A Feasibility Study of Solar-Wind Hybrid System in Urban Area of Bangladesh

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CERTIFICATION

This thesis paper titled **"A Feasibility Study of Solar-Wind Hybrid System in Urban Area of Bangladesh"** submitted by the group as mentioned below has been accepted as 'Satisfactory' in partial fulfillment of the requirements for the degree B.Sc. in Electrical Electronic and Communication Engineering on December, 2014.

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DECLARATION

This is to certify that the work presented in this thesis paper titled **'A Feasibility Study of Solar-Wind Hybrid System in Urban Area of Bangladesh '** is the yield of study, analysis, simulation and research work carried out by the undersigned group of students of Electrical Electronics and Communication Engineering (EECE-9), Military Institute Of Science and Technology (MIST), Mirpur Cantonment, Under the supervision of Brig Gen Shaikh Muhammad Rizwan Ali, Dean, Faculty of Science and Technology (FST).

It is also declared that neither of this thesis paper nor any part thereof has been submitted anywhere else for the award of any degree, diploma or other qualifications.

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DEDICATION

To Our Beloved Parents

ACKNOWLEDGEMENT

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ABSTRACT

Utilization of renewable energy resources have been the most important and prospective field to seek new energy sources to meet up the increasing demand in power all over the world specially in a developing country like Bangladesh. Among the renewable resources, wind and solar being the most popular ones due to abundant ease of accessibility and convertibility to the electricity. The paper presents the next generation of power energy systems where generation will not be dependent on fossil fuel, using solar and wind energy systems. The thesis is emphasized on the feasibility study of hybrid energy system (comprising solar and wind) from literature followed by evaluation of performance through simulation. The primary focus of this study is to develop a dynamic model for a small standalone hybrid power generation system for the urban as well as coastal areas and compare their performance.

For designing and studying the feasibility of the system, software named 'HOMER' was used. HOMER software has been used for analyzing the performance of the system. Different performance analysis includes feasibility, sensitivity, cost and sustainability were measured using the software.

Our designed solar wind hybrid power system capacity is 650 Watts. It is proposed as the model with LED lights and limited fans which are considered as domestic load. It is found that the proposed system reduces CO_2 emission.

REMARKS

Dept. Head's Remark:

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List of Abbreviations

BPDB- Bangladesh Power Development Board

BCSIR- Bangladesh Council of Scientific and Industrial Research

CSR- Climatologically Solar Radiation

FST- Faculty of Science and Technology

GHI- Global Horizontal Isolation

GIZ- German Development Cooperation

HPS- Hybrid Power System

HOMER- Hybrid Optimization Model for Electric Renewable

IRENA- International Renewable Energy Agency

IDCOL- Infrastructure Development Company Limited

LED- Light Emitting Diode

LGED- Local Government Engineering Department

MCB- Miniature Circuit Breaker

NREL- National Renewable Energy Laboratory

PV- Photovoltaic

RERC- Rehabilitation Engineering Research Center

RET- Renewable Energy Technology

SWERA- Solar and Wind Energy Resource Assessment

SREDA- Sustainable and Renewable Energy Development Authority

SHS- Solar Home System

WECS- Wind Energy Conversion System

WTG- Wind Turbine Generator

Chapter 1

Introduction

1. Introduction

Energy plays an important role in all types of development, including economic development. The world total energy annual consumption generally increases, with the vast majority of energy being produced by fossil fuels such as coal, oil and natural gas. In 2002 fossil fuels provided the three quarters of the total. With the current energy consumption rate, proven coal reserves should last for about 200 years, oil for approximately 40 years and natural gas for around 60 years. With constantly increasing development, diminishing fossil fuel resources and related environmental problems (e.g. emissions), sustainable development and the manner in which energy is produced and consumed is reconsidered. Renewable energy i.e., energy generated from solar, wind, biomass, geo-thermal, hydropower and ocean resources, could increase the diversity of energy supplies and offer “clean”-environmental friendly energy.

In numerous remote and rural areas in the world, a noteworthy number of domestic consumers, farms and small businesses are not connected to a main electrical grid system. According to statistics made in recent years, it is found that almost 33% of the world’s population does not have access to electricity [1, 2]. This is exceptionally real in the developing countries, where large distances and the lack of capital are some of the obstacles to the development of a grid system. This can even be found in developed countries such as Great Britain, where there are a significant number of consumers without a grid supply.

Although wind and solar energy sources are significantly less productive compared to fossil fuels, the use of photovoltaic **(**PV) cells and wind turbines [3] has increased rapidly during the last years, especially in developed countries. Photovoltaic (PV) cells are electronic devices that are based on semiconductor technology and can produce an electric current directly from sunlight. The best silicon PV modules currently commercially available have an efficiency of over 18%, and it is expected that in about 10 years’ time module efficiencies may raise to 25%. Wind power is basically electricity produced by a generator, which is driven by a turbine according to flowing air’s aerodynamics, and is one of the fastest growing renewable energy technologies around the world. PV modules and wind turbines [4] are now widely used in developed countries to produce electrical power in locations where it might be inconvenient or expensive to use conventional grid supplies, while other homeowners who choose the renewable energy sources prefer to connect their energy system to the grid as a huge ‘battery’ for some convenient grid-tied situation. However, when electricity grids are

non-existent or rudimentary, all forms of energy can prove very expensive. In such cases, solar and wind energy can be highly competitive. The fact that natural energy resources are intermittent and storage batteries are expensive, has led to the utilization of so-called hybrid renewable energy systems. Any power system that incorporates two or more of the following is referred to as a hybrid power system: PV panels, wind turbines, or diesel, propane, gasoline generators. For small loads, the most common combinations are PV-wind hybrid system.
PV and wind is a good match, because inland wind speeds tend to be lower in summer, when solar energy can compensate, and higher in winter, when sunshine falls to very low levels. In this paper, a PV-wind hybrid system is presented able to supply electricity to a private house, farm house or a small company or an apartment, with electrical power depending on the site's needs. The aim of this study is to introduce the local PV-wind hybrid system's working principle by reviewing one case where the system is connected to the grid.[5]

1.1Motivation

Being a modern part of the civilization, government of Bangladesh has its urge to develop its economy as well as serve its citizen with the utilities as a part of its duties. Recent statistics shows that the power sector of Bangladesh has been lagging behind in its power sector due to its dependence in gas and hydro power stations to generate major portions of power. Although at present the power sector has shown a quick growth due to installation of quick rental power plants, still it is not the ultimate solution for a country's overall power generation. That is why renewable energy comes into the discussion.

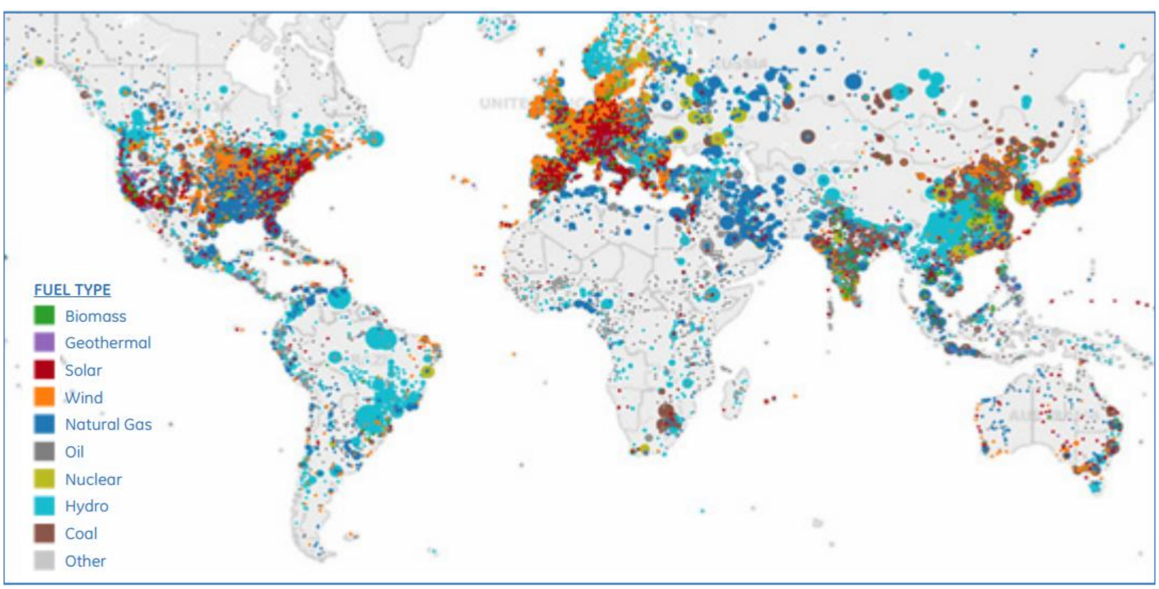

Fig 1.1: Global power plants.

There are many rural areas and newly expanded urban areas, where grid supply has not reached yet but an opportunity of using renewable energy has always been available. Moreover, the dependence of economy on depleting fossil fuel has reached at its highest peak, which concerns the government. That is why interest has grown in rebuilding the power generation sector with sustainable energy economy. Having said that, it is to be informed that wind solar hybrid energy is the fastest growing energy sources at an increasing rate of 25 35% annually over the last decade in the whole world [6, 7].

Bangladesh has a centralized economy in its capital and other urban regions which makes it difficult to provide utilities like electricity in every city. For example Dhaka is the capital city where 43% electricity is used in households; industrial commercial demands are fulfilled by the rest of the supply. Recent measurements are quick initiatives for stopping the crisis; still, it is not a secured future for our power sector. A proper prophesized plan is needed which will not only emphasize upon the importance of using renewable energy, but also show its attention over the application and implementation of the energy in every power related sector.

1.2Objective:

The objective of this project is to investigate for the best design layout (connection topology), model and simulate the selected topology for different power management strategies of the HPSs, which consists of renewable energy sources (PV arrays and wind generator), conventional backup energy source (diesel engine generator) and energy storage bank (battery bank) to sustainably and efficiently satisfy the energy demand.

In this thesis paper we are motivated by the use of renewable energy in hybrid power system to establish a theoretically proved small power solution which can be provided in the urban areas. It is important to be notified that, the system is Off Grid system, so that it can be used as a smart solution for the urban households as well as a backup solution during the time of load shedding.

In this project wind and solar energy is used as the source of energy resources. The energy will be stored in a convenient storage system and regulated or inverted to the consumption of the load. We can say a hybrid system with loads, renewable power sources, energy storage, power converters, load management options or a supervisory control system will be studied, analyzed, designed, modeled, simulated and implemented in this thesis project.

1.3Project Description

A solar wind hybrid power system is considered as the ideal solution for the average users living in small households. Considering a fixed place in Dhaka city, we analyze the feasibility of the system. We analyzed various geographical parameters, such as wind speed, solar irradiation, altitude, shading factors and geographical position. Collecting those data, the system is designed for a specific amount of load averaged on the basis of usual electrical uses in the households. Then a system is designed with solar panel, wind turbine and other devices. The analysis is completed with reports and evaluations on various analyses which include the cost analysis of the system.

The simulation based software HOMER is used in this analysis. This software is used to design the suitable system, simulate the meteor data to calculate the total renewable energy, the demand load and most importantly to evaluate the total cost for the system.

Chapter 2

Solar Power System

2.1 Solar Energy

Solar energy is energy from the sun. It is renewable, inexhaustible, environmental pollution free. Solar energy originates with the thermonuclear fusion reactions occurring in the sun. It represents the entire electromagnetic radiation (visible light, infrared, ultraviolet, x-rays, and radio waves). This energy consists of radiant light and heat energy from the sun. Out of all energy emitted by sun only a small fraction of energy is absorbed by the earth. Just this tiny fraction of the sun's energy is enough to meet all our power needs. Solar energy technologies include solar heating, solar photovoltaic, solar thermal electricity, solar architecture and artificial photosynthesis, which can make considerable contributions to solving some of the most urgent energy problems the world now faces.

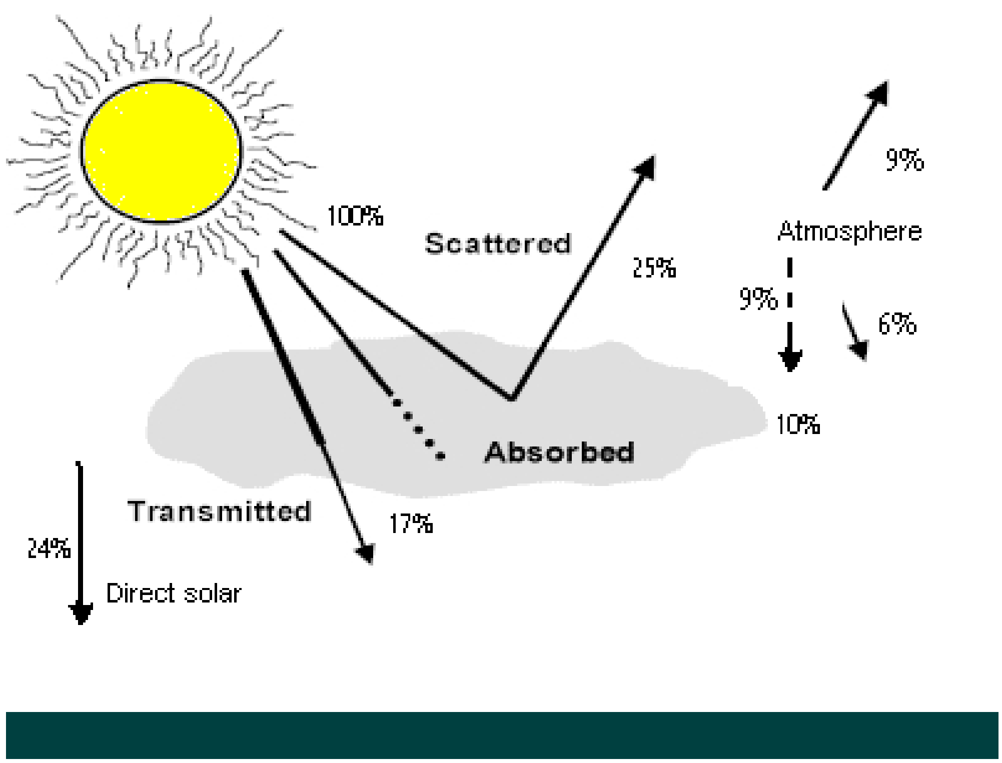

Fig 2.1: Amount of solar energy received by surface.

The surface receives about 47% of the total solar energy that reaches the Earth. Only this amount is usable.

2.2 Solar Systems

Solar power is the conversion of sunlight into electricity either directly by using photovoltaic or concentrated solar power. A solar cell, or photo-voltaic cell (PV), is a device that converts light into electric current using the photoelectric effect. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam [8].

Advantages of solar power:

a. The sun is a free energy source.
b. The production of solar energy is pollution-free.
c. The technological advancements in solar energy systems have made them extremely cost effective.
d. Most systems do not require any maintenance during their lifespan resulting in less maintenance cost.
e. Solar power can be used in remote areas where it is too expensive to extend the electricity power grid.
f. Solar energy is infinite.
g. Solar cells are also totally silent.

Disadvantages of solar power:

a. The initial cost of purchasing and installing solar panels is high.
b. The location of solar panels is of major importance in the generation of electricity. Areas which remains mostly cloudy and foggy will produce electricity but at a reduced rate and may require more panels to generate enough electricity.
c. Unlike other renewable source which can also be operated during night, solar panels prove to be useless during night.

2.3 Photovoltaic technologies

The solar-generated electricity is called Photovoltaic (or PV). Photovoltaic (PV) cells are electronic devices that are based on semiconductor technology and can produce D.C electric current directly from sunlight. When light energy strikes the cell, electrons are emitted. The electrical conductor attached to the positive and negative scales of the material allow the electrons to be captured in the form of a D.C current. The generated electricity can be used to power a load or can be stored in a battery.

Photovoltaic system is classified into two major types:

a. Off-grid (Standalone) systems and
b. Grid-tie system.

Off-grid PV systems, as the name implies, are systems that are not connected to the public electricity grid. These systems require an energy storage system for the energy generated because the energy generated is not usually required at the same time as it is generated (DGS, 2008). In other words, solar energy is available during the day, but the lights in a stand-alone solar lighting system are used at night so the solar energy generated during the day must be stored for use in the night. They are mostly used in areas where it is not possible to install an electricity supply from the mains utility grid. They are therefore preferable for developing countries like Bangladesh where vast areas are still frequently not supplied by an electrical grid.

A grid-connected photovoltaic power system or grid-connected PV system is an electricity generating solar PV system that is connected to the utility grid. The system needs to be wired with an inverter that creates ac electricity, which is needed for linking to the utility grid. Unlike off-grid systems, a grid-connected system rarely includes an integrated battery solution, as they are still very expensive [9].

2.4 Basic components of solar power

The major components include PV modules, batteries, charge controller and inverter. The most efficient way to determine the capacities of these components is to estimate the load to be supplied.

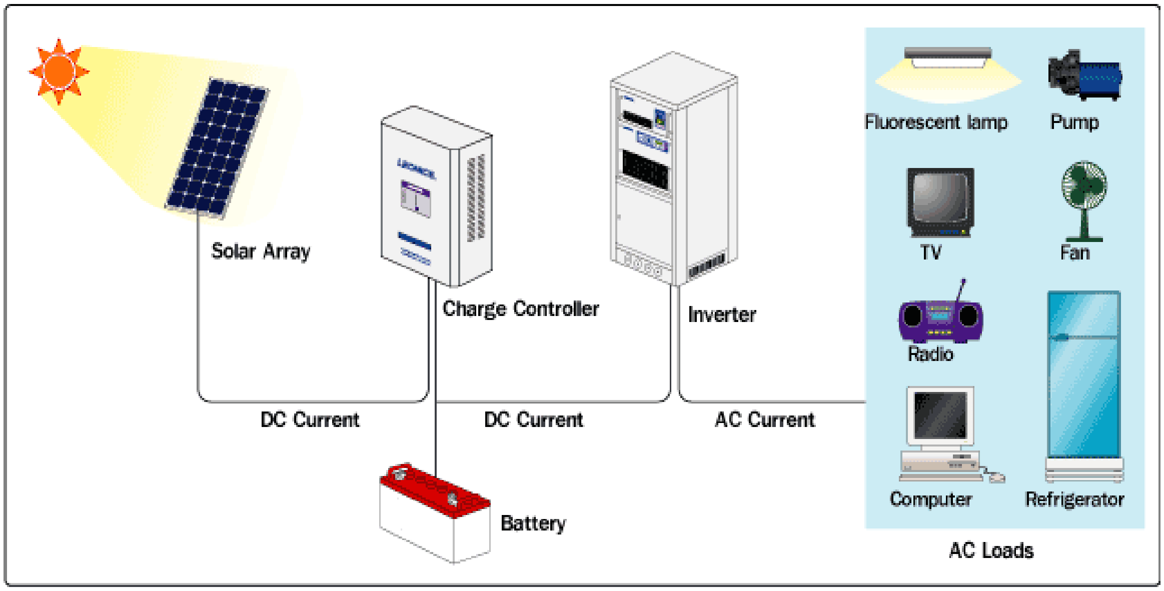

Fig 2.2: Basic components of solar power system.

The size of the battery bank required will depend on the storage required, the maximum discharge rate, and the minimum temperature at which the batteries will be used. When designing a solar power system, all of these factors are to be taken into consideration when battery size is to be chosen.

Lead-acid batteries are the most common in PV systems. Deep cycle batteries are designed to be repeatedly discharged as much as 80 percent of their capacity and so they are a good choice for solar power systems.

2.5 Photovoltaic effects and equivalent circuit

The photovoltaic effect is the creation of voltage or electric current in a material upon exposure to light. The photovoltaic effect was first observed by French physicist A. E. Becquerel in 1839.

The origin of the photovoltaic potential is the difference in the chemical potential, called the Fermi level of the electrons in the two isolated materials. When they are joined, the junction approaches a new thermodynamic equilibrium. Such equilibrium can be achieved only when the Fermi level is equal in the two materials.

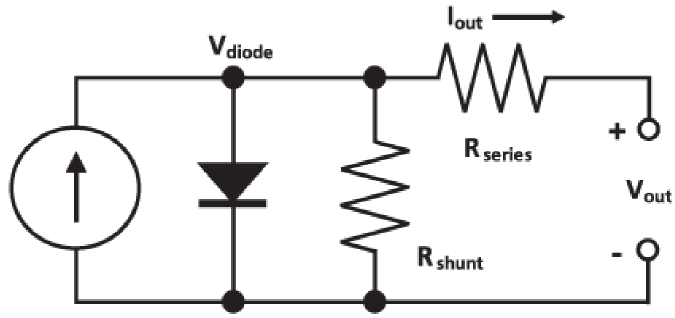

Fig 2.3: Equivalent circuit of a solar cell.

This occurs by the flow of electrons from material to other until a voltage difference is established between the two materials which have the potential just equal to the initial difference of the Fermi level. This potential drives the photocurrent.

Metallic contacts are provided on both sides of the junction to collect electrical currents induced by the impinging photons on one side. Conducting foil (solder) contact is provided over the bottom (dark) surface and on one edge of the top (illuminated) surface. Thin conducting mesh on the remaining top surface collects the current and lets the light through. The spacing of the conducting fibers in the mesh is a matter of compromise between maximizing the electrical conductance and minimizing the blockage of the light. In addition to the blocking elements, several enhancement features are also included in the construction. For example, the front face of the cell has anti-reflective coating to absorb as much light as possible by minimizing the reflection. The mechanical protection is provided by the cover glass applied with a transparent adhesive.

2.6 Photovoltaic (P.V) Solar Modules:

PV module is an indispensable component of this system. The photovoltaic cell is also referred to as photocell or solar cell. The common photocell is made of silicon, which is one referred to as photocell or solar cell. The common photocell is made of silicon, which is one of the most abundant elements on Earth, being a primary constituent of sand. Photovoltaic (PV) modules convert sunlight into direct current (DC) electricity. The modules can be wired together to form a PV array that is, wiring modules in series, the available voltage is increased and by wiring in parallel, the available current is increased.

To determine the size of PV modules, the required energy consumption must be estimated. Therefore, the PV module size in KWp is calculated as:

PV module size=Daily Energy Consumption/Insolation*Efficiency

Where, Insolation is in KWh/m^2/day and the energy consumption is in watts or kilowatts.

The most common solar technology is crystalline Si. Two types panels namely Monocrystalline Silicon panels and Polycrystalline Silicon panels are available in the market.

a. **Monocrystalline Silicon panels:** In monocrystalline Silicon panels, crystal lattice of entire sample is continuous. Monocrystalline silicon panels should be utilized when a higher voltage is desirable. This would be in an instance where the DC power has to travel some distance before being utilized or stored in a battery bank. These panels are also the most efficient PV technology, averaging 14% to 17%.

b. **Polycrystalline Silicon panels:** Polycrystalline Silicon panels are composed of many crystallites of varying size and orientation. Polycrystalline silicon panels have efficiencies of 12% to 14% and can often be purchased at a lower cost per watt than monocrystalline silicon panels. This type of panel sees the widest use in polar applications. [10]

Thin film solar panels:

Thin film solar panels are made by depositing one or more thin layers (thin film) of photovoltaic material on a substrate. Thin Film technology depends upon the type of material used to dope the substrate. Thin-film technologies include amorphous silicon, cadmium telluride, copper-indium diselenide, and others. Although these panels have low cost, they have comparatively low efficiency (8%-10%) [10].

2.7 Batteries and Battery sizes of the solar power system:

The principal problem to overcome with any PV system is that the sun does not shine on everywhere with equal intensity. Daily and annual fluctuations in solar insolation necessitate storing excess energy for later use. Batteries are the technological solution most commonly employed for this purpose.

A battery stores electrical energy in the form of chemical energy. For a PV-battery system to function effectively, the electrochemical processes must work in both directions—in other words, the system must be rechargeable. To this end, batteries perform three main functions in a stand-alone PV system:

a. Autonomy–by meeting the load requirements at all times, including at night, during overcast periods, or during the winter when PV input is low or absent.
b. Surge-current capability –by supplying, when necessary, currents higher than the PV array can deliver, especially to start motors or other inductive equipment.
c. Voltage control–thereby preventing large voltage fluctuations that may damage the load [10].

The battery to be used:

a. Must be able to withstand several charging and discharging cycles.
b. Must have low self-discharge rate.
c. Must be able to operate with the specified limits.

Any battery suitable for PV applications will be a deep-cycle type of battery. Deep-cycle batteries are designed to deliver a typically lower current for the size of the battery, but they are capable of withstanding numerous deep discharges without damage. The most common type of battery found in PV systems is the lead acid battery because their initial cost is lower and they are readily available everywhere. [10]

Batteries are rated in Ampere-hour (Ah) and the sizing depends on the required energy consumption. If the average value of the battery is known, and the average energy consumption per hour is determined, the battery capacity is determined by the equations 2(a) and 2(b):

BC=2*F*W/Vbatt ……………………………………………2(a)

Where, BC = Battery Capacity

F = Factor of Reserve

W = Daily Energy

V_{batt} = System DC Voltage

The Ah rating of the battery is calculated as:

Ah rating=(Daily energy consumption(KW)/ (Battery Rating (Ah) at a specific voltage

………………………………2(b)

2.8 Charge controllers

Regardless of the battery type chosen for a particular system, a charge controller remains an essential component. The primary function of a charge controller is to prevent the battery bank from being overcharged when there is abundant solar insolation available. Overcharging a battery can lead to electrolyte imbalances and depletion. In cases of severe overcharging, batteries can be completely destroyed along with any instrumentation in the vicinity [10].

The controller to be used requires the following features [11]:

a. Prevent feedback from the batteries to PV modules.
b. It should have also a connector for DC loads.
c. It should have a work mode indicator.

There is a wide range of charge controllers available, and the design requirements of the system dictate which charge controller should be utilized. The maximum charge rate is the first parameter to consider along with the system voltage. The amp rating of the charge controller should be oversized by a minimum of 25% for enhanced reliability.

2.9 Solar inverter:

An inverter is a device that converts DC power from the battery bank to AC power for various loads. In smaller PV systems, it may be possible to eliminate this component altogether. In larger systems incorporating components that demand AC power, an inverter must be utilized. Also, if the instrument site is located some distance from the power production site, an inverter allows for an efficient means of getting electricity to the point of use. Alternating current is easier to transport over long distances and has become the conventional modern electrical standard.

There are two fundamental categories of inverters: synchronous and static or stand-alone. Synchronous inverters are capable of being tied into the electrical grid, or utility power. Static inverters are designed for independent, utility-free power systems and are the type most often used for remote PV applications.

A second inverter classification refers to the type of AC waveform they produce. Inverters are available in square wave, modified square wave, and sine wave outputs.

For P.V Solar Power Systems, the inverters are incorporated with some inbuilt protective devices. These include [12]:

a. Automatic switch off if the array output is too high or too low.
b. Automatic re-start.
c. Protective scheme to take care of short circuit and overloading.

Generally the inverter to be used that would produce the quality output must have the following features:

a. Overload protections.
b. Miniature Circuit Breaker Trip Indicator (MCB).
c. Low-battery protection.
d. Constant and trickle charging system.
e. Load status indicator.

Chapter 3

Wind Energy System

3.1 Wind Power

The first use of wind power was to sail ships in the Nile some 5000 years ago. The Europeans used it to grind grains and pump water in the 1700s and 1800s. The first windmill to generate electricity in the rural USA was installed in 1890. Today, large wind power plants are competing with electric utilities in supplying economical clean power in many parts of the world. The average turbine size of the wind installation has been 300 KW until the recent past. The newer machines of 500 to 1000 KW capacities have been developed and are being installed. Prototypes of a few MW wind turbines are under test operations in several countries is a conceptual layout of modern multi megawatt wind tower suitable for utility scale operations. Wind power is energy extracted from the wind, passing through a machine known as the windmill. Electrical energy can be generated from the wind energy. This is done by using the energy from wind to run a windmill, which in turn drives a generator to produce electricity. The windmill in this case is usually called a wind turbine. The turbine transforms the wind energy to mechanical energy, which in a generator is converted to electrical power. An integration of wind generator, wind turbine, aero generators is known as a wind energy conversion system (WECS).

3.2 Component of wind energy project

Modern wind energy systems consist of the following components:

a. A tower on which the wind turbine is mounted.
b. A rotor that is turned by the wind.
c. The nacelle which houses the equipment, including the generator that converts the mechanical energy in the spinning rotor into electricity.

The tower supporting the rotor and generator must be strong. Rotor blades need to be light and strong in order to be aerodynamically efficient and to withstand prolonged used in high winds. In addition of these, the wind speed data, air density, air temperature need to be known amongst others.

3.3 Wind power modeling

The block diagram in the following figure shows the conversion process of wind energy to electrical energy.

Various mathematical models have been developed to assist in the predictions of the output

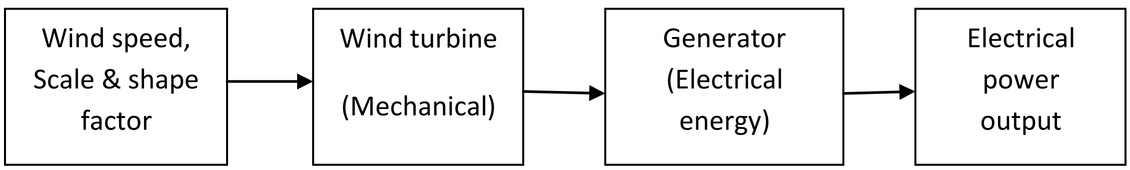

Fig 3.1: Block diagram of a wind turbine generation process

power production of wind turbine generators (WTG), a statistical function known as Wiebull distribution function has been found to be more appropriate for this purpose. The function is used to determine the wind distribution in the selected site. The Wiebull distribution function has been proposed as a more generally accepted model for this purpose.

The two parameter Wiebull distribution function is expressed mathematically in equation as:

$$F(v) = \frac{K}{C}\left(\frac{v}{C}\right)^{K-1} \exp\left[-\left(\frac{v}{C}\right)^{K}\right]$$

It has a cumulative distribution function as expressed in following equation and is given as:

$$M(v) = 1 - \exp\left[-\left(\frac{v}{C}\right)^{K}\right]$$

Where v is the wind speed, K is the shape parameter and C is the scale parameter of the distribution. The parameters K and C therefore characterized the Wiebull distribution.

To determine K and C, the approximations widely accepted are given in following equations respectively.

$$K = \left(\frac{\sigma}{v'}\right)^{-1.09}$$

$$C = \frac{v' \times K^{2.6674}}{\left(0.184 + 0.816k^{2.73859}\right)}$$

Where

σ is the standard deviation of the wind speed for the site. v' is the mean speed.

3.4 Power content of the wind

The amount of power transferred to a wind turbine is directly proportional to the area swept out by the rotor, to the density of the air, and the cube of the wind speed. The power P in the wind is given by:

$$P = ½ \, C_p. \, \rho.A. \, V'^3$$

Where

Cp is the turbine power coefficient. A theoretical maximum value of 0.593 has been proposed for Cp. ρ is air density and A is the rotor swept area. A is given by

$$A = \frac{\Pi D^2}{4} \quad (m^2)$$

Where, D is the rotor blade diameter (m).

Chapter 4

A proposed plan for Solar-Wind Hybrid Home System

4. Design and Implementation of Solar-Wind Hybrid Home System

Hybrid systems are the ones that use more than one energy resources. Integration of systems (wind and solar) has more influence in terms of electric power production. Such systems are called as “hybrid systems”.

Hybrid solar-wind applications are implemented in the field, where all-year energy is to be consumed without any chance for an interrupt. It is possible to have any combination of energy resources to supply the energy demand in the hybrid systems, such as oil, solar and wind. This project is similar with solar power panel and wind turbine power. Differently, it is only an add-on in the system.

Photovoltaic solar panels and small wind turbines depend on climate and weather conditions. Therefore, neither solar nor wind power is sufficient alone. A number of renewable energy expert claims to have a satisfactory hybrid energy resource if both wind and solar power are integrated within a unique body.

In the summer time, when sun beams are strong enough, wind velocity is relatively small. In the winter time, when sunny days are relatively shorter, wind velocity is high on the contrast. Efficiency of these renewable systems show also differences through the year. In other words, it is needed to support these two systems with each other to sustain the continuity of the energy production in the system.

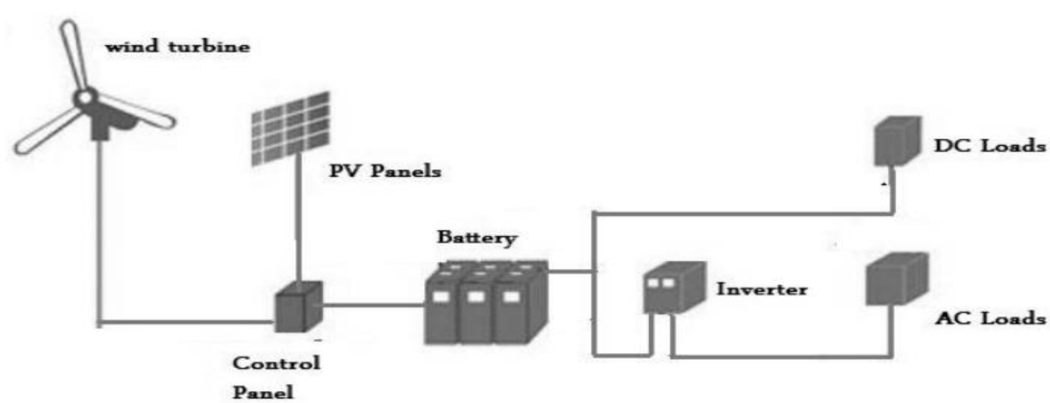

Fig 4.1: Hybrid System.

In the realized system, a portion of the required energy for an ordinary home has been obtained from electricity that is obtained from the wind and solar power. Experimental setup for the domestic hybrid system consists of a low power wind turbine and two PV panel. Depending on the environmental conditions, required energy for the system can be supplied either separately from the wind or solar systems or using these two resources at the same time is in show Figure 4. Control unit decides which source to use for charging the battery with respect to condition of the incoming energy as seen in Figure:

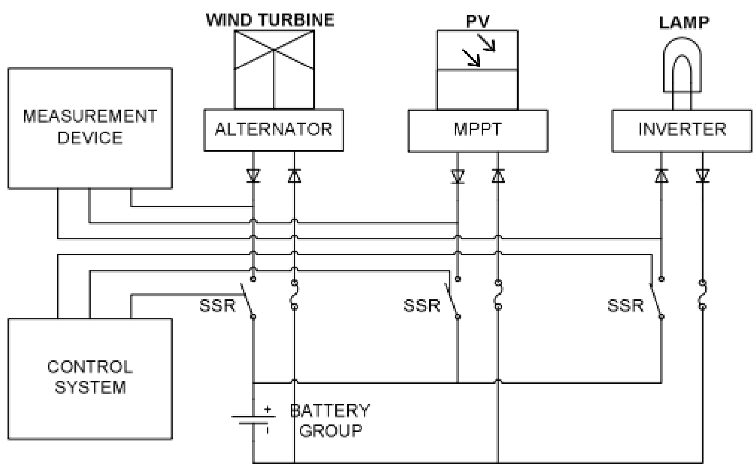

Fig 4.2: System Block Diagram.

Wind turbine first converts the kinetic energy to mechanical energy and then converts it to the electricity. The wind turbine in the system consists of tower, alternator, speed converters (gear box), propeller. A picture of the constructed hybrid system is shown in Figure:

Fig 4.3: A figure of constructed hybrid system.

The kinetic energy of the wind is converted to the mechanical energy in the rotor. The rotor shaft speed, 1/18, is accelerated in the reduction gear and then transmitted to alternator. The electricity that comes from the alternator can be directly transmitted to DC receivers as well as it can be stored in the batteries.

The solar panels in the system convert the day light directly in to electricity. The properties of the PV module (PM 065, Solen Energy Corporation) in the system are given in the Table.

Open Circuit Voltage	18.5V
Short Circuit Current	9.25A

Some specifications of wind turbine has mentioned below-

Rated Power	300 W
Rotor Regulation	1 m
Rated Wind Speed	15 m/s
Start Up Wind Speed	3 m/s
Working Voltage	24 V DC
Break System	Electromagnetic Stall
Security Wind Speed	45 m/s
Working Wind Speed	4.25 m/s
Weight	8 Kg

Chapter 5

Hybrid Power System in Bangladesh

5.1 Introduction

Renewable energy helps in reducing poverty, aid in energy shortage and environmental degradation such as desertification, biodiversity depletion and climate change. Over-exploitation of biomass in meeting the need of energy in the rural areas is causing environmental degradation. Renewable energy helps to solve those problems if it is widely used in the rural Bangladesh where people primarily depend on biomass energy. [13]

Power generation in Bangladesh was almost mono-fuel dependent, i.e. indigenous natural gas considering its apparent huge availability. About 89% of power previously comes from natural gas and the rest is from liquid fuel, coal and hydropower. The present share of renewable energy was only 2.5% [13]

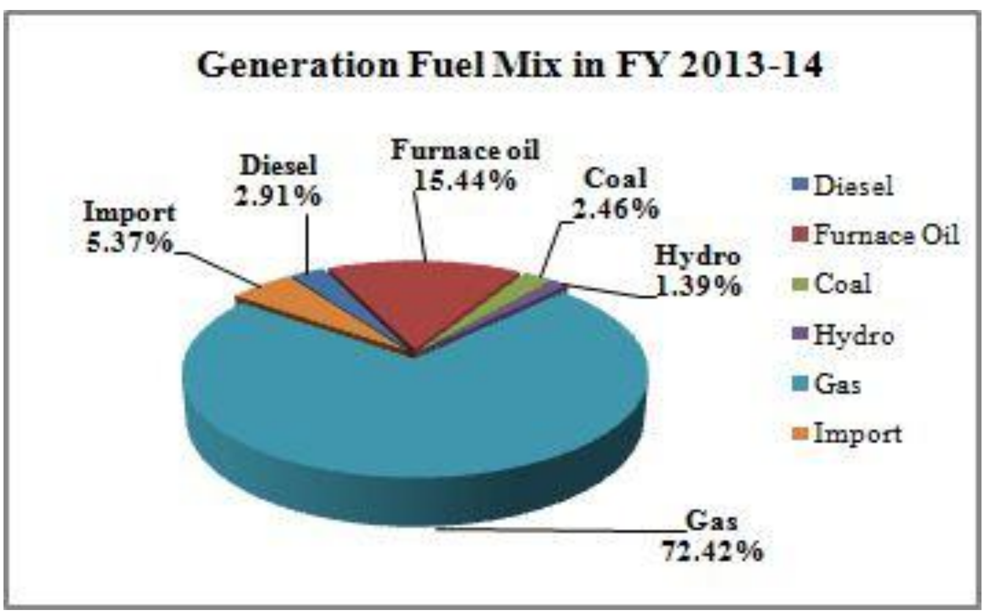

Fig 5.1: Generation Fuel Mix in FY 2013

However, in recent years, it was evident that actual scenario is other way round and adequate supply of natural gas has been at stake due to depleting existing gas reserves.

The uncertainty has been constraining development of further gas based power generation expansion program. Taking this into cognizance the government has prepared master plan named “Power System Master Plan 2010” to develop an energy balanced sustainable power system in the country. Under the new generation expansion plan substantial proportion will be generated from liquid and coal based source. In that case the above scenario will significantly change. Development of renewable energy is one of the important strategies adopted as part of Fuel Diversification Program. According to the plan 15% of total electricity generation will come from renewable and new energy sources.

5.2. Solar Resources:

Global and diffuse radiation measurements at RERC, Dhaka University kept suspended for a decade were restarted in 2002 as part of SWERA Program. The activities have been continuing since then. Eppley pyranometers with a computer interfacing card and a micro computer have been employed. Data are measured every minute and integrated values over an hour are used to obtain hourly, monthly and annual values. Calibrations with a new pyrheliometer and a new K&Z pyranometer are occasionally made. To estimate radiation values over Bangladesh sunshine duration and cloud cover measured by Bangladesh Meteorological Department at 31 stations are used employing correlations developed at RERC.

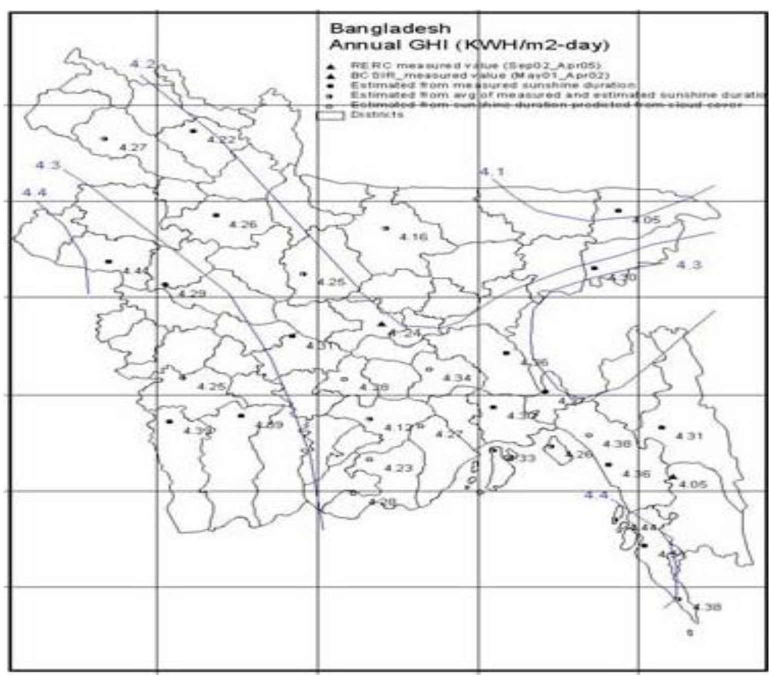

Fig 5.2 : Annual values of Global Horizontal Insolation (GHI) for 31 locations in Bangladesh

The whole area of Bangladesh has been covered by independent assessments of NREL using the CSR (Climatologically Solar Radiation) model which utilized information on cloud cover, water vapors, trace gases and aerosols over the years 1985-’91 and produced a 40×40 km resolution map. Their annual map has been tuned to Dhaka pyranometer data and the tuned GHI (Global Horizontal Isolation) map of NREL is shown below. [14]

Fig 5.3: GHI map of NREL tuned to Dhaka

Fig 5.4: GHI map of DLR tuned to Dhaka

5.3 Wind Resources:

Bangladesh is situated in the latitude between $20^0 34^{'}$-$26^0 38^{'}$N and longitude between 88^0-92^0E. The country has a 724km long coastal ling long the Bay of Bengal, which belongs to Bangladesh. The wind blows over Bangladesh from March to September with a monthly average 3m/s to 6m/s[15] . The peak wind speed occurs during the months of June to July [15]. Park of wind turbines in coastal areas, can be incorporated in electricity grid on a substantial basis and could add reliability and consistency to the electricity generated by the Kaptai Hydro-electric power Station from March to September, during which load shedding becomes critical than winter season.[16]

5.4 Development of renewable energy in Bangladesh

Being aware of the finite stock of fossil fuels and their negative impact on the environment, countries across the world are now leaning towards renewable energies like solar energy, wind energy, bio-energy, hydropower, geothermal and ocean energy in efforts to ensure energy security. The use of renewable energy has risen considerably in recent times, both in developed and in developing countries. REN21's Renewable 2014 Global Status Report indicates that renewable energy provided an estimated 19% of global energy consumption in 2012 compared to 16.7 % in 2010. More than hundred countries now have renewable energy policy of one kind or the other.

Keeping pace with the global trend, Bangladesh has also attached due importance to development of renewable energy. National plans -- Five Year Plan, Power System Master Plan -- and policy documents including National Energy Policy, Industrial Policy 2010 underscored renewable energy. Development of renewable energy has been identified as one of the programmers of Bangladesh Climate Change Strategy and Action Plan. Renewable energy options are also included in the Bangladesh National Building Code. 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.

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. Under this program, projects for electrification of rural health centers, educational institutions, E-centers at union levels, religious establishments and remote railway stations are required to be implemented by authorities concerned. Private sector is expected to implement commercial projects like Solar Irrigation, Solar Mini Grid, Solar Park and Solar Rooftop applications.

The government is gradually meeting part of the lighting and cooling load of public offices by installing solar panels. The national capacity of solar power development currently exceeds 150 MW. Most of the capacity addition is from Solar Home Systems (SHS) implemented by Infrastructure Development Company Limited (IDCOL), a government-owned financial institution. Until recently, more than 3 million SHSs have been installed with aggregated capacity of about 135 MW. The international community recognizes Bangladesh's SHSs as the fastest growing solar power dissemination program in the world.

Today, hydropower makes up the largest share of electricity generated from renewable sources as the global capacity reaches 1,000 GW. The only hydroelectric power plant was established at Kaptai with present installed capacity of 230 MW. Bangladesh Power Development Board (BPDB) identified two other sites at Sangu (140 MW) and Matamuhuri (75 MW) for large hydropower plants. Further exploitation of hydropower appears to be limited due to flat terrain of Bangladesh. Several studies have identified a few sites having potential ranging from 10 kW to 5 MW, but no appreciable capacity has yet been established.

Except for two pilot wind-power plants at Muhuri Dam (0.9 MW) in Feni and Kutubdia Island (1.0 MW) in Cox's Bazaar, comprehensive assessment of wind power potential is still ongoing. BCSIR, LGED, Bangladesh Centre for Advanced Studies, German Development Cooperation (GIZ) and Renewable Energy Resource Centre of Dhaka University assessed wind resource, at some length, in a few sites. Currently, Power Division is implementing a project with support from USAID to develop wind map for Bangladesh. Potentials of ocean and geothermal energy are yet to be explored in Bangladesh while global capacities reached 530 MW and 12 GW respectively.

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 renewable energy may overtake natural gas by 2015 and perhaps coal by 2035.

However, due to lack of clear knowledge base on renewable energy and their co-benefits, many people, even some energy professionals, are skeptical about the prospect of renewable energy. They mostly exaggerate the price of renewable energy and are of the opinion that renewable energy technologies are not mature enough to become viable options. Consequently, negative perception persists over renewable energy, hindering wider deployment.

Reliable information and best practices can overturn doubts, and show that renewable energy is the promising and sustainable energy option for Bangladesh, while newly established SREDA can play a vital role in catering to the same. [17]

Chapter 6

Results and Discussion

6.1 Introduction

The HOMER renewable energy software grew out of NREL's village power project. This was part of the US government's response to the Rio Earth Summit in 1992. Throughout the 1990's NREL was very active helping developing countries incorporate renewable power into their rural electrification program .NREL needed a model for its internal use to understand the design trade-offs between different systems configurations. The original HOMER utilize specialized optimization software and ran on UNIX software.

The Hybrid Optimization Model for Electric Renewable (HOMER) is a software tool that simulates and optimizes an electric power system combining traditional and renewable generation sources. Its combination of logical details, rapid runtimes (scores of annual simulations per second), transparent methodology, and accessible interface are unique feature among power modeling tools. It performs detailed chronological simulation at an hourly (or even minute by minute) level. If model intermittent renewable power sources, such as wind and solar is simultaneously sufficiently transparent and intuitive to inform higher level policy discussions without the help of lengthy interpretation by dedicated engineering staff. For either grid-tied or off-grid environments, HOMER helps to determine how variable resources such as wind and solar can be optimally integrated into hybrid system.

HOMER also determines the economic feasibility of a hybrid energy system and optimizes the system design and allows users to really understand how hybrid renewable systems work [18]. HOMER can compare the results and show a realistic projection of capital and operating expenses. HOMER determines the economic feasibility of a hybrid energy system optimizes the system design and allows users to really understand how hybrid renewable system works.

As distributed generation and power projects continue to be the fastest growing segment of the energy industry, HOMER can serve utility tool to telecom system integration and many other types of project developers to mitigate financial risk of their hybrid power projects.

6.2 Features with Advantages and Limitations

HOMER is software which uses different types of energy sources to generate a simulation of hybrid power generation and compare the result. To specify its kind we can introduce its noticeable features:

a. HOMER provides the accurate and detailed linear simulation and optimization in a model that is relatively simple and easy to use.
b. It can be used in various type of power system project. For a village or community-scale power system, HOMER can model both the technical and economic factors involved in the project.
c. For larger systems, HOMER can provide an important overview that compares the cost and feasibility of different configurations; then designers can use more specialized software to model the technical performance.
d. HOMER is accessible to large set of users, including non-technical decision makers. Chronological simulation is essential for modeling variable resources, such as solar and wind power and for combined heat and power application where the thermal load is variable.
e. HOMER's sensitivity analysis helps determine the potential impact of uncertain factors such as fuel prices or wind speed on a given system, over time.
f. HOMER models both conventional and renewable energy technologies.

NREL of US describes its overall features into three steps [19]:

a. Simulation- Estimate the cost and determine the feasibility of a system design over the 8760 hours in a year.
b. Optimization-Simulate each system configuration and display list of systems sorted by Net Present Cost (NPC).
c. Sensitivity Analysis- Perform an optimization for each sensitivity variable.

HOMER has certain features that can be advantageous for engineers and professionals to demonstrate a compact design optimized with variable parameters and cost comparisons. It is a strong alternative to any hybrid optimization software which can simulate analyze and compare hybrid power generation system in a effective way. However the limitations are spotted in some details. For example, simultaneous load calculation of both ac and dc load is not possible in this software. The followings show the advantages and limitation of the HOMER 2 software [20]:

Advantages:

a. Homer searches for the optimal systems.
b. Considering all RET's at a time.
c. Analyze grid or off-grid rural.
d. Electrification system. It reports both of optimal and near optimal solution.
e. Hourly analysis.
f. Sensitivity analyses to determine the effect of the inputs.
g. Results are based on life cycle economics.
h. More detailed than RET Screen software.
i. It can model AC or DC load

Limitations:

a. It cannot model both AC and DC loads (load modeling AC or DC at a time).
b. Calculate net present cost only.
c. Though GHG analysis is not available, it can obtain carbon emission (tone/year).

6.3 Simulation and Its Result

HOMER is a very helpful tool for calculating Hybrid system related data. This is the only software that directly merges the connected systems into hybrid and then asks for the input. After the inputs are given, HOMER calculates it and gives the user a feedback on the hybrid system one is planning to design.

The design of a 650W solar-wind small hybrid power system for urban area and remote areas is a proposed project where all the necessary calculations required for setting up the project is needed. For this reason the help of HOMER is needed. After putting the inputs in the software and giving necessary data the software calculates the systems need and requirements and then give user the obtained output.

After putting on every data of the site and taking MIST as a project site the solar and wind data were placed before calculating the total project. The 350W solar panel sited on the model proposal was taken as solar power generating equipment and the 300W wind turbine was taken as the wind power generating equipment. Battery of capability 24V and 150 Ah was taken for the storage purpose while 1KW solar-wind hybrid converter was used to invert the DC power coming out from the turbine and panels to AC. The charge controller was used to control the charges and that controller was also hybrid of category. All the data used were downloaded from interne so variability may have been there in practical scenes.

6.3.1 Creating a Project on Homer 2

At the beginning of the program the "Equipment to Consider" window appears where we can add an equipment to consider as a part of system designed, we can give some details and name. Additional notes can be sited for query.

Then the components are to be connected as shown in the figure as the system to be designed. There are options for connecting PV, wind turbine, converter, battery, generator and many more.

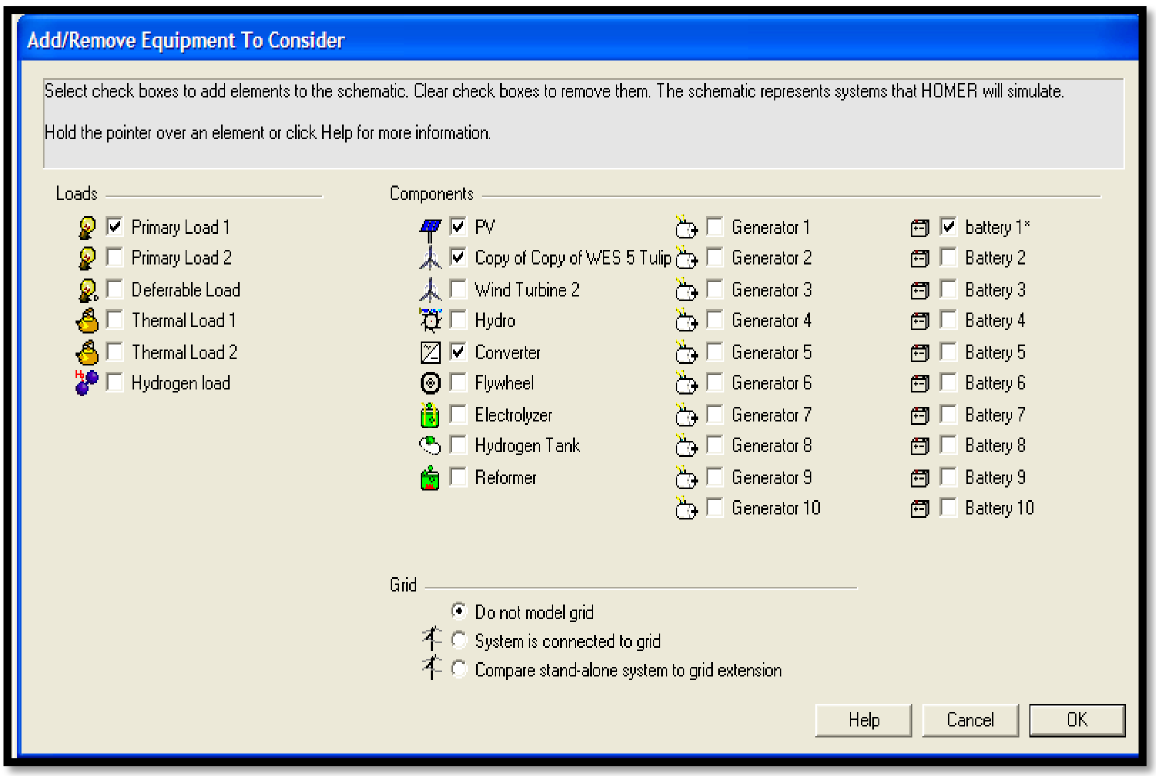

Fig 6.1: Add/Remove Equipment to consider.

Then user has to fulfill all the component details and the required resources for generating renewable energy. The cost of component and the site detail are mainly important to know before starting for any plan.

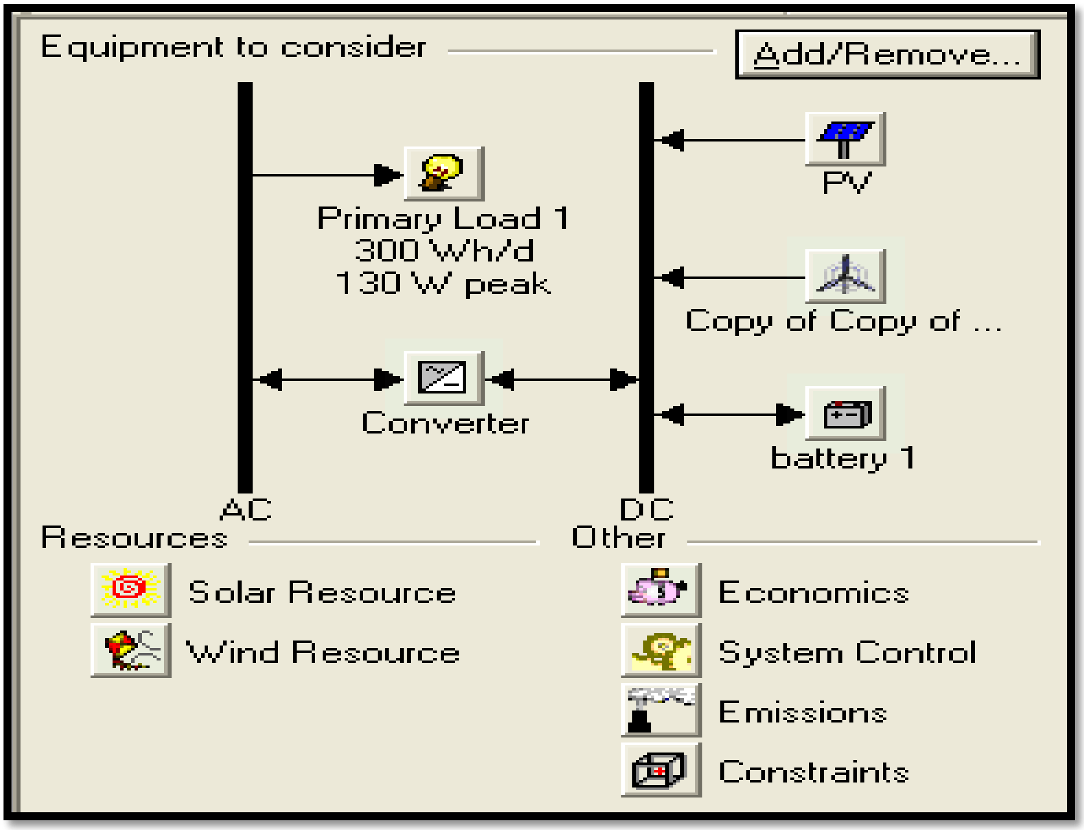

Fig 6.2: Creating schematic.

Here the components are connected as the project desired. After adding the components that are needed to have a hybrid project of 650W solar-wind every detail of the solar and solar and wind resources are to be known. Here the software itself helped to have detailed resource information by connecting to the internet for the solar data only. But the wind data were given manually from NASA Surface Meteorology and Solar Energy website.

6.3.2 Setting Solar Resources:

The much updated software automatically gives the coordinates of the place and solar radiation of PV panel and it can be downloaded manually.

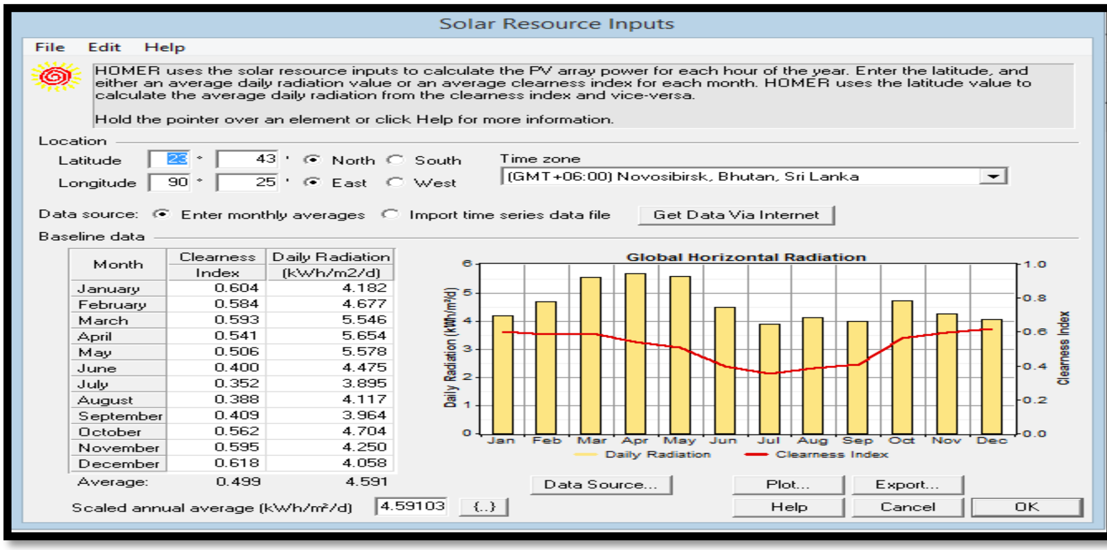

Fig 6.3: Solar Resource Inputs.

In Figure 6.3, data retrieved from homer energy website on Dec 8, 2014 were put as baseline data. Data set is from NREL and Cell area/ dimension is taken to be 40km×40 km. The cell mid point is 23^0 46’ N $90^0$17’ E. Here scaled annual average is 4.591KWh/m^2/day.

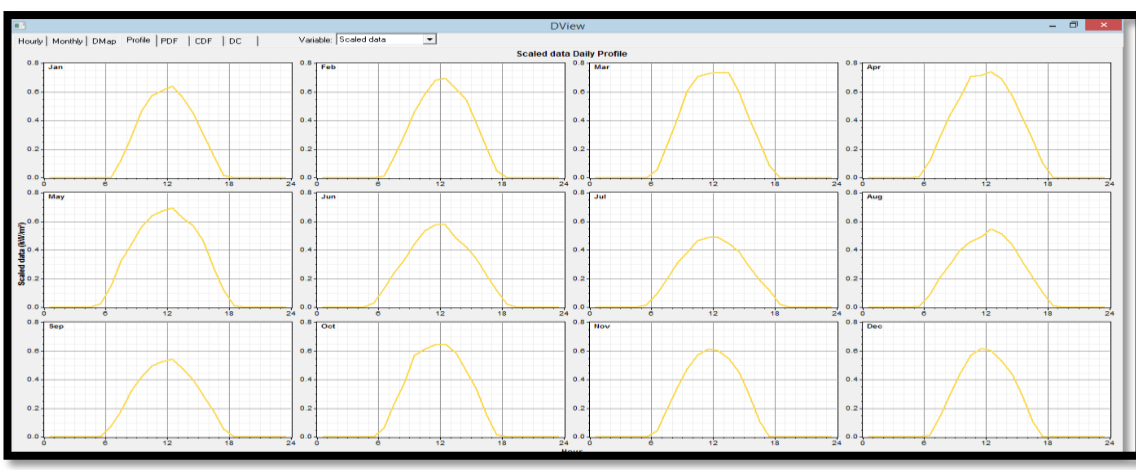

Fig 6.4: Profile of Solar Resource.

Then the solar resources are ready for use. In figure 6.4, profile shows us how solar radiation differs in different months.

6.3.3 Setting Wind Resources:

Here data related to wind resources were given manually by taking 10 years average. We have considered MIST, Mirpur Cantonment as our location.

Monthly Averaged Wind Speed At 50 m Above The Surface Of The Earth (m/s)

Lat 23.43 Lon 90.25	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
10-year Average	2.36	2.66	2.83	3.19	3.20	3.07	2.74	2.41	2.17	1.85	2.08	2.20	2.56

Minimum And Maximum Difference From Monthly Averaged Wind Speed At 50 m (%)

Lat 23.43 Lon 90.25	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Minimum	-11	-16	-19	-13	-13	-11	-8	-9	-9	-11	-13	-12	-12
Maximum	13	20	24	24	21	8	8	10	9	11	16	7	14

Fig 6.5: Data for Wind Resource.

In figure 6.5, monthly average wind speed and maximum and minimum wind speed is given.

After getting the data from "eosweb.larc.nasa.gov" we manually loaded the data.

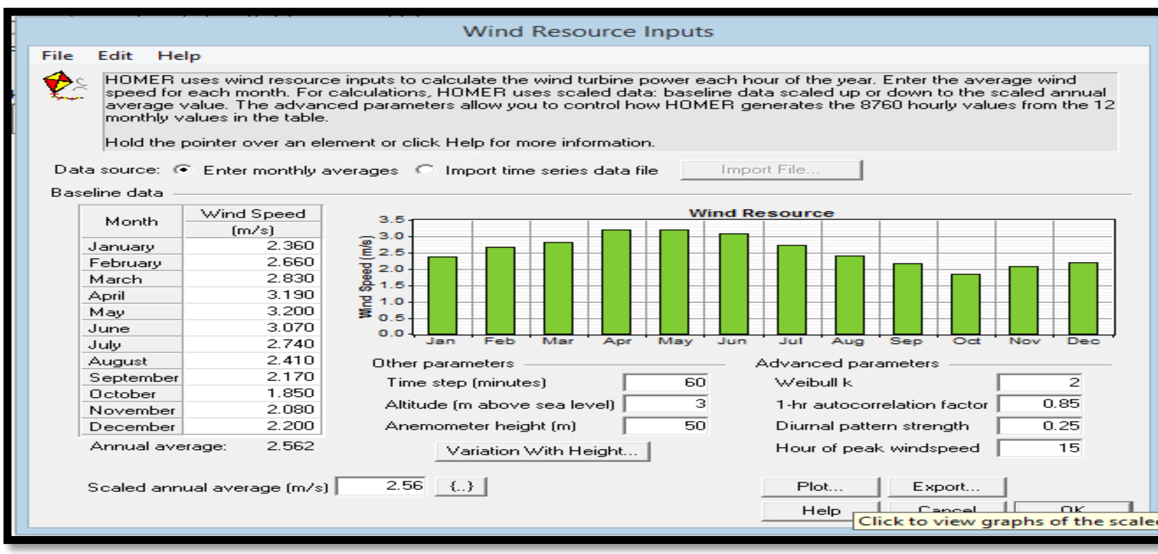

Fig 6.6: Wind Resource Inputs.

In the figure 6.6, annual average wind speed is 2.56 m/s. Maximum wind speed is 3.20m/s and minimum is 1.85m/s. Scaled annual average is 2.56 m/s. Anemometer height is 50m and in the figure 6.7, variability of wind speed in different months is shown below in the profile of wind.

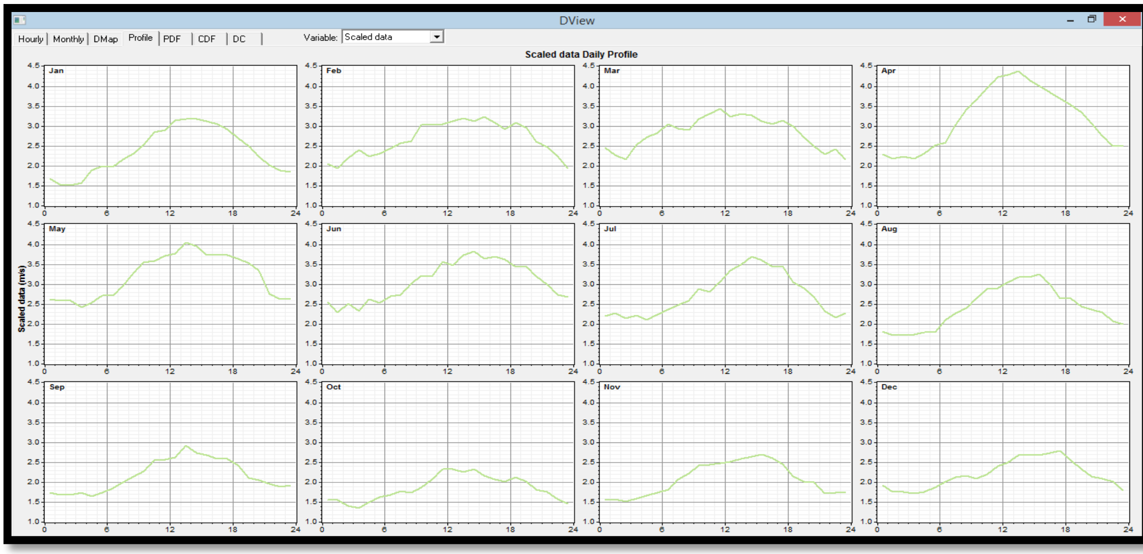

Fig 6.7: Profile for Wind Resource.

From the above data the wind speed was obtained and wind speed vs. power output curve can be achieved. It may be noted that, to get torque and start the wind power generation is 3 m/s which is not much available in Dhaka. The physical wind turbine which was planned in the 50m height (above MIST administrative building) and we failed to get data.

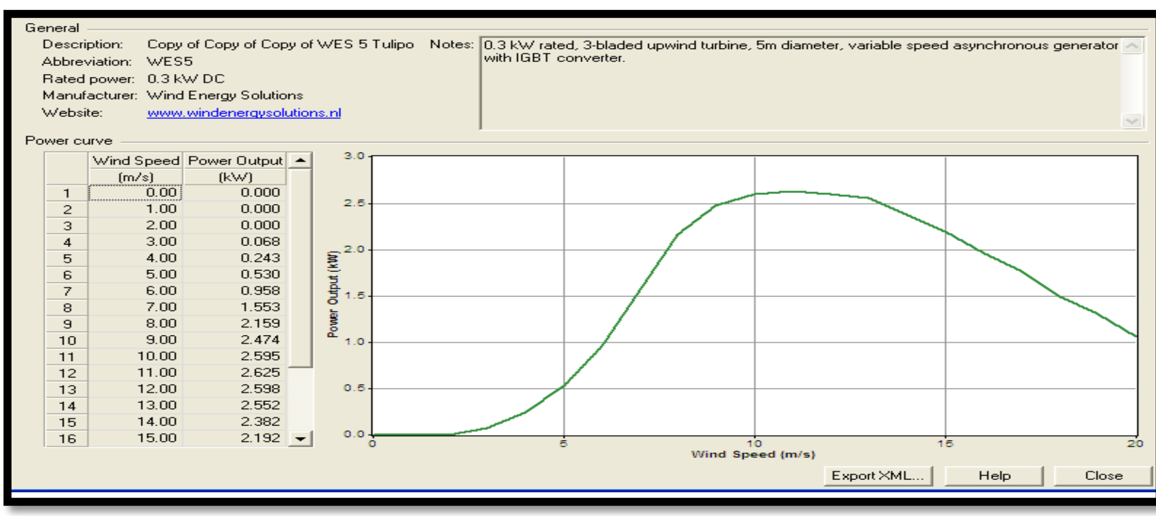

Fig 6.8: Power Output vs. Wind Speed Curve.

In the figure 6.8, the curve clearly shows that 5 m/s wind speed allows getting minimum 530 Watt (maximum power output).

6.3.4 PV Inputs

We have considered a 350W PV module which costs nearly $175. It supplies dc power to the charge controller or converter. We have assumed it will give support for 20 years. The tilt angle of solar module was 23^0. Physically the 350 Watt PV module was established on the rooftop of MIST administrative building. Fig 6.9 depicts PV inputs of the simulation.

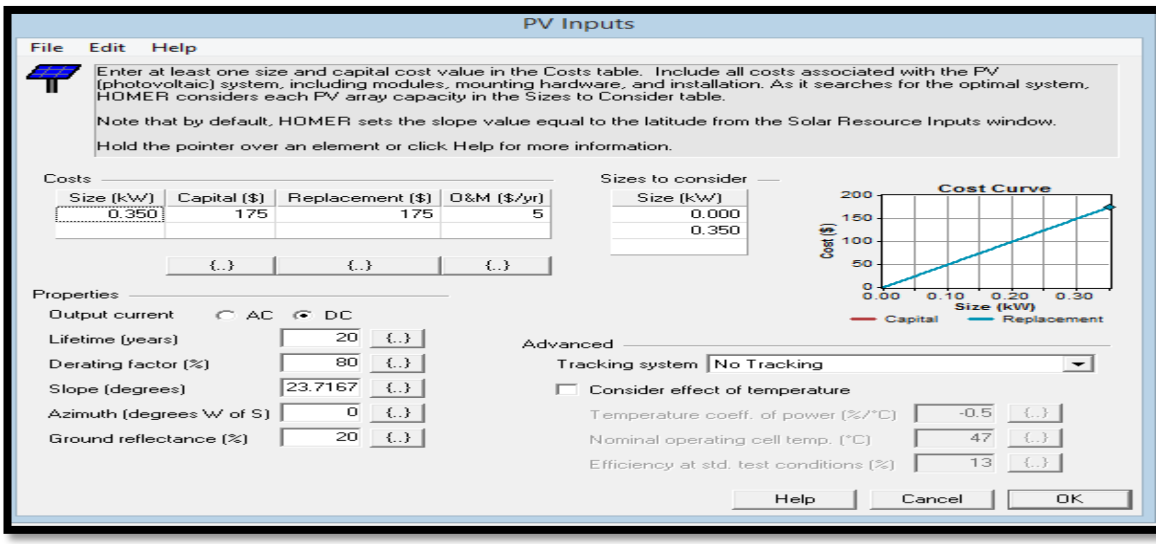

Fig 6.9: PV Inputs.

6.3.5 Wind Turbine Inputs

Our installed wind turbine is a 300W small wind generator which is a kind of horizontal axis wind turbines. Its front cover wind leaf wheel hub, the permanent magnet generator, revolving body and tail section are suitable for good wind resources. It works with low noise. Its performance characteristics are-

a. Lower start up wind speed
b. Large installation angle design to improve start torque
c. Motor score groove design to remove magnetic resistance and reduce the start up wind speed
d. Wind turbine with compact design
e. The same power output than conventional motor is small in size
f. Under strong wind have good stalling characteristics and avoid overload

Technical specifications of installed wind turbine are mentioned below-

Rated Power	300 W
Rotor Regulation	1 m
Rated Wind Speed	15 m/s
Start Up Wind Speed	3 m/s
Working Voltage	24 V DC
Break System	Electromagnetic Stall
Security Wind Speed	45 m/s
Working Wind Speed	4.25 m/s
Weight	11 kg

For homer analysis we have used WES 5 Tulipo wind turbine with 300W rating. It costs $220 with a life time 15 years to make consideration. The O&M per year is considered $5. The Fig 6.10 depicts the wind turbine inputs.

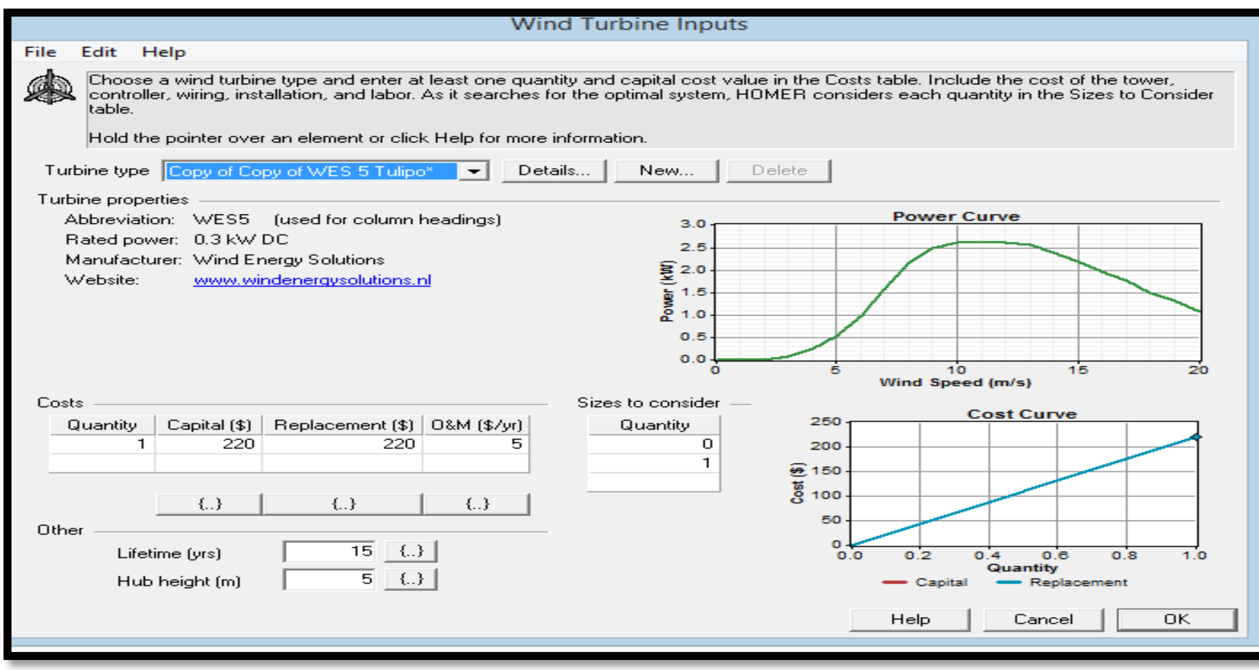

Fig 6.10: Wind Turbine Inputs.

6.3.6 Choosing Battery Details

The battery we have installed is 24 Volt, 150 Ah, 3.6 KWh with lifetime throughput is 1000 KWh. Fig 6.11 shows the input panel for battery.

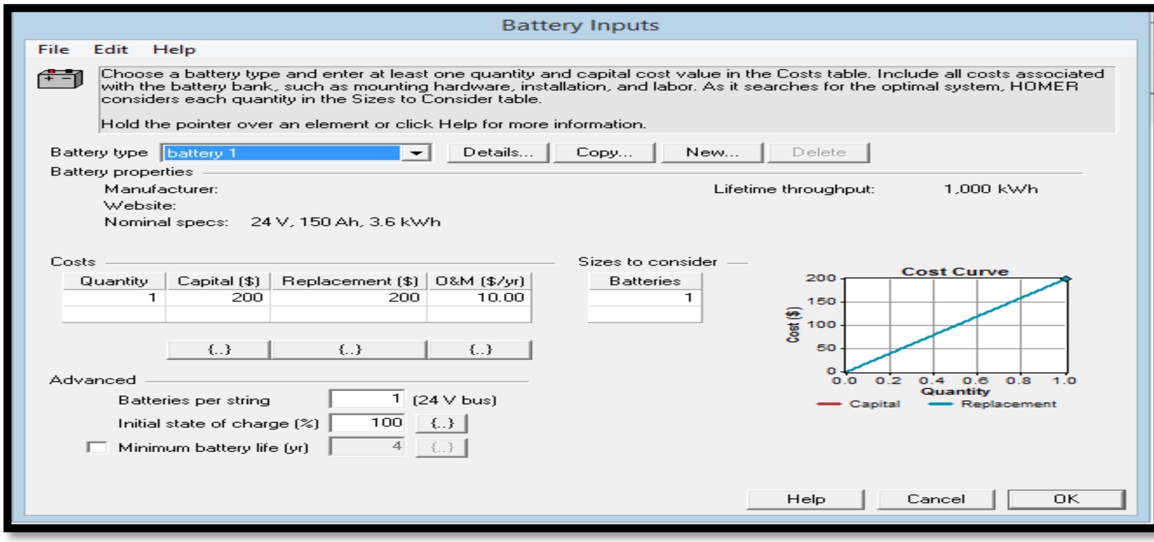

Fig 6.11: Battery Inputs.

6.3.7 Primary Load Characteristics

The primary load considered here is basically residential load. The average daily load was assumed 0.3 KWh/day (Though the load requirement may increase but due to solar panel limitation we have restricted our load within the limit 0.3 KWh/day. And the result in the analysis is given below in fig 6.12.

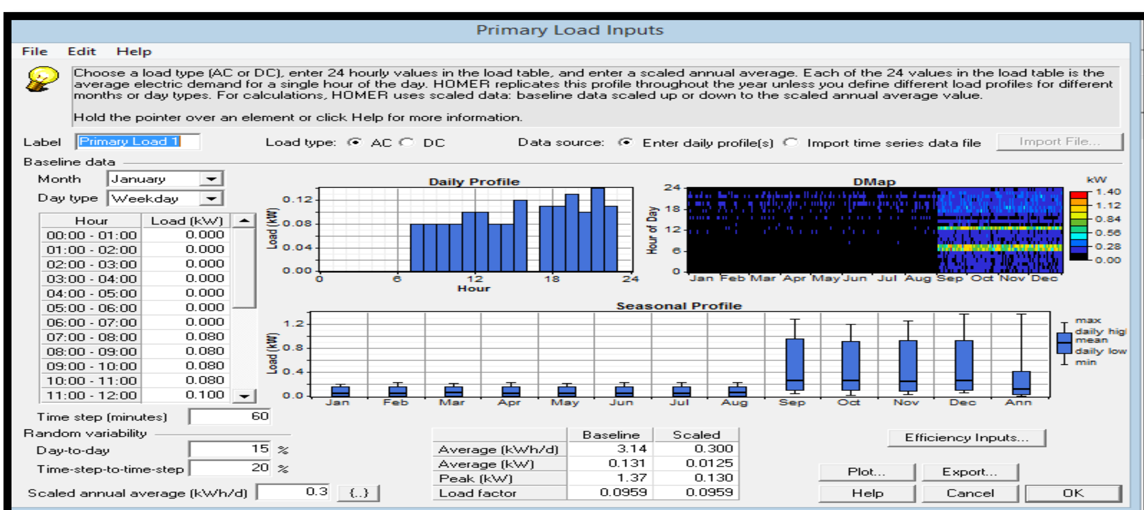

Fig 6.12: Primary Load Inputs.

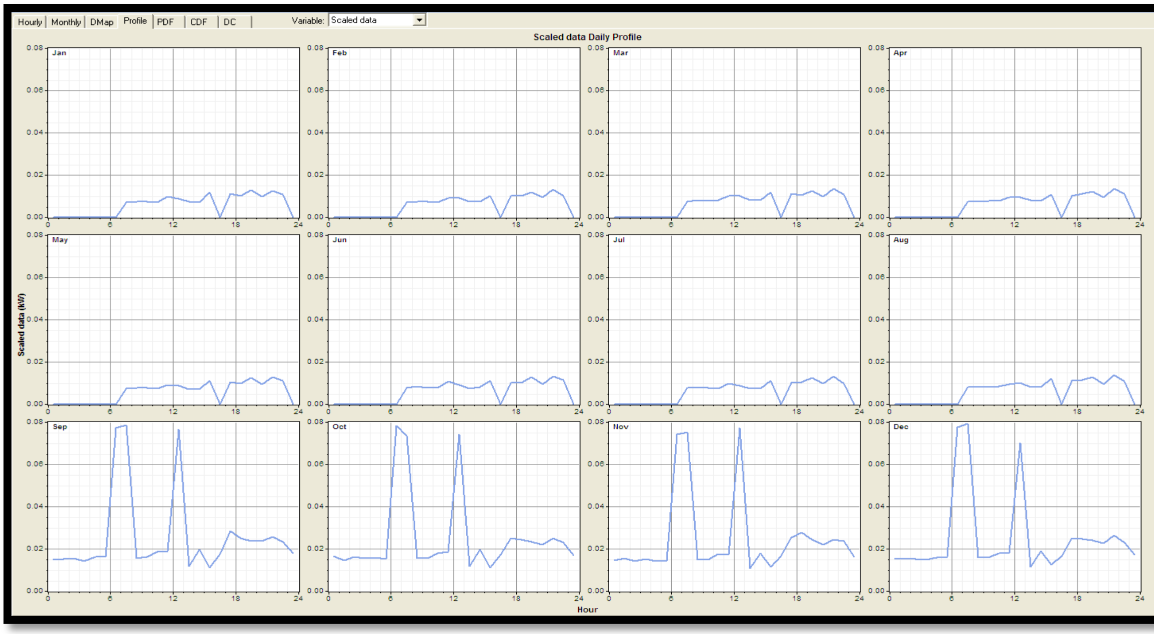

Fig 6.13: Profile for Primary Load

In the figure 6.13, we have shown the primary load variation throughout the year.

6.3.8 Results (Sensitivity and Optimization)

Sensitivity result:

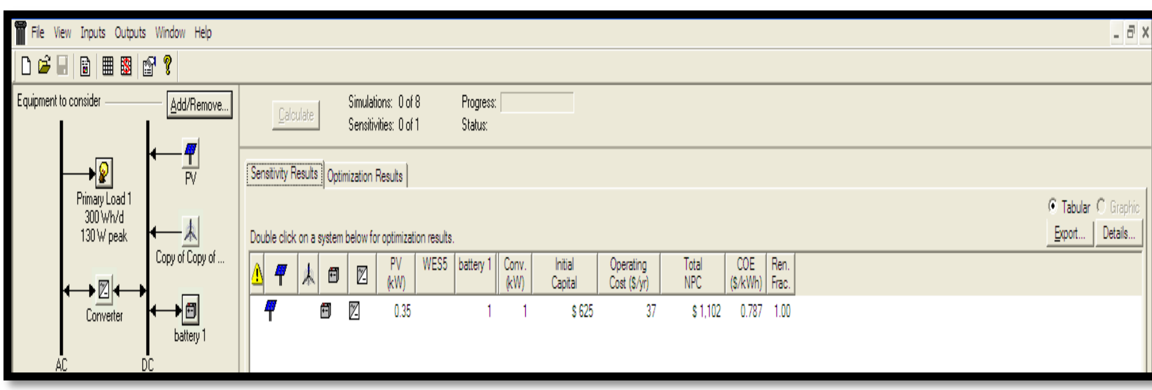

Fig 6.14: Sensitivity Result

In figure 6.14, we see HOMER selects only PV power solution for power supply without the wind power. Here the initial cost is $525 and the operating cost is $37.

Optimization result:

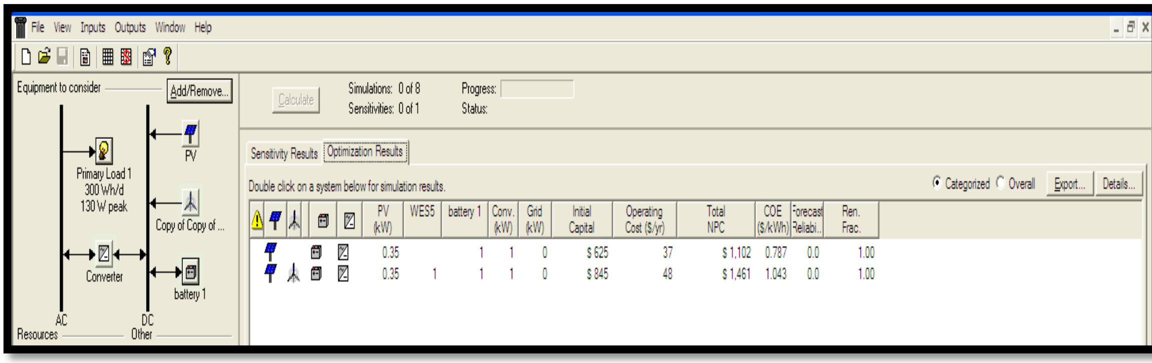

Fig 6.15: Optimization Result

In figure 6.15, optimization result shows us how cost and power generation differs for the system with wind system and without wind generation. Here we see the cost differs much in that two cases. Despite the integration of wind generator with additional cost, system performance did not increase.

6.3.9 Overall Result

Cost summary:

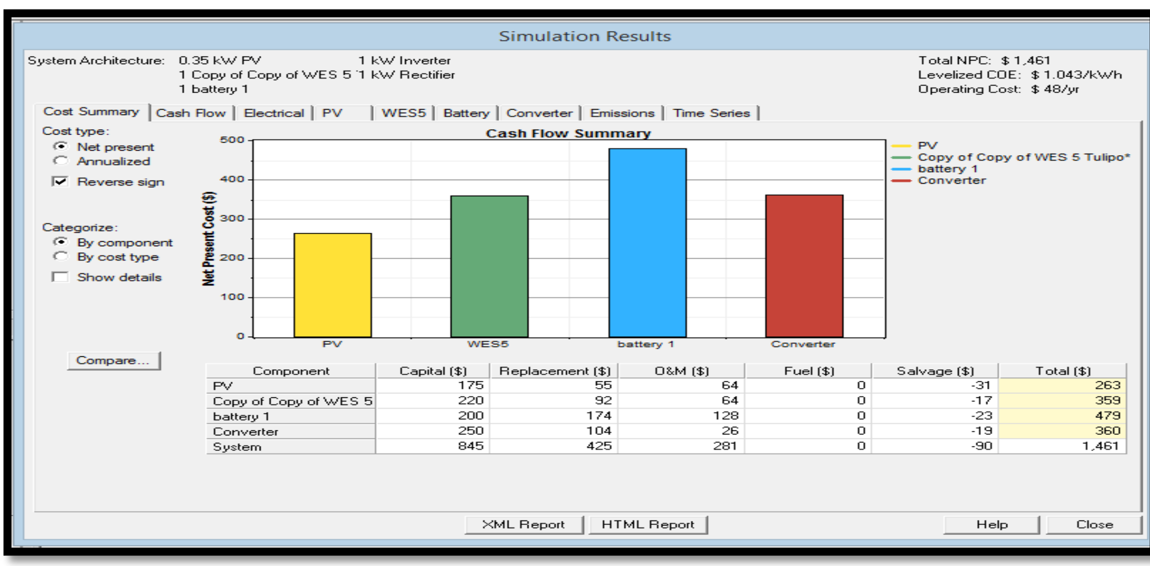

Fig 6.16: Cost Summary

Fig 6.16 depicts that the total capital is $845. And the replacement cost is $425 when maintenance cost is $281 throughout the year. It seems the Battery cost is high.

Cash flow:

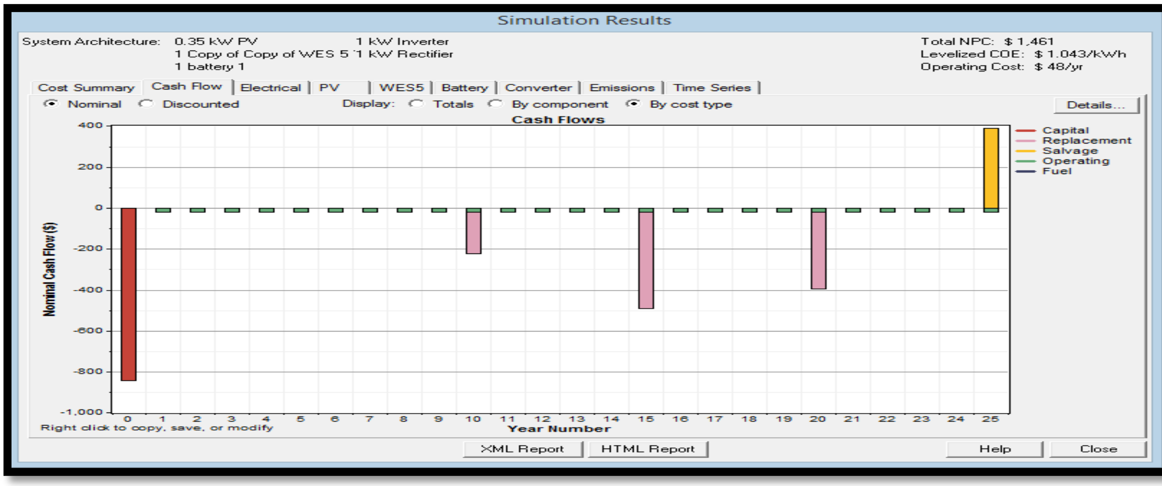

Fig 6.17: Cash Flow

In Fig 6.17, Cash flow shows up to how many years the investment will continue to support. It is seen that new investment will be required after 25 years.

Power production:

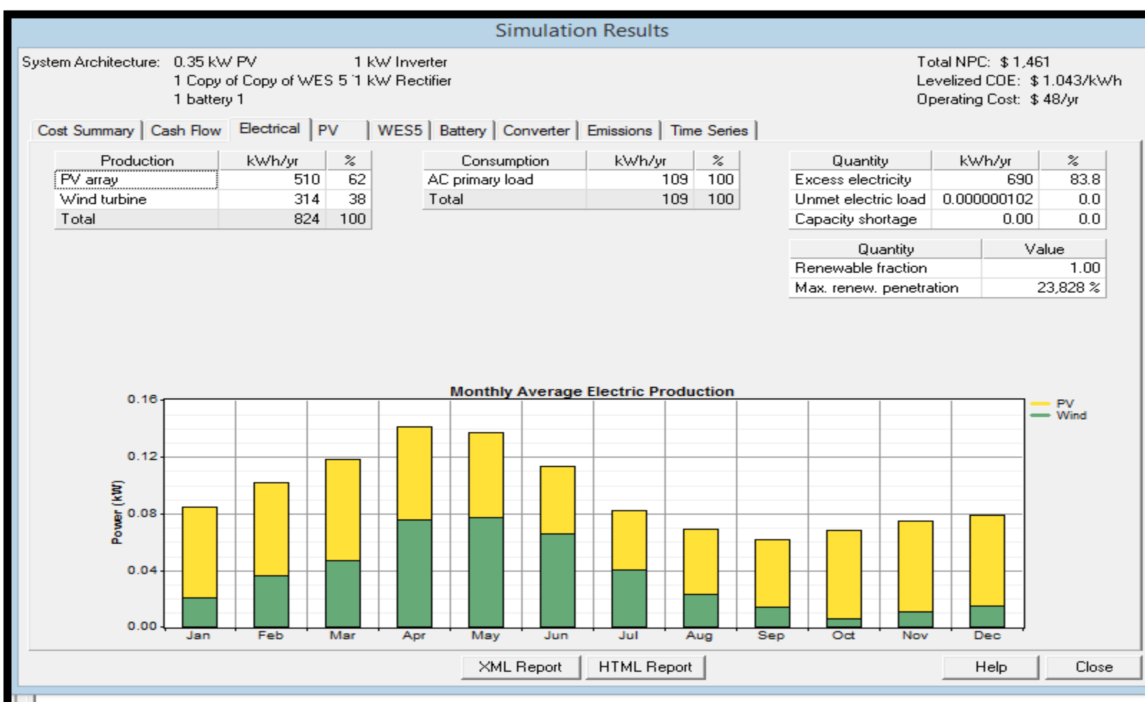

Fig 6.18: Power Production

After calculation, From Fig 6.18 we can deduce that :

a. Total renewable power output- 824 KWh/yr
b. Total electricity load served-109 KWh/yr
c. Production from PV array-510 KWh/yr
d. Production from wind turbine-314 KWh/yr
e. Excess electricity-690 KWh/yr
f. Unmet electricity load-0.000000917 KWh/yr
g. Capacity shortage-0 KWh/yr
h. Maximum renewable penetration-23.829%

PV Output:

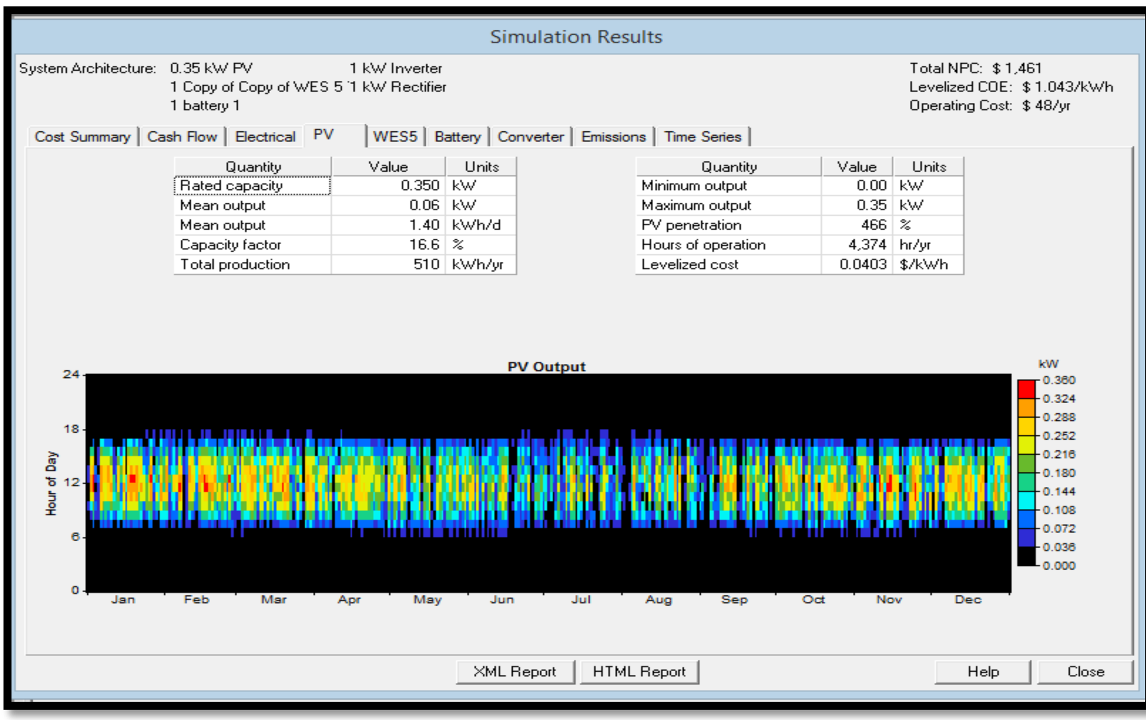

Fig 6.19: PV Output

The figure 6.19 shows, total production from PV panel is 510KWh/year. With capacity factor 16.6%, hours of operation is 4374 hr/yr.

Wind Turbine Output:

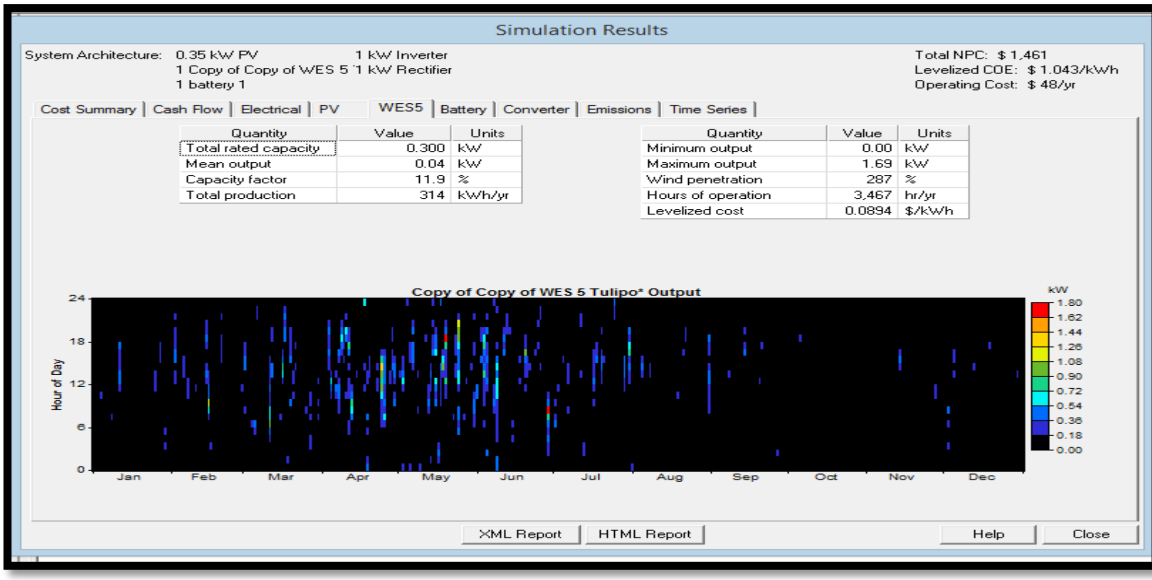

Fig 6.20: Wind Turbine Output

The figure 6.20 shows that total production from wind turbine is 314 KWh/yr. With capacity factor 16.6%, hours of operation is 3467 hr/yr.

Battery Output:

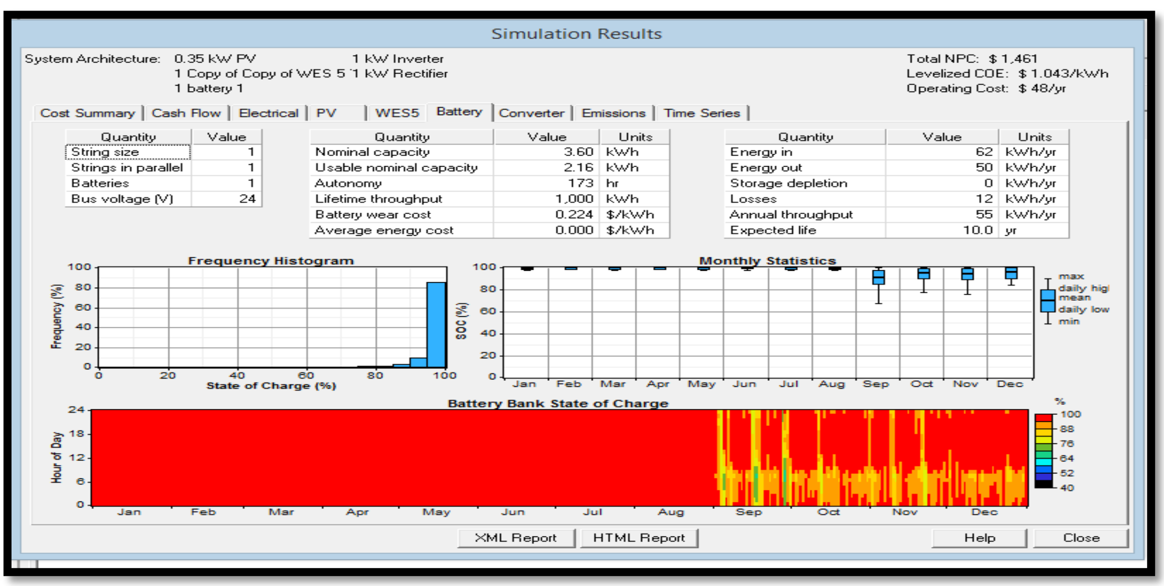

Fig 6.21: Battery Output

The figure 6.21 shows that bus voltage is 24V. Nominal capacity is 3.60 KWh. Usable capacity is 2.1 KWh. Loss of power and annual throughput are 12 KW/yr and 55 KWh/yr.

Converter Output Analysis:

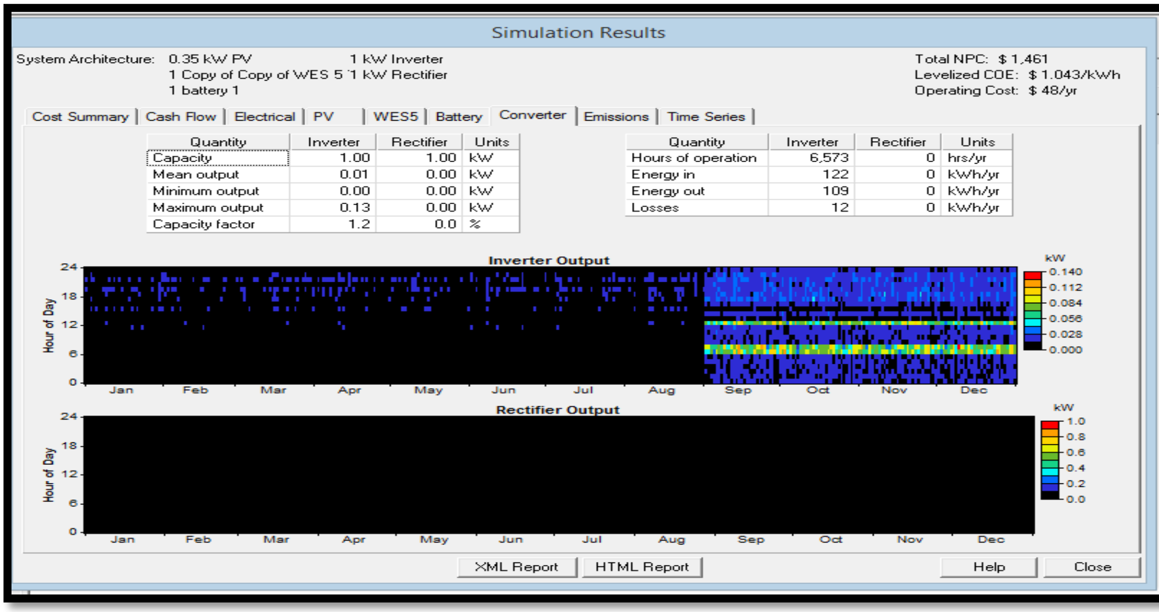

Fig 6.22: Converter Output Analysis

The figure 6.22 shows that the converter output when the energy output of the inverter is 109 KWh/yr, the input is 122 KWh/yr.

Total renewable power output:

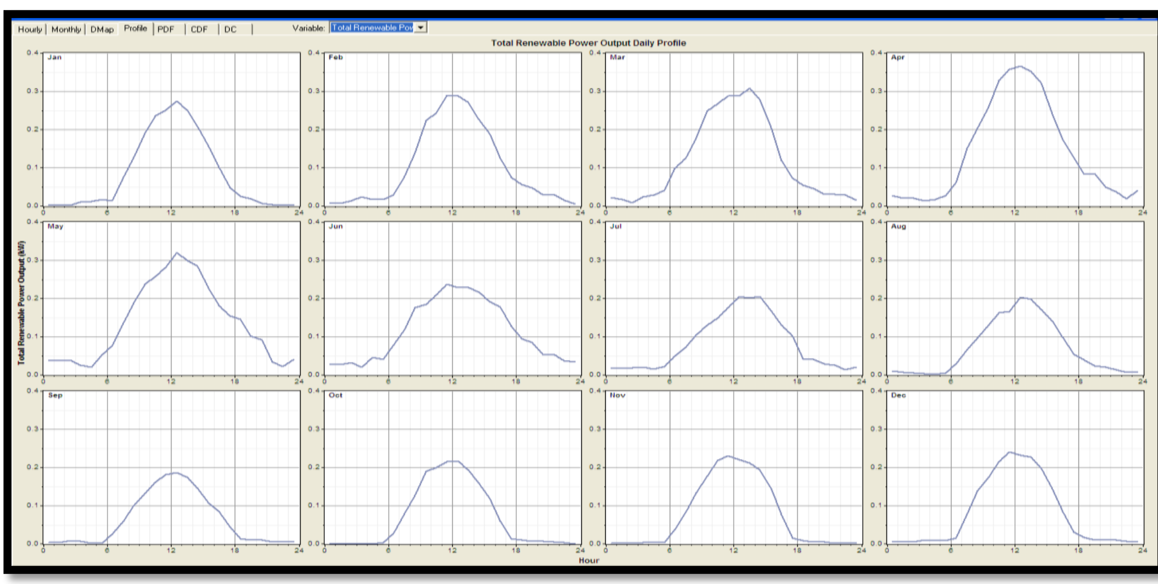

Fig 6.23: Total Output Power

Figure 6.23 shows us total renewable power in different month. It is seen that during the months of April and May, the total output is highest amongst all the months.

Total Electrical Load Served:

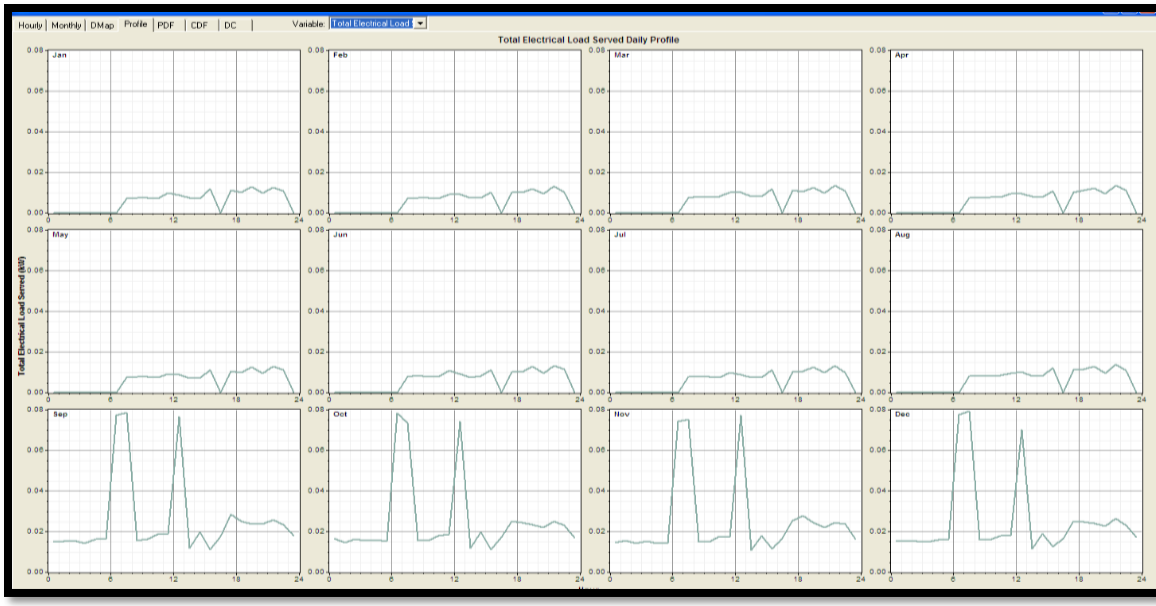

Fig 6.24: Total Electrical Load Served.

Figure 6.24 shows the month wise yearly profile of electrical load served.

6.3.10 Discussion on Performance of the Hybrid Power System

It is seen that total renewable power output was gained and the data shows that every year the system is going to generate 824KWh/yr which is quite good and normal for residential use in Bangladesh. Here the battery can survive for two days and can meet the demand load as well. Here most noticeable thing is that 62% of the generation comes from the solar power system and another 32% comes from wind turbine. As the load is residential load, load is fed very nicely by the designed hybrid system for use in the urban areas or in low power demand areas.

Looking at the result generated by HOMER 2 few good decisions can be made. The cost summary shows that the total cost needed $845 which is equivalent to 65288 taka (@ 1 US Dollar=77.26Taka). The total operation and maintenance cost is $281 which is equivalent to 21711 Taka (@ 1 US Dollar=77.26Taka) and there is no fuel cost as it totally depends on PV and wind based system. So if any family wants to decrease the electric bill they can definitely use this hybrid power system. Another thing that should be considered is the cash flow graph. It has importance to have a clear view on it because that cash flow bars will help us to understand how long the system is going to stand without any more investment on it and after how many years the user should invest again. So this is much sustainable and economically viable system as it continues for 25 years.

To welcome green energy in our country and also to increase the use of renewable energy by cutting cost to gas driven electricity generation, we can easily adopt such kind of hybrid power system to reduce the demand on our national grid. So the system will not only make the user entity benefited but also will help the national electric grid to meet the rising demand of electricity every hour.

The cost of fuel is increasing day by day in our country as well as in the whole world. At the same time, the national resources are becoming less due to excess use of these non-renewable resources. The next generation will face the scarcity of power everywhere. At that time the remaining power sources will be confined within renewable power sources.

Chapter 7

Practical Project and Future of the Proposed Hybrid System

7.1 Introduction

Power is one of the most important factors for a developing country like Bangladesh. Like the rest of the countries of the world, the demand for power is increasing day by day in our country. At present, power failure has become an acute problem for this country. In recent times, establishment of important physical infrastructures, setting up of new power plants and the pace of industrialization in the country has slowed down due to energy supply shortage. The plan that has been proposed here is simply a small solar wind hybrid system. Its generating capacity is less but it can make a great effect on the economy of the country. In urban areas where scarcity of electricity is clearly noticeable it can bring a change in using power. Any person interested in having a own generation system can simply use this proposed plan.

The concept of green power or some can say green energy or green world is rising up day by day. In today's world people have become conscious about the scarcity of power so they are planning to get the power from different sources like solar wind hybrid power system. Now the conscious governments are imposing various rules on demand of taking new connection of national electric grid. The government is taking long term decisions to meet the national demand. In such condition we should come forward to think something different to make the country without any scarcity of power.

So when there is abundant possibility of setting up enormous amount of renewable energy systems based on the constant renewable energy resources of solar and wind, a successful future and sustainability can be assured for the next generation. So privilege was taken to design a 650W small solar wind hybrid system for the urban areas dwelling people. Bangladesh is a country where there are abundant sun rays for harnessing or harvesting solar energy from the sun. Again wind energy is sometimes in this country good to have power output for small purpose of load meeting demands. So merging both solar and wind power that are available in this country and costs no money to buy them, it s good to have solar wind hybrid power system in every house. The system is not only going to save the user a huge amount of money but also contributing on the consumptions of limited natural resources that are still available on earth but only for a short period of time.

7.2 Design Overview

The system that has been designed as solar wind hybrid system is quite enough to meet up the demand of a small family dwelling in urban areas. Noticeably in the urban areas the families are now a day small and having 3-4 members only at their home. And the demand of power needed is more or less 2.00 KWh per day. So if the system is set up then sometimes it can fulfill the demand partially or fully. So the system can be set up at their rooftop.

The wind swept area is about only one and a half meter and the solar panel is about one meter square. So a small place is required to set up the whole thing. The other things such as charge controller, inverter, and battery banks can be easily kept inside the house. So it can be estimated easily that the total system would not cost the owner more than 4 meter square even if at maximum. But it is necessary to keep all components at close position to help them good monitoring at different conditions.

7.3 Practical Project and Its Limitation

Fig 7.1: Project Site

The total thesis project was done throughout the year of 2014. The process of thesis work was completed as under:

a. The need of power generation in our present context compelled us to work on this thesis subject.
b. According to the supervision of thesis supervisor we have started theory part of the subject.
c. The next step was collection of data, both solar and wind.
d. We have used these data in HOMER software and got the framework of project model.
e. According to the data, load, software model and resources available, we have modeled our project. Then we have implanted the solar panels and wind turbine.

Fig 7.2: Solar Panel

Fig 7.3: Wind Turbine

During the whole project work, we have faced a few difficulties. Though many of them were overcome, however, few hindered our progress. Some of them are highlighted below:

a. Resources for the thesis work and data collection was insufficient. For data, we had to depend mostly on internet. But for this project, we required practical data of the area which were difficult to collect.
b. The budget shortage put us in dilemma to complete the project work. For which we could not complete the total project that we had aimed at.
c. As seasonal changes are very prominent, there was lack of solar and wind power to run the project.
d. Regarding the wind data, we faced problems to collect the data of coastal area that restricted us to work on urban areas only. (Though the net data from BAF were collected for last year, it did not give the same for year 2014).

e. 3m/s was the minimum wind speed for achieving torque in wind turbine. From August 14 till the end of November 14, we failed to get this torque in the position above 50 m.
f. It is suggested that the LED tube bulb with 7 Watt(4 ft long) should be used instead of CFL bulb. Purchase process could not be started in time.

7.4 Sustainability of the System

The small solar wind hybrid power system for urban areas is a very good project that can be used in many places of the urban areas. The prospects are getting vast day by day. The necessities are increasing day by day, so scopes are being created as well. But in each and every way the system can be sustainable because-

a. The proposed system is small package so it fits to many places.
b. Again the user does not need any fuel that may cost him routine money like patrol diesel and etc.
c. As the system does not use any fuel there is no emission of green house gas.
d. The system does not make any sound pollution.
e. Anyone using it can help the national grid electricity for lower the pressure on it.
f. The system can help an owner of it by not only in electricity but also in economy.
g. No air pollution is possible here.
h. Human can be benefitted by using it because power crisis is the major problem in our country.
i. The renewable resources use makes it helpful for the eco-balance.
j. The system is eco-friendly.

Considering all these matters stated above it can be easily said that the proposed model is really sustainable and can help in the sustainable development which is the major concern of our today's earth.

7.5 Multipurpose Use of the System

The project that has been designed can be of many uses in modern world. Some of them are discussed briefly:

a. Use in urban areas for the purpose of the home electricity and for standing zero power building where renewable energy are the only sources of power.

b. Use in the rural areas where people are still in want of electricity but that par is not connected to power grid.
c. Use in the small pump or motor running project.
d. Use in street lighting.
e. Use in the underground lighting.
f. Use in the small medical centre.
g. Use in the rest room lighting.
h. Use in any place needing load 0.3 KW

7.6 Reasons behind Its Unavailability

People are not interested to use this low output (650W) devices and the demand in a home system increased to more than 1KW.

Due to its high initial cost, everybody thinks that the cost is much high. But as it does not depend on fossil fuel, the overall cost over a period of time is low for hybrid system.

7.7 Recommendations

a. In urban areas hybrid power system (solar + wind) is as good as standalone solar power system as existing wind throughout the year fails to generate starting torque for the turbine. As such, instead of hybrid (Solar + wind) , only solar based power system is suggested for home use.
b. Urban areas especially in Dhaka, the buildings are very closely placed. As such for low raised buildings, instead of hybrid system, solar system with inverter is suggested. Use of LED lights will reduce the power consumption and thereby support urban home power system most efficiently

Conclusion

For a community to raise itself out of subsistence and into an upward spiral of increased prosperity, certain basic services must be available and affordable. These include drinkable water, health care, education, transportation and communication. Access to reliable electricity is a precondition for the provision of many of these services and an active catalyst for sustainable development.

The provision of electricity has a direct impact on society. The improvement of communication and social activities, as well as health and educational services and facilities, clearly boost living standards and consequently prevent urban migration, provide a stronger sense of community, reduce mortality and improve gender equality.

Electricity access has also a substantial impact in terms of economic development by increasing productivity and economic growth as well as local employment. The possibility of preserving specific products, having irrigation facilities and powered processing equipment, will increase the production capacity as well as the quantity and quality of the product placed in the market.

Diesel based power system will sooner or later grow to be a barrier for rural areas due to the operating cost, the high need of maintenance, their acoustic and environmental polluted nature and the geographical difficulties to deliver the fuel to remote areas. Retrofitting hybrid power system to the existing diesel based plants will significantly minimize delivery and transport problems and will drastically reduce maintenance and emissions representing an advantageous and more suitable solution for rural areas.

Any combination of renewable energy technologies with an optional backup with LPG, gasoline, or diesel is possible the way to determine the most appropriate technological solution for hybrid systems implies always a feasibility study based on gathering field data for specific site and on a life cycle cost analysis. Technical, economic, financial and socio cultural considerations must all be included in the decision process to ensure the appropriate choice of technologies and operational and ownership scheme. Location, resources evaluation and load analysis are among the basic criteria to be considered to design an optimal power solution.

Once the most appropriate system configuration has been chosen, a carefully and responsible selection of components should be carried out considering quality ,yield, regular maintenance requirements, after self service availability, cost of servicing, warranty, spare parts availability and price.

Reaching the non-electrified rural population is currently not possible through the extension of grid, since the connection is neither economically feasible, nor encouraged by the main actors. Further the increases in oil prices and the unbearable impacts of this energy sources on the users and on the environment are slowly removing conventional energy solutions, such as fuel based systems from the rural development agendas.

The plan that has been proposed in this thesis book is a small hybrid system that can be of use for the users of urban areas especially where now a day the scarcity of electricity is a common phenomenon, so users are attempting to own their personal power generation systems.

Hybrid systems have proved to be the best option to deliver high quality community energy services to urban areas at the lowest cost and with maximum social and environmental benefits. Indeed by choosing renewable energy, developing countries can stabilize their CO_2 emissions while increasing consumption through economic growth.

But, achieving sustainable economic and widespread use of hybrid systems will only be possible if local management schemes, effective policies, and meaningful finance and international co-operation with industrialized countries are put in place. Though the private sectors rule in rural electrification is growing somewhat, governments and the donor community are still very much needed to provide not only initial start-up financing but the appropriate infrastructure and energy models, as well as a continuous engagement in some fashion.

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