DESIGN AND COST ANALYSIS OF A SOLAR PV STORAGE SYSTEM

A Project and 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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CERTIFIACTION

This is to certify that this project and thesis entitled "DESIGN AND COST ANALYSIS OF A SOLAR PV STORAGE SYSTEM" is done by **Md. Kamrul Islam** (ID: 172-33-467**)** **Md. Azizul Islam** (ID: 172-33-497) 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 31 January 2021.

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DECLARATION

The project and thesis entitled "DESIGN AND COST ANALYSIS OF A SOLAR PV STORAGE SYSTEM" submitted by, **Md. Kamrul Islam** (ID: 172-33-467**)** & **Md. Azizul Islam** (ID: 172-33-497) Session: Fall 2021 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering on 31 January 2021.

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List of Abbreviation

BERC	Bangladesh electricity regulatory commission
BREB	Bangladesh rural electrification board
DESCO	Dhaka electricity supply company
KV	Kilovolt
KW	Kilowatt
KWh	Kilowatt Hours
MW	Mega watt
MV	Mega Volt
PF	Power Factor
PV	Photo voltaic
PGCB	Power grid company of Bangladesh
MPPT	Maximum Power point tracking

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Chapter 1

BASICS OF SOLAR PV SYSTEM

1.0 Introduction

When solar system was not invented there was no idea about renewable energy. But still that time scientist are try to discover something which is related to renewable energy. At the very first time French physicist **Edmond Becquerel** in 1839 invented the photovoltaic effect when he research with a cell made of metal electrodes in a conducting solution. He saw that the cell provides electrical energy when its exposed on light.

Later in 1873 **Willoughby Smith** saw that selenium have a function of photoconductor.

In 1883, American inventor Charles Fritz first time discovered modern solar system. From that time until now every researcher try to implement modern solar system.

Solar energy has brought a massive change with us. Previously solar (PV) technologies were divided into smaller parts. It currently produces a large amount of electricity as it is connected to the grid. The price of solar technology is slowly coming down a lot compared to the previous 30 years. For example, the cost of high power band solar modules has decreased from about $27,000/kW in 1982 to about $4,000/kW in 2006.

The installed cost of a PV system declined from $16,000/kW in 1992 to around $6,000/kW in 2008 (IEA-PVPS, 2007; Solarbuzz, 2006, Lazard 2009). The rapid expansion of the solar energy market can be attributed to a number of supportive policy instruments, the increased volatility of fossil fuel prices and the environmental externalities of fossil fuels, particularly greenhouse gas (GHG) emissions.

1.1.0 Define Solar System

Solar System: We have many planetary systems like ours in this universe. Our planetary system is named the solar system because our Sun is named Sol, after the Latin word for Sun soils and anything related to the Sun we call solar.

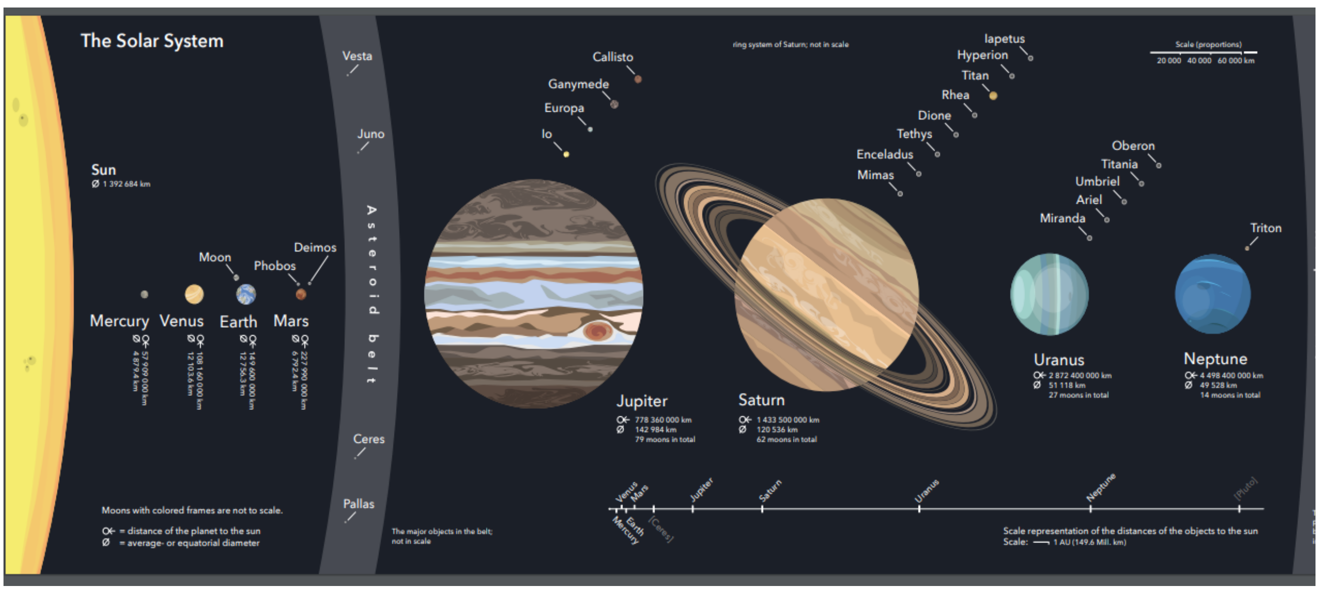

Figure 1.0 the solar system.

Source: https://en.wikipedia.org/wiki/Solar_System

1.1.1 Solar PV System.

A photovoltaic system, also PV system or solar power system is a power system designed to supply usable solar power by means of photovoltaic. It converts solar energy to electrical energy. It's also known as a power converter.

The solar photovoltaic system is mainly divided into three parts.

1. Grid-tied system,

2. Grid hybrid system, and

3. off-grid system.

1. Grid-tied system: A grid tied system is a system that usually has no storage. These systems can qualify for state and federal incentives which help to pay for the system. Grid-tied systems are simple to design and are very cost effective because they have relatively few components. The main objective of a grid-tied system is to lower your energy bill and benefit from solar incentives.

The biggest disadvantage of this system is that power generation is disrupted when the light goes out. We use the grid hybrid system to solve this problem

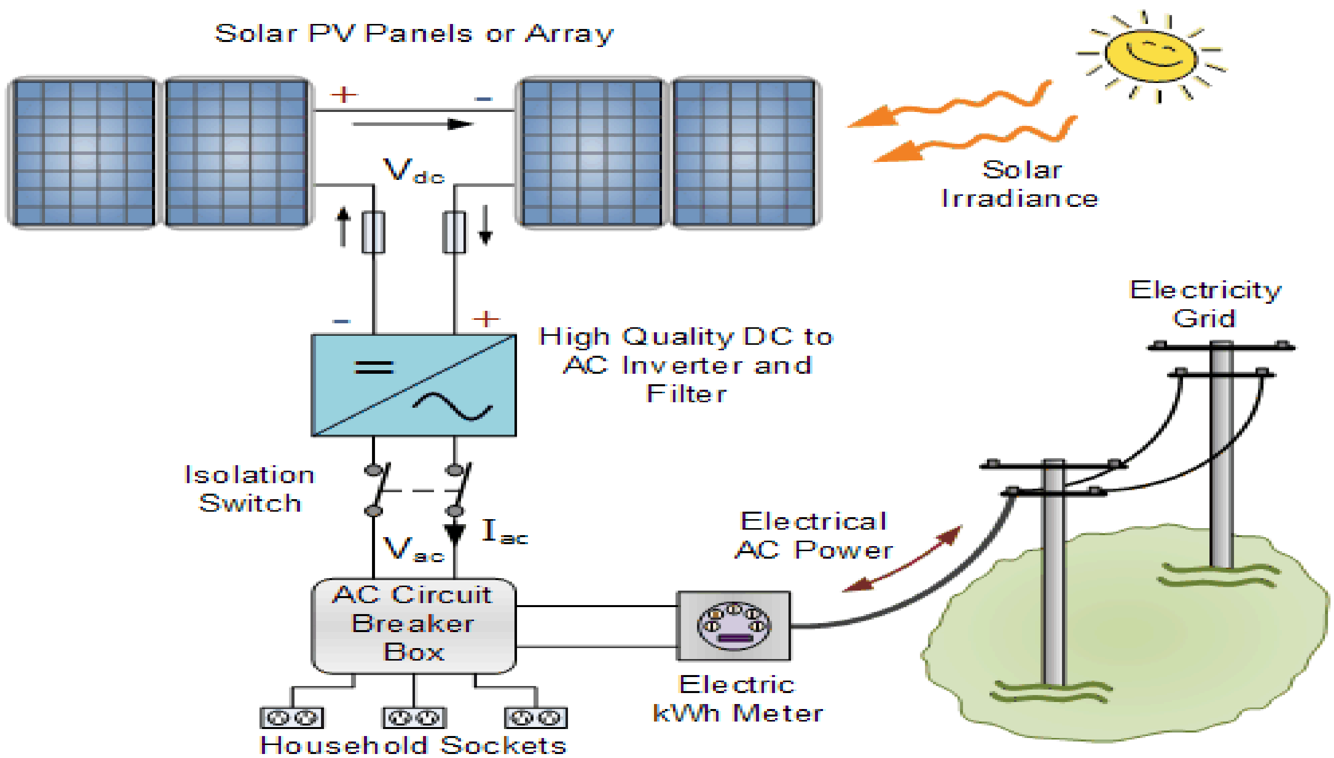

Figure1.1: Grid tied system

Source:

https://www.alternative-energy-tutorials.com/solar-power/grid-connected-pv-system.html

2. Grid hybrid system: This system is very popular at present. This system is very similar in design and component of a grid tied system. But in this system we have a battery backup system. When the light goes off the get the energy from the battery.

Figure1.2: Grid hybrid system

Source:
https://blog.greeniconsystems.com.ng/2020/06/10/what-are-the-components-of-a-solar-power-storage-system/

3. off-grid system: Off grit system means you are not connected any power system and no utility system. This is a very reliable medium. This is appealing because you are 100% self-sustaining your energy use. But one of the biggest drawbacks is that it requires a battery to back it up. which can be expensive, bulky, and not very environmentally friendly which defeats the purpose of going solar.

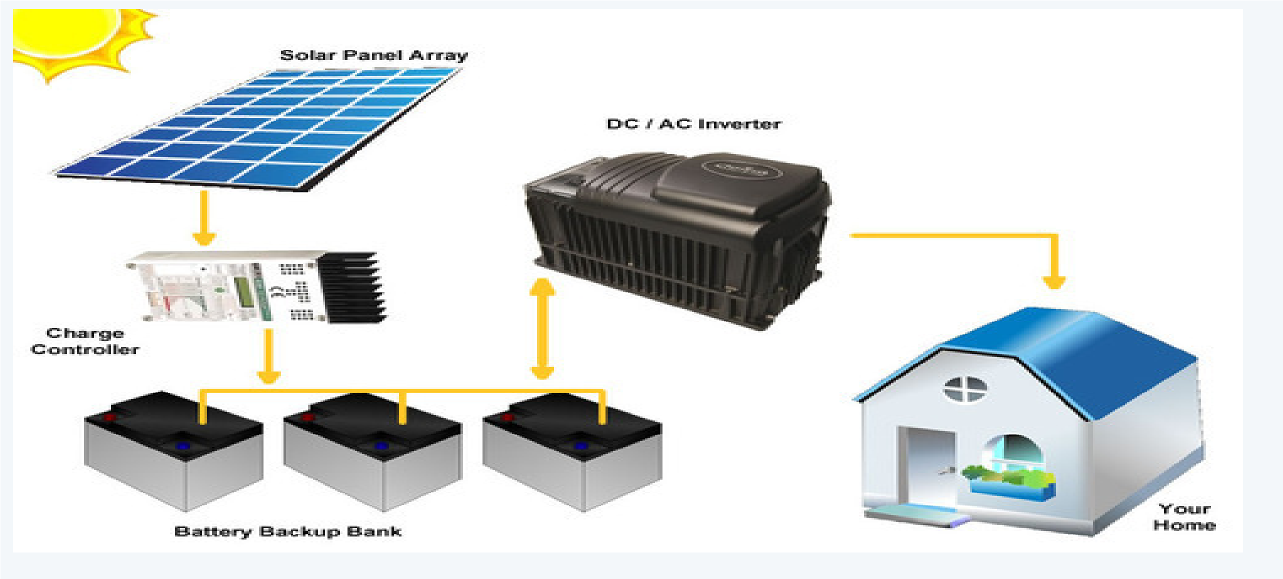

Figure1.3: Off Grid system.

Source: http://solartechsystem.com/index.php/off-grid-system/?lang=en

1.2 Problem Statement

This solar system was designed, and constructed by us. Here we find out some statement proposal.

PV solar models produce a large and dynamic range of power generation efficiency at different costs. Here we have tried whether it is more feasible than fossil fuel. We think it is more feasible than a fossil fuel.

Ongoing research and development of PV panel as shown increasing in the power efficiency of emerging Technology. As additional materials are discovered to produce greater outputs efficiencies are reaching up.

Currently we can see that some chemical substrate like as gallium arsenide, silicon, cadmium telluride are used most of the PV panel. This chemical is very highly toxic. Where excessive use of these chemicals causes a great deal of damage to the human body.

We have another statement here generally our society are used to using electricity from many sources. But the biggest challenge for us now is how people will accept the solar system now. If our analysis can prove to people that it is feasible then maybe it will be easier for us.

1.3 Objectives

1. Determine the financial feasibility of solar storage system.

2. Determine the entrepreneurial attitude of solar storage system.

3. Enhancing the technology by continuous research and development.

4. How consumers can get electricity at night.

1.4 Methodology

1.4.1 Study design

For this purpose we have some information and research question is listed below. We have divided our information into two parts.

1. We have got the information from different medium.

2. Some information we have collected by field survey.

3. Some information we have to collect from the rating of substation.

The financial feasibility of grid connected solar storage system for different applications. Data to be analyzed bellow.

1. We will bring our specific area under our system.

2. Bringing the houses that are under normal electricity under our system.

3. Bringing industries under our storage system.

4. We have this storage system for uninterrupted power supply

1.4.2 Information collection: Initially we tried to collect the data by going to our specific substation. We basically tried to meet their annual demand. And our secondary data has been collected by us from different websites, various magazines, and annual demand letters and asking with local people.

1.4.3 Data Analysis: We did our data analysis mainly with Microsoft Excel software. We also compared our data with PDB BPDP EGCB PGCB BRDB. We also tried to see if it was economically feasible.

1.5 Thesis Outline

The outline of the thesis is to find a suitable energy storage solution for the PV plant. Basically this design is for the storage system.

1. Our main goal is to install a two megawatt solar storage system.

2. Creating a Suitable Economical Analysis that will be acceptable to all the consumers.

3. Above all, to achieve the goal so that we can go to our final production.

Chapter 2

LITERATURE REVIEWS

2.1 Electricity background of Bangladesh

Bangladesh is a developing country. As the days go by the country is moving forward. The country is developing and the demand for electricity is increasing. Ahsan Manzil in Dhaka was first electrified on December 7, 1901 in Bangladesh. In the beginning, people were reluctant to have electricity because there was not much demand. The first commercial power house in Bangladesh was set up in 1930 at Dhanmondi. When Bangladesh became independent in 1971, the first Bangladesh Rural Electricity Board was formed. And also began to be electrified by more and more different private companies. Before independence, the total power generation capacity of Pakistan was 21 MW. And after independence, Bangladesh Power Development Board started its journey in Dhaka City with only fifteen hundred megawatts of electricity. The Government of Pakistan formed the Water and Power Development Authority (WAPDA) in 1947 and 1959 for power development. From 1960 to 1970 power generation increased from 88MW to 475MW. In 1972, after independence, the government formed the first Bangladesh Power Development Board (BPDB) to improve the country's power system. The achievement highlight of BPDB considering time period from 1972 to 1995 is: power generation capacity 2818 MW high voltage transmission line network 132 kV 2469 km & 230 kV 419 km highest voltage 230kV capacity transmission line of the country East-west (Tongi-Ishurdi) interconnector is switched on in December 1982. BPDB created electricity facility most of the district city area, but government had make sense that for developing the whole country electricity need in rural area, especially for irrigation. So, government created REB (Rural Electrification Board) in

October 1977 who works for electrification in rural area all over the country through PBS (Palli Bidyut Samity) except major district town.

The utility electricity sector in Bangladesh has one national grid with an installed capacity of 21,419 MW as of September 2019. The total installed capacity is 20,000 MW (combining solar power). Bangladesh's energy sector is booming. Recently Bangladesh started construction of the 2.4 gigawatt (GW). Rooppur Nuclear Power Plant expected to go into operation in 2023. According to the Bangladesh Power Development Board in July 2018, 90 percent of the population had access to electricity. However per capita energy consumption in Bangladesh is considered low.

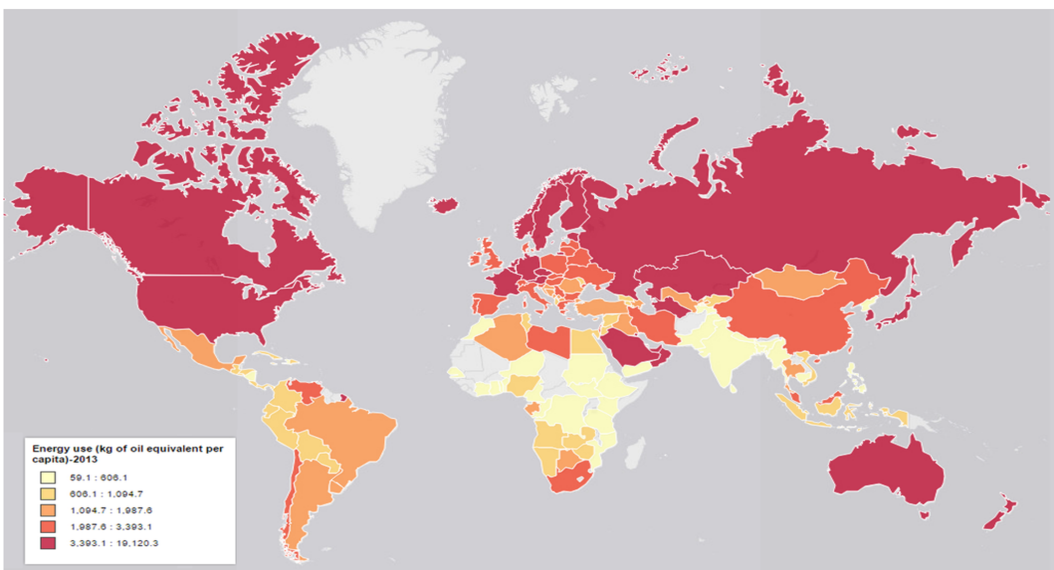

Figure2.1: World Energy consumption

Source:https://en.wikipedia.org/wiki/List_of_countries_by_energy_consumption_per_capita#/media/File:World_Map_-_Energy_Use_2013.png

2.2 Electricity generation of Bangladesh

The demand for electricity is increasing day by day. In Bangladesh installed electricity generation at 2017 is 15351 megawatt (MW) . In 2018 it rises to 20,000 megawatts (MW). A country needs electricity for the most of its economic activities. The most used electricity in Bangladesh is in the industrial sector. Electricity is also used in business, agriculture and residential area.

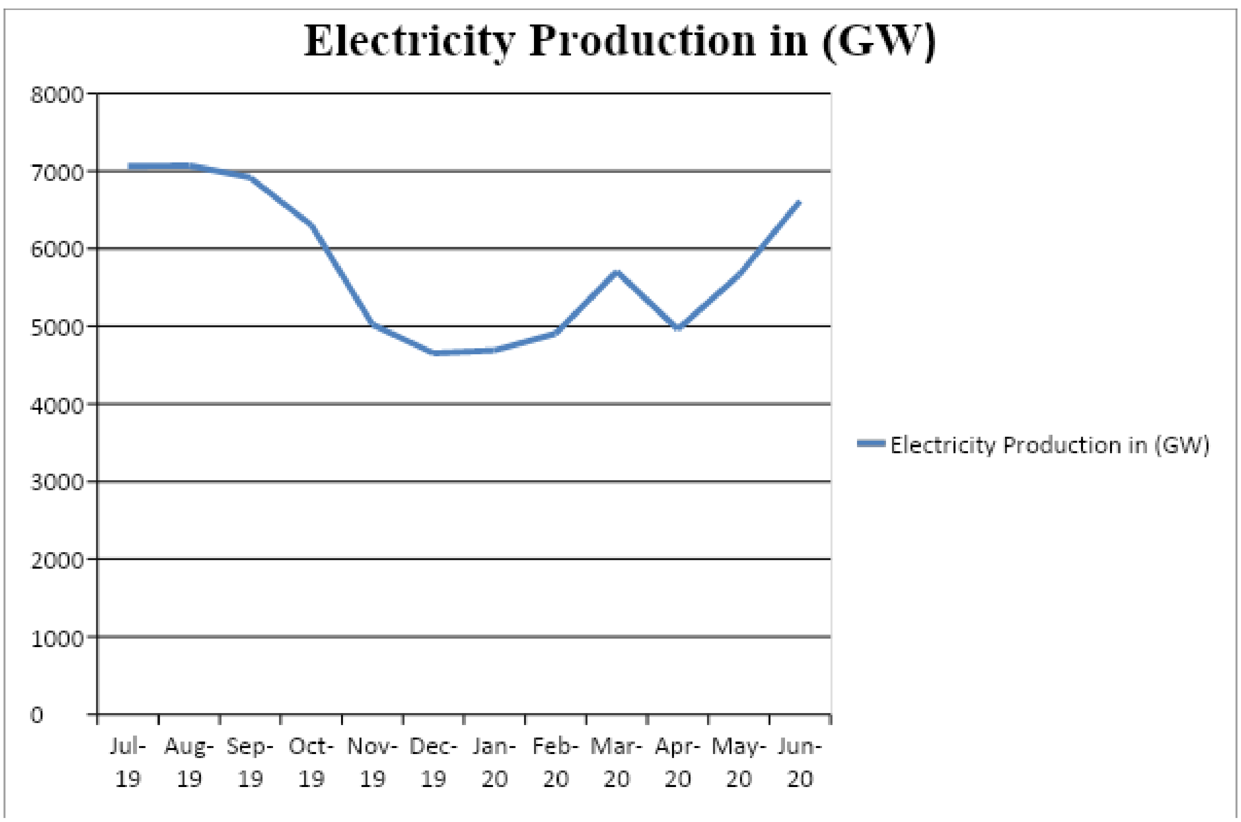

Figure2.2: Electricity Production of Bangladesh in 2019-2020

2.3 Electricity consumption of Bangladesh

Delays in the implementation of new capacity additions, low utilization of existing capacity due to maintenance problems, and rapid increase in power consumption. Power consumption depends on power generation and consumer consumption. At present 95% of the people of Bangladesh use electricity. And the demand for electricity in various industries is increasing day by day. As a result, the amount of electricity consumption is increasing day by day.

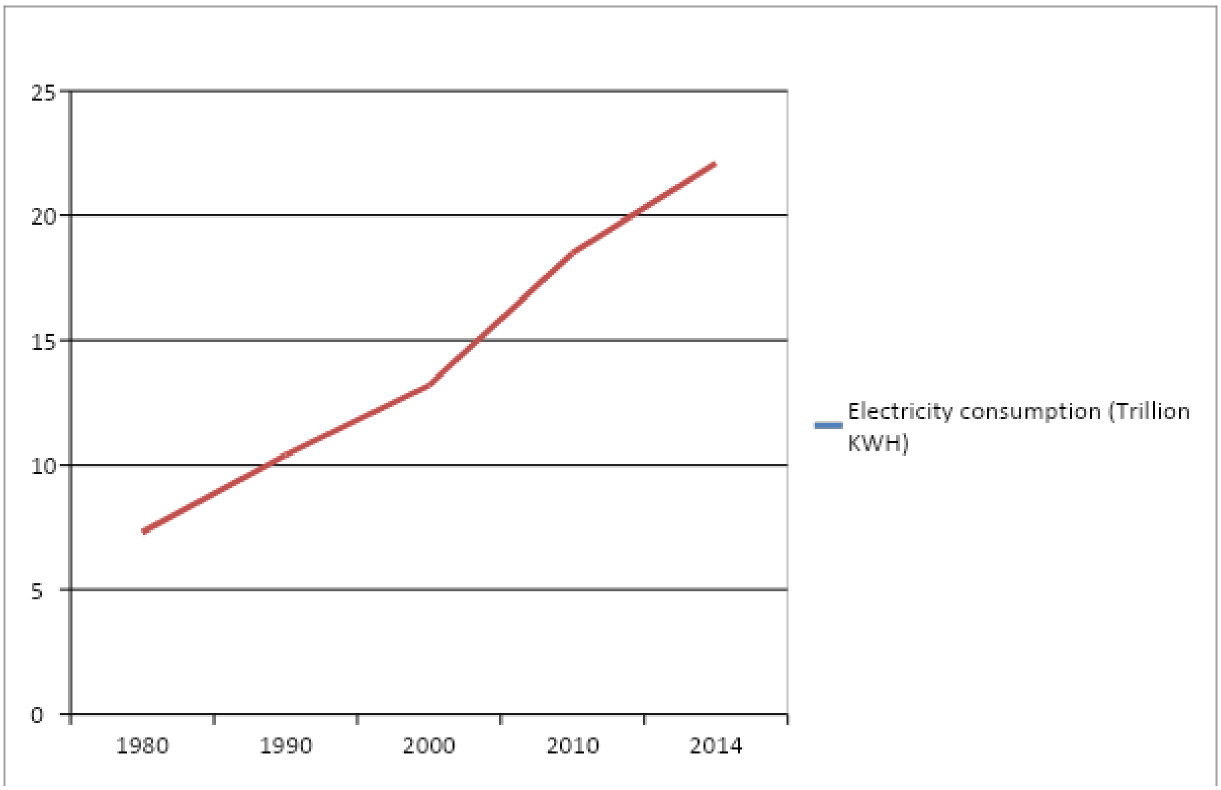

Figure2.3: Electricity consumption of Bangladesh in 1980-2014

Source:https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?end=2014&locations=BD&start=1971&view=chart

2.4 Background of solar Energy at Bangladesh

Bangladesh is located in between latitudes 20°34' and 26°39' north and longitudes 80°00' and 90°41' east. Where it is a best place to produces solar energy. Where the sun lights is very plentiful. It makes the use of solar panels very effective in this environment. Here the daily solar radiation is 4-6.5 kWh/m².and maximum radiation is generally received in the months of March-April and minimum in December-January. Solar is a good medium for power generation where it is not possible to generate enough electricity using other fuels.

2.4.1Total solar energy production of Bangladesh: Solar energy has received a huge response in the last two years. As a renewable energy, people have now adopted solar energy very widely. Off grid solar home system is very popular in our country. But now on-grid system is going to be introduced in different places with the funding of different agencies and the government's own funding. Solar energy is a suitable source for solar power generation. At present, Bangladesh generates 22,787 MW of electricity from solar energy. In 2019, another mega project of 372 MW was undertaken. And the government has set a target in 2020 that one-tenth of total electricity should come from solar energy.

2.4.2 Grid connected solar system in Bangladesh

With the energy crisis and rising demand for electricity, the government is now focusing on renewable energy instead of energy. And that's why the government is thinking of connecting the solar system to the grid and that is why the government took up a project in 2018.In 2018 The under of Sustainable and Renewable Energy Development Authority (SREDA) 27.34 MW solar electricity is connected to the grid. The government is trying to connect solar energy to the grid every year. According to that goal the government has undertaken a large project of 310 MW by 2024.

2.4.3 Impact of solar grid system

Once we can bring solar panels under power generation, we will not need the cost of power generation. At first we need a huge amount of installation cost. Then there is no need to spend anything without maintenance cost only. So it will be acceptable to the whole community.

2.5 Solar storage system

This time electricity is very important things. Without electricity you can think a moment. If the solar system is without storage system, when the light goes off we can get any electricity. If the system is solar home system the storage is very needy. Because in the evening we don’t get any sun light that’s why a pv panel doesn’t produce any electricity. In this reason a storage system is very needy when the pv panel doesn’t produce any electricity. Various type of home appliances and electronics need power at night. If a home have any backup system all the home appliances will be good.

2.5.1 Grid connected solar storage system

A huge amount of the energy produced by a PV system will be connected to the grid and the demand for solutions to enable better use of this energy through the use of energy storage is increasing.

If battery storage is connected the grid system when the grid have pick time this back system will come in handy. As oppose to If the grid system only depends on the solar system the storage system is very needy.

We can divide two type of grid connected solar system (SSS)

1. Storage system with integrated inverter

2. Independent storage systems

2.6 Summery of the chapter

This chapter represents a synthesis of the project’s research objectives and summarizes emerging issues including possible implications associated with broad uptake of residential PV with battery storage. The paper also outlines a systems framework that conceptualizes at a high-level the methodological approach that is being applied as part of this research project.

Chapter: 3

THEORETICAL MODEL

3.1 Introduction of grid connected solar storage system

Grid connected solar system is a system that where the electricity generated the PV panel to the grid and a storage system is include there. It has a huge amount of storage system where a lot of energy stored there.

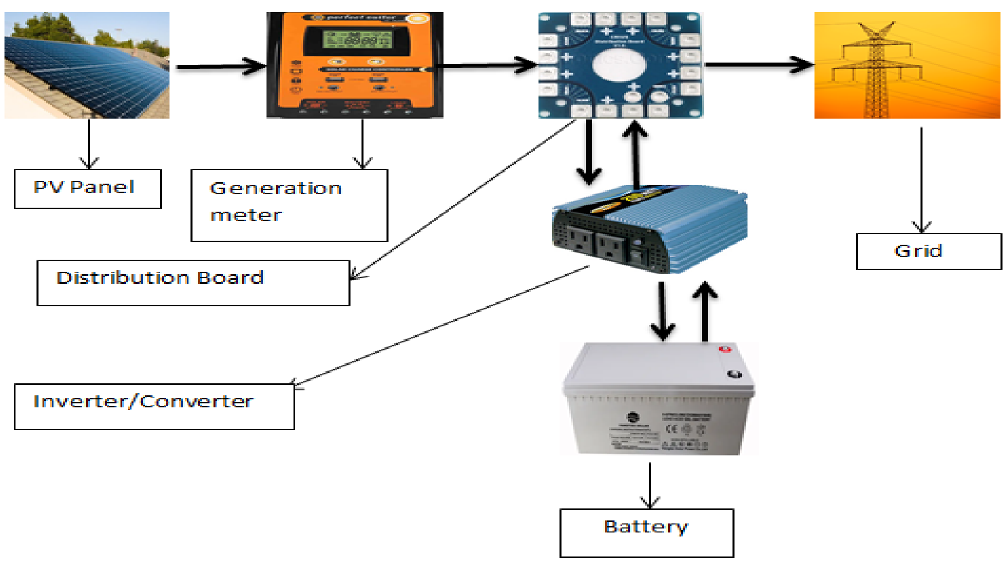

Figure3.1: grid connected solar system

In this project we will connected 2 MW output power with storage system.

Since it will connect to the grid so it will be 3 phase. Here we need high power PV panel, charge controller, battery, and inverter.

3.2 Basic Solar Storage system Components

PV Panel: A device which converts light energy to electrical energy is known as Photovoltaic panel or solar panel. Basically it's a p-n junction diode. Panels are made from silicon (Si), gallium arsenide (GaAs), Cadmium telluride (CdTe). These are connected in series to get more voltage from the solar cell. A module's total power is expressed in "watt peak (Wp)" Measured under regular experimental conditions of 1000 W / m2 irradiance, 250C temperature and 1.5 AM photon spectrum.

V-I characteristics of PV panel

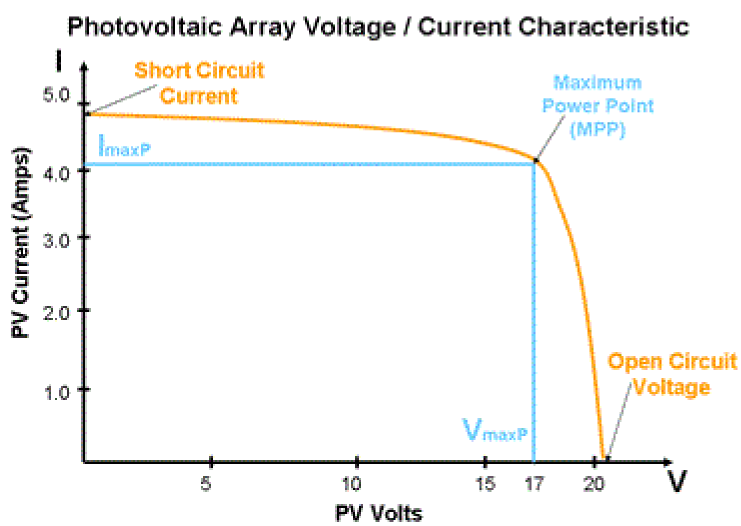

Figure 3.2: V-I characteristics of pv panel

Source: https://www.electrical4u.com/solar-cell/

Generation meter: A generation meter is a meter that reads the generated electricity. This meter measures all the units that your renewable system generates and it is the units which the ROCs are charged from this meter.

Distribution Board: A typical distribution board consisting of circuit breaker, panel board, Electrical panel etc. Using the board electrical energy is transmitted via branches to reach the exact end user.

Converter/Inverter: It is a typical multi-functional device. Which converts dc to ac or ac to dc. The device acts as both an inverter and a converter.

Battery: An electrochemical cell that transforms chemical energy into electrical energy. They consists of two electrodes an anode and a cathode with an electrolyte between them. During the day time when the electricity generated by the PV module is stored in the batteries. Due to their comparatively low cost and low sensitivity to the variance in temperature, lead-acid flooded style batteries are usually used.

3.3 Overview of solar energy

3.3.1 Solar irradiation in Bangladesh

The solar angle varies from 40 to 90 degrees because of its position. Bangladesh 's expected solar irradiance ranges from 215 W / m2 each day in the northwest to 235 W / m2 each day in the southwest.

Table 3.1 Monthly solar irradiation data in Bangladesh.

Month	Dhaka	Chittagong	Barisal	Khulna	Mymensingh	Rajshahi	Rangpur	sylhet
January	4.36	4.42	4.34	4.29	4.37	4.32	4.34	4.37
February	4.92	4.98	4.95	4.88	5.08	5.25	5.22	5.04

March	5.59	5.44	5.37	5.58	5.81	5.95	6.1	5.6
April	5.76	5.51	5.65	5.83	5.86	6.33	6.2	5.62
May	5.3	5.11	5.25	5.53	5.19	5.74	5.74	4.84
June	4.53	4.16	4.05	4.2	4.47	5.04	4.76	4.22
July	4.23	4.04	3.89	3.89	4.12	4.41	4.19	4.18
August	4.29	4.18	3.91	3.9	4.18	4.36	4.29	4.3
September	4.01	4.01	3.83	3.83	3.82	4.03	3.89	3.94
October	4.32	4.28	4.29	4.29	4.3	4.42	4.67	4.36
November	4.28	4.25	4.23	4.23	4.38	4.46	4.66	4.26
December	4.21	4.28	4.24	4.21	4.19	4.21	4.26	4.17

3.3.2 Energy calculation of solar irradiation

Solar energy It usually depends on the position of the sun. A panel is usually operational for about 10 to 12 hours from sunrise to sunset.

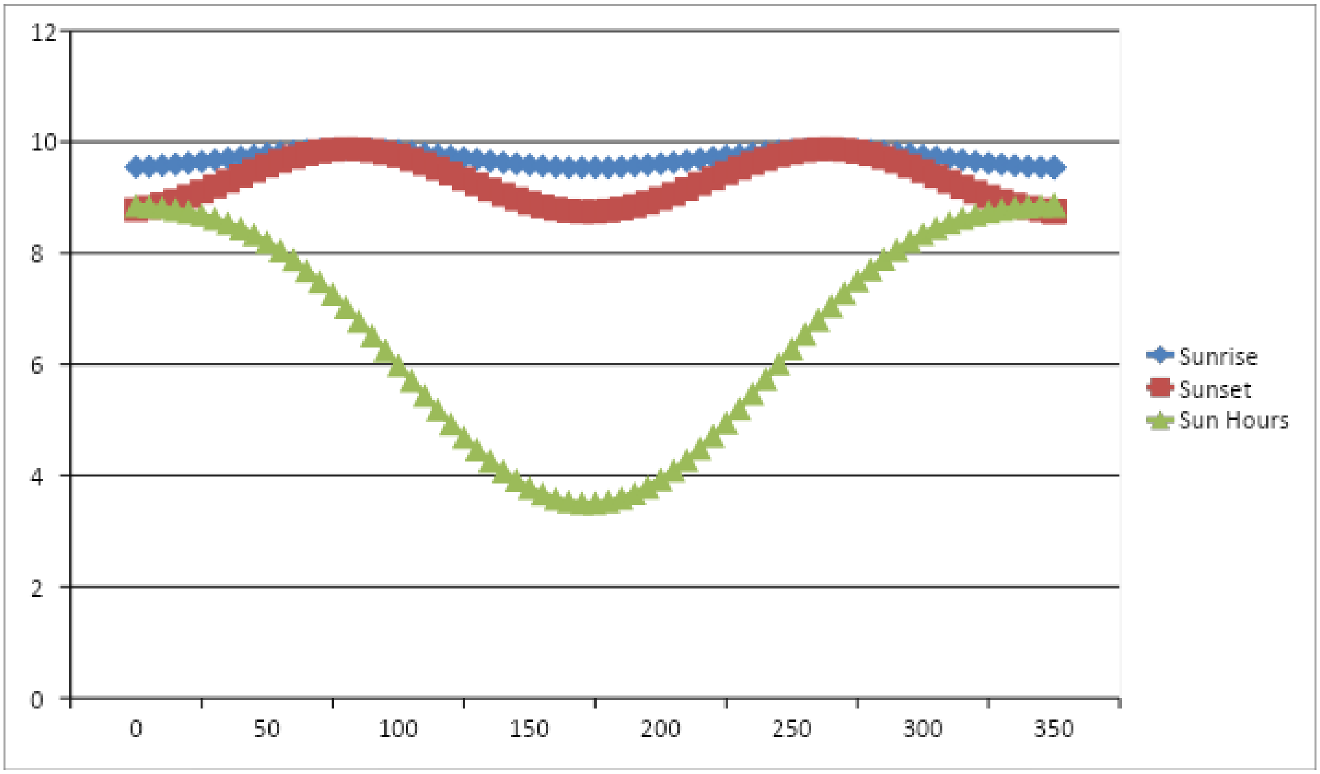

Figure3.3: Solar Irradiation

Solar energy calculation depends on the every sunrise and sunset. The sun rises for 24 hours across the year near latitudes above 67 °. Here below the equations to produce the plots described above. In solar time these equations are determined. In the Sun's location, the correction is given between local solar time and local time. The distribution is based on the trigonometry of the sphere, a basic identity from the cosmic law of cosine.

The sum of hours of daylight is simply the time between sunrises:

$\mathrm{Cos}(c)=\cos(a)\cos(b)+\sin(a)\sin(b)\cos(C)$

Where a,b and c are the arc length.

c=h

$c=\Theta$

$a=\frac{1}{2}\pi-\varphi$

$b=\frac{1}{2}\pi-\sigma$

$\cos(\Theta)=\sin(\varphi)\sin(\sigma)+\cos(\varphi)\cos(\sigma)\cos(h)$

the equation can be derived from a more general formula.

$\cos(\Theta)=\sin(\varphi)\sin(\sigma)\cos(\beta)+\sin(\sigma)\cos(\varphi)\sin(\beta)\cos(\Upsilon)+\cos(\varphi)\cos(\sigma)\cos(\beta)\cos(h)-\cos(\sigma)\sin(\varphi)\sin(\beta)\cos(\Upsilon)\cos(h)-\cos(\sigma)\sin(\beta)\sin(\Upsilon)\sin(h)$

Density of solar flow on the tangent of a plane in the earths sphere but above most of the atmosphere.

$$Q=\{s_0 R_E^2 R_0^2 COS(\Theta) \quad COS(\Theta) > 0 \; 0 \qquad COS(\Theta)\leq 0$$

The average of Q over a day is the average of Q over one rotation, or the hour angle progressing from h = π to h = −π

$$Q^{-day} = -\frac{1}{2\pi}\int_{\pi}^{-\pi} Q\,dh$$

Now $\sin(\varphi)\sin(\sigma)+\cos(\varphi)\cos(\sigma)\cos(h_0)=0$

$\cos(h_0)=-\tan(\varphi)\tan(\sigma)$

If $Q^{-day}=0$

$\frac{R_0^2}{R_E^2}$ Is nearly constant over the course of a day, and can be taken

Now the integral

$$\int_{\pi}^{-\pi} Qdh = \int_{h_0}^{-h_0} Qdh$$

$$= S_0 \frac{R_0^2}{R_E^2} \int_{h_0}^{-h_0} cos(\Theta)dh$$

$$= S_0 \frac{R_0^2}{R_E^2} [\ \mathrm{hsin}(\varphi)\sin(\sigma)+\cos(\varphi)\cos(\sigma)\cos(h)]$$

$$=-\ 2S_0 \frac{R_0^2}{R_E^2}[\ h_0\sin(\varphi)\sin(\sigma)+\cos(\varphi)\cos()\cos(h_0)]$$

Therefore

$$Q^{-day} = \frac{S_0}{\pi}\ \frac{R_0^2}{R_E^2}\ [\ h_0\sin(\varphi)\sin(\sigma)+\cos(\varphi)\cos(\sigma)\cos(h_0)]$$

Now,

Ϭ=€ sin(Θ) and

$$\frac{R_0}{R_E} = 1+e \cos(\Theta-\varpi)$$

A simplified equation for irradiance on a given day is

$$Q = S_0(1+0.034\cos\ (2\pi \frac{n}{365.25}\ )\ )$$

Where n is the number of the day.

3.4: Overview of solar storage system

Solar energy is a well-known electrical source. In the beginning it was very expensive but now it is within reach. But in the beginning it was used only for solar home systems. Currently, due to the energy crisis, many countries are becoming dependent on solar. And that's why storage systems are needed. Need for renewable energy storage is important due to the continual climate change and the fickle nature of the weather upon which renewable energy sources depend. Although a grid connected storage system is very expensive. If we think of economic feasibility, it is much more useful than ordinary electricity. These applications can be categorized into: utility interactive, stand-alone and hybrid systems

3.4.1 Types of storage system

Energy storage systems include a method where Electricity imported from the power grid is converted to a forms that can be saved on off-peak demand. There are many energy storage systems that are available. Such developments are also classified in accordance with the objective of energy Keep on, hold on.

Here we have 5 types of storage system.

1. Mechanical energy storage

2. Electrochemical energy storage

3. Chemical energy storage

4. Electrical energy storage

5. Thermal energy storage (TES)

Chapter: 4

HARDWARE DESIGN OF SSS

4.1 Implementation of storage system

Storage system depends on the output of a PV panel. In this system we need 2 MW output of a panel. For this requirement we need some extra panel. Here we will have some loss in this system. Our projected design of this system is given bellow.

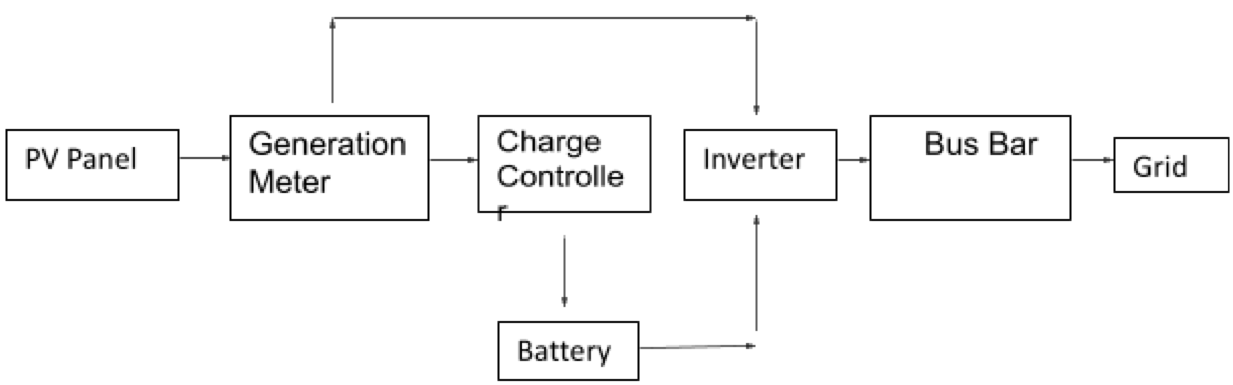

Figure 4.1: Modeling of solar storage system.

4.2 Solar Panel selection

Before picking a solar panel, here are few things to consider. If you do not bear this stuff in mind, the project will be in the midst of losses. Two types of solar cells are typically used, one being mono crystalline and another being polycrystalline. And in this project, we will use mono crystalline solar cells to think about performance and durability.

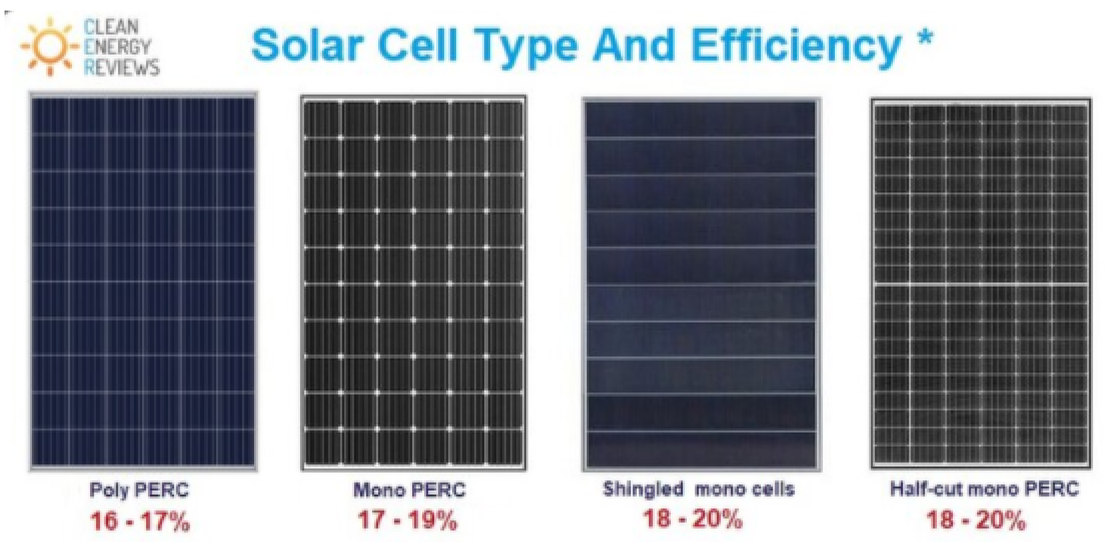

Figure 4.2: Type of solar Cell.

We typically concentrate on seven topics when choosing a panel.

1. Solar Panel Cost

2. Solar Panel Quality

3. Energy Efficiency

4. Temperature Coefficient

5. Durability

6. Size

7. Types of Solar Cells Used

Table 4.1: Top 5 Solar cells in global Market:

No	Company	Manufactured	Max Efficiency	Warranty(year)
1	LG	Sth Korea, USA	21.7%	25
2	Sun power	USA, Mexico, China	22.6%	25
3	REC	Philippines	21.7%	20
4	Solaria	Singapore	20.5%	25
5	Panasonic	Sth Korea, USA	20.35%	25

In order to calculate our budget and performance, we will use this Panasonic Mono crystalline Solar Cell in this project.

4.2.1 Estimate of solar panel

We will use the Panasonic solar cell in this project. Since our maximum output of this project is 2 MW. So we would use this Panasonic solar panel to think about our maximum efficiency. The model of our solar panel is Panasonic VBHN330SA17. Which rating are 32V and 5.70A and 330W. It will charge $309.38 at current market prices.

4.3 Charge Controller selection

Without charge controller we can't store our energy. So it's a very important thing which we are used. Although we can use a lot of charge controller but we want a better efficiency from this project. If I want a better performance of a charge controller I need to concentrate 2 topics. They are

1. Voltage selection and

2. Current capacity

Table 4.2: Top 5 Charge controllers in global Market.

No	Name	Type	Battery Voltage	Max Input Voltage	Max Current Output
1	EPEVER MPPT Charge Controller	MPPT	12-24V	100V	30A
2	Outback Flexmax 8000 FM80 MPPT 8000 AMP Solar Charge Controller	MPPT	12-60V	150V	80A
3	MidNite Solar Classic 150 Charge Controller	MPPT	12-72V	150V	96A
4	Victron SmartSolar MPPT 100/50 Solar Charge Controller	MPPT	12-48V	150V	100A
5	Renogy Wanderer	PWM	12V	25V	30A

We will use ‘’Outback Flexmax 80 FM80 MPPT 80 AMP Solar Charge Controller’’ considering the output of the solar panel and the input of the battery.

4.4 Battery Selection

One of the easiest ways to store healthy power is by solar batteries. Batteries are needed because there is no power backup when there is no sun during the day. As a result, the importance of grid-connected storage systems is rising day by day. We would first consider the type and maintenance of the battery before selecting a battery. Based on these factors, we can divide the battery into three parts.

1. Flooded Lead-Acid Batteries

2. Sealed Lead-Acid Batteries

3. Lithium Batteries

4.4.1 Estimate of Battery

Lithium Batteries: Flooded lead acid batteries have some disadvantages. The worst part is that it requires a lot of space and requires regular maintenance. Sealed Lead-Acid Batteries and Flooded lead acid batteries have same operation. But sealed batteries have one more disadvantage which is this battery doesn’t have any self-discharge.

Initially lithium batteries were usually used for mobile phones and laptops. But at this time it is at the top of popularity and is slowly being used as a solar battery. It has many advantages, among them are:

1. Better Longevity

2. There is no maintenance cost

3. Better efficiency

4. Huge storage capacity

4.5 Inverter Selection:

A Typical grid tied system need a huge type of inverter system. If can’t decide which one is best inverter Then it will have a huge detrimental effect on our project. In this project we need 2MW output from inverter. We have a lot of inverter in our local market and global market. For our better efficiency and better output and better longevity we would use a renowned Brand.

4.5.1 Estimate of Inverter

Since we will connect our output of the inverter to the grid, we need a three phase inverter.

Figure 4.3: ZONZEN ZZ-ZB 10kW grid tied inverter.

This is Chinese product and we picked a PV grid tied Inverter. The Model of the Inverter is ZONZEN ZZ-ZB.

And here is the specification of this inverter

MPPT voltage range: 100-150 V

Output power: 10kW

Connection: 50Hz grid frequency and 3 phase 4 wire connection

The efficiency of this inverter: 97%

AC voltage: 230 Volt.

4.6 PV Panel Mounting

Mounting depends on the solar angle. We have various type of mounting system. Before solar panel mounting we need to know about the availability of the options. We have 3 types of mounting systems.

1. Pole Mounting

2. Ground Mounting

3. Roof Mounting

We will usually deal with ground mounting in this project.

Ground Mounting: For this mounting system, we typically retain a flexible standard. When it comes to 2-post steel, a higher structural stability is ensured when soil or load conditions are difficult. It can be easily mounted through foot plates and fixed anchors.

Figure 4.4: Ground mounting system.

Durability features enough for 2-post steel. The selected materials provide effective and long-term protection. They guarantee high resistance for maximum service life. We will get service here after about 20 years

Chapter: 5

COST AND CALCULATION OF SSS

5.1 Calculation of solar storage system

5.1.1 PV Panel

To calculate the performance of solar panels, developers normally use standard test conditions (STC). And to do that we first have to check the wattage of the panel. Standard test conditions for watts of solar panels indicate that the solar panel runs at 77 degrees Fahrenheit whereas the panel provides 1000 watts for each square meter of sunlight.

Here we have Panasonic 330 wattage a panel and 7 hours daylight per day. Now

Solar panel watts x average hours of sunlight x 75% = daily watt-hours

$330 \times 7 \times 75\ \% = 1732.5$ WH

$= 1.73$ KWH.

One panel produces a total of 1.73 KWH of electricity in 6 hours a day.

If we connect the entire panels in series. So the number of panels for 4 MW of electricity output:

= 4000÷1.73

= 2312.13

= 2313

So we need the 2313 panels to produce 4MW electricity.

5.1.2 Charge Controller

Here we will use outback Flexmax 8000 FM80 MPPT 8000 AMP Solar Charge Controller" now,

How many charge controllers do we need?

Charge controller = Total Battery watt/wattage of charge controller

= 2000000/8000

= 250

5.1.3 PV Array Design

To design PV array the most important thing is to choose a proper inverter and combiner box.

ZONZEN ZZ-ZB 10kW inverter's MPPT voltage range = 100-500 V

Panasonic VBHN330SA17module's open circuit voltage = 69.7 V

7 module in series = 69.6* 7

= 487.2 V

This is within the inverter's MPPT voltage range. We didn't put more modules due to safety.

Module's maximum power voltage = 30.9 V

Inverter MPPT voltage range: 100-500V.

(100-500V)/7 = 14.28 - 71.42 (module maximum power voltage = 57.14)

So, power maximum power voltage is in the inverter's voltage range.

ZONZEN ZZ-ZB 10kW inverter's current rating:

Inverter's rated voltage = 360 V

Maximum current: (10000/360) = 27.77 A

At 694.04 W/m2 maximum short circuit current = 6.01 A

If we put 3 parallel string (1 string consist of 7 series module) = 3*6.01

= 18.03 A

ASMA SCCB-10 combiner box maximum input fuse rating = 600 V, 20A

As we need to arrange 2313 modules we need such 7 configuration

5.1.4 Inverter

Number of inverter =Total no of PV Panel/(no of panel in series in a string × no of parallel string)

= 1157 / (7*3)

= 55.09

= 56

5.1.5 Combiner Box

56 combiner box is needed us which is equal to the number of inverter. Here we can use SMA SCCB-10 combiner box.

5.1.6 Battery

If the solar panel generates excess electricity during pick hour, we should store it.

Figure 5.1: 50kw online Battery stake

All the stakes of battery we can connect to series. Because of here we can follow the rules of Battery banking system. This is series charging and discharging system.

The model of the battery stack we will use Sendon SDA10-48100.

- ✔ Each of the stack has 240 VDC
- ✔ 4 stacks in series we get almost 1000 VDC
- ✔ Each of the stacks current capacity 100AH
- ✔ 4 stacks in series current capacity is 400AH
- ✔ 4 stacks in parallel we get 2.2 MW output

5.2 Result from theoretical calculation

Considering this storage system we need 4 MW Producing power from panel. In this system we need almost 2313 Panel. Here 2MW using for day time to the grid and another 2MW we use for charging the battery system. From the storage system we get 1000V from the battery stack and output power of the Battery stack is 2.2 MW.

5.3 Total Cost calculation of solar storage system

No	Element	Description	Quantity	Total Cost
1	PV Panel	Panasonic VBHN330SA17	2313	$715595.94
2	PV Panel stand		111	$42180
3	Charge controller	Outback Flexmax FM8000 MPPT 8000 AMP Solar Charge Controller	250	$153924.5
4	Battery	Sendon SDA10-48100.	4*8=32 32*4=128	$178048
5	Inverter	ZONZEN ZZ-ZB 10kW grid tied inverter	56	$144720
6	Combiner box	SMA SCCB-10	56	$27160
7	Surge Arrester		56	$4760
8	Lightning Rod		7	$7000
9	Mounting			$67289.9
10	Generation Meter			$9800
11	Wiring			$14720
12	Transportation, installation, LC, maintenance	40% of all costs		$546079.336

Total	**$19112776.76**

Table 5.1: Cost calculation of solar storage system

5.3 Energy cost of the system (Per Unit)

Our proposed PV storage system life is 20 years. Now, the energy cost per unit of the designed system will be:

Cost of the system (Total): $1911277.676

Daily bright sunshine hours: 7 hours

Proposed Capacity of the system in MW: 2MW

Avg. energy produced per day in kWh: 2000*7= 14000

Energy produced in 20 years in kWh: 14000*20*365 = 102200000

Cost per unit of energy in USD: (Total cost of the system/ Energy produced in 20 years)

= (19112776.76/102200000)

= 0.0187

So we could be able to generate per unit of energy at 0.0187 $ or (0.0187*84.80) TK

= 1.6 TK.

Chapter: 6

COST ANALYSIS AND DISCUSSION OF SSS

6.1 Per unit electricity cost of GE

In business area cost is very important term, where profit or loss is concern. Cost of electricity is how much one spent or pays to generate, distribute or consume electricity. Electricity is the main power source in all over the world. So the cost of the electricity is important to improve economic and social benefits.

The new tariff will take effect on 1 March 2020, said the newly appointed Chairman of the BERC, Md Abdul Jalil, while revealing the announcement at the Commission's conference room on Thursday. There were four additional representatives of the committee involved.

The retail power tariff has been increased from Tk 6.77 to Tk 7.13 per unit (each kilowatt-hour) and Tk 4.77 to Tk 5.17 at wholesale level.

6.2 Per unit electricity generating expenditure of SSS and other plants

Bangladesh's power sector is heavily dependent on fossil fuels, as natural gas and coal are the country's main sources of power generation. In the meantime the governments try to focus on renewable energy. Most of the electricity generation are depends on gas. Here is the per unit generating cost of electricity in Bangladesh.

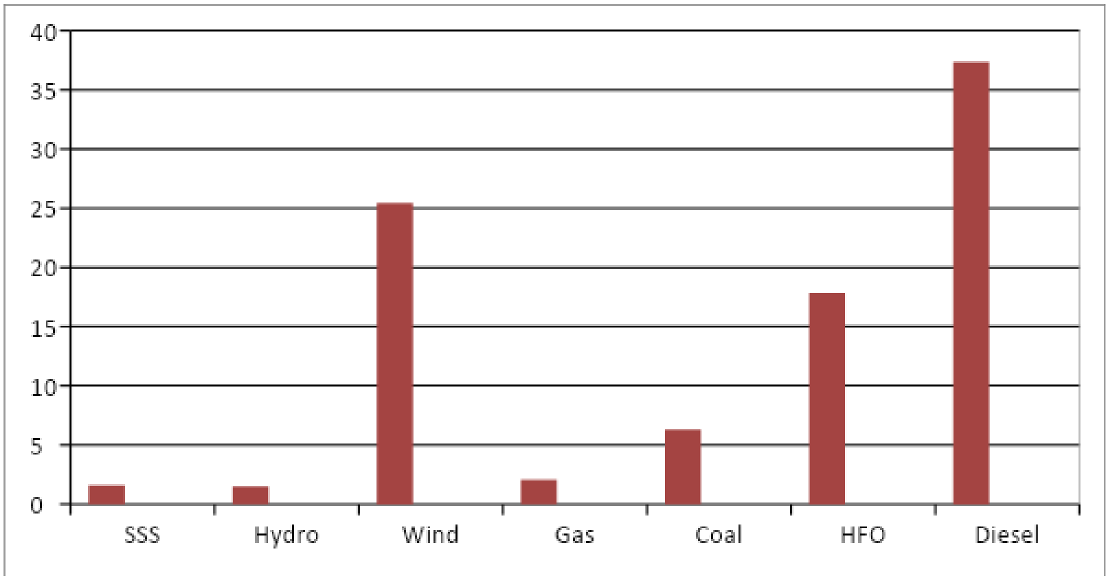

Figure 6.1: Per unit generating cost in TK

Source: Source: Annual Report. 2014. Bangladesh Power Development Board Dhaka.

(http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=5&Itemid=6)

6.3 Maintenance cost of SSS & GEC

Solar panel installation is a long-term investment that can serve you well for decades with very minimal maintenance, but that doesn't mean you can install once and then ignore them. Plan on a yearly inspection and cleaning, and stay cognizant of potential problems such as overhanging trees or storm damage. To ensure that such investments stay in great shape and continue to offer benefits, it is important to have solar panels professionally maintained and cleaned on a regular basis.

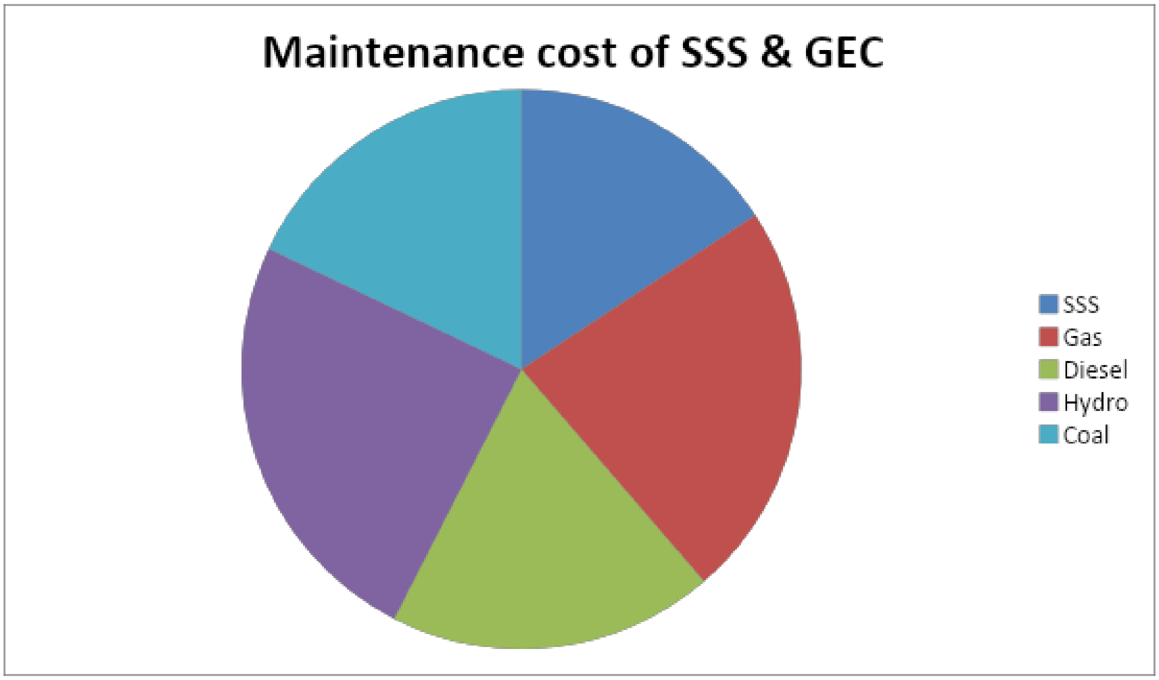

Figure 6.2: Maintenance cost of SSS & GEC

6.4 Significance between per unit cost of SSS and GEC

Here we can see that difference between SSS and GEC is a lot of. Different methods of electricity generation can incur significantly different costs, and these costs can occur at significantly different times relative to when the power is used. Calculations of these costs can be made at the point of connection to a load or to the electricity grid, so that they may or may not include the transmission costs. The costs include the initial capital, and the costs of continuous operation, fuel, and maintenance as well as the costs of de-commissioning and remediating any environmental damage.

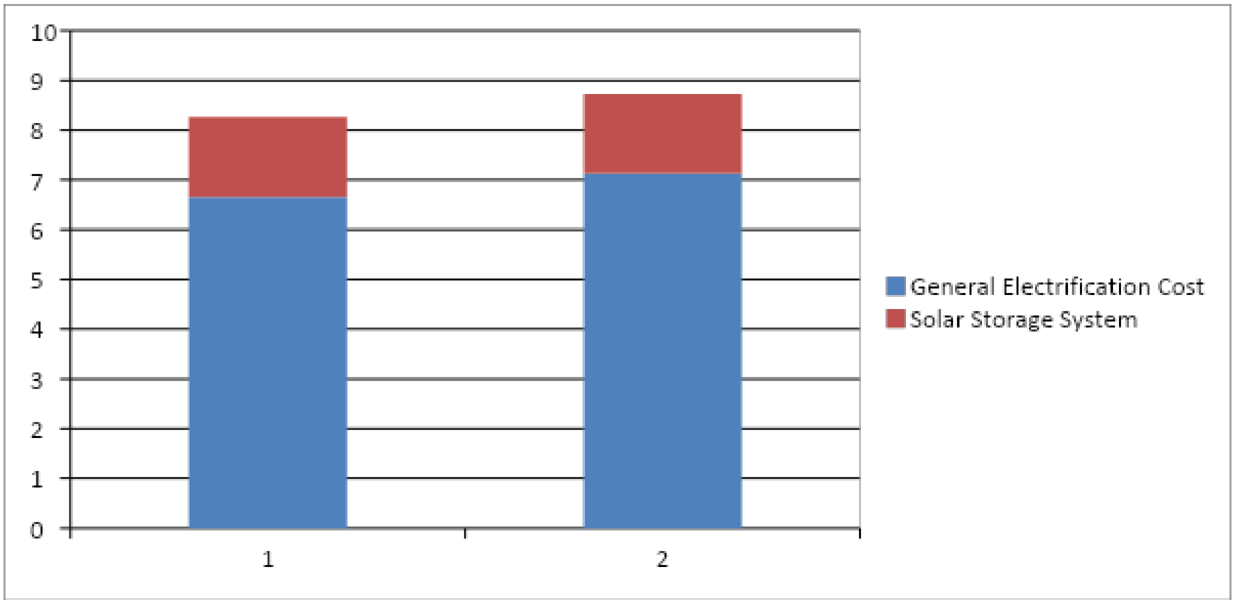

Figure 6.3: Significance between per unit cost of SSS and GEC

6.5 Consumers Satisfaction between GEC & SSS

Consumers are the first priority of our project. So we always think about our consumers. We have a small research on online about this. Here our satisfactory level is quite high. If we have done this project our society and also our government will be satisfied.

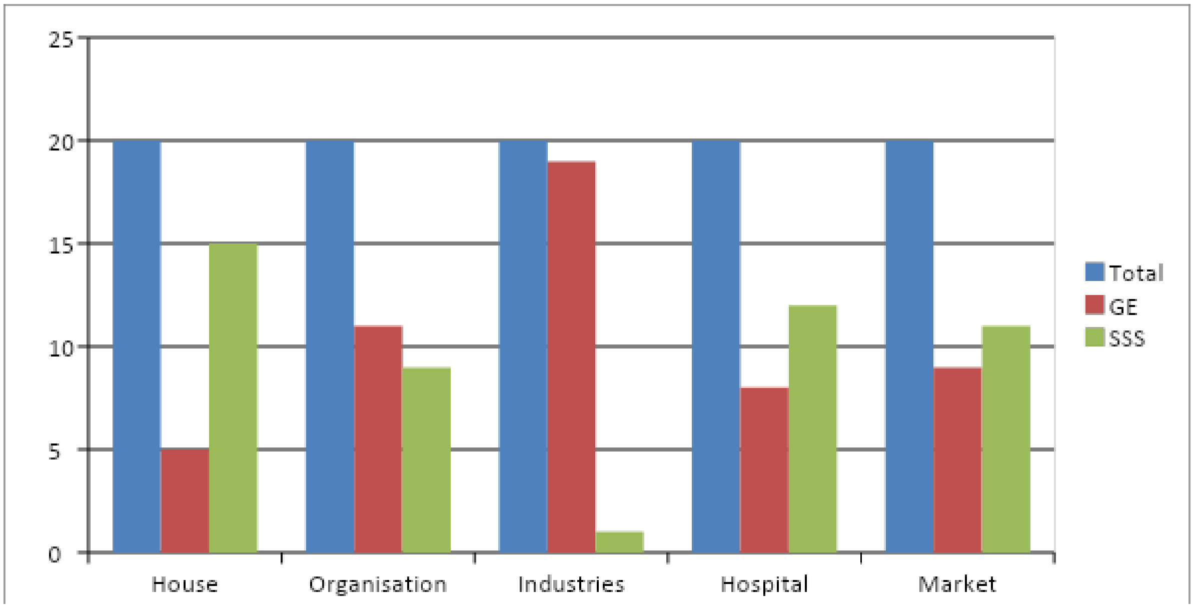

Figure 6.4: Consumers Satisfaction between GEC & SSS

Chapter: 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusion

Now-a-days all of the traction force, character and also sturdiness in the world end up being depending upon energy. We are facing fuel shortage for electricity generation and in the near future the whole World going to face the same scarcity because of world's limited fuel stock. So worldwide renewable energy demand and research are rising and our government also taking steps for green energy.

Physically, solar energy constitutes the most abundant renewable energy resource available and, in most regions of the world, its theoretical potential is far in excess of the current total primary energy supply in those regions. Solar energy technologies could help address energy access to rural and remote communities help improve long-term energy security and help greenhouse gas mitigation. On the other hand we also need to improve solar storage system due to lack of electricity at night. Day by day in our country our governments try to increase solar grid system and solar storage system (SSS) also.

The fundamental barrier to increasing market-driven utilization of solar technologies continues to be their cost. The current growth of solar energy is mainly driven by policy supports. Continuation and expansion of costly existing supports would be necessary for several decades to enhance the further deployment of solar energy in both developed and developing countries, given current technologies and projections of their further improvements over the near to medium term. Overcoming current technical and economic barriers will require substantial further outlays to finance applied research and development, and to cover anticipated costs of initial investments in commercial-scale improved-technology production capacity.

7.2 Limitations

In our country we have a lot of issue to do something new they are

1. Purchasing of solar storage system is fairly high initially.

2. Although solar energy can still be collected during cloudy and rainy days, the efficiency of the solar system drops.

3. Uses a Lot of Spaces.

4. Associated with Pollution

7.3 Future work

- Load calculation

- Reducing system cost
- System’s cost payback analysis

7.4 Recommendations

The concept of solar storage system isn't new. Off-grid solar photovoltaic (PV) and wind electricity generation on remote properties has long used battery storage to capture the unused electricity for later use. It's very possible that within the next five to 10 years, most homes with solar panels will also have a battery system.

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APPENDIX

1. Solar panel watts x average hours of sunlight x 75% = daily watt-hours

2. Charge controller = Total Battery watt/wattage of charge controller

3. Number of inverter =Total no of PV Panel/(no of panel in series in a string × no of parallel string)

4. Total Supply cost = Energy purchase cost + System Loss + Distribution cost

5. Energy Produced in 20 years = Avg. energy produced per day in kWh * Years * Day