PERFORMANCE & COST ANALYSIS OF SOLAR ROOFTOP SYSTEM UNDER DHAKA POWER DISTRIBUTION COMPANY (DPDC)

A Thesis submitted in partial fulfillment of the requirements for the Award of Degree of

Bachelor of Science in Electrical and Electronic Engineering

By

MD. ASHADULLAH AL GALIB

ID: 151-33-2354

MD. KOWSER AZOM

ID: 151-33-2426

Supervised by

PROFESSOR DR. M SHAMSUL ALAM

Dean Faculty of Engineering

Department of EEE

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

FACULTY OF ENGINEERING

DAFFODIL INTERNATIONAL UNIVERSITY

JANUARY 2019

Certification

This is to certify that this thesis entitled "Performance & cost analysis of solar rooftop system under Dhaka Power Distribution Company (DPDC)" is done by the following students under my direct supervision and this work has been carried out by them, This work has been completed by the Solar rooftop System under the DPDC & Daffodil solar lab 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 January 2019.

Supervised By

_____

Prof. Dr. M. Shamsul Alam

Professor

Department of EEE

Dean, Faculty of Engineering

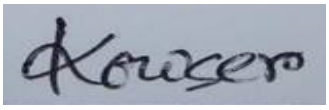
Daffodil International University

Signature of the candidates

_____

Name: MD. ASHADULLAH AL GALIB

ID: 151-33-2354



_____

Name: MD. KOWSER AZOM

ID: 151-33-2426

Dedicated To

Firstly we want to dedicate this thesis to almighty God. Also we dedicate this paper to our Parents, honorable Teachers & all of our friends.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

List of Abbreviations

BD	Bangladesh
SRS	Solar Rooftop System
SHS	Solar Home System
Govt.	Government
IDCOL	Infrastructure Development Company Ltd
DPDC	Dhaka Power Distribution Company
PV	Photovoltaic

ACKNOWLEDGEMENT

At the end of our thesis, we would like to thank the Almighty GOD who bestowed us with knowledge to make this thesis possible and unforgettable experience for us.

Then we would like to take this opportunity to express our appreciation and gratitude to our thesis supervisor **Professor Dr. M. SHAMSUL ALAM, Dean Faculty of Engineering** for being dedicated in supporting, motivating and guiding us through this thesis. This thesis can't be done without his useful advice and helps.

We also want to convey our thankfulness to our honorable co-supervisors & all of our honorable teachers **Department of EEE** for their help, support and constant encouragement.

Apart from that, we would like to thank our entire friends for sharing knowledge, information and helping us in making this thesis a success. Also thanks for lending us some tools and equipment.

To our beloved family, we want to give them our deepest love and gratitude for being very supportive and also for their inspiration and encouragement during our studies in this University.

ABSTRACT

Daily headlines make everyone aware of the dangerous long-term effects of power generation from the fossil fuels. It is widely believed that continuing to depend on fossil fuels to generate electricity can cause serious environmental problems. We also know that non-renewable energy come from a finite resource so it doesn't continuously flow of energy. That's why renewable energy is one of the way for solve this problem. Solar energy is the best option of renewable energy. Solar energy is one of the most popular form of renewable energy in BD. The use of solar panel is increasing rapidly all over the world. Fortunately, the location of Bangladesh is quite suitable for harnessing solar energy. However, large area is still uncovered either by grid electricity or by electricity generated from renewable sources. In the off grid areas of Bangladesh, solar home system (SHS) is getting popular day by day due to its Declining price and due to favorable financial packages offered through Infrastructure Development Company Ltd. (IDCOL). A solar rooftop system, is a photovoltaic system that has its electricity-generating solar panels mounted on the rooftop of a residential or commercial building or structure. In our thesis we work over presence performance of SRS. We try to show the presence Circumstance of SRS in percentage, consumer opinion, data analysis & calculation of cost per unit. Most of the interviewed people do not either maintain the system or want to repair it. It is very unfortunate that most of the systems were found inactive or not connected in a proper way. Although urban people are more likely to know the efficient use of solar energy, they still prefer fossil fuels for their power generation so we provide some recommendation in our survey for increasing the SRS as like as net metering system, increasing consumer awareness, provide training for how to maintenance, provide lone for install the SRS. All those recommendation for the achievement of sustainable growth in the production of solar rooftop energy.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Power is one of the most important factors in developing country. Bangladesh is one of the dense populated & developing country for this reason the demand of power is increasing day by day. Though many power generation units have been added to the national grid to solve the power crisis issue, but it is not enough. High demand and increasing need of power have created challenge for the power stations to meet the demand. That's because Bangladesh is offering many options and opportunities for utilizing renewable energy sources for generating electric power.

1.2 Review of Solar Energy

The sun and wind were the only sources of energy on the beginning of Earth. The sun has given heat and light for millions of years and is directly responsible for sustaining all life on earth. All the forms of energy is started with sun. Such as wind is made by temperature which is come from sun.

As the human population increased over time, so did humanity's dependence on fire. This increase in population led to severe shortages of wood in some areas of the world. By the sixteenth century, for instance, Great Britain had so few trees left because of overcutting that the British people had to switch to a completely new source of fuel.

In place of trees, they began to use coal. Coal, oil, and gas are called fossil fuels because they are extracted from fossilized plant and animal material from deep under the ground [1]. Coal, petroleum, and natural gas are considered nonrenewable because they can't be replenished in a short period of time. Day by day the fossil fuel is decreasing for maintain the present energy demand of the population in all over the world. So now a days all the empirics are thinking about the different ways to cover the present demand of energy all around the world decreasing the use of fossil fuel. So all the empirics depends on the renewable energy to recover the demand.

At present, installed Generation capacity (July'2018) has increased to 16048 MW [2]. Maximum generation in history is 11,387 MW as on 18/07/2018[3]. At present, 56% of the total electricity generation of Bangladesh is from the power plants under public sector and 46% of the net generation of the country is from private sector.

Bangladesh has 15 MW solar energy capacity through rural households and 1.9 MW wind power in Kutubdia and Feni. Bangladesh has planned to produce 5% of total power generation by 2015 & 10% by 2020 from renewable energy sources like wind, waste & solar energy. The country's prospect of geothermal energy extraction has also been discussed by researchers. Studies carried out by geologists suggested geothermal resources in northwest and southeast region [2].

There is another difficulties that is a huge number of people lives in remote and rural areas all over the world without electricity. To make the scenario more difficult, people are sparsely populated in these places. Out of many other reasons for not being electrified are very low power demand and heavy economic burden to the government to build Infrastructure etc. This difficulties can be solved to depends on solar home system it's like the off grid renewable system are regarded as one of reliable and cost effective technological solution for the electrification of remote and rural areas.

The proper electricity distributed area like urban area only depends upon the electricity which provide from the government or non-government distribution institutions. If the consumers on the urban area installed the Solar Rooftop System (SRS) they can produce some electricity. They can use the electricity by storing to the Instant Power Supply (IPS) system. The system will help to reduce per unit cost in the pick demand hours. And when the consumer produce extra energy they can provide it to the on grid system. Those the consumer will be benefited when the net metering system will started in our country it help to count the amount of electricity which the consumer provide to the grid. And annually they will be payied from the government institution who provide the electricity.

1.3 Problem Statement of Solar

In Bangladesh there are a lot of problems for proper utilize and proper production of solar energy they are, High installment cost & Low quality of solar panel in Bangladesh. The life of battery is very low in Bangladesh for off grid system. The people who set up the solar rooftop system under policy obligation don't concern about their solar system so they have no panic about the disorder SRS. There are no proper training to maintain and care about the solar system. The consumer have a psychological problem that is they think the solar system is just waste of money because there is no net metering system.

1.4 Objectives

The objectives of this thesis are

1. To investigate about all the solar rooftop system and collected some information as well as some data from the consumer under DPDC.
2. To apply our survey data and calculate and compare per unit cost between solar under DPDC and Daffodil solar lab.
3. To study about solar system.

4. To design graph of zonal SRS situation.
5. Finally we reached our conclusion and have given some recommendation

1.5 Outcomes

- If the consumer generate extra electricity and net metering system is developed in solar system they will be paid by the organization. Then the consumer will be interested to increase their solar system as well as they will concern about the proper utilization of solar energy.
- The people will be interested to set new solar system or will be increased the solar system. If some govt. privet organization provide some loan.
- For proper utilization of solar energy and maintenance of solar system, consumer needs some training. If the proper training has been given, then the production of electricity will increase as well as the efficiency will increase.
- For better production and reduce per unit cost of electricity from the solar system. We have to reduce the solar panel cost. And ensure the better quality of solar panel.

1.6 Thesis Outline

This Thesis is organized as follows:

1. Introduction.
2. Literature review.
3. Methodology.
4. Data analysis and Result.
5. Conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are many types of energy in Bangladesh as well as all over the world. For the more and more energy demand now a days the fossil fuel is decreasing day by day that is why we should improve the use of renewable energy and depend upon those energy. In this chapter the types of energy are explained as well as here discuss about the renewable energy and broadly explained about the solar system.

2.2 Definition of energy

Energy is the ability to do work, and work is moving something against a force, like gravity. There are a lot of different kinds of energy in the universe, and that energy can do different things.

2.3 Energy conversion and transformation

Energy can neither be created nor destroyed; energy can only be transferred or changed from one form to another. For example, turning on a light would seem to produce energy; however, it is electrical energy that is converted [4]. Various transformations of energy are shown in the figure: 2.1 below

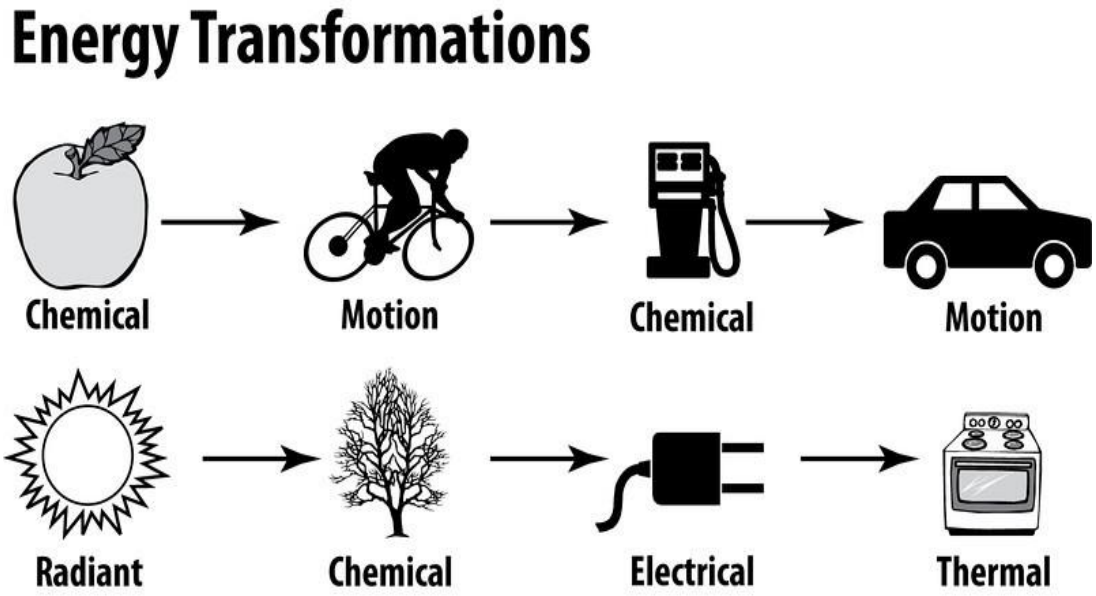


Fig: 2.1- Energy Transformation

— Energy produces light.

— Energy produces heat.

— Energy produces motion.

— Energy produces sound.

— Energy produces growth.

2.4 Classification of energy

There are 4 types of energy they are:

- Primary and Secondary energy.
- Conventional and Non-conventional energy.
- Commercial and Non-commercial energy.
- Renewable and Non-renewable energy.

2.4.1 Primary and secondary energy

- The term primary energy is used to designate an energy source that is extracted from a source of natural resources. That has not undergone any transformation or conversion other than cleaning or removing. Such as: sunlight, coal, gas etc.
- Secondary energy refers to any energy that is obtained from an energy source employing conversion or transformation process. Such as: electricity, coke, oil, thermal etc.

2.4.2 Conventional and non-conventional

- Conventional energy are those that are obtained through commonly use technology. The sources of energy used for mass generation of power. Such as: thermal, hydro-power, nuclear power.
- Non-conventional energy are obtained using new and novel technology. The non-conventional sources of energy used for generating lesser magnitude. Such as: wind power, tidal power, biomass power, geo- thermal energy, solar power.

2.4.3 Commercial and Non-commercial

- Commercial energy are those that are traded wholly in the market place and have market price. By far the most important forms of commercial energy are electricity, coal and refined petroleum products.
- Non-commercial energy are those which don't pass through a market place and accordingly do not have a market price. Such as: cow-dung, firewood, agro waste etc.

2.4.4 Renewable and Non-renewable

- A non-renewable resource is a natural resource that cannot be re-made or re-grown at a scale comparable to its consumption.
- If non-renewable resources are resources that cannot be re-made at a scale comparable to its consumption, what are renewable resources?

If any primary energy is obtained from a constantly available flow of energy. The energy is known as Renewable energy.

There are many types of renewable energy.

- Hydro-power.
- Wind power.
- Solar energy.

Hydro-electric power:

A generation station which utilizes the potential energy of water at a high level for the generation of electrical energy is known as hydro-electric power.

Hydro-electric power station are generally located in hilly areas where dams can be built conveniently and large water reservoirs can be obtained. Water head is created by constructing a dam across a river or lake. From the dam, water is led to a water turbine. The water turbine captures the energy in the falling water and changes the hydraulic energy into mechanical energy at the turbine shaft. The turbine drives the alternator which converts mechanical energy to electrical energy. In fig: 2.2 we can see the schematic diagram of Hydro-Electric power station.

In our country there is only a hydro-electric power station on the karnaphuli river at kaptai named as ‘karnafuli hydroelectric power station’. The install capacity of karnafuli hydroelectric power station is 230 MW[5].

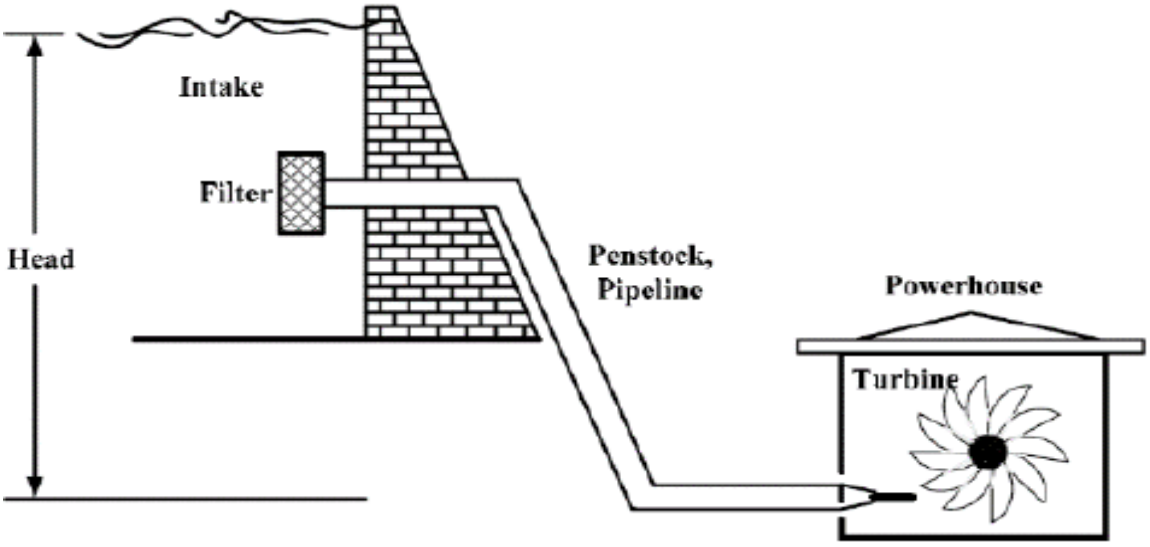


Fig: 2.2- Schematic Diagram of Hydro-Electric Power Station

Advantages of hydro-electric power:

- It require no fuel only water is used for the generation of electricity.
- It is quite neat and clean as no smoke and ash are produced.
- It is comparatively simple and requires less maintenance.
- It is robust and has a longer life.

Disadvantages of hydro-electric power:

- It involves high capital cost due to construction of dam.
- There is uncertainty about the availability of huge amount of water due to dependence on weather conditions.
- Skilled and experienced hands are required to build the plant.

Wind power:

Wind is also another renewable energy source that could be utilized to overcome the energy crises of the Bangladesh. In our country there is no any suitable wind data available.

Therefore, the proper depiction related to the availability of wind energy cannot be obtained. Bangladesh has a 724 km long coast line and many small islands in the Bay of Bengal, where strong south-westerly trade wind and sea-breeze blow in the summer months and there is gentle northeasterly trade wind and land breeze in winter months [6]. Along the coastal area of Bangladesh, the annual average wind speed at 30m height is more than 5 m/s [7]. Wind speed in northeastern parts in Bangladesh is above 4.5 m/s while for the other parts of the country wind speed is around 3.5 m/s [7, 8].

Coastal locations of Bangladesh such as Chittagong, Kutubdia and Cox's Bazar have immense potential to produce electricity from wind energy. By using one year data of Bangladesh Centre for Advanced Studies, it has been found that at 50 meter height in these areas the wind speed varies from 4.1 to 5.8 meter/second with a power density of 100-250 w/m2 [9]. An analysis of wind energy measurement done by RISOE shows locations with power density above 200 w/m2 over 2000 km2 which is very good to set up wind turbines and expand wind energy in Bangladesh [9]. To check whether wind energy can be a potential renewable source of electricity, small scale wind turbines can be installed in areas in Bangladesh such as St. Martins Island, Patenga, Bhola, Barguna, Dinajpur, Thakurgaon and Panchagar [7]. So from the above discussion we see that there is a huge possibility of extracting electrical or mechanical energy from the wind in Bangladesh.

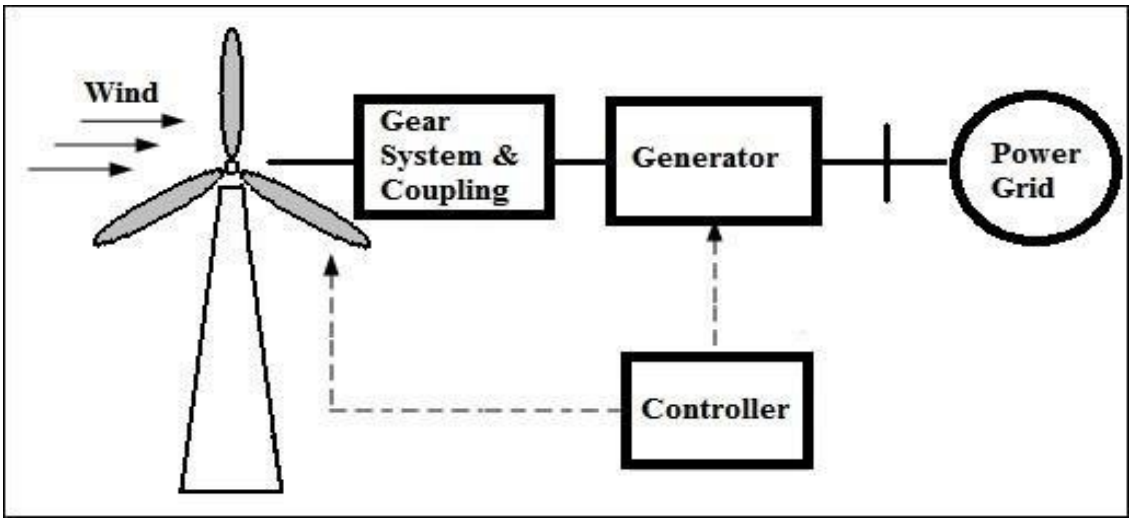


Fig: 2.3- Schematic Diagram wind Power Station

Advantages of wind energy:

- It require no fuel only wind is used for the generation of electricity.
- It is quite neat and clean as no smoke and ash are produced.
- Less maintenance cost.
- It emits no air pollutants or greenhouse gases.

Disadvantages of wind power:

- High installment cost.
- Technology immaturity.
- Difficult to land selection.

In Bangladesh there is a little bit land available hilly areas with huge water reservoirs. For this reason we can not build economically and the man power are so poor for handle hydro power generation.so it is difficult to build in Bangladesh effectively. And Bangladesh is on of the seasonal wind country so the circulation of wind is varying per season in Bangladesh .that is the main difficulties to produce electricity using wind mill. And the maintenance is not easy in wind energy so the wind energy is also not very much effective in this country.

On the other hand the solar energy is more simple, efficient, economic, and effective to produce electricity comparably the other renewable energy in Bangladesh.so now a days the solar energy is vastly used all around the country.

2.5 Solar Energy

Fig: 2.4 Solar panel

Solar energy is, simply, energy provided by the sun. From fig: 2.4 the sun light fall to the solar panel and energy is in the form of solar radiation, which makes the production of solar electricity possible.

Electricity can be produced directly from photovoltaic, PV, cells. (Photovoltaic literally means “light” and “electric.”) These cells are made from materials which exhibit the “photovoltaic effect” i.e. when sunshine hits the PV cell, the photons of light excite the electrons in the cell and cause them to flow, generating electricity.

Solar energy produces electricity when it is in demand – during the day particularly hot days when air-conditioners drive up electricity demand. In use, solar energy produces no emissions. One megawatt hour of solar electricity offsets about 0.75 to 1 tone of CO2 [10]

2.5.1 History of solar energy

On those early days in the earth people only depends on sunlight and wind energy. Then again all the energy comes from the sun. Solar energy was used by humans as early as 7th century B.C. when history tells us that humans used sunlight to light fires with magnifying glass materials. Later, in 3rd century B.C., the Greeks and Romans were known to harness solar power with mirrors to light torches for religious ceremonies. These mirrors became a normalized tool referred to as "burning mirrors." Chinese civilization documented the use of mirrors for the same purpose later in 20 A.D.

Another early use for solar energy that is still popular today was the concept of "sunrooms" in buildings. These sunrooms used massive windows to direct sunlight into one concentrated area. Some of the iconic Roman bathhouses, typically those situated on the south-facing side of buildings, were sunrooms. Later in the 1200s A.D., ancestors to the Pueblo Native Americans known as the Anasazi situated themselves in south-facing abodes on cliffs to capture the sun's warmth during cold winter months.

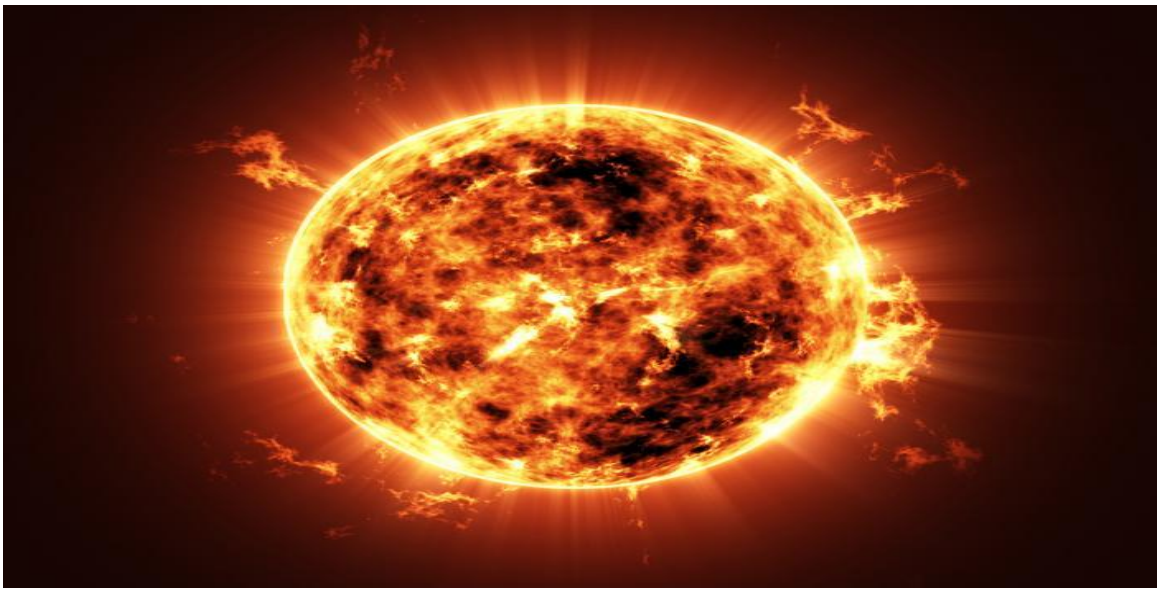


Fig: 2.5 Sunlight radiation

In the late 1700s and 1800s, researchers and scientists had success using sunlight to power ovens for long voyages. They also harnessed the power of the sun to produce solar-powered steamboats. Ultimately, it's clear that even thousands of years before the era of solar panels, the concept of manipulating the power of the sun was a common practice.

In 1873, Willoughby Smith discovered that selenium had photoconductive potential, leading to William Grylls Adams' and Richard Evans Day's 1876 discovery that selenium creates electricity when exposed to sunlight. A few years later in 1883, Charles Fritts actually produced the first solar cells made from selenium wafers – the reason some historians credit Fritts with the actual invention of solar cells.
However, solar cells as we know them today are made with silicon, not selenium. Therefore, some consider the true invention of solar panels to be tied to Daryl Chapin, Calvin Fuller, and Gerald Pearson's creation of the silicon photovoltaic (PV) cell at Bell Labs in 1954. Many argue that this event marks the true invention of PV technology because it was the first instance of a solar technology that could actually power an electric device for several hours of a day [11].

2.6 About solar panel

We described in this article about the parts that means those elements which are used for construct the solar panel & the types of solar panel.

2.6.1 Parts of solar panel

Solar panels are devices that convert light into electricity. They are called "solar" panels because most of the time, the most powerful source of light available is the Sun, called Sol by astronomers. Some scientists call them photovoltaics which means, basically, "light-electricity." The following figure: 2.6 shows different parts of the solar panel.

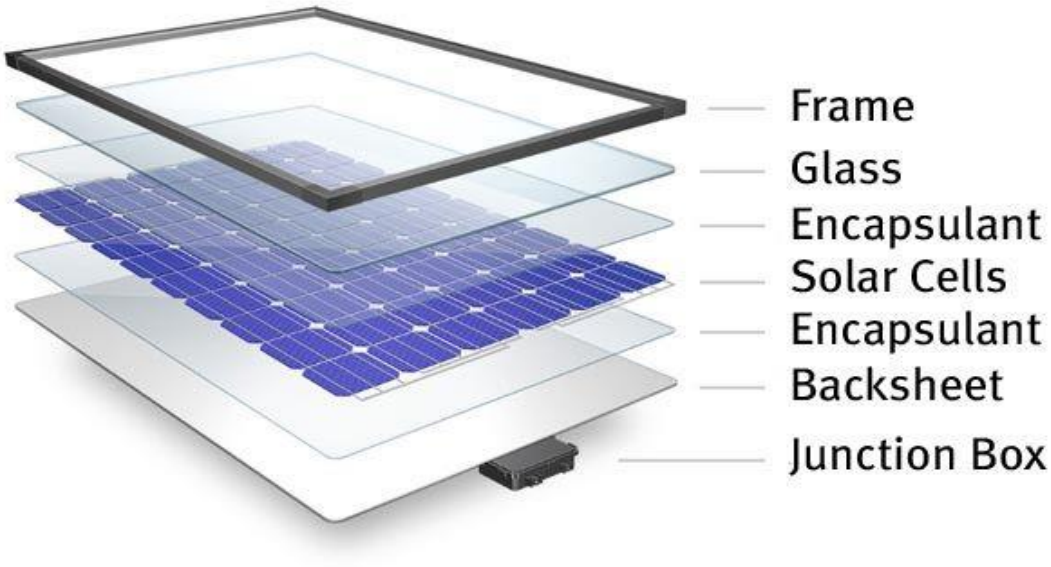


Fig: 2.6 Parts of solar panel

Frame: Solar frame is made by aluminum. It used to adjust all those element needed in solar panel.

Glass: Mainly glass is used because it's cheap. The cover glass needs to offer low reflection, high transmissivity and high strength. And it helps to proper production of electricity because it's protect the dust fall down to the solar cell.

Encapsulant: Encapsulant mainly made by Ethyl vinyl acetate (EVA). EVA comes in thin sheet those are inserted between the solar cell and the top surface and rear surface.

Solar cell: Solar cell is a photovoltaic cell, which is made by silicon and germanium. Between two cells there is a thin aluminum layer.

Back sheet: Back sheet is made by polyvinyl fluoride (PVF). For cheap solar back sheet module is produced by polyethylene terephthalate (PET).

Junction Box: A PV junction box is jointed to the backward of the solar panel. It wires the four connector together and is the output interface of the solar panel.

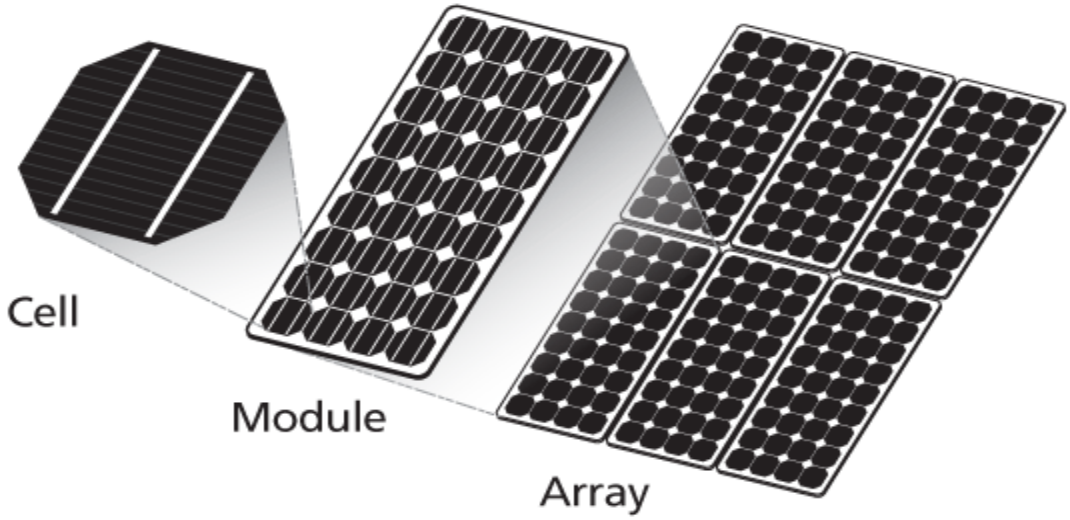


Fig: 2.7 Solar Cell, Module & Array

A number of solar cell inter connected to each other and it form to the solar module or PV module. The total number of cells in a module will vary, as will the module's effectiveness. That's shown in fig: 2.7. Because a single solar module can only produce so much electricity, multiple modules are often interconnected to create a larger solar panel: the backbone of a solar PV system.

2.6.2 Types of solar panel

Monocrystalline:

Monocrystalline silicon solar panels are the most common and most efficient type of solar panel. Monocrystalline silicon is made by taking a melted vat of silicon, adding a crystalline "seed" to solidify the silicon into bars, which is then cut into squares or "wafers" that make up a solar panel.

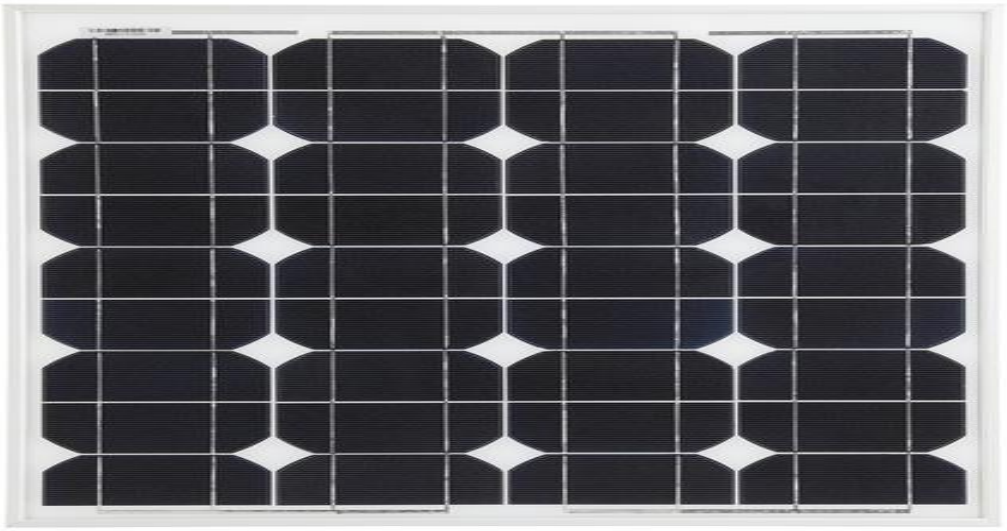


Fig: 2.8 Monocrystalline solar cell.

Polycrystalline:

Polycrystalline silicon is similar to monocrystalline silicon but has fewer steps in its development process. The crystals used to solidify the silicon are not made at the same level of quality and are not as consistent as monocrystalline. These solar cells are square-cut (straight corners), tend to be a bit bluer in color, and look like they have shiny confetti inside.

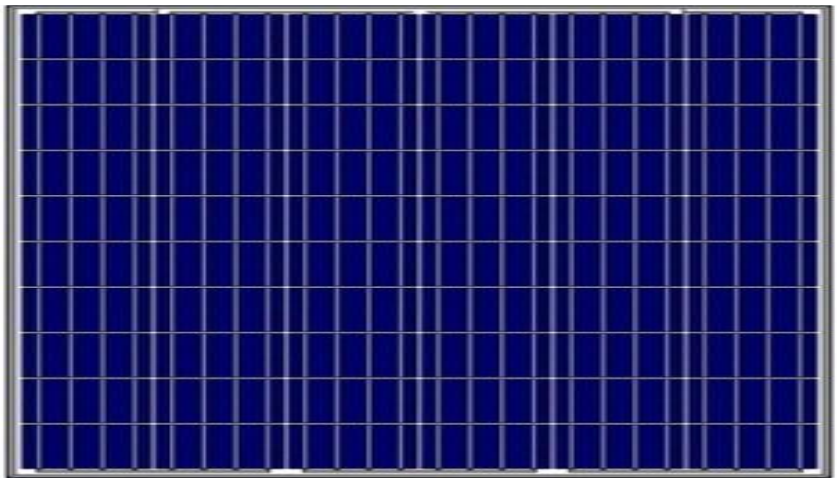


Fig: 2.9 Polycrystalline solar cell.

Thin-film solar cell:

A thin-film solar cell is a second generation solar cell that is made by depositing one or more thin layers, or thin film (TF) of photovoltaic material on a substrate, such as glass, plastic or metal. Thin-film solar cells are commercially used in several technologies, including cadmium telluride (Cd,Te), copper indium gallium diselenide (CIGS), and amorphous thin-film silicon (a-Si, TF-Si).

Fig: 2.10 Thin-film solar cell.

SILICON TYPES OF SOLAR PANELS SUMMARY

Table: 2.1 Silicon types of solar panels summary:

Silicon Cell Type	Efficiency	Key Advantages	Key Disadvantages
Monocrystalline	15%-24%	Most efficient, durable, proven, aesthetically pleasing	Highest cost

Polycrystalline	12%-16%	Lower cost, improving efficiencies	Lower efficiency, poorer aesthetics
Thin film	7%-13%	Low cost, easy to make, best aesthetics	Low efficiency, less proven

2.7 Working principle of solar

Photovoltaics directly convert solar energy into electricity. They work on the principle of the photovoltaic effect. When certain materials are exposed to light, they absorb photons and release free electrons. This phenomenon is called as the photoelectric effect. Photovoltaic effect is a method of producing direct current electricity based on the principle of the photoelectric effect [12].

The operation of a photovoltaic (PV) cell requires three basic attributes:

- The absorption of light, generating either electron-hole pairs or excitons.
- The separation of charge carriers of opposite types.
- The separate extraction of those carriers to an external circuit. [13]

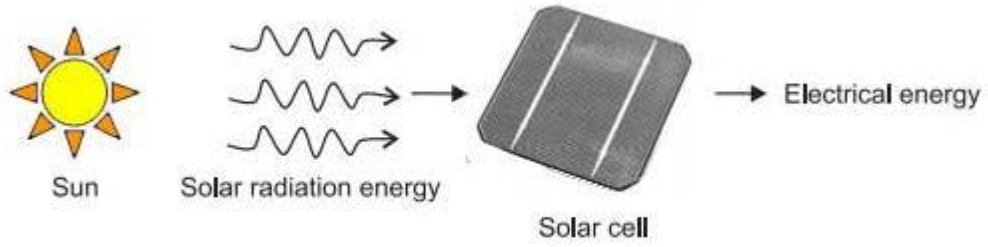


Fig: 2.11 solar radiation to electrical energy.

In solar panel the photon particle is represent as heat energy comes from the sun. Which is fall down to the junction of silicon and germanium and as a result it is converted heat energy to DC electricity. The DC electricity from the panel comes to the Maximum Power

Point Tracking (MPPT) module. The MPPT or Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. In fig: 2.8 the energy production from the solar system is shown.

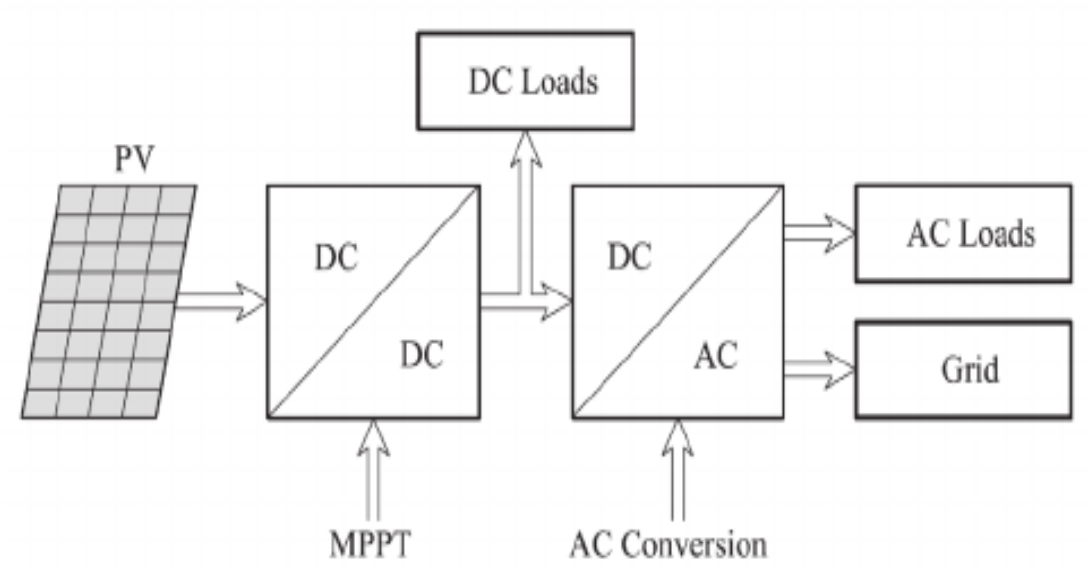


Fig: 2.12 Block diagram of solar system.

After that some people store the DC electricity on the battery and wants to use DC component like as DC fan, DC light etc. It is known as off grid system. In this system if the consumer use the electricity in pick demand hour the proper electrification will occur.

Otherwise when the people wants to use AC component as well as they used to provide electricity to the grid it's needed the DC electricity convert to AC electricity by using DC to AC inverter. After personal use when extra electricity are produce on the system consumer can provide the extra electricity to the nation grid it is known as on grid system.

2.8 Present performance of solar in the world

Investments in solar PV capacities are now rapidly growing in both grid connected and off grid mode. Solar generation has been a reliable source for supplying electricity in regions without access to the grid for long. However, the penetration of solar energy as a grid connected power source has increased significantly only in the last decade. Thus the overall share in net energy generation still remains low at only 1% (2015) globally and is bound to only increase in future.

GLOBAL TRENDS:

PV is mainstream technology. Global installed capacity for solar-powered electricity reached around 227 GWe at the end of 2015 , while total capacity for solar heating and cooling in operation in 2014 was estimated at 406 GWth . Photovoltaic (PV) has been the mainstream solar power technology as shown in Figure 2.9 below.

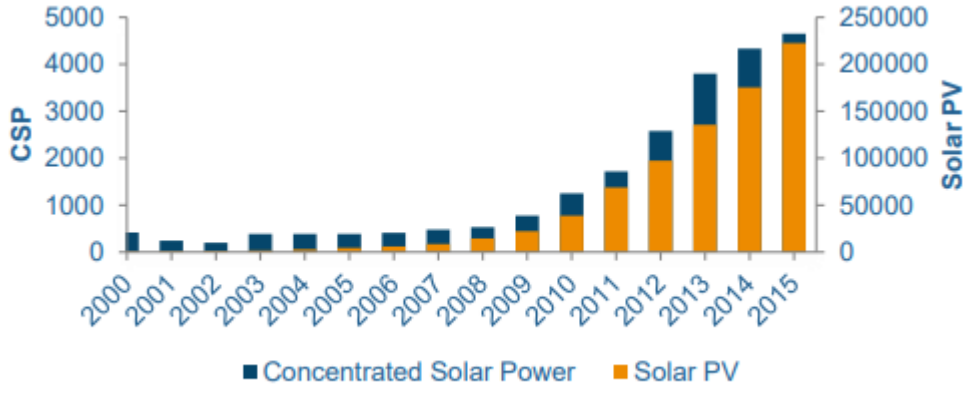


Fig: 2.13 Global Installed Solar Power Capacity, 2000-2015 (MW) [14].

Top 10 solar energy installed country

Table: 2.2 Top 10 solar energy installed country [15].

No:	Country Name	Capacity(MW)	Share of RE
01	**China**	78100	25.8%
02	**Japan**	42800	14.1%
03	**Germany**	41200	13.6%
04	**United States**	40300	13.3%
05	**Italy**	19300	6.4%
06	**United Kingdom**	11600	3.8%
07	**India**	9000	3.0%
08	**France**	7100	2.3%
09	**Australia**	5900	1.9%
10	**Spain**	5500	1.8%

2.9 Present performance of solar in Bangladesh

Solar energy has the greatest potential of all the sources of renewable energy. If only a small amount of this form of energy could be used, it will be one of the most important supplies of energy specially when other sources in the country have depleted energy comes to the earth from the sun. Solar Energy can be a great source for solving power crisis in Bangladesh.

Bangladesh is situated between 20.30 and 26.38 degrees north latitude and 88.04 and 92.44 degrees east which is an ideal location for solar energy utilization [16]. The days vs hours of sunlight shown in fig: 2.10.

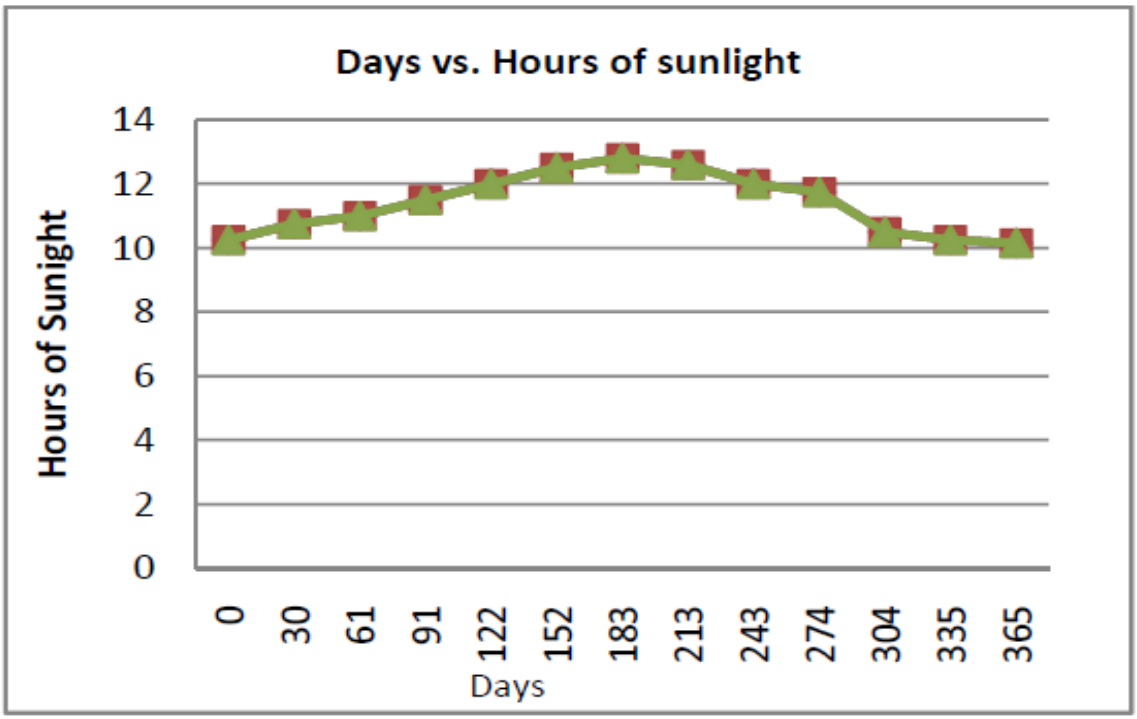


Fig: 2.14 The amount of hours of sunlight in Bangladesh.

BPDB has planned to implement Solar Park Projects on IPP/PPP basis under the Roadmap of ADB's 500 MW Solar Power Mission such as-[17]

i) 40-45 MW Solar Park Project adjacent to Bangabandhu Bridge,Tangail and Sirajgonj area.

ii) 2-3 MW Solar Park Project adjacent to PGCB Grid Sub-station compound, Ishwardi.

iii) 1-2 MW Solar Park Project adjacent to PGCB Grid Sub-station compound, lhenaidaha.

iv) 30 MW p Solar Park Project adjacent to new Dhorola Bridge, Kurigram.

2.10 Solar Home System

Solar energy is one of the most popular form of renewable energy. The use of solar panel is increasing rapidly all over the world. Fortunately, the location of Bangladesh is quite

suitable for harnessing solar energy. However, large area is still uncovered either by grid electricity or by electricity generated from renewable sources. In the off grid areas of

Fig: 2.15 solar home system

Bangladesh, solar home system (SHS) is getting popular day by day due to its declining price and due to favorable financial packages offered through Infrastructure Development Company Ltd. (ID-COL). Around 50,000 SHS are being installed every month under IDCOL program only. Already IDCOL has achieved a target of installing two million SHS by March 2013[18].The area where there is no electricity they use the solar home system. In the rural area in Bangladesh mainly use in the SHS. It's mainly the off grid system.

2.11 Solar roof-top system

Roof-top solar power systems provide energy for both office and households. This comes as an efficient alternative to supplement conventional grid energy and substitute usage of generators.

Fig: 2.16 solar rooftop system

A rooftop photovoltaic power station, or rooftop PV system, is a photovoltaic system that has its electricity-generating solar panels mounted on the rooftop of a residential or commercial building or structure.

Government has set up the goal of providing electricity to all by 2020 and to ensure reliable and quality supply of electricity at a reasonable and affordable price. Development of Renewable Energy is one of the important strategies adopted as part of Fuel Diversification Program. In line with the Renewable Energy policy 2009, the Government is committed to facilitate both public and private sector investment in Renewable Energy projects to substitute indigenous non- renewable energy supplies and scale up contributions of existing

Renewable Energy based electricity productions. The Renewable Energy Policy envisions that 5% of total energy production will have to be achieved by 2015 and 10% by 2020 [19].

2.12 Conclusion

For occupying the energy demand now a days without carbon emission and saving the fossil fuel renewable energy is the best option for us. In Bangladesh the share of renewable energy around 5% of total energy generation. And the share of solar energy around 55.13% of total renewable energy. The vision in 2020 the share of renewable energy will be 10%. The main focus to increase the share in renewable energy is solar.

CHAPTER 3

METHODOLOGY

3.1 Introduction

We worked about solar rooftop system under Dhaka Power Distribution Company (DPDC) and also in our campus solar rooftop lab. We have divided our work into two parts, firstly we have visited to DPDC and completed a survey in the solar rooftop system under DPDC. Secondly we have collected meter reading from our campus solar rooftop lab. Then we combined and compare both work and finally we reached to a decision.

3.2 Working Strategies

We have completed our thesis with in some chronological steps. Like we made a questionnaires which we provided to the consumer for collecting information. Than we selected the site & did a meeting with the authority of DPDC. After that we have completed our survey as well as collected some information. Finally we reached to a conclusion. In fig: 3.1 we show the chronological working strategies in our thesis.

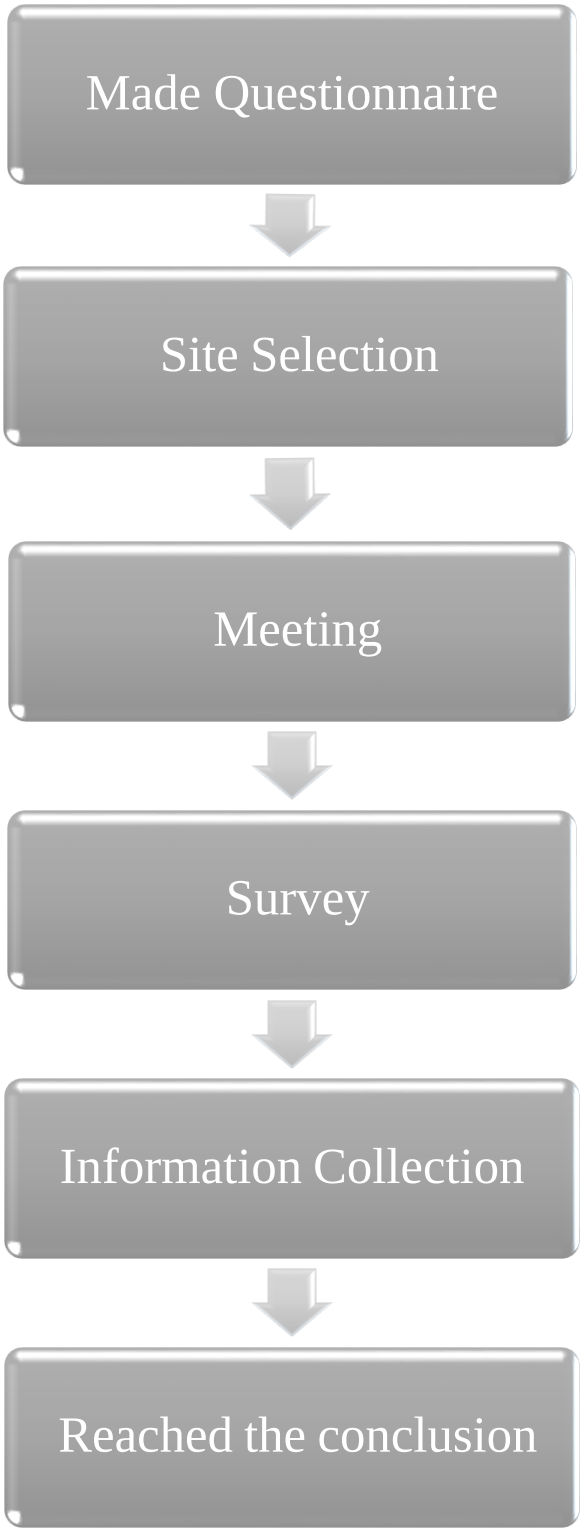


Fig: 3.1 Flow chart of our working strategies

3.3 Site selection for our survey

In our survey work we choose Narayanganj NOCS. There are two zonal office in Narayanganj NOCS they are 1.Narayanganj East (fig: 3.1) and 2.Narayanganj West (fig: 3.2). The site we have selected in Narayanganj for our survey the screen short from google map has been given below.

3.3.1 Narayanganj East

Narayanganj East zone is near to the NOCS main office. The maximum consumer under Narayanganj East are residential. And the maximum SRS are operating in on grid system. The maximum number of consumer situated in this area. In this area the consumer situated closely between each other. We can see the Narayanganj East zone in fig 3.1 below.

Fig: 3.2 selected site (East zone).

3.3.2 Narayanganj West

Narayanganj West zone is a far distence to the NOCS main office. The maximum consumer under Narayanganj West are comertial. And the maximum SRS are operating in on grid system. The less number of consumer situated in this area. In this area the consumer situated Far away between each other. We can see the Narayanganj west zone in fig 3.2 below.

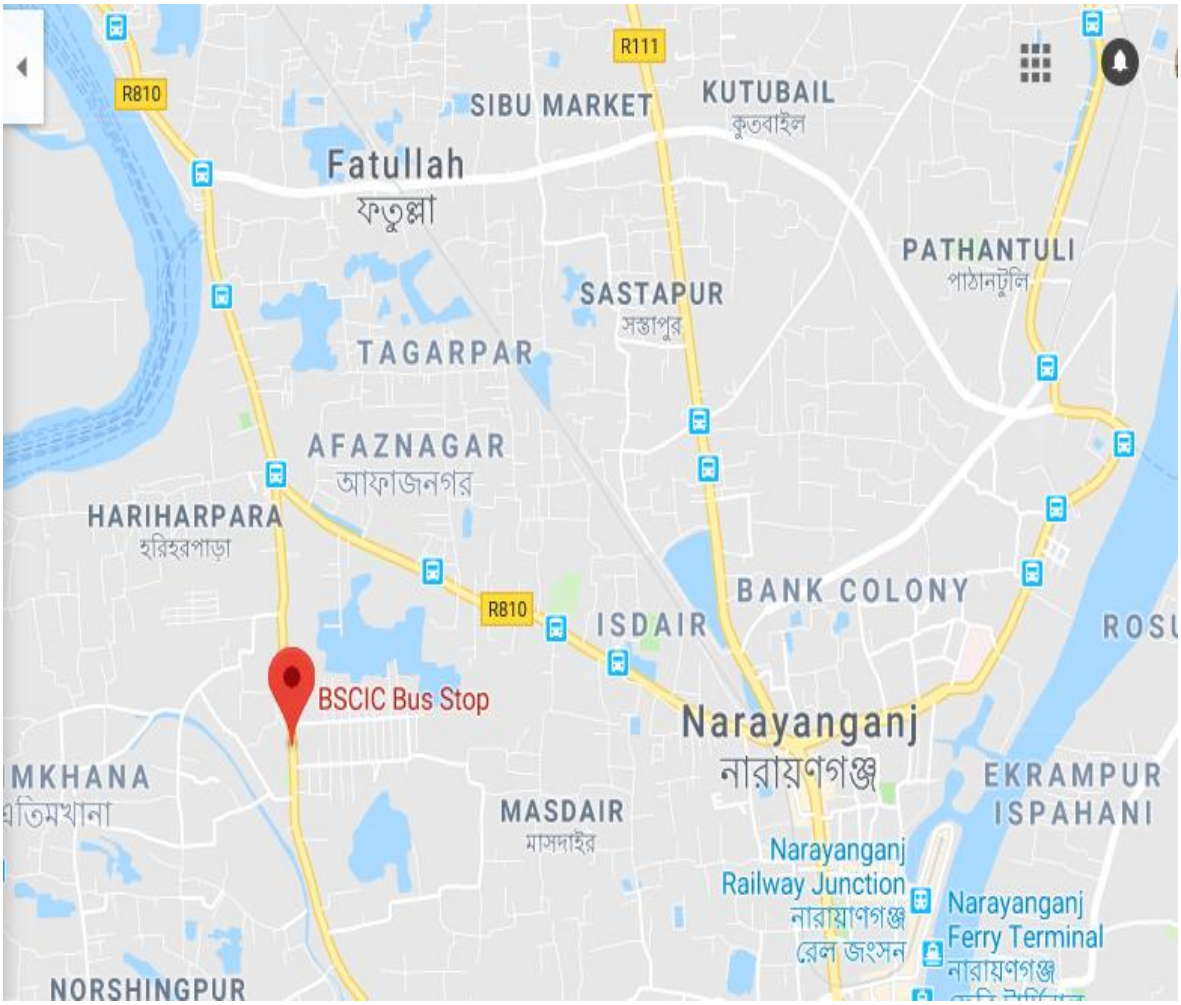


Fig: 3.3 selected site (west zone).

3.4 Survey Work

Within this Thesis, the general objective of the research is to assess the Customer Satisfaction of the solar rooftop system (SRS) service in Bangladesh. But it is required to check out that how the installed systems are operating and if the users are being benefited by the installed solar system. In order to study the above mentioned issue the specific objectives basically consisted in the basis of those question below:

Table: 3.1 Survey Questionnaires for (SRS) under DPDC.

SL No:	Indicator	Questions	Description
01	Consumer information	Owner Name: Consumer No.: Name of the NOCS: Address :	In this question section we have just collected basic information about consumer.
02	Information of Installment	Date of installation: Capacity: What kind of solar rooftop system (SRS) are you installed? i) Do you use the electricity from your system? ii) In which purpose?	We asked the consumer about the installation date, capacity, and types. Some consumer installed on grid and some are installed off grid SRS.
03		i) Is your SRS in operation? ii) Do you test it regular basis? iii) How many days ago?	In SRS the main problem of proper utilization of energy is

	Maintenance	i) What is the main reason for the system disorder? ii) Do you want to repair it?	lower maintenance of the system. Most of the consumer do not know how to clean and maintain properly. They were not trained from any local or govt. institution.
		Do you get any training for SRS operation?	
		i) Do you ever clean your SRS? ii) How often it is done?	
04	Consumer Opinion	Do you think this SRS is useful?	Before started this question section We told them about net metering system and its benefit. Then some consumer interested to develop their present SRS's capacity. Some of them think about the total system is useless and just waste of money. All the consumer installed their SRS for Policy obligation.
		Why do you install this SRS?	
		Do you think, it is a waste of money?	
		How much electricity do you get from SRS?	
		i) Is the meter reading of the solar electricity taken? ii) How often it takes place?	
		Do you have any record on solar electricity?	
		From where you bought SRS?	
		i) Are you fed your solar electricity to the grid? ii) Is there any support from govt.?	
		Do you face any kind of survey?	
		Do you want to increase the capacity of your SRS?	

05	Installment cost	What is the total cost of SRS?	We asked the consumer the total installment cost of their SRS. Some of them clear about the cost of installment and some of them don't clear about the cost of installment.
		Inverter cost	

Based on the various questions described in the table: 3.1 above, we have different types of information from consumers. Firstly we collected all those introduction of the individual consumer like consumer ID, address, name of the NOCS and many more.

Than we have asked some questions to the consumers, such as- what kind of SRS are installed in consumer off grid or on grid? We asked the consumer what do they think about the SRS, is that useful or not or it is waste of money? We checked the SRS is in operation or not. And why they install the SRS is that their own choice or policy obligation and what are the total installment cost of SRS. We have checked the SRS meter and collect the meter reading. And we saw their previous record papers of SRS. Have you got any training from the government or private agency? How to maintain and the cleaning process of the SRS and do you maintain this properly? We also asked to the consumer do you want to increase the capacity of their SRS.

3.5 Work outline of Cost Analysis

When we visited to our required area than we have collected some meter reading from the SRS meter one of the best productive SRS under Narayanganj NOCS (east zone) is H.D.L Kazi bari (61/ Bhasha shohid A.K.M Samsujjoha road, Narayanganj) we visited there at 20th November 2018. The total generation was 3571.56 kWh. And we noted the data from Daffodil solar lab on 26th November 2018. The total generation was 734.6 kWh. The maximum consumer are installed their SRS for public obligation that is why they don't have proper concern to it. They just buy for full fill the requirement. The quality of the solar is not so good because they set up their SRS with very low cost. Then we think that what will happen if the consumer set better quality SRS. And finally we saw the better quality of SRS given the expected energy. The approximate per unit cost compare and calculation has been given in chapter 4.

3.6 Conclusion

In this chapter we describe about our working procedure and the question pattern which we provided to the consumer given in table 3.1. We tried to tell about the benefit from SRS in present power condition and convince them to increase their capacity and quality. We have also explained about the net metering system and the benefit of net metering system.

CHAPTER 4

DATA ANALYSIS & RESULT

4.1 Introduction

Background, concept, policy and present situation of solar electrification dissemination for bringing performance of SRS development in urban areas have been discussed. It is observed from the previous discussion that energy plays the key role for development. Due to rise of fuel price and increasing carbon emission worldwide, there is a global shift towards renewable energy like solar, wind etc. Being in tropical region, Bangladesh is a solar energy rich country. Solar energy can play a vital and secure energy source for sustainable development. The main objective of this study is to assess the impacts of solar energy in rooftop system under DPDC in Bangladesh. We have been surveyed with a structured questionnaire of 25 consumer under Narayanganj NOCS. The survey results are analyzed as follows in the following sections.

4.2 Category of Consumer

There are difference types of consumer in our survey area (Narayanganj NOCS) like industrial, residential, bank, school and hospital. In east zone of Narayanganj NOCS maximum consumer are residential on the other hand in west zone the maximum consumer are industrial. The condition and situation of the consumer in our survey area are given in pie chart fig 4.1 (East zone) and in fig 4.2 (West zone) below.

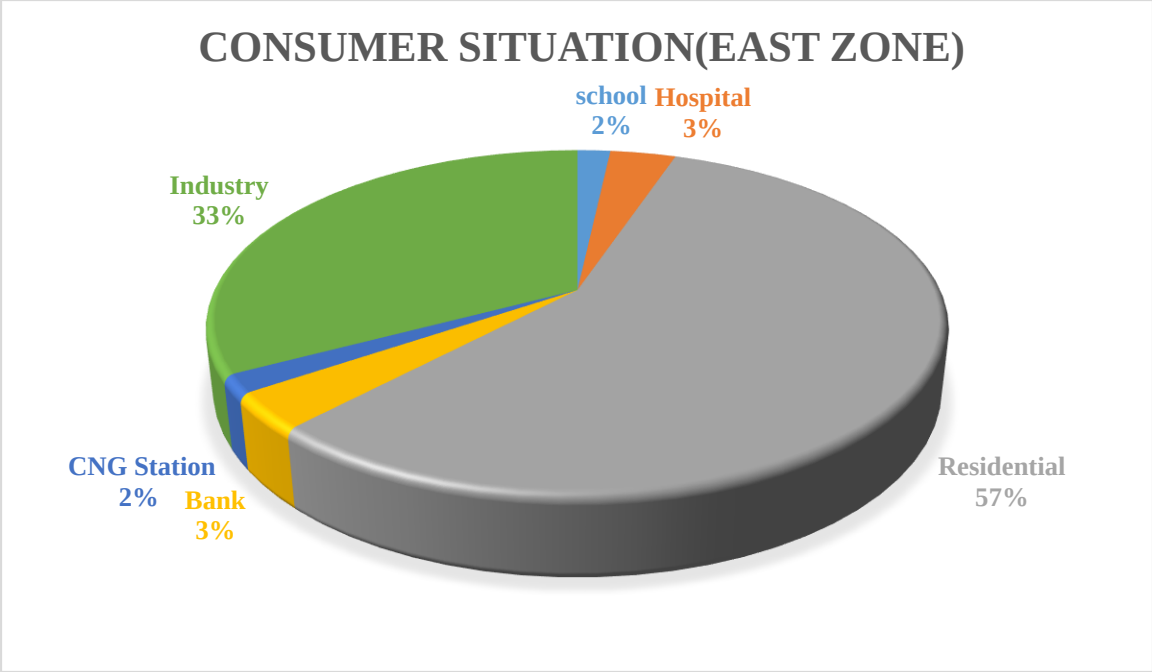


Fig: 4.1 Consumer Situation (East zone).

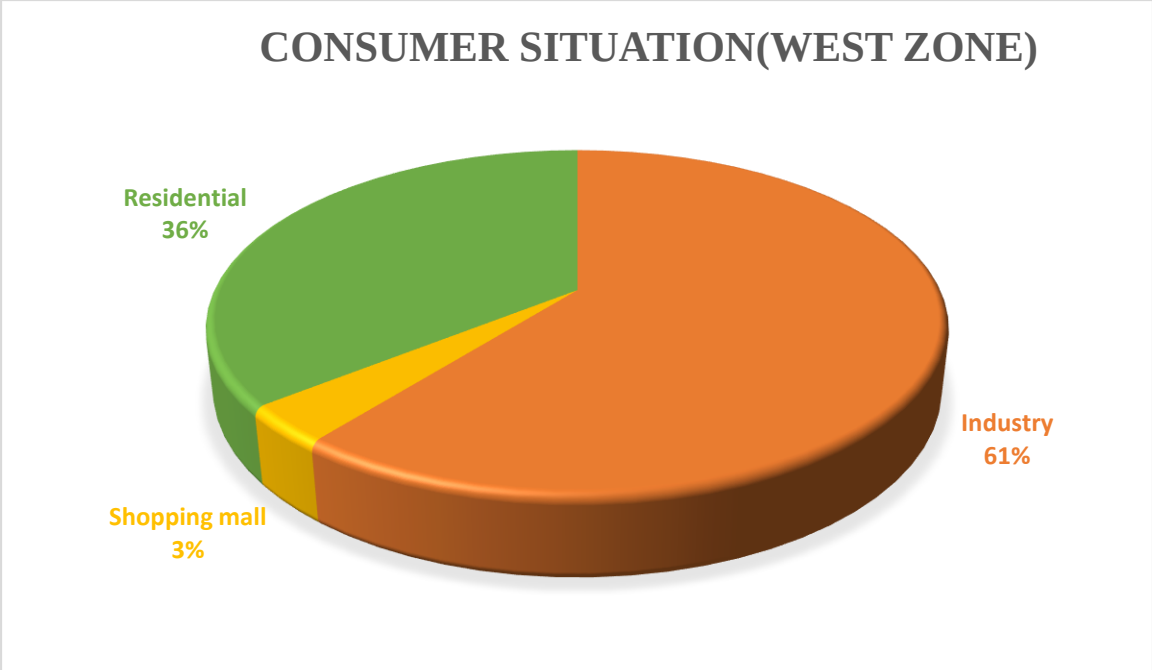


Fig: 4.2 Consumer situation (West zone).

In east zone the total number of consumer is 58 among them 19 are industrial, 1 CNG station, 1 school, 2 hospital, 2 bank and 33 residential. On the other hand in west zone we have found 28 consumers among them 17 are industrial, 1 shopping mall and 10 residential.

4.3 Maintenance and Cleaning

The maximum number of consumer do not know how to clean & maintain the SRS just because lacking of proper training we have tried to show approximate percentage about the consumer who clean & maintain their SRS in fig:4.3 and fig:4.4.

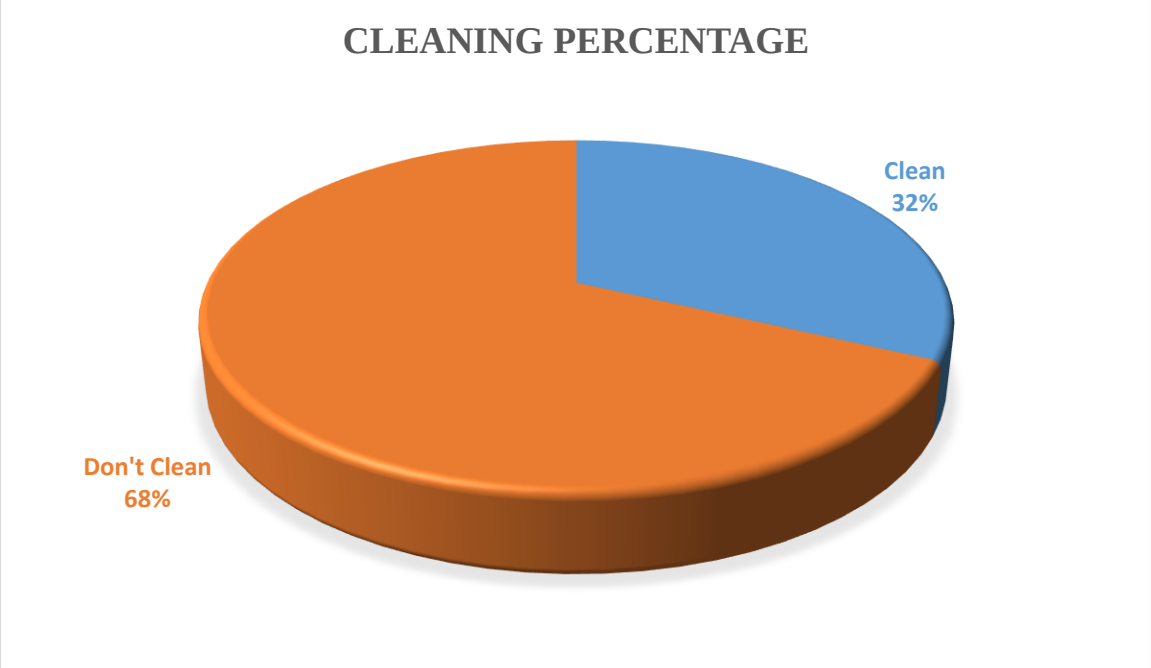


Fig: 4.3 the percentage of consumer who clean or don't clean their SRS.

Around 100 % of the consumer have no training from any public or private organization so they don't know how to proper maintain their SRS. So unfortunately the proper utilization of energy interrupted.

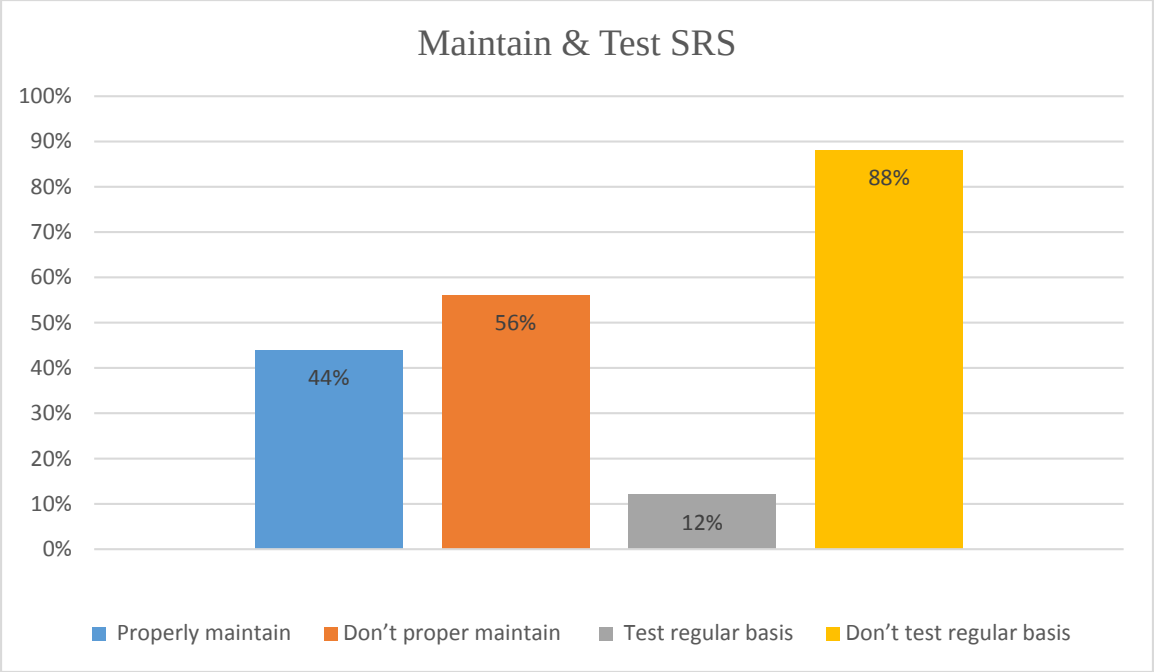


Fig: 4.4 percentage of consumer those proper maintain or not their SRS.

4.4 Statement of Consumer

A lot of information we have found from the consumers. We asked some question to the consumer for collecting the information the questionnaires has given in table: 3.1. The maximum number of SRS are on grid and a few number are off grid. The percentage of on grid & off grid has shown in fig: 4.5.

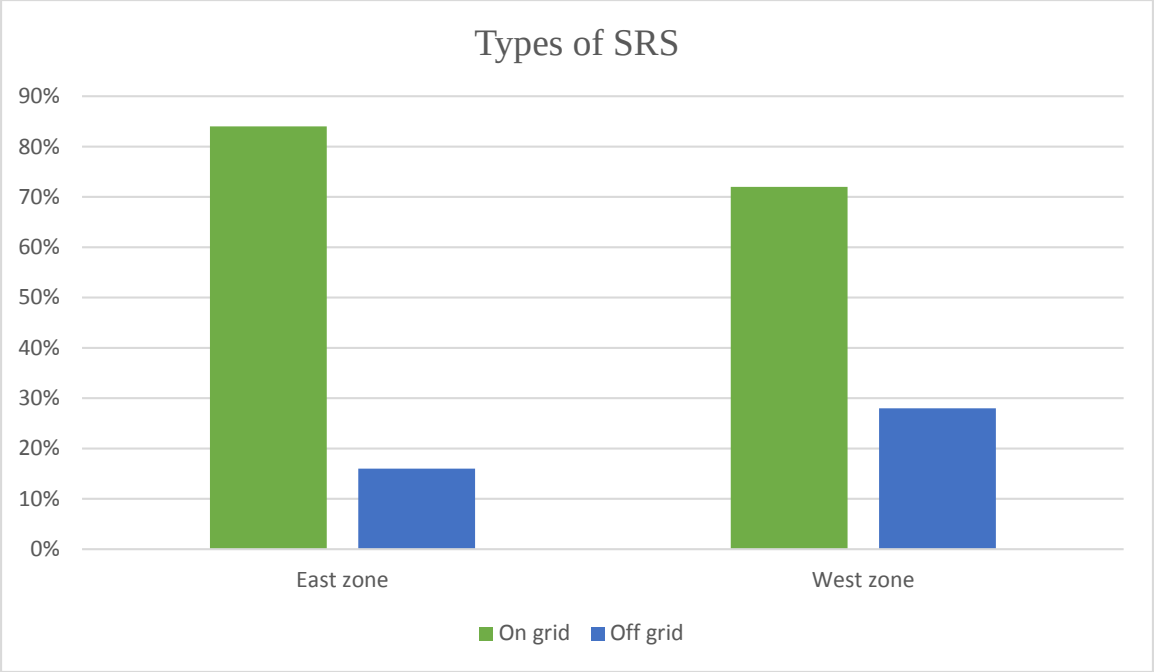


Fig: 4.5 Types of SRS (on grid or off grid)

Many of the consumer think about the SRS is just waste of money some consumer think it is use full to us. Maximum consumer think SRS is waste of money and they do not want to increase their capacity. The consumer who benefited from the SRS and think it's useful they want to develop their SRS. The percentage of consumer realization (useful or waste of money) given in fig: 4.6.

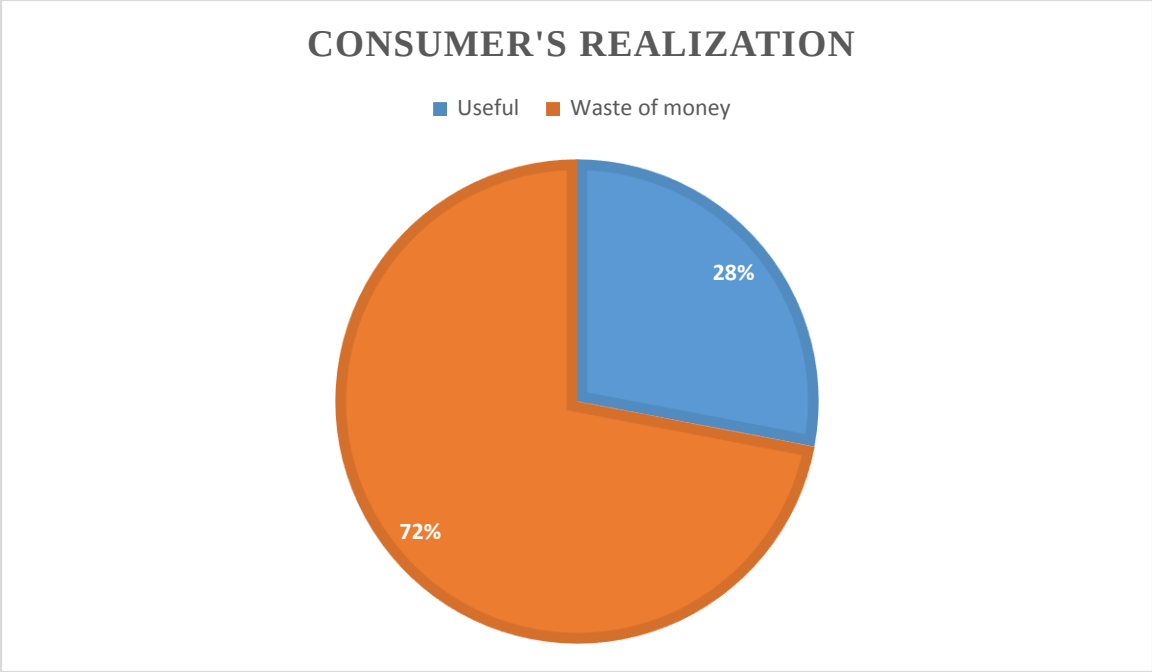


Fig: 4.6 Consumer realization.

In table: 4.1 we try to show the percentage of the consumer who think it's useful and want to increase their capacity and some of the consumer got interest to increase when we told them the benefit of net metering. But the maximum consumer don't want to increase the capacity.

Table: 4.1 Statement of consumer about SRS capacity.

Does consumer increase the capacity of SRS	Percentage	Description
Yes	24%	Some consumer want to develop their capacity of the SRS if they are benefited from the SRS as well as

		starting of net metering system.
No	44%	They just set up the SRS for public obligation and they have no concern about their SRS so they don't want to increase the capacity.
Don't know	32%	For absent the owner of the SRS the information has not clear to us.

4.5 Present Circumstance of SRS

We observed from our survey the maximum number of SRS in residential area in operation but in industrial the maximum number of SRS are disorder. How many percentage of all SRS are in operation or disorder in our survey has been given below in fig: 4.7

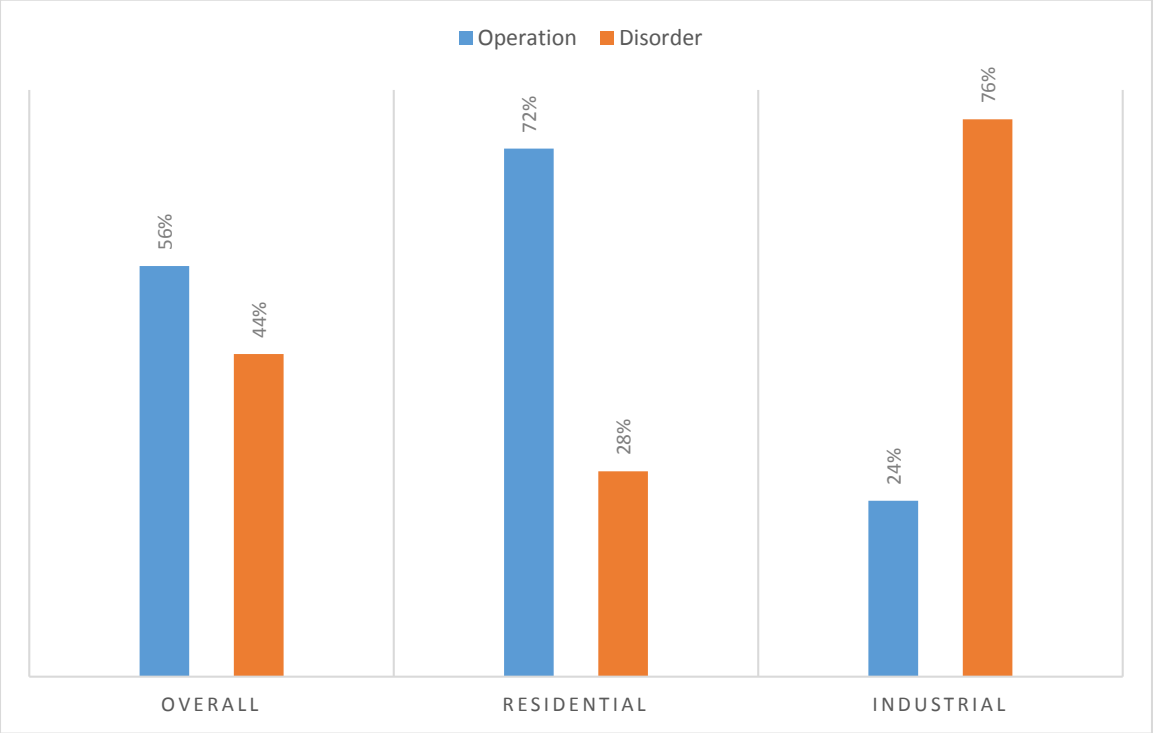


Fig: 4.7 Operation & Disorder percentage of SRS (East zone)

The maximum consumer have no concern to their disorder SRS to repair them. A few number of them wants repair. The approximate percentage given in table: 4.2 below.

Table: 4.2 Percentage of the consumer who wants to repair or not.

Consumer wants to repair	24%
Consumer don't want to repair	76%

4.6 Calculation

In article 3.5 we have declared some quality analysis between one of the best productive SRS under narayanganj NOCS (East zone) & Daffodil solar lab.

For consumer:

Let, life time of SRS is 15 years

Installed capacity = 4.8 kW

Total installment cost = 303000 TK

Electricity generation = 3571.56 kWh (for 9 month).

∴ Per month generation = $\frac{3571.56}{9}$ = 396.84 kWh.

∴ Yearly generation = 396.84 × 12 = 4762.08 kWh.

And life time generation = 5042.208 × 15 = 71431.2 kWh.

∴ Per unit cost (without maintenance cost) = $\frac{303000}{71431.2}$ = 4.242 TK /kWh (approximate).

For solar lab:

Installed capacity = 1 kW

Total installment cost = (80× 1000) + 15000 = 95000 TK

Electricity generation = 734.6 kWh (for 5.8 month).

∴ Per month generation = $\frac{734.6}{5.8}$ = 126.65 kWh.

$\therefore$ Yearly generation $= 126.65 \times 12 = 1519.8$ kWh.

And life time generation $= 1519.8 \times 15 = 22797$ kWh.

If the capacity of SRS improved to 4.8 kW

Then the life time generation $= 22797 \times 4.8 = 109425.6$ kWh.

In this case the total installment cost $= (80 \times 4800) + 15000 = 399000$ TK.

$\therefore$ Per unit cost (without maintenance cost) $= \frac{399000}{109425.6} = 3.65$ TK (approximate).

Per unit cost difference between consumer & solar lab $= (4.242 - 3.65)$ TK

$= .59$ TK

$= 59$ Paisa.

From this simple and approximate calculation we have come to the conclusion that the consumer just reach the requirement for new connection they buy their SRS in chip rate from the market. And they have no concern about the quality of the SRS so they set very poor quality of SRS but unfortunately more loss occur. For reducing the loss the consumer should develop quality full SRS.

From the above calculation we got that in Daffodil solar lab SRS's per unit cost is 59 paisa less than from the consumer SRS's per unit cost. So the SRS of solar is cost effective than the consumer SRS because the quality & maintenance is better in solar lab SRS.

4.7 Findings from Survey

In our observation we found a lot of comments from the consumers under DPDC. They have said about some problems and some benefits from the SRS. The maximum consumers under DPDC do not have any concern about the SRS because the public obligation. They just full fill the requirement for setting new electricity connection from DPDC. Some problems and some benefit are written below.

4.7.1 Problems

The consumer face a lot of problem for install SRS as well as maintenance also other perspective in SRS. Some common problem are described in table: 4.3 below.

Table: 4.3 Problems finding from the survey.

SL No:	Problems	Suggestion
1	High cost of installment of SRS	We need to increase self-production of solar panel & reduce the tax when we import the solar panel.
2	They do not have any training for maintenance from any govt. or private agency	Govt. should provide some training to the consumer for maintenance & cleaning.
3	They are not paid any things for producing extra electricity	If net metering installed then the consumer will be benefited.

4	Some consumer thing about the SRS is just waste of money	As because they are not benefited from their SRS .They think it's just waste of money so we need to make them (consumer) very much concern to their SRS.
5	They do not get any support provide from the Govt.	If govt. or private institution give some loan without interest or a little bit interest the consumer will be interested to increase the capacity or new people will also set SRS.

4.7.2 Benefits

Though the consumer have a lot of problem in SRS but some consumer are benefited from their SRS and they will be benefited if govt. or govt. organization take some necessary step. Some of benefit has shown in table: 4.4 below.

Table: 4.4 Benefits finding from the survey.

S.L No:	Comments
1	The consumers who have off grid SRS they are benefited using their own electricity.
2	There is no CO_2 emission in SRS that why there is no greenhouse effect.
3	When the load shedding occur then the SRS is use as backup source.

4.8 Future Work

- If net metering system will onset then the consumer will be benefited and they increase their SRS.
- If we inform to the consumer how to maintain and clean the SRS then the electricity production and utilization will be increased as well as the efficiency will be increased.
- If govt. or private agency will be created awareness about SRS then increase the SRS.
- Some consumers higher the SRS from agency for a few month just setup a new electricity connection from DPDC. If the govt. supervise about this problem properly then the SRS will increase.
- If the consumer uses the electricity in instant power supply (IPS) system from their SRS during peak demand hour then the demand of electricity in peak hour will be reduced as well as the cost per unit will also be reduced in peak hour.

4.9 Conclusion

In this chapter we discussed about the outcomes of all the information we have gathered from the consumer. We also describe about the present situation as well as modes of consumer about their SRS.

CHAPTER 5

Conclusion & Recommendation

Conclusion

Development of renewable energy is one of the important strategies adopted as part of fuel variegation program. However, under the changed situation, renewable energy would have a significant contribution to the global climate change and carbon trading concept. It is the time to come forward and contribute together in those renewable energy sources to generate electricity instead of completely depending on conventional energy resources. Using renewable energy resources and implementing related technologies appropriately may alter the status of life of urban and rural people and offer income-generating chances that would compensate social immoralities and environmental hazard in Bangladesh.

For utilize and solve the present problem of energy demand solar energy is the best choice for BD. In Dhaka city the power distribution company DPDC take a step to develop the present situation of solar energy its solar rooftop system (SRS). The new consumer who wants to set a new connection they are compelled to install the SRS.

Recommendation

- The initial cost is the main disadvantage of installing a solar energy system, largely because of the high cost of the semi-conducting materials used in building it. If govt. provide loan to the consumer then they will be interested to increase or install the SRS.
- Govt. should provide proper training about maintenance & cleaning the SRS the generation will increase as well as the system will more effective.

- DPDC should not give only the requirement for new connection they should also check and make aware of the consumer's SRS in regular basis.
- DPDC should insure the quality of the SRS.
- Government should reduce VAT/taxes on solar accessories and raw materials especially batteries and solar panel and strive to remove the gap between demand and supply.
- If the govt. organization implement the net metering system then the consumer will increase the capacity as well as they will concern about the proper utilization of energy generation. And the consumer will be paid an amount of money when they produce extra electricity & provide it to the grid.

References

[1] http://www.scienceclarified.com/scitech/Energy-Alternatives/The-Development-of-Energy.html

[2] https://en.wikipedia.org/wiki/Electricity_sector_in_Bangladesh

[3] https://www.dhakatribune.com/bangladesh/power-energy/2018/07/22/domestic-power-generation-hits-new-high

[4] http://www.courseslumenlearning.com/introchem/chapter/the-three-low-of-thermodynamics

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

[6] http://www.sdnbd.org/wind.htm

[7] M.l Khan, M.T. Iqbal and S. Mahboob, "A wind map of Bangladesh", Renewable Energy (2004),Volume: 29, Issue: 5, Publisher: Elsevier, Pages:643-660, ISSN: 09601481, DOl: 10.1 016/j.renene.2003.1 0.002

[8]T.V. Ramachandra, B.V. Shruti, " Wind energy potential mappings in Karnataka, India, using GIS", Energy Conversion and Management 46 (2005) 1561- 1578,doi: 10.10 16/j.enconman.2004.07.009

[9] "Final Report of Solar and Wind Energy Resource Assessment (SWERA)-Bangladesh", Renewable Energy Research Centre (RERC), University of Dhaka, Bangladesh, Available at:http://xa.yimg.com/kg/groupsI14503985/20 14718 169/name/SWERA BangIa desh FullReport.pdf

[10] http://www.greenoughsolarfarm.com.au/solar-energy/what-solar-energy

[11] https://news.energysage.com/the-history-and-invention-of-solar-panel-technology/

[12] https://www.electricaleasy.com/2015/12/solar-power-system-how-does-it-work.html

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

[14]https://www.worldenergy.org/wpcontent/uploads/2017/03/WEResources_Solar_2016.pdf

[15] https://en.wikipedia.org/wiki/Solar_power_by_country

[16] Fahim Hasan, Zakir Hossain, Maria Rahman, Sazzad Ar Rahman, "Design and Development of a Cost Effective Urban Residential Solar PV System", December 2010. Availableat:http://dspace.bracu.ac.bd/bitstream/handle/10361/ 1467/Final%20Report.pdf?sequence= 1

[17] Bangladesh Power Development Board. [Online].Available: http://www.bpdb.gov.bd

[18] https://ieeexplore.ieee.org/document/6861704

[19]http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=26&fbclid=IwAR05WUOJF6Az0MKJB6LwSduz8MsDz9WsGJvX2CvlggNtlnxYyIO9zotTY3g