DESIGN A GRID CONNCETED PV SOLAR SYSTEM FOR IIUC FEMALE ACADEMIC BULIDING

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ELECTRICAL AND ELECTRONIC ENGINEERING

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THESIS SUBMITTED IN FULFILMENT OF THE

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BANGLADESH

RECOMMENDATION

This is to certify that Md.Ohidul Alam Tipu (ET111028) and Biswajit Kanungo (ET111038) students of International Islamic University Chittagong (IIUC) under the department of Electrical and Electronic Engineering, has completed the thesis as a partial fulfillment of Bachelor degree titled by "Design A Grid Connected PV Solar System For IIUC Female Academic Building" successfully under my supervision and guidance. To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other university/institution for the award of any other degree or diploma or any other publication.

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DECLARATION

We hereby declare that the thesis titled "Designing a grid connected PV solar system for IIUC female academic building" submitted to the department of Electrical and Electronics, in partial fulfillment of the Bachelor of Science in Electrical and Electronics Engineering, is our original work and was not submitted elsewhere for the award of any other Degree or Diploma or any other Publication.

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ABSTRACT

This study aims at developing a standard procedure for the design of a grid connected PV solar system for IIUC campus using rooftops of those building which are favorable to the sunlight and other system is car parks. Bangladesh is facing an acute shortage of energy. Natural gas is the main source of electricity generation in Bangladesh. But the limited gas reserves cannot fulfill the necessities of both domestic requirements and industrial and commercial demands, especially demands for electricity generation for long. Due to this shortage of electricity, not only we are facing load shedding across the country but also the industrial sector is badly affected. Since load shedding occurs, the campus faces so many problems due to absence of continuous power. To ensure continuous power supply, we have chosen solar power as our second way to fed power which will be grid connected. This will be beneficial way to make up the power crisis. A grid-connected photovoltaic power system will reduce the power bill of our campus as it is possible to sell surplus electricity produced to the local electricity supplier. These are comparatively easier to install as they do not require a battery system. Grid interconnection of photovoltaic (PV) power generation systems has the advantage of effective utilization of generated power because there are no storage losses involved. A photovoltaic power system is carbon negative over its lifespan, as any energy produced over and above that to build the panel initially offsets the need for burning fossil fuels. Even though the sun doesn't always shine, any installation gives a reasonably predictable average reduction in carbon consumption.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

This study is being conducted with the aim of developing a standard procedure for the design of large scale grid connected PV solar system for IIUC female academic building using the roof of the building and car parks. Large grid connected PV solar systems are capable of providing an energy supply for multiple consumers. The electricity generated can be stored, used directly, fed into a large electricity grid powered by central generation plants (grid-connected or grid-tied plant), or combined with one, or many, domestic electricity generators to feed into a small electrical grid (hybrid plant) PV systems are generally designed in order to ensure the highest energy yield for a given investment. Grid-connected solar Photovoltaic (PV) systems employ the direct conversion of sunlight into electricity which is fed directly into the electricity grid without storage in batteries. This will be a very good way to boost the existing electricity production capacity in the country, which is mainly from gas. This will contribute positively to the worsening energy situation in the country. Solar energy, being a renewable source, will also provide energy without pollutants and greenhouse gas emissions. This can go a long way to help mitigating the adverse effect of global warming as well as contribute to sustainable energy development. It will also set the pace for similar projects to be developed in other institutions thereby helping attain the target of 10% renewable energy in the electricity generation mix set by the government.

Our present power generation capacity is only around 6500 MW whereas the total power requirement is 7500 MW. So, we are able to generate only 70% of our total electricity demand. There is a rising demand on the energy sector for rapid industrialization, urbanization, high population growth, increasing food production, rising standard of living etc.

Solar energy could be a major source of power generation in Bangladesh. Bangladesh government plans to make it mandatory to install solar panel on rooftops of every multistoried and hi-rise building.

As solar energy is one of the cleanest and simplest forms of energy, we can hope to find. Solar energy is readily available anywhere and everywhere in the earth. It can be used it to generate electricity at the point of consumption. Solar powered building is based on this concept.

1.2 Objective

The main goals of this thesis are:

1. To analyze the different types of solar photovoltaic system
2. To survey the site and load consumption of IIUC female academic building.
3. To design a grid connected PV system for IIUC female academic building
4. To analyze the cost estimation using HOMAR ENERGY software

1.3 Chapter Outline

There are five chapters in this thesis.

Chapter 1: Introduction- provides information about motivation and the objective of the thesis.

Chapter 2: Literature Review –provides current status of solar energy and related works around the world. In another sections discussed about the sources of CO_2, potential of solar energy and types of solar photovoltaic system.

Chapter 3: System designing and Data collection- provides Load survey of IIUC female academic building and monthly energy consumption, site selection, system configuration and the detailed components of the system.

Chapter 4: Simulation and Cost analysis- provides information about the simulation results and cost analysis.

Chapter 5: Conclusion-provides information about conclusion, Limitation, future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Over the many years, many research, work and implementation have been done on the evaluation of solar energy, designation of many systems, solar PV technologies. In this section, an overview of some important techniques, system of designing PV solar energy will be discussed.

2.2 Current Status of Solar energy in Bangladesh

Bangladesh is one of the potential regions of renewable energy. The use of renewable energy as risen considerably in recent times, both in developed and in developing countries. REN21's Renewables 2014 Global Status Report indicates that renewable energy provided an estimated 19% of global energy consumption in 2012 compared to 16.7 % in 2010 [1].

Bangladesh has also attached due importance to development of renewable energy. National plan - Five Year Plan, Power System Master Plan -- and policy documents including National Energy Policy, Industrial Policy 2010 underscored renewable energy.

A dedicated policy, Renewable Energy Policy of Bangladesh, has been in force since 2009, which envisions having 5% power from renewable energy sources by 2015 and 10% by 2020. The government has established Sustainable and Renewable Energy Development Authority (SREDA) to promote renewable energy and energy efficiency. To strengthen international cooperation, Bangladesh became one of the initial members of the International Renewable Energy Agency (IRENA), the only inter-governmental agency working exclusively on renewable energy. Those endeavors manifest Bangladesh's commitment towards development of renewable energy [1].

Bangladesh receives an average daily solar radiation in the range of 4-5 kWh/m^2. Encouraged by the availability of solar radiation, Power Division has initiated a program to generate 500 MW of solar-based electricity.

Private sector is expected to implement commercial projects like Solar Irrigation, Solar Mini Grid, Solar Park and Solar Rooftop applications.

Renewable energy is no more an ambitious expensive venture. Because of high research and development cost of renewable energy, it continues to lag in relation to conventional energy. For example, cost of solar PV panels declined more than 60% in the past three years. International Energy Agency projects that electricity generation from renewables may overtake natural gas by 2015 and perhaps coal by 2035.

The country of Bangladesh has installed over 3 million new residential solar energy systems (as of May 2014), with support coming from the World Bank and other various agencies, according to recent reports [2].

Bangladesh Power Development Board (BPDB) runs the following projects [10] .

650 KWp (400 kW load) Solar Mini Grid Power Plant at remote Haor area of Sullahupazila in Sunamgonj district under Climate Change Trust Fund (CCTF) on turnkey basis [2].

8 MWp Grid Connected Solar PV Power Plant at Kaptai Hydro Power Station, at Rangamati on turnkey basis and 3 MWp Grid Connected Solar PV Power Plant at Sharishabari, Jamalpur on IPP basis is being installed.

Installation of Solar Roof Top Systems in all BPDB offices across the country is a continuous process. More than 223 kWp solar PV systems have already been installed and installations of about 407 kWp solar PV systems are under planning/implementing stages [3].

2.3 Works on solar technologies around the world

There are huge works, research, thesis, implementation, design consideration and Improvement on solar technologies is going on around the world as well as in our Country. That is why we have more than company doing business, implementation and research on solar technologies.

University student around the globe works with solar system. Like A group of Students of Ahsanullah University of science and technology designed a solar system for their university [2].

Solar PV is currently the fastest growing power generation technology in the world with about 38,584MW capacity installed in the year 2010. In all, Europe alone contributes about 70% of the total installed capacity of PV systems with North America, Japan, China and Australia following in that order (EPIA et al 2010). Grid-connected systems make up the majority of these figures and this is as a result of favorable incentives such as feed-in tariff schemes, tax rebates and investment subsidies. (EPIA et al, 2010; REN21, 2011) [4].

The solar PV industry has also seen tremendous improvement in cell efficiencies for the various technologies available on commercial scale. This improvement in technology and the continuous growth of the PV market has led to drastic reduction in the cost of solar PV systems on the global market (EPIA et al, 2010) [4].

A group of students of the Pennsylvania State University has designed and simulated a distributed photovoltaic system for their university as their thesis. Again Rajamangala University of Technology Thanyaburi of Thailand installed PV system for their university to promote solar energy project. Scientist works on developing the solar panels, like scientist of Korea and California has develop a new way of boosting the efficiency of plastic solar panels . By this they make it more competitive to traditional solar panels. Commercial buildings, houses, Offices, companies are installing solar system for green energy, Such as the largest solar Powered building in Dezhou, Shandong Province in northwest China.[5]

Figure 2.2: The World's Largest Solar Energy Office Building Shines in China[5]

Figure 2.2 shows the world's largest solar energy office building shine in china. This is run by solar energy.

We can also find 100% solar powered buildings. Like the stadium for the world game 2009 in Taiwan was 100% solar powered. The 100% solar powered building in Taiwan.

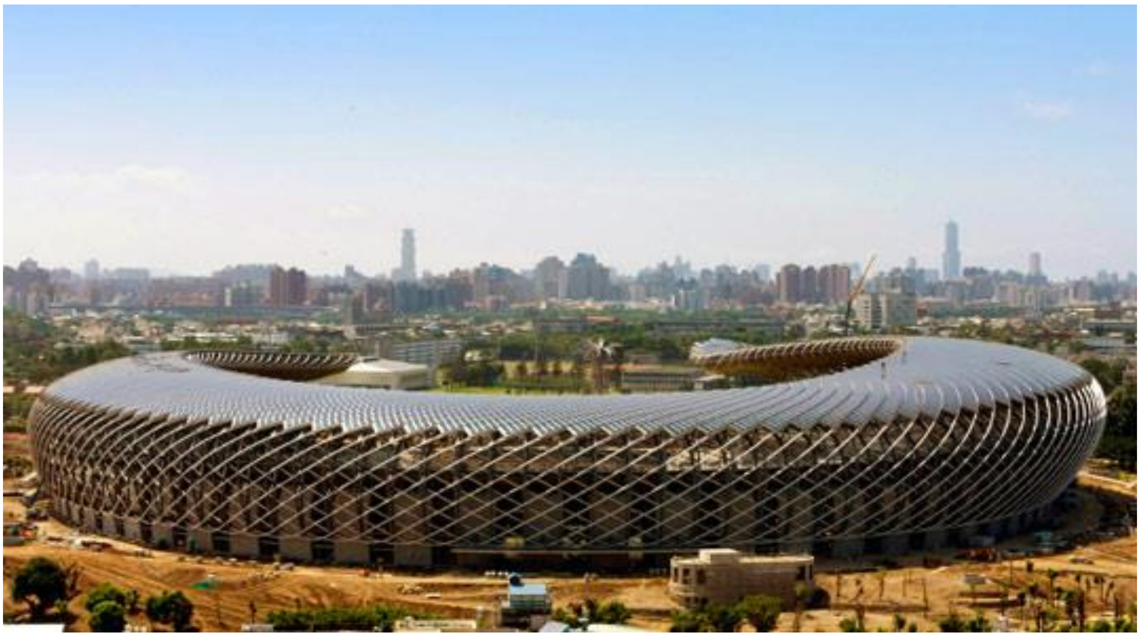


Figure 2.3: The 100% solar powered building in Taiwan[6]

Figure 2.3 shows the 100% solar powered building in Taiwan. It has 8,840 solar panels in the roof and can produce 1.14 million KWh/year. By this it can prevent 660 tons of carbon dioxide to release in the environment. Many works like research, improvement etc. on solar technologies is going on around the world and in our country as well. Solar energy is mainly site based with some key factors [6].

2.4 Overview

2.4.1 What is PV solar system?

Solar cells convert sunlight directly into electricity. Solar cells are often used to power calculators and watches. They are made of semiconducting materials similar to those used in computer chips. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. This process of converting light (Photons) to electricity is called the photovoltaic (PV) effect.

2.4.2 How PV works

When sunlight strikes the solar panel, photons from the light are absorbed by the semiconductor atoms, which then release electrons. The electrons, flowing from the negative layer (n-type) of semiconductor, flow to the positive layer (type), producing an electrical current.

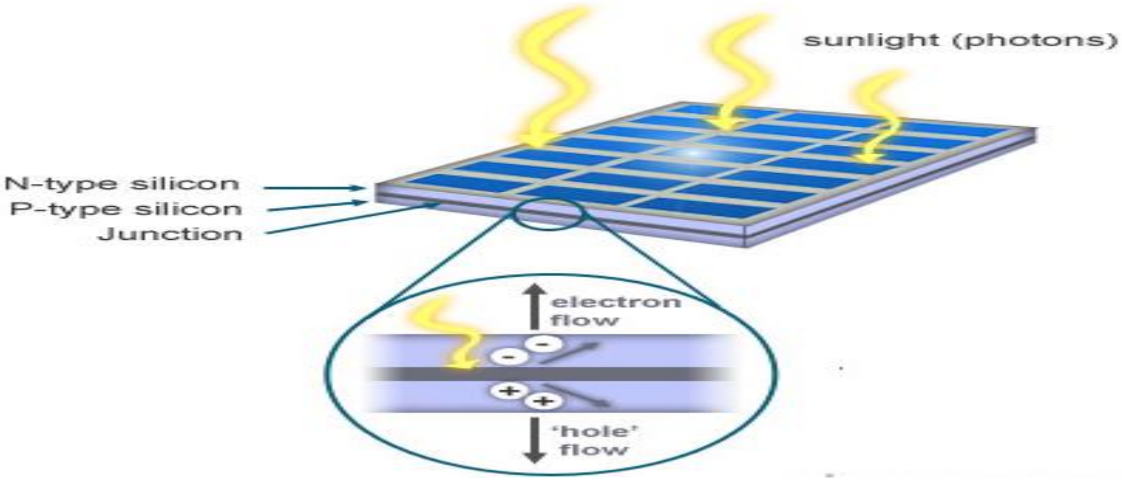


Figure 1.1: The working principle of PV solar energy [7]

Figure 1.1 shows the working principal of Photovoltaic system where sunlight strikes the PV module creating losing electron flowing through the conductor and producing current [7].

2.4.3 Why we use solar power?

The main sources of world's energy generation are the fossil fuels (gas, oil, coal) and nuclear power plants. Due to the usage of fossil fuels, greenhouse gases (CFC, CH4, O3, but mainly CO2) emit into the atmosphere. From the nuclear power plant, carbon is released in a small amount (90 grams equivalent of carbon dioxide per kilowatt hour). But the radioactive waste remains active over thousand years which is a potential prospect of polluting environment [8].

2.4.4 Potential of solar energy

There is a huge potential of solar energy. It is so huge that the total energy needs of the whole world can be fulfilled by the solar energy. The total energy consumption of the whole world in the year 2008 was 474 exa Joule (1EJ=10^18 J) or approximately15TW (1.504*1013 W). Almost 80%-90% of this energy came from fossil fuel. From the sun earth receives 3,850,000 EJ of energy which is equivalent to 174 pet watts (1 PW=1015 W). The earth does not hold all the energy, a part of it reflects back. After reflection earth receives 89 PW of energy. Of this huge amount only less than 0.02% is enough to replace the fossil fuel and nuclear power supply in the whole world at present. By this we can easily understand the great potential of solar energy [9].

Considering greenhouse effect, other environmental impact, cost, risk and availability solar energy has the greatest potential among all the energy sources.

2.5 Source of environmental pollution

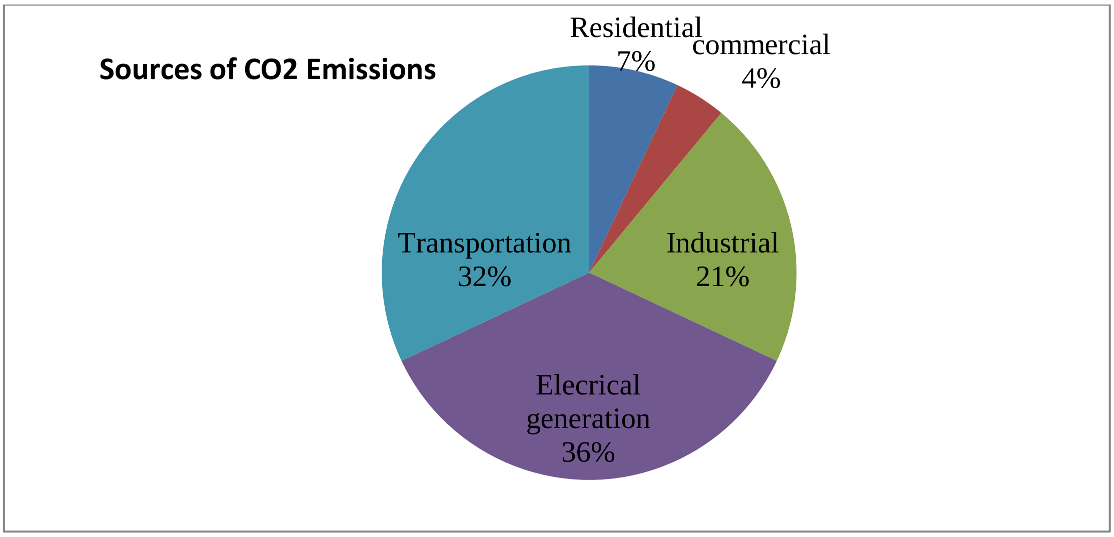


Figure 2.1: Sources of carbon dioxide emissions [2]

Figure 2.1 shows that electricity generation is the source of the highest emission of Carbon dioxide. So, production of this clean energy is actually contributing the highest towards global warming. Global warming as well as the environmental pollution is, in our times, the greatest environmental threat to human being. On the other hand, there is an alarming energy crisis worldwide as fossil fuel Reserves decrease and the ageing power plants are going to close in near future. From the aspect of global warming and shortage of natural gas, scientists and Engineers are looking for clean, renewable energies. Solar energy is the one of the best options. Because the earth receives 3.8 YJ [1YJ = 1024 J] of energy which is 6000 times greater than the worlds consumption [2].

Bangladesh is facing an acute shortage of energy. Natural gas is the main source of electricity generation in Bangladesh. But the limited gas reserves cannot fulfill the necessities of both domestic requirements and industrial and commercial demands, especially demands for electricity generation for long. Our present power generation capacity is only around 4200 MW whereas the total power requirement is 6000 MW. So, we are able to generate only 70% of our total electricity demand. Due to this shortage of electricity not only we are facing load shedding across the country but also the industrial sector is badly affected. Resulting in reduced industrial output and diminished export earnings. There is a rising demand on the energy sector for rapid industrialization, urbanization, high population growth, increasing food production, rising standard of living etc. Solar energy could be a major source of power generation in Bangladesh. Bangladesh government plans to make it mandatory to install solar panel on rooftops of every multistoried and hi-rise building. As solar energy is one of the cleanest and simplest forms of energy, we can hope to find. Solar energy is readily available anywhere and everywhere in the earth. It can be used it to generate electricity at the point of consumption. Solar powered building is based on this concept [2].

Considering the above aspects, solar power option for the IIUC campus is being studied in this work.

2.6 Types of solar system design

There are two categories of system design.

They are-

1. Grid-tied or connected
2. Off-grid or standalone

Another form of system may contain a supplementary or back-up system is called hybrid system.

Grid connected system can be subdivided into two categories.

1. Grid back-up
2. PV generation or Grid interactive [1].

2.6.1 Grid-Tied Solar Photovoltaic (PV) Systems

If the building is already connected to the mains power network or a connection to the national grid would be easy and not too expensive to arrange, a Grid-Tied Solar Photovoltaic system is often the most cost effective PV System to install. A Grid-Tied PV system offers the potential to make a profit on the energy we generate, whilst significantly reducing the energy bills and making a contribution to lowering CO_2 emissions. Any excess electricity is automatically exported to the grid, at night and in winter the grid connection is used in the normal way. Essentially a grid connected solar PV system provides a second source of power directly into the properties consumer/distribution unit.

2.6.2 Off-Grid Solar Photovoltaic (PV) Systems

An Off-Grid Solar PV System is self-contained and uses batteries to store and release electricity when the Solar PV Panels aren't active such as at night. An Off-Grid PV solution is ideal for remote buildings, application specific functions such as for powering machinery, temporary solutions, pumps, boats, pretty much anywhere where mains electricity isn't available and or isn't needed.

Figure 2.5: Block diagram of off grid solar PV system

Figure 2.5 shows the block diagram of off grid solar PV system which is not connected to the grid. This system of solar PV has the battery storage capacity which is connected to the charge controller and inverter to fed AC power for distribution

2.7 Why we prefer Grid-Tied Solar Photovoltaic (PV) Systems

The demand of electricity is increasing day by day and that much demand can't be meeting up by the conventional power plants. Partly, those plants create much pollution. CO2 emissions are getting more and more. Considering those aspects, Renewable energy takes place instead of conventional energy that will be better. Solar power is one of the renewable energy. Grid connected PV solar system is more reliable than other PV system. If generated solar energy is integrated to the conventional grid, it can supply the demand from morning to afternoon that is the particular time range when the SPV system can fed to grid. Grid connected systems have demonstrated as advantages in natural disasters by providing emergency power capabilities when utility power was interrupted.

2.8 How the systems work

Solar grid-tied PV systems convert energy from sunlight directly into electricity. A Grid-Connect Solar Photovoltaic (PV) System acts as a mini power station on the roof, feeds power to home, and surplus power back to the Grid. Solar systems for domestic homes generally consist of solar panels, an inverter and a metering system. Most solar power systems use PV modules (panels) installed on a rooftop to create and collect energy from sunlight. An inverter converts the Direct Current (DC) electricity generated by solar panels into Alternating Current (AC), the form of electricity conventionally used in homes. The system is connected through a meter to the grid. Solar systems allow using solar power when it is generating electricity during the day and put any excess back into the grid. As soon as needy more electricity than the system can generate, the electricity will automatically be supplied from the grid. At night, the building draws energy from the grid.

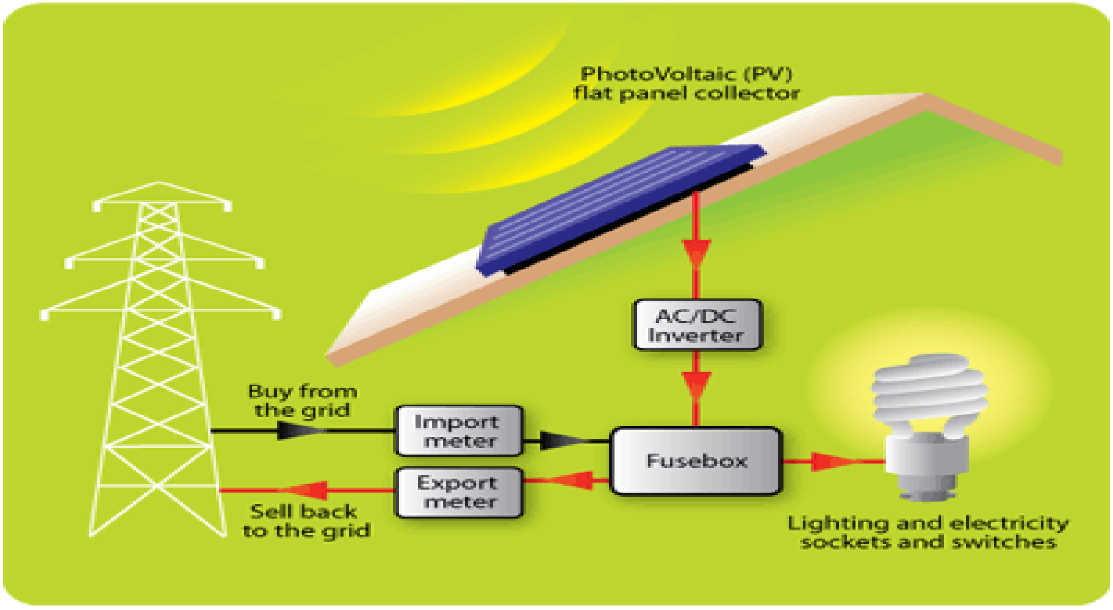


Figure 2.6: Block diagram of grid connected PV system [7]

Figure 2.6 shows the block diagram of grid connected PV system consisting of many components like solar panel, converter and fuse box and load and the grid connection. The solar panels generate electricity whenever the sun is shining. This electricity supplies the needs of the house – and then any excess is exported to the electricity grid. (The exported electricity is sold to the same company from which the household buys its electricity when it needs more than it's generating.)Part of this system is an inverter which connects your PV panels electrically to your house and also to the electricity grid. The inverter's main role is to take the electricity generated by the PV panels (low voltage DC) and match it to the grid electricity supply (230 volts AC). Many inverters also do "maximum power point tracking" (MPPT), which optimizes the PV panels' output [7].

2.9 Popularity of PV system

For a long time the expense of PV panels limited them to specialist uses where the electricity they supplied was the cheapest of the available options. Things have made PV more commonly available. Chinese companies supplying PV panels on a massive scale have caused corresponding price drops; and improved technology for grid-tied systems has made installing them on a house much easier. A partial reason for both these changes is that many countries are pushing to increase the amount of energy they get from renewable sources – and most of them are doing this because they want to reduce their greenhouse gas emissions. In many of these countries small-scale renewable generation, such as grid-tied PV, is easier to implement than large-scale renewables. This has meant it's heavily promoted and even subsidized in some countries.

2.10 Components of a solar PV system

Basic components of grid-connected PV systems without batteries

1. Solar PV Panels / PV Modules
2. A Grid-Tie Inverter
3. Cables & Accessories
4. Isolators.
5. Disconnecting switch
6. Mounting System
7. Monitor
8. Generation Meter [10].

2.11 Block diagram

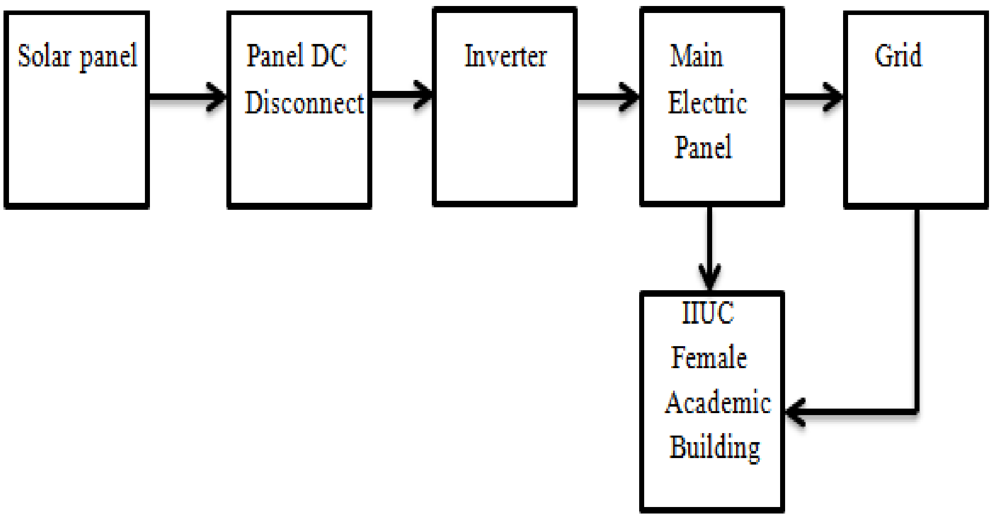


Figure 2.7:Block diagram of grid connected PV solar system

In the figure 2.7 indicates the block diagram of solar PV system where the solar panel produces DC power and the power will converter the DC power through panel disconnecting switches. The output power will be converterted into AC power and fed into the main electric box. The main electric box will deliberate AC power to the load and the grid.

2.10.1 Solar panel

Solar panels produce electricity from sunlight. The first solar panel-powered satellite was launched in 1958 by Hoffman Electronics. A solar panel consists of number of photovoltaic (PV) solar cells connected in series and parallel. These cells are made up of at least two layers of semiconductor material (usually pure silicon infused with boron and phosphorous). One layer has a positive charge; the other has a negative charge. When sunlight strikes the solar panel, photons from the light are absorbed by the semiconductor atoms, which then release electrons. The electrons, flowing from the negative layer (n-type) semiconductor, flow to the positive layer (p- type), producing an electrical current. Since the electric current flows in one direction (like a battery), the electricity generated is DC.

2.10.2 Inverter

Inverters are used for the fulfillment of the following criteria.

- Converting the DC power coming from the PV modules or battery bank to AC Power
- Ensuring that the frequency of the AC cycles is 60 cycles per second
- Reducing voltage fluctuations
- Ensuring that the shape of the AC wave is appropriate for the application, i.e. a pure sine wave for grid-connected systems

Criteria for Selecting a Grid-Connected Inverter– The following factors should be Considered for a grid-connected inverter:

- The voltage of the incoming DC current from the solar array or battery bank.
- The DC power window of the PV array
- Characteristics indicating the quality of the inverter, such as high efficiency and good frequency and voltage regulation
- Additional inverter features such as meters, indicator lights, and integral safety disconnects
- Manufacturer warranty, which is typically 5-10 years
- Maximum Power Point Tracking (MPPT) capability, which maximizes power output

Most grid-connected inverters can be installed outdoors, while most off-grid inverters are not weatherproof [10].

There are essentially two types of grid-interactive inverters

1. Those designed for use with batteries and
2. Those designed for a system without batteries.

Power Quality– Inverters for grid-connected systems produce better than utility-quality power. For grid-connection, the inverter must have the words “Utility-Interactive” printed directly on the listing label.

Voltage Input– The inverter’s DC voltage input window must match the nominal voltage of the solar array, usually 235V to 600V for systems without batteries and 12, 24 or 48 volts for battery-based systems.

AC Power Output– Grid-connected systems are sized according to the power output of the PV array, rather than the load requirements of the building. This is because any power requirements above what a grid-connected PV system can provide is automatically drawn from the grid [10].

2.10.2 Combiner Box

Wires from individual PV modules or strings are run to the combiner box, typically located on the roof. These wires may be single conductor pigtails with connectors that are pre-wired onto the PV modules. The output of the combiner box is one larger two wire conductor in conduit. A combiner box typically includes a safety fuse or breaker for each string and may include a surge protector [11].

CHAPTER 3

DATA COLLECTION AND SYSTEM DESIGNING

3.1 Load survey of IIUC female campus

To Survey load consumption in IIUC female campus, the total energy consumption per month is collected from the construction and planning division. That was the first step to go. In this part, we observed the total load of whole building in a month and analyzed the total energy bill from July 14 to Jun 15. We collected those papers from IIUC Engineering construction office [11].

3.2 Electrical Energy Consumption

Annual Electrical energy consumption of IIUC female campus is about 237000 kwh/year. The total off peak energy consumption is about 194000 KWh/year and the peak energy consumption is 43000 kWh. Average monthly energy consumption including off peak and peak energy is 19,750 kWh [11].

3.3 Monthly Energy consumption in IIUC female academic building

The monthly, yearly and average energy consumption of IIUC female academic building is collected from the construction and planning development department which is provided by the power development board. The peak and off peak energy consumption is shown in the table 1 below.

Here, the peak hour and the off peak hour of IIUC female academic building is determined by the load consumption. The peak hour is from 8 am to 8 p.m. and the off peak hour is from 9 p.m. to 7 a.m.

Table 1: Monthly Electric bill of IIUC female academic building [11]

Month	Off peak energy consumption(KWh)	Peak energy Consumption(KWh)
July-14	32500	0
August-14	25000	5000
September-14	15000	5000
October-14	28500	2500
November-14	14000	3000
December-14	10000	500
January-15	7500	2500
February-15	5000	1500
March-15	15000	5000
April-15	14500	5000
May-15	14000	9000
Jun-15	13000	4000
Average-15	16166.6667	3583.3333

The Energy Consumption by IIUC female campus is given by the bar chart

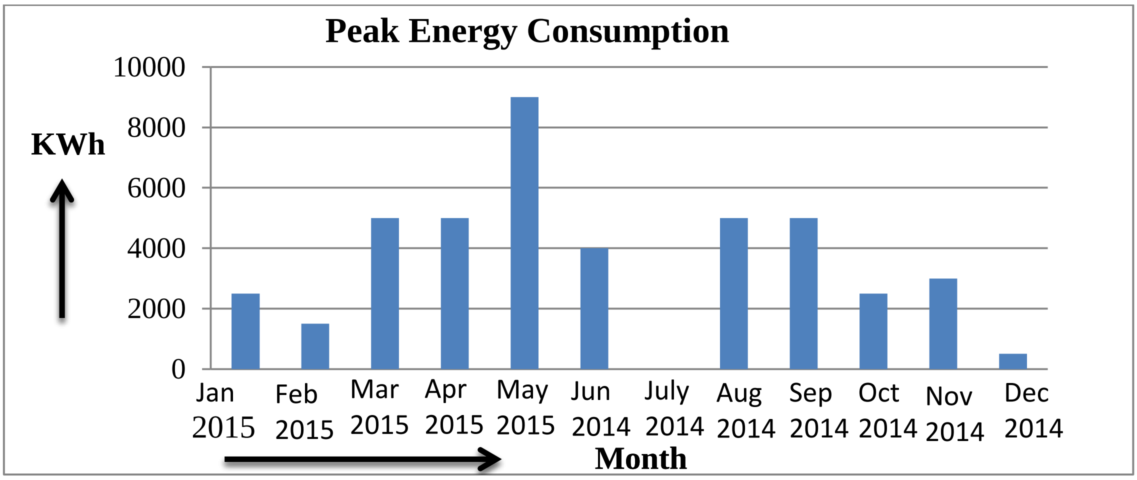


Figure 3.1:Peak energy consumption of IIUC female campus.

Figure 3.1 shows the peak energy consumption of IIUC female academic building where as the on July 14 the energy consumption is minimum and on May 15 the energy consumption is maximum.

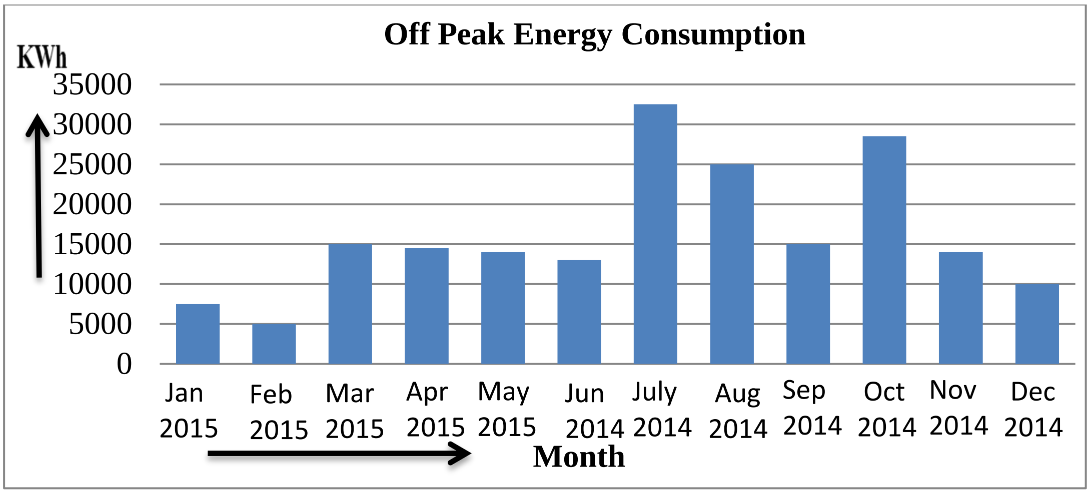


Figure 3.2: Monthly off peak energy consumption of IIUC female campus

In the figure 3.2 the off peak energy consumption is shown where on the month of February-15, the energy is minimum. On the contrary, the maximum off peak energy consumption is fixed on the month of July-14.

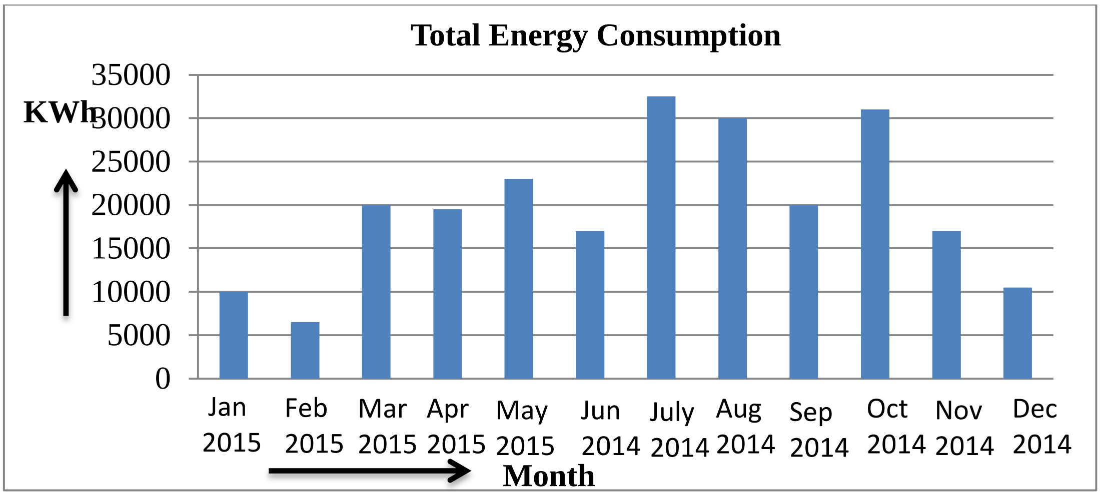


Figure 3.3: Total energy consumption IIUC female campus

Figure 3.3 shows the total energy consumption where it indicates the maximum and minimum energy consumption of a month. The maximum total energy consumption is drawn on the month of July-14 and the minimum maximum total energy consumption is drawn on the month of February-15.

3.4 Daily load profile

Annual energy consumption for female campus, July-14 to Jun-15 is 237000 KWh.

Average energy consumption (KWh/d) = Total energy consumption of a year/ 12 month = 237000/365

Average energy consumption per day = 649.3151 KWh/d

The scheduling of Load consumption in IIUC female academic building is defined in the Table 2.

Table 2: Scheduling of Load consumption in IIUC female academic building

Hours	Load(KW)
12:00-01:00 A.M	17.200
01:00-02:00 A.M	174.410
02:00-03:00 A.M	16.950
03:00-04:00 A.M	16.210
04:00-05:00 A.M	18.120
05:00-06:00 A.M	19.120
06:00-07:00 A.M	32.495
07:00-08:00 A.M	39.120
08:00-09:00 A.M	40.852
10:00-11:00 A.M	39.450
11:00-12:00 P.M	40.870
12:00-01:00 P.M	42.250
01:00-02:00 P.M	45.870
02:00-03:00 P.M	42.870
03:00-04:00 P.M	40.000
04:00-05:00 P.M	28.127
05:00-06:00 P.M	25.120
06:00-07:00 P.M	23.120
07:00-08:00 P.M	22.125
08:00-09:00 P.M	21.250
09:00-10:00 P.M	18.120
10:00-11:00 P.M	17.128
11:00-12:00 P.M	15.487

From the data, we analyze load data hourly is inserted in HOMER energy software.

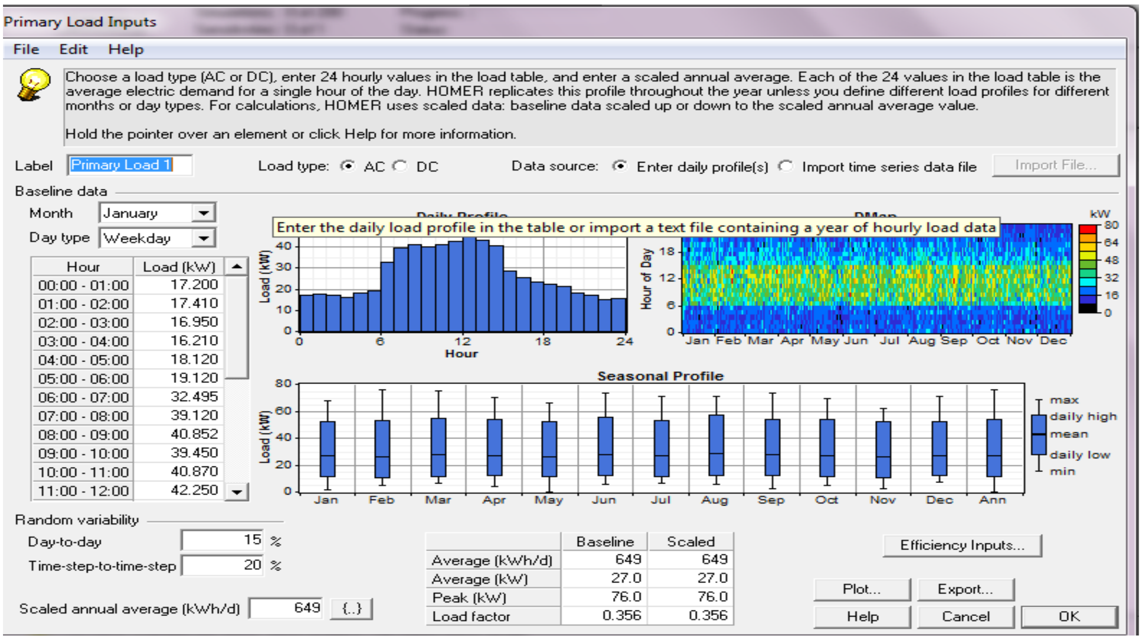


Figure 3.4: Primary input load profile from HOMAR Energy simulation

Figure shows the primary input load profile from HOMAR energy software simulation. On the basis of the peak and off peak hour of IIUC female academic building, the schedule of load profile is determined.

3.5 Site selection

International Islamic university Chittagong female campus is a potential area of implementing a solar system design. It is located at chandgaon, Chittagong city beside Shadinota complex. This is 6 storied incomplete building which is the female campus of International Islamic University Chittagong. Its roof space is very long. But from big space, we selected a part of area whose dimensions are 212450 square foot or 19736.605 m^2. Due to expense, not much load demand, distance, large and small combination, shading problem and structural characteristics of building us not used all roof area for this designing.

Considering above reasons, we measured roof top area is 19672.6157 Square feet or 1827.586m^2.

3.6 Site location of the project

The location of the female campus is collected from Google map which is given bellow

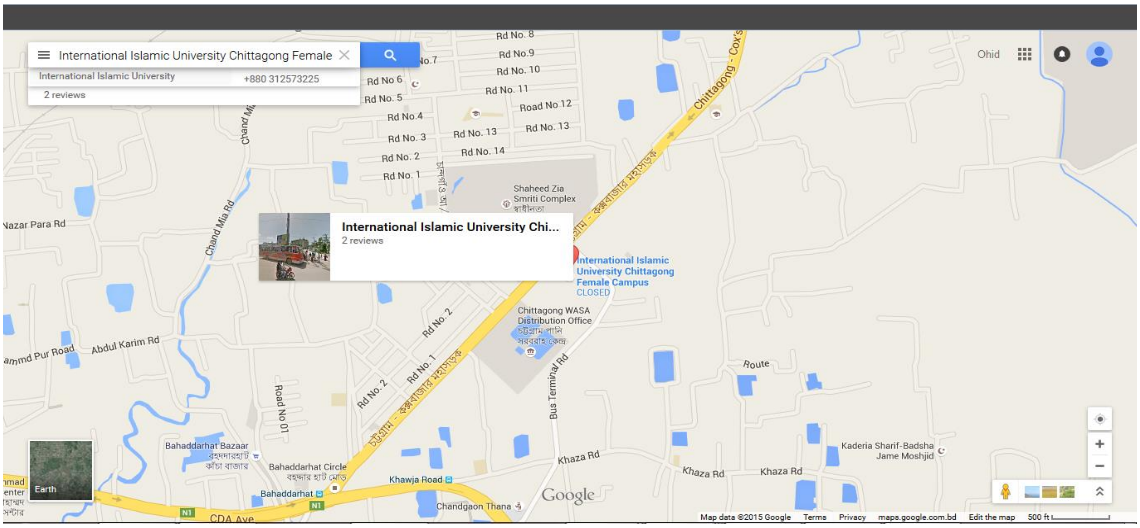


Figure 3.5: IIUC female campus site location from Google Map [12]

The Figure 3.5 shows the location of IIUC female campus which is collected from Google map [12].

Figure 3.6: Roof top view of IIUC female campus [12]

Figure 3.6 shows the original roof top view of IIUC female campus which is selected for the implementation of the design proposed configuration of grid connected PV solar energy.

Total roof area (which we are selected for mounting PV array) =15738.1 Square feet or 1827.586 m^2. But all area is not useable, because of PV array gap and mounting purpose of PV array. So we use only 80% roof area.

Actual useable roof area = (1827.586*80%) square meter

= 1462.0688 meter square

3.7 Solar Radiation

In the solar resource window, we put the local latitude (28 degree 20 minutes) and longitude (91 degree 48 min) for Chittagong in Bangladesh [6]. The time zone is given GMT +6:00. Then we gathered data from the internal where the scaled annual average radiation for Chittagong in Bangladesh is 4.758 kwh/m*2/day. We found the solar irradiance by simulating in Homer Energy. It is very important to know the irradiation and insulation of a site when anyone is going to design a solar PV system for that site. Depending on the sun shine, irradiance and insulation varies with place to place. Daily average Bright Sunshine hours in Chittagong city are provided in the Table 3.

Table 3: Daily average Bright Sunshine hours in Chittagong city [13]

Month	Sunshine hours
January	8.05
February	8.34
March	8.45
April	8.40
May	7.13
June	3.99
July	3.85
August	5.19
September	6.32
October	7.01
November	7.61
December	8.72
Average	7.51

Table 4: Daily solar radiation from HOMAR ENERGY

Month	Clearness Index	Daily Radiation(kwh/m*2/d)
Jan	0.644	4.597
Feb	0.626	5.126
March	0.596	5.634
April	0.55	5.76
May	0.527	5.786
Jun	0.39	4.335
July	0.368	4.048
Aug	0.398	4.224
Sep	0.411	4.083
Oct	0.554	4.725
Nov	0.6	4.409
Dec	0.647	4.391
Average	0.512	4.758

In the HOMAR simulation software, we have collected the value of the solar resource.

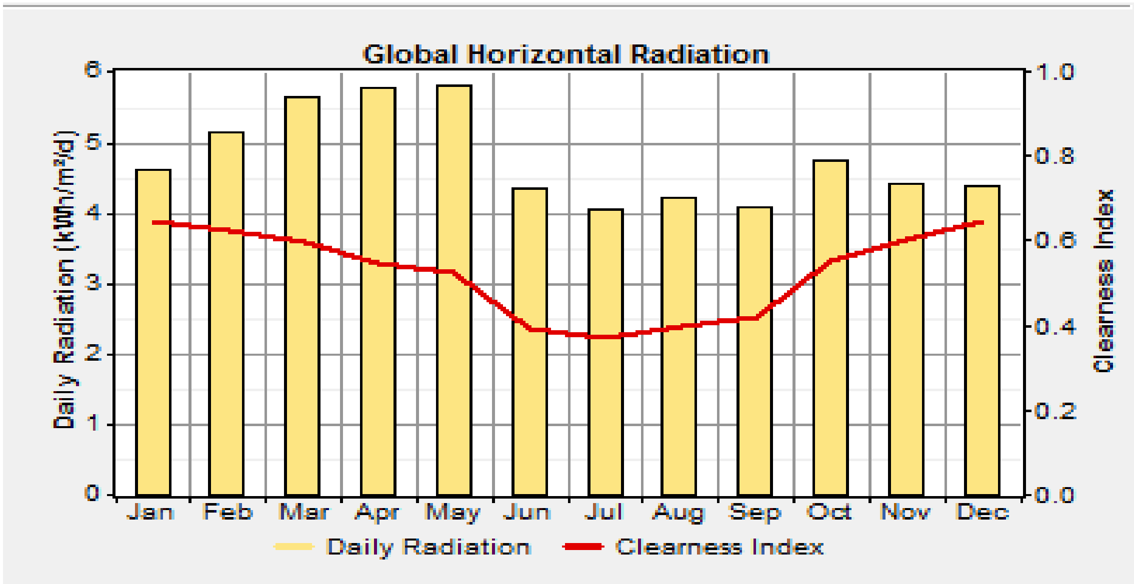


Figure 3.7: Solar resource data From HOMAR energy software

Figure 3.7 shows the solar resource data from HOMAR energy software which indicates the clearness index with respect to the daily radiation.

The daily average bright sunshine hours in Chittagong is 7.51 hours and the average solar radiation is 4.758 kwh/m*2/d.

Irradiance of a site is given by the following relation.

$$\text{Irradiance} = \frac{\text{Average radiation}}{\text{Average daily bright sunshine hours}} \ \text{kWh / m}^2$$

$$= \frac{4.758 * 1000}{7.51} \ \text{W/m}^2$$

$$= 633.56 \ \text{W/m}^2$$

From the formula, the irradiance of Chittagong is 633.56 W/m^2.
For this irradiance the PV module will give 178.22 watt/ m^2.

3.8 System Configuration

There are many possible configurations of solar PV system. Each of these configurations has its own advantages and disadvantages. Generally, Systems configuration of PV system may be divided into two main categories.

- Off-grid – uses PV technology that is not connected to a utility grid.
- On-grid – uses PV technology that is connected to a utility grid.

Off-grid PV systems in-turn may be divided into two main types

- Stand-alone PV systems with energy generation coming from the PV modules and may come with a storage system – such as a battery.
- Hybrid PV systems with the addition of auxiliary generation units such as a wind turbine or diesel generator [8].

In our work, at first we considered possible configurations for IIUC female academic building.

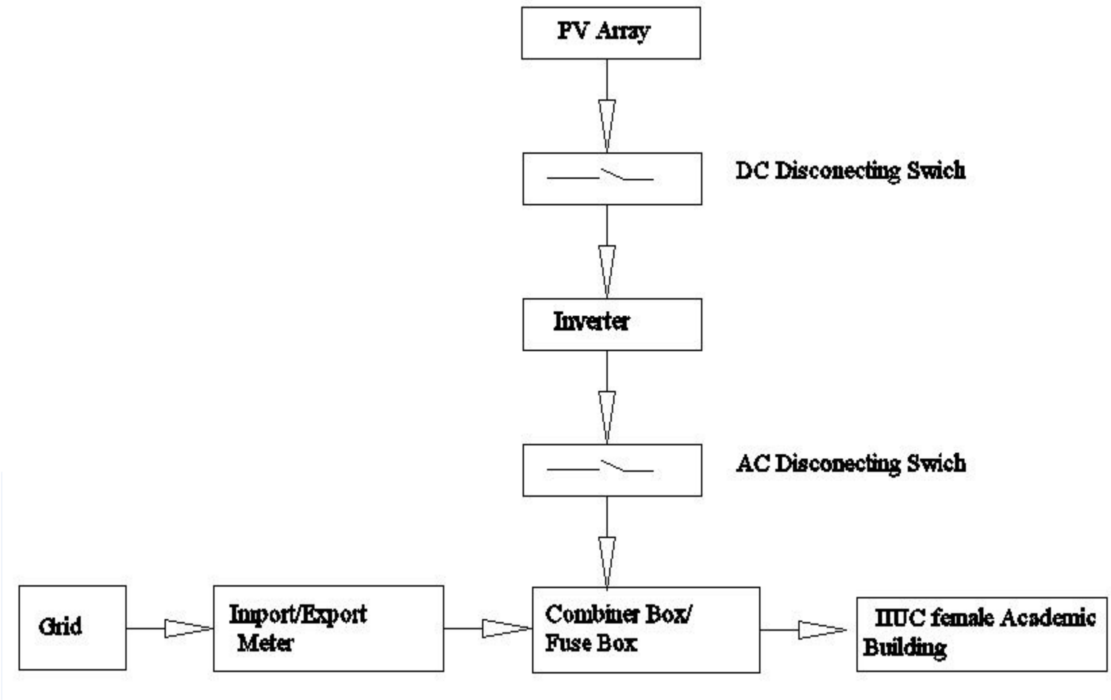


Figure 3.8: Block Diagram of the configuration of Solar PV system for IIUC female academic building.

Figure 3.8 shows the block diagram of the proposed configuration of solar PV system for IIUC female campus which comprises solar power to inverter through DC disconnecting switch and then to the main fuse box and finally the main fuse box is mutually connected to the grid and to the IIUC female campus load through meter to the grid.

But we need more energy to run the campus. Average monthly energy consumption including off peak and peak energy is 19750 kWh and we can theoretically produce 25933.33 kWh per month.

At 633.2 watt/m^2 insolation the selected PV module can produce = 178.22 W

Daily average bright sunshine hour = 7.51

Total no. of modules = 800

Total energy supply = Maximum Power at defined irradiance of a solar panel * Average bright sunshine hour * 365 days * total no. of solar panels

= 178.5* 7.51 * 365 * 800

= 391.43622 MWh/year.

Considering 80% of panel's output efficiency the total energy supply=391.43622 MWh/year.
So, the daily output energy is 852.60 KWh/day.

Energy generation per month = 178.22 * 800 * 7.51 * 30
= 32122.37 kWh/ month
= 32.1223 MWh/month

Actual system capacity = 800*178.22 W
=142576 W
= 142.576 KW

Total system capacity = 800*315 W
= 252000 W
=252 KW

3.9 Module Selection

There are many manufacturers company around the world. From the consideration of the characteristics of those PV modules, we have selected a PV module named Sunpower^{Tm}. The selected PV module's efficiency, power range varies 310-315Wp and monocrystalline types are favorable to our design. The Comparison of Some manufacturers PV module are below in the Table 4.

Table 5: Comparison of Some manufacturers PV module

Manufacturer Name	Series	Type	Power Range (Wp)	Efficiency	Price per Wp
Sunpower^{TM}	SPR-E19-315	Monocrytalline	310-315	19.3%	0.547$
Shine Solar	SS245-605	Polycrystalline	225-245	14-15.2%	0.423$
Infinity new Energy	JNE-300-6A	Polycrystalline	300-315	15.5-16.3%	0.471$

While selecting PV module, we have chosen the Sunpower^{TM} 315 solar panel which provides today’s highest efficiency and performances. The Sun power 315 panels reduced voltage-temperature coefficient, anti-reflective glass and exceptional low light performances attributes provide outstanding energy delivery per peak power watt.

Figure 3.9: Picture of selected PV module [14]

Figure 3.9 shows the picture of selected PV module which is selected for producing photovoltaic energy. The configuration and the specification for the design procedures the product is so much preferable.

Table 6: Provisional technical data of selected PV module [13]

Electrical parameters	Value
Peak power, P_{max}	315 W
Rated voltage, V_{mpp}	54.7 V
Rated current , I_{mpp}	5.76 A
Open circuit voltage, V_{oc}	64.6 V
Short circuit current, I_{sc}	6.14 A
Maximum system voltage, VL	600 V
Temperature coefficients	
Power	-0.38%/K
Voltage	-176.6mv/K
Current	3.5ma/K
NOCT	45^0 C +/-2^0 C
Series Fuse ratings	

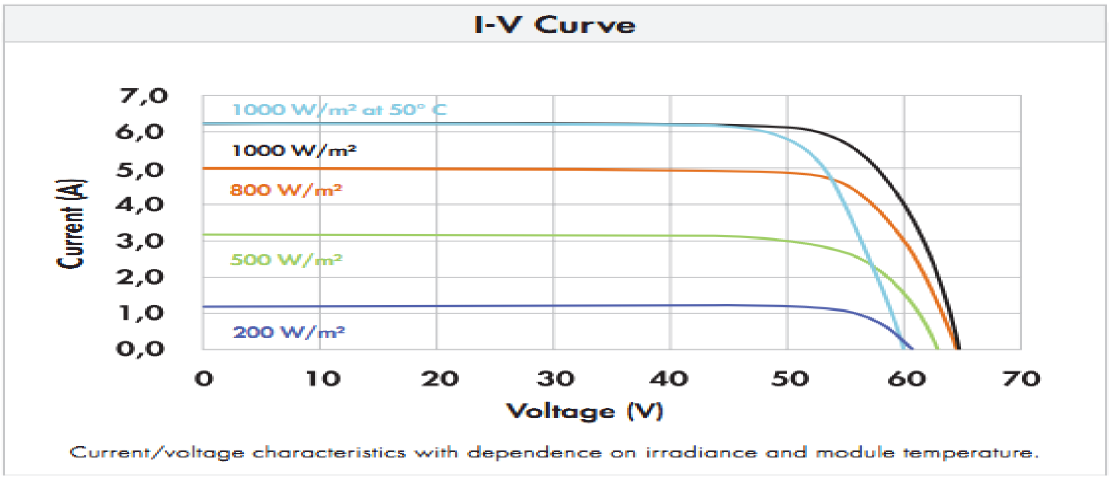


Figure 3.11: I-V characteristics curve of the selected PV module [13]

3.10 Number of Module

In this part, the number of PV module can be defined by using roof top measurement and the area of selected PV module. After finding number of PV module, the no. of inverter, combiner box and other necessary module can be selected.

Number of module:

$$\frac{\text{Total Usable roof area}}{\text{Area of selected PV module}}$$

$$= \frac{1472.069\text{m}}{1.84}$$

= 800

= 800

Total number of module is 800.

3.11 PV array Sizing

Module Open circuit voltage, Voc = 64.6

The MPPT voltage range for selected inverter, V_{max} = 580~800/580

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

Maximum number of Module in series =800 /64.6 =12

At 633.2 W/m2 maximum short circuit = 6 A

Maximum input current for selected inverter, = 36 A

Maximum number of parallel module = 36 /6 = 6

If we put 6 parallel string (1 string consist of 12 series module) = 6*6=36 A

This is in inverter's range and also in combiner box range.

Therefore, our chosen PV array design is 6 parallel strings each consist of 12 series modules for 1 combiner box and 1 inverter.

3.12 Inverter Selection

The SMA Tripower STP-15000TL is a 15kW commercial inverter that operates at 480Vac, rated for 1000Vdc or 600Vdc systems. The SMA Sunny Tripower is the commercial solution for decentralized PV power plants. This three-phase transformer less inverter is UL listed for up to 1000 V DC maximum system voltage and has peak efficiency above 98 percent. The OptiTrac Global Peak minimizes the effects of shade for maximum energy production. The Sunny Tripower delivers a future-proof solution with full grid management, and communications and monitoring features. The inverter offers flexibility with a wide input voltage range and two independent MPP trackers. Suitable for both 600 Vdc and 1,000 Vdc solar installations, the Sunny Tripower allows for flexible design and a lower cost of energy [8]

Figure 3.12: The picture of selected inverter (Sunny Tripower) [8]

Table 7: Provisional technical Data of selected Inverter

Input	Value
Maximum Dc power	15260 W
Maximum input voltage	1000 V
MPP voltage range with a line voltage of 230 V/ rated input voltage	580-800V/ 580V
Minimum input voltage/start input voltage	570 V/ 620 V
Maximum input current	36 A
Output	
Rated power	15000 W
Maximum apparent AC power	15000 VA
Nominal AC voltage range	160-280 V
Maximum output current	24 A
Maximum efficiency	98.5 %/ 98.3%

3.13 Number of Inverter Calculation

No of inverter =Total no of module/ (no. of module in series in a string*no. of parallel string)

= 800/ (12*6)

= 11

Total number of Inverter = 11 no.

3.14 Combiner Box Selection and Sizing

Brand Name: TRESS

Model Name: TLS 6 INPUT

Figure 3.14: Solar PV array combiner box [8]

Figure 3.14 shows solar PV array combiner box whose function is to combine wires from different panels.

Specification of Solar PV array combiner box (TLS 6 INPUT) is given below in Table 8

Table 8: Specification Solar PV array combiner box [8]

Specification	
Maximum strings	16 or more
Max current of each string	15-20A
PV voltage range	200-900Vdc
Ambient temperature	-45^0~75^0

3.15 Number of combiner box

Total number of combiner box is equal to the total number of inverter, Total number of combiner box = 5

As we need to arrange 800 modules we need such 5 configuration

3.16 Wire Sizing

Rated short circuit current is 8.11 A from the PV module. If there is an effect of higher insolation and lower temperature access current can flow. To prevent these to happen the safety factor is considered. Average insolation at Chittagong city is 633.2 W/m^2.

Therefore maximum short circuit current will be = 6 A

For 6 parallel string = 6*6 = 36 A

Considering 35% safety factor Maximum current rating is 12.8 A.

So, we have chosen 12.8 A rating wiring.

CHAPTER 4

SIMULATION AND COST ANALYSIS

4.1 Simulation and overall performance analysis

We have selected a simulation software to design a friutfull PV system for IIUC female academic building. The name of the simulation software is HOMAR ENERGY software. HOMAR has several built-in mathematical models for components such as PV module,converter, battery, Load profile and other important tools.

4.2 Designing PV as Input

The equipment considered in the optimization is shown in the figure . The equipment is needed in this respect such as Grid input, PV module, Converter and Loading system.

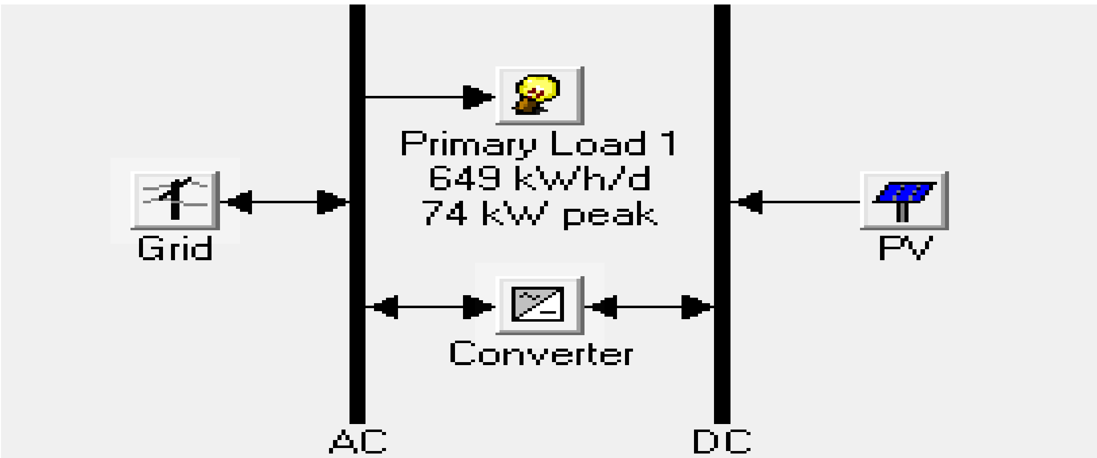


Figure 4.1 : PV Input designing Diagram

Figure 4.1 shows the PV input designing diagram from HOMAR energy simulation where PV is deliberating DC power to the Converter and converter is inverted DC to AC power and power is fed to the load. The load is measured from the scheduling of the peak and off peak energy consumption where the daily energy consumption is 649 KWh/day and peak power is 74 KW. The AC power deliberated from converter is also given and taken from the grid.

4.3 PV module as input

Here we estimated PV as input specially sizes and the cost per Kilo Watt which are specified as 70000/KW. Maintenance cost was not caught into the estimation because no maintenance is needed for the panels. Derating factor is 80% and the life time is considered as 20 year.

Table 9: PV sizing cost per KW

Size(KW)	Capital(BDT)	Replacement(BDT)	O & M (BDT/yr.)
1.000	70000	0	1000
52.000	3640000	0	52000
102.000	7140000	0	102000
152.000	10640000	0	152000
202.000	14140000	0	202000
252.000	17640000	0	252000
302.000	2114000	0	302000
352.000	24640000	0	352000
402.000	28140000	0	402000
452.000	31640000	0	452000

Table 10: Nominal value of PV module from HOMAR

Parameters	Value
Sizes to be consider	52,102,152,202,252,302,352 KW
Life time	20 yr.
Derating factor	80%
Tracking system	No tracking
Slope	22.8 degree
Ground reflectance	20%

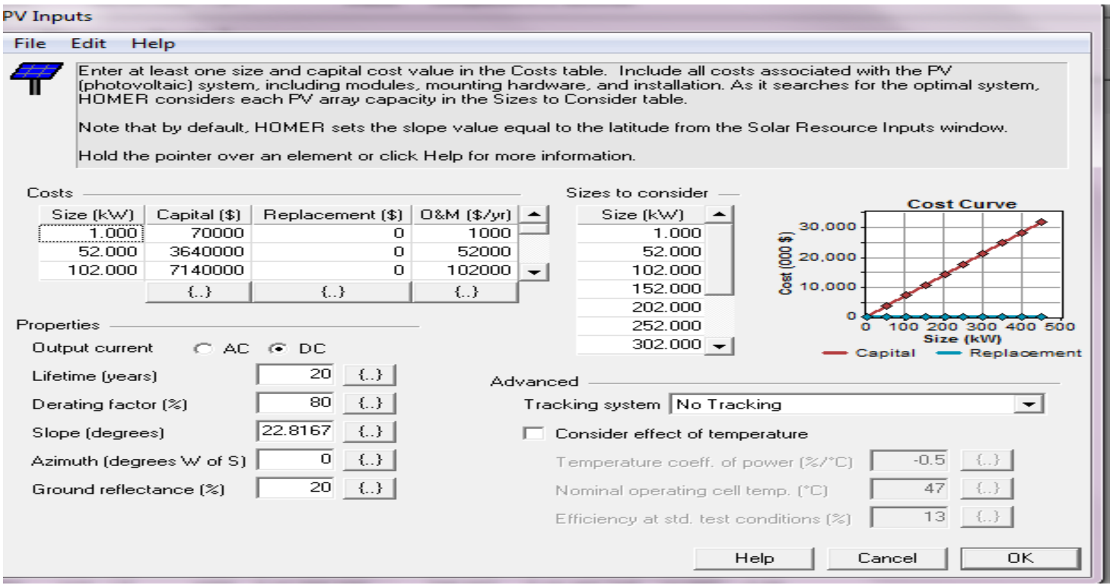


Figure 4.3 :PV input

Figure 4.3 shows the size & capital cost value in the costs table and the graph of cost curve. From the figure, the properties of PV inputs such as output current, life time derating factors and the tracking system is defined and clarified.

4.4 Converter as input

The efficiency and the life time were considered as 90% and 10 years for the sizes to be considered. The sizes of the converter were varied from 150 to 200KW. The converter input variables and its value is shown in the table.

Table 11: Converter cost/size in KW from HOMAR

Size(KW)	Capital (BDT)	Replacement (BDT)	O & M ($/yr.)
1	80000	48000	0
67	5360000	3216000	0
117	9360000	5616000	0
167	13360000	8016000	0
217	1736000	10416000	0
267	2136000	12816000	0
317	2530000	15216000	0
367	29360000	17615000	0

Table 12: Nominal value of converter module from HOMAR

Parameters	Value
Sizes	120, 150, 170,180,190 KW
Life time	15 yrs.
Inverter efficiency	90%
Rectifier relative capacity	100%
Rectifier efficiency	85%

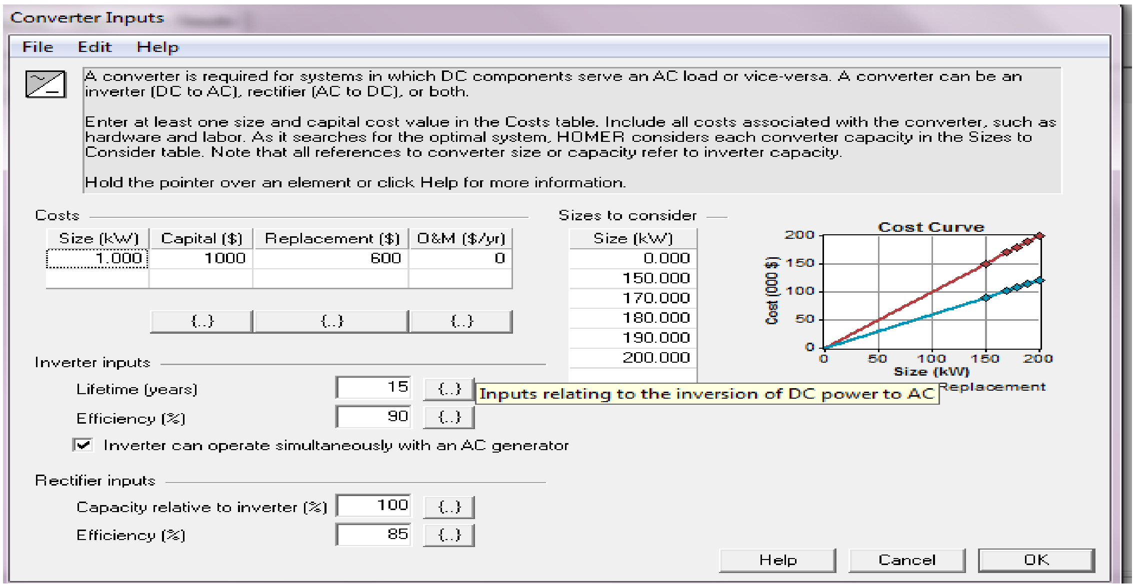


Figure 4.5: Converter Inputs

Figure 4.5 shows converter input panel from HOMAR energy software. From the figure the sizes, its capital cost, replacement cost, life time, and efficiency are defined.

4.5 Grid Input

Considering aspects of the sellback rate and prices of power per KWh, IIUC female campus demand and the rate of that power, Grid inputs are shown in the below in the figure 4.6

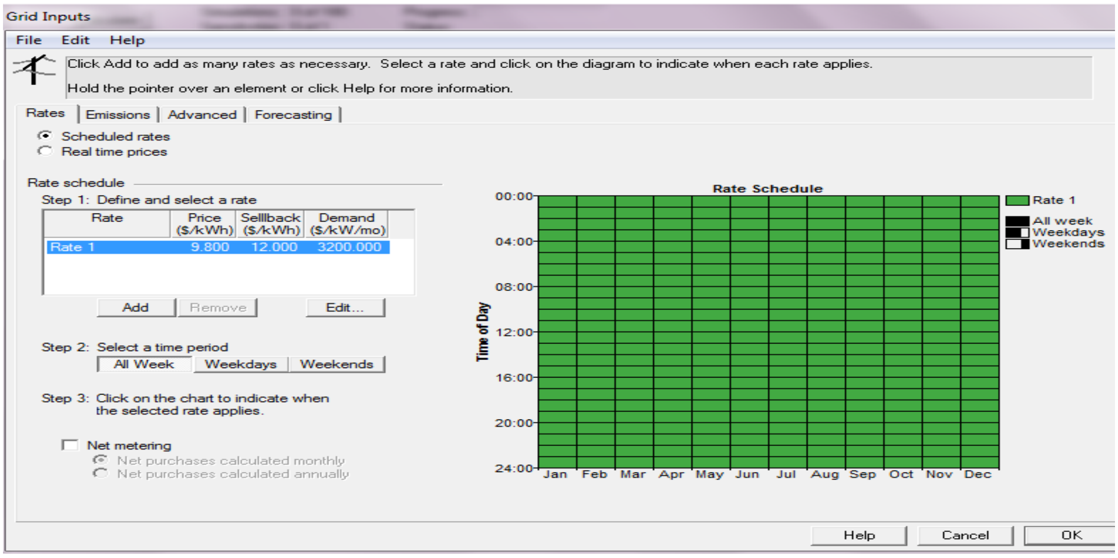
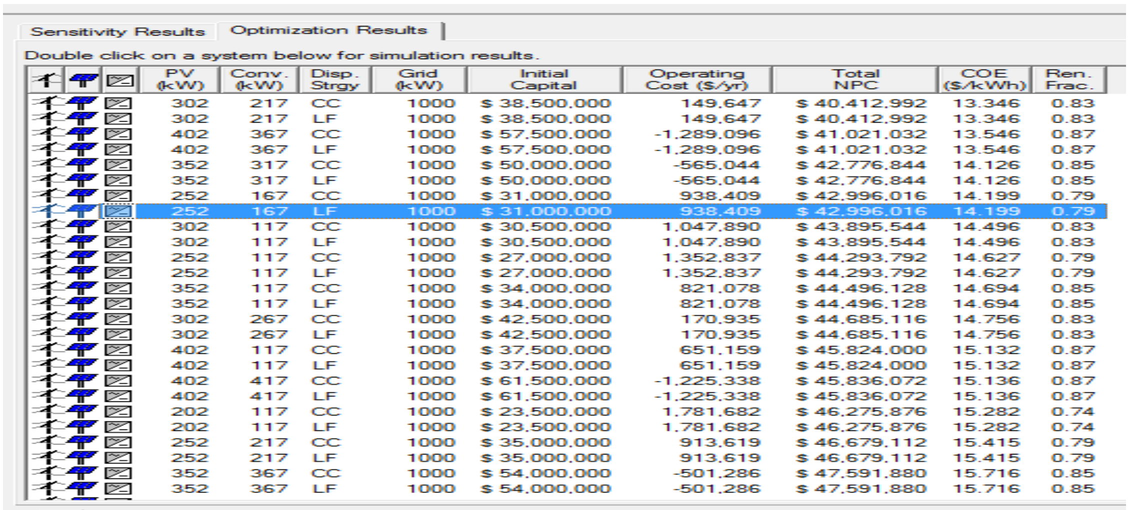


Figure 4.6 : Grid input

Figure 4.6 shows grid input from HOMAR energy which indicates the prices of KW fed from grid is 9.80 BDT/KW and sell back to the grid rated at 12 BDT/KW. The demand rate of energy is at 3200 BDT/month.

4.6 Overall Calculation review

The overall calculation optimizes the sensitivity value of the total system. The result obtained from the optimization provides the initial installation cost or capital cost as 31000000 BDT while operating cost 938409 BDT. The total net present cost is 42996016 BDT and per unit cost of energy is 14.199 BDT.



Sensitivity Results | Optimization Results

Double click on a system below for simulation results.

PV (kW)	Conv. (kW)	Disp. Strgy	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
302	217	CC	1000	$ 38,500,000	149,647	$ 40,412,992	13.346	0.83
302	217	LF	1000	$ 38,500,000	149,647	$ 40,412,992	13.346	0.83
402	367	CC	1000	$ 57,500,000	-1,289,096	$ 41,021,032	13.546	0.87
402	367	LF	1000	$ 57,500,000	-1,289,096	$ 41,021,032	13.546	0.87
352	317	CC	1000	$ 50,000,000	-565,044	$ 42,776,844	14.126	0.85
352	317	LF	1000	$ 50,000,000	-565,044	$ 42,776,844	14.126	0.85
252	167	CC	1000	$ 31,000,000	938,409	$ 42,996,016	14.199	0.79
252	167	LF	1000	$ 31,000,000	938,409	$ 42,996,016	14.199	0.79
302	117	CC	1000	$ 30,500,000	1,047,890	$ 43,895,544	14.496	0.83
302	117	LF	1000	$ 30,500,000	1,047,890	$ 43,895,544	14.496	0.83
252	117	CC	1000	$ 27,000,000	1,352,837	$ 44,293,792	14.627	0.79
252	117	LF	1000	$ 27,000,000	1,352,837	$ 44,293,792	14.627	0.79
352	117	CC	1000	$ 34,000,000	821,078	$ 44,496,128	14.694	0.85
352	117	LF	1000	$ 34,000,000	821,078	$ 44,496,128	14.694	0.85
302	267	CC	1000	$ 42,500,000	170,935	$ 44,685,116	14.756	0.83
302	267	LF	1000	$ 42,500,000	170,935	$ 44,685,116	14.756	0.83
402	117	CC	1000	$ 37,500,000	651,159	$ 45,824,000	15.132	0.87
402	117	LF	1000	$ 37,500,000	651,159	$ 45,824,000	15.132	0.87
402	417	CC	1000	$ 61,500,000	-1,225,338	$ 45,836,072	15.136	0.87
402	417	LF	1000	$ 61,500,000	-1,225,338	$ 45,836,072	15.136	0.87
202	117	CC	1000	$ 23,500,000	1,781,682	$ 46,275,876	15.282	0.74
202	117	LF	1000	$ 23,500,000	1,781,682	$ 46,275,876	15.282	0.74
252	217	CC	1000	$ 35,000,000	913,619	$ 46,679,112	15.415	0.79
252	217	LF	1000	$ 35,000,000	913,619	$ 46,679,112	15.415	0.79
352	367	CC	1000	$ 54,000,000	-501,286	$ 47,591,880	15.716	0.85
352	367	LF	1000	$ 54,000,000	-501,286	$ 47,591,880	15.716	0.85

Figure 4.7: Overall simulation results from HOMAR energy simulation

4.6 Cash flow simulation results

In the following table, total capital cost is 31000000 BDT, replacement cost of the component of the project is 3344799 BDT and total net present cost is 42996020 BDT. Those cost are described in the Table 13.

Table 13: Net Present cost

Component	Capital (BDT)	Replacement (BDT)	O & M (BDT)	Fuel (BDT)	Salvage (BDT)	Total (BDT)
PV	17640000	0	3221408	0	0	20861406
Grid	0	0	6052392	0	0	6052392
Converter	13360000	3344799	0	0	-622573	16082226
System	31000000	3344799	9273297	0	-622573	42996020

4.7 Electrical Output simulation results

Considering the PV module size is 142.57 KW and the converter size is 167 KW. The electrical output is given bellow in the Table 14.

Table 14: Electrical Output

Component	Production (KWh/yrs.)	Fraction
PV array	379631	78%
Grid purchases	104915	22%
Total	484546	100%

Average Monthly electrical production in given below in figure

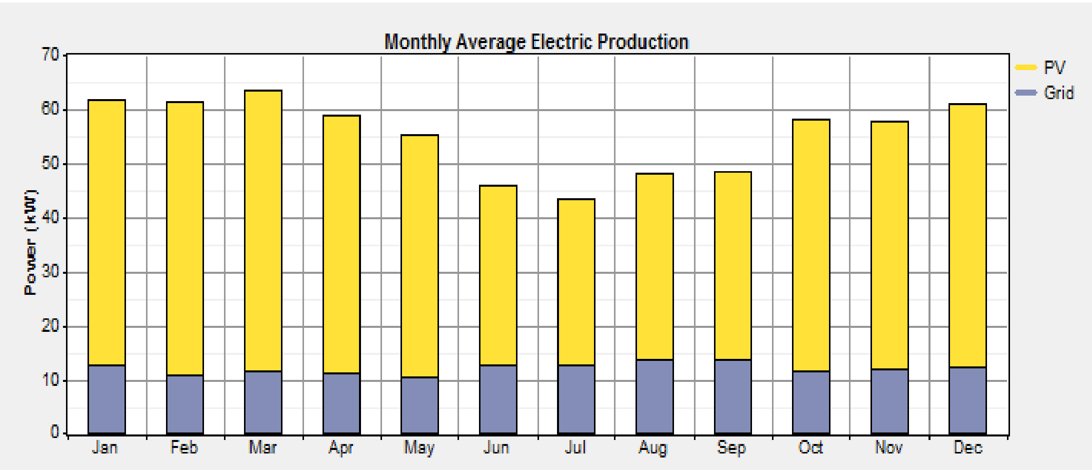


Figure 4.7: Monthly average electrical Production

Figure 4.7 shows the monthly average electrical production curve. The curve indicates the power variations with respect to the month of a year. In March, the average electric production is higher and in July, it is minimum. There are two indications named PV and Grid.

In the load distribution, IIUC female campus consumes 237884 kWh/year. Grid sales are around 202291 kWh/year. The load distribution is given below in the Table 15.

Table 15: Load Distribution

Load	Consumption (KWh/yr.)	Fraction
AC primary load	236884	54%
Grid sales	202291	46%
Total	439175	100%

4.9 PV Output simulation results

Here in the PV output simulation results optimizes 43 KW. Daily output is 1040 KWh and maximum peak output is 377 kW. Finally, livelier cost of PV is 4.30 BDT. The PV output results are given below in the Table 16.

Table 16: PV Output in KW

Quantity	Value	Quantity	Value
Rated Capacity	252 KW	Minimum Output	0.00 KW
Mean Output	44 KW	Maximum Output	250 KW
Mean Output	1,568 KWh/day	PV Penetration	160%
Capacity Factor	17.2 %	Hours of Operation	4,374 hr/yr.
Total Production	379631 KWh/yr.	Livelier Cost	4.30 BDT/Kwh

4.10 Converter as Simulation results

The maximum output of the converter is 167 KW. The output of Converter is described in the given table 17.

Table 17: Converter Output in KW

Quantity	Inverter	Quantity	Inverter
Capacity	167 KW	Hours of operation	4374 hr./yr.
Mean output	38 KW	Energy in	371401 KWh/yr.
Minimum output	0 KW	Energy out	334260 KWh/yr.
Maximum output	167 KW	Losses	37141 KWh/yr.
Capacity factor	27.6%		

4.11 Simulation results for Grid Output

Considering the Grid sale capacity is 97 KW and energy purchasing rate from grid is 9.80 BDT/KWh and sellback rate is 12 BDT/KWh [10].

Grid output is given below in the table 18.

Table 18: Grid output

Month	Energy purchased (KWh)	Energy sold (KWh)	Net purchases (KWh)	Peak demand (KW)	Energy charge (BDT)	Demand charge (BDT)
Jan	9326	21150	-11825	48	-162411	153861
Feb	7203	19172	-11969	43	-159473	138952
Mar	8455	21560	-13105	45	-175864	142768
Apr	7941	19120	-11178	45	-151611	145329
May	7733	18201	-10468	36	-142628	114312
Jun	9117	10896	-1779	47	-41406	150176
Jul	9242	9958	-717	55	-28931	175416
Aug	10134	11638	-1504	56	-40342	180584
Sep	9694	12338	-2644	52	-53053	161831
Oct	8554	19085	-10531	45	-145192	144066
Nov	8523	18379	-9857	43	-137028	137900
Dec	8993	20792	-11800	42	-161379	132976
Annual	104915	202291	-97375	56	-1399319	1783175

4.12 Review of System Capacity of PV and Converter

PV system mean output is 44 KW found from the simulation results and maximum output is 250 KW. We found the actual PV output is 142.576 KW and converter output is 167 KW.

4.13 Mathematical calculation of effective power output

Output Power = (total no. of PV solar panel * maximum power defined irradiance of a solar panel) Wp

= (800 * 178.22) WP

= 142.576 KW

Power output of designed PV system is 142.576 KW at 25^0 C

4.14 Power output from HOMAR simulation

From HOMAR energy simulation we get the effective power output is 379631 KWh/year and daily power output is 1040 KWh/day.

4.15 Cost Estimation

To implement the proposed solar PV system for IIUC female campus, we need to have a clear concept on the implementation cost. In these consequences, we have calculated the approximation cost in BDT. All the components we have required implementing a solar PV system. These components are: PV modules, inverters, combiner boxes, and surge arrestors, lightning rod, mounting, meters, wiring also we have to consider the transportation, installation, and LC and maintenance costs. After doing calculation the total cost stands around 157179403 BDT. In this Table 17, the approximate cost analysis is described below in the Table 19.

Table 19: Approximate Cost analysis

Component	Cost per unit (BDT)	Life time (years)	Overall Cost (BDT)
PV module	70000 BDT /KW	20	(70000*252)=17640000
Inverter,	80000 BDT /KW	15	(167*80000)= 13360000
Combiner box	3200/piece		3200*5=16000
Replacement cost			33447998
Grid Interconnection	---		100000
Maintenance & operating cost			92737978
Wiring, other cost			500000
Salvage cost			-622573
Total Cost			157179403

In simulation we also found that Initial cost is BDT.

4.16 Per unit energy cost

We consider our proposed PV system life is 25 years. So, the cost per unit of energy by the designed system will be:

Total cost of the system : 157179403 BDT (from table)

Average daily bright sunshine hours : 7.51

Estimated capacity of the designed system : 252 KW

Avg. energy produced per day in KWh : 142.68*7.51 = 1071.5268 KWh

Energy produced in KWh per year : 1071.5278*25*365 = 9777691 kWh

Cost per unit of energy in BDT : (Total cost of the system/ Energy produced in 25 years)

= (3362175000 / 9777691)

= 16.07 BDT

So, we could be able to generate per unit of energy at 16.07 BDT

4.17 Discussion

In the designation of grid connected PV solar system. We have collected more information regarding the design. Firstly, we have selected a fixed area which total feasible roof area for our proposed system is about 1462.586 square meters. Using this area, we can install 252 KW peak. We have also collected the solar irradiance and average bight shine hours are 4.758 KWh/m^2/day and 7.51. With respect to that value, the effective output is 142.576 KW. Considering 85% of panels output, we stand out the total production energy is 391.43622 MWh/year. In IIUC female Campus average energy consumption is 649.3151 KWh/day .Annual energy consumption of IIUC female campus is 237884 Kw. But daily energy production is 852.60 Kw/h day. We have sold energy from grid according to the electric bill of IIUC female campus, the amount of it 329961 Kwh/year.

Above consideration, we found out that it will be beneficial to the IIUC female campus, because of reducing its annual electricity bill and can be sold to the grid .It reduce also the CO_2 emission and concern about the climate change. After calculating above Cost, the total cost stands out 157179403 BDT.

Finally, we are able to generate per unit of energy at 16.07 TK. Our proposed PV system life time is around 25 years. We calculated those cost, output, power grid input grid output and others utility from Homer energy Software. There are few deviations between this data and practical data.

Thus, we have design a successful grid connected PV solar system for IIUC female campus which can be implemented in future

CHAPTER 5

CONCLUSION

5.1 Conclusion

Our proposed system of solar energy will benefit to the IIUC female academic building, comparing all cost and the production of solar energy. The roof tops of the IIUC female campus supply's more bright sunshine which can mitigate the solar power for IIUC female academic building. The output & maintenances cost is lower than other designed system. The main disadvantages of the proposed system are that the initial and capital cost are comparatively higher .But it will be reduced compared to the maintenances and fuel cost. Meanwhile it is friendly to the nature.

5.2 Limitations

1. Backup system will not be added because of absence of any battery.
2. Only designing for the system of grid sale capacity.
3. Rainfall or other variable circumstances wasn't considered.

5.3 Future Work

Battery backup will be added to implement a designing grid connected PV to reserve Power. The Market price will be really taken off when electricity from PV becomes cheaper than other grid sources. This is a future work regarding the PV solar energy.
Analysis and feasibility of cost reduction potential is also the possibilities. Analysis of the life cycle emissions of solar PV is the next target to follow. Further analysis is to explore how to manage the grid systems balancing with significant levels of solar PV development.

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List of Abbreviations

PV	Photovoltaic
KW	Kilo Watt hours
MWh	Mega Watt hours
MW	Mega Watt
REN	Renewable Energy
IRENA	International Renewable Energy Agency
MWp	Mega Watt peak
AC	Alternating Current
DC	Direct Current
MPPT	Maximum Power Point Tracker
Wp	Watt peak