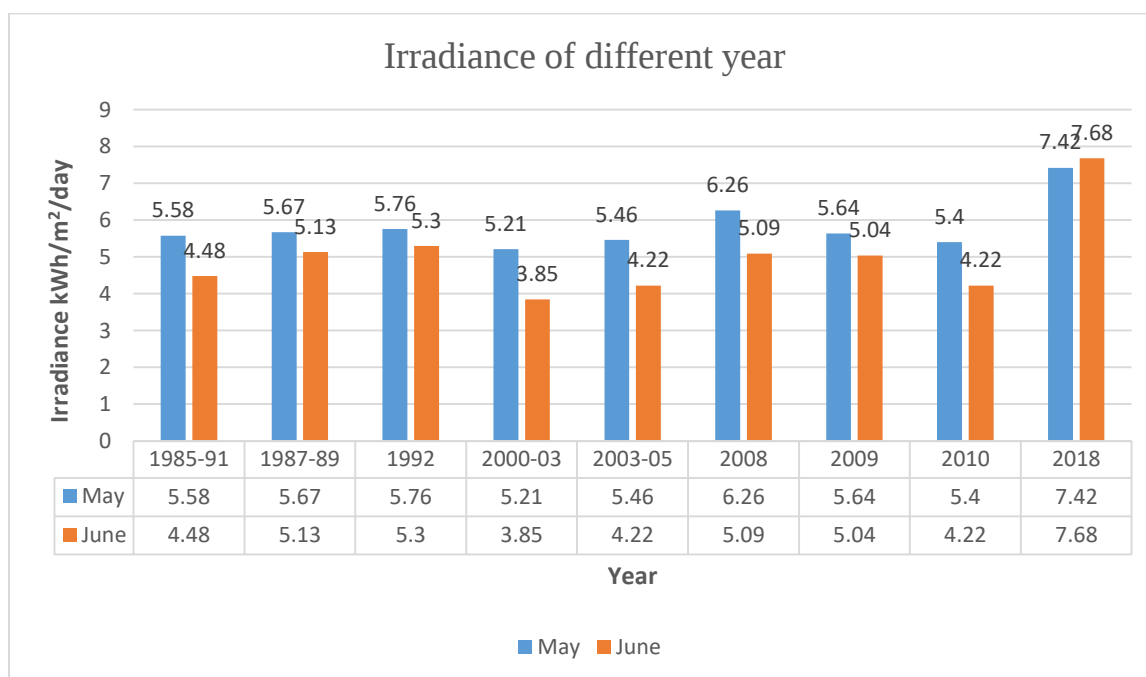


Figure 4.19: Different Years Irradiance

Figure-4.14, after analyzing we can say that in the month of September, we got the highest amount of Irradiance than October. In the year 1985-1991, May & June average solar irradiation was 5.58 & 4.48 kWh/m²/day and it was increased into 5.67 & 5.13 kWh/m²/day in 1992. But in 2000-03, May & June average irradiation was 5.21 & 3.85 kWh/m²/day which was increased into 5.46 & 4.22 kWh/m²/ day in 2003-05. In 2008, irradiation was increasing, and the value was 6.26 & 5.09 kWh/m²/day. Again in 2010, irradiation was decreasing, and the value of 5.4 & 4.22 kWh/m²/day. Moreover, in 2018, irradiation was increasing, and the value of 7.42 & 7.68 kWh/m²/day.

Furthermore, in 2018, Irradiance is highest than another year, for that reason, we can certainly say that global warming is increasing day by day.

4.4 Summary

In data analysis chapter we describe about our work. We work on 45 w solar panel in Dhanmondi area. Here we measure daily irradiation and Pmax for May and June. We got monthly average irradiance for May is 309 w/m² and 320 w/m² for June. And also got monthly average Pmax for May is 9.17 W and 10.23 W for June. We measured separately average irradiation and Pmax for sunny day and rainy day for both month May and June. We got average irradiation for May is 476w/m² and 359 for June in sunny day. By measuring both May and June we analyze that the average irradiation of June is better than May. So the Pmax of June is also better than May.

Chapter 5

Conclusion

5.1 Conclusion

At present days the impetus, progressive and sustainability of a civilization depend on energy. For utilizing the solar power more effectively, it is very important to measure the irradiation of that country time to time because the sun 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 May and June 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 May 7.42 kWh/m²/day and June was 7.68 kWh/m²/day. And corresponding power produced by 45W solar panel was 9.17 W and 10.23 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 enhance 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 family situation for education as it provides clear light and fresh air as well as longer studying hours for kids. In 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 of information, education and entertainment for using TV, Radio and mobile phone. Improve economic growth, quality education, health benefit and access to information can significantly rise 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, that why solar energy will be the main source of electricity. Immense prospect of solar electricity in rural area of Bangladesh Researchers are acknowledged that. Now Researchers are try 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 that how much power can be produced in the month of September & October 2018 from a solar system. We have worked only for two months but in future we can measure power and irradiation throughout the year along with the analysis of panel efficiency. This work is long time processing. These are minimum one years and maximum two or three years. The future scopes this work is very bright. We work the solar irradiation and power. In future this work is to fix up standardization of solar energy, effect of dust and to determine of the battery losses.

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