STUDY OF THE SOLAR IRRADIATION PATTERN OF BANGLADESH FOR ELECTRICITY GENERATION

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

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Certification

This is to certify that this 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 30 January 2018.

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Dedicated to

Our Parents

CONTENTS

LIST OF FIGURES

LIST OF TABLES

List of Abbreviations

SHS	Solar Home System.
PV	Photovoltaic.
UV	Ultra Violet.
GDP	Gross Domestic Product.
NGO	Non-Governmental Organization.
IDCOL	Infrastructure Development Company Limited.
BOS	Balance of System.
STC	Standard Test Condition.
OPC	Operational Condition.
DC	Direct current.
PVT	Polyvinyl Fluoride
BUET	Bangladesh University of Engineering and Technology.
GS	Grameen Shakti.
IRE	Institute of Renewable Energy.
EVA	Ethylene Vinyl Acetate
AGM	Absorbed Glass Mat.
KWp	Kilowatts peak.

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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 July and August 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 (July and August) 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 one of the world's most dense and poorest countries. 17% of the population may be called "very poor" due to low income [1]. This is due to low access to modern energy services. Its infrastructure is small, inadequate and weakly managed. So, today's power crisis is increasing. Due to this crisis, huge gap was created by the poorly managed area of power. This gap in demand and production is now a huge problem in this country. Due to its growing demand, the lack of electricity and fuel supply was the main reason. Increased demand for electricity due to rising population and rising economic activity. Trying to meet the demand of natural gas, coal, fuel, peat and other non-renewable energy production. Renewable energy is also served in different ways. In absolute terms, due to population growth, the number of renewable energy has increased significantly. This issue has been selected in various ways about the current situation of energy compared to previous years and given some convenient solutions to the future energy sector of this country. The purpose of this research is to analyze current and past energy situation and analyze their assets in Bangladesh, to identify problems. Their solution and willingness to take that path to meet the needs of the country's future capabilities.

1.2 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 villages 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.

1.2.1 Gas Sector

Natural gas is the main homegrown source in Bangladesh, which is 75% of the commercial power of the country. [3]. So far, 24 gas fields have been discovered, of which two are located in the operator area. Currently gas is produced from 18 gas fields (79 gas wells) [4]. Two gas fields (Sylhet and Kailashitola) were examined. To reduce the reliability of natural gas, alternative energy resources or scientific solutions should be discovered. Despite the current government's efforts to produce power generation, the country's economic development and energy production will be affected by natural gas for a few years and it will continue. Now there are many advancements in the government advance. Recently, the production of 1750 to 2250 mmcfd gas has increased, and currently producing 79 wells of 18 gas fields [5]. Presently the country's total and reliable power generation capacity is 6887 MW and 5091 MW, resulting in a loss of 1674 MW per day [6]. In December 2015, it will be probable to supply 880 million cubic feet of gas to the national gas grid every December and after the implementation of the long-term plan it will be possible to supply additional 2800 million cubic feet. Every day the national gas grid supplies 2000 million cubic feet per day [7]. Data related to gas production are shown in Table 1.1

Table 1.1 Bangladesh Gas Sector 2010-2011 [7]

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

1.2.2 Sector of Coal Side

Coal is an important force in Bangladesh. The existence and development of coal industry for national economic security is very important. As of 2009-10, the share of gas for electricity generation was 89%, while the share of oil and coal was 5% and 3.5% respectively. [8] If coal can replace gas, then it can be a good alternative to the situation above. But it was not because,

because of the serious management crisis, coal is suffering from problems. In the last few decades nobody has thought of coal mine as reasonable. The country was not fully prepared for the crisis when the supply was low. Coal provides 28% of our initial energy [9]. However, thanks to the formal progress of coal-based power plants, it may change in a short time. It can contribute more than what has been done so far. Electricity generation will be 20,000 MW in 2020, of which 50% will be coal-based [10]. Coal conservation in the five fields of Bangladesh is 3.0 billion tones equivalent to 67 billion tons of gas, which can provide energy demand for 50 years [11]. With the choice of technology and mining method, the recovery rate varies. About 85% of coal can be retrieved from Barapukuria, Phulbari and Dighipara if modern mining technology is adopted. It will ensure regular supervision and monitor supervision. Khalasipire Koal Sim can be the ideal candidate for methane, when we can wait a few years for the technical development of mining Jamalganj coal mine [12].

1.2.3 Current Situation of Electricity

Due to small and insufficient power infrastructure, there are some serious problems in Bangladesh. In that case our cost rate is not satisfactory with the increasing demand. It can create a dangerous situation for Bangladesh's energy sector. The main source of electricity should be more in order to meet the needs of the people. In 2008, 47% of the population got access to electricity, but in 5 years it increased by 62%, which means that it increased by 15%, which is renewed, but 38% still lacks electricity, and Henan has not yet been defeated [13].

1.2.4 Current Situation in Renewable Energy

Renewable technologies are widely used in developing countries, but it is still a very small procedure in Bangladesh. To achieve sustainable solutions, the amount of investment and possible conditions of technology is required. Despite the reliability of natural resources, the government of Bangladesh is trying to upgrade the renewable energy system. Many revenues are being introduced by the government in renewable energy projects. Bangladesh Bank, IDCOL and some private commercial banks are moving forward to provide financial assistance. Moreover, the government has increased revenue incentives, including discount rebate on new renewable energy products, e.g. Solar panels, solar panel production accessories, LED lighting, solar powered light and wind power plant [14]. In table 1.2 shown how many power generate from renewable energy.

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

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

1.3 Potential upcoming of energy region in Bangladesh

Bangladesh has faced nearly difficulties for nearly a decade due to acute power crisis. Drought known as coal of natural gas and commercial primary energy sources are known in Bangladesh, but they are limited in comparison to the country's improvement supplies. By taking some creativities and operational accurately by the government, Bangladesh may probably happen its first-time energy demand.

1.3.1 Natural Gas

The demand for gas in Bangladesh has always increased. Natural gas is often supplying power generation and according to forecast of Petro Bangla Production and Marketing Division, the demand for gas has increased by 2015 and the demand will increase to 4162 MMCFD [15].

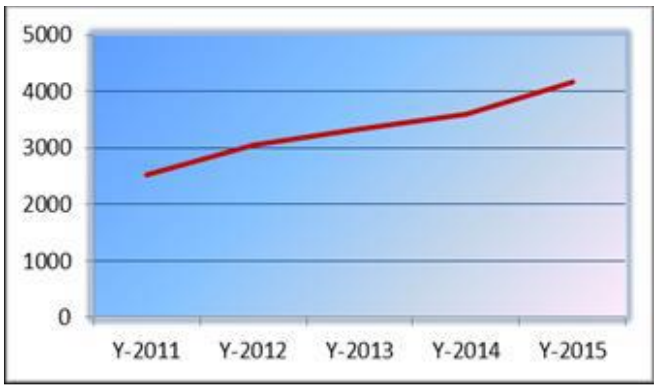

Fig 1.1 Demanded Plans of Gas (2011-2015) [13]

In 2013, there was a shortage of 470 MMCFD [13] with the production of 2270 mmcfd so that the dependence of natural gas in the future would be reduced further.

In order to maintain a stable or moderately stable energy scheme in Bangladesh, it is essential to minimize the use of natural gas. Since there are a number of studies on the reliability of natural gas, it has finally attracted the consideration of the Bangladesh administration. Straight society are attentive of the reduced saving of natural gas. Later, here is a possibility of increasing mandate for new presented organizations like fuel, coal, renewable and nuclear energy in fig 1.1. The deprivation of this dependence is plagued by any economic error because if so, the gas may look like to be the low-cost way to meet national energy needs.

1.3.2 Coal and Fuel

Coal can fund more than what has been done thus outlying. Coal procedure impending later 2005 may carry important changes in energy structure by rewarding for natural gas. Ignorance of setting up of coal-based power plants can be completely incapable of meeting natural gas needs [17, 18]. In 2025, if coal-fired power plants supply 32,837 megawatt of electricity to 41,899 megawatts, the condition will improve. According to the projection of high GDP growth by 2025, about 449.44 metric tons (450 megawatt) of coal will be used in the power sector [16]. These are considered by the government for consideration of national coal policy. According to the statistical data of coal power and forecast, if this year's annual demand is 32,837 MW, the energy cost will be 375 (5x75) million tons for the next 5 years and 2050 additional 750 (additional 750) 10x75 million for the next ten years. Tone will be needed. From 2005 to 2035, up to 2030, there would be total demand for 120 million tonnes of coal coal extraction (Fig 1.2). Therefore, saving of coal is not enough to meet the needs of more than 25 years. The economic condition of the country will depend on the import of fuel.

In the future, if the state plan of coal is implemented, at that time some problems of energy emergency will be solved. Conservational actions are in use to sidestep contamination because of the process of coal tide, but the power system will be smart and adequate. Once it is ready to invest a good amount of money on the country's coal policy, it will be easier to get sustainable energy. For the moment, humble resource organization will main to the import of fuel from away which prevents the country's economic growth.

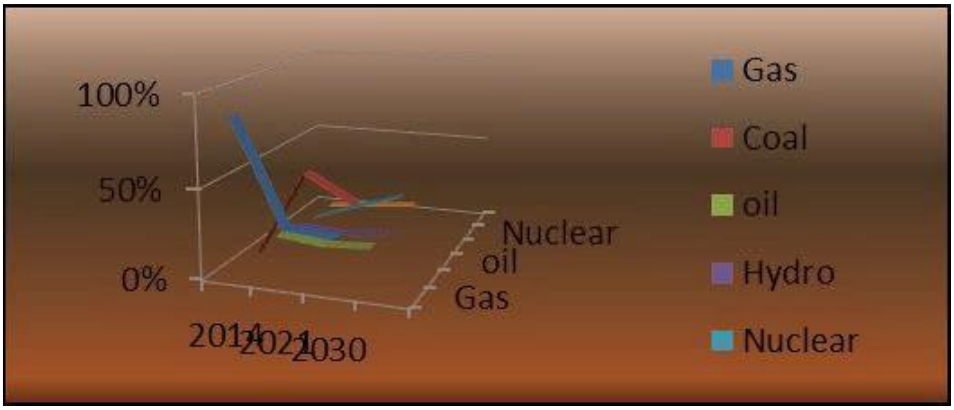

Fig 1.2 Ratio Target of Power Generation till 2030 *[16]*

1.3.3 Power Sector of Future Generation

A combination of energy has been suggested by the Planning Commission o Bangladesh, and deliberate it in 2010-2021 [19]. Fig 1.3. By 2020, the administration targets the power generation of electricity and aims to twin the substation capability.

Our government will have to invest more than ever to fulfill the 2020 goal. Through this growth share, they can make the most of set up power and after deductions generation by every generation of Catholics. Bangladesh's power plant has increased tremendously in a small period too if it carry on, then shortly will be able to overawed the power crisis. Active renewable energy and the implementation of nuclear power attack will alteration the situation in a limited years.

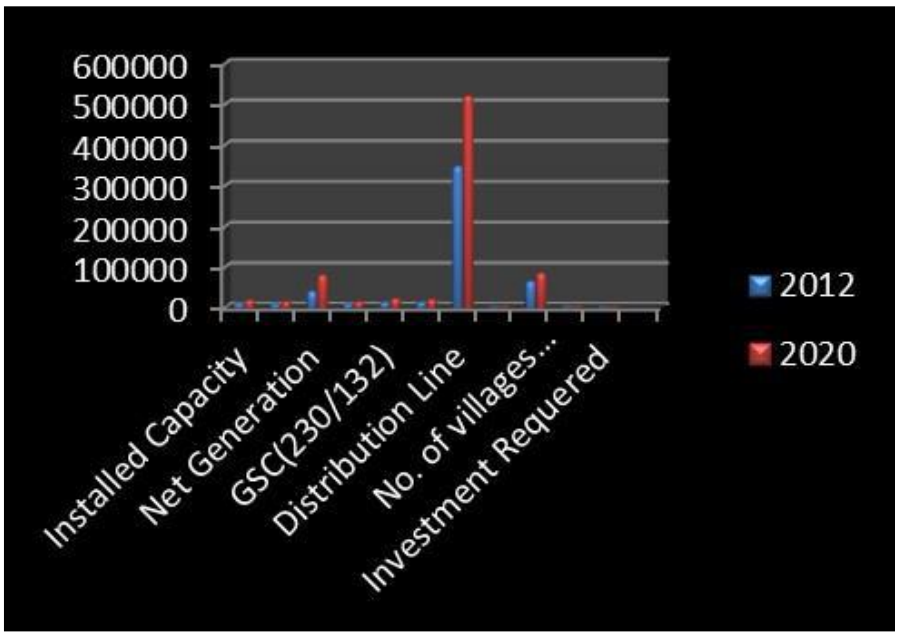

Fig 1.3 Power Sector Estimate of Power Sector till 2020 [20]

1.3.4 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 plant. [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.

1.4 Problems

No method is careful model. One of the major problems is that the country's energy distribution is unbalanced and therefore most of the natural gas will be responsible for the production of power. There is a problem in Bangladesh's energy sector that needs to be focused.

1.4.1 Natural Gas

Though Bangladesh is amusing in natural gas, it is still not satisfactory due to lack of progress in the sector and the lack of balanced power planning. The lack of funds for the development of natural gas resources and increasing fuel efficiency, including some concerns of energy security, are causing pressure to take on the path of destabilizing power.

1.4.2 Coal

Cole is another energy resource in our country. It is notable reserve, unutilized lies. Bangladesh does not have long-term energy security, but if resources are used properly then it will get better position in power supply. The current crisis is high in coal and a useful solution to this crisis is not the sight. Fig 1.4. It has been mentioned that the rate of use of coal has increased in 25 years but very rarely. Due to poor technological progress, the rate of use of coal is not as high as other countries. The government has planned to produce a large scale electricity by imported coal but it can reduce targets due to the destructive economic conditions and the lack of infrastructure.

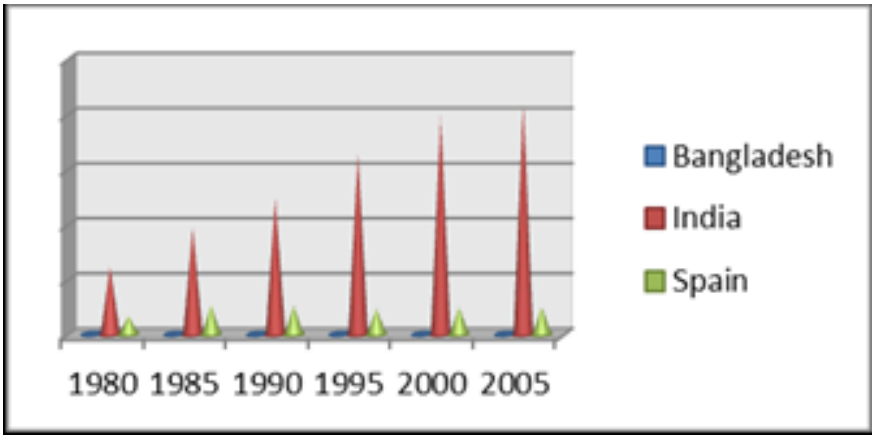

Fig 1.4 The rate of use of coal, in Bangladesh, India and Spain for 25 years [13]

In that case, our government will have to take some advanced technological movements to meet the requirements of the country. Bangladesh also needs some trained workers for coal mining so that we can get desired results like other countries.

1.4.3 Fuel

Bangladesh is a fuel importing country, so if CNG-run vehicles are stopped, it can be an economic burden for Bangladesh because it will put pressure on importing high amounts of fuel. Moreover, the demand for fuel and diesel is increasing, due to the shortage of natural gas, electricity will be turned into expensive oil-powered power plants. Our government has to focus on appropriate plans to eat more fuel and make it effective for everyone.

1.4.4 Renewable Energy

Renewable energy systems are still unused in Bangladesh. Countries such as Australia, India, Canada have started revolutionary renewable strategies to improve their power system. While other countries are integrating renewable power systems, the implementation of Bangladesh renewable energy based power plants and the implementation of SHS in villages is underway. Also the current cost of the renewable energy system is quite new to it and it costs too much capital. Another lack of weather can be difficult to generate due to renewable energy dependence and uncertain whether due to the energy needed.

1.5 Recommendations

The future of energy sector in Bangladesh depends mainly on reserve resources. And if there is a lack of natural resources then the country is dependent on the source of imported energy which is not effective because it is not effective for the developing country like us. In this case, we need to take some initiative that can be the right way to improve our energy sector in the future. Improving coal production, importing fuel from other countries and implementing improved renewable technology systems can be a good way of preserving natural gas. The power distribution system should be more balanced and reduce the dependence on natural gas to reduce the resources needed to be reduced. Like many other developing countries, Bangladesh faces huge challenges for supplying affordable, reliable and equitable fuel for the citizens. It is an inappropriate plan to use the resources provided. This needs to be overcome. Technical progress for the development of energy sector in Bangladesh is very commendable. We can rely on "Smart Grid" which is the most captivating concept. It provides safe, reliable, clean, high power supply and it can accept various sources of power generation, high market based electrical power exchange, customer demand etc. Again, the country needs to find alternatives to importing gas and electricity. Bangladesh has the opportunity to import power from Tripura to a small size. Recently, the Indian government has expressed interest in a large scale power transmission plan for power transmission from the 2000 MW hydroelectric power plant in Subansiri in Arunachal Pradesh. [22] It will be a great opportunity for Bangladesh. Since Bhutan and Nepal have huge hydro power potential with India's trade capacity for more than a decade, Bangladesh will have to take up arms as a partner in the power business with them.

1.6 Conclusion

The energy crisis in Bangladesh has been going on for a long time and if our government ignores problems according to our energy sector for the next decade. After all the discussions, we knew the hazardous situation of our energy system with some future initiatives that need to be implemented properly. Also, if our government can make use of non-conventional power resources as well as the progress of technology, it is a bent condition of Bangladesh's energy system. Use resources in a balanced and proper way, meeting energy needs and achieving a surplus.

1.3 Objectives

The objectives of this project and thesis are

- 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 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.

1.4 Scopes

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

1.6 Project/Thesis Outline

This Project/thesis is organized as follows:

Chapter 1: Introduction.

Chapter 2: Literature Review.

Chapter 3: Solar Panel & Solar System.

Chapter 4: Methodology.

Chapter 5: Data Analysis.

Chapter 6: Conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Permanent power source is a miracle that is accessible from accessible resources, which are intelligently provided for human duration, for example, daylight, wind, rain, tide, wave and geological heat. Power generation, wind and water heating / cooling, transportation, and rustic (off-network) life-power administration's permanent power source often dominates in four major areas. Before the withdrawal of coal in the mid-nineteenth century, all the animals used were durable. Often, the most well-known source of sustainable power sources without any doubt, which, incidentally, burns biomass, 790,000 years ago. The use of biomass for the fire has not actually gone anywhere between 200,000 and 400,000 years ago, somewhere somewhere several years later, for several years. It is possible to send the second old use of the sustainable electricity source to the water and send winds with the last target. This training can return to the Persian Gulf and blue vessels for anywhere from 7000 years. In the history of the written history, the need for traditional sustainable energy sources was man's work, animal control, and water control, junction, grain squashing ventilation, and reproductive biomass. In the 1900s, the vivid use of the film in the US shows the oil and burning gas with strange thought in 2010, with wind and sun-powered operations in 1900.

2.2 Types of Renewable Energy

There are various kinds of durable power sources. The greater part of these sustainable energy sources is unexpected in one way or option in the light of the sun. Wind and hydroelectric power are the direct consequences of the difference between the surface of the Earth, which affects the winds (air) and air ventilation. Direct changes in the use of sun-driven dialite board or compiler. Biomass is involved in die-light in viable plants. Other sustainable energy sources which do not depend on daylight are geological vitality, which is a difference between the first

warmth of the Earth's synthesis and the tidal life that a delayed consequence of radioactive rays at the outer layer.

2.2.1 Solar Energy

Which heat and light produced by sun. Which energy converted from that's heat and light by solar panel is called solar energy (Fig 2.1). Solar energy is a renewable and eagerly obtainable foundation of energy on planet Earth. This type of violet depends on the control of the nuclear adjustment from the center of the sun. This vivid solution and may vary in a few different ways. Long sun-driven compilers based on sun-powered compounds or sun-based fans with sun-cooling water with sun-based water warming, which keeps an eye on the mirrors and boilers or photovoltaic cells in the progress of the diary's direct transformational progression in daylight for day-to-day use. Surprisingly, now we have a plague to completely control our society completely.

Fig 2.1 Figure of Solar energy

2.2.2 Wind Power

Due to the temperature of the surface of the Earth, due to air emitted, it is driven by the surface temperature of the Earth, when sunlight is illuminated (Fig 2.2). Sapphire water or incident power can be used in the air life, yet the vibrant amount of vibrant quantity is required for the basic inclusion.

Fig 2.2 Figure of Wind power

2.2.3 Hydroelectric energy

Energy from hydroelectric power water movement emerged. There is a mass of water. It reads and flows downward due to gravity. When it is transferred, then it is dynamic energy that can be used. Kinetic energy speed power. To add hydropower power, power plants need to be installed in an area with flowing water (Fig 2.3). Block or dive water which may include a dam it. It may comprise lone or other artificial lake.

Fig 2.3 Figure of Hydroelectric Energy

2.2.4 Biomass

Phrasing for animating from plants. This form of life is used spontaneously in spontaneous worldwide. Sadly, everyone is encouraged to eat plants for cooking and warming. This method is an approximate proportion of carbon dioxide gases in the restored climate and a necessary her payer for irrational air in numerous regions. At present, a part of the biomass biodegradable animal is methane and automatically fuels alcohol production and electric power plants (Fig 2.4).

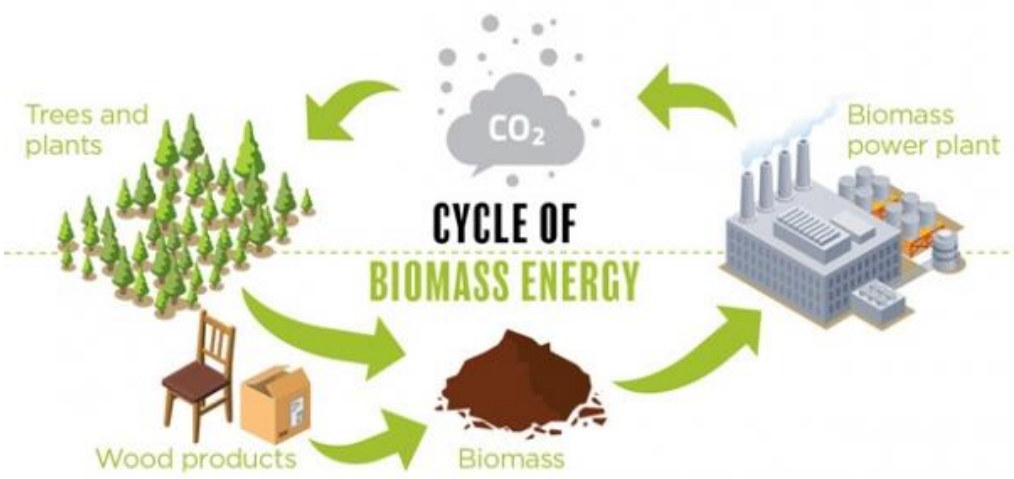

Fig 2.4 Figure of Biomass Energy

2.2.5 Hydrogen and fuel cells

This is not necessarily the right energy source, but the accessibility is exceptionally large and used when the pollution is the lowest. Hydrogen can carry fuel in a car regularly, just like a food item. These perfect intake fuel can mean a strong conservation of urban community pollution. Or on the other hand, hydrogen can be used in energy components, which are equivalent to the battery to control the electrical engine. Claiming the amount of hydrogen in sufficient quantity to demand both the generation claims. Due to the necessity of living for producing intrinsic hydrogen gas, the result of the pollution of the city's power plants is the result. Family line hydrogen has some synonyms, for example, sun-based power, which can basically correct these photos.

2.2.6 Geothermal power

Lives from the first occupation of the planet and extend from radioactive damage to warmth, in each place, bits everywhere. Geological trends in specific areas (expanded at temperatures with greatness) are sufficient to utilize the production capacity. This feasibility is kept in some parts of the world and numerous special summaries limit its usefulness. The other kind of zyothal life is the warmth of the living world, the vitality of the earth. In all cases the soils will generally be in regular temperature, annual natural, and can be used with warm siphon for heating a work in winter and cooling work during the summer. In this type of living, the mercury can reduce other power requirements for preserving the temperature, but it cannot be used to get the family line.

2.2.7 Other forms of energy

Importance of water from the reservoir, water and hot hydrogen rhythm can be used for the production of electricity. Each of these has been estimated in some detail so that the final result is not to be relied upon to correct the experience of some huge distortion and to fix the upcoming living accident.

2.3 Solar Energy

Earth receives a conniving supply of varnish based on the sun. Sun, a normal star, is a synthesis reactor that has been burning for more than 4 billion years. For a year, for a year, the world is alive enough to provide vitality. In one day, our current population has a more viable commitment than exiting within 27 years. Indeed, "the measurement of the radiation based on the sun-sun-propagating earth over the three-day period can make all petro finance differentiated between the sterile evacuation sources." Sun-based biography is a free, perpetual resource, yet it is outfitting a common new guess. The ability to use sun-based power for warmth was the main revelation. In 1772, a major Swiss researcher, Horace de Saur, created the foundation stone of the main warm sun, which was later used to heat the water and cook bhakti. The primary trading patent of the Sun-based Water Radiator went to Clarence Kemp in the United States in 1891. This structure was bought by two California presidents and by 1897, 33% of passages were introduced.

2.3.1 Producing electricity from solar energy

The sun-based biography was the second brainchild to give strength to. In 1839, a French physicist named Edmund Bekele realized that the "photovoltaic effect" of the Sun could be photographed (photograph = light, voltaic = electrical potential). In the 1880s, Selenium photovoltaic (PV) cells were shown that 1-2% of productivity could be transformed lightly by the productivity ("the efficiency of the sun-based cell is possible by the photovoltaic cell's potential lumen level"). But it has not been acknowledged how the changes happen. Photovoltaic power along this line was a curiosity for a long time, because it was highly inconvenient to transform into electricity in the light of daylight. “Albert Einstein did not raise a clear explanation about the "electronic effect of the photo" in the mid-1900s, for which he received the Nobel Prize for the person who began to understand the photovoltaic effect of the person.

2.3.2 Importance of Solar Energy for Rural Electrification in Bangladesh

In 1971, there were 250 electric power out of 87,928 villages of Bangladesh's independence year. [28] The Bangladesh Government (GOB) is committed to developing a program for supplying electricity to rural areas. Article 16 of the Constitution of Bangladesh states, "The farmers will take effective action to bring about a fundamental change in rural areas through the promotion and development of rural electrification system, rural electrification system, cottage and other industries, in the areas of education, communication and public health, in urban and rural areas. Discrimination can be removed from the living standards in the area "[29]. BPDB was formed to manage and expand the electricity network, which is basically concentrated 14 Electricization in urban centers NRCA is commissioned to conduct a comprehensive study to increase rural electrification. NRCA has created a master plan by emphasizing on the provision of power for agricultural mechanization, irrigation and rural industries. The master plan was adopted in 1977, and only after the reconstruction next year. [30] By January 2014, more than 50,194 villages 84, 22, 246 domestic lines and 53.34% people entered electricity and the remaining 46.66% depend on kerosene and other sources. By 2020, ArabB has defined a goal of bringing all the cities of Bangladesh under the power supply. However, it must be mentioned that the electricity of the village does not mean that all families will be connected immediately, the ability to create primary connection costs is a problem for

a certain number of families. Therefore, only a small minority (10%) rural Bangladesh has access to electricity. In addition, the quality of the supply is often discontented [31] due to load shedding and voltage variability. Expanding distribution line setup is costly due to the dominance of several areas of remote areas, broad areas of water, regular flooding, mountainous and river islands. In this situation decentralized power supply with writing can present an effective and costly alternative to conventional grid-based power plants. Natural gas reserves have been tired very soon and the petroleum consumption in Bangladesh seems to be a reasonable step to fully develop sustainable long-term energy scenes [32] due to the increased use of import-based, renewable energy sources. Though the natural landscape of Bangladesh is enormous in size, the possibility of hydropower generation is quite limited. The only hydroelectric power station of the country, the Karnaphuli power plant's total production capacity is 230 MW, of which about 5% of the electricity's total installed capacity. Due to negative environmental and social causes due to the construction of the Karnaphuli power plant and the construction of the reservoirs, prolonged social unrest is created in the local population. Again, Bangladesh is also limited in the lack of wind speed due to the use of electricity from wind power. As well as livestock waste or crop residues like biomass, electricity production is still in the initial stage of development and testing. Bangladesh is geographically located at an optimum position to maintain sunlight, which is available in most cases in most of the year. The average daily radiation of solar power is technically useful for the use of voltic power of 4.5 kWs per square meter [31] for power purposes.

2.4 Advantages of Solar Energy

2.4.1 Renewable Energy Source

Among all the dwelling houses of the sun-driven boards, the best thing is that the sun-driven biography is actually a durable power source. It has hardware in every aspect of the world and is consistently achievable. We cannot make up short on sun-based biographies, contrary to a part of the other emerging velocity. As long as the sun remains, the sun's foundation will be open, with this line we will be ready for less than 5 billion years when researchers will dust the consonant sun.

2.4.2 Diverse Applications

Sunlight-based lively can be attached to different purposes. You can start energy (photovoltaic) or warm (sun-based warm). The zodiacal zoology of the sun can be used as a result of zones without access to astronomy matrices, to drain water into the water with limited clean water supply and to control the satellite in places. Sun-based biographies can be integrated into fixing used for the same structure. Relatively present in the present-day fantastic transparent sunlight-based biography windows.

2.4.3 Low Maintenance Costs

Sun oriented vitality frameworks all around needn't bother with a considerable measure of support. We just need to keep them reasonably perfect, so cleaning them a couple of times each year will carry out the activity. If all else fails, you can generally depend on got the hang of cleaning township, which offer this administration from nearly £25-£35. Most solid sun powered board craftsman's offer 20-25 years personnel. Additionally, as there are no portable parts, there is no wear and tear. The inverter is generally the just a single part that should be change following 5-10 years since it's evermore attempting to follower sunlight based vitality into power (sun oriented PV) and warmth (sun based warm). Aside from the inverter, the links likewise require resistance to guarantee your sun oriented power framework keeps running at greatest effectiveness. In this way, after spread the underlying expense of the close planetary system, you can expect next to no cost on support and fix work.

2.4.4 Technology Development

Innovation of the sun-driven power industry will be progressing every minute and citizenship approaching. Progress of quantum material science and nanotechnology can increase the fluctuation of sun-operated boards and doubling, even threefold as the electrical contribution of sunlight-based power structures.

2.5 SHS's and socio-economic development structures

Figure 2.5 is the structure of SHS and socio-economic development. This is an example of multi-secret links on the quality of life among the Grid community of communities on the quality of the SHS. It refers to the social and economic benefits that beneficiaries can achieve in rural areas using the SHS. This structure focuses on the specific areas of education, health, agricultural information, environment and micro enterprise connections, including the different sectors of the solar power plant in the rural areas. It depends on the mix of models and discovery from relevant composition.

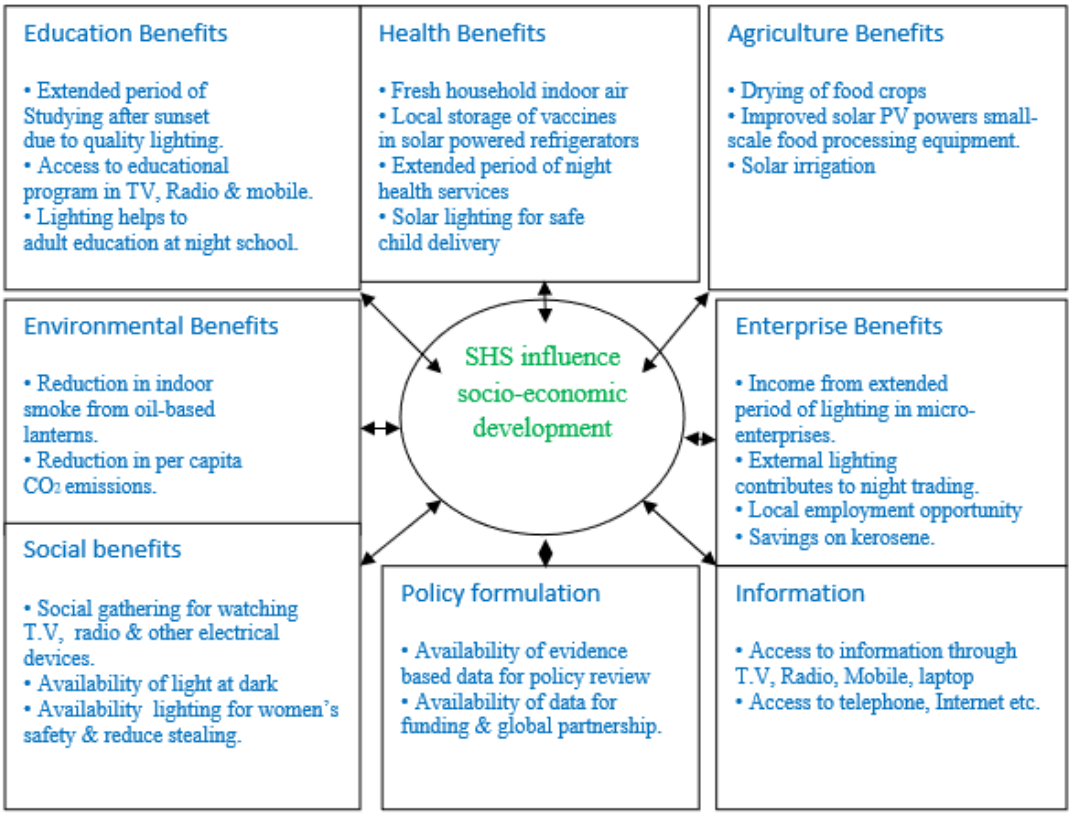

Fig. 2.5 SHS and Socio-economic Development Framework

CHAPTER 3

SOLAR PANEL & SOLAR SYSTEM

3.1 Introduction

Introduced by the International Energy Agency, the Sun-run PV schedule has expanded by 227 GW by the end of 2015 [25]. Power has increased 10x since 2008, more than 1.3% of all prerequisites. In spite of various arrangements, administrative and advertising activities adopted by various laws across the world, the cost of penicillin has been surpassed by surplus sunlight-based PVT being an original driver of this progress. As can be found in Figure 15, penicillin consumption is not limited to sunlight-based PV (after 2008) backup. Indeed, sunlight-based PV was not estimated as an ideal animated source, and was characterized by lower cell function and high cost of polycylation. The greater part of the policy delivery before 2005 was used by IT business and thus the supply was needed. The system draws attention to the many environmental changes in the countries created by the countries and for the significant expansion of sun-based PVs, for example, Germany, the United States and Japan logically follow the interests of polycylics and by 2008-09 there was excessive amount of polycolic advertising. It has collapsed in polycylic costs and as a result, dragging in the segment of the giant for the sake of the segment and large solar powered PV costs. The truth is said, there were huge points in the market that a large number of industrial players were required to stop their polycylic fabrication facilities, because overall income and wars were cost-focused with the production of sugar. The total sun-based PV framework is a solidified bundle of various components. These elements are unmatched and coordinated through significant efforts by various players on a huge inventory network, including sunlight-based modules and equations of structure (BOS) - electronic pumps, mounting structures, electrical base and various important parts (now and again). Biological storage [26].

It is also extra essential to comply with the enhancement of the sales functionalities, in the same way, an important descendant of lifestyle has taken an essential work to the solar powered PV. It is additionally necessary to allude to that enhancement in cell efficiencies recently has

likewise assumed an imperative job in qualifying sun powered PV as a vital wellspring of vitality.

3.2 Solar Panel

A sun oriented board is an arrangement of sunlight based photovoltaic modules electrically related and mounted on a supporting structure. A photovoltaic module is a bundled, associated get together of sunlight based cells. The sunlight based board can be utilized as a module of a bigger photovoltaic framework to produce and supply power in business and private applications. Every module is evaluated by its DC yield control under standard test conditions (STC), and traditionally goes from 100 to 320 watts. The productivity of a module decides the zone of a module given the equivalent appraised yield - a 8% effective 230 watt module will have double the region of a 16% proficient 230 watt module [27]. A solitary sunlight based module can create just a blemished measure of intensity; most establishments contain numerous modules. A photovoltaic framework ordinarily incorporates a board or a variety of sun powered modules, an inverter, and now and then a battery and additionally sun powered tracker and interconnection wiring [28].

Figure 3.1 A solar array composed of a solar panel with 24 solar modules in rural area.

Solar panels manufacture electricity from sunlight. The first solar panel-powered satellite was launched in 1958 by Hoffman Electronics [29]. The primary sunlight based PV– based country zap venture in Bangladesh was started with the money related help of France like as in fig: 3.1, with an aggregate introduced limit of 62 kilowatts crest (kWp), of which 29,414 kWp originated from battery charge stations and the rest from SHS [30]. A sun based board

comprises of number of photovoltaic (PV) sun powered cells associated in arrangement and parallel. These cells are comprised of somewhere around two layers of semiconductor material (normally unadulterated silicon implanted with boron and phosphorous). One layer has a positive charge; alternate has a negative charge [31]. At the point when daylight strikes the sun oriented board, photons from the light are consumed by the semiconductor particles, which at that point discharge electrons. The electrons, spilling out of the negative layer (n-type) of semiconductor, stream to the positive layer (p type), delivering an electrical flow. Since the electric flow streams in a single manner (like a battery), the power produced is DC.

3.3Kinds of Solar Energy

There are two kinds of solar energy.

1. Electricity Production (Photovoltaic or PV Technology)
2. Water Heating (Solar Thermal or Flat Plate Technology)[8].

3.4 Photovoltaic Solar Power

Sun based vitality is vitality that is available in daylight. It has been utilized for a great many years in a wide range of routes by individuals everywhere throughout the world. And in addition its conventional human uses in warming, cooking, and drying, it is utilized today to build power where other power supplies are missing, for example, in remote spots and in space. It is getting to be less expensive to make power from sunlight based vitality and much of the time it is currently aggressive with vitality from coal or oil. The most widely recognized sort

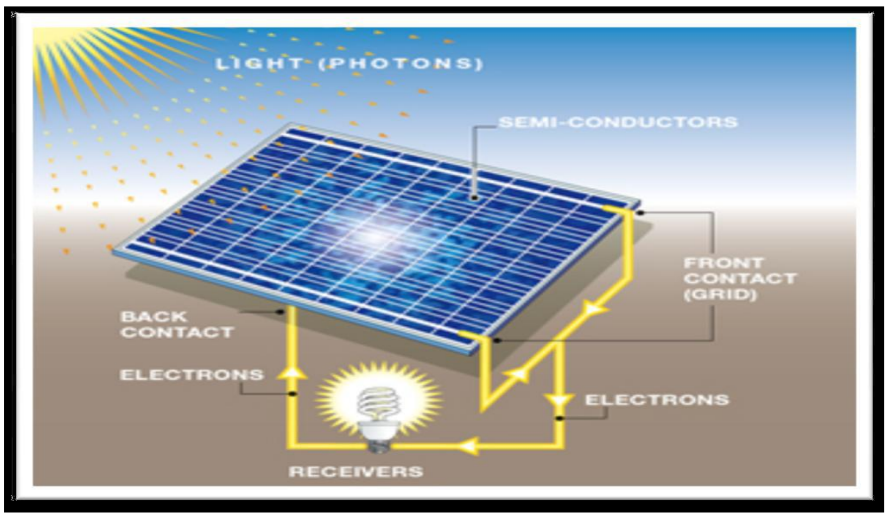

Figure 3.2 Photovoltaic Solar Power.

of sun based vitality is photovoltaic cells are appeared in fig 3.2, which specifically convert light to power. Photovoltaic (PV) cells create semiconductor innovation to make an interpretation of sunlight based radiation specifically into an electric flow which can be utilized promptly or put away for sometime later [32].PV cells are regularly gathered as "modules" to deliver clusters which can create control for circling satellites and other rocket.

As of late, with the consistent reject of assembling costs (declining 3% to 5% every year as of late) , employments of PV innovation have developed to incorporate home power age, and framework associated power generation[10]. Establishments of PV frameworks have additionally been becoming due in substantial part to thorough motivating force programs which help consolidate the expenses of these frameworks and furthermore allow clients to publicize over-burden power back to the general population matrix.

With the developing require of sunlight based power new advancements are being presented and available innovations are rising. There are four kinds of sunlight based PV cells [33].

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

3.4.1 Single Crystalline or Mono Crystalline

It is far and wide exhibited and the most proficient cells assets among all. They deliver the most power per square foot of module. Every cell is cut from a solitary precious stone. The wafers at that point additionally cut into the state of rectangular cells to exploit the quantity of cells in the sun powered board.

3.4.2 Polycrystalline Cells

They are finished from comparative silicon material aside from that as opposed to being developed into a solitary gem, they are dissolved and filled a shape. This structures a square that can be cut into square wafers with less discard of room or material than round single-gem wafers.

3.4.3 Thin film panels

It is the most topical innovation acquainted with sun based cell innovation. Copper indium dieseline, cadmium telluride, and gallium arsenide are for the most part thin film assets. They are straight stored on glass, hardened steel, or other very much coordinated substrate materials. Some of them perform marginally superior to crystalline modules underneath low light conditions. A thin film is thin-a couple of micrometer or a less vital sum.

3.4.4 Amorphous Silicon:

Nebulous silicon is latest in the thin film innovation. In this innovation unstructured Silicon vapor is kept on two or three miniaturized scale meter thick nebulous movies on tempered steel rolls. Contrasted with the crystalline silicon; this innovation utilizes just 1% of the material [34].

3.5 Components of a Solar PV System

A run of the mill sun based PV framework comprises of sun oriented board, charge controller, batteries, inverter and the heap. Figure 3.3 demonstrates the square graph of such a framework.

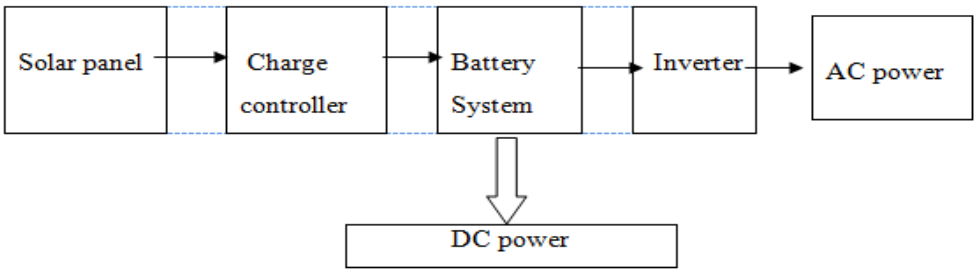

Figure 3.3 Block diagram of a typical solar PV system [13].

3.5.1 Charge controller

At the point when battery is incorporated in a framework, the prerequisite of charge chief approaches. A charge controller controls the farfetched voltage develop. In a brilliant bright day the sun powered cells deliver more voltage that can prompt battery hurt. A charge controller safeguards the parity in charging the battery [35].

Charge controller connection is mainly two types-

- Parallel or shunt controller
- Series controller

3.5.1.1 Parallel or shunt controller

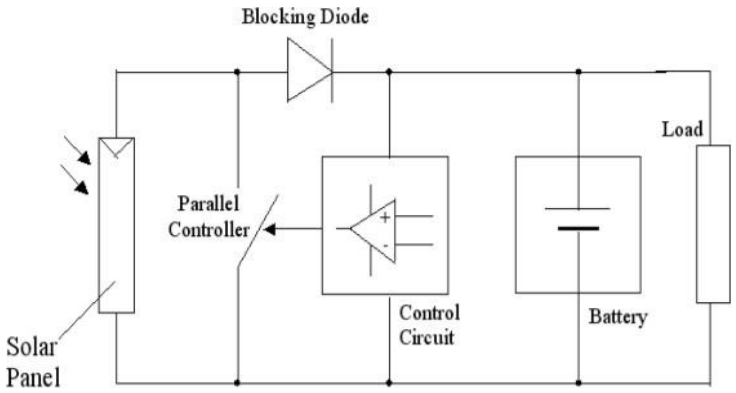

Fig. 3.4 Use of Parallel Controller in Solar Home System

In this system (Fig. 3.4), charge controller is in parallel with the battery and load. When the battery is absolutely charged, then the solar panel is short circuited by the controller. In this system, a blocking diode is needed. So that reverse current would not battery to the panel. When the battery is charged through this block diode, it gets hot. There are some disadvantages of shunt controller such as:

- Loss of electricity
- Huge amount of short circuit current (Isc) flows through the switch (FET), when the panel is short circuited,
- Compared to series controller, shunt controller gets hotter.

3.5.1.2 Series controller

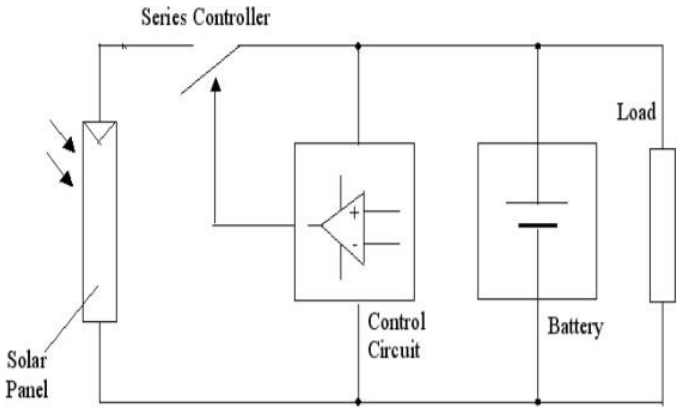

Fig. 3.5 Use of Series Controller in Solar Home System

In this system (Fig 3.5), charge controller is connected in between with the solar panel and battery. To terminate the flow of electricity to the battery, the series controller should be off from the battery. There's no need of blocking diode during this system, but in several reasons, it is used to terminate the method of discharging at night. The resistance should be maintained as low as possible to minimize loss of the electricity. Advantages of series controller:

- Blocking diode is not required.
- Compared to shunt controller, series controller switch is handled with low voltage.
- Low switching noise.
- It is possible of precision charge and PWM technique of the battery.

3.5.2 Batteries

Batteries (Fig 3.6) are exceptionally helpful in the nearby planetary group. In day time daylight is here the board assimilate the warmth and deliver power and this time the vitality charge to the battery. At that point the evening battery is help to provide for stream globule, fan, light, TV and so forth. There are three component fluid lead corrosive, lithium particle and saltwater.

Figure 3.6 Battery

3.5.2.1 Lead acid

Lead corrosive batteries are a tried innovation that utilized in off-framework vitality forms for a considerable length of time. While they have a moderately little life and lower than other sort of battery, they are additionally one of the base expensive choices as of now available in the home vitality stockpiling segment. For property holders, lead corrosive can be a decent alternative, who need to go off the lattice and need to introduce loads of vitality stockpiling.

3.5.2.2 Lithium ion

The greater part of the new home vitality stockpiling frameworks, similar to the, utilization some type of lithium particle substance synthesis. Lithium particle batteries which are lighter and over minimized than lead corrosive batteries. They have a higher and longer life expectancy when contrasted with lead corrosive batteries. Be that as it may, lithium particle batteries are over exorbitant than their lead corrosive partners.

3.5.2.3 Saltwater

The saltwater battery is a newcomer in the home vitality stockpiling industry. Since saltwater batteries don't contain substantial metals, that is the reason other home vitality stockpiling alternatives, depending rather on saltwater electrolytes. We must be discarded with extraordinary frameworks, a saltwater battery can be effectively reused. Since, batteries which utilize overwhelming metals, including lead corrosive and lithium particle batteries, so it will be another procedure saltwater batteries which are generally not tried, and the one organization that makes sun oriented batteries for home use petitioned for financial protection in 2017.

3.5.3 Inverter

Sun oriented board in fig 3.7 produces dc power yet the greater part of the family unit and mechanical machines require air conditioning current. Inverter changes over the dc current of board or battery to the air conditioner current. We can parcel the inverter into two classes. Regularly accessible inverters can yield in I or 3 stage, 50 or 60 hertz, and 117 or 220 volts, and can go in steady yield control from a couple of hundred

Watts to thousands of kilowatts. Gigantic utility scale inverters are made to yield at 480 volts AC or higher and have limits past 1000 kilowatts [36].They are.

- Stand alone and
- Line-tied or utility-interactive.

Figure 3.7 Inverter

3.6 Tracking Systems

Following frameworks fig 3.8 are equipment gadgets every now and again utilized on shaft mounted sun powered clusters to allow the situating of the sun oriented boards to seek after the development of the sun. This helps verify that there is most extreme presentation for the sun oriented cells. A following framework can grow the yield of your PV framework by up to 30% in the late spring and 15% in the winter over non-followed frameworks. Following frameworks are typically private as being either inactive or dynamic. In an inactive framework the tracker pursues the sun from east to west with no utilizing any sort of electric engine to control the development. Rather the framework pivots from a course of action of warmth and gravity. Since no outer establishment of power is required such frameworks are perfect for remote off-the-matrix situations or use with water siphoning frameworks where peak the pinnacle order is in the mid-year. Following frameworks are likewise now and then classified with regards to the quantity of hub they track against. Straightforward one pivot frameworks turn just left to right instead of in a curve. A two pivot following framework will follow both left to right and here and there. This permits it all the more effectively to pursue the genuine curve of the sun directly as the day progressed.

Inactive following frameworks have a few restrictions. To start with, they are to some degree powerless against high breezes which can divert the tracker from the best possible course. They can likewise be to some degree lazy in moving in chilly temperatures since they are mechanically instead of electronically determined.

Dynamic following frameworks are controlled by little electric engines and require some kind of sort out module to guide them. They are practically identical in way to deal with the frameworks supporting goliath TV dishes. Dynamic frameworks require some electric power which can emerge out of an outer source or from the sun powered boards themselves relying on the model [37].

The central issue with trackers is regardless of whether the strengthening cost, of a following framework, both introductory expense and upkeep cost, is advocated by the extra electric power they produce. Following frameworks require protection and include a decent piece of intricacy to the framework basically

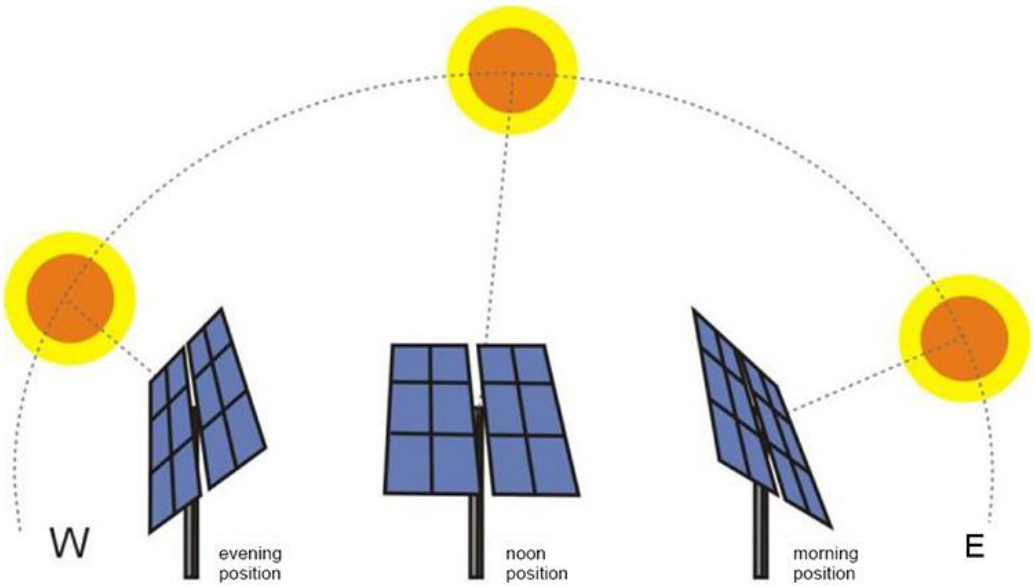

Figure 3.8 Tracking System.

3.7 Solar Generation Technology

There are two possibilities to Generate power from Solar Energy.

1. Roof Top System
2. Off Grid System

3.7.1 Roof Top System

In this fragment, you can introduce sun based power plant on your rooftop, deliver power in the day time and specifically trade them into AC control and use for burdens amid day time or fare to Grid and save money on EB Bills. This framework is the biggest part normal for applications over 100 KW up to MW estimate. In this framework, you can just utilize sun powered power when created and not put away by any stretch of the imagination.

3.7.2 Off Grid System

In this portion, you can introduce sun based power plant on your rooftop top, produce power and collect it in the battery. The framework capacities in such a way – the battery is charged primary worry by sun powered power and if not by EB control. At the point when the battery is full, on the off chance that the sun oriented power is accessible – the heap is related to sunlight based power – notwithstanding when EB control is accessible. At the point when

sunlight based isn't accessible, if the battery is full – the heap is associated with EB control if accessible. At the point when both Solar and EB control isn't accessible – the heap is provided from battery. Typically these frameworks are exceedingly reasonable for power imprint circumstances and for limits going from 1 KW to 100 KW.

3.8 Kinds of Solar Energy

There are two kinds of solar energy.

1. Electricity Production (Photovoltaic or PV Technology)
2. Water Heating (Solar Thermal or Flat Plate Technology)[38].

3.9 Photovoltaic Modules

PV modules are done from sun based cells related in plan and parallel to get the perfect current and voltage levels. Sun fueled cells are exemplified as they should be weatherproofed and electric accomplices also should be outrageous and utilization free. The ordinary manufacture of a PV module can be found in figure 3.9.

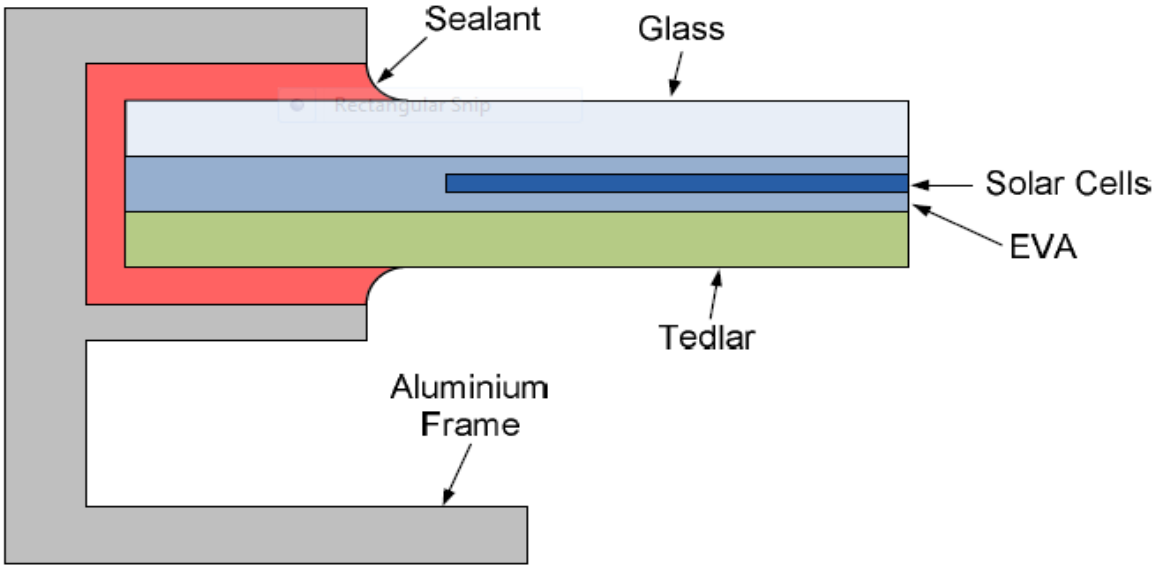

Figure 3.9 PV Module typical construction.

As the phones are weak, they are embodied in a sealed shut layer of Ethylene Vinyl Acetate (EVA), a polymer, so the phones are padded and in that way are limited amid transport and

taking care of. The best cover is a safety glass treated with an antireflection covering so the best light is transmitted to the phone. The underneath is a sheet of polyvinyl fluoride (PVF), likewise known Tedlar, a manufactured polymer (CH2CHF)n that comprises an obstruction to dampness and keeps the cell from substance assault. An aluminum outline is utilized to make less complex mounting and taking care of and to give extra assurance. Frameless modules are here and there utilized in exteriors for stylish reasons. This ordinary development is utilized in light of the fact that the PV module needs to "endure" outside for no less than 20-25 years under differing climate conditions, some of the time extraordinary. This development guarantees at any rate the lifetime of the PV modules. Truth be told, PV board producers give a certification of no less than 20 years, for instance BP Solar guarantees 85 % of slightest sum justified power yield following 25 years of administration, 93 % of the base justified power yield at 12 years and a five-year guarantee of materials and workmanship[18]. Such a long assurance is enormously since a long time ago contrasted with most items and is because of the unique development of PV modules.

3.10 Solar Cell

A sun powered cell or photovoltaic cell in fig 3.9 is an electrical gadget that changes over the vitality of light unswervingly into power by the photovoltaic impact. It is a type of photoelectric cell, unmistakable as a gadget whose electrical attributes, for example, flow, voltage, or obstruction, differ when presented to light. Sun powered cells are the development squares of photovoltaic modules, or else known as sun oriented boards.

Sun oriented cells are depicted as being photovoltaic independent of whether the source is daylight or a fake light. They are utilized as a photograph identifier (for instance infrared indicators), identifying light or other electromagnetic radiation close to the recognizable range, or estimating light force.

Figure 3.10 Solar Cell

The task of a photovoltaic (PV) cell requires 3 essential characteristics [40]

- The combination of light, generating either electron-hole pairs or exactions.
- The separation of charge carriers of opposite types.
- The separate withdrawal of those carriers to an external circuit

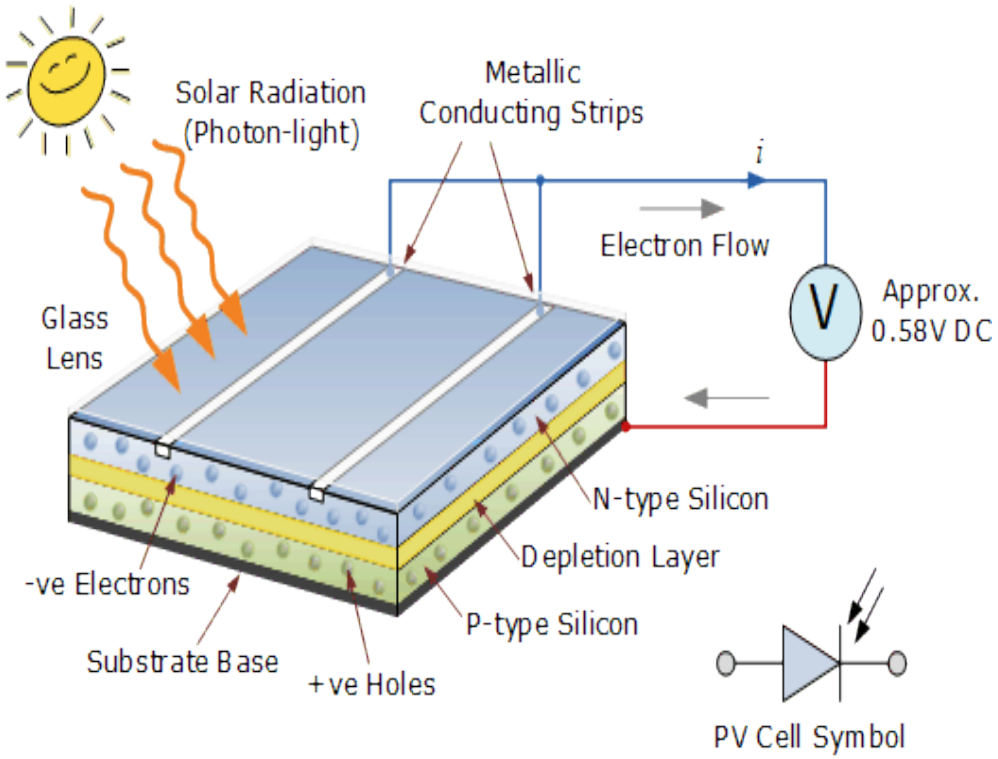

Figure 3.11 Structure of Solar cell.

The basic steps in the procedure of a solar cell are as in fig 3.10 and fig 3.11

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

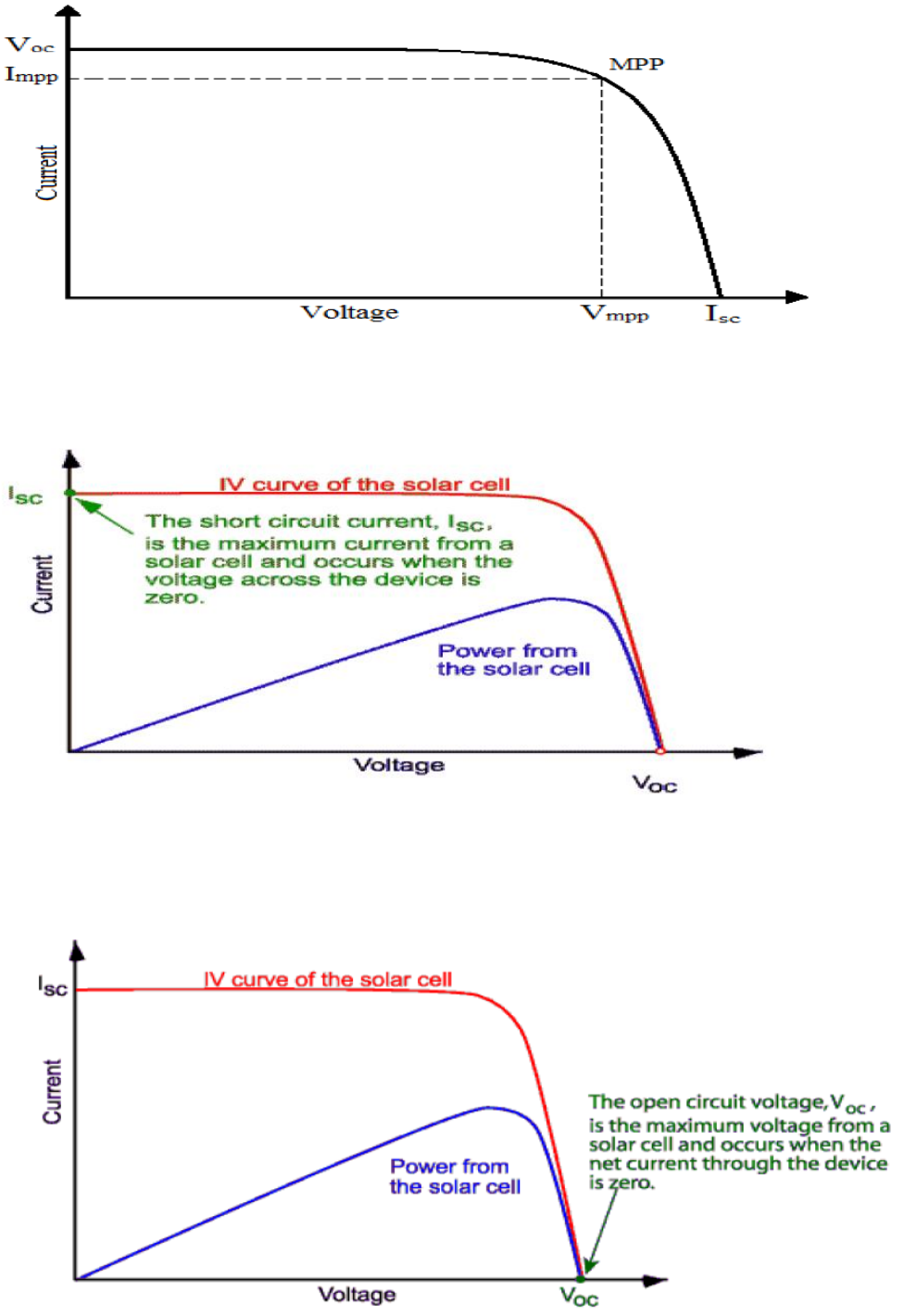

Figure 3.12 I-V characteristics of the PV cell [20].

3.11 Conclusion

Photovoltaic advances, utilized appropriately, may enhance the greatness of life of provincial individuals and give pay producing openings. Manageable improvement through new innovations requires a model that solely addresses social, financial, and environ-mental issues. This sun oriented based undertaking depicts how a proper structure may make accessible these components, making salary producing conduct while mitigating neediness and preserving normal assets. The Bangladesh practice demonstrates that wide open jolt through sunlight based power can best be spread using exhibitions; this methodology produces required from adjacent networks. In supporting sun based power age in country territories, focus must be paid to neighborhood possession with an appropriate blend of identity and aggregate proprietorship and the executives. Guaranteeing privately created and open system is likewise basic in creating support for this innovation. given that power for addressing lighting needs of family units and country markets can yield positive outcomes, incorporating enhancements in personal satisfaction and expanding salary and business openings. Grameen Bank and BRAC, which presently give smaller scale credit to country poor people, to the arrangement of bigger advances to town organizations for RETs. Sun powered power organizations encompassed by the limitation of a speculation of Tk. 200,000, current vitality assets, and vitality request—would have the capacity to give work to two-fifths of LMFs in the examination towns. These effect can imply that a creating nation can all the more quickly accomplish the MDGs. The push toward utilized in Bangladesh could be similarly proper to the next creating nations with comparable financial conditions.

CHAPTER 4

METHODOLOGY

4.1 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.

4.2 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 [24]. Apart from schools, universities, hospitals, restaurants and shopping centers, apart from Dhanmondi's original double-decker rooms, there are apartment complexes.

A study area (Fig 4.1) 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.

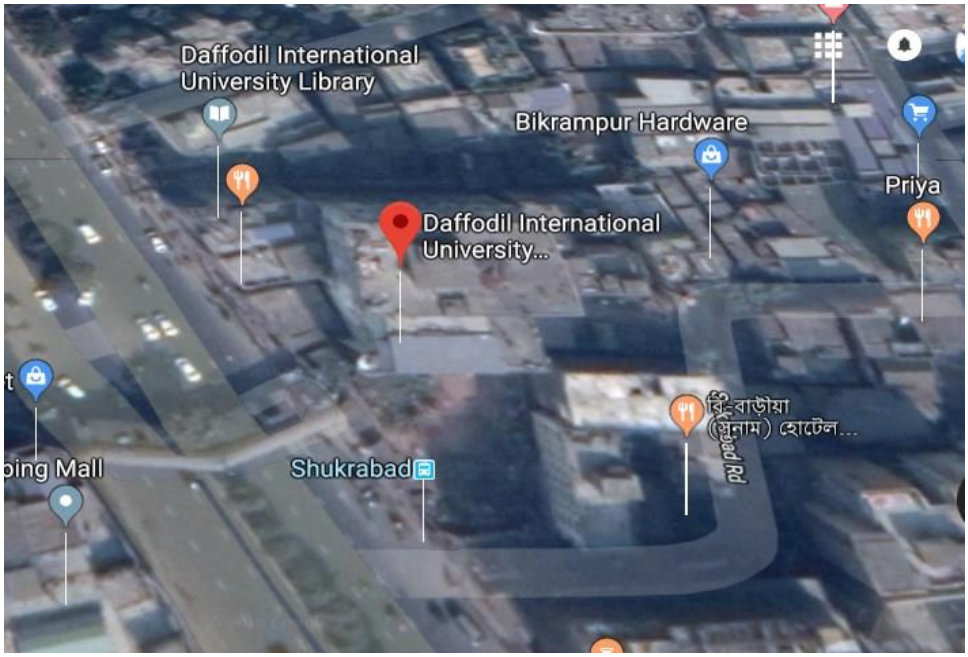

Figure 4.1 Steady Area (DIU AB Building)

4.3 System Design

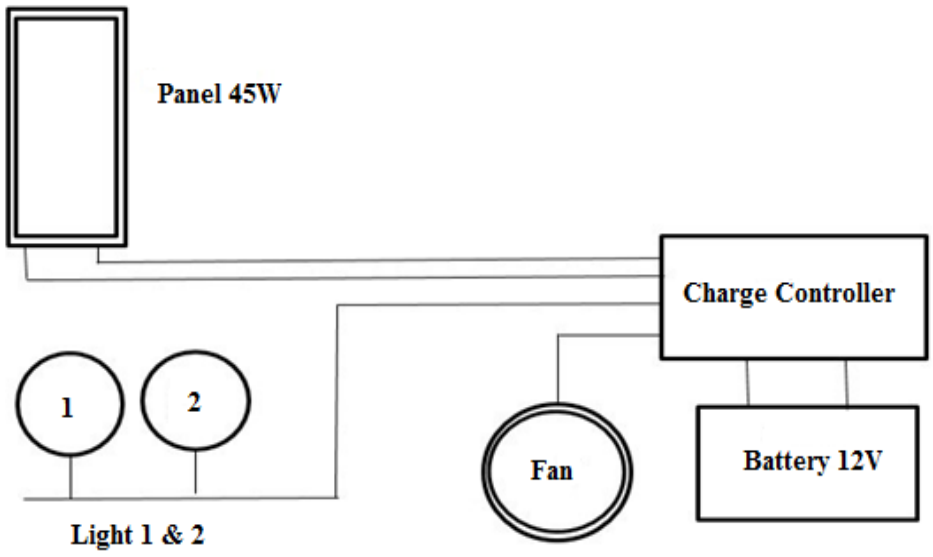

Fig 4.2 System Design (45W)

4.4 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 current current 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.

4.5 60watt Solar Panel

The 60watt solar panel is medium cell. This area of 0.44m^2. There are some features in the 60watt solar panel. The cells of the solar made in Germany (Fig 4.3).

4.5.1 Electrical Specifications

I.	Maximum Power(PmP)	60wp
II.	Open Circuit Voltage(Voc)	21.5v
III.	Short Circuit Current(Isc)	3.76A
IV.	Voltage at Maximum Power(Vmp)	17.5v
V.	Current at Maximum Power(Imp)	3.46A
VI.	Module Dimension	805*550*35mm
VII.	Module Weight	5.9+-3%

Figure 4.3 60 Watt Solae Panel

4.6 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

4.6.1 Photovoltaic Meter

The photovoltaic meter (Fig 4.5) 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/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.

Figure 4.4 Photovoltaic Meter

4.6.1.1 Electrical Specifications

Table 4.1 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%

4.6.1.2 General Specifications

DISPLAY AND MEMORY:

Features: 128x128pxl custom LCD with backlight

Memory capacity: 256kbytes

.

POWER SUPPLY:

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

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

4.6.2 Irradiance Meter

When we measurement our data we connected the irradiance meter (Fig 4.5) 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 / m² - 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 / 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 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 4.5 Irradiance Meter

4.6.2.1 Technical Specifications

Table 4.2 range & accuracy

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

4.6.2.2 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°C - 50°C

Storage temperature: -20°C - 60°C

4.6.3 Temperature Sensor

Temperature sensor (Fig 4.6) 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 4.6 Temperature Sensor

4.7 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 (Fig 4.7) in a process or program analysis, documentation or management in different fields.

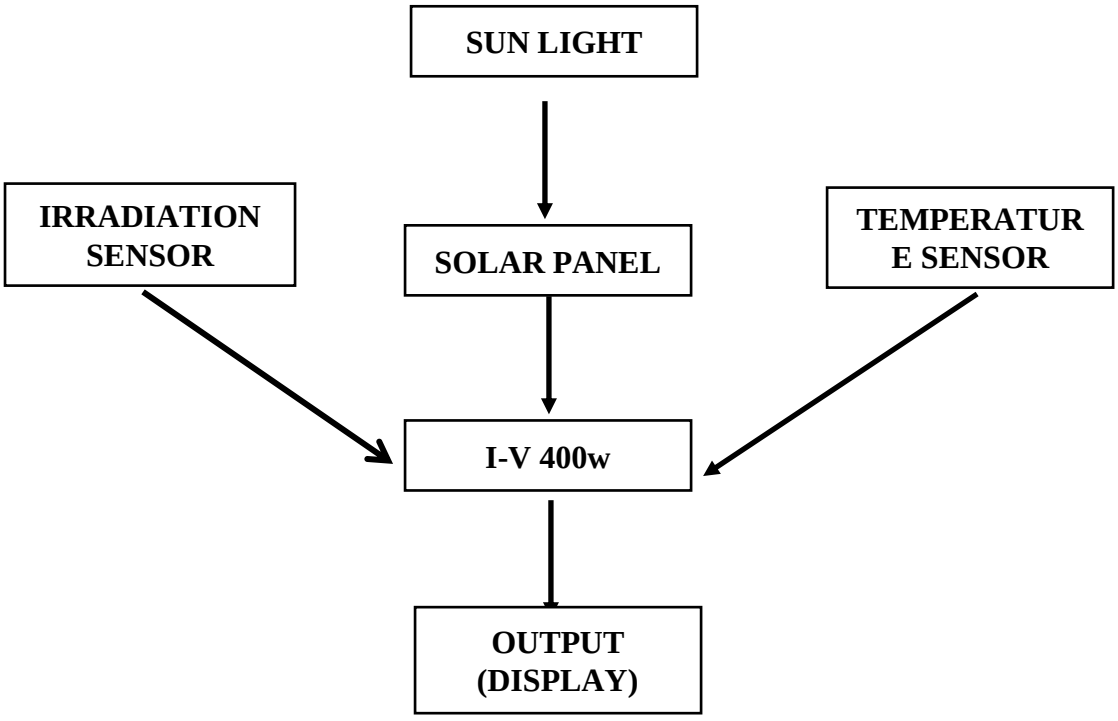

Fig 4.7 Flow Chart

4.8 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-5

Table 4.3 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

4.9 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.

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 60 watts
V. The solar panel connected the whole meter then the data is here the photovoltaic meter. We take a picture in all data.

Figure 4.8 Data Measuring

VI. 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.

4.10 Put the Data in Lab Sheet

We collected the data in a day ten or twelve times. We collect the data 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.

Table 4.4 represents parameter-wise data of 60 watt solar panel of a single day (6th July, 2018)

SL	Time (Sunrise to Sunset)	Irradiance (W/m2)	Voltage (V)	Current (I)	Vmpp(V)	Impp(I)	Fill factor	Pmax (W)
1	5:16	0						0.00
2	6:16	89	19.3	0.23	15.8	0.19	0.68	3.00
3	7:16	166	19.4	0.30	16.9	0.20	0.58	3.38
4	8:16	527	20.3	1.02	18.8	0.83	0.75	15.51
5	9:16	350	19.6	1.41	15.8	1.24	0.71	19.59
6	10:16	749	19.8	2.20	15.8	1.98	0.72	31.28
7	11:16	421	19.7	0.99	18.1	0.76	0.71	13.76
8	12:16	194	19.5	0.50	14.6	0.32	0.47	4.60
9	13:16	755	19.9	1.35	18.3	0.91	0.62	16.65
10	14:16	723	19.9	1.59	17.5	1.36	0.75	23.80
11	15:16	375	20.2	0.85	18.9	0.60	0.66	11.34
12	16:16	248	19.5	0.61	17.9	0.47	0.71	8.41
13	17:16	0						0.00
14	18:49	0						0.00

Starting from sunrise to sunset. Where,

Voc= Open circuit voltage

Isc= Short circuit current

Vmpp= Maximum power at voltage

Impp= Current at Maximum power

FF= Fill factor

Pmax= Vmpp*Impp

Efficiency= Pmax/ Irradiance* panel area

CHAPTER 5

DATA ANALYSIS

5.1 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 is 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.

5.2 Result:

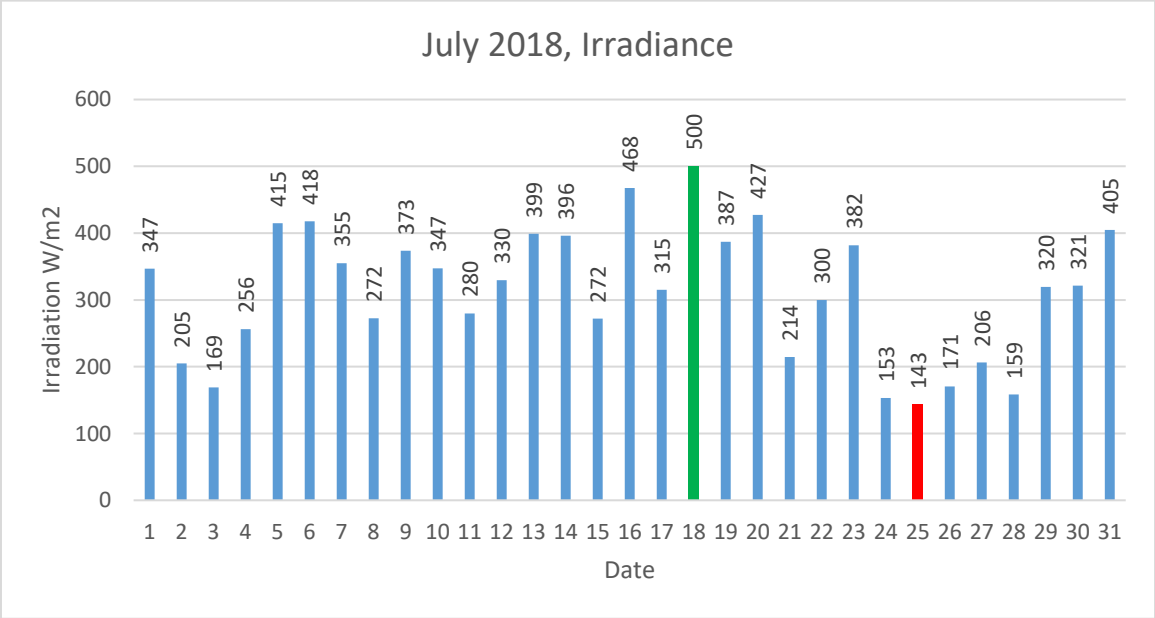

Figure 5.1: Daily irradiance for July

Figure 5.1 shows the data of solar irradiation of July 2018. On 01 to 31 July 2018, the highest value of solar irradiance was measured that was 500 W/m2 and the lowest value of the solar irradiance was measured that 143 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.

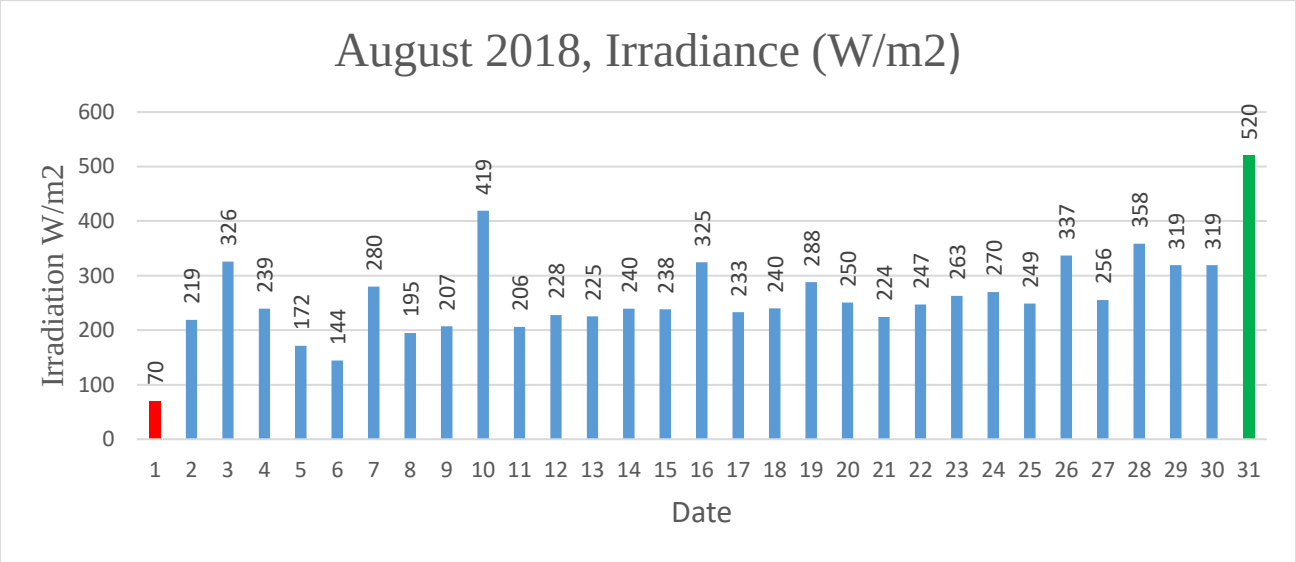

Figure 5.2: Daily irradiance for August

Figure 5.2 shows the data of solar irradiation of July 2018. On 01 to 31 August 2018, the highest value of solar irradiance was measured that was 520 W/m2 and the lowest value of the solar irradiance was measured that 70 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.

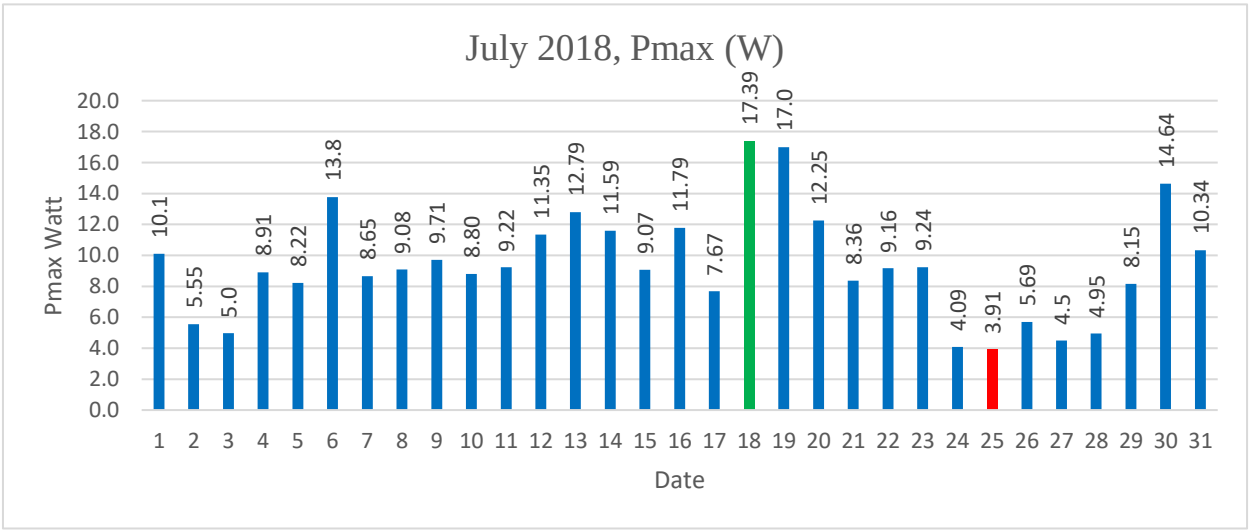

Figure 5.3: Daily pmax for July

Figure 5.3 represents the power generation curve of 60 W solar panel in July 2018. On 01 to 31 July 2018, we have found the highest value of maximum power 17.30 W and the lowest value of minimum power 3.91W in August 2018

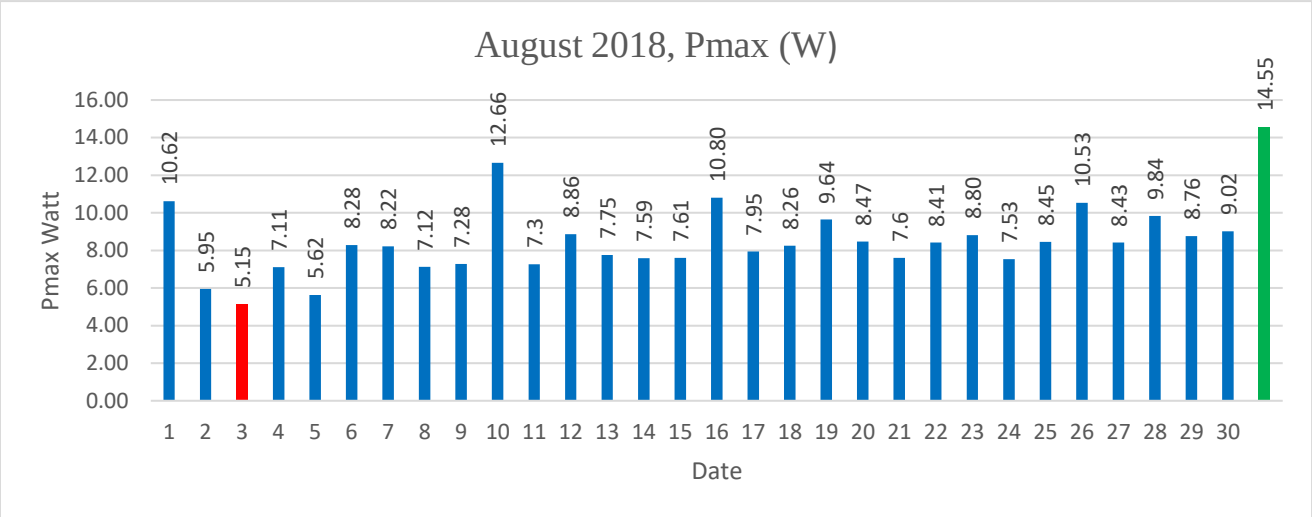

Figure 5.4: Daily Pmax for August

Figure 5.4 represents the power generation curve of 60 W solar panel in August 2018. On 03 to 31 July 2018, we have found the highest value of maximum power 14.55 W and the lowest value of minimum power 5.15 W in August 2018

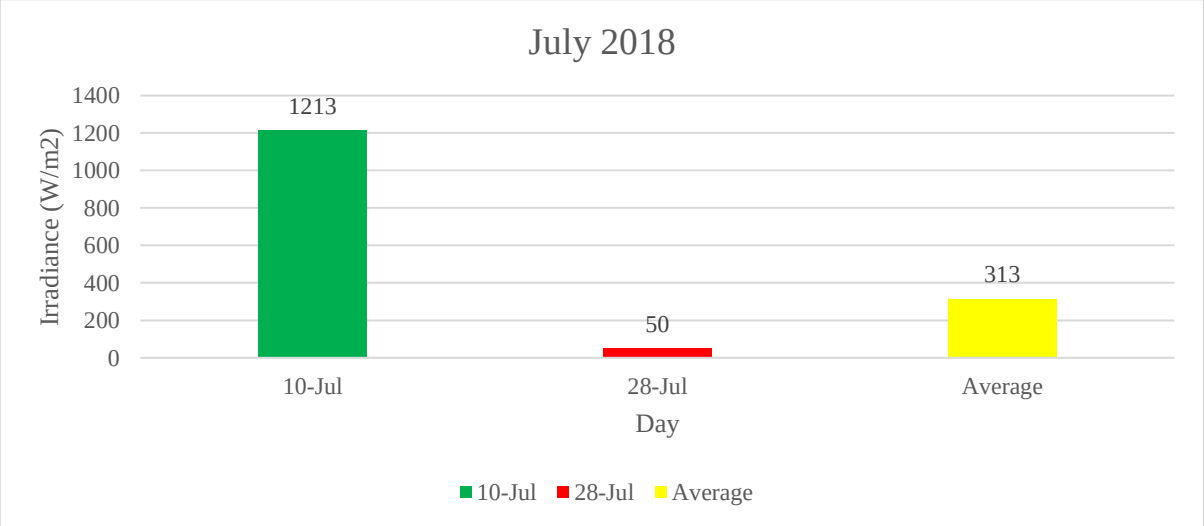

Figure 5.5 Irradiation graph for July (highest, lowest & average)

Figure 5.4 shows the data of solar irradiation of July 2018. On 10th July 2018, the highest value of solar irradiance was measured that was 1213 W/m^2 and on 28 July 2018, the lowest value of irradiance was found that was 50 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, July 2018 monthly average irradiation is 313 W/m^2 per day or 7.5 kWh/m^2/day.

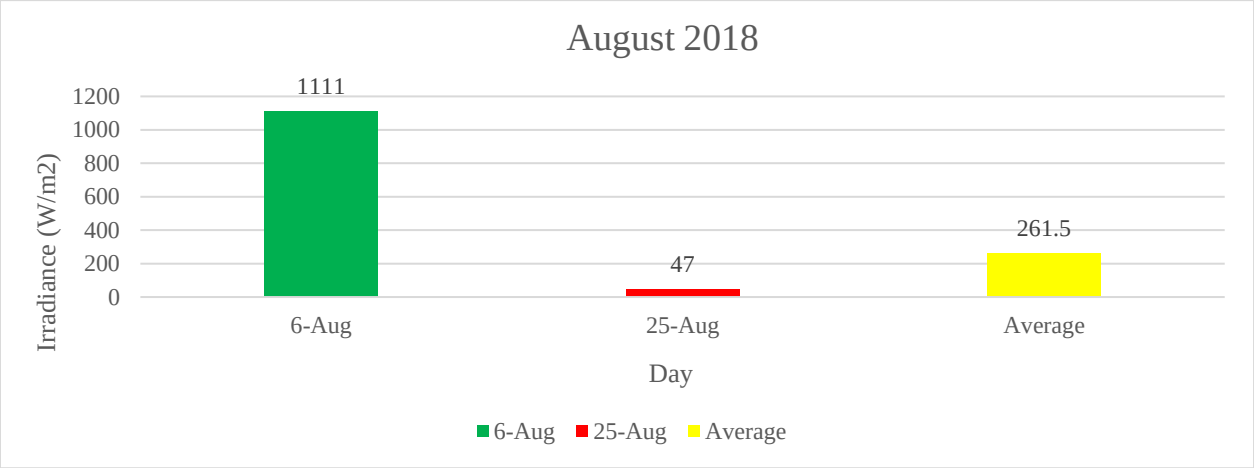

Figure 5.6: Graph Irradiation for August (high, low & average)

Figure 5.6 shows the data of solar irradiation of August 2018. On 6th August 2018, the highest value of solar irradiance was measured that was 1111 W/m^2 and on 25th August 2018, the lowest value of irradiance was found that was 47 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, August 2018 monthly average irradiation is 261.5 W/m^2 per day or 6.28 kWh/m^2/day.

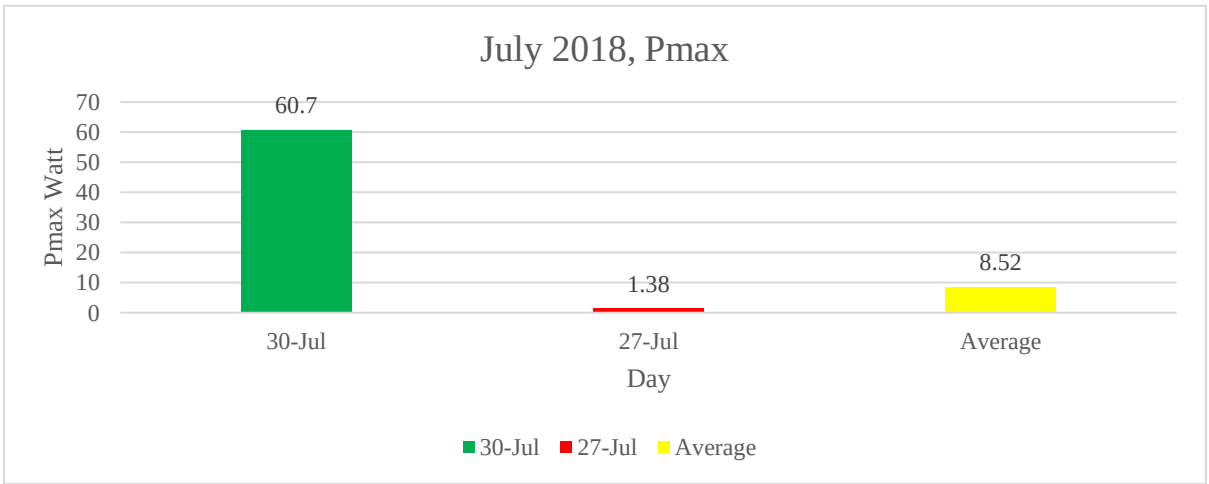

Figure 5.7: Pmax graph for July (high, low & average)

Figure 5.7 represents the maximum power generation curve of 60 W solar panel in July 2018. On 19 July 2018, we have found the highest value of maximum power 60.7 W and the lowest value of minimum power 1.38 W in 13 July 2018. Monthly average power is 8.52 W.

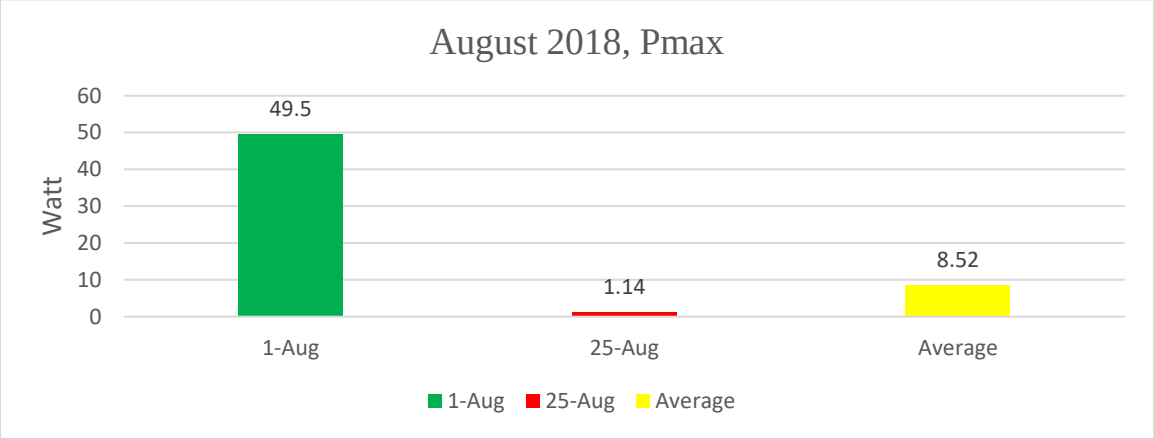

Figure 5.8: Graph Pmax in August (highest, lowest & average)

Figure 5.8 represents the maximum power generation curve of 60 W solar panel in August 2018. On 1st August 2018, we have found the highest value of maximum power 49.5 W and the lowest value of minimum power 1.14W in 25th Jun 2018. Monthly average power is 8.52 W.

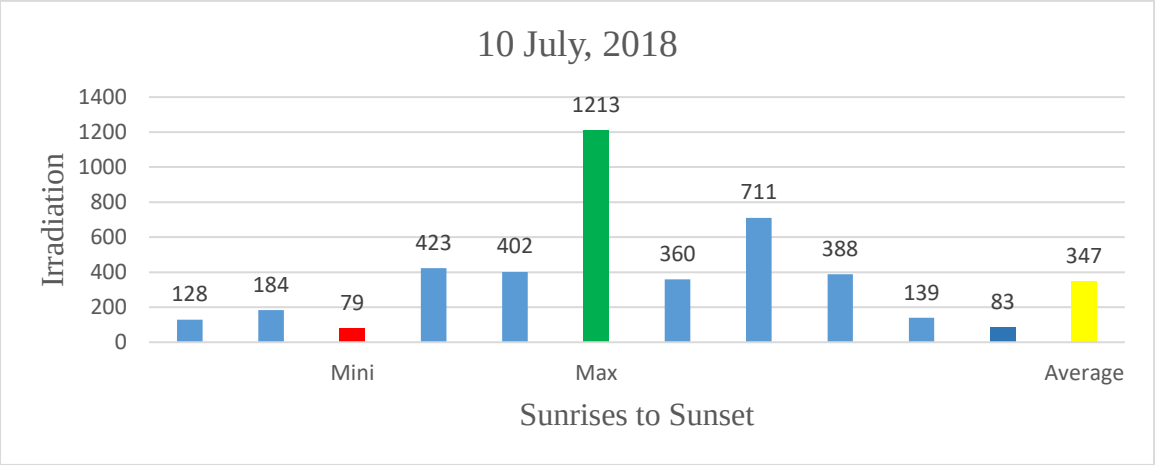

Figure 5.9: Irradiation of Sunny day in July

Figure 5.9 shows the data regarding the irradiance of sunny day in July 2018: During sunny day, we get the highest irradiance 1213 W/m^2 and minimum irradiance 79 W/m^2 . In sunny day, we measured our data every hour. The average irradiance of sunny day is 347 W/m^2.

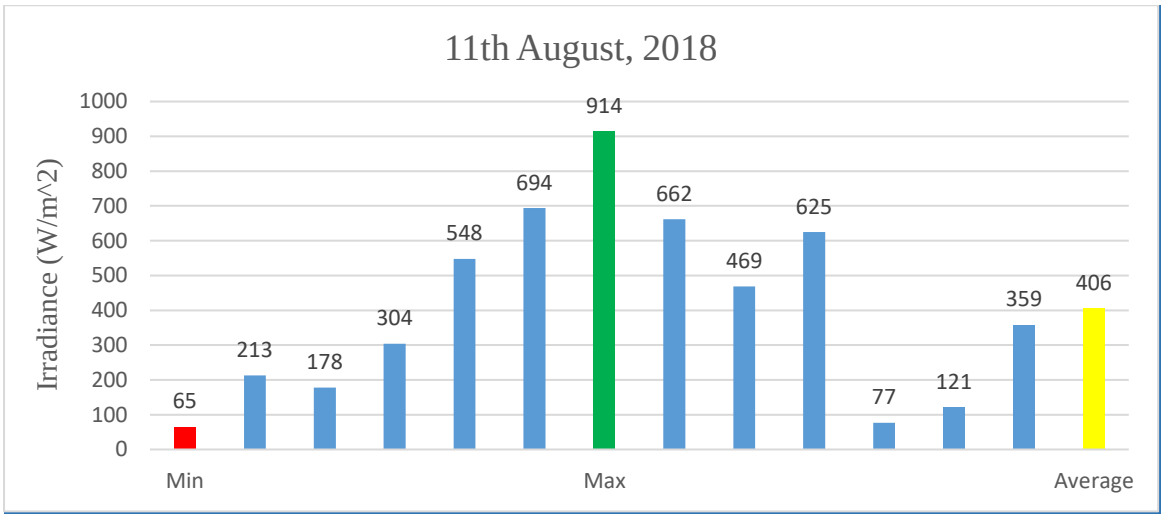

Figure 5.10 Sunny day irradiation for August

Figure 5.10 shows the data regarding the irradiance of sunny day in August 2018: During sunny day, we get the highest irradiance 914 W/m^2 and minimum irradiance 65 W/m^2 .In sunny day, we measured our data every hour. The average irradiance of sunny day is 406 W/m^2.

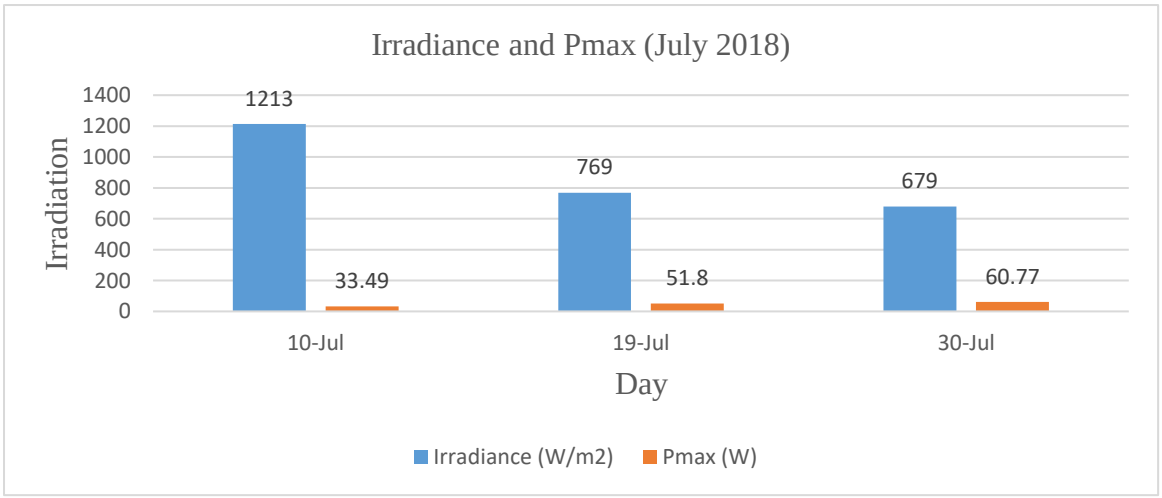

Figure 5.11: Irradiance and Pmax in July

Figure 5.11 On 10th July 2018, the measured irradiance was 1213 W/m^2 and the corresponding power produced by that panel was 33.49 W. However, the matter of concern that, on 19th & 30th July 2018, the measured irradiance was 769 & 679 W/m^2 but the power produced by the panel was 51.8 & 60.77 W which was higher than the previous one. The average power of sunny day is 17.0 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 (17.0 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.

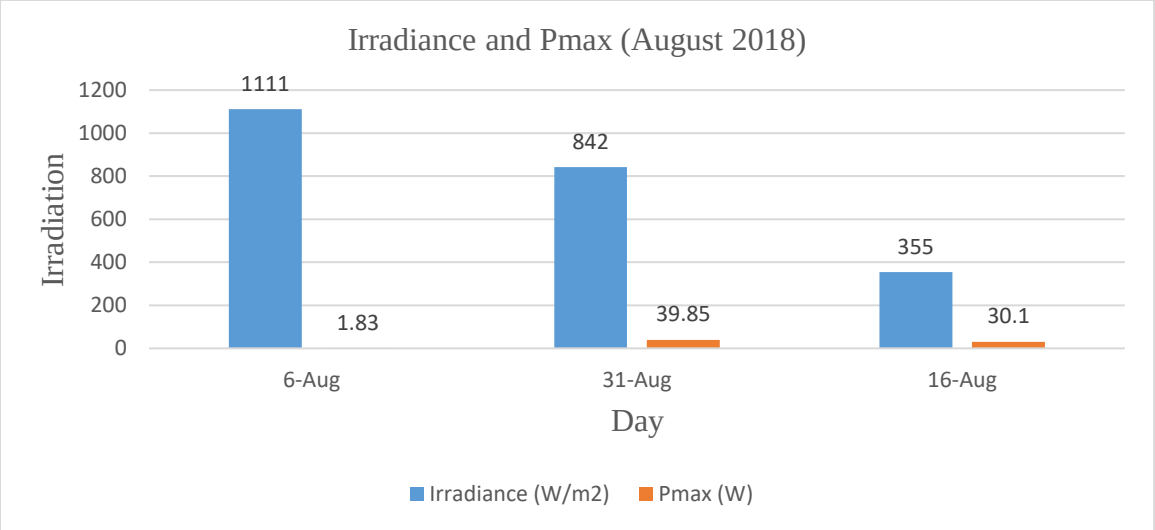

Figure 5.12: Irradiance and Pmax in August

Figure 5.12 On 6th August 2018, the measured irradiance was 1111 W/m^2 and the corresponding power produced by that panel was 1.83 W. However, the matter of concern that, on 16th & 31st August 2018, the measured irradiance was 355 & 842 W/m^2 but the power produced by the panel was 30.1 & 39.85 W which was higher than the previous one. The average power of sunny day is 10.80 W.

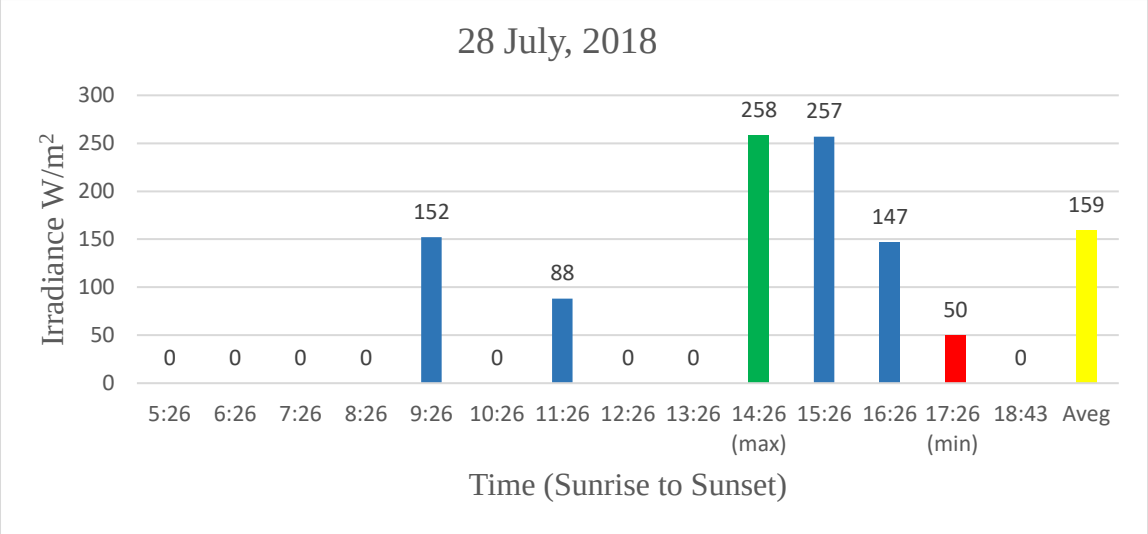

Figure 5.13: A rainy day Irradiance of July

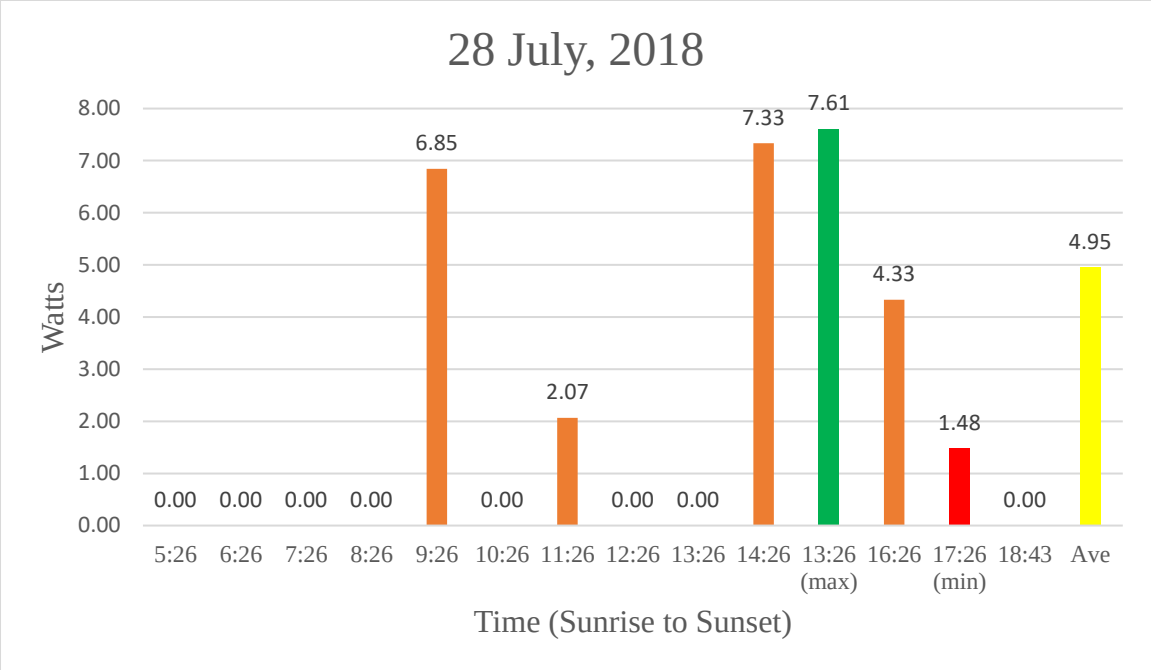

Figure 5.14: Pmax for a rainy day

Figure 5.13 shows only rainy-day irradiance in July 2018: in rainy day, average irradiance is 159 W/m^2. We got the highest & lowest irradiance 258 W/m^2 & 50 W/m^2 respectively. In rainy day, maximum time we cannot measure our required data in time. On 28 July 2018, 58 W/m2 (Fig. 5.13 & Fig. 5.14) solar irradiance was measured whereas the corresponding power was 7.33 W in time 02:26 PM.

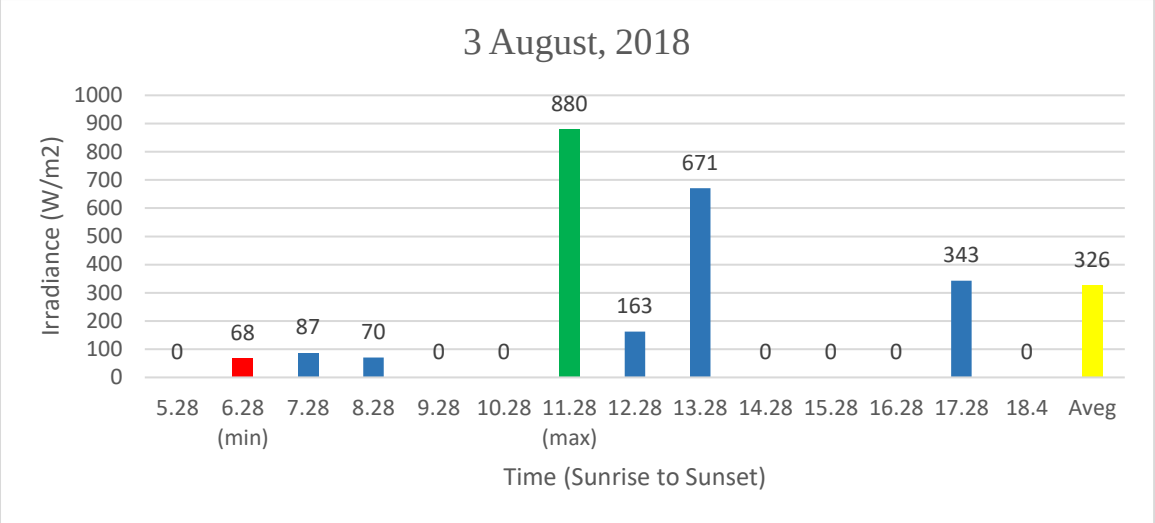

Figure 5.15: Irradiance for a rainy day (August)

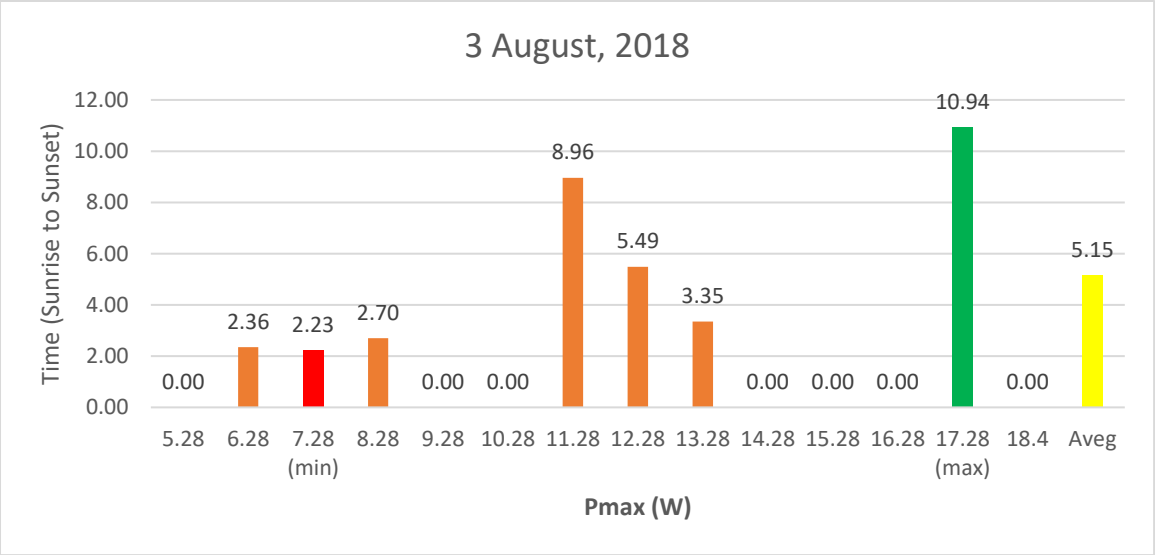

Figure 5.16: Pmax for a rainy day (3rd August)

Figure 5.15 shows only rainy-day irradiance & Figure 5.16 shows the Pmax in August 2018: in rainy day, average irradiance is 326 W/m^2. We got the highest & lowest irradiance 884 W/m^2 & 68 W/m^2 respectively. In rainy day, maximum time we cannot measure our required data in time. On August 2018, 68 W/m2 (Fig. 5.15) solar irradiance was measured whereas the corresponding power was 2.36 W and On 3rd August 2018, 884 W/m2 solar irradiance was measured whereas the corresponding power was 8.96 W.

Table 5.1: Two months Irradiation and Pmax (July & August)

Date	Jul-18		Aug-18	
	Irradiance (W/m2)	**Pmax (W)**	**Irradiance (W/m2)**	**Pmax (W)**
1	347	10.1	70	10.62
2	205	5.55	219	5.95
3	169	5.0	326	5.15
4	256	8.91	239	7.11
5	415	8.22	172	5.62
6	418	13.8	489	8.28
7	355	8.65	280	8.22
8	272	9.08	357	11.45
9	373	9.71	265	8.52
10	347	8.80	419	12.66
11	280	9.22	460	11.8
12	330	11.35	228	8.86
13	399	12.79	393	11.43
14	396	11.59	545	14.70
15	272	9.07	400	9.91
16	468	11.79	325	10.80
17	315	7.67	266	8.56
18	500	17.39	331	10.69
19	387	17.0	288	9.64
20	427	12.25	223	8.86
21	214	8.36	224	7.6
22	300	9.16	240	9.08
23	382	9.24	194	5.45
24	153	4.09	270	7.53
25	143	3.91	270	5.68
26	171	5.69	337	10.53
27	206	4.5	316	8.13
28	159	4.95	358	9.84
29	320	8.15	319	8.76
30	321	14.64	319	9.02
31	405	10.34	520	14.55

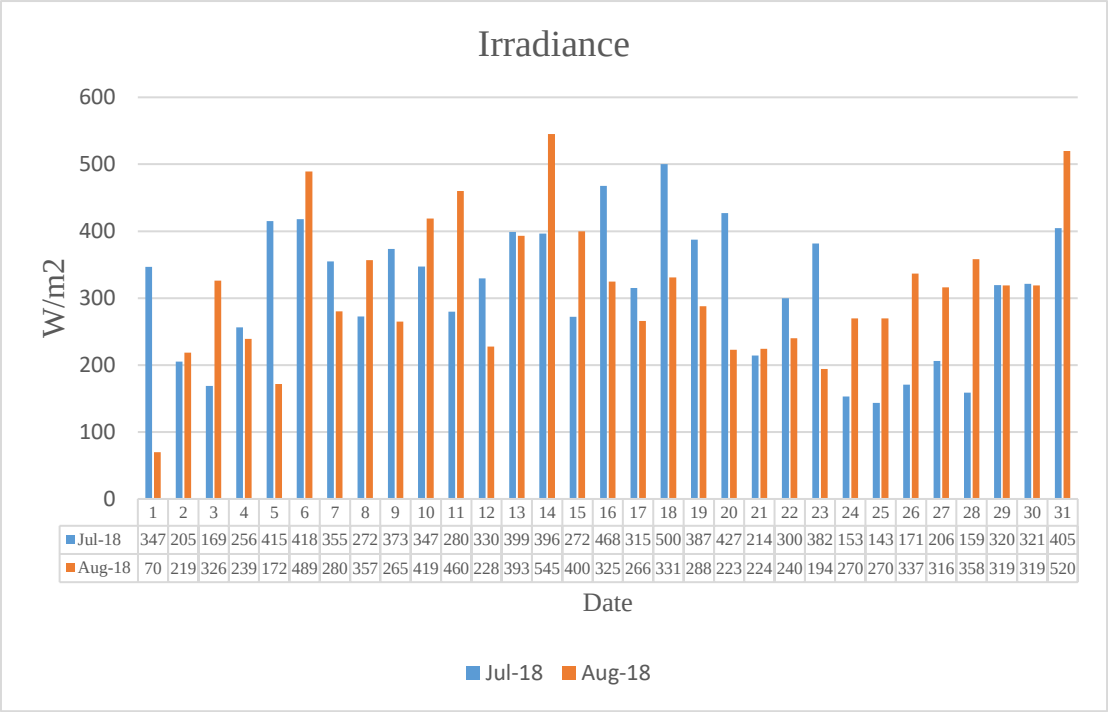

Figure 5.17: Two month irradiation (July & August)

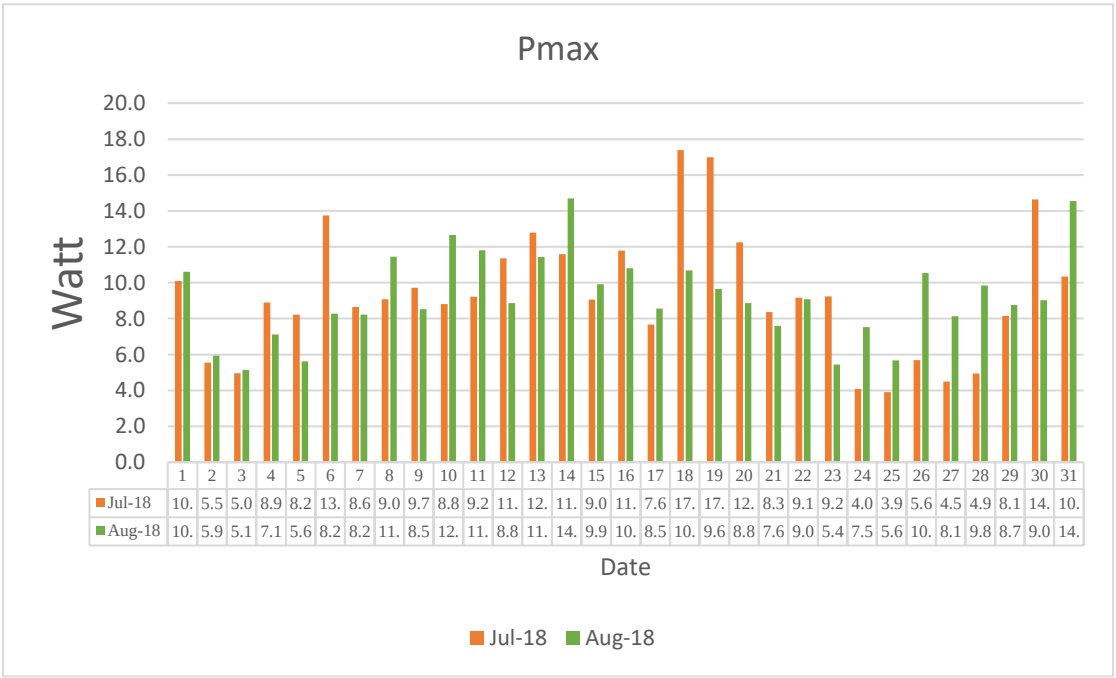

Figure 5.18: Pmax for two month (July & August)

In figure 5.17 by measuring irradiation for both month July and August we see that the irradiation of August is better than July. Since getting power is depend on irradiation so the

irradiation of August get more power than July. So we can say August is better in both two month July and August. In figure 5.18 shows that Pmax of the full month both July and August. In previous figure we saw that the average Pmax of July is 9.6 and Pmax of August 9.2. The Pmax of July is better than August

5.3 Comparison of Solar Radiation Data among Different Years

Table 5.2: Data of Monthly Average Solar Irradiance in 2008, 2009 & 2010 [7].

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
July	261.1	235.1	225.8
August	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 in between 2009 and 2010 because in 2010, only 4.50 $kWh/m^2/day$ irradiation was measured as shown in Table 5.2.

Solar radiation data were collected from Renewable Energy Research Center (Dhaka University), National Renewable Energy Laboratory and Development and Research is given in Table 5.3. Most of these solar radiation data were collected from DU for Dhaka with different cities in Bangladesh.

Table 5.3: Collected Solar Irradiance Data of Bangladesh from 1985-2006 were Presented Below [8]

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
July	5.58	5.67	5.76	5.21	5.46	5.09
August	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.

Table 5.4: 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	July	5.58
	August	4.48
1987-89	July	5.67
	August	5.13
1992	July	5.76
	August	5.3
2000-2003	July	5.21
	August	3.85
2003-2005	July	5.46
	August	4.22
2008	July	6.26
	August	5.09

2009	July	5.64
	August	5.04
2010	July	5.4
	August	4.22
2018	July	7.51
	August	7.48

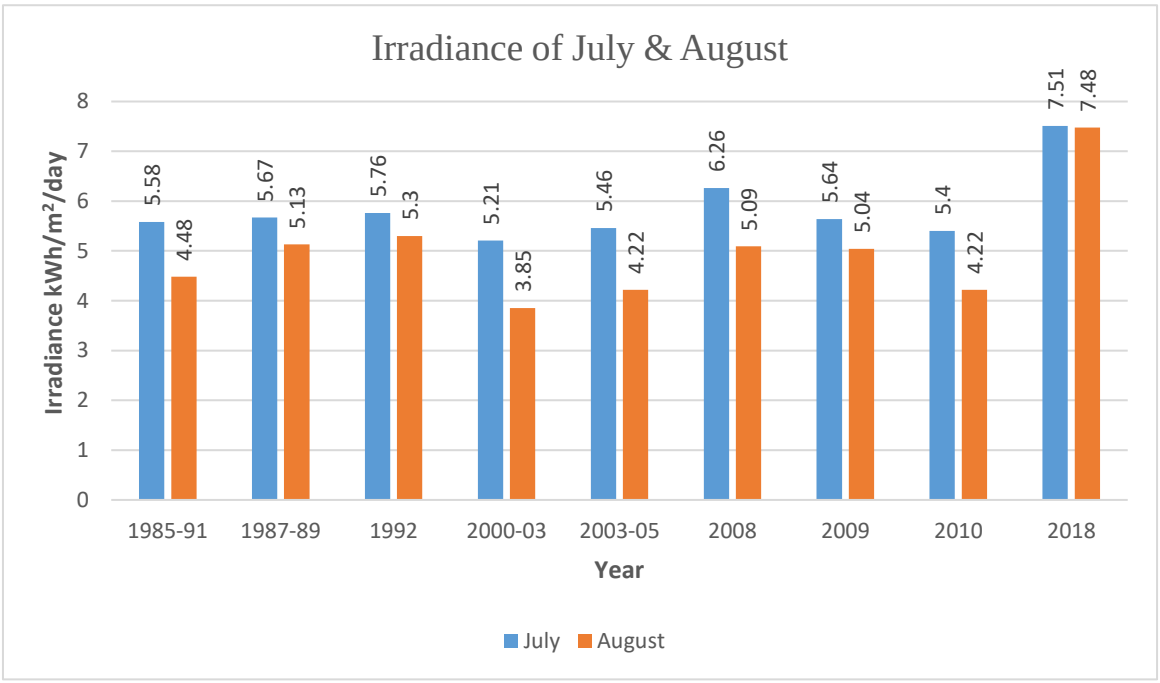

Figure 5.19: Different Years Irradiance

Figure 5.19, 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, July & August average solar irradiation was 5.58 & 4.48 kWh/m^2/day and it was increased into 5.67 & 5.13 kWh/m^2/day in 1992. But in 2000-03, July & August average irradiation was 5.21 & 3.85 kWh/m^2/day which was increased into 5.46 & 4.22 kWh/m^2/ day in 2003-05. In 2008, irradiation was increasing, and the value was 6.26 & 5.09 kWh/m^2/day. Again in 2010, irradiation was decreasing, and the value of 5.4 & 4.22 kWh/m^2/day. Moreover, in 2018, irradiation was increasing, and the value of 7.51 & 7.48 kWh/m^2/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.

5.4 Summary

In data analysis chapter we describe about our work. We work on 60 w solar panel in Dhanmondi area. Here we measure daily irradiation and Pmax for July and August. We got monthly average irradiance for July is 312 w/m2 and 313 w/m2 for August. And also got monthly average Pmax for July is 9.6 W and 9,2 W for August. We measured separately average irradiation and Pmax for sunny day and rainy day for both month July and August. We got average irradiation for July is 312 w/m2 and 313 w/m2 for August in sunny day. By measuring both July and August we analyze that the average irradiation of August is good than July. And the Pmax of July is better than August.

CHAPTER 6

CONCLUSION

6.1 Conclusion

Bangladesh is a small country with greater population. Bangladesh is one of the most densely populated countries with 79% of the population living in rural areas. The main problem with the development of energy crisis is the problem. Countries generally experience the supply of non-essential demand supply of electricity. Both fossil fuels depend on private sector and state-owned power plants. Natural gas supply is not enough to meet the demand. More importantly, the existing oil and gas will be tired once a day. So we have to think about other sources of energy. Solar power energy may be an alternative source.

Solar energy renewable energy has the highest probability of all sources. So, solar power may be the source of energy to solve the electricity crisis in Bangladesh. Moreover, Bangladesh is located between 20.30 to 26.38 degree North Latitude and 88.04 and 92.44 Degree East, which is a good geographical location for solar energy use.

To use solar energy more effectively, due to the change in the radiation of the sun over time, it is very important to measure the radiation of that country. In this thesis, our main objective was to find sun radiation in Dhaka in July and August in order to estimate solar power generation and using this information, we can easily understand the electricity production and create a standard form of power generation of SHS in 2018. Here we see that the 7.5 July KVH / m2 / day and the average radiation of August 7.48 was the same energy produced by the noh / m2 / day and 60W solar panels, 9.6 watts and 9.2 watts respectively.

6.2 Future Scope

In this research, we try to clarify that how much power can be produced in the month of July & August 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.

Reference

[1] Ulanoff, Lance (2 October 2015). "Elon Musk and Solar City unveil 'world's most efficient' 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.

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

[4] Md. Saydur Rahman, S.K Saha, Md. R.H Khan, U.H, SMH Chowdhury. 2013. "Present situation of Renewable Energy in Bangladesh: Renewable Energy Resources Existing in Bangladesh" Global Journals Inc (USA).

[5] Mohammad Hossain. 2015. "Achieving Sustainable Energy Targets in Bangladesh" The Magazine of the United Nations.

[6] "Power System Master Plan 2016 Summary" Power Division, Ministry of Power, Energy and Mineral Resources Government of the People's Republic of Bangladesh. https://0x9.me/vBlF6.

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

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

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

[10] M. Hussain. 1987. "Bangladesh Energy Resources and Renewable Energy Prospects".

[11] 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.

[12] Mazharul Islam. 2008. "Renewable Energy Prospect and Trends in Bangladesh".

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

[14] Md. Habib Ullah, T. Haque & Md. M. Hasib. "Current Status of Renewable Energy Sector in Bangladesh and a Proposed Grid Connected Hybrid Renewable Energy System".

[15] Khairul Anam and H. A. Bustami. "Power Crisis & Its Solution through Renewable Energy in Bangladesh".

[16] M. Rofiqul, M. Rabiul, M. R. A. Beg. 2008. "Renewable Energy Resources and Technologies Practice in Bangladesh".

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

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

[19] A. K. Azad. 2011. "A Review on Renewable Power Sources: Prospects of Bangladesh and Scotland," EBook, St. Andrew's University, Scotland, UK.

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

[21] 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".

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

[23] 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.

[24] Ahmed, Syed Shabbir (2012). "Dhanmondi Thana". In Islam, Sirajul; Jamal, Ahmed A. Banglapedia: National Encyclopedia of Bangladesh(Second ed.). Asiatic Society of Bangladesh

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

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

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

[28] 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_impact_of_large_scale_concentrated_solar_power_400na2_en.pdf

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

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

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

[32] Applications of Solar PV

[33] 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

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

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

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

[37] 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 Published by the Centre of Energy Studies, BUET, Volume 1, **PP** 1-9, November 1999

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

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

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

[41] http://pveducation.org/pvcdrom/solar-cell-operation/efficiency

[42] Applications of Solar PV

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

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