HYBRID ENERGY SYSTEM: POWER GENERATION FROM RENEWABLE SOURCES FOR COASTAL AREAS IN BANGLADESH

By

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A Final Year Design Project (FYDP) submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering

Department of Electrical and Electronic Engineering
Brac University
September 2022

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Declaration

It is hereby declared that

1. The Final Year Design Project (FYDP) submitted is my/our own original work while completing degree at Brac University.
2. The Final Year Design Project (FYDP) does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Approval

The Final Year Design Project (FYDP) titled "Hybrid Energy System: Power Generation from Renewable Sources for Coastal areas in Bangladesh" submitted by

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4. Pritom Biswas (18321007)

of Summer, 2022 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering on 01/09/2022.

Examining Committee:

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Ethics Statement

All the studies and works in our project have been voluntarily done by us. Besides, all the resources and data used in the project have been taken from authentic sources and carefully cited. We have carefully avoided any kind of copying or plagiarism. Also, no payment was made to any person who was directly or indirectly in our project. Our goal was to make the maximum benefit for mankind, so we took great care on minimizing any sort of environmental issue.

Abstract/ Executive Summary

Bangladesh has always trouble producing enough electricity to meet the demand which is a major hindrance to the development process. The whole world is facing the crisis of fossil fuels as well as Bangladesh. To reduce the dependency on these fossil fuels, we proposed a hybrid renewable energy system for the coastal areas of Bangladesh, specially Kuakata. We determined the most optimized solution among the multiple designs which is solar-wind hybrid system using HOMER software. Then we build a prototype of the solar wind hybrid system using Arduino microcontroller. The wind turbine is modelled using induction motor to generate AC electricity. The two batteries are used to store the electricity and supply to the small loads. The renewable hybrid system reduces dependency to the grid electricity and it also reduces the environment pollution.

Keywords: HOMER; Hybrid System; Solar System, Wind Turbine, Renewable Energy

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NPC	Net present cost
O&M	Operations and Maintenance
LCOE	Levelized Cost of Energy
IRR	Internal Rate of Return
ROI	Return on Investment

Chapter 1

Introduction

1.1 Introduction

1.1.1 Problem Statement

Bangladesh uses electricity more frequently than any other country, but it has always had trouble producing enough of it to keep up with demand. Bangladesh's power industry is heavily reliant on fossil fuels because the nation primarily generates electricity from coal and natural gas. In Bangladesh, natural gas accounts for about 62.9% of the electricity generated, with diesel accounting for 10%, coal for 5%, heavy oil for 3%, and renewable energy for 3.3%. [1]. It is not an issue for recent days from 1971 Bangladesh is facing this same problem. According to a recent analysis, the United States will have enough coal, natural gas, and oil starting in 2016 for 114, 52, and 50 years respectively [2]. So, if we do not save natural resources and start using renewable sources we will run out of our stocks. However, electricity generation by utilizing renewable energy such as PV cells, wind turbines, biomass energy has increased rapidly in recent years. Our project presents a hybrid Power system that harnesses two renewable energies to generate electricity. Here our system control relies mainly on microcontrollers. When compared to each unique mode of generation, it ensures the best use of resources and hence increases efficiency. Also, it also reduces the dependence on one single source as we are using a hybrid renewable system. Composition of two renewable energies can minimize each other's side effects and can produce uninterrupted electricity. This hybrid power generating system is suitable for industries and also domestic coastal areas. We have a similar hybrid system in Bangladesh using solar cells and wind turbines on the island of St. Martin. [3]. Since it is an island and 9 kilometers south of our Bay of Bengal, it is impossible to produce power using the national grid there.[3]. Comparing this system to diesel generators can cut carbon emissions by 14 tons annually [4]. One wind turbine can generate 3 kW of power per day and 8 kW of power from solar PV in a day [3]. Bangladesh may also be able to generate 100 Megawatts of hybrid power from coastal locations, according to surveys [5].

1.1.2 Background Study

Our project presents a hybrid Power system that harnesses two renewable energies to generate electricity. As our project will be designed for coastal areas, we are considering Kuakata situated in Kalapara Upazila in Patuakhali district. It is a coastal place as the famous Kuakata beach is situated there named “Sagor Konna”. On the other hand, our system will not be connected to the grid. Actually, after having a national grid system in Kuakata dwellers suffer from 10 to 12 times of load shedding per day and sometimes that load shedding occurs 10 hours also which increase dwellers sufferings. Our project will try to reduce the load shedding by providing some households with renewable energy. For our project we are considering 280 households and our project will produce power for those households. For 1 household we are considering 1 refrigerator, 1 LED TV, 5 LED lights, 3 fans, 1 water motor and other loads such as mobile, battery charges and miscellaneous. Besides, we have assumed that the refrigerator and fans will be on all day long as well as LED lights will be on in the evening to 12 AM. Moreover, the water motor will activate for 1 hour each day. Here power consumptions of each load are being discussed:

Appliances	Quantity/Household	Unit (KWh)	Power (KWh)
Refrigerator	1	80	80
LED Light (20 watt)	5	20	100
Fan	3	60	180
LED TV	1	17	17
Motor	1	250	250
Others	2	20	40

Table 1: Power Consumption Data for Each Appliance

Load profile

TIME(Hour)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Load (KW)	72.8	72.8	72.8	72.8	72.8	72.8	72.84	72.8	72.8	72.	142.8	84	72.8	105.56	100.8	100.8	100.8	100.8	100.8	100.8	100.8	100.8	100.8	100.8

Figure 1: Hourly Load Consumption at Kuakata (data taken from HOMER software)

Here, peak load is 17.41 kW peak and average consumption is 165.59 kWh/day.

Now, this is our load of Homer Software:

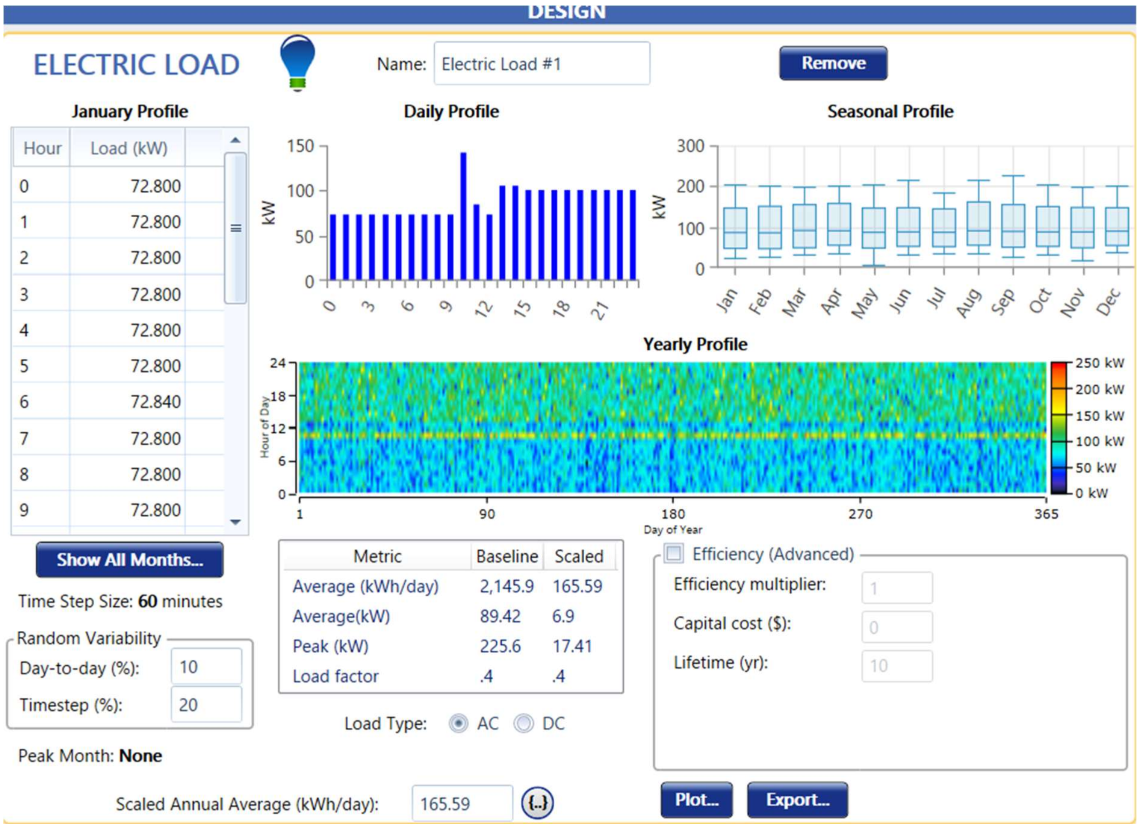

Figure 2: Load Profile at Kuakata by Homer Pro

Renewable resources at selected location:

This resource information is taken from Homer Software by selecting the location of Kuakata. Wind and solar information were default in Homer software but Biomass and Hydro stream flow information were taken from other websites.

Solar radiation:

Month	Clearness Index	Daily Radiation (kWh/m/day)
Jan	0.559	4.034
Feb	0.537	4.434
Mar	0.526	5.001
Apr	0.491	5.146
May	0.466	5.108
Jun	0.361	4.003
Jul	0.320	3.511
Aug	0.361	3.829
Sep	0.387	3.793
Oct	0.500	4.292
Nov	0.559	4.149
Dec	0.585	4.016

Table 2: Available Solar Radiation for Each Month (HOMER software)

Resources of Homer Software:

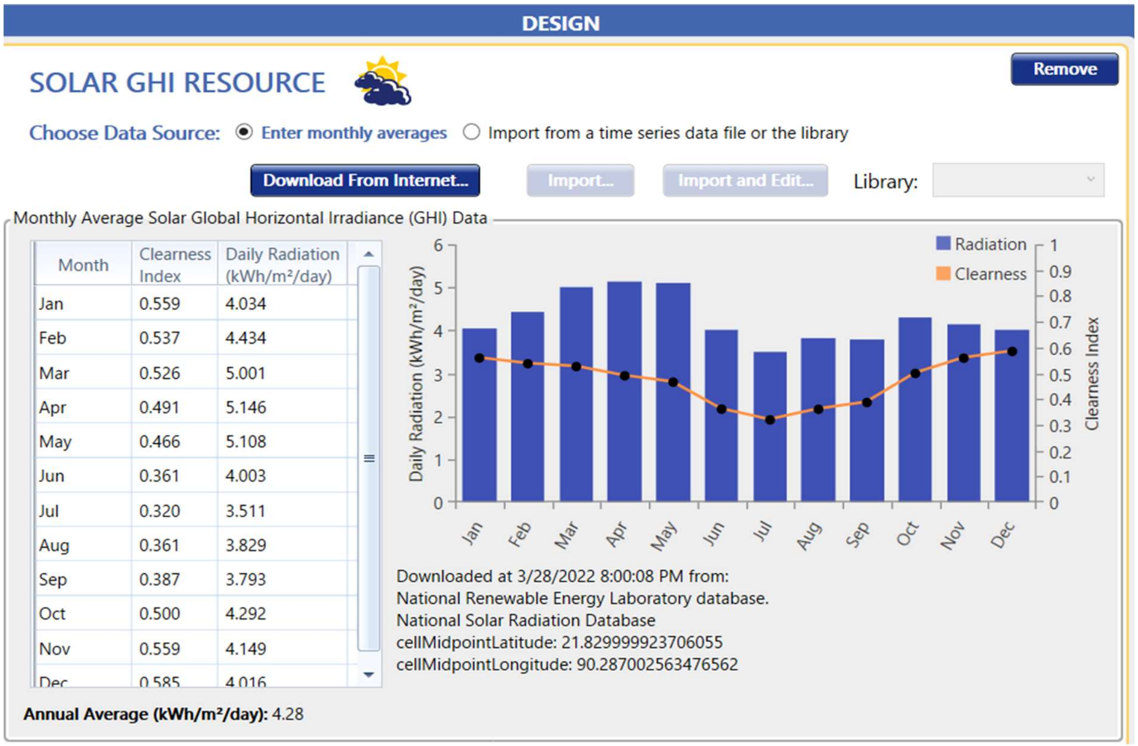

Figure 3: Solar Irradiation Data

Wind speed information

Month	Average wind speed (m/s)
Jan	3.820
Feb	3.800
Mar	4.750
Apr	5.510
May	5.850
Jun	7.090
Jul	7.340
Aug	6.510
Sep	5.170
Oct	3.920
Nov	3.640
Dec	3.630

Table 3: Available Wind Speed for Every Month (HOMER software)

Here, resources of wind speed of homer software:

Figure 4: Available Wind Speed

Hydro resources:

Month	Stream flow (L/s)
Jan	438.590
Feb	382.500
Mar	510.000
Apr	892.200
May	1,275.000
Jun	1,540.000
Jul	1,785.000
Aug	1,030.000
Sep	765.000
Oct	1,275.000
Nov	508.000
Dec	676.300

Table 4: Available Stream Flow for Each Month [6]

Here, hydro resources of Homer software of stream flow:

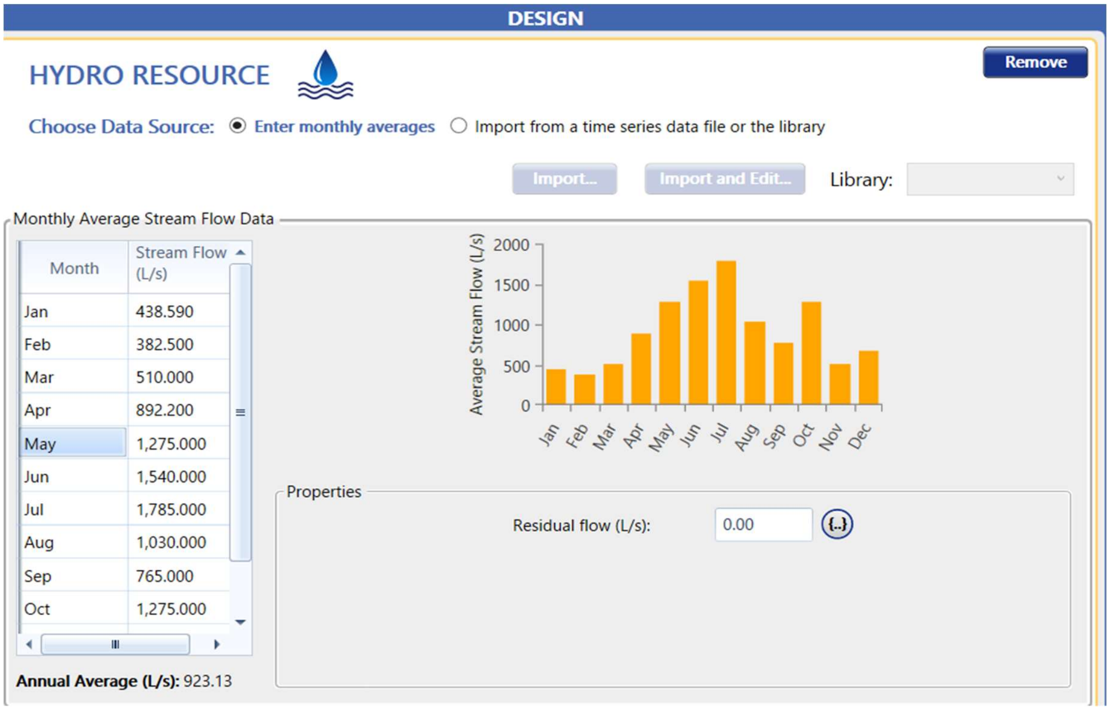

Figure 5: Available Streamflow at Payra River

<u>Biomass resources:</u>

Month	Available Biomass (tones/day)
Jan	1.400
Feb	1.700
Mar	1.400
Apr	1.400
May	1.400
Jun	1.700
Jul	1.700
Aug	1.400
Sep	1.400
Oct	1.400
Nov	1.700
Dec	2.200

Table 5: Available Biomass Resource for Each Month [7]

Here, homer resources of biomass:

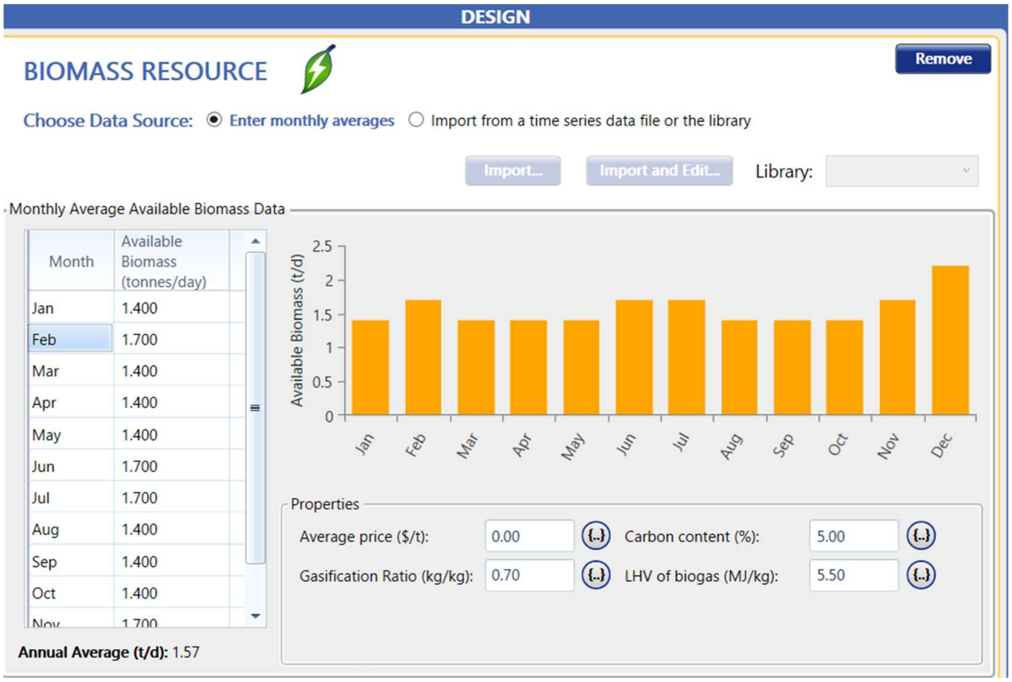

Figure 6: Available Biomass Resource

Solar and wind energy is regarded as the most plentiful and potential sources of renewable energy.

Year	Solar (MW)	Wind (MW)	Hydro (MW)	Biomass (MW)	Biogas (MW)	Others (Tidal, Wave)	Total (MW)
Until 2018	350	2.9	230	0	1.08	0	583.98
2019	84	0	0	0	1	0	85
2020	100	38	0	0	2	0	140
2021	120	80	0	15	3	0	218
2022	150	120	0	15	4	0	289
2023	165	170	0	15	4	0	354

2024	165	170	0	15	4	0	354
2025	165	170	0	15	4	2	356
2026	165	170	0	15	4	4	358
2027	165	170	0	15	4	6	360
2028	165	170	0	15	4	8	362
2029	165	170	0	15	5	10	365
2030	165	170	0	15	5	10	365
Total	2124	1600.9	230	150	45.08	40	4189.98

Table 6: Government's year-wise target of electricity production from different renewable energy sources [8]

1.1.3 Literature Gap:

While performing the background research we faced some difficulty to find some data. For example, we could not find recent year data of biomass and water resources, so we had to use the data from 2015. Bangladesh produces 3.3% of its electricity from renewable energy using different power plants [9]. But there is no such source to know about the installment cost of a plant. That is why we had to use default Homer Software values. Basically, in hydro power plants the data of stream flow was not available properly. The neap tide values and the stream tide values were not available on Liter per second values and for that we had to convert values.

1.1.4 Relevance to current and future Industry:

The renewable energy sector is rapidly expanding in Bangladesh. Bangladesh depends on natural resources, yet there are not enough of them. For this reason, the government prefers to produce electricity using renewable sources of energy. The Ministry of Power, Energy, and Mineral Resources announced their policy guidelines in 2008, which marked the beginning of Bangladesh's journey toward renewable energy policy [10]. According to the policy, by 2041, about 40GW of electricity will be generated from renewable sources [11]. Bangladesh is a country with a high population density, which leads to an overcapacity issue. Because of this reason our government has to pay a high price as a result of this. In contrast, renewable sources are portable, affordable, and simple to use in both on- and off-grid systems. It is completely clean energy and has thousands of environmental benefits. Bangladesh generates 3% from renewable sources and hydroelectric power produces 60%, solar 39.5% and wind energy produces 0.5% in 2019 [9]. To sum up, Bangladesh has a huge potential for renewable sources. Using renewable energy can make drastic changes to our country.

1.2 Objectives, Requirements, Specification and Constraints

1.2.1. Objectives:

The main objective of the project is to implement a power system that is a hybrid of both Photovoltaic and wind powers. The step-by-step objectives are:

- To study the characteristic curves and effect of variation of environmental conditions like temperature and irradiation on them
- To study different renewable energy sources in Bangladesh and their comparison in terms of progressiveness.
- To simulate the renewable power system and track its maximum power point.
- Implement a hybrid system.

1.2.2 Functional and Nonfunctional Requirements:

Functional

- The system must store energy in the battery from both the solar cell and wind turbine.
- The system must be a smart system which can observe the charging and discharging status of the battery. According to the status, it must regulate the direction of power from the producing end to the batteries and load.
- The system must have an inverter connected so that energy stored in the battery can be drawn by the DC loads as well as AC loads.

Non-functional

- The system will invert the solar and wind power into grid power and then it will be connected to the grid system.

- The system will have an additional battery for backup purposes. When the load will be more than the normal and the main battery voltage becomes low, then the power supply will be turned off from the main battery. Then the smart system will look whether the alternative battery can supply the power to the load or not. If the alternative battery meets the demand, then the power supply will automatically resume.

1.2.2 Specifications:

System specification	Sub-System	Requirements	Components	Components Specifications	Comment
Photovoltaic-wind hybrid system	Solar System	Microprocessor for controlling the power system	Arduino Uno	• ATmega328P • Operating Voltage: 5V • Input Voltage: 7-12V • SRAM: 2 KB • Frequency: 16 MHz	Used to control the whole hybrid power system7
		Display	16 x 2 LCD Display	• Minimum logic Voltage: 4.5 V • Minimum logic Voltage: 5.5 V	Used to show charging, discharging and voltage level status

				• Supply Current: 2mA	
		Voltage Measurement	Voltage Sensor Module DC 0-25V	• Voltage input range: DC 0-25V • Voltage detection range: DC 0.02445V-25V • Voltage Analog Resolution: 0.00489V	Used to detect AC or DC voltage level
		Photovoltaic Cell	Solar Panel 90*90mm	Polycrystalline silicon Max work voltage:5V Max work current: 200ma Dimension: 90mm×90mmx3mm	Used to generate electricity from sunlight
	Wind System	Wind Turbine	Induction Motor	• Three phase induction motor	Used to convert mechanical energy to

					electrical energy
		AC-DC Converter	Bridge Rectifier	• Single phase bridge	Used to convert the ac voltage of wind turbine to dc voltage
		Step-up Voltage	Boost Converter	• Input Voltage: 10V – 30V DC • Output Voltage: 12V – 35V DC • Output Current: 10A MAX	Used to increase the voltage level
	Storage and Supply System	Battery		• Voltage: 12 V • Capacity: 8.5 Ah	Used to store the hybrid energy
		Switch	4 Channel 5V Relay Module	• 15-20mA Driver Current • AC250V 10A; DC30V 10A	Used to ON/OFF when necessary while current is flowing

		DC-AC Converter	Inverter	• DC 12V to AC 220V	Used to convert the DC to AC voltage

Table 7: Components Specifications

This specification is required for prototype projects. As we are implementing a prototype one for hardware.

1.2.3 Technical and Non-technical consideration and constraint in design process:

With any project, there are limitations and risks that need to be addressed to ensure the project's ultimate success. During the duration of our project, we addressed the following non-technical constraints.

Time: We had one year or 3 semesters to complete our final year design project. In this duration we had to make a proper report of our project, make a suitable circuit simulation of the multiple approaches and final design of our optimal solution. We completed our project by using our project planning skill and perfect utilization of time.

Cost: At the very semester of FYDP, we made an estimated budget, but because of the current world economic situation, the price of every component was raised. So, it took a little more price to complete our project than we estimated before.

Technical Constraints: There were some technical constraints that we had to ensure. Those are as follows:

PCB design: We wanted to design a PCB, which will minimize the size of our project and make it more presentable. But as we are using AC voltage and some modules, the PCB could not support it. So, we decided to avoid designing a PCB.

<u>Induction motor:</u> We are using an induction motor as an induction generator to model the wind turbine for our project. As this is too costly and unavailable in the market, we were allowed to use it from the machine laboratory. While using this, we had so many limitations, such as we could not use higher capacitive load from the capacitor bank, as it supplies high current which can burn the rotor coil. We followed these limitations since we did not want to harm our university's assets.

1.2.4 Applicable compliance, standards, and codes:

PV modules imported into the nation must adhere to International Electrotechnical Commission standards IEC 61215:2016, IEC 60904-1:2013, and IEC 60904-9:2013, according to the Sustainable and Renewable Energy Development Authority (SREDA). Batteries and charge controllers must meet the standards of IEC 61427-1:2016, and IEC 61400 must meet the requirements for wind turbines [12].

- The design certification and type approval requirements for terrestrial photovoltaic (PV) modules suited for long-term operation are outlined in IEC 61215-1:2019. This standard is meant to be applicable to all terrestrial flat plate module types, including thin-film and crystalline silicon modules. This test sequence's goal is to ascertain the module's electrical and thermal properties and, to the extent practicable within realistic time and cost restrictions, to demonstrate that the module is capable of withstanding lengthy exposure in the climates specified in the scope.[12]
- Procedures for measuring the current-voltage characteristics (I-V curves) of photovoltaic (PV) devices in actual or simulated sunlight are outlined in IEC 60904-1:2013. These steps can be used with a single solar cell, a group of solar cells, or a PV module.[12]

- Essential design specifications are outlined in IEC 61400-1:2019 to guarantee the structural integrity of wind turbines. Its goal is to offer an adequate level of protection against harm from all threats for the duration of the anticipated lifetime. This paper covers every component of a wind turbine, including the support structures, internal electrical systems, mechanical systems, and control and protection mechanisms. Any size of wind turbine can use this material. IEC 61400-2 can be used for small wind turbines.[13]
- IEC 61427-1:2013 is a component of a series that provides general information about the specifications for secondary batteries used in photovoltaic energy systems (PVES) and about the common test procedures used to confirm battery performance. Cells and batteries used in photovoltaic off-grid applications are the subject of this section. It is possible to use this standard with all secondary batteries. [12]

1.3 Systematic Overview/summary of the proposed project

For Bangladesh shortage of electricity is a massive problem. Besides, for electricity Bangladesh is dependent on fossil fuels and the reserves of fossil fuels are limited. That is why we have proposed a system of power generation of hybrid of two renewable sources. It will reduce the dependency on fossil fuels and also reduce the environment pollution. This is where our hybrid renewable system is used. Bangladesh has adequate solar radiation and coastal areas of Bangladesh have enough wind speed which is sufficient for generating power. Our system will produce power for coastal areas where we have sufficient solar energy and wind resources. This will reduce dependency on fossil fuels and reduce some pressure on the grid system. As Bangladesh is suffering from severe load shedding nowadays, our hybrid power generation system will decrease some of that.

As this project is designed for coastal areas, we have decided to consider Kuakata for our power generation work. We have considered some load profiles of 280 households in the Kuakata area and calculated the estimated load and peak load. On the other hand, our project is dependent on renewable energy so we had 3 multiple design approaches which is PV- Biomass system, PV- Hydro system and PV-Wind system. Here we have done some background information analysis from Homer Software. We have gathered some information about the solar, biomass, wind and hydro resources of Bangladesh. The Bangladesh government is also trying to develop power plants using renewable sources.

1.4 Conclusion

To sum up, Bangladesh has adequate solar radiation and coastal areas have wind speed sufficient for generating power. Our system will produce power for coastal areas where we have sufficient solar energy and wind resources. This will reduce dependency on fossil fuels and reduce some pressure on the grid system

Chapter 2

Project Design Approach

2.1 Introduction

Our goal is to design a hybrid renewable power generation system, so that we can reduce the dependency on fossil fuels to generate electricity. There are different types of renewable sources such as solar, wind, biomass, hydropower, nuclear energy, thermal energy etc. But considering Bangladesh's context we selected Solar along with Wind, Biomass or Hydropower since these sources are very much available in our country as well as cost efficient and easy to maintain for our country.

2.2 Identify multiple design approach

2.2.1 Photovoltaic Hydropower hybrid system:

Bangladesh could produce 230 MW of electricity using the hydropower system from Kaptai Dam using this technology, which combines solar energy with moving water like rivers [14]. The main problem, however, is that it can create flooding and destroy a lot of people's land, as happened with the Kaptai Dam as well [15]. Following the construction of the Kaptai Dam in the 1960s, the Karnaphuli River's waters permanently drowned Chakma Raja's home, turning it into the "river of tears" [15].

2.2.2 Photovoltaic Biomass Hybrid System:

Along with animal and household waste, agricultural waste also contributes a sizable amount of biomass resources, which explains the nation's enormous potential for biomass [16]. A hybrid system that incorporates solar power could be another way to provide electricity, but it would produce relatively little and fall short of our country's needs. According to a recent survey, Bangladesh could only produce 5 MW of electricity from biomass in 2018 [16].

2.2.3 Photovoltaic Wind Hybrid System:

The Sitakunda wind and solar energy resources have demonstrated that an optimized wind-PV-battery can meet the local community's electricity needs with a COE of USD 0.363/kWh, which is exceptionally efficient and environmentally friendly and outperforms all other alternative methods [17]. At Feni and Kutubdia, there are currently 2 MW of installed wind turbines [16]. As a result, it is clear that the Photovoltaic Biomass Hybrid System is environmentally friendly and has a higher electricity production capacity than the competition. Because of this, the Photovoltaic Biomass Hybrid System is the foundation of our project concept.

2.3 Describe multiple design approach

To achieve our desired goal, we have considered three different approaches. The alternatives are: Solar-Wind Hybrid System, Solar-Hydro Hybrid System and Solar-Biomass Hybrid System. We have taken solar radiation as our primary energy source since sun beams are easily available in our country. The three alternative designs are explained below:

2.3.1 PV-Wind Hybrid System:

The combination of renewable energy sources, wind & solar are used for generating power called a wind solar hybrid system. This system is designed using solar panels and small wind turbine generators for generating electricity. Solar power system can be defined as the system that uses solar energy for power generation with solar panels. The solar power system consists of three major blocks namely solar panels, solar photovoltaic cells, and batteries for storing energy. The electrical energy (DC power) generated using solar panels can be stored in batteries or can be used for supplying DC loads or can be used for inverters to feed AC loads.

Wind energy is also one of the renewable energy resources that can be used for generating electrical energy with wind turbines coupled with generators. Wind turbine can be defined as a fan consisting of 2 or 3 blades that rotate due to blowing wind such that the axis of rotation must be aligned with the direction of blowing wind. Wind aero-generator is installed on a tower having a minimum height of 18 meters. from the ground level. Because of the height, the aero-generator gets wind at higher speed and thereby generates more power. There are different types of wind turbines, but the frequently used wind turbines are horizontal axis turbines and vertical axis turbines.

Wind and solar energy are complementary to each other, which makes the system generate electricity almost throughout the year. The main components of the Wind Solar Hybrid System are wind aero generator and tower, solar photovoltaic panels, batteries, cables, charge controller and inverter. The Wind - Solar Hybrid System generates electricity that can be used for charging batteries and with the use of an inverter we can run AC appliances.

We have also used a diesel generator in case of power failure for bad weather conditions. Model name of the solar panel is Canadian Solar MaxPower (CS6X-325P) and the wind turbine is Bergey Excel 10 (XL10).

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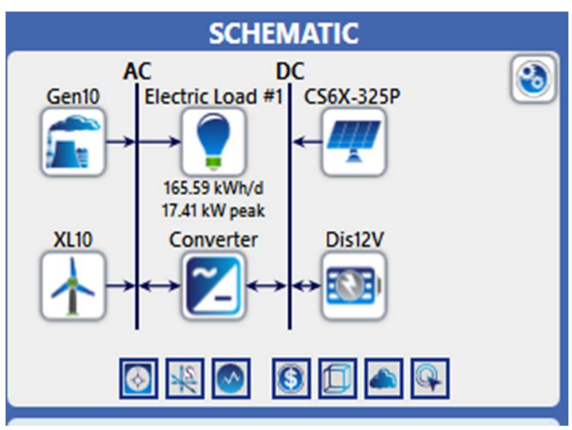


Figure 7: PV-Wind Hybrid Power Plant

2.3.2 PV-Hydro Hybrid System:

For this design, we will use solar panels along with a micro hydro plant to collect natural renewable resources.

The hydroelectric power plant is a producer of renewable energy that is pollution-free and environmentally friendly. The plant converts the kinetic energy of water to produce mechanical energy in the form of a hydro turbine spin, which is then used to turn a generator to produce electrical energy. Micro-hydropower has a scale power lower than 100 kW. The condition of the hydro that can be utilized as an electricity-producing resource is that it has a particular flow and height capacity because electricity generated by micro-hydropower is also very dependent on the height of the waterfall and hydro discharge. The higher the flow capacity and height from the installation, the higher the electrical energy that can be generated.

We have also used a diesel generator in case of power failure for bad weather conditions. Model name of the solar panel is Canadian Solar MaxPower (CS6X-325P) and a 5KW generic Micro Hydro power plant.

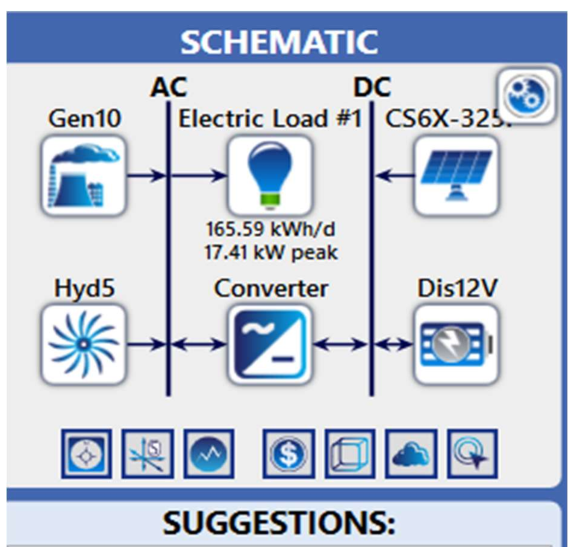


Figure 8: PV-Hydro Hybrid Power Plant

2.3.3 PV-Biomass Hybrid System:

For this design, we will use solar panels along with a Biomass plant to collect natural renewable resources.

Biomass power is electricity generated from renewable organic waste that would otherwise be dumped in landfills, openly burned or left in the woods as fodder for forest fires. In Biomass power plants, wood waste or other waste is burned to produce steam that runs a turbine to make electricity.

We have used batteries to store the energy. We have also used a diesel generator in case of power failure if sufficient biomass is not produced. Model name of the solar panel is Canadian Solar MaxPower (CS6X-325P) and a 500 KW generic biomass power plant.

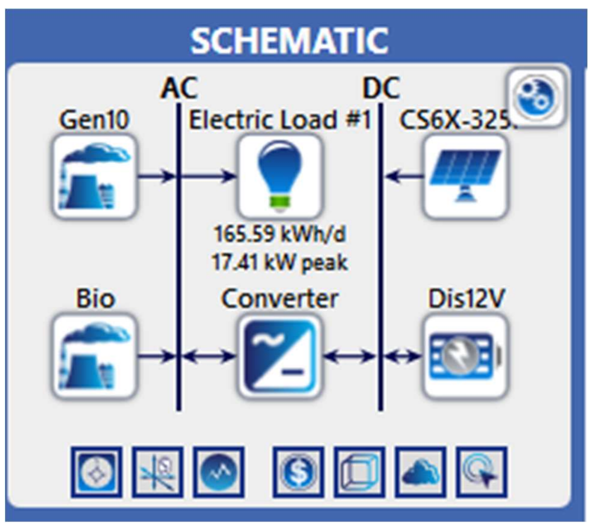


Figure 9: PV-Biomass Hybrid Power Plant

2.4 Conclusion

In this section, we have designed 3 different approaches for our project in homer pro software. After doing a proper background research we came to the conclusion that these 3 approaches are the best suitable solution for our country.

Chapter 3

Use of Modern Engineering and IT Tool

3.1 Introduction

For software implementation we have used HOMER Pro, PVsysts and Proteus 8.9 Professional. Homer is for the actual implementation of our project which will be implemented on our desired location. We have used this software for calculating the optimum solution and overall cost of the project. Here we have come to a conclusion that PV Wind hybrid power generation is the most optimal solution and most cost effective. Proteus 8.9 professional was for the simulation of our prototype project and PVsysts was for sizing the PV array.

For hardware implementation we have used Arduino Uno, 4 channel relay, voltage sensor, boost converter, inverter LCD display and solar panel. These components together are able to generate our desired output. But for the wind turbine part we could not use the actual wind turbine because it was very expensive. for the wind turbine part, we have used a induction motor.

3.2 Select appropriate engineering and IT tools:

3.2.1 IT tools

i) Homer Pro MicroGrid Analysis Tool 3.14.5 evaluation edition

ii) Proteus 8.9 Professional

iii) PVsysts

3.2.2 Engineering Tool

i) Arduino Uno

ii) 4 Channel Relay

iii) Voltage Sensor

iv) Boost Converter

v) Inverter

vi) LCD display

vii) Solar panel

viii) Voltage regulator

xi) Induction Motor

3.3 Use of modern engineering and IT tools

3.3.1 IT tools

For simulation and analysis of our design we have use the following simulation softwires:

I. **Homer Pro Microgrid Analysis Tool 3.14.5 evaluation edition**- This software is very much useful for analyzing renewable energy-based projects. We used it to get a complete idea of load consumption at our selected location. Also, this software gives us the data of available resources for our project. After completing the simulation, we can have a clear idea of capital cost, maintenance expenses, number of PV panels, wind turbine or batteries needed etc. Besides, Homer software provides us with the optimum solution of all the multiple design approaches. It also tells us how much electricity can be produced on our suggested multiple design approaches if excess electricity is produced Homer explains that also.

Figure 10: Homer Pro Software

II. **Proteus 8.9 Professional:** We are actually implementing a prototype of our project because wind turbines are very expensive and it is not possible for us to produce a huge project on a small budget. For the prototype project we are using ARDUINO Uno, Relay, Inverter, PV cells and other components. It is easier for us to use Arduino Uno in Proteus Software. We need to code for Arduino Uno in Arduino IDE software and paste that code into proteus software. We found an easier way to implement our project. So, we used Proteus Software.

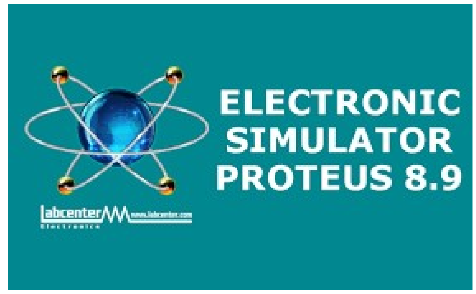


Figure 11: Proteus 8.9 Professional

III. **PVsysts**: This software is used for only photovoltaic parts. This software mainly calculates how many areas we need to implement our all-PV cells. This helps for sizing PV cells.

Figure 12: PVsyst Software

3.3.2 Engineering Tools:

I. **Arduino Uno:** Arduino uno is basically a microcontroller based on ATMEGA328P. It is an important board for electronic projects. It has 14 input/ output pins which we can connect with a breadboard. In our project the Arduino is basically the heart of our project. Internal decisions whether solar will be on or wind turbine or battery everything is controlled by Arduino Uno. It mainly connects all components and helps to do every component's job by coding. Even which readings will be shown in LCD is coded by Arduino. Basically, we can code anything according to our necessity in Arduino Uno.

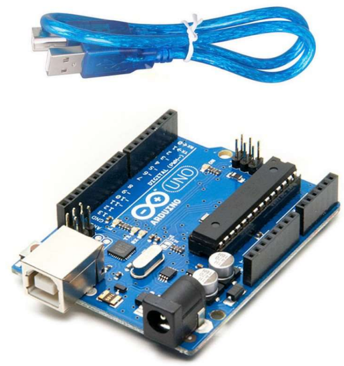


Figure 13: Arduino Uno R3

II. **4-Channel Relays:** 4 channel relay is an electrical switch which can be turned on or off when current is flowing and can be controlled by a microcontroller as we used Arduino Uno. It has 4 channels and must be powered on by 5 V of Arduino. Our project has 4 parts. Solar, wind, backup battery and main battery and for that reason we have 4 relays. For example, when the generation voltage of solar is greater than threshold voltage the relay will be on and the battery will be charged. On the other hand, with solar when voltage is produced from wind energy and that voltage is greater than the threshold voltage another relay of the wind turbine will be powered on. Besides, when solar and wind both sources are not

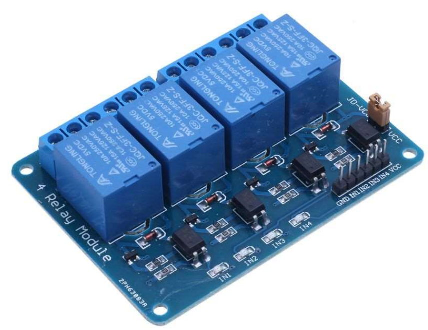


Figure 14: 4-channel relay

generating threshold voltages the relay and solar will be turned off and the relay of the battery will be turned on. Without a 4-channel relay we would not be able to charge the battery according to our availability of sources.

III. **Voltage sensor:** voltage sensor is a sensor which can control the voltages and can detect DC or AC voltages. It basically acts like a multimeter for our project. It mainly measures voltage of individual sources and shows it to 7 segment displays. For that reason, we can know how much voltage is being generated through each source.

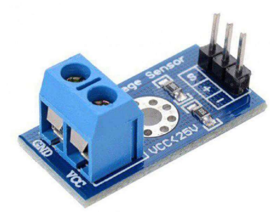


Figure 15: Voltage Sensor

IV. **Boost converter:** Boost converter is a DC-to-DC converter which can increase voltage of output. The principle of boost converter works like a step-up transformer. We will connect the converter to the wind turbine part. We cannot produce our desired threshold voltage through a wind turbine so we connect a DC-to-DC converter which can step up the voltage as per our necessity.

V. **Inverter:** Inverter is a device which transforms AC current into DC current. The current we will produce with these renewable sources is DC current. But the load that we are conducting will be AC load such as LED, phone charger etc. For that reason, we need to invert the DC voltage to AC one before using it for daily appliances.

Figure 16: Inverter

VI. **LCD Display:** As an LCD display, we have used a 16x2 LCD display. Main purpose of an LCD display is to show to everyone which source will be turned on and how much voltage is producing it. For example, solar and wind both are on and they are generating 13V. So, the LCD voltage will display solar and wind are turned on and display that 13V. Because of the LCD display we can know which source is on as well as how much voltage it is generating.

Figure 17: LCD Display

VII. **Solar panel:** We are going to use solar energy for producing electricity. For that reason, we badly need a solar panel or PV panel. Solar panel takes energy from the sun and produces voltage from it. For utilizing renewable energy from the sun, we need solar panels.

Figure 18: Solar Panel

VIII. **Adjustable Voltage regulator (LM 317)**: Our wind turbine part produces AC voltage. So here we used a bridge rectifier to generate that AC voltage into DC voltage. But this conversion creates a ripple on DC voltage which we do not expect. That is why a 12 V voltage regulator is used to produce ripple voltage to perfect 12V DC voltage

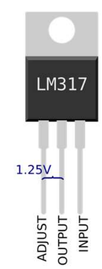


Figure 19: LM317

IX. **Induction motor (as Induction generator)**: To model the wind turbine we are using an induction motor as an induction generator also, a DC motor as a prime mover. The induction generator will supply AC voltage after rotating it over the synchronous speed.

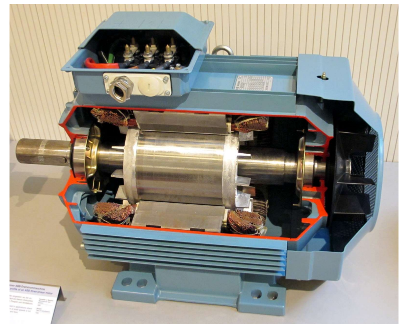


Figure 20: Induction Motor

3.4 Conclusion

Both modern IT tools and modern engineering tools have led us to desired output. For multiple designs we have decided 3 options and Homer software guided us to choose the most optimal one. After that we did a software simulation to see the result. And now engineering tools are used for hardware implementation. We have designed this project for coastal areas and we will make a prototype of this.

Chapter 4

Optimization of Multiple Design and Finding the Optimal Solution

4.1 Introduction

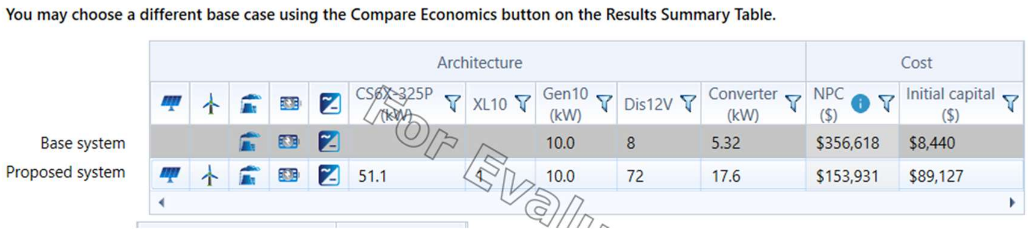
To achieve our desired goal, we have considered three different solutions. The alternative solutions are: Solar-Wind Hybrid System, Solar-Hydro Hybrid System and Solar-Biomass Hybrid System. In every design, we have taken solar radiation as our primary energy source because sun lights are easily available everywhere in our country. In order to optimize multiple designs and find optimal solutions, we used Homer Pro MicroGrid Analysis Tool. It is used for analyzing renewable energy-based projects. We can have a clear visualization of capital cost, maintenance expenses, number of PV panels, wind turbine or batteries needed etc. in the alternative solutions. Moreover, it provides us with the optimum solution of all the multiple design approaches.

4.2 Optimization of multiple design approach

4.2.1 PV-Wind Hybrid System

Component	Capital($)	Replacement($)	O&M($)	Fuel($)	Salvage($)	Total($)
Bergey Excel 10	$25,000.00	$1,594.04	$258.55	$0.00	-$898.34	$25,954.25
CanadianSolar MaxPower CS6X-325P	$29,078.81	$0.00	$10,159.91	$0.00	$0.00	$39,238.73
Discover 12VRE-3000TF	$29,520.00	$28,335.16	$9,307.81	$0.00	-$1,437.07	$65,725.91
Generic 10kW Fixed Capacity Genset	$5,000.00	$0.00	$2,218.36	$15,139.83	-$55.90	$22,302.30
System Converter	$527.93	$223.99	$0.00	$0.00	-$42.16	$709.76
System	$89,126.75	$30,153.19	$21,944.64	$15,139.83	-$2,433.46	$153,930.94

Table 8: PV-Wind Hybrid System Cost Summary


You may choose a different base case using the Compare Economics button on the Results Summary Table.

	Architecture					Cost	
	CS6X-325P (kW)	XL10	Gen10 (kW)	Dis12V	Converter (kW)	NPC ($)	Initial capital ($)
Base system			10.0	8	5.32	$356,618	$8,440
Proposed system	51.1	1	10.0	72	17.6	$153,931	$89,127

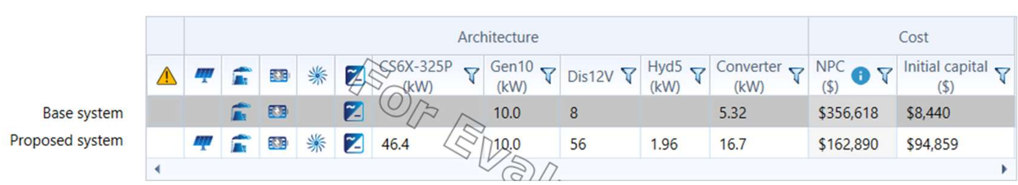
Figure 21: PV-Wind Hybrid System Economic Comparison

For the optimized PV-Wind hybrid system, there will be 51 CanadianSolar MaxPower solar panels required. It will cost around 39 thousand dollars. Then we will need a Bergey Excel 10 wind turbine and 72 numbers of Discover 12VRE-3000TF batteries to store the energy. Also, we will use a Generic 10 kW fixed capacity genset generator for backup purposes which will cost around 22 thousand dollars including the fuel cost. Finally, we need a system converter to supply electricity to the AC loads. This whole optimized proposed system requires approximately 153 thousand dollars to meet the required demand.

4.2.2 PV-Hydro Hybrid System

Component	Capital($)	Replacement($)	O&M($)	Fuel($)	Salvage($)	Total($)
5kW Generic	$40,000.00	$0.00	$15,513.02	$0.00	$0.00	$55,513.02
CanadianSolar MaxPower CS6X-325P	$26,398.55	$0.00	$9,223.45	$0.00	$0.00	$35,622.00
Discover 12VRE-3000TF	$22,960.00	$22,248.91	$7,239.41	$0.00	-$906.89	$51,541.43
Generic 10kW Fixed Capacity Genset	$5,000.00	$0.00	$1,970.15	$12,753.91	-$183.66	$19,540.40
System Converter	$500.65	$212.41	$0.00	$0.00	-$39.98	$673.09
System	$94,859.20	$22,461.32	$33,946.03	$12,753.91	-$1,130.53	$162,889.94

Table 9: PV-Hydro Hybrid System Cost Summary



	Architecture					Cost	
	CS6X-325P (kW)	Gen10 (kW)	Dis12V	Hyd5 (kW)	Converter (kW)	NPC ($)	Initial capital ($)
Base system		10.0	8		5.32	$356,618	$8,440
Proposed system	46.4	10.0	56	1.96	16.7	$162,890	$94,859

Figure 22: PV-Hydro Hybrid System Economic Comparison

For the optimized PV-Hydro hybrid system, there will be 47 CanadianSolar MaxPower solar panels required. It will cost around 36 thousand dollars. Then we will need a 5kW Generic hydro power plant and 56 numbers of Discover 12VRE-3000TF batteries to store the energy. Also, we will use a Generic 10 kW fixed capacity genset generator for backup purposes which will cost around 19.5 thousand dollars including the fuel cost. Finally, we need a system converter to supply electricity to the AC loads. This whole optimized proposed system requires approximately 163 thousand dollars to meet the required demand.

4.2.3 PV-Biomass Hybrid System

Component	Capital($)	Replacement($)	O&M($)	Fuel($)	Salvage($)	Total($)
CanadianSolar MaxPower CS6X-325P	$44,666.06	$0.00	$15,605.98	$0.00	$0.00	$60,272.04
Discover 12VRE-3000TF	$39,360.00	$36,320.72	$12,410.42	$0.00	-$3,319.70	$84,771.44
Generic 10kW Fixed Capacity Genset	$5,000.00	$0.00	$1,752.97	$12,064.11	-$295.45	$18,521.62
Generic 500kW Biogas Genset	$1,500,000.00	$0.00	$2,714.78	$0.00	-$148,413.57	$1,354,301.20
System Converter	$764.38	$324.31	$0.00	$0.00	-$61.04	$1,027.65
System	$1,589,790.45	$36,645.03	$32,484.14	$12,064.11	-$152,089.76	$1,518,893.96

Table 10: PV-Biomass Hybrid System Cost Summary

	Architecture					Cost	
	CS6X-325P (kW)	Gen10 (kW)	Bio (kW)	Dis12V	Converter (kW)	NPC ($)	Initial capital ($)
Base system		10.0		8	5.32	$356,618	$8,440
Proposed system	78.5	10.0	500	96	25.5	$1.52M	$1.59M

Figure 23: PV-Biomass Hybrid System Economic Comparison

For the optimized PV-Biomass hybrid system, there will be 79 CanadianSolar MaxPower solar panels required. It will cost around 60 thousand dollars. Then we will need a Generic 500 kW Biogas Genset which will cost 1.3 million dollars and 96 numbers of Discover 12VRE-3000TF batteries to store the energy. Also, we will use a Generic 10 kW fixed capacity genset generator for backup purposes which will cost around 18.5 thousand dollars including the fuel cost.

Finally, we need a system converter to supply electricity to the AC loads. This whole optimized proposed system requires approximately 1.5 million dollars to meet the required demand.

4.3 Identify optimal design approach

Overall comparison of three alternatives:

System Name	PV-Wind		PV-Hydro		PV-Biomass	
Capital Cost ($)	89126.75		94859.2		1,589,790.45	
Maintenance Cost ($)	21944.64		33946.03		32,484.14	
Replacement Cost ($)	30153.19		22461.32		36,645.03	
Total cost ($)	153930.94		162889.94		1,518,893.96	
Excess Electricity	22.1%		23.3%		35.8%	
Overall lifetime	PV array	25 Years	PV array	25 Years	PV array	25 years
	Wind Turbine	20 Years	Micro Hydro Plant	20 Years	Biomass Plant	20,000 Hours

Table 11: Overall optimization result from Homer

From the overall comparison of three alternatives, PV-Wind hybrid system requires a capital cost of around 89 thousand dollars where PV-Hydro hybrid system and PV-Biomass hybrid system require capital cost of 95 thousand dollars and 1.5 million dollars respectively. In addition, the PV-Wind hybrid system has a lower total cost including maintenance cost and replacement cost than the other two hybrid systems. So, the PV-wind hybrid system is the most cost-efficient energy system among the three alternatives. Moreover, PV-Biomass produces 35.8 % excess electricity where PV-Wind produces only 22 % excess electricity. Therefore, the PV-Wind system has less waste of energy. Though the wind turbine and hydro plant have the same lifetime which is around 20 years, the wind turbine has a longer lifetime than the biomass plant. So, among the three alternatives, we identified the Solar-Wind hybrid system as the optimal design.

4.4 Performance evaluation of developed solution

Solar-Wind hybrid system is the developed solution which can fulfill our objectives. Here, we are using CanadianSolar MaxPower CS6X-325P solar panels which will meet the 77.7 % electricity demand of that particular coastal area. The Bergey Excel 10 model wind turbine will be set at a hub height of 15 meters and it will meet the 18.8% electricity requirements. The remaining 3.5 % electricity backup will come from the Generic 10 kW Fixed Capacity Genset generator. By this solar-wind proposed hybrid system, we can produce 99,963 kWh electricity per year. 60,439 kWh AC primary load consumption can be met by this system. Additionally, there will be 20,841 kWh/year excess electricity which is approximately 23.2%.

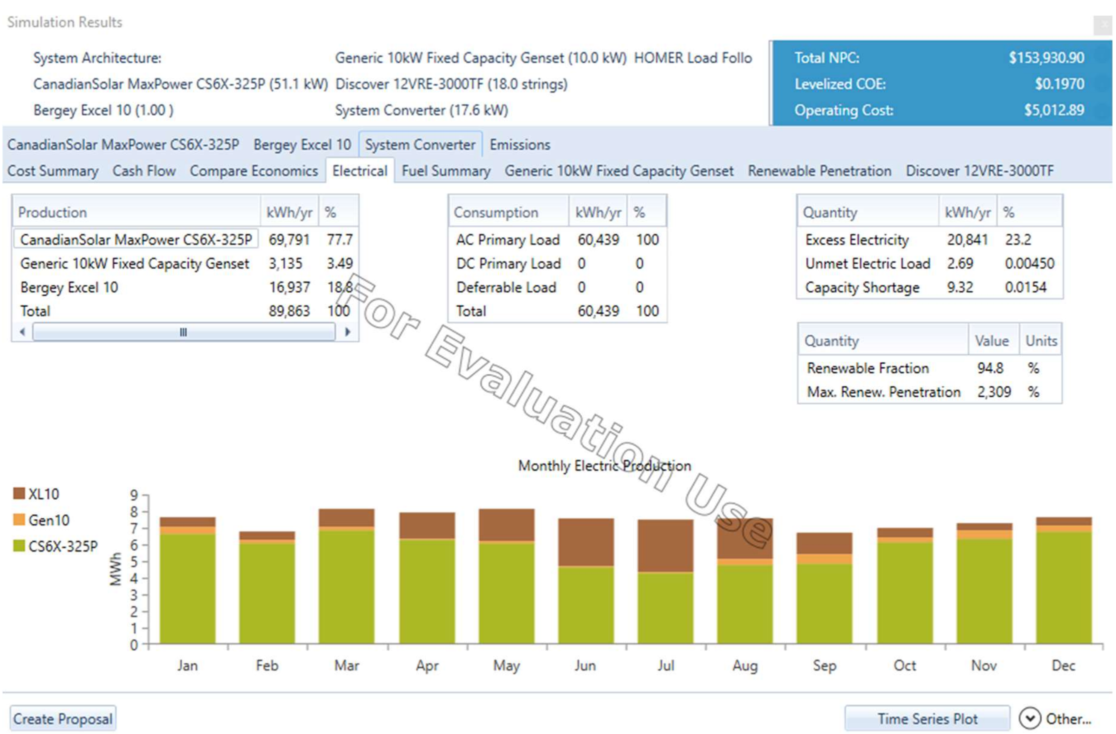


Figure 24: Electrical Summary of the proposed system

Lastly, there will be a 9.32 kWh/year capacity shortage which is negligible as it is only 0.01%. Therefore, a solar-wind hybrid system can easily meet our load requirements of 165.59 kWh/day and 17.41 kW peak demand.

4.5 Conclusion

From analyzing the multiple design solutions, we can see that the PV-Wind system is less expensive than the other PV-Hydro and PV Biomass systems. Besides, PV-Wind systems have less excess electricity than PV-Hydro and PV-Biomass systems.in a system when excess electricity is less than 30% it is the optimum solution. Here, in PV-Wind excess electricity is 22.1% which is less than the other two alternatives. So, we have selected the PV Wind system as the optimum solution considering that we have enough renewable resources to implement our project. Our project is easy to manufacture since it takes less capital cost. Moreover, its maintenance expenses are also lower than the others. Finally, the PV-Wind system has a longer lifetime which will make our project more sustainable.

Chapter 5

Completion of Final Design and Validation

5.1 Introduction

In this chapter we will discuss the methodology and design process of our project. First, we will discuss the methodology. After that, we will explain different parts of our project. In addition, we will make a complete prototype which we have simulated in proteus software.

5.2 Completion of final design

5.2.1 Methodology:

Our project will be a smart automated power management system. The steps we are using are given below:

I. We have connected a 5W mini monocrystalline solar panel with breadboard. Also we are using a 200W bulb as a light source.

II. We are modeling the wind turbine using an induction motor as an induction generator and a DC motor as a prime mover since a small wind system is not available in the market.

III. The wind turbine produces AC voltage, so we are using a rectifying circuit along with an adjustable voltage regulator.

IV. We have used 4 voltage sensors to measure the voltage we are getting from Solar, Wind, Battery and the backup battery.

V. A 16*2 LCD displays have been used to show the voltages and battery status whether it is charging or discharging.

VI. The Arduino will take the values of the voltage regulators and take actions according to the code. Arduino is controlling the 4-channel relay module.

VII. We have taken a threshold voltage level 10V, when we get more than 10 volts, the relay gets on and charges the battery and works as a switch between two batteries. If the solar and wind system gives more than 10V individually, the batteries take charge, else the relay circuit remains off. Similarly, if our main battery charge drops to below 10 V, the relay shifts the load to our back up battery.

VIII. Finally, the inverter takes 12V DC as input and supplies us 220V AC.

5.2.2 Software Simulation

At first, we built our prototype project in Proteus software and ran the simulation to troubleshoot any technical problem in the project. Here we used dc source as the solar array and ac source as the wind turbine. We built the custom voltage sensor model with 7.5k and 30k resistors along with voltmeter because this voltage sensor will be used in the hardware project.

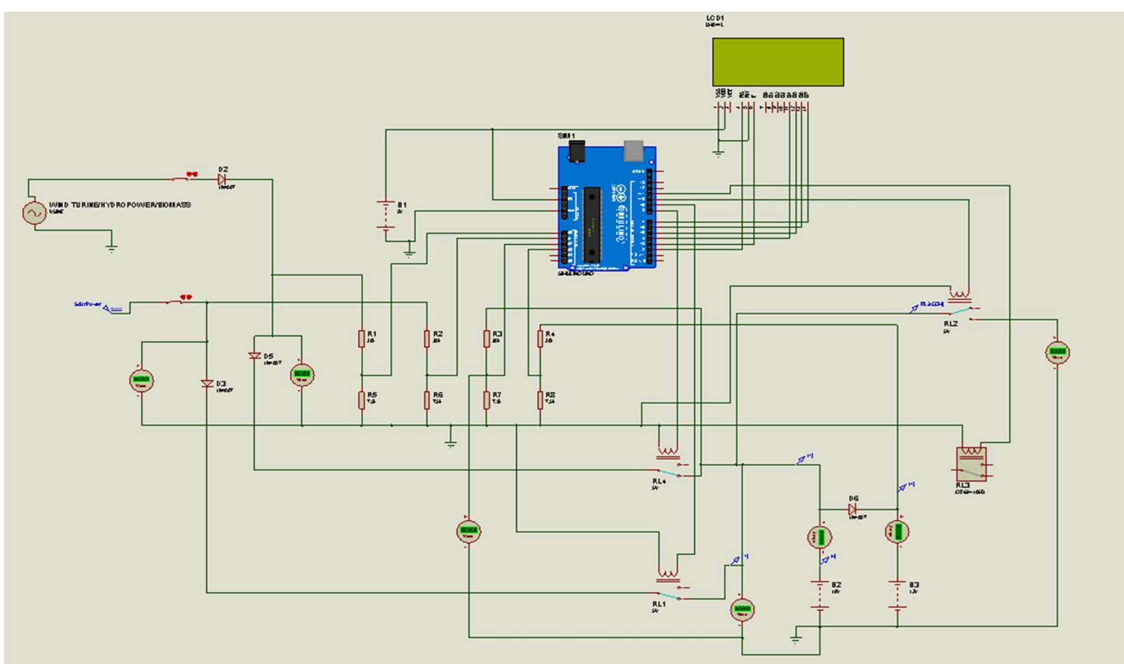


Figure 25: Software Circuit Diagram

5.2.3 Developed Prototype:

Based on the software project, we implemented the hardware prototype. Basically, there are four major systems in our developed prototype. The first system is a solar system where we used a 5-watt mini solar panel as our solar plant. A 200-watt bulb is used to generate voltage from the solar panel. Secondly there is a wind system in our project. As we had to implement the hardware project indoors, we modeled a wind turbine. For that we used the phase induction motor as the induction generator. We used a dc motor as the prime mover and coupled it with the induction motor to generate electricity. We used a capacitor bank connected in delta connection with the induction motor to increase the generated ac voltage.

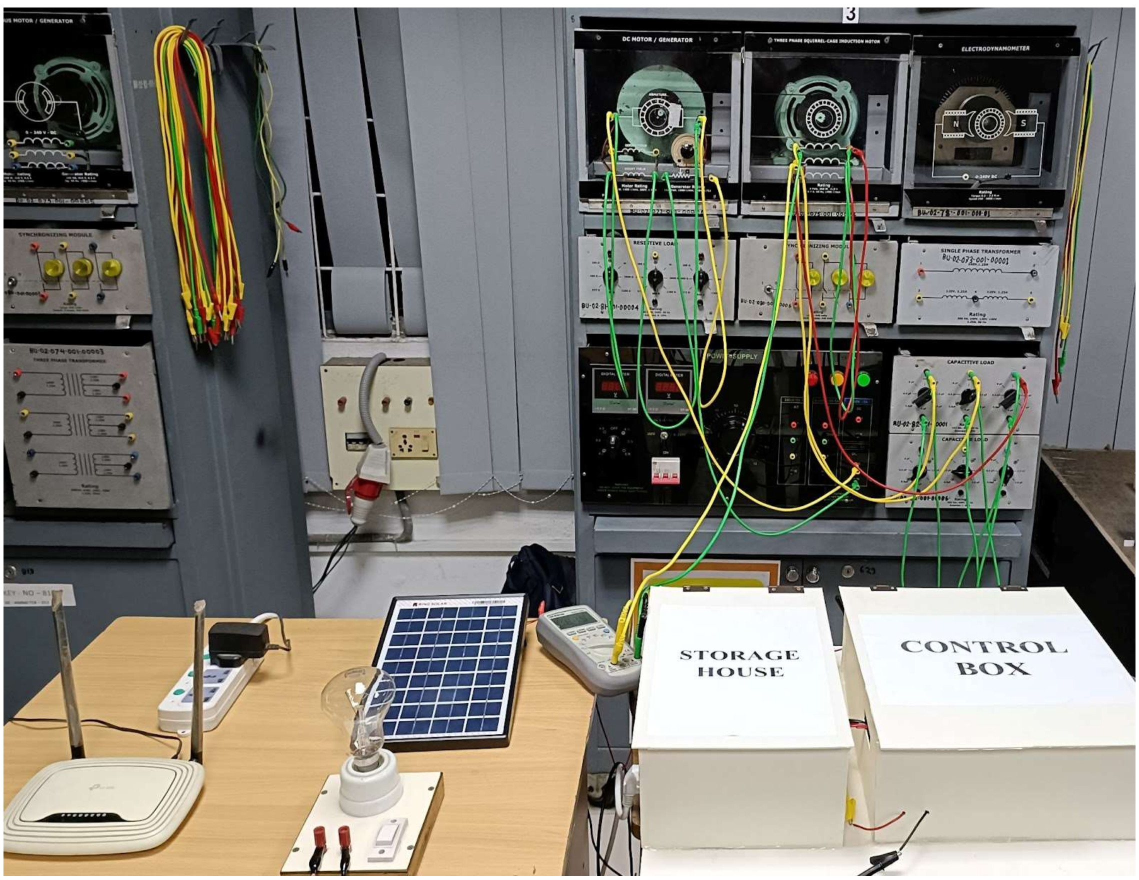


Figure 26: PV-Wind prototype project

The third major system is the control box. Inside it, there is an AC to DC conversion circuit to make the ac voltage of the wind turbine to dc using a bridge rectifier. Then the dc supplies of both the power sources are connected to the voltage sensors and relay. The 4-channel relay works as the charge controller between the power sources and the batteries. There is a microcontroller in the control box which is the heart of the project as all the decision making comes from this component. There is also an LCD display connected with the microcontroller to display the charging and discharging status of the batteries.

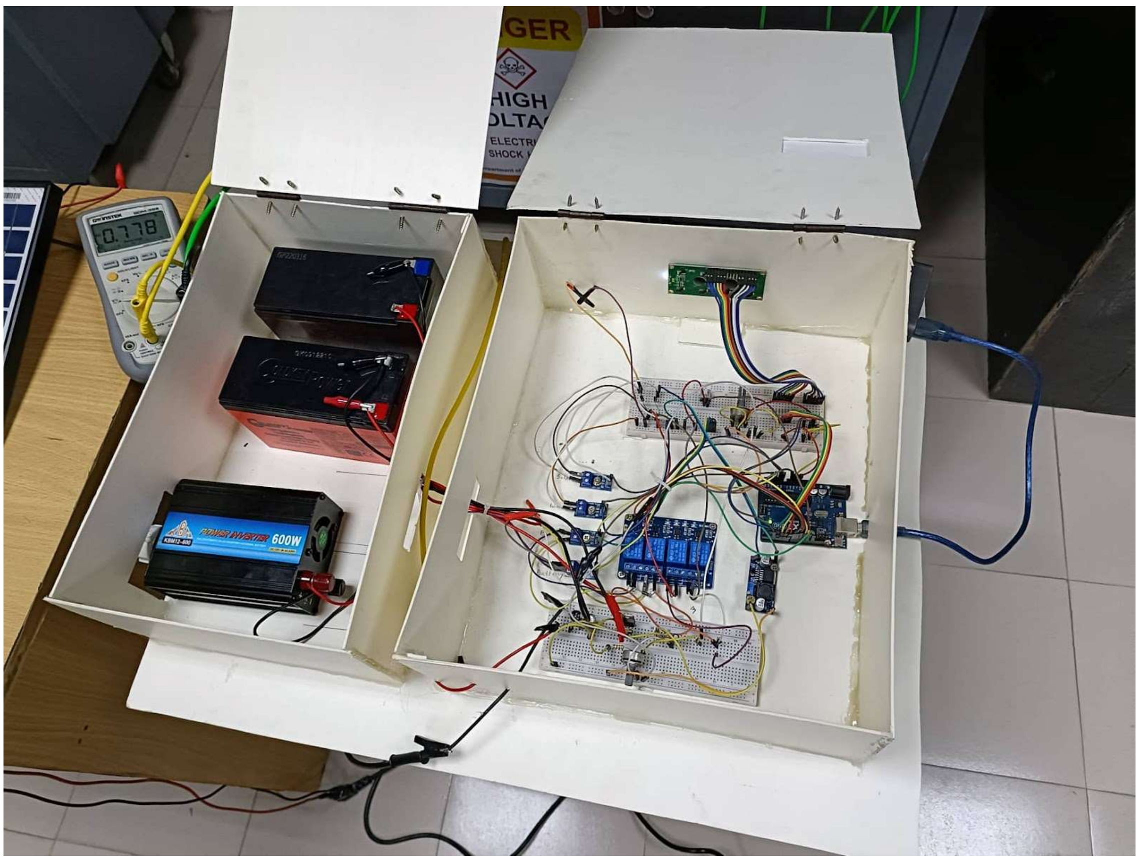


Figure 27: Control Box and Storage House

Lastly, in the storage house there are two batteries. One is the main battery and the other is for the backup purposes. These batteries are connected to the inverter through the relay. From the inverter we can supply the AC electric loads.

5.3 Evaluate the solution to meet desired need:

From this solar-wind hybrid prototype project, we were expected to run some small ac loads. For this purpose, we made a load profile with some small ac devices.

Devices	No.	Power Consumption (W)	Hours of Use per Day	Power Consumption per Day (Wh/day)
LED Bulb	2	10	5	50
Small Fan	1	10	10	100
Smartphone Charger	1	9	1	9
Wi-Fi Router	1	4	12	48
Door Bell	1	2	0.05	0.1
Fire Alarm	1	0.4	-	-

Table 12: Load for prototype

After charging the batteries from the solar and wind sources, we connected these loads to the inverter. These devices were perfectly running from this project. Though we had to change some designs which we made primarily such as the wind turbine. We had to use capacitive load to increase the output voltage of the wind turbine.

5.4 Conclusion

The main purpose of this prototype project was to build a PV-wind hybrid system where some ac loads can run. At first, we made the load profile for these small devices. To implement the prototype, we had to make the algorithm first, then made a software prototype to troubleshoot technical problems. After that we built the hardware project according to the software one. While implementing the hardware, we also faced some difficulties to meet our desired needs. Finally, after completing all the connections, we were able to run those loads. Therefore, our developed solution as per final design is fulfilled.

Chapter 6

Impact Analysis and Project Sustainability

6.1 Introduction

After implying our project in the coastal areas of Bangladesh will lead inhabitants to face a lot of consequences. These consequences will change their life positively. coastal people will have more health benefits, society will be safer and their culture will be more cherished. As we are using renewable sources which will lead to lowest carbon emission which will change the health of the coastal area. Besides, the environment will be purer and these consequences will be shown for the wellbeing of the society. The safety condition will be stronger enough that can reduce all of the crimes that occur on coastal areas. Moreover, the legal and cultural position of the society will get stronger. Besides, the sustainability of our project is vast. as this solution is cheaper than conventional fuel energy systems with more environmental, health and societal benefits. So, we are assured that the impact of our project is dependable and will change our society.

6.2 Assess the impact of solution

Health

In spite of the fact that traditional energy sources like coal, gas, and oil can considerably improve our economy, they can also create social, environmental, and economic problems in our country. These resources might not be as eco-friendly and release hazardous gases including carbon dioxide, carbon monoxide, sulfur dioxide, along with mercury, cadmium, and other harmful substances.[18]. In addition, it emits carbon at a variable rate of 87%, which contributes to deforestation and the greenhouse effect.[19].Acid rain and soil erosion are brought on by toxic compounds produced by burning fuel, which when combined with food can result in deadly diseases. On the other hand, hybrid renewable energy systems have the ability to almost completely eliminate the production of harmful compounds while still producing less carbon. Since there are fewer carbon emissions, they cannot be the cause of climate change and global warming. According to WHO estimates, 7 million people every year pass away from diseases including stroke, heart disease, lung cancer, chronic obstructive pulmonary disorders, and others because of exposure to small particles in polluted air that enter the lungs and cardiovascular system deeply [20]. In comparison to coal, which emits between 1.4 and 3.6 pounds of CO2E/kWh, burning natural gas produces emissions per kilowatt-hour (CO2E/kWh) that range from 0.6 to 2 pounds. On the other hand, solar and wind each contribute between 0.07 and 0.2 pounds of CO2E/kWh over their lifetimes [21]. Using hybrid renewable energy will improve the health of the people of Bangladesh.

Societal

Bangladesh needs to import a huge amount of petrol oil from Singapore, China, India, Malaysia and South Korea mainly because of the higher demand of electricity [22]. The price of gas has been progressively increasing as a result, upsetting society. Natural resources are also in short supply. Therefore, if we do not conserve natural resources and switch to renewable sources, we will eventually run out of supply. If power is produced from renewable sources, living standards will rise while fuel prices won't increase. Lower carbon emissions will significantly enhance people's health, which will also have an effect on society's state. Utilizing renewable energy sources wisely can have positive effects on the local economy, health, employment prospects, consumer choice, living standards, social bonds, income development, demographic effects, social bonds, and community development.[18]. However, Iceland is the only country which is 100% dependent on renewable energy [23]. There are few social problems and less crimes [24]. If Bangladesh starts using renewable sources for electricity production more societal problems will be reduced.

Safety

This project guarantees to continuously provide electricity for Bangladesh's coastal regions. Since it is highly difficult to supply grid electricity to some distant islands, such Maheshkhali and St. Martin, this project will be the only way to address their electricity problems. The inhabitants of coastal areas will be able to install more sodium lights in their streets and highways with the help of electricity generated from renewable sources. On the other side, human trafficking is a serious offense in Bangladesh, with the coast serving as its primary operating location. According to border security force’s research from 2018, more than 50,000 women and children are allegedly trafficked to India every year.[25]. Smuggling, drug sales, illicit fishing, and other forms of black enterprise are associated with crime patterns in coastal locations [26]. We can install CCTV cameras for security and extra street lighting to deter crime if we have access to enough electricity.

Legal

For establishing a hybrid renewable energy production, we need to take some legal permission. Here we want to establish a hybrid renewable energy project for coastal areas. For establishing a solar park project, we need to take care of some major precautionary measures.

- We must choose any publicly or privately owned land for suitable sites, and we must do a pre-feasibility analysis of the land, including its type and category, communication facilities, expected solar park capacity, and facilities for grid connectivity for the power produced [27].
- The private businessman and BPDB will execute a power purchase agreement (PPA). A "Land Lease Agreement" (LLA) will be executed between the private entrepreneur

and the relevant ministry/ division or its subordinate department or the authority controlled over the land if the Solar Park will be built on government-owned land. A Power Division Implementation Agreement (IA) will be signed on behalf of the government [27].

- According to the Renewable Energy Policy, business owners will need to obtain a waiver certificate or license rather than a license from the Bangladesh Energy Regulatory Commission (BERQ) in order to develop a solar park with a capacity up to 5 MW. A license for a minimum of 20 years may be provided with the requirement that it be renewed annually in order to encourage alluring investments for carrying out such projects.[27].

For wind turbine installations we need to consider some legal requirements. These are some legal issues we should envisage before implementing in coastal areas.

Land Use Permission: The Project Developer ("PD") should make sure that the land being chosen for the wind power project is able to be utilized legally for this purpose and that all land use/land cover restrictions are in conformity. Since Bangladesh has a very limited supply of wind resources, SREDA will grant a land use "No Objection Certificate (NOC)" after reviewing the project's plan [28].

Availability of wind resources: Based on the numerous characteristics measured for this purpose, the project developer must guarantee the availability of wind resources at the location. Additionally, the project developer must use industry best practices to guarantee the accuracy of the data collected [28].

<u>Noise study:</u> In Bangladesh, the permitted sound level for quiet places is 50 dB during the day and 40 dB at night. The PD will pay for noise research, which will be included in the final design so that the noise level conforms with Bangladesh's current Noise Pollution (Control) Rules. The impact of noise from turbines will be compared to the current ambient noise levels [28].

<u>Culture</u>

The target audience for this initiative is the population of Bangladesh's coastal regions. Numerous ethnic groups, including the Chakma, Marma, Rakhaine, and others, reside in coastal locations like Cox's Bazar and Patuakhali [29]. They celebrate their own unique kinds of holidays. Because the Hindu community in Kuakata Sea Beach celebrates Rash Purnima, and because the Rakhine community celebrates its well-known water festival in Cox's Bazar [30]. Because more lights will be used to efficiently conduct festivals if renewable energy sources are used for electricity, residents will be able to spend their holidays in greater safety. Additionally, the police will be more aware of the need for calm holiday celebrations.

6.3 Evaluate the sustainability

Statistics say that not more than 3 percent out of 10 million people living in the coastal zone and in most of the island have no access to electricity presently. Providing electricity from the national grid in those areas is still considered as very inefficient [31]. Therefore, people living in those coastal areas will have access to electricity. The hybrid system saves a huge amount of fuel annually compared to the standalone diesel system. Also, the reduction in fuel consumption has avoided the emission of vast amounts of CO2, NOx and SO2 into the atmosphere annually [34]. Therefore, the justification of hybridizing the diesel generator is that the hybrid energy system is less costly with better environmental performance [32].

As a coastal area, the location experiences high wind speed. The wind speed during the monsoon is highest and lowest in winter. According to the survey done in different coastal areas of Bangladesh, the wind speed varies from 2.8 m/s to 5.9 m/s. The average wind speed is 4.1 m/s at the height of 30m. A 1kW wind turbine can produce 3170 kWh energy every year from this wind potential [34]. According to the Bangladesh meteorological department and NASA website, the solar radiation range is 4 kW/m2 /d to 5.9 kW/m2 /d [34]. Therefore, solar wind hybrid systems can easily provide more electricity efficiently than other power systems to the locality of those coastal areas [33].

6.4 Conclusion

After implying our project in the coastal areas of Bangladesh will lead inhabitants to face a lot of consequences. These consequences will change their life positively. Coastal people will have more health benefits, society will be safer and their culture will be cherished. This solution is cheaper than conventional fuel energy systems with more environmental, health and societal benefits. To conclude, we are assured that the impact of our project is dependable and it will definitely sustain for a long time.

Chapter 7

Engineering Project Management

7.1 Introduction

For engineers, project management includes careful planning and communication of that plan to a team of engineers. It involves the identification of project goals and milestones as well as the development of multiple scenarios and contingency plans. In our first week of FYDP, four of us sat in on a discussion about how we would set our goals for each semester and divided our tasks. This helped us to keep everyone involved in the project and keep a tract on our day-to-day work. Furthermore, it allowed us to inform our weekly progress to our ATC panel regularly.

7.2 Define, plan and manage engineering project

Project start date	16/10/2021
Project end date	01/09/2022

FYDP(P)

		TASK NAME	ASSIGNED TO	START
	Concept note	Background research, tentative problem statement	Anushka	Week 1
		Tentative objective	Emad	Week 2
		Multiple designe approaches	Pritom	Week 3
		Specifications, Requirements	Nahin	Week 4
		Applicable Standards and codes	Emad	Week 5
		Constraints, Conclusion	Anushka	Week 6

FYDP (P)	Proposal report	Project Plan and Gantt chart	Emad	Week7
		Methodology, Budget	Pritom	Week8
		Expected outcome	Nahin	Week9
		Impact	Anushka	Week 9
		Sustainability	Nahin	Week 10
		Ethical Consideration	Emad	Week 10
		Risk Management and Analysis	Anushka	Week 11
		Safety Consideration	Pritom	Week 11

Figure 28: FYDP(P) Project Plan

In FYDP(P), we had divided activities among us to complete the project in time. Firstly, we had planned to initiate our project by studying some research papers. After doing our research we find our objectives. Then we had made some suitable approaches to solve the problem and made a design methodology. Finally, we prepared our budget, calculated whether our project will sustain or not and roughly thought about the risks that can hamper our project.

FYDP(D)

		TASK NO	TASK NAME	ASSIGNED TO	START
FYDP (D)	Research and Learning	1	Selecting Appropiate location	Anushka	Week 1
		2	Background Research and Servey	Anushka	Week 2
		3	Selecting Suitable Software	Nahin	Week 2
					Week 3
		4	Software Learnig	Everyone	Week 4
	Simulation and Report Writing				Week 5
					Week 6
		5	Homer Software Simulation	Everyone	Week 7
					Week 8
		6	Proteus Software Simulation	Pritom and Nahin	Week 9
					Week 10
		7	Report Writing	Emad and Anushka	Week 11

Figure 29: FYDP(D) Project Plan

In the second semester of our project FYDP(D), we have completed our software simulation. For this part, we have divided our activities into seven different segments. Initially, we have done some online research and surveys to select a suitable location. Then, we did a homer simulation to find an optimal solution. After that, we performed a proteus analysis of our prototype for functional verification. Thus, we have completed this design report.

FYDP(C)

	Task No	TASK NAME	ASSIGNED TO
FYDP (C)	Task 1	Component selection	Anushka
	Task 2	Budget justification	Pritom
	Task 3	Component purches	Emad
	Task 4	Project building	Nahin
	Task 5	Problem solving	Emad
	Task 6	Report writing	Everyone

Figure 30: FYDP(C) Project Plan

In our last semester of FYDP, we actually built our prototype. In order to do that, we bought the required components and started connecting them according to our software circuit. We faced various problems such as not finding the appropriate component and so on.

7.3 Evaluate project progress

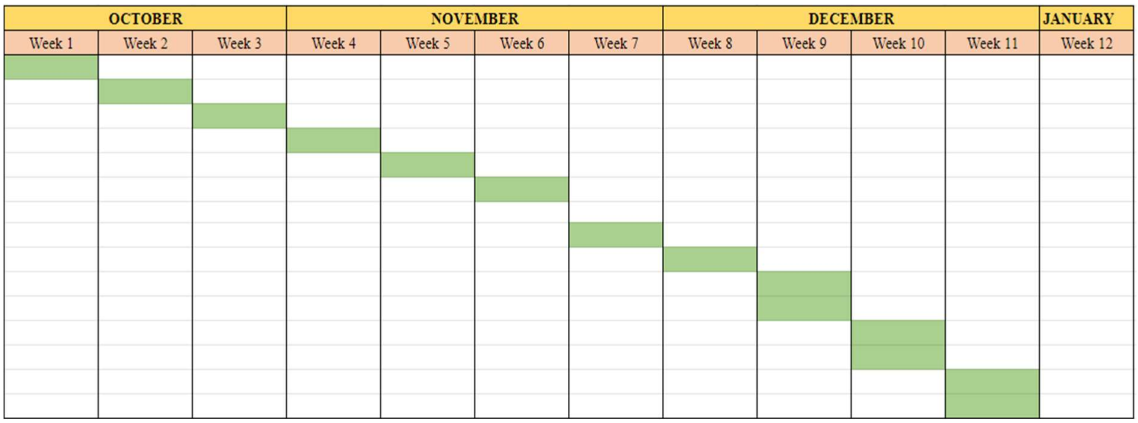


Figure 31: FYDP(P) Timeline

Figure 32: FYDP(D) Timeline

Figure 33:FYDP(C) Timeline

7.4 Conclusion

Project planning is essential for the success of any project. Without planning, a project may be susceptible to common project management issues such as missed deadlines, useless investment, cost overrun etc. As we have done our planning properly, we were able to overcome all those risks and completed the project in time.

Chapter 8

Economic Analysis

8.1 Introduction

The project economics of any project requires that one estimate both the costs and the benefits from the project through time. Economic analysis aims to ensure that scarce resources are allocated efficiently and investment brings benefits to a country and raises the welfare of its citizens.

8.2 Economic analysis

Our required components for the hardware prototype and total budget are given below:

Components	Quantity	Price (Tk)
Arduino Uno	1	1300
LCD Display	1	250
Voltage Sensor	4	400
Solar Panel	1	600
Boost Converter	1	110
Battery	2	2200
4 Channel 5V Relay	2	250
Inverter	1	900
Breadboard	2	240
Jumper Wires	120	240

Wires	2	30
Rectifier Circuit	1	50
		Total = 6,570

Table 13: Budget justification

Budget Justification:

Arduino Uno: We need a microcontroller and we chose Arduino UNO. It assists us to observe whether the batteries are charging or getting discharged. It costs around 1200 Taka.

Solar panel: A Polycrystalline silicon made and which is encased and protected by a durable outer poly frame 90 mm X 90 mm Solar panel will cost around 580 takas.

Battery: There are two batteries, one is the main battery and the other is an alternative battery and each 12-volt battery will cost around 1100 taka. So, 2 batteries will take 2200 taka.

Relay: We need 4 channel relays for 2 batteries for switching purposes or else we won't be able to supply constant supply and our batteries will be overcharged. It costs around 250 Taka.

Inverter: Solar system will supply dc power but our load will take ac supply that's why we need an inverter for running our loads. Inverter will cost around 900 takas.

LCD display: For all types of parameters reading, we need an LCD display and it will cost around 160 takas.

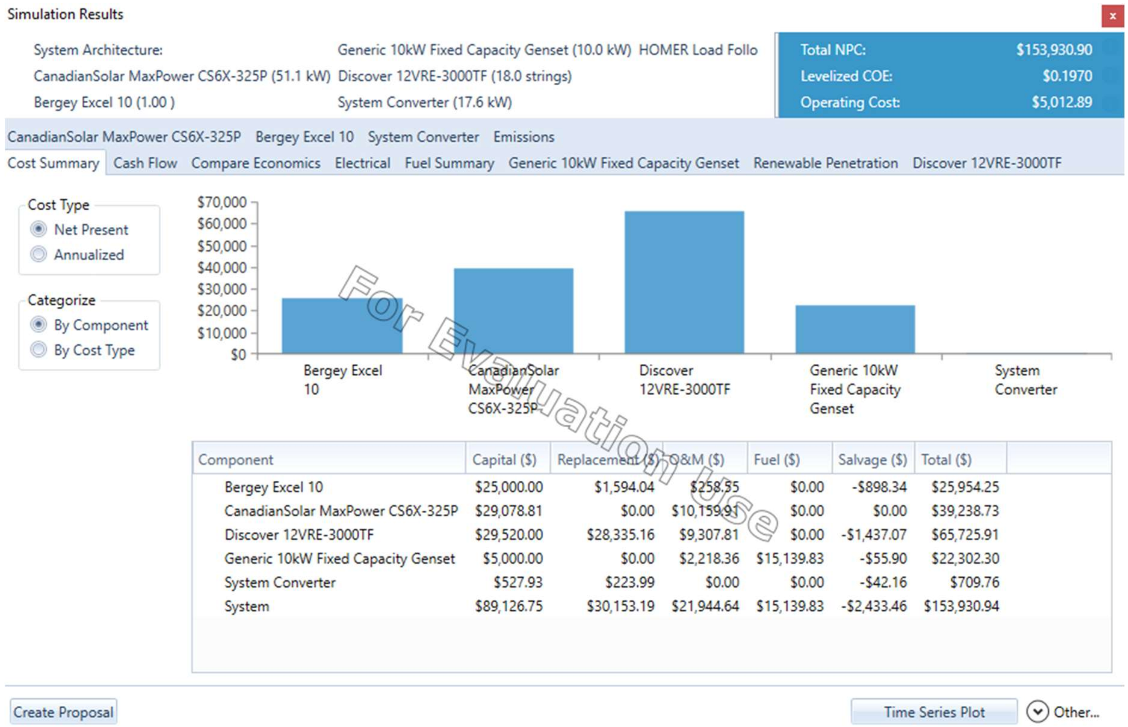


Figure 34: Cost Summary of PV-Wind Hybrid System

8.3 Cost benefit analysis

In our project plant for kola Para, Kuakata; we calculated our project plant cost and electricity outcome from homer pro software.

We applied solar and wind resources data of our targeted area from NASA website and applied our rated value of components and their costing and then using homer analysis we could successfully achieve the below data.

Cost Summary

	Base Case	Lowest Cost System
NPC	$356,618	$153,931
Initial Capital	$8,440	$89,127
O&M	$26,933/yr	$5,013/yr
LCOE	$0.456/kWh	$0.197/kWh

Figure 35: Short cost summary from Homer analysis.

We can see that our lowest cost system is 153931 USD and initial capital is 8440 USD. If we convert this money in our local currency, it will be 14614029.50 BDT.

Economic Metrics

IRR	28%
ROI	23%
Simple Payback	3.5 yr

Figure 36: Economics matrix from Homer analysis.

ROI (Return on Investment) and easy payback are related concepts. The time span over which the return is received is known as the payback period. In financial analysis, the internal rate of return (IRR) is a statistic used to calculate the profitability of possible investments. The amount of money made back from investment is return on investment. From the economic metrics chart, our Homer analysis says that just after 3.5 year our benefits will start and this will be a great source for economic development in coastal areas. Our ROI is 23 % and IRR is 28%.

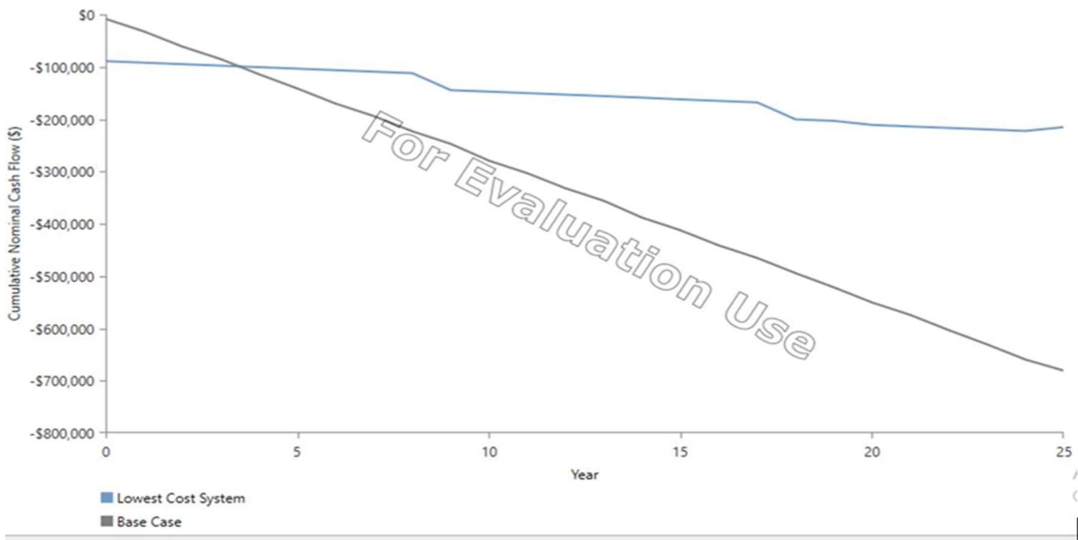


Figure 37: Cumulative Nominal Cash flow

The base case capital cost less the existing system capital cost is the cumulative nominal cash flow in year zero. The discount rate at which the base case and current system's net present costs are equal is known as the internal rate of return (IRR). The above graph has two lines. Blue lines represent the lowest cost system and black line represents the base case where we see how our hybrid system saves money over the project lifetime.

8.4 Evaluate economic and financial aspects

The electricity we can achieve from this project is given below. We achieved this from Homer's analysis.

Production	kWh/yr	%
CanadianSolar MaxPower CS6X-325P	69,791	77.7
Generic 10kW Fixed Capacity Genset	3,135	3.49
Bergey Excel 10	16,937	18.8
Total	89,863	100

Figure 38 : Produced electricity from Homer analysis.

So, we can say,

Each year produced electricity = 89863 KWh/year

Total cost= 153930.94 USD

= (153930.94*94.94) BDT

[By 2022-dollar rates]

= 14614029.50 BDT

Minimum project lifetime = 25 years

Produced electricity till lifetime = (25*89863) KWh

= 2246575 KWh

Per Unit cost = (14614029.50/2246575) BDT

= 6.50 BDT

Current electricity unit price on market = 8.16 BDT

Benefit from each unit= 1.66 BDT

So, we can see, it has a high chance to supply electricity with a benefit of 1.66 taka per unit.

8.5 Conclusion

In this current situation where fuel price is extremely increasing, this project will be so beneficial. Bangladesh is majorly dependent on imported fuel for supplying electricity. We already experienced fuel shortages many times for which the electricity unit cost rose extremely and load shedding happened frequently.

This project is totally dependent on renewable energy and there is no chance of energy shortage. So, this will compete very strongly with the current electricity market and dominate in the future.

Chapter 9

Ethics and Professional Responsibilities

9.1 Introduction

Engineering is a valuable and sophisticated job. Engineers are required to uphold the highest standards of honesty and integrity as members of this profession. The quality of life for every individual is directly and significantly impacted by engineering. As a result, engineers must provide services with integrity, objectivity, fairness, and equity, and they must be committed to preserving the health, safety, and welfare of the general public. Engineers are held to a professional code of conduct that mandates adherence to the highest standards of moral behavior.

9.2 Identify ethical issues and professional responsibility

Our goal for this project is to keep our environment clean and to decrease the carbon emission by reducing the use of fossil fuel. To benefit mankind, we must ensure that our project will not harm any living creature. Furthermore, every individual task for example report writing, project management and all work should be done without plagiarism and unique. Besides, IEEE referencing with proper citation is a must work to do if we take ideas from other documents as reference.

9.3 Apply ethical issues and professional responsibility

Our research was conducted within the ethical framework of carrying out research. We ensured that intellectual property rights and patent laws were observed. Duplication of work was highly avoided and due reference by way of citation is given where information from other scholars was used. Recognized international standards were referred to where necessary to ensure that high quality research was produced. Any project implemented under this under this paper would be governed by the existing laws, policies and guidelines like environmental law, private sector power generation policy, renewable energy policy etc.

9.4 Conclusion

A professional code of conduct for engineers stipulates adherence to the highest moral standards. Any project carried out under this would be subject to all applicable laws, regulations, and policies, including those governing the environment, private sector power generation, renewable energy, etc. We made sure that patent and intellectual property laws were followed. Besides, duplication of work was strictly avoided, and if data from other researchers was used, proper credit was given through citation. To conclude, we know our ethical responsibility and we have tried to keep our work ethical and unique.

Chapter 10

Conclusion and Future Work

10.1 Conclusion

In a world of huge crisis of coal, fuel and gas for generating electricity, this hybrid system can be considered an effective solution especially for that area where electricity supply is very insufficient. This renewable system uses natural sunlight and wind for generating electricity which are some green energies and they are not harmful to earth whereas coal plants produce excessive ashes which make the environment unhealthy. Our hybrid renewable system has great potentiality for meeting up the load demand without harming any environmental particles. In this modern technology world, developing countries are focusing more on green energy and huge research is being created on them. Our hybrid renewable systems are a reflection of them and it is needed to support in our country to reduce solar panel and wind turbine prices.

To complete this project, we found a solar panel on the market but the wind turbine was not available on market so we used an induction motor for supplying ac current because in big wind turbines, rotor is moved by a low-speed shaft connected to the propeller and rotor moves a generator which produces ac current. We tried to keep the actual wind turbine mechanism. Again, we were only getting 5 volts current from our 25 volts solar panel. Then we changed the solar tilt angle (which should be changed in different seasons by 15 degrees) and then we could achieve 21 volts current supply from our 25 volts solar panel. So, our solar efficiency increases to 84%. Again, AC current that comes from our induction motor of our wind turbine didn’t produce proper sine waves even after using capacitors. So, converting sine waves to dc signals has improved our graph problem. Then we managed to overcome our problems successfully and our project started producing our expected current output.

10.2 Future work

We have a plan to propose this project to a broad area like other coastal areas such as Moheshkhali, Monpura Island where electricity is a big issue. This project has long sustainability that can produce continuous electricity in any weather condition without affecting any nonrenewable resources like fuel and coil which has become a big crisis now. There are alternative options like integrated power systems or diesel generators but they cannot fulfill the power demand.

We have plans to add a solar tracker system which will help the solar panels to rotate towards the maximum sunlight so that solar efficiency gets much higher for getting the maximum power output we can achieve. Our plan is building a smart monitoring system for our system maintenance so that any of our system components lose their productivity. Our selected area Kolapara will get service from our hybrid renewable system by maintaining a well-planned distribution method where schools, hospitals and other important institutions will get priority over other consumers who will get electricity supply according to their demand.

Chapter 11

Identification of Complex Engineering Problems and Activities

11.1: Identify the attribute of complex engineering problem (EP)

P1 Depth of knowledge required:

This basically means without in-depth knowledge of complex engineering we cannot continue our project. In depth knowledge includes all courses and knowledge we earned from our three or four years of engineering life and apply that knowledge to problem solving skills. To speak truly, the project needs to be complex so that the knowledge we understand theoretically in our courses must be applied here. The problem must be complex enough to be a university level work. This is the most important attribute we need to follow and without this we cannot conduct our research.

P2 Range of conflicting requirements:

These attributes represent the conflicting issues of engineering, technical and other aspects. attributes explains if we have any type of conflicts in our project and how we address this issue and resolve it. When we solve our problems do we come up with an issue that causes conflict that solves one and adjusts the other.

P3 Depth of analysis required:

In our problem solving, if there is any type of problem which we have no proper solution for, we need to think critically and originally to formulate a suitable solution. Sometimes problems can be so complicated that we need to think deeply and come up with new ideas which were not invented previously. We need depth of analysis and critical thinking capability to resolve those issues.

P4 Familiarity of issues:

When the problem is not that much familiar or familiar but we need to introduce new issues are familiarity of issues. Frankly, if we solve any problem which is new, many people do not know about it or we are addressing new questions we need to unravel.

P5 Extent of applicable codes:

The standard codes or applicable standards from professional engineering we need to follow to conduct our research. Here in our project if the research is popular there must be standard codes from government or professional engineers that must be followed. These codes must be followed by students. and if there is any problem which was not invented previously or a completely unique problem which has no applicable codes then this step can be ignored.

P6 Extent of stakeholder involvement and needs:

Involving different types of stakeholders and addressing their needs to our project is represented by this attribute. This attribute basically means requirements of all of the stakeholders must be addressed in our solution.

P7 Interdependence:

All of the problems will be more complex in our project which was mentioned here before. but the problems can be dependent on subproblems or smaller components. This sub solution cannot be physically but mathematically.

11.2: Provide reasoning how the project address selected attribute (EP)

We are using hybrid renewable sources for power generation that is why we had to collect data for different types of renewable sources. Basically, we are making this project for coastal areas so we must have a depth of knowledge of wind speed, solar radiation of coastal areas and many more other topics. So, we are fulfilling P1 Depth of knowledge required which is a must requirement.

In our actual implementation project higher wind speed will produce more power which is beneficial to us. But higher wind speed will create more sound pollution which will be painful for inhabitants of coastal areas. Because of this we have a conflict with our requirements and we fulfill P2 Range of conflicting requirements.

Our project will generate power using renewable sources which can be used for different purposes. For example, it can be used for household uses, can be used for the rest house and hotels of coastal areas. Besides it can be used for industrial use for operating mills and factories. We will consider every type of needs and requirements of stakeholders. This is how we complete P6 Extent of stakeholder involvement and needs.

As a subsystem we are going to use the wind turbine part, photovoltaic part and battery part. They all can operate together and as a replacement also which is explained earlier in this proposal note. Basically, every subsystem and component are connected and dependent on each other. As a result, we have fulfilled P7 interdependence.

11.3 Identify the attribute of complex engineering activities (EA)

A1 Range of resources:

It involves the use of diverse resources such as people, money, equipment, materials, information which is the most essential part of any problem-solving project. without these assets projects cannot be conducted at all. developing plans such as budget, time management can be a good initiative to properly use the resources

A2 Level of interaction:

For our project management we need to interact with project managers, technical engineers or other staff and there can be significant problems and issues that arise from interaction. Our job will be to merge those conflicts and do the most optimal solution. that can protect the needs of both parties.

A3 Innovation:

This mainly represents that the problem solving we are completing is involving creativity of using engineering or not. This also represents how we are going to introduce our new techniques or innovation and improve the efficiency of our project? Innovative solutions need more creativity to become more effective.

A4 Consequences for the society and the environment:

Attribute says what will be our impact and consequences after we introduce this problem solving. The project must create some consequences if we apply this solution to our society. then the question will be what are the consequences and how will this affect our life.

A5 Familiarity:

Sometimes in this problem-solving process we might experience some incidents which were not experienced before or sometimes some issues may arise which are completely new or even may increase the communication difficulty. Our ultimate goal will be to resolve those issues and make effective communication.

11.4 Provide reasoning how the project address selected attribute (EA)

In our hybrid renewable energy generation project, we must have resources like money, equipment, material and so on for implementing hardware. That is why we have to maintain effective communication with BRAC University authority, lab attendants and also faculties. So, we fulfill A1 Range of resource attributes.

After implementing the project, we will have huge societal and environmental consequences which is mentioned earlier in this proposal note. So, we also fulfill A4 Consequences for society and the environment.

Attributes of Complex Engineering Problems (EP)

	Attributes	Put tick (√) as appropriate
P1	Depth of knowledge required	☑
P2	Range of conflicting requirements	☑
P3	Depth of analysis required	☐
P4	Familiarity of issues	☐
P5	Extent of applicable codes	☐
P6	Extent of stakeholder involvement and needs	☑
P7	Interdependence	☑

Note: Project must have P1, and some or all from P2-P7

Attributes of Complex Engineering Activities (EA)

	Attributes	Put tick (√) as appropriate
A1	Range of resource	☑
A2	Level of interaction	☐
A3	Innovation	☐
A4	Consequences for society and the environment	☑
A5	Familiarity	☐

Note: Project must have some or all of the characteristics from attributes A1 to A5

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Appendix A.

Related code/theory:

```
#include <LiquidCrystal.h>

LiquidCrystal lcd (2,3,4,5,6,7);

int out;

int out1;

int rawv;

int wind;

int solar;

int bat1;

int bat2;

int solarrelay=9;

int windrelay=8;

int batrelay=10;

int bat1relay=11;

int sw=12;

void setup ()

{

lcd.begin(16,2);

pinMode(solarrelay,OUTPUT);

pinMode(windrelay,OUTPUT);

pinMode(batrelay,OUTPUT);

pinMode(bat1relay,OUTPUT);
```

```
pinMode(sw,INPUT_PULLUP);
digitalWrite(solarrelay,HIGH);
digitalWrite(windrelay,HIGH);
digitalWrite(batrelay,HIGH);
digitalWrite(bat1relay, HIGH);
}
void loop ()
{
wind=(analogRead(0)/4.092/10); //wind out
solar=analogRead(1)/4.092/10; //solar out
bat1=analogRead(2)/4.092/10;//batt out
bat2=analogRead(3)/4.092/10; //batt1 out

lcd.setCursor(0,0);
lcd.print("W:");
lcd.print(wind);
lcd.print(" S:");
lcd.print(solar);
lcd.print(" B:");
lcd.print(bat1);
lcd.print(" E:");
lcd.print(bat2);
if(digitalRead(sw)==LOW) // if switch is on
{
if(bat1>10)
```

```
{
digitalWrite(batrelay,LOW);
lcd.setCursor(0,1);
lcd.print("Bat1 Load On");
delay (1500);
}
else
{
digitalWrite(batrelay,HIGH);
lcd.setCursor(0,1);
lcd.print("Bat1 Low");
delay (500);
}
if (bat1<9 && bat2>10)
{
digitalWrite(bat1relay, LOW);
lcd.setCursor(0,1);
lcd.print("Bat2 Load On"); delay
(1500);
}
else
{
digitalWrite(bat1relay, HIGH);
}
}
```

```
else
{
digitalWrite(batrelay,HIGH);
digitalWrite(bat1relay, HIGH);
}
if(wind>=10 && solar<10)
{
lcd.setCursor(0,1);
lcd.print("St:Wind On");
digitalWrite(windrelay,LOW);
delay (500);
}
else if (wind<10 && solar>=10)
{
lcd.setCursor(0,1);
lcd.print("St:Solar On");
digitalWrite(solarrelay,LOW);
delay (500);
}
else if(wind>=10 && solar>=10)
{
lcd.setCursor(0,1);
lcd.print("St:Solar & Wind On");
digitalWrite(solarrelay,LOW);
digitalWrite(windrelay,LOW);
```

```
delay (500);
}
else
{
lcd.setCursor(0,1);
lcd.print("St:Not Charging");
digitalWrite(solarrelay,HIGH);
digitalWrite(windrelay,HIGH);
}
delay (1500);
lcd.clear();
}
```