SOLAR IRRADIATION PATTERN ANALYSIS FOR ELECTRICITY GENARATION OF BANGLADESH

A 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 "**SOLAR IRRADIATION PATTERN ANALYSIS FOR ELECTRICITY GENARATION OF BANGLADESH**" is done by the following students under my direct supervision and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on 30 December 2018.

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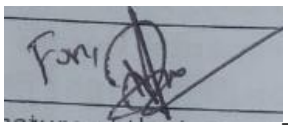

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Dedicated to

Our Parents

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List of Abbreviations

DPDC	Dhaka Power Distribution Company
SHS	Solar Home System
IDCOL	Infrastructure Development Company Limited
BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electrification Board
REP	Renewable Energy Policy
LGED	Local Government Engineering Department
HOMER	Hybrid Optimization Model for Electric Renewable
PO	Partner Organization
CC	Charge Controller
GOB	Government of Bangladesh
OCV	Open Circuit Voltage
SCC	Short Circuit Current
MPP	Maximum Power Point
GEF	Global Environment Facility
GTZ	German Technical Cooperation
CDM	Clean Development Mechanism
GS	Grameen Shakti
BRAC	Bangladesh Rural Advancement Committee
UNFCC	United Nations Framework Convention on Climate Change
MDG	Millennium Development Goal
UNCTAD	United Nations Conference on Trade and Development
WWF	World Wildlife Fund
WSSD	World Summit on Sustainable Development

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ABSTRACT

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. For this we design a concept for an inexpensive solar panel support system on top of flat roof building. This aims is to reduce cost of such system when it mitigate the unique challenges with self-cleaning system and protection against theft. The system also includes a single axis sun tracking mechanism which is basic mechanical in order to improve the performance of the circuit when it minimize the overhead in terms of cost and also power consumption. Here we discuss the benefits of solar energy and how it meets the challenges to give a better feedback. Through the whole research our main aim is to find out the irradiation of sun in Dhaka city in the month of October and November 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 (October & November) two months and analyze the data to get average irradiation and find the relationship between solar irradiation and power and by using this data we can easily understand the electricity production by solar home system and create a standard form of power production of solar home system in 2018.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Energy is a standout amongst the most serious essential ingredients required to enhance neediness and to achieve financial advancement of a nation. Petroleum product, daylight, air, water source and atomic power plant are the sources of vitality all through the world. Real vitality source is as yet petroleum product however the save is falling. Non-renewable energy source is being utilized however it transmits ozone hurting substances for an Earth-wide temperature boost which is a notice to environmental change and biological advancement. In this condition supportable and secure energy are the significant alert around the world. Under these circumstances there is a development in progress in the vitality segment. It is going on because of reduction in petroleum product accessibility, decrease of worldwide outflows for relieving environmental change and vitality security. Under the changed perspective sustainable power source particularly sun oriented vitality is getting to be boundless for it centrality in effect to worldwide environmental change and carbon exchanging prospect.

Joined Nations Framework Convention on Climate Change (UNFCC) has stepped up with regards to Clean Development Mechanism (CDM). In this sole circumstance, sunlight based vitality is getting to be boundless wellspring of vitality all through the world. To take care of the expanding demand for power in the ventures, transportation and family unit utilize many created nations are now utilizing sun based vitality as inexhaustible sources. This isn't just gathering the higher segment of vitality request yet additionally giving noteworthy financial benefit and keeping up clean condition. Bangladesh is a developing country facing with acute electricity shortage. The rural societies of Bangladesh are the worst victims of this disaster having limited or even in many cases no entree to grid electricity. Solar energy has been proven to be a very favorable resource to improve the continuing electricity shortage. This paper investigates the role of microfinance to grow a sustainable energy management system by the use of Solar Home Systems (SHSs) in the off grid communities of Bangladesh. Infrastructure Development Company Limited (IDCOL) funded by international donor organizations is the pioneer of the SHS program in Bangladesh. Grameen Shakti (GS) is a

leading partner organization of IDCOL in implementing the program. These partner organizations offer a number of SHS letters that include a solar panel, charge controller, battery, lamps and other fixtures.

1.1.1 Present prospect of sustainable energy

Bangladesh is an intensely populated sticky nation which has no enough supply of vitality. At present around 90 percent (counting sustainable power source) of populace approaches power, the per capita vitality consumption is just 464 KWh per annum [1]. Remaining 10 percent of the populace trusts upon expensive lamp oil and regular sources. Bangladesh is still exceptionally compacted to its capital city. Numerous areas outside the capital don't get appropriate commitment. Needy individuals can't have enough cash to have power for their day by day exercises. Numerous remote islands and good countries are not connected to national matrix lines. Since mounting the national matrix in those detached regions is over the top expensive and are not monetarily savvy, sunlight based vitality could be a compelling choice to satisfy the power necessity in these off-framework territories. As of late utilize Solar Home System (SHS) is expanding quickly for sunlight based power, however it has high essential expenditure. As a creating nation Bangladesh and its kin are experiencing force and power needs. Be that as it may, the environmental condition and favorable atmosphere conditions give strange chance to apply sun powered power for pretty much every component of our country, urban, semi urban job of Bangladeshi populace.

1.2 Problem Statement

Power preparation of Bangladesh lay on petroleum offshoots both in private part and state possessed power plants. About 89% of created control originates from carbon delivering enough to take care of the demand. Flow gas crop measurements in Bangladesh can't bolster local needs just as more extensive power age for the nation. The present save of oil and gas will be broken soon. In the interim worldwide there is an interest for perfect and viable vitality. The requirement for developing inexhaustible sources of vitality like sun powered, wind, bio-mass, and so forth has a more noteworthy feeling of acquire weight. As a sultry nation Bangladesh is blessed with sun based vitality. In this circumstance sun based vitality is a dependable, sensible and safe vitality for the nation. Be that as it may, the flow offer of sustainable power basis for power generation is just 0.5% of the aggregate. Premier persons of Bangladesh live in wide open zones. There is solid interest for power availability in remote

towns. Bangladesh has embedded with a lot of sunlight based vitality. We have much idle to be a sunlight founded power rich nation. Institutional, monetary and innovative capacities go about as vital issues for achievement a foreseen measurement of sun powered power generation and tasks. Yet, we have absence of data and joined examination in this field.

Sun based vitality focused provincial zap began in the nation in 1988 at Norshingdi. Power Development Board (BPDB), Rural Electrification Board (REB), Local Government Engineering Directorate (LGED), Infrastructure Development Company Limited (IDCOL) and a generous number of saved segment offices including Non-Government Organizations (NGO) are full in sun powered power advancement. Sun oriented power is logically being utilized in a wide scope of off-network applications. Since the starter of SHS, Bangladesh has presented more than 3.5 million units. In this viewpoint scheming the financial effect of SHS would be an outline for misleading rustic advancement elective vitality display in the nation. The present examination is expected to recognize the elements related with the utilization of sun based vitality and sun oriented power framework and how far it has been prevailing with regards to dwindling poverty in provincial territory of the nation.

1.3 Objectives

The objectives of the study are as follows:

- To col1ect solar irradiation and maximum power data in Dhaka for (October & November) two months.
- To study data to get average irradiation and find the link between solar irradiance & 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

Bangladesh has a large annoyed demand for energy. The country commonly skills irrepressible demand-supply gap of electricity, particularly during summer.

The energy gap is one of the largest blockages for economic progress in Bangladesh. By some estimates Bangladesh economic advance could have been around 8% had it not been

controlled by energy shortage. To endure and rolling economic advance, government of Bangladesh is actively involved in energy disaster organization. The national energy policy has the clear goal of supplying the whole country with electricity by 2021. Bangladesh accepted renewable energy policy-2008, which needs having at least 5% power from renewable sources in the drive mix by 2015 & 10% by 2020. Till now, national volume of renewable energy based power is about 472.03 Mega Watt (MW) and its 50% mainly comes from solar energy [2].

SHS can change the lives of people in the rural area. Solar power may be a way of growth provided that solar electricity solutions for households, agriculture, healthcare, education, telecommunication, rural streets and marketplaces. Government, development partners, research institutions, NGOs and private organizations are working for turning Bangladesh into an energy-efficient country through the application of idle solar energy. Solar power is the most potential source among the renewable energy capitals in Bangladesh. By taking suitable policy, rules and regulation, it is possible to mitigate country's growing electricity claim using solar energy. The current research therefore will classify the factors related with operation of SHS and it socio-economic influence in rural areas.

1.5 Thesis Outline

This thesis is organized as follows:

Chapter 1 Introduction.

Chapter 2 Review of selected literature and conceptual overview of SHS in socio-economic impact in off-grid area.

Chapter 3 Methodology.

Chapter4 Analyzes data, results and simulates the theoretical works.

Chapter 5 Concludes with some recommendations of this paper.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

Reasonable, open and secure supply of vitality plays a main impetus for financial improvement of a nation. Various current checks uncover how country jolt from sun oriented power specifically helps in financial advancement of the nation in different techniques. In this condition, sun oriented vitality is generally seen as a good innovation for power age in detached area of the rising nations. This section activities to distillate on the audit of chosen writing, key idea of sun based power as main thrust for financial development, likewise issues and issues of solar irradiation for electricity generation in our country.

2.2 Types of Energy

Energy is the power we use for transportation, for heat and light in our homes and for the construction of all kinds of products. There are two sources of energy: renewable and nonrenewable energy.

- **Nonrenewable Sources of Energy**

Most of the energy we use comes from fossil fuels, such as coal, natural gas and petroleum. Uranium is another nonrenewable source, but it is not a fossil fuel. Uranium is distorted to a fuel and used in nuclear power plants. Once these natural capitals are used up, they are gone forever.

The process of meeting these fuels can be harmful to the biomes from which they come. Fossil fuels are put through a procedure called combustion so as to produce energy. Combustion announcements pollution, such as carbon monoxide and sulfur dioxide, which may add to acid rain and global warming.

- **Renewable Sources of Energy**

Renewable sources of energy can be used over and over again. Renewable assets contain solar energy, wind, geothermal energy, biomass and hydropower. They produce much less pollution, both in meeting and production, than nonrenewable sources.

2.3 Renewable energy

Renewable energy is shaped by means of natural resources that are continually replaced and never run out. Just as there are many natural sources of energy, there are many renewable energy technologies. Solar is one of the most famous, wind power is one of the most widespread, and hydropower is one of the oldest. Other renewable technologies yoke geothermal energy, bioenergy or ocean energy to produce heat or electricity.

Equally exciting are new enabling technologies that help to manage renewable energy so it can be produced day and night while consolidation the electricity grid. These allowing technologies include battery-storage, supply prediction and smart grid technologies.

2.3.1 Hydropower

Hydropower uses the force or energy of moving water to produce power. This power is also called ‘hydroelectricity’.

Hydropower is shaped while falling water is charmed through water turbines. The weight of the streaming water on turbine sharp edges pivots a pole and drives an electrical generator, acclimating the movement into electrical vitality.

Hydropower is the most dynamic and built up sustainable power source innovation, and conveys some dimension of power age in excess of 160 nations around the world.

Hydropower plants extend from little to huge explicit plants and tremendous joined plans associating various expansive hydropower plant.

Our key hydropower project providing knowledge to recover the design and operation of small hydro systems, where much of the possible development of hydropower manufacture exists. The influence of this project has gone world-wide, attracting attention from the United States, Indonesia and the Mekong.

Figure 2.1: Hydro Power plant

2.3.2 Bio-energy

Bioenergy is gotten from biomass to create power and warm, or to deliver fluid powers for transport. Biomass is any natural matter of as of late living plant or creature beginning. It is accessible in numerous structures, for example, horticultural items, ranger service items, civil and other waste. Generally, woody biomass has been utilized for bioenergy, anyway later advances have extended the potential assets to incorporate rural deposits, oil seeds and green growth.

These progressed bioenergy innovations take into consideration the reasonable improvement of the bioenergy business, without rivaling the conventional horticultural industry for land and assets.

Bioenergy offers the potential for considerable economic welfares, including:

- growing energy security
- reducing greenhouse gas releases
- inspiring regional development

Figure 2.2: Biogas energy

2.3.3 Geothermal

Geothermal imperativeness is secured as warmth in the earth. The glow is made by the normal spoil in excess of countless times of radiogenic segments including uranium, thorium and potassium.

Geothermal imperativeness can be drawn from the high temp water mixing among rocks underneath the world's surface, or by driving infection water into the hot shakes and rehashing the warmed water to the outside. This can drive steam turbines to yield control.

Geothermal essentialness holds the certification of being a manageable power source foundation that could authorize 24 hours consistently, giving baseload ability to homes and arrangements. Geothermal essentialness can be used for 87heating and cooling objectives.

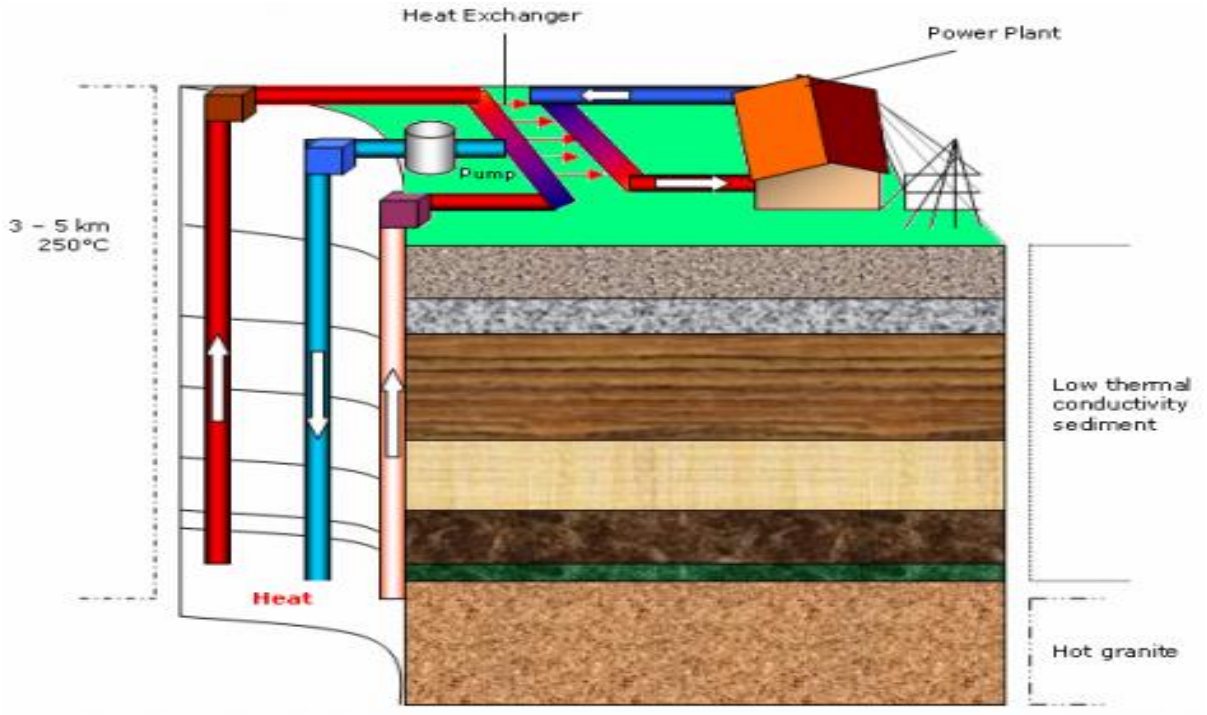


Figure 2.3: Geothermal Energy plant

2.3.4 Hybrid/enabling technologies

- A cross breed innovation is one that incorporates a sustainable power source age innovation with other vitality age frameworks.
-
- Cross breed advances can diminish the hazard for savers and certification moment dependability and moderateness. They can likewise bolster a compliment change to increasingly sustainable power source age in future. For instance, Ruler Island of Australia, Sustainable Mix venture is a world-premier power framework that will supply over 65% of Lord Island's vitality needs by methods for sustainable power source, falling the island's carbon dioxide discharges by over 95%.
- **Hybrid technologies**

A case of a half breed innovation would be a power plant which syndicates and accomplishes power amass from something like two advances. For instance, a plant that blends sunlight

based vitality innovation with vitality from gas, or another inexhaustible source, to give a common vitality stream that energies the plant's capacity age.

- **Enabling (or related) technologies**

Allowing and connected technologies are those which use, or more easily allow, one renewable energy source to be used with one another.

These technologies are especially predominant in the fields of energy storing, grid management and linking, information and communication, charting and resource documentation, predicting and exhibiting.

2.3.5 Wind energy

Wind control is delivered by changing over the dynamic essentialness of the air into useable power with wind turbines. Wind is made by complex frameworks including the insurgency of the Earth, the glow of the sun, the cooling effect of the oceans and polar ice tops, temperature tendencies among land and sea, and the physical effects of mountains and diverse impediments. Wind turbines convert the intensity of the breeze into a torque (rotational power), which is then used to instigate an electric generator to make control. Wind imperativeness control stations (known as wind farms) by and large draw on the yield of different breeze turbines through a central affiliation point to the power grid. Over the world there are both on-shore (aground) and offshore (out to sea) wind imperativeness adventures.

Figure 2.4: Wind mill

2.3.6 Solar energy

Daylight based imperativeness is essentialness shaped by the glow and light of the sun. Daylight based power is encircled when this imperativeness is changed into power or castoff to warm air, water, or diverse substances. Australia has the most important ordinary sun controlled radiation per square meter of any landmass on the planet. Broad scale sun situated power is quickly creating in Australia. More than two million Australian nuclear families eventually have an adjacent planetary gathering on their rooftop.

Field's financed sun based endeavors have broken something close to 11 sun situated cell efficiency world records. There are before long two key sorts of sun controlled imperativeness advancement.

- **Solar photovoltaic**

This innovation modifies daylight specifically into power by methods for photovoltaic (PV) cells. The sun oriented PV cells are shared in boards. They can be imagine housetops, coordinated into building structures and vehicles, or associated by the thousands crosswise over fields to make huge scale sunlight based power plants. Aim sun powered PV utilizations fields of sun-following mirrors called heliostats to quintessence daylight onto profoundly efficacious PV cells arranged inside a headset at the highest point of a pole or tower.

- **Solar thermal**

This technology alters sunlight into thermal energy (or heat), which in the previous has been used mostly for space heating or to heat water (such as in a solar warm water scheme).

This heat energy can be accustomed drive a cooling cycle to deliver solar-based cooling, or to variety steam that can be used to produce electricity by means of a steam turbine. Solar thermal energy can also be used in some industrial processes that presently use gas to yield heat.

- **Concentrating solar thermal technology**

This machinery changes sunlight into thermal energy (or heat), which in the past has been used mainly for space heating or to heat water (such as in a solar warm water scheme).

This warmth vitality can be utilized to drive a cooling cycle to convey sun powered based cooling, or to make steam that can be utilized to deliver power utilizing a steam turbine. Sun oriented warm vitality can likewise be utilized in some modern strategies that by and by use gas to yield warm.

Concentrating sunlight based warm innovation vitality stockpiling framework. Vitality would then be able to be discharged from capacity as required, day and night. Harvests the sun's warmth to deliver productive, vast scale control companion. It utilizes a field of mirrors to reflect daylight onto a warm collector, which exchanges the warmth to a warm vitality stockpiling framework. Vitality would then be able to be unconfined from capacity as necessary, day and night.

- **Emerging solar energy technologies**

Study and expansion continues to improve current solar energy skills while classifying developing novelties such as photosynthetic-based solar energy technologies and solar improved fuels. Innovations and developments in solar energy technology and improved fuels will advantage everybody by making reasonable and dependable energy more nearby to more businesses and households.

2.3.7 Reason behind using solar energy

Solar energy is a main renewable energy source with the possible to meet many of the trials before the world. There are many motives to approve its share in the energy market. This power source is rising in admiration because it is flexible with many benefits to people and the environment. Here is some benefits of using solar energy-

- **Solar Is Clean and Safe**

  Sun oriented is a safe extra which can supplant present non-renewable energy sources like coal and gas for accomplice of power that yield air, water, and land contamination. The World Natural life Store (WWF), takes note of that power age gather from non-renewable energy sources makes tainting of air driving corrosive rain, harmed woods territories, and influenced horticultural generation prompting loss of billions of dollars around the world. Atomic power contaminates water and arrive and has molded natural catastrophes. Utilization of sunlight based vitality will dispose of these perilous, unclean ramifications from utilizing traditional non-renewable energy sources.

- **Prevents Destruction of Habitats**

Unblemished woods are demolished for evacuation crude materials like fossil or atomic energizes. Trees much of the time expel and use carbon dioxide from the air to make their nourishment, and this carbon is then saved in them. At the point when timberlands are cut for end crude materials for traditionalist vitality, this real carbon sink disappears and furthermore rises environmental change. "The vast majority of creatures ashore" live in woods, giving to WWF, and lost areas diminishes their occupants. Changing to sun oriented power is basic to keep these conditions entire for the creatures who live there notwithstanding keep on keeping the air new.

- **Cheap and Reliable Energy Source**

Logical improvements and approach and diminishes by the legislature have shortened the mind-boggling expenses of sunlight based plans. The estimation of sun powered PV boards have lessened by 60% and the expense of the sunlight based power plot by half allowing to the Energy.gov report. So sun based vitality is presently practical with traditionalist vitality establishments.

The progressively costs are less and the essential favorable position is enhanced vital to ensuing interests in vitality costs rendering to Greenpeace. This happens in light of the fact that the contribution for sun oriented vitality is free and clean daylight albeit non-renewable energy sources are mined and elated over long lack of approachability providing for another Greenpeace report. The Greenpeace account reasoning that in the U.S., the costs to concurrence with natural issues from utilization of "grimy power sources" twofold or even triple the cost of power from moderate bases like coal. Sun powered vitality is huge to encourage balance and possibly evacuate, these extra expenses.

2.4 Renewable generation capacity by energy source

Toward the finish of 2017, worldwide inexhaustible accomplice limit added up to 2,179 GW. Hydro represented the biggest offer of the worldwide aggregate, with an associated limit of 1,152 GW. Wind and sun powered vitality represented the vast majority of the parity, with limits of 514 GW and 397 GW individually. Different renewables included 109 GW of

bioenergy, 13 GW of geothermal vitality and 500 MW of sea vitality (tide, wave and sea vitality). Equivalent to a year ago, sustainable associate limit expanded by 167 GW or +8.3% amid 2017. This continued the pattern of 8-9% yearly limit development as of late. Sun oriented vitality took in front of the rest of the competition once more, with a limit upsurge of 94 GW (+32%), trailed by wind vitality with an expansion of 47 GW (+10%). Hydropower and bioenergy volumes expanded by 21 GW (+2%) and 5 GW (+5%) individually. Geothermal vitality enhanced by just shy of 1 GW. Inexhaustible limit development keeps on being goal-oriented generally by new establishments of sun oriented and wind vitality, which together represented 85% of all new limit introduced in 2017 [3].

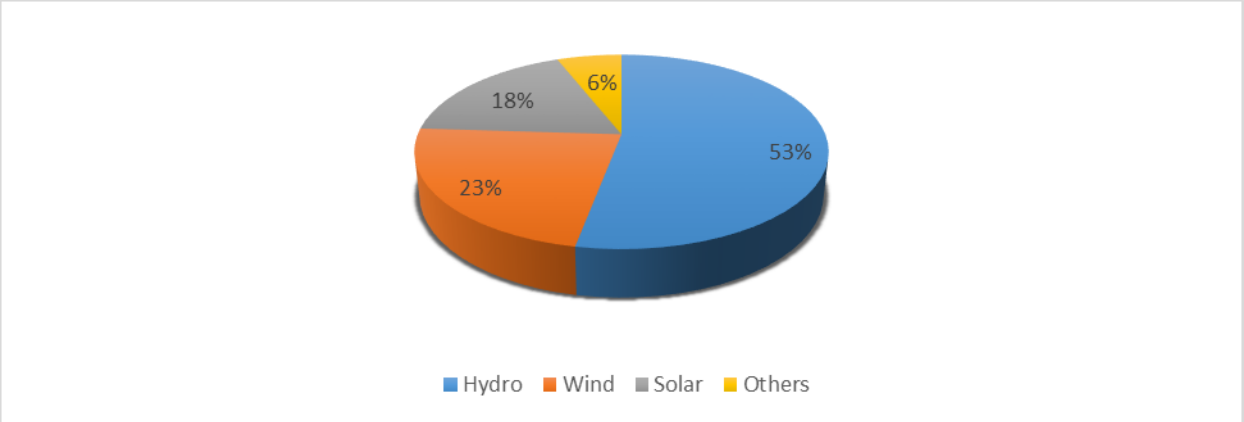


Figure 2.5: Renewable energy generation capacity

2.5 Solar Photovoltaic (PV) Technologies

One of the basic sun controlled imperativeness progresses is sun arranged PV, where a semi-transport material is used to change sunlight to control straight. There are different photovoltaic advances advanced to date, few are promoted in any case others remain at think level.

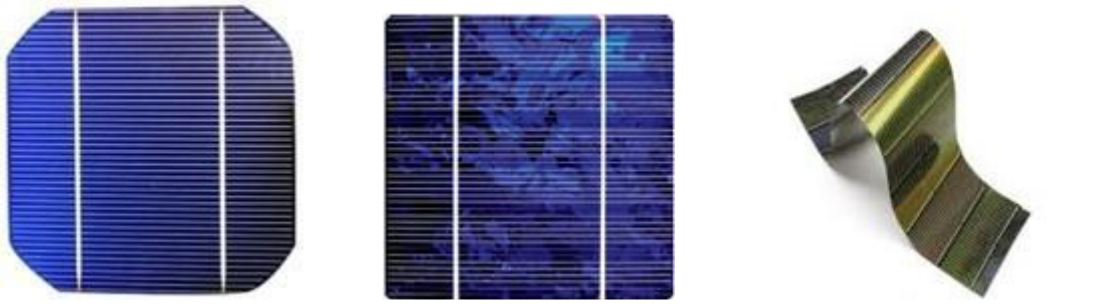
The daylight based PV ask for is at present vanquished by crystalline silicon (c-Si) development, of which two sorts are used. The first is mono crystalline, framed by cutting wafers (up to 150 mm separate crosswise over and 200 microns thick) from a high-

ethicalness single valuable stone boule. The second is polycrystalline, made by cutting a cast square of silicon first into bars, and a short time later into wafers.

The essential buoy in crystalline silicon cell present day incorporates a development toward polycrystalline advancement. Regardless, it may be seen that PV producers are diminishing the expense for making mono crystalline, which may gravitate toward to the present expense for polycrystalline and be altogether increasingly forceful later on.

Close to jewel like silicon cells, other PV cell progressions including vague silicon (a-Si), thin-film and common cells are financially available. Vague silicon sun based cells require only 1% of the material (the silicon) required for the delivery of crystalline silicon cells. It might be produced in any shape or measure, and can be made wisely.

Undefined silicon cells were the fundamental kind of daylight based cells to be castoff in the use of customer things, for instance, watches, smaller than usual PCs and other non-essential outside applications; and given their little cost, they have been recognized by other greater scale jobs.



a) Mono crystalline solar cell b) Polycrystalline solar cell c) Amorphous silicon solar cell

FIGURE 2.6: Different types of solar cells

Thin-film modules are worked by putting very thin layers of photosensitive assets onto an ease sponsorship, for example, glass, treated steel or plastic. Thin-film fabricating techniques result in lower make costs contrasted with the more material escalated crystalline innovation. A value advantage which is promise adjusted by lower proficiency rates of progress of the diverse kinds of thin-film modules (contingent upon the dynamic material utilized), cadmium telluride (CdTe), and copper-indium (CIS/CIGS) have achieved beneficial practicality to certain degree.

If there should be an occurrence of natural sun oriented cells, there are various distinctive innovations, including color sharpened sun oriented cells, radio wire cells, atomic natural sun powered cells and absolutely polymeric gadgets. The color cell is nearest to advertise presentation, while the other conceivable organic sun based cell thoughts are as yet being examined.

2.6 Types of solar PV system

The immediate change of daylight into power is called photovoltaic sunlight based vitality transformation. A basic part of Photograph Voltaic (PV) framework is the sun oriented cell, in which the photovoltaic impact happens. At the point when light falls on the semiconductors of the cell, it delivers a little electric flow. Photovoltaic modules, or boards, comprise of various cells associated together to give voltages and flows sufficiently high for down to earth use. Increasingly basic in country charge programs is the utilization of sun oriented PV as remain solitary frameworks in families, social foundations, or spots of gainful or business exercises. There are commonly two kinds of PV frameworks: off-network and lattice tied relying upon their association with the utility matrix.

1. Off-grid DC/AC PV system: (DC without inverter, AC with inverter)

- **Off-Grid DC system (without inverter):** The DC yield is straightforwardly engaged to DC loads. Overabundance control is put away in the battery banks adroit by the charge controller. Normal uses of this framework are found in RVs, water crafts, lodges, cultivate machines, or country wire administrations. A reinforcement generator might be included.

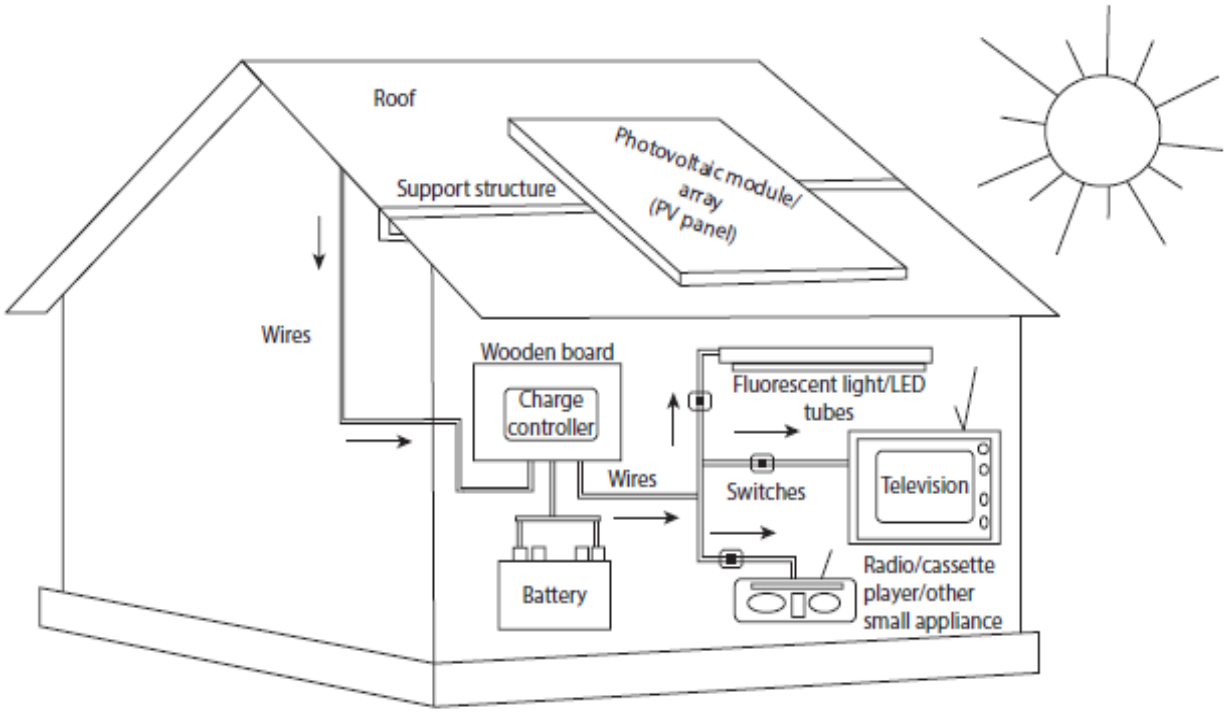


Figure 2.7: Off-Grid DC system (without inverter)

- **Off-grid AC system (with inverter):** An inverter is additional to this system. The conveyed imperativeness is ingested to the inverter that changes over DC to air conditioning power for conventional electric applications. Additional imperativeness is kept in batteries and an elective support generator can be incorporated.

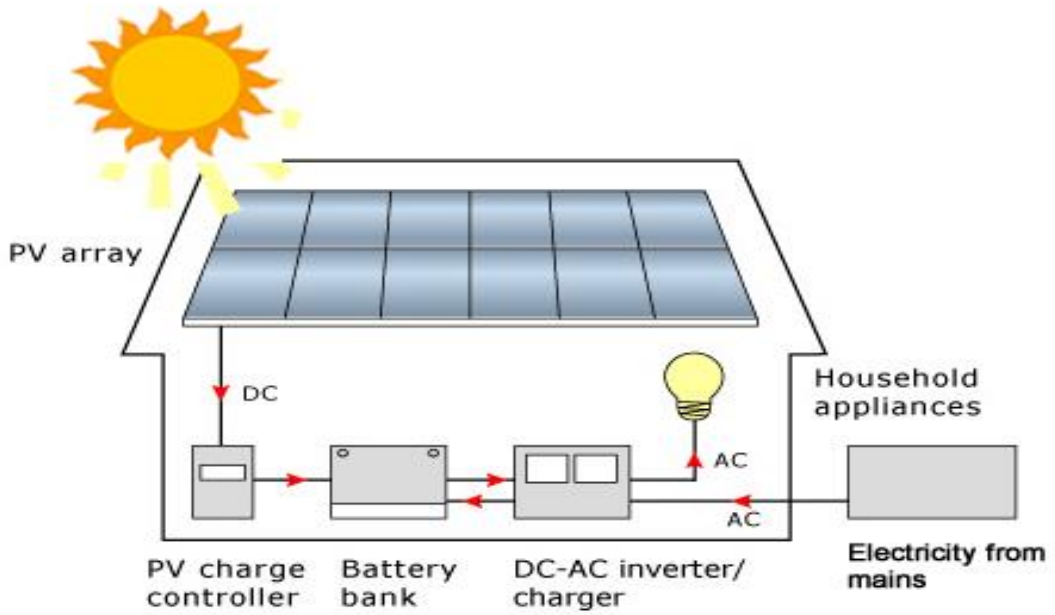


Figure 2.8: Off-Grid AC system (with inverter)

- **Hybrid system:** In this structure additional reasonable power source generator is added to deliver more power. For example, the breeze turbine holder be added to deliver control from wind. This arrangement is significant in spots where the atmosphere is brilliant and windless all through summer yet cloudy and swirling all through winter. This structure is generally off-arrange and the excess essentialness is kept in batteries. If neither the PV board nor the breeze turbine makes enough power, fortification power, for instance, a diesel generator can be added to convey the extra essentialness.

Figure 2.9: Hybrid system

2. Grid-tied system: With battery backup or no battery backup.

- **Grid-tied system (without battery backup):** In this system, the conveyed DC is changed to air conditioning and used adjacent. The daylight based power manufacture is checked by the sun situated creation meter. In case there is an excess essentialness, the imperativeness can be sustained into the power sort out. If the PV structure does not make enough power inferable from higher intrigue, required essentialness can be drawn from the cross section. This methodology of drawing in or urging capacity to the system is checked by the passage/import meter.

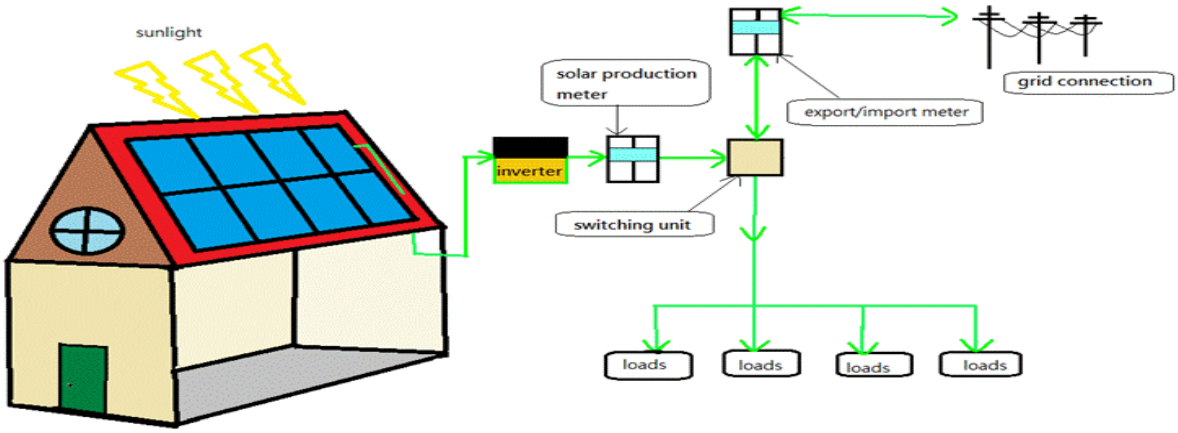


Figure 2.10: Grid-tied system (without battery backup)

- **Grid-tied with battery backup system:** In this system, the changed over air conditioning is used adjacent or set away in batteries. The charge controller demonstrates the battery volume and excess essentialness is secured in the batteries for fortification. In case the batteries spread their full limit, the plenitude essentialness can be supported into the power system. Or maybe, if the PV structure doesn't convey enough power, required imperativeness can be drawn from the cross section. This method is done mechanically through a net metering stage.

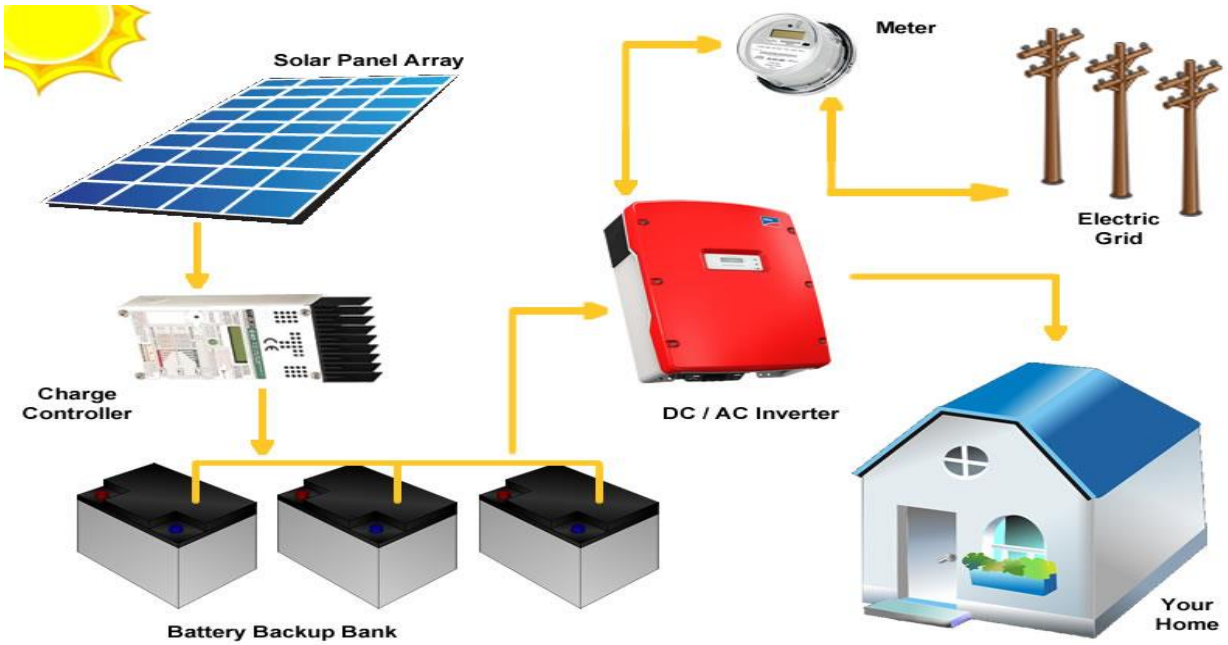


Figure 2.11: Grid-tied with battery backup system

2.7 Solar PV global capacity

Worldwide growth of photovoltaics is tremendously dynamic and varies strongly by country. The world added more volume from solar PV than from any other type of power making technology. Extra solar PV was connected than the remaining capacity accompaniments of fossil fuels and nuclear power combined. In 2017, solar PV was the top source of new power volume in numerous major markets, counting China, India, Japan and the United States. Globally, at least 98 GW (dc) of solar PV capacity was installed (on- and off-grid), increasing total capacity by nearly one-third, for a growing total of approximately 402 GW (Figure 2.12). Averagely, the equal of more than 40,000 solar panels was installed each hour of the year [4].

The vital market development with respect to 2016 was expected basically to China, where new establishments were up over half. India's market multiplied, while other significant markets (Japan and the Unified States) tightened. For the fifth year continuously, Asia hid every single other region, representing 75% of worldwide backups.

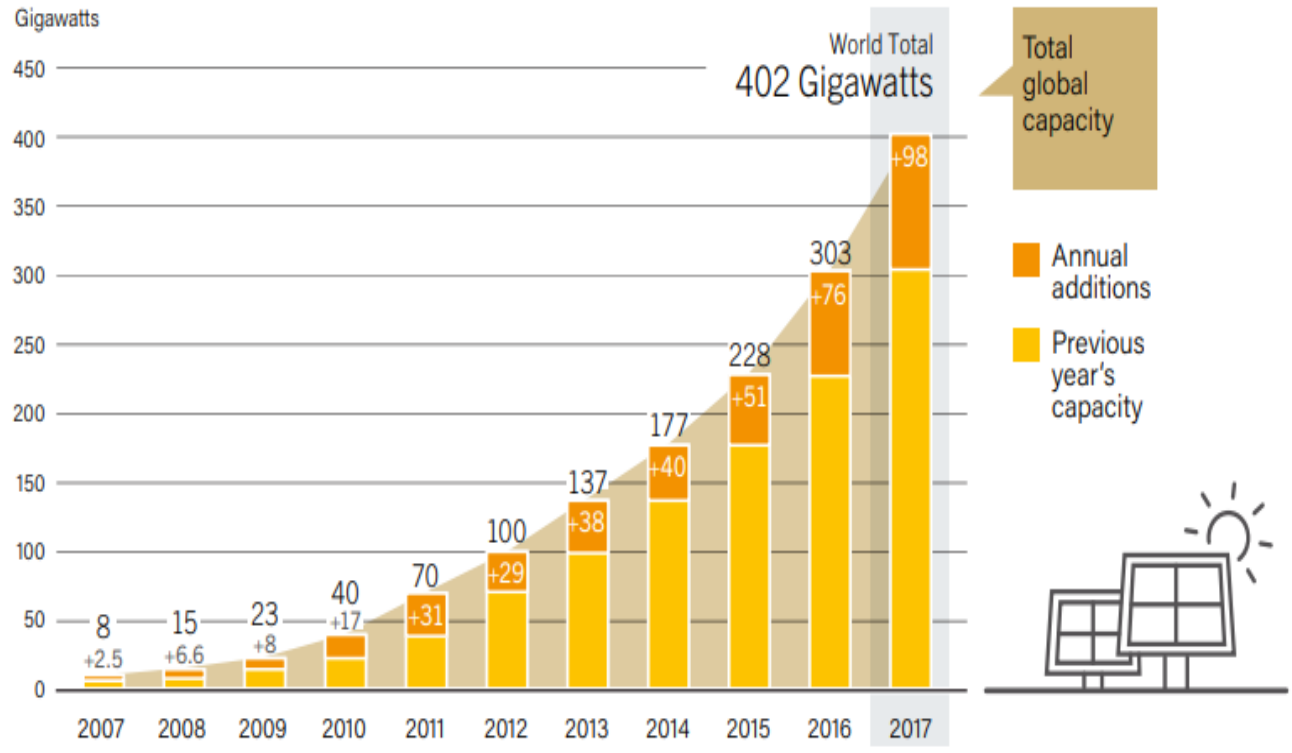


FIGURE 2.12: Solar PV Global Capacity and Annual Additions, 2007-2017

The best five national commercial centers – China, the Assembled States, India, Japan and Turkey – were responsible for about 84% of again introduced limit. Before the finish of 2017,

each landmass had introduced no less than 1 GW and something like 29 nations had 1 GW or a greater amount of size.

All inclusive, request development was owing to a great extent to the aggregate lowness of sun oriented PV shared with the rising interest for power in creating nations, just as to the expanding attention to sunlight based PV's capability to help contamination, lessen CO2 discharges and convey vitality get to. Sun powered PV likewise is meeting mounting enthusiasm for a few republics in delivering power locally. However, most worldwide interest keeps on being driven to a great extent by government incitements and controls. Difficulties stay to be deliver a discourse before sunlight based PV can turn into a noteworthy wellspring of power all inclusive.

2.8 Technical background of SHS

Daylight based Vitality is the imperativeness from the Sun. It is consistently called 'elective imperativeness' to oil subordinate and has been castoff by individuals gone for a substantial number of years. The photovoltaic/sun situated module (Figure 2.13) changes over the light into power. It regularly has a limit of between 20 to 100WP. Customary SHS work at 12 volts arrange current (DC) and use powerful fluorescent or Light Discharging Diode (Drove) lights and applications to make best use of the giving power. A normal 50WP SHS can give satisfactory ability to work four minimal glaring lights, and a little 15-inch high complexity television for up to five hours. Regardless, the extent of various machines is normally obliged.

A total SHS photovoltaic framework comprises of numerous parts so it can work effectively and proficiently. So as to deliver power, various innovations must be set up. Along these lines, a home framework sun powered photovoltaic framework comprises of rising structures, sun based PV modules and exhibit, inverter, charge controller and battery bank.

Mounting structure: Photovoltaic cells must be mounted on a strong, stable structure that can course of action the group and drive forward through atmosphere conditions like breeze, rain, and breaking down over periods. These structures are normal with the end goal that they can incline the PV show at a settled edge strongminded by close-by degree, the presentation of the structure, and electrical load supplies. So as to get the most significant yearly power yield, modules in the northern countries are pointed towards the south, arranged at an edge comparable to the area opportunity. The rack mounting procedure is the most extraordinary

used method since it is flexible, solid, and easy to make and present. Concerning the PV shows that are mounted on the ground, following instrument mechanically moves the sun arranged sheets to seek after the sun crossways the sky in order to give greater essentialness. Most customary trailers are one-center point and two-center. One-center point trackers are expected to seek after the sun from east to west. Two-rotate on the other hand, empower the photovoltaic cells to remain pointed specifically at the sun for the span of the day. Obviously, the more urbane and advanced photovoltaic system headings an increasingly costly rate and security cost.

Solar PV modules and arrays: A photovoltaic module (PV module) is a packed, connected assembly that usually consists of 6x10 solar cells which alter sunlight into electric energy. The modules are linked in series and/or parallel to provide the voltage and current levels needed. The array is typically mounted on a metal structure and slanted to face the sun.

Figure 2.13: Solar PV modules

Solar power Inverters: The assurance of utilizing inverter is to change over the low voltage coordinate flow (DC) power created by the sun oriented modules and batteries into high voltage rotating flow (air conditioning) power, which is acclimated give control in our homes, just as, the nearby transmission. From now on, this part of the photovoltaic plan permits to get the power that utilization to make home uses work.

Figure 2.14: Solar Power Inverter

Charge controller: The charge controller is a gadget that deals with the electric move through the framework, and shields the battery from harm. In the event that batteries are allowable to routinely cheat, their future will be sensationally decreased. A controller will detect the battery voltage, and diminish or stop the charging current when the voltage turns out to be sufficiently high. On the off chance that a PV module produces 1.5% of the battery's ampacity (outrageous current) or less, at that point no charge controller is attractive.

Figure 2.15: Charge Controller of SHS

Battery Bank: The battery bank covers at least one profound cycle batteries associated in arrangement and additionally parallel contingent upon the voltage and current limit wanted. The batteries stock the power formed by the sunlight based cluster and release it when require it.

Figure 2.16: Battery Bank

AC and DC loads: These are the applications (for example lights or radios), and the mechanisms (ex. water pumps and microwave repeaters), which ingest the power generated by PV array.

Cables & Accessories: Solar Home System is an outdoor claim. Hence, we need cables, which doesn't get injured easily and can ensure low voltage drop lengthways with low power losses.

Balance of System: These components deliver the interconnections and standard safety features required for any electrical power system. These include- array combiner box, properly sized cabling, fuses, switches, circuit breakers and meters.

2.9 Advantages of Solar Home Systems

- The energy we get from this technique is renewable.
- It protects our money by deducting electricity bill.
- It can be used in various submission.
- It needs low cost maintenance.

2.10 SHS electrification approach

SHS is significantly fitting for dispersed nation control supply in rising countries generally speaking and Bangladesh in express. For dispersed commonplace charge purposes in making countries, the SHS is the principle realistic usage of PV advancement. This is similarly the circumstance for Bangladesh, where SHSs are by far the most significant advancement for decentralized power sidekick from an economical power source.

2.11 Progression of worldwide SHS dissemination

The use of sun fueled power extended at the revelation of photovoltaic cell in 1839 by French physicist Edmond Becquerel. Consecutive researchers have industrialized cells with more capability. The fundamental energy for sun arranged developments for nation stay lone shock rose amid the 1970s. A money related improvement happened when Dr. Elliot Berman could structure an increasingly reasonable sun based cell bringing the expense down from $100 per watt to $20 per watt. This enormous cost supports opened up innumerable that were not attentive before because of stunning costs. The 1973 oil boycott and 1979 imperativeness crisis caused a difference in essentialness approaches the world over and passed on restored thought with respect to creating sun situated advances. Some place in the scope of 1970 and 1983 photovoltaic effects grew rapidly, anyway falling oil costs in the mid 1980s lifeless the improvement of sun controlled photo volt from 1984 to 1996. By the mid-90s, distinctive exercises were hurled to scale up into far reaching SHS commercialization and government upheld scattering programs. Since 1997, daylight based zap has speedier in view of supply matters with oil and combustible gas, an Earth-wide temperature help concerns and the upgrading money related position of PV in regard to other essentialness advancements. Prior to the completion of 2005, 2.4 million SHSs had been presented worldwide with a normal yearly foundation of more than 270,000 structures [6].

Spread of SHS depends upon moderateness. According to F. D. J. Nieuwenhout acceptable organization system is required to make adventures attainable. Nuclear family choice in structure sizes is routinely too much controlled in promoter sponsored exercises. Smaller systems sold for cash can be a conventional decision to credit structures by offering to extended moderateness [7]. Subordinate upon their size, expenses of SHS look at contrast between US$ 100 and US$ 1,100. There are in like manner vital esteem contrasts for different countries recognizable. Adjacent costs lay on segments, for instance, commitments, appraisals, and assignments, the span of mechanical and get-together structures, the scale and cost of publicizing and diverse organizations, the dimension of competition, limit utilization in make, bargains and modifying and the cost of advantages for working capital and basic costs. The other huge issues to be considered are the high starting costs, the establishment of a responsive and suitable system and the ensuring of significant worth things and organizations. Dropping the market expenses of SHSs by impacting the above components is a basic game plan of various SHS spread tasks. Starting late by far most of the overall

improvement in SHS bargains has concentrated on two or three Asian countries, specifically India, Sri Lanka, Nepal, Bangladesh, Thailand, and China. In these countries, the issue of moderateness has been overwhelmed either with scaled down scale credit or by moving little gets ready for cash.

2.12 SHS dissemination in Bangladesh

The primary involvement with SHSs in Bangladesh was expanded from 1997 advances when the REB actualized a French-subsidized pilot venture for the zap of 850 family units on a far off waterway island in the locale of Narsingdi [8]. This pilot venture was connected utilizing the purported 'charge for administration' show. The SHSs had a place with the REB, while the clients needed to pay an underlying security store and month to month settled levies for the utilization of the framework. As the client was not the proprietor of the framework, REB was in charge of establishment, support, fix, and extra of the SHS parts. Applications, for example, lights and TVs had a place with the clients. The undertaking demonstrated the specialized feasibility and financial reasonableness of SHSs in country regions of Bangladesh. Learning from this task ended up being extremely helpful for the plan of later SHS scattering programs [9].

Follow-up exercises by the REB to scatter more SHSs, be that as it may, have been "incredibly moderate" (ISLAM 2004: 19). Two parallel plans utilizing the 'charge for administration' display began in 2002. The program 'Dissemination of Renewable Energy Technologies' accentuations on remote areas of chose locales with a last focus of 6,000 scattered SHSs. Despite the fact that as of April 2006 just 605 SHSs had been associated. The undertaking was supported by the Government of Bangladesh (GOB) with no guarantees of remote giver organizations. The second program, 'Rustic Electrification through Solar Energy', is supported by the World Bank. Its objective was to introduce 16,000 SHSs by 2007. As of April 2006 just 694 frameworks had been dispersed [10] [11].

Invigorated by the accomplishment of the REB pilot venture in Narsingdi, NGOs before long ran quick with their very own SHS circulation programs. First business exercises in regards to SHSs were started by Grameen Shakti (GS), which was perceived in 1996 as a NGO individual from the celebrated Grameen group of associations to embrace sustainable power source benefits in remote provincial territories of Bangladesh [12].In 1997, the action started

selling SHSs by following ‘cash sale’ and ‘credit sale’ approaches. GS offers different backing options of which all lead to complete system possession for the customer:

- The user has to pay 15% of the total system value as down payment. The residual 85% of the cost is to be repaid within 36 months with a 5% to 6% service charge contingent on mode of payment (‘credit sale’);
- The user has to pay 25% of the total system price as down expense. The residual 75% of the cost is to be repaid within 24 months with a 4% service control.
- The user pays the total amount in cash and receives 4% discount (‘cash sale’) [13].

The principal financing plan was utilized in the early application arrange and later Completed with the last two methodologies. Free after-deal benefit is sure for a long time, with standard upkeep benefit given by GS staff amid their visits to gather the regularly scheduled payments. After the three years of free administration, after-deal benefit is accommodated an insignificant expense of about US$ 5 every year [14]. As of September 2002, around 10,275 SHSs with a complete limit of 0.5 MW had been introduced by GS in different remote zones of the nation. The quantity of every year sold SHSs by GS enlarged from 375 out of 1998 to 3,196 out of 2001, showing high fame of both the framework and the separate publicizing technique.

Another period of SHS raise began in 2002 with the use of the 'Provincial Electrification and Renewable Energy Development Project' (REREDP), which is mutually subsidized by the World Bank, Global Environment Facility (GEF), the German Kreditanstalt für Wiederaufbau (KfW) and German Technical Cooperation (GTZ). The Substructure Development Company Limited (IDCOL), a legislature had object, scatters SHSs through 16 taking an interest associations (POs), viz. experienced NGOs, for example, GS or the Bangladesh Rural Advancement Committee (BRAC) (together dispersing over 85% of the complete number of SHSs) just as various littler NGOs and private activities. The POs pitch the SHSs to families and private companies for the most part through 'money deal' and miniaturized scale credit plans like the one of GS (see above). Likewise, the POs select the task territories, introduce the frameworks, and convey upkeep bolster. IDCOL conveys renegotiating enhancements to the POs and channels remittances to lessen the expense of the frameworks there with making them progressively sensible to rustic clients. Likewise, parts of the awards are utilized to help the formal improvement of the POs [15]. As IDCOL's essential goal is the commercialization of SHSs, the measure of awards was gradually diminished amid the most recent years from US$ 90 for each framework in 2002 to as of now

US$ 50 for each framework. US$ 40 of this cash is utilized to lessen the moving cost of the SHSs (US$ 375 for a 50 Wp framework), while US$ 10 for every framework is utilized for institutional improvement motivations behind the POs [16]. Other than giving monetary help, IDCOL sets specialized particulars for the sun powered hardware, gives specialized, calculated, limited time, and preparing help to the POs and screens the PO's execution [17]. IDCOL's underlying target was to scatter 50,000 SHSs before the finish of June 2008. Be that as it may, because of surprising high SHS deals this objective had just been achieved in September 2005, three years in front of timetable and US$ 2 million underneath evaluated venture costs. As the notoriety of SHSs proceeds with, IDCOL set another objective of 200,000 SHSs to be sold by 2009. With more than 100,000 SHSs sold by January 2007, the IDCOL customized is one of the quickest rising sustainable power source programs on the planet [18].

2.13 SHS electrification as driving force for socio-economic development

In September 2000, the Unified Countries General Gathering's committed to an overall relationship to accomplish Thousand years Advancement Objectives (MDGs) continually 2015.

Dropping rural desperation finished common progression is looked as a key responsibility to achieving these targets and under holding the necessity for developing access to display day essentialness propels (UNCTAD/2010:2). New and boundless bases of imperativeness have gotten a great deal of thought since the World Summit on Practical Improvement (WSSD) held in Johannesburg in 2002 as Johannesburg Plan of Execution (JPOI). The JPOI underscored help for Plan 21, the result report of the 1992 Joined Countries Gathering on Condition and Improvement [19]. MDG 7 – ensuring common sensibility – indorses supportable power source propels as a strategy for extending access to these organizations. In this joining Sun oriented, wind, and hydroelectric power get unmistakable for making immaterial carbon spreads just as help decrease poverty through improved essentialness access in underserved domains. The availability of moderate, secure and normally trustworthy essentialness supply is as such the essential key to accomplish the MDGs and to reduce the welfare opening on the overall scale.

Money related advancement depends upon imperativeness. At the point when all is said in done, essentialness isn't wary as a fundamental human need. Already, commonplace imperativeness, explicitly, was not comprehensively known as a crucial need like water and sustenance in the headway rings. Regardless, essentialness, particularly control is required for tending to major needs, for instance, prosperity, cultivation, guidance, information and other infrastructural organizations and demonstrates an indisputable association with per capita pay and human headway file. Regardless of the way that commonplace charge does not inescapabiltiy decline desperation, its relationship to destitution decline can't be denied. By and by a-days daylight based power is a technique for progression given that control answers for nuclear families, agribusiness, restorative administrations, guidance, media transmission, common paths and fairs, similarly as government and private affiliations. It is helping rural life making compensation creating believability and activities. This is in like manner saving condition by substituting fuel lights and encouraging imperativeness access for the far away districts. Beside this, sun arranged imperativeness is perseveringly powerful to incorporate into various creative application in the market. Out of the blue, extended use of sun based imperativeness has been recognized as alternatives as opposed to grid control supply in distant common locales for poverty decline (World Bank, 2003). Starting late the association of essentialness to supportable enhancement and destitution decline has been expanded on the planet. It is understood that detachment of intensity benefits in commonplace and pre-urban regions is ordinarily lined up with dejection and it is among the most huge issues facing everybody (Joined Countries progression Program, 2004). At the ninth session of the Unified Countries Commission on Maintainable Advancement (CSD-9) limitless and natural imperativeness were seen among the key essentialness issues for functional human enhancement. A couple of creators have given examination of the association between imperativeness (power) and major overall subjects, for instance, prosperity, guidance, water, sex, etc. Natural charge may be careful as basic essential to improve money related condition in nation domains.

Arne Jacobson gives an assessment of the social consequences of provincial shock with sun arranged essentialness in Kenya. In the mid 1980s just around 4 percent of nation nuclear families in Kenya were associated with electrical structure. Beginning at now, sun controlled power has ascended as a key choice rather than natural zap. The examination typifies that the benefits of sun based shock are gotten essentially by the rural salaried class. Sun situated power accept a leaving work in supporting financially creative and preparing related

activities, yet "Connective" applications, for instance, television, radio and mobile phone charging as often as possible get a higher need. Sun controlled shock is closer settling to amplified television use, the augmentation of business segments, progressively commonplace urban correspondence, and diverse techniques that extension nation urban accessibility than to desperation helping, practical enhancement or the fitting advancement improvement [20]. Vijay Laxmi and others found that because of bio-fuel use, time consumed and hardship continued in fuel gathering, prosperity impacts hurt from air pollution, extended load of cleaning utensils, dividers, floors and articles of clothing, natural changes, and so on, are negative externalities [21]. Tarujyoti Buragohain considered the impact of sun controlled imperativeness in nation enhancement in India. Use of light oil is reducing in nation zones was found in the examination.

Very nearly 53 to 69 percent communicated that there is basic upgrade in their youths' preparation, and 37 to 78 percent itemized that there is improvement in the ordinary of living after the foundation of daylight based lighting. Recipients by and by put more vitality in pay making works out. Bad behavior rate has furthermore declined in light of availability of sun fueled street lights in the town [22].

In Bangladesh, Barkat (2002) completed a very troublesome examination on the money related and social impact of a natural zap program on where they found that admission to nation shock critically influences the decline of both pay dejection and all components of human destitution (prosperity, guidance and women fortifying). The examination furthermore found that nation access to control innaty influences cultivating progression, industrialization, business and business works out. Plus, it influences human capital course of action through data building intervened by power driven media presentation [23]. Sun arranged essentialness progresses (sun based water framework, nearby lighting system) make pay making practices for male landless and flanking agriculturists and for women from such nuclear families, while diminishing natural issues, like deforestation and indoor air defilement from cooking with low quality fills. The use of one electric light is obviously better than light oil lights and candles [24]. Chowdhury guided an examination to find the monetary and social effects of handy nation essentialness on down and out people and organization and the leading body of two substructure adventure which use sun controlled imperativeness. The examination found that giving force through daylight based imperativeness has a multidimensional result on provincial work. It not simply upgrades the desire for ordinary solaces of the provincial

people yet also improves access to information, better prosperity for women and youths and an extension of indoor pay making works out. Regardless, poor upkeep, nonattendance of particular data and planning hampered the movement and settling components of daylight based essentialness advancement in the commonplace system. For upgrading ground-breaking organization of sun based imperativeness headways, there is a need to upsurge end-customer awareness of structure use, end-customer capacity to research issues and measurement of organization, quality and comfort of frameworks for upkeeps [25]. Khan considered the utilization of practical power hotspot for world destitution decline similarly with respect to meeting the goals of the MDGs. His examination shows a couple of associations between the headway of essentialness organizations and meeting the MDGs with respect to diminishing desperation, achieving basic guidance, progressing sexual introduction fortifying and ensuring common reasonability [26].

The essential associated sorts of sun based PV in common Bangladesh are sun situated home lighting systems presented in nuclear families and adjacent market/bazaar (top). The achievement of sun based PV little scale utilities is inferable from a couple of components. These fuse the propriety of a step by step obligation structure and the rate similarly as real promoting that clears up the daylight based essentialness based system's abilities, favorable circumstances, and objectives as opposed to other available options in contrast to potential customers. Offering capacity to social affair lighting needs of nuclear families and commonplace markets can yield constructive results, fusing upgrades in close to home fulfillment and total compensation and business openings. There is moreover a positive linkage between instance of sun arranged PV and meeting the objectives of the gathered Country's Thousand years Advancement Objectives. Sun fueled cells the practically sometimes used shape sun based development can be used for a wide different assortment of usages, for instance, daylight based power plants, in the rooftops of structures, on street lights, etc [27]. Individual fulfillment is essentially life destinations of budgetary headway that can be practiced through better preparing, prosperity, access to information, indoor lighting, among others. Basic impacts of sun based PV systems consolidate better nature of light; indoor smoke and fire dangers from light oil lights are lessened. In addition sun based PV charge provides for upgrade eminence of life in off-structure natural systems through the prompt effect of the advancement on nuclear family success and try pay.

The prime employment of sun based imperativeness is changing the lives of people in the nation zone. Daylight based zap can upgrade the individual fulfillment of common nuclear families through useful effects that can just with huge exertion be conveyed in monetary terms. Presenting sun based power in homes helps families with a better than average assortment of assignments. By using a SHS adolescents' can think

2.14 Summary

Finally we can say about solar energy that the sun is a powerful source that can help us by giving us clean refillable energy in order to power our world. The usage of this energy is free which does not create effluence and if we can use it wisely then it will help us become less dependent on other most costly and damaging procedures of power.

On the other hand variability in the electrical market has created a good opportunity for home owners wishing to cut down their electricity bill. In this prospect solar energy provides reliable electrical group for many years and will be finally paid for itself. State and federal inducements help ease the costs of a system. Investments and energy supplies are subject to change due to location in relation to the sun and differing households need. Unused electricity should be stored for using it later or selling to the grid through net metering. More information is needed here on counting how well solar provides for residents during days of low solar exposure. Also the battery efficiency should be taken into account when storing electricity to use it in future. Since solar energy is comparatively new to the energy market, not much data has been found on the actual lifetime of a panel/system.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this section, we will discuss the process of data collection method and research tools. The primary data that we collected from our study area.

3.2 Site Selection

A study area (Fig.3.2) 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 located Dhaka 1215, Bangladesh. Different types of solar panel have installed there such as 45W, 60W and 100W. We study the performance analysis the power of 60W off grid solar panel.

Figure-3.1: Study Area

3.3 Satellite View

Fig. 3.2: Satellite View

3.4 System Design

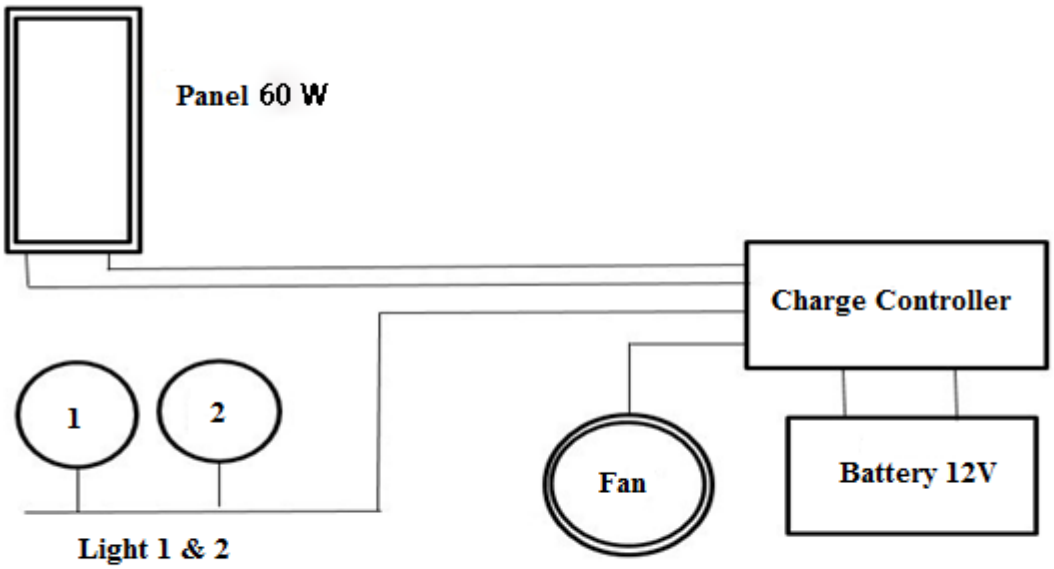


Fig. 3.3: System Design (60W)

3.5 Research Machineries & Tools

Some tools have been used to collect data such as

- I-V 400w, temperature sensor
- 60W solar panel
- Irradiation sensor (HT304N).

3.5.1 60W Solar Panel

The cells of the solar made in Germany. To measure power in Standard Test Condition (STC) cell temperature is 25°C. These solar cells made in Germany and the efficiency of the 60W panel is 14%.

3.5.1.1 Electrical Specifications

Maximum power:	60 W
Open circuit voltage:	21.5V
Short circuit current:	3.76A
Voltage at maximum power:	17.5V
Current at maximum power:	3.46A
Module dimension:	805*550*35mm
Module weight:	5.9KGS±3%
Module Efficiency:	14.00%

Fig. 3.4: 60W Solar Panel

3.5.2 I-V 400W

I-V 400w allows to measure of the I-V characteristic of the main characteristic parameters both of a single module and of a whole photovoltaic scheme up to a maximum of 1000V and 10A. The obtained data are then treated to anticipate the I-V characteristic below standard test conditions (STC) and comparing with rated data. Irradiation and temperature sensor plays a tremendous role for extrapolation of the I-V characteristic under the standard test conditions. Open circuit voltage and short circuit current can measure through the device. With a mobile device, HTANALYSIS™ helps to determine and understand problems may have the in-PV Installations.

Fig. 3.5: I-V 400 W Photovoltaic Panel Analyzer

3.5.2.1 Electrical Specifications of I-V 400 W

Table-1: range, resolution and accuracy

Parameter	Range (V)	Resolution (V)	Accuracy
VDC Voltage @ OPC	5.0 –999.9	0.1	± (1.0%rdg+2dgt)
IDC Current @ OPC	0.10- 10.00	0.01	±(1.0%rdg+2dgt)
Max Power @ OPC (Vmpp>30V, Impp>2A)	50 – 9999	1	±(1.0%rdg+6dgt)
VDC Voltage (@ STC and OPC), IVCK	5.0- 999.9	0.1	±(4.0%rdg+2dgt)
IDC Current (@ STC and OPC), IVCK	0.10- 10.00	0.01	±(4.0%rdg+2dgt)
Max Power @ STC (Vmpp>30V,	50- 9999	1	±(5.0%rdg+1dgt)

Impp>2A)			
Irradiance (with reference cell)	1.0- 100.0	0.1	±(1.0%rdg+5dgt)
Temperature of module (with auxiliary PT1000 probe)	-20.0 – 100.0	0.1	±(1.0%rdg+1°C)

3.5.2.2 General Specifications of I-V 400 W

DISPLAY AND MEMORY:

Features: 128x128pxl custom LCD with backlight

Memory capacity: 256kbytes

Saved data: 249 curves (I-V curve test), 999 IVCK

POWER SUPPLY:

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

Autonomy of SOLAR I-V: > 249 curve (I-V curve test), 999 IVCK test Approx. 120 hours (yield test).

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

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

OUTPUT INTERFACE

PC communication port: optical/USB

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

MECHANICAL FEATURES

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

Weight (batteries included): 1.2kg

ENVIRONMENTAL CONDITIONS:

Reference temperature: 23°C - 5°C

Working temperature: 0° - 40°C

Working humidity: <80%HR

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

Storage humidity: <80%HR

GENERAL REFERENCE STANDARDS:

Safety: IEC/EN61010-1

Safety of measurement accessories: IEC/EN61010-031

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

IEC/EN60904-5 (Temperature measurement)

Insulation: double insulation

Pollution degree: 2

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

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

Max altitude of use: 2000m

3.5.2.3 Temperature Sensor

It senses temperature from the solar cell and sends data to the I-V 400w.

Fig. 3.6: Temperature Sensor

3.5.2.4 Irradiation Sensor (HT304N)

This device (Fig. 3.7) can able to measure as MONO PANELS or MULTI PANELS. It is a passive sensor and does not necessary any power supply.

Fig. 3.7: Irradiation Sensor

3.5.2.4.1 Technical Specifications

Table-2: range & accuracy

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

3.5.2.4.2 General 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

3.6 Flow Chart

A flowchart is a kind of diagram that represents a workflow or process. The flowchart displays the steps as boxes of frequent kinds and their order by connecting the boxes with arrows. We used flowcharts in exploring, documenting or managing a procedure or program in various fields.

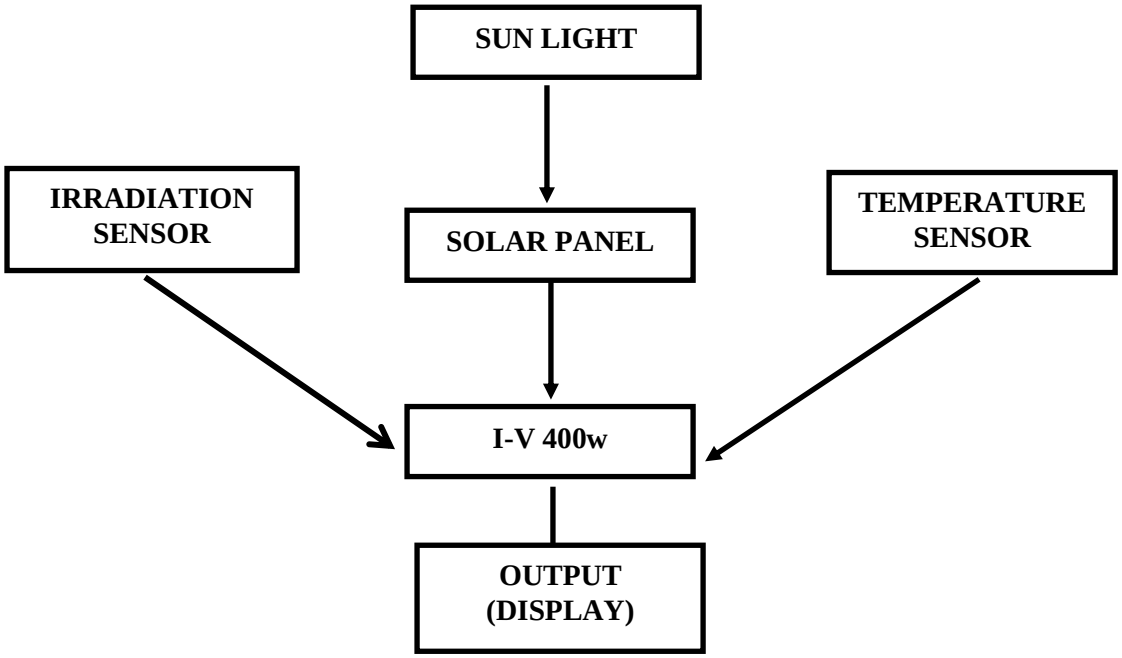


Fig. 3.8: Flow Chart

3.7 I-V 400 W Calibration

Before starting the measurement, we must have to calibrate I-V 400 W. For I-V 400 W calibration parameters has given below Table-3

Table-3: I-V 400 W Calibration.

Pmax	50 W
Voc	21.42 V
Vmpp	17.10 V
Isc	3.20 A
Impp	2.92 A
Toll-	1.0 W

Toll+	1.0W
Alpha	0.033 %/°C
Beta	-0.34 %/°C
Gamma	-0.42 %/°C
Noct	45 °C
Tech.	STD
Rs	1 Ω
Degr	0.0 %/yr

3.8 Data Measurement Technique

In October, we collected data from sunrise to sunset (time 5:49 to 17:45) besides In November, we collected data from sunrise to sunset (time 6:03 to 17:19) and used I-V 400w photovoltaic panel analyzer to measure data. Firstly, setting up irradiation and temperature sensor connect with I-V 400 W photovoltaic panel analyzer. Secondly, 60 W solar panel output cables connected with I-V 400 W and The measured data was in Standard Test Condition (STD) form then which we converted these data into Operational Condition (OPC) form.

Fig. 3.9: Data Measuring

Table- 4: Data Sample of 8th November 2018 for 60 W solar panel

SL	Time (Sunrise to sunset)	Irradiance (W/m^2)	Voltage (V)	Current (I)	Vmpp(V)	Impp(I)	Fill Factor	Pmax (W)
1	6:08	0						0
2	7:08	56	18.7	0.35	16.21	0.22	0.52	3.5662
3	8:08	83	19.01	0.52	15.61	0.3	0.48	4.683
4	9:08	486	20.2	1.12	16.3	1.02	0.74	16.626
5	10:08	630	20.1	1.55	15.5	1.44	0.72	22.32
6	11:08	548	20.2	1.52	15.7	1.4	0.72	21.98
7	12:08	751	19.6	1.81	15.4	1.61	0.7	24.74
8	13:08	630	19.9	1.49	14.9	1.38	0.69	20.562
9	14:08	153	19.3	0.38	15.6	0.34	0.73	5.304
10	15:08	153	19.3	0.38	15.6	0.34	0.73	5.304
11	16:08	111	19.5	0.28	16.2	0.24	0.71	3.888
12	17:15	0						0

Table-4 represents parameter-wise data of a single day (November 8th, 2018) starting from sunrise to sunset. Where,

Voc= Open circuit voltage

Isc= Short circuit current

Vmpp= Voltage at maximum power

Impp= Current at maximum power

FF= Fill factor

Pmax= Maximum power

CHAPTER 4

DATA ANALYSIS, RESULTS AND DISCUSSIONS

4.1 Introduction

In order to utilize solar power more effectively we have to measure the irradiation of our country time to time for its importance as well as radiation changed over time. In this thesis our main strength was to find out the irradiation of sun in our Dhaka city. The Latitude & longitude of Dhaka respectively 23.70° & 90.37°.For Dhaka city in the month of October and November because of estimating the power manufacture of the solar panel and the data that we used easily we can understand the electricity production by solar and also generate a standard form of power production of solar of 2018. Our focus of this thesis is the dimension of solar irradiation, and the consistent power generated by 60W panel. There are some parameters such as irradiance, Pmax. Equivalent power is the multiplication between irradiance and panel area (0.44 m^2). Also, Equivalent power is the input power of total solar panel (45W) & Pmax is the output produced power. We have measured the data by I-V 400W Photovoltaic Panel analyzer (Operational Condition).

4.2 Irrediance

Solar irradiance (SI) is the power per unit area acknowledged from the Sun in the form of electromagnetic radiation in the wavelength range of the calculating instrument. The solar irradiance integrated over time is called solar irradiation.Total Solar Irradiance (TSI) is a measure of the solar power over all wavelengths per unit area. The SI unit of irradiance is watt per square metre (W/m2).

4.2.1 Irrediance of October 2018 for 60W panel

The data (Figure 4.1) of solar irradiation of October 2018 for 60 Watt panel. Here we can see the highest value of solar irradiance was on 2nd October that we measured and that was about 510 W/m^2 and the lowest value of irradiance was found on 12th October that was about 70 W/m^2 and the main reason behind this scene was sunny day and foggy day. On the sunny days we got the highest value and on the foggy day we got the lowest value.

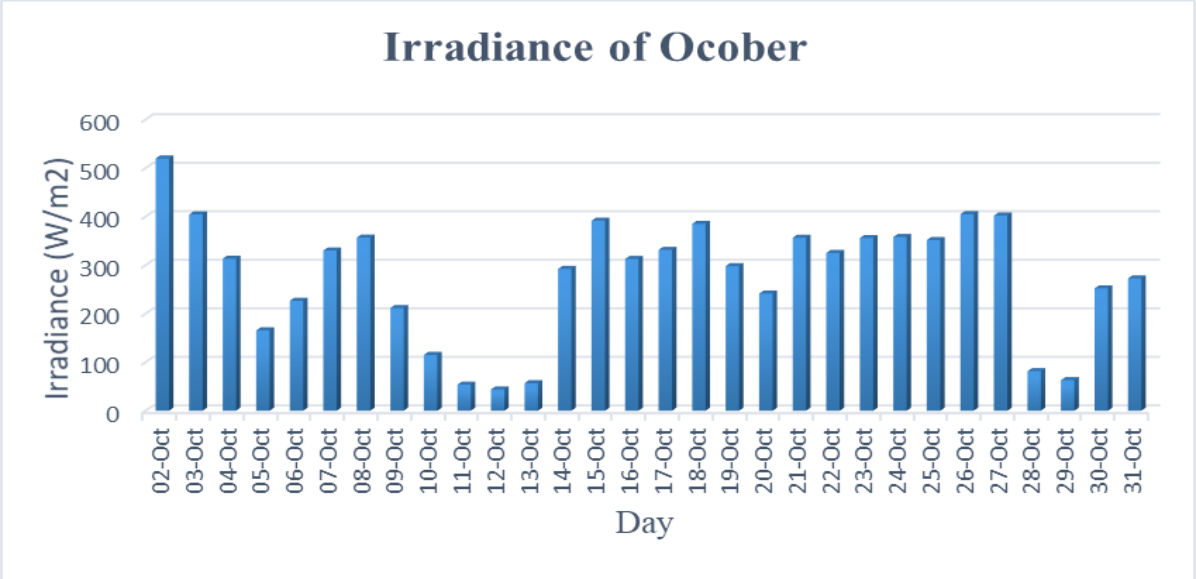


Figure 4.1: Irradiance vs Day of October 2018 for 60 W Panel

4.2.2 Irradiance of November 2018 for 60 W Panel

The data (Figure 4.2) of solar irradiation of November 2018 for a 60 Watt panel. Here the highest value of solar irradiance was on 26th November and that was about 475 W/m² and the lowest value of solar irradiance was on 2nd November that was about 175 W/m² and the main reason behind this scene was the change of weather.

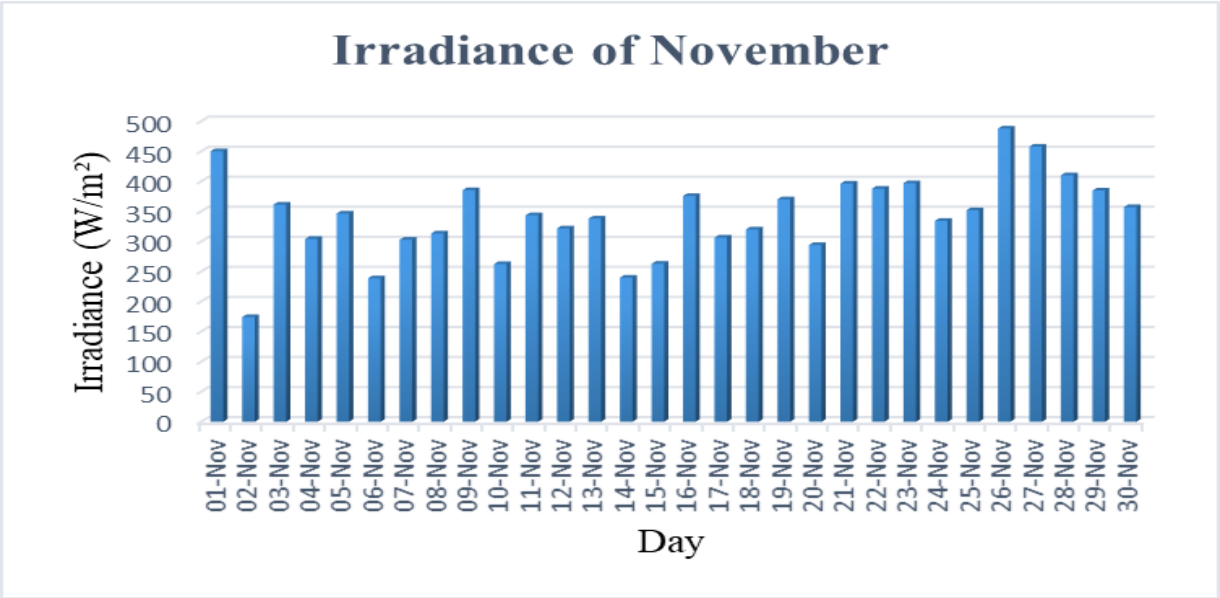


Figure 4.2: Irradiance vs Day of November 2018 for 60 W Panel

4.2.3 Irradiance comparison between October and November 2018 for 60W Panel

Figure 4.3 represents the solar irradiance comparison between October and November of 2018 for a 60 W solar panel. The highest values were 510 W/m²on 2nd October and 475 W/m² on 26th November where the lowest value of solar irradiance were about 70 W/m2 on 12th October and 175W/m2 on 2nd November.

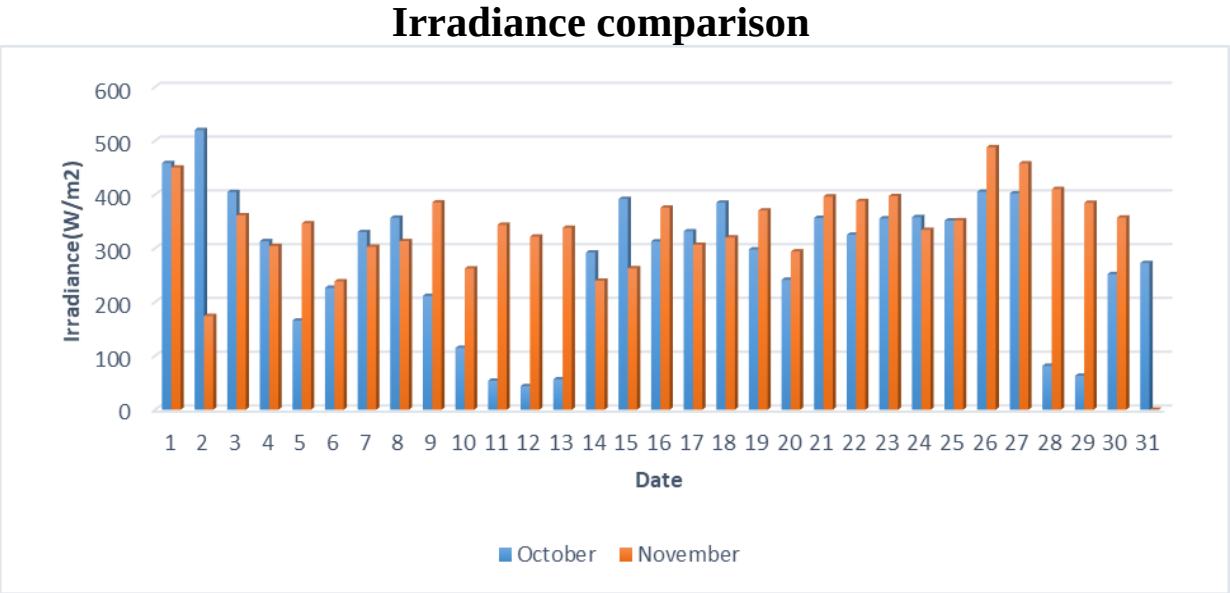
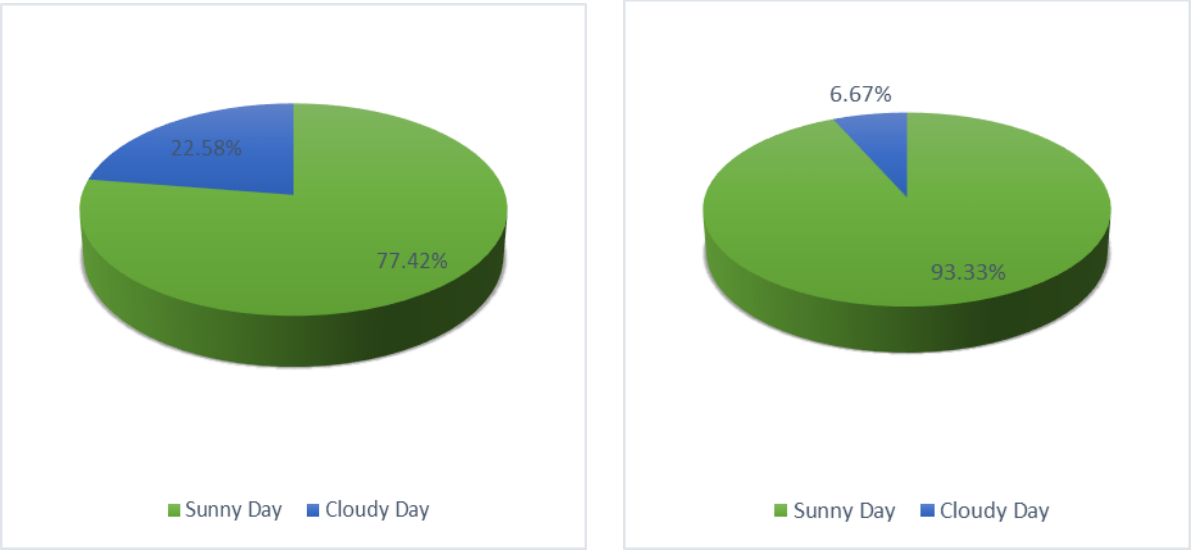


Figure 4.3: Irradiance comparison between October and November for 60W Panel

4.2.4 Sunny Day and Rainy Day of Irradiances

Figure 4.7 represents the comparison between sunny day and cloudy day of October and November 2018. Here we can see in October sunny days were about 77.42% where the cloudy days were about 22.58%. On the other hand in November the sunny days were about 93.33% where cloudy days were about only 6.67%. So we got much more irradiance throughout the month of November.



October **November**

Figure 4.4: Irradiance Comparison between Sunny Day vs Rainy Day of October and November 2018

4.3 Power

Solar power is arguably the cleanest, most dependable form of renewable energy available, and it can be used in several forms to help power our home or business. Solar-powered photovoltaic (PV) panels convert the sun's rays into electricity by exciting electrons in silicon cells using the photons of light from the sun. This electricity can then be used to supply renewable energy to our home or business. The SI unit of power is watt .The equation of power, $P = V \times I$

4.3.1 Power of October 2018 for 60 W panel

Figure 4.8 represents the maximum power generation curve of a 60 W solar panel in October 2018. On 18th October we got the highest value of maximum power 25.2 W and the lowest value of maximum power 2nd October that was about 0.9 W.

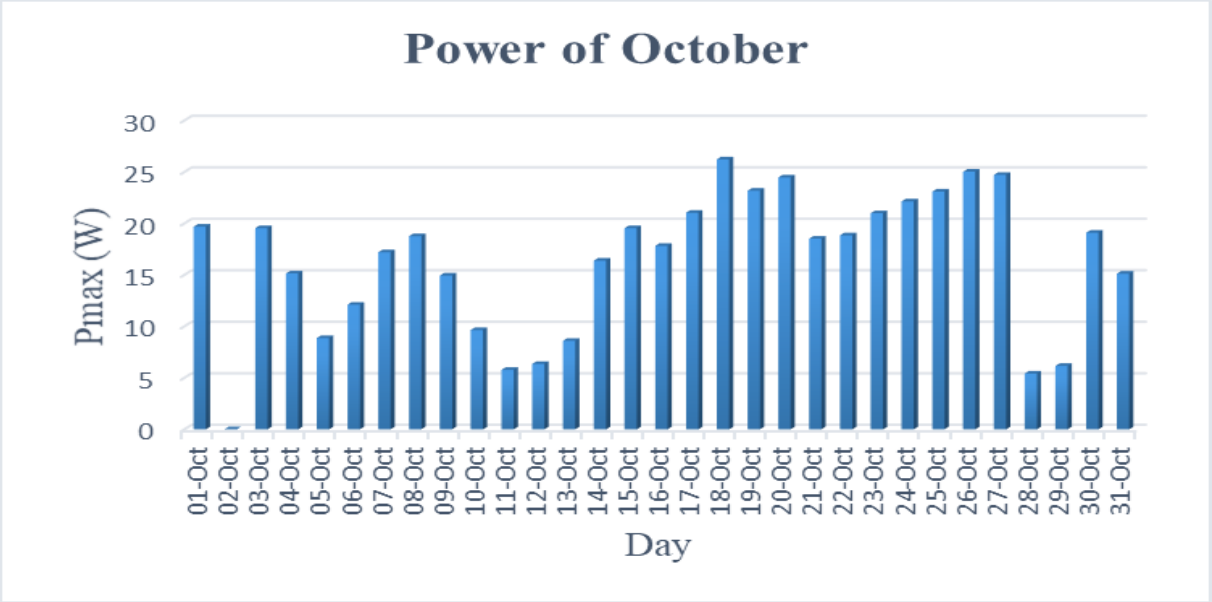


Figure 4.5: Power vs Day of October 2018 for 60 W panel

4.3.2 Power of November 2018 for 60 W panel

Figure 4.9 represents the maximum power generation curve of a 60 W solar panel in November 2018. On 29th November we got the highest value of maximum power 23 W and the lowest value of maximum power was on 2nd November and it was about 10 W.

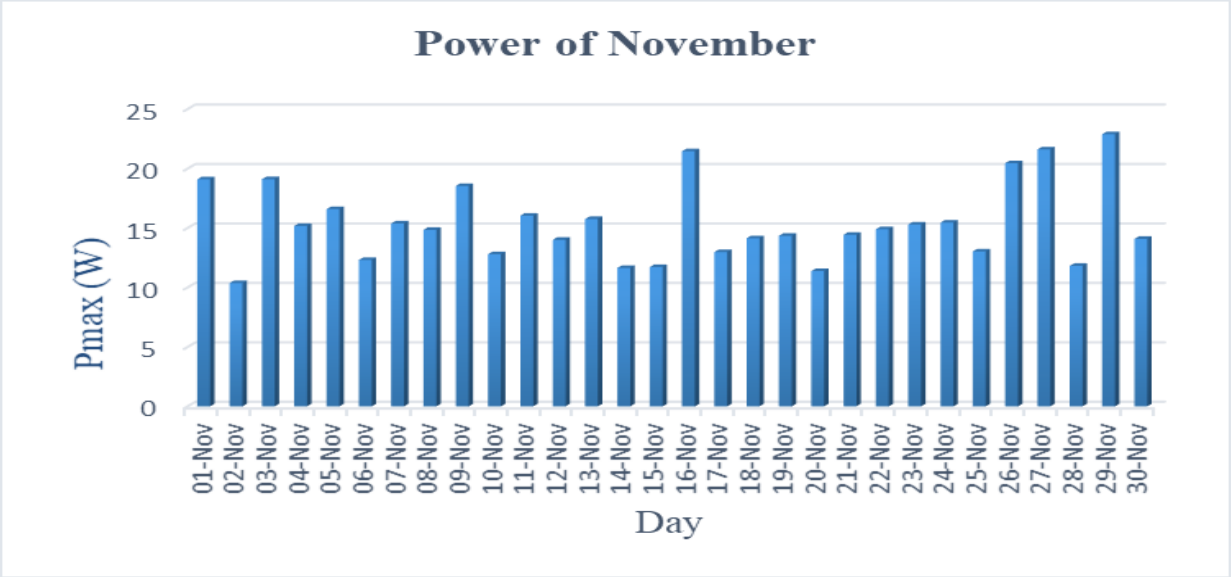


Figure 4.6: Power vs Day of November 2018 for 60 W panel

4.3.3 Power Comparison between October and November 2018 for 60W Panel

Figure 4.10 represents the maximum power generation curve comparison between October and November month of 2018 for a 60 W solar panel. The maximum power generation curve

that shows the highest values were 25.2 W on 18th October and 23 W on 29th November where the lowest values were about 0.9 W on 2nd October and 10 W on 2nd October.

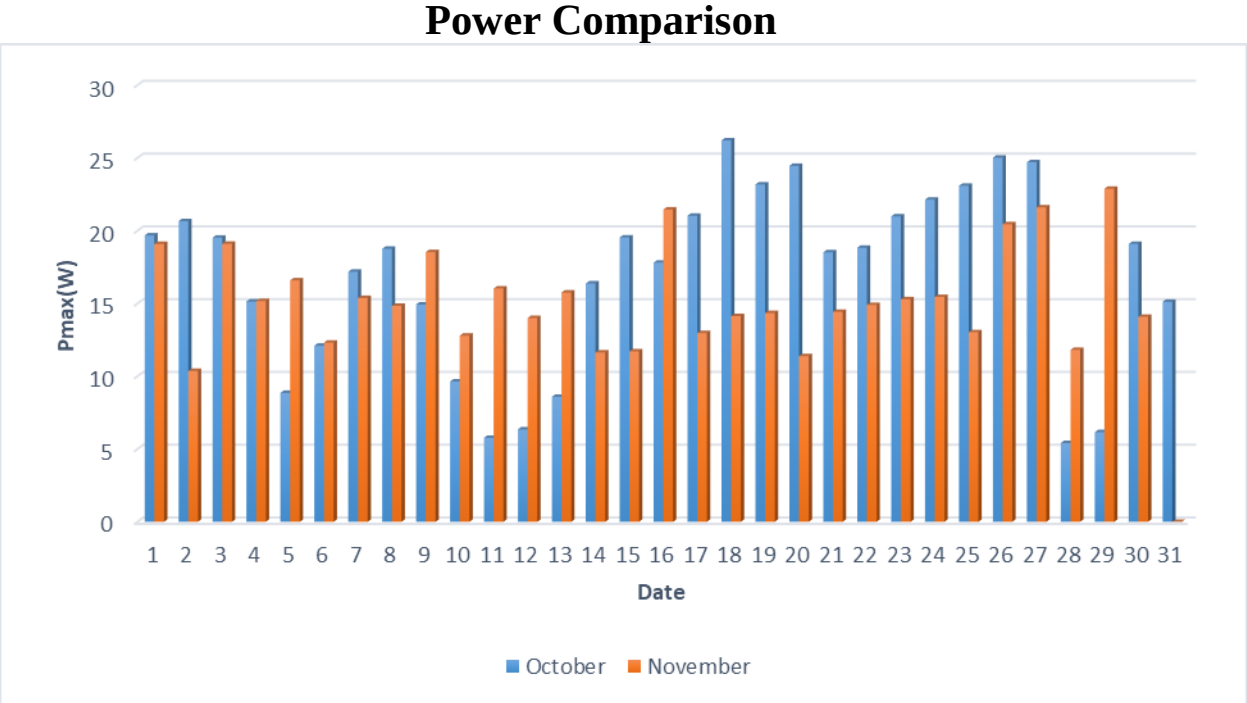


Figure 4.7: Power Comparison between October and November 2018 for 60W Panel

4.4 Efficiency

Solar cells efficiency of currently ranges from around 20% up to a height range of around 40%, while this is improving. The rest of the sunlight that falls in the panel is spoiled as heat. More photovoltaic cells that are efficient have been discovered (up to 43% efficient) but these are new discoveries and are expensive to produce industrially [28].

Here,

Irradiance ($_{avg}$) of November = 42.5857 W/m²

$P_{max\ (avg)}$ of November = 15.3865W

Area of panel for 60 W = 0.44 m²

So the average efficiency of November = $P_{max\ (avg)}$ of November/ (Irradiance ($_{avg}$) of November * Area of panel for 60 W)

Table-5: Panel Efficiency of November 2018

Month	60W Panel (%)
November	8.19

The next table represents the comparison of efficiency between October and November 2018. Here for a 60W solar panel we got more efficiency 8.19% during the month of November where in October it was only 7.86%. The reason behind this, there is more sunny days in November than October.

4.5 Comparison of Solar Radiation Data among Different Years

This is the data of Monthly Average Solar Irradiance in 2008, 2009 & 2010.

Table-6: Data of Monthly Average Solar Irradiance in 2008, 2009 & 2010 [30].

Month	Solar Irradiance(W/m^2) (2008)	Solar Irradiance(W/m^2) (2009)	Solar Irradiance(W/m^2) (2010)
January	164.9	165.6	151.5
February	209.8	219.1	186.7
March	225.7	228.3	238.2
April	283.3	273.1	236.7
May	261.1	235.1	225.8
June	212.4	210.3	176
July	176.2	197	201.6
August	174.1	177.5	166.3
September	189.6	166.8	165.5
October	179.7	189.1	175.2
November	208.1	164	168
December	123.7	142.5	159.2
Annual average Irradiance(W/m^2)	209.05	197.36	187.55
Annual Average ($kWh/m^2/day$)	5.01	4.73	4.50

In the year 2008, annual average solar irradiation was 5.01 $kWh/m^2/day$ and the value of irradiation in 2009 was decreased and that was 4.73 $kWh/m^2/day$. There was also a

deteriorating 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- 6.

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

Table-7: Collected Solar Irradiance Data of Bangladesh from 1985-2006 were Presented Below [**31**]

Month	**NREL (1985-91)**	**RERC (1987-89**	**RERC (1992)**	**DLR (2000-2003)**	**RERC (2003-2005)**	**RERC (2006)**
January	4.18	4.29	3.34	4.58	3.16	3.4
February	4.68	4.86	4.05	4.81	4.46	3.79
March	5.55	5.53	5.24	5.31	4.88	5.04
April	5.65	5.23	6.02	5.84	5.28	5.06
May	5.58	5.67	5.76	5.21	5.46	5.09
June	4.48	5.13	5.39	3.85	4.22	4.8
July	3.9	3.87	4.2	3.76	4.48	3.84
August	4.12	3.92	4.87	4.11	4.12	4.73
September	3.96	4.5	5.38	3.76	3.78	5.15
October	4.7	4.61	4.93	4.19	3.57	3.18
November	4.25	4.22	3.72	4.47	3.92	3.35
December	4.06	3.89	3.39	4.34	3.19	2.84
Annual Average (kWh/m^2-day)	4.59	4.64	4.69	4.52	4.21	4.45

In the year 1985-1991, annual average solar radiation was 4.59 kWh/m^2/day and it was increased into 4.64 kWh/m^2/day in 1987-89. But in 2000-03, yearly 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-8: Collected Data from 1985-2005, 2008-2010, 2018 and Compare Irradiance Among them were Presented Below [30] [31]

Year	Month	Irradiance kWh/m^2/day
1985-1991	October	4.7
	November	4.25
1987-89	October	4.61
	November	4.22
1992	October	4.93
	November	3.73
2000-2003	October	4.91
	November	4.47
2003-2005	October	3.57
	November	3.92
2006	October	3.18
	November	3.35
2008	October	4.31
	November	4.90
2009	October	4.54
	November	3.9
2010	October	4.20
	November	4.03
2018	October	7.62
	November	7.8

Table-8, after analyzing we can say that in the month of October, we got the highest amount of Irradiance than November. In the year 1985-1991, October & November average solar irradiation was 4.7 & 4.25 kWh/m^2/day and it was increased into 4.93 & 3.73 kWh/m^2/day in 1992. But in 2000-03, October & November average irradiation was 4.91 & 4.47 kWh/m^2/day which was reduced into 3.57 & 3.92 kWh/m^2/ day in 2003-05. In 2008, irradiation was cumulative, and the value was 4.31 & 4.90 kWh/m^2/day. Again in 2010, irradiation was decreasing, and the value of 4.20 & 4.03 kWh/m^2/day. Moreover, in 2018, irradiation was increasing, and the value of 7.62 & 7.8 kWh/m^2/day.

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

4.6 Synopsis

The following chapter, we have deliberated about data analysis and results about the irradiance and maximum power generation of a 60 W solar panel during the month of October and November of 2018. These whole two months we have taken irradiance and maximum power that is generated by a 60 W panel on the roof top of our academic building. We have taken data at several time from morning to the sunset and got different results and values of irradiation and maximum power generation. Then we have taken the average value of irradiation and power generation. From our data analysis we have seen that during the month of October we have got less irradiation and power than of November. The reason behind this difference is only the more numbers of sunny days in November .The average sunny days are about 93%. We have discussed it briefly in previous. We all know that in winter due to foggy weather we can't get expected irradiation and power but the average irradiation and power that we have got during these two months of October and November 2018 was expected enough.

CHAPTER 5

CONCLUSION AND DISCUSSION

5.1 Conclusion

Overall enthusiasm for essentialness will be more than twofold by mid-century and more than triple persistently end. Dealing with this interest is society's driving test. Maintainable power source progress in existing imperativeness advancements can overcome any impediment between the present creation and tomorrow's needs. The colossal unfamiliar ability of the sun situated imperativeness is a pleasant opportunity to meet our future essentialness needs. By and by the open door has just traveled every which way to retain helper set up for using this unfamiliar resource.

Bangladesh, tricky east of India on the Narrows of Bengal, is a South Asian nation of lavish greenery and numerous conduits. It is situated between 20.87°N and 26.48°N scope and 88.35°E and 92.3°E longitude [29]. The region of Bangladesh contains of around 147,570 square kilometers of absolute territory joined by various waterways. Bangladesh is a tropical nation feeling dry climate from September to May and experiencing rainstorm from June to August. It comprises of eight divisions named Dhaka, Chittagong, Khulna, Rajshahi, Barisal, Sylhet, Rangpur and Mymensingh. Practically all locales are experiencing power emergency. Power supply in the provincial regions is inadequate which scarcely address the issues especially in a few territories where power has not come to yet. Portions of new power plants are exorbitant yet the interest is expanding. To take care of the total demand of power, employments of sun based vitality could be a major chance and the measure of sun powered vitality episode over Bangladesh makes it helpful. Albeit sun oriented home framework is very famous in Bangladesh. The establishment of sun based home frameworks give a helpful and viable method for power by providing excellent, dependable, clean, and naturally inviting vitality administrations It hugy affects the lives of the off matrix region individuals in Bangladesh by furnishing them with various immediate and backhanded financial

advantages. In any case, some specific confinements like high age cost, absence of adequate back up help by battery, visit battery additional because of high rate of DOD, absence of good quality sunlight based board, yield decrease because of shading and residue development, inconsistent task amid blustery seasons and shady climates and so forth present genuine dangers to the wide scale utilization of SHS in future. As the off network country families don't have any decision yet to utilize the SHS as it is the accessible wellspring of power, any PV based focal power age will change the general situation in the use of discrete sun oriented home framework.

For utilizing the solar power more effectively, it is very important to measure the irradiation of that country time to time because the sun radiation is altered over time. In this thesis, our main aim was to find out the irradiation of sun in Dhaka city in the month of October and November so that the power manufacture by the solar panel can be estimated and by using this data we can easily understand the electricity production by SHS and create a standard form of power production of SHS in 2018. Here we find that the average irradiation of October 7.62 kWh/m^2/day and November was 7.8 kWh/m^2/day. The consistent power produced by 60W solar panel was 16.93 W and 13.4 W respectively.

5.2 Future Scope

In this research, we try to elucidate that how much power can be produced in the month of October & November 2018 from a solar system. We have worked only for two months but in future we can amount power and irradiation throughout the year along with the analysis of panel efficiency.

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