SOLAR AND WIND CONNECTED HYBRID RENEWABLE ENERGY SYSTEM FOR SMALL SCALE APPLICATIONS

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A thesis 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.

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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis 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 thesis 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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Abstract

This paper represents a miniature project on hybrid renewable system using solar and wind energy. As Bangladesh is the 8th most populous country in the world, so the demand of electricity is always at peak. Because of this disruption of electricity, houses-medical centers, primary schools in those affected areas suffer from a lot of problems due to lack of proper treatment and other basic needs. To minimize this problem, we came out with an innovative project- idea of building a miniature hybrid renewable energy system based on solar and wind energy.To build this project, we used Arduino as microcontroller chip and for simulating the system we used PROTEUS simulation model. We are also adding an alternative battery as back-up energy supplement for our project in case of either wind or solar is not available/broken or in case of any failure in the main system. We believe the combination of wind, solar and backup battery will be enough to fulfill the demand of electricity which we have shown in the miniature project.

Keywords: Renewable Hybrid Energy, PV Panel, Wind Turbine, Storage Battery, Arduino, PROTEUS

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Table of Contents

List of Tables

List of Figures

List of Acronyms

IPS	Instant power supply
NREL	National Renewable Energy Laboratory
MW	Megawatt
PV	Photovoltaic
Ga	Gallium
SREDA	Sustainable and Renewable Energy Development Authority
WECS	Wind Energy Conversion System

Chapter 1

Introduction

1.1 Outline of Renewable Energy

In a certain period of time, any energy that is directly regenerated from the sun like thermal energy, photovoltaic energy and photochemical energy indirectly from the sun like wind energy, hydropower or other movement naturally regenerates from Nature and natural resources **[1]**. Renewable energy does not include fossil fuels, wastes of fossil origin, or wastes of inorganicorigin.

Some common forms of renewable energy -

- Wind power
- Hydropower
- Biomass
- Solar energy
- Geothermal energy
- Biofuel

As this hybrid project largely based on wind and solar therefore, we will deliberately focus on wind and solar section.

1.1.1 Wind Energy

To drive the wind turbines, air current can be used. Modern wind turbines have a nominal output between 600 kW and 5 MW; however turbines with a nominal output of 1.5 to 3 MW are most commonly used for commercial use. The performance of the turbine depends on the third power of the wind speed **[2].** As the wind speed increases, the productivity will greatly increase. The typical flow rate is about 20-40%, which is particularly advantageous in the higher range. Worldwide it is assumed that the potential of wind energy is more than five times to the current global energy production. This will require huge space of land for using the wind turbines, especially to those places with lofty wind reservoir. Marine resources have average wind speeds that are 90% higher in compare with land, so marine resources could provide significantly more energy **[3]**. Wind energy is renewable and does not generate greenhouse gases.

1.1.2 Solar Energy

We get solar radiation from the sunbeam as a solar energy. Solar power production is basically depending on heat engines and photovoltaics. A non-exhaustive list of other solar applications includes cooling using solar buildings, daylight, hot water, etc. For industrial purposes solar cooking and high temperature processes heat. Solar technology is often referred to as indirect solar or direct solar **[3]**. It depends on how they apprehend compresses and transmit the solar energy. Direct solar systems include the use of photovoltaic modules and solar collectors. Consume energy. Indirect solar technology includes aligning buildings with the sunbeam, materials with good thermal quality scattering properties, and designing spaces with natural air circulation **[4]**.

1.1.3 Statistics of Wind and Solar System in Bangladesh

The small portion of energy demand of Asian country part stuffed by star electrical phenomenon (PV) system and therefore the point read of Bangladesh in perspective of radiation 241 0' 0″ N range and 901 0' 0″ E line of longitude. The gross production of alternative energy in Bangladesh is 500 MW and the total percentage of renewable energy 39.5 percent **[6]**. Bangladesh state-owned infrastructure development company restricted (IDCOL) have already put in 3 million solar home systems (SHS) by providing clean energy over thirteen million of the agricultural population. Bangladesh receives a median daily radiation within the vary of 4-5 kWh/m. The new mega electricity project vision 2021, enforced by Prime Minister’s electricity. International post quotes that Asian country put in over 50,000 SHS (Solar Home System) and Bangladesh is that the quickest growing nation round the world **[6]**.

The world is developing rapidly in renewable wind energy, and turbines are being used to convert wind energy into electrical energy. Bangladesh has produced 900 kW of wind power at Sonagazi Mukhuri Dam in Feni and a 1,000 kW hybrid power plant on Kutubdia Island; Grameen Shakti, Bangladesh Advanced Research Center (BCAS), BRAC, Bangladesh Army, IFRD A total of 19.2 kilowatts of electricity have been installed in various coastal areas of Bangladesh. The electrification of wind turbines in Bangladesh requires further feasibility studies. However, BPDB recently identified 22 wind power and onshore wind farm locations in the coastal areas of Bangladesh. In addition, BPDB has designed a 50,200 MW Anawara wind farm in the Chittagong area, and a 15 MW wind farm in Feni Mukhuri Dam, Mognamaghat Cox's Bazar, Anwara Beach Parks in Chittagong, Kepupara of Borguna and Kuakata in Patuahali **[6]**.

1.2 Objectives

The usage of hybrid renewable energy system is significantly important for the world since worldwide energy utilization is expanding day by day, while existing energy sources are not sufficient to meet the power demand **[4]**. A hybrid renewable energy system can be profoundly efficient by combining renewable energy sources (solar, wind) and is regarded as a perfect explication over the issue. According to the Sustainable Advancement Situation, Renewable energies will represent more than 30% within the worldwide energy mix by 2040 **[2]**. According to our world in data, we can see the breakdown of renewable technologies by their individual components – hydropower, solar, wind, and others.

Bangladesh cannot sustain a fast rental power station project for an extended time. So, it has become inevitable for us to create a different scope of producing electricity to fulfill the demand. In Bangladesh, Hybrid energy system happening in St. Martin Island but we want to use it in some basic area level **[1].** There is plenty of sunshine during the day, which is a huge bless for Bangladesh because it averages about 4.5 kWh/m2/day per year and the annual average wind speed is 3.10 m/s **[2].** Therefore, the hybrid system is one of the best choices for future to provide power demand.

1.3 Social Impact of the Project

The power supply system basically designed to get optimal reliability for the future of power sector. Power supply depends on alternative energy sources and backups like energy storage sub-units as applicable to hybrid renewable energy power. The term hybrid means a mixture of two or more different unit with about same results for a specific purpose. A hybrid solar renewable energy sources is always good to supply a ruler community with reliable electricity for a long term **[3].** Hybrid resources that can be improved by connecting energy storage devices so that the energy converters are protected by energy storage devices to achieve a loss energy supply from zero. As we want to implement this in various sectors thus some impacts can be are:

- This is a onetime implementation. Once it’s set, can be used for long time with no more costing more than 20-25 years **[4].**
- Rural areas in which no electricity for more than month to month due to natural calamities problem can be solved with this implementation.
- As this project is hybrid renewable energy based, so energy can be produced from both solar and wind. If anyone of them gets weak or damaged then other can be used as the backup supplementation.

- This is environment friendly and suitable to use.
- This is basically a low-cost plan.

1.4 Thesis Outline

This thesis consists of five chapters organized as follows:

- **Chapter 1** represents an Outlines of renewable energy, it's objectives and social impact of the project.
- **Chapter 2**, gives a comprehensive literature review on general adequacy assessment, which are introduction to wind turbine and solar panel.
- **Chapter 3** describes about the circuit diagram and explanation of the project. This chapter includes introduction of block diagram, flow chart, circuit diagram and explanation of the project.
- **Chapter 4** includes about a section methodology which gives detail about used components in project, introduction to hardware module, block diagram, circuit setup, explanation of circuit setup and the load calculation.
- **Chapter 5**, conclusions and summary of this thesis project are highlighted and some future works are also added at the end.

Chapter 2

Solar and Wind Energy Systems

2.1 Wind Energy Systems

2.1.1 Introduction & Background

Power problems are one of the serious difficulties to the world's surroundings. In Washington Archive, a large number of articles on renewable energy resources and demanding elements for upcoming energy sector are placed nicely **[5]**. In that archive, wind energy told to be the fastest growing sector for renewable energy. Some experts believe that this trend will need many research and development, as well as a national contribution to give the technology an economic stronghold. The best time for wind energy began in the late 1970s and the first wind turbines told to be found in California in the 1980s. Today the industry is growing day by day worldwide **[3]**. "It is growing because it has become the most economical renewable energy source due to the tremendous growth in the market," he said. Now the costs are between some cents per kilowatt/hour, so we have maintained wind costs in a systematic way over the past decades "to bring them into a competitive range with some conventional technologies."

2.1.2 Working of Wind Energy System

Almost every wind turbine is made of three rotor blades that are mounted on a tubular steel tower. Variants with two wings or with concrete or steel lattice towers are less common. At 100 feet or more above the ground, the tower allows the turbine to move. Benefit from the higher wind speeds at higher altitudes. Turbines capture energy from the wind with their propeller blades, which act like an airplane wing. When the wind blows, it forms a low pressure airbag on one side of the blade. The low pressure airbag pulls the blade towards itself, causing the rotor to turn. This is called a lift. The force of lift is much stronger than the force of the wind against the face of the blade, which is known as drag. The combination of lift and drag makes the rotor turn like a propeller. To increase the rotor's speed, a group of gears are used and the significant speed of the rotor allows the turbines generator to produce alternative current.

2.1.3 Types of Wind Turbine

Wind turbines are mainly two types -

I. Horizontal axis

II. Vertical axis

I. Horizontal Axis

Wind turbine with a horizontal axis, the rotor shaft rotates horizontally. The figure shows an arrangement of a machine with a horizontal axis. This system builds with a mounted rotor with more than two blades that face the wind, spins around a horizontal axis, and an electric spinning generator. Blades made of composite material and reinforced fiber plastic due to their heavy strength and less weight. Windmills are manufactured in European countries also other parts of the world with an output of a few kilowatts to several megawatts **[10]**.

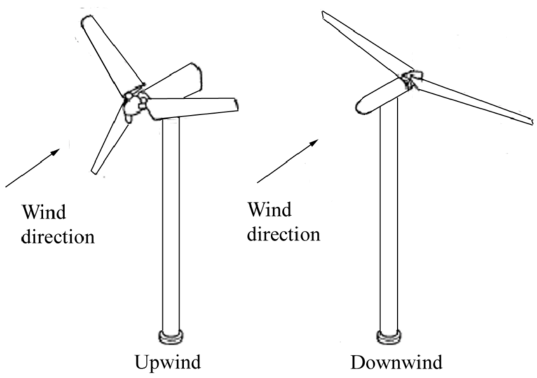

Fig 2.1: Horizontal Wind Turbine [14]

II. Vertical Axis

In wind turbines with a vertical axis, the rotor shaft runs vertically **[4]**. The build function of the tower is easy here as parts can be used near the ground below.

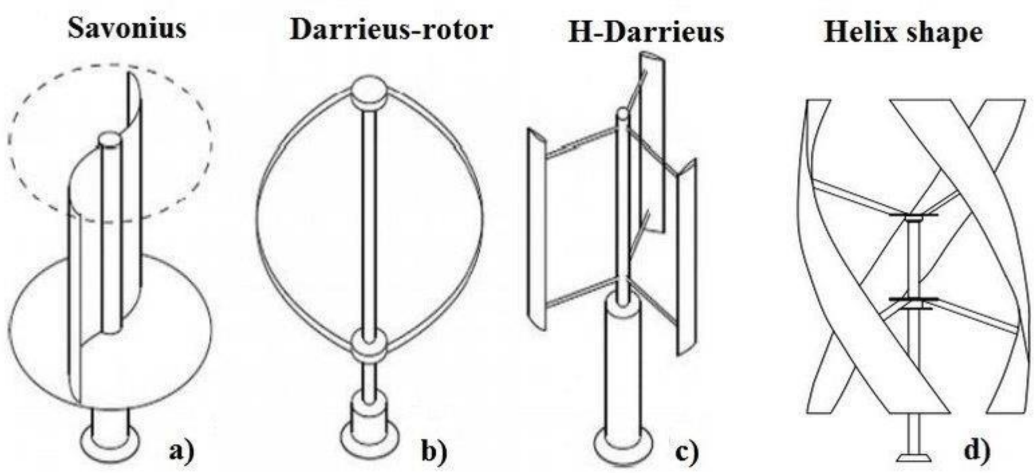

Fig 2.2: Various Axial Types of Wind Turbine [14]

Vertical axis can be divided into two types -

I. Darrieus

II. Savonius

I. Darrieus Rotor

This turbine requires less area. It mainly shaped as an egg beater with two or three bladesshaped.

II. Savonius Rotor

Savonius turbine is more like S-fashioned regarded from top.it turns rather slow, however had excessive torque used for grinding.

2.1.4 Site Selection for Installing Wind Turbine

In a wind turbine farm, many turbines are connected with each other in order to produce electricity for the public network. Electricity is sent to consumers through transmission and distribution factor. The suitable location for a wind turbine is an area with frequent strong winds. On a global scale, NREL will create wind maps that contain wind speed data measured at monitoring stations throughout the year weather models **[7].** For some locations, the average wind speed will calculate wind energy. According to this wind energy calculation, a small geographical area is assigned to wind energy categories from one to seven. This information will help to determine the best areas for wind farm development. Plots with a wind energy rating of 3 or higher are suitable for the construction of wind farms. Small wind turbines can be installed onland of level 2 or higher**.** The main reflections in site selection for WECS are mainly focused on its economic, social environment & other considerations. Some of the notable specifications for site selections are:

a) Location where the available high average wind speeds are in the 6m/ s to 30m/ s range all year round, as the power developed is proportional to the cubic of wind speed. The minimum wind speed at the selected location must be greater than 3.5 to 4.5 m / s, this is the lower limit at which the current wind turbine begins to rotate, which is referred to as wind speed.

b) WECS should be far away from cities and forests, because buildings and forests will obstruct air flow. There should be no tall buildings within 3 kilometers of the installation site.

c) The soil surface must have high soil strength to reduce foundation costs.

d) The installation should be far away from residential areas to prevent the noise generated by windmills from affecting residents in the surrounding areas.

2.2 Solar Energy Systems

2.2.1 Introduction

Solar panel is a structure of direct solar energy, which is used describe how solar panels use solar energy. Solar panel receives rays of the sun and directly translates it into electrical energy **[11]**. Solar cells or PV cells are basically organized in a grid on form in the upper surface of the solar panel. The solar panel receives the sunbeam and stores the energies in the batteries which further reshapes to electrical energy. PV panels are usually made of crystalline silicon, which can be used in the manufacturing places like the microprocessor manufacturing sector as well as the more demanding Ga. Specializing in the manufacture of arsenic compounds for photovoltaic (solar) cells.

2.2.2 Working Principles of Solar System

Solar panels directly collect solar radiation and transfer it into electrical energy. The solar panel consists of several independent solar cells. These solar cells work like large semiconductors and use large-area p-n junction diodes. In sunlight, p-n diodes convert solar energy into usable electrical energy **[4]**. The energy produced by photons hitting the surface of the solar panel causes electrons to escape from their orbits and is released as the solar cell's electric field pulls them out. The free electrons in the directional current of the metal contacts in the solar cell can be used to generate electricity. If the amount of PV cells in a solar panel more/ larger, the greater the attribute of the solar cell and the higher amount of electricity the PV panel shall generate. The transition from sunbeam to useful electrical power energy is called the photoelectric effect **[9]**. The photoelectric effect is caused by the p-n diode's characteristics because the solar panel does not contain any moving parts.

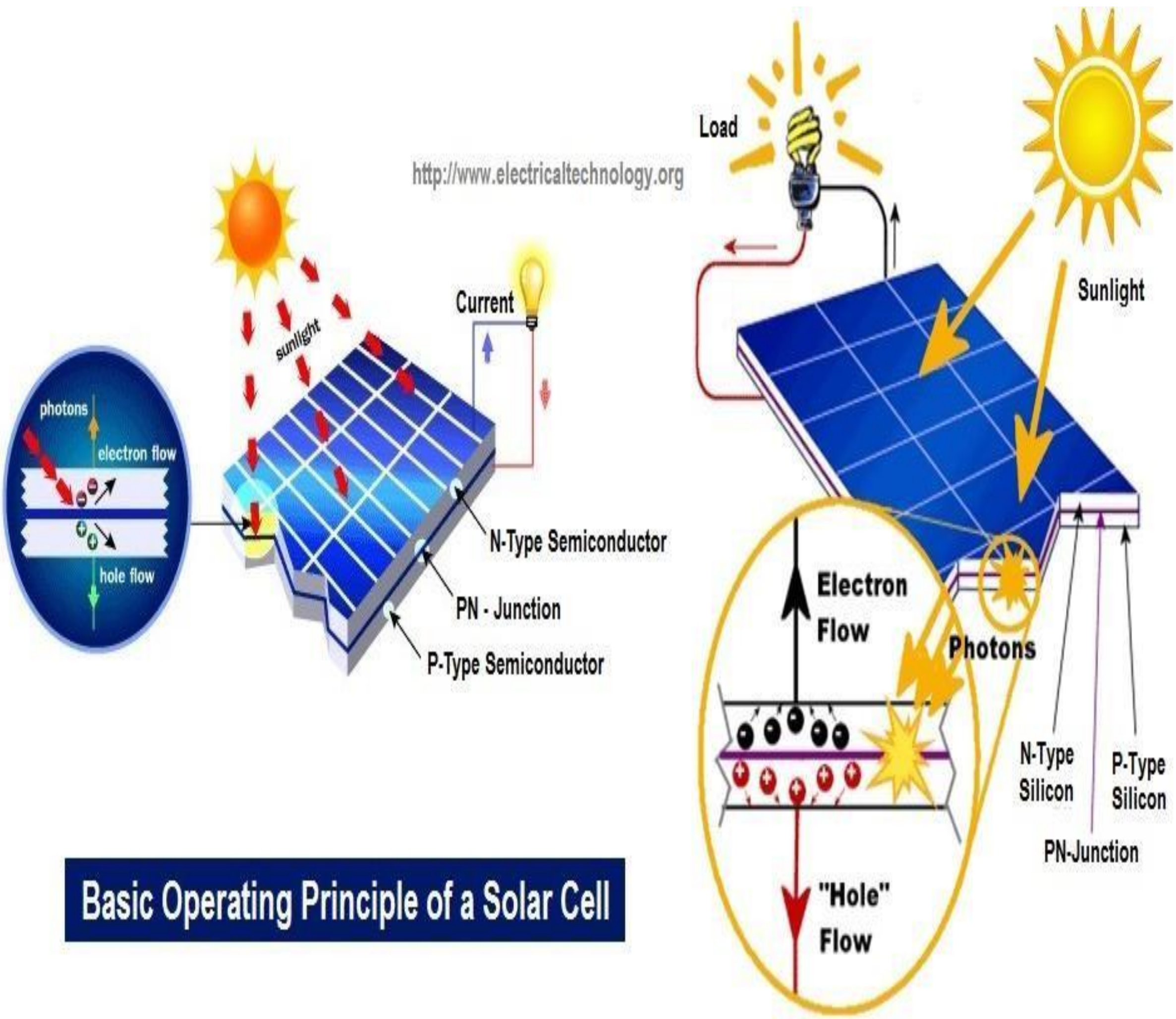

Fig 2.3: Operating principle of solar panel [11]

2.2.3 Different Kinds of Solar Panel

I. Monocrystalline Panel

Monocrystalline plates are built with crystalline silicon, which comes from a large sheet that has been cut to different size of the plate, creating a single cell. Metal strips are placed across the entire cell and works a conductor that traps electrons. Mono panels are slightly smaller and more effective than polycrystalline panels, but not more expensive than polyethylene panels **[11]**.

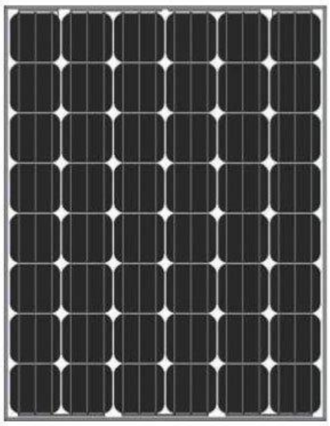

Fig 2.4: Monocrystalline Solar Panel [15]

II. Polycrystalline Panel

Polycrystalline plates built with small cells instead of one big cell. Poly are less efficient than mono panels and said to be cheaper than mono for the manufacturer, although they're very similar. There are several ways to make a polycrystalline silicon cell **[11]**.

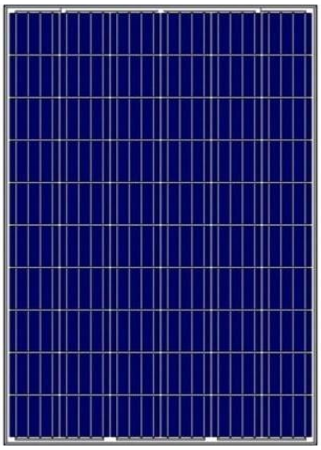

Fig 2.5: Polycrystalline Solar Panel [15]

III. Cast Poly-silicon

This process uses silicon into a large block that, after cooling it can be cut into thin layer for use in photovoltaic cells. These cells are group up into a plate and then conductive metal strips are placed over the cells which are connected together and form a continuous electrical current through the plate **[11]**.

Fig 2.6: Cast Polysilicon [15]

Chapter 3

Methodology

3.1 Required Components:

This section contains the details estimation of the components of our project. To do this project successfully, first we planned to make a hardware module combined with software part. We have designed a circuit module, where many kinds of devices are used with a microcontroller chip. To set-up the hybrid renewable energy system project, components that we used to make our project are as given below:

Table 3.1 Required Components List

Name of the Components	Rating	No. of the Components
Arduino UNO	Operating Voltage 5V	1
4- Channel Relay	Maximum Load: AC 250V/10A, DC30V/10A	1
Voltage Sensor	Min 0V Max 25V	1
LCD Display	5V	1
Boost Converter	Output Max 28V	1
Solar Panel	Max Power 18V	1
Wind System	Input Voltage 12V Rated Power 24 watts	1
Battery	12V, 1.3Ah/20HR	2
Switch	Max Voltage 250V	1
Inverter	220V	1
Breadboard	400 Tie Points	1
Jumper Wires	Male to female Port Female to Male Port	50

3.2 Hardware Module:

In this chapter, we will discuss about many components that we have used to establish this project. Some of the major components are discussed below:

I. Arduino:

Arduino Uno is basically a microcontroller card where Microchip ATmega328P is used. It helps to create electronic projects **[13]**. A physical programmable circuit board (which is called a microcontroller) and software or IDE (Integrated Development Environment) is used to conduct the proceedings of an Arduino UNO.

Fig 3.1: Arduino Board [15]

People who are starting to use electronic projects, they are very keen to use the Arduino platform for various reason. It is popular among them because of its uniqueness as it doesn't requisite any kind of individual hardware for writing the new codes. We can just use USB cable. A simplified version of C++, that is used in Arduino IDE to learn programming easily. Finally, Arduino provides a customary type issue which will divide the operate of the microcontroller into another package **[14].**

II. 4-Channel Relay Module:

The relay is used as an electrical switch which can be turned on or off while current is flowing and that can be monitored with a voltage as low as 5V provided by the Arduino pin. It is really easy to control the relay module with Arduino. It is consisted of four channels (these blue cubes). There are various models which have one, four and eight channels. It must be powered by a suitable voltage that is 5V for Arduino card. So, in our project, we used a 4-channel relay module to ease our work **[13]**.

Fig 3.2: 4-Channel Relay Module [15]

It is a 4-channel 5V relay interface board. Every channel requires 15 to 20 mA of current to drive it. Different kinds of high current devices are controlled by it. This is designed with a high current relay which can work at 250V AC 10A or 30V DC 10A.Because of its good interfacing function it can be directly monitored by a microcontroller.

III. Voltage Sensor:

The voltage sensor is a sensor which is used to compute and control the voltage value of the object. The voltage sensor can detect AC or DC voltage levels. Here, voltage is the input of the sensor whereas switch, analog voltage signal, current signal or audio signals are the outputs. **[14]**.

Fig 3.3: Voltage Sensor [15]

A sensor is a device that recognizes certain types of electrical or optical signals and reacts to them. The execution of voltage sensors and current measurement methods has become an outstanding alternative for conventional current and voltage measurement techniques.

IV. Boost Converter:

A boost converter is basically a DC/DC converter that increases voltage (when current decreases) from power supply to load. It is a switching power supply that consists at least two semiconductors, namely a diode and a transistor, and at least one energy storage element: a capacitor, an inductor, or both.

Fig 3.4: Boost Converter [15]

For reducing voltage ripple, filters which are made of capacitors also sometimes combined with inductors which are usually attached to the output and input of the converter **[14].**

V. Inverter

An inverter is the opposite of a converter, which was originally a large electromechanical device that converts AC to DC. In our project, the energy that are stored in the reserve battery and alternative one is being converted to AC load by this inverter **[15].**

Fig 3.5: Inverter

3.3 Circuit Setup:

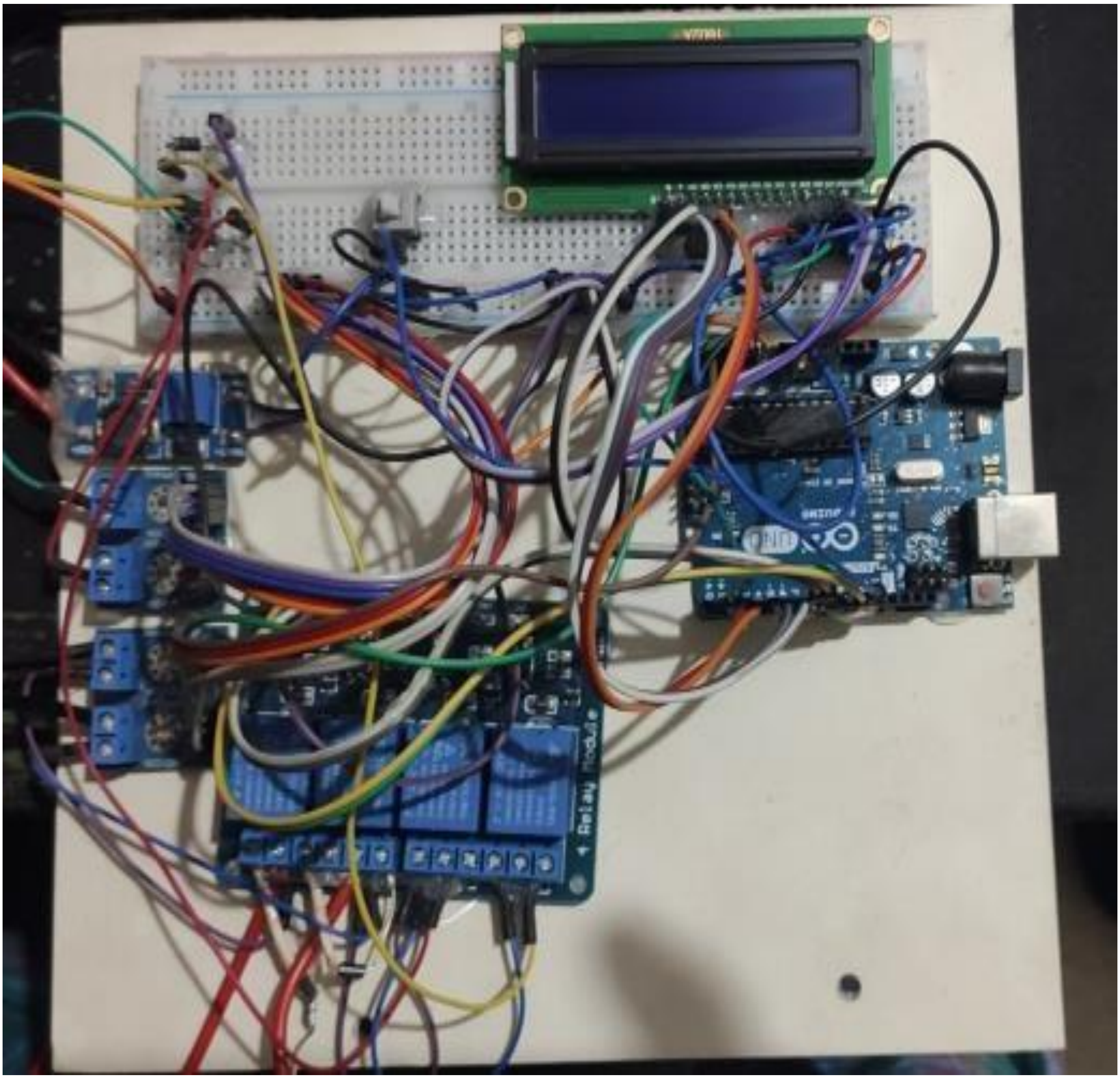

Fig 3.6: Circuit Setup

3.4 Explanation of Circuit Setup:

3.4.1 Planning:

For our thesis project work, we intended to do a project on renewable energy system with wind and solar. But as situation is not favoring us so we are doing this huge project to a miniature project which can further be implemented to many powers sector of Bangladesh by enlarging this miniature project. To do this miniature project, we bought some components mentioned above. But as wind turbine not available for us to use in this miniature project, so by the help of a DC motor we converted mechanical energy to electrical energy which we used as wind turbine.

Table 3.4.1 Price of the Components Used

Components	Total Number of Components	Price(Tk)
I. Arduino UNO	1	800
II. Voltage Sensor	4	270
III. 4 Channel Relay	1	400
IV. Boost Converter	1	450
V. Solar Panel	1	1450
VI. Wind Turbine	1	2500
VII. Battery	2	3000
VIII. LCD Display	1	160
IX. Switch	1	5
X. Inverter	1	700
XI. Breadboard	1	120
XII. Jumper Wires	50	50
Total Cost:		**9905**

3.4.2 Implementation:

From planning part as we mentioned to do a miniature project so to build the circuit setup, we connected solar panel and wind turbine to a breadboard. By the help of breadboard, the energy generated from solar and wind turbine is stored in two of the batteries (reserve and alternative one). An inverter is connected with the batteries to supply power to the AC loads. As this project is a smart project system, so we used a microcontroller which is Arduino UNO. This microcontroller assists us to observe whether the batteries are charging or getting discharged, when power is being supplied to the load from the batteries. In addition, voltage sensors are used to calculate and monitor the voltages. We used 4-channel relay module as switching purpose. While sensing voltage with voltage sensor, if the main battery supply power voltage becomes <10V then power supply will be turned off from the main battery power supply.

Then it will look whether the alternative one can supply the power to the load or not. If alternative meets the demand of supplying >10V the power supply will automatically resume. But again, if the alternative battery's supplying voltage becomes <10V then automatically power supply will shut down and only batteries will be charging at that moment. Normally, batteries will be charge and discharge simultaneously and again power is supplying to the load from the batteries. Whenever power supply demand is greater than power generation then this above tripping phenomena will occur. This whole process will be displayed in an attached LCD crystal display **[17]**.

Fig 3.7: Complete Circuit Setup View

Chapter 4

Circuit Diagram and Explanation

4.1 Introduction of Charge Controller

We use relay as charge controller for our project. We know that charge controller regulates the direction of power from the producing end to the batteries and load. Controller can keep the batteries completely charged without overcharging**.** When the AC load side consumes electricity, the mechanism turns out that the controller allows the AC load side to flow from the producing end to the batteries, the AC load side, or two of them together. When the controller determines that the batteries are completely charged, it will reduce/ stop the transmission of electric power from the generating side. When the AC loads have drawn too much power from the batteries and stop flowing until the batteries are sufficiently charged again **[12]**. This last feature can significantly extend the life of batteries. The main heart of solar systems is required to observe and control the energy that goes to and fro to the battery. To make sure whether the batteries overcharging or not the way we can organize it by managing the generation of power by the solar panel. The charging controller should also ensure that connected AC loads do not overcharge and damage the battery of solar panels. Solar panels usually emit 15-17 volts and the charge controller converts this to 12-14 volts and charges the battery. The battery often requires a higher voltage than it already needs to charge the battery.

The charge regulator prevents the batteries from being overcharged and it stops loading when the batteries are completely charged and that will provide higher battery efficiency. Failure to use the charge controller damages the battery. If we are planning to use large solar panel system, the best one is to have an advanced charge controller. This will provide us comprehensive data's on how many volts & amps the battery has charged. Advanced charge controllers will notify us the amperage in the batteries

[1]. The charge controller can automatically disconnect the battery when it becomes empty. For larger systems such as pipelines or water pumps, high pressure charge controllers are used called MPPT (Maximum Power Point) which can convert DC-DC voltage.

4.2 Systematic Block Diagram:

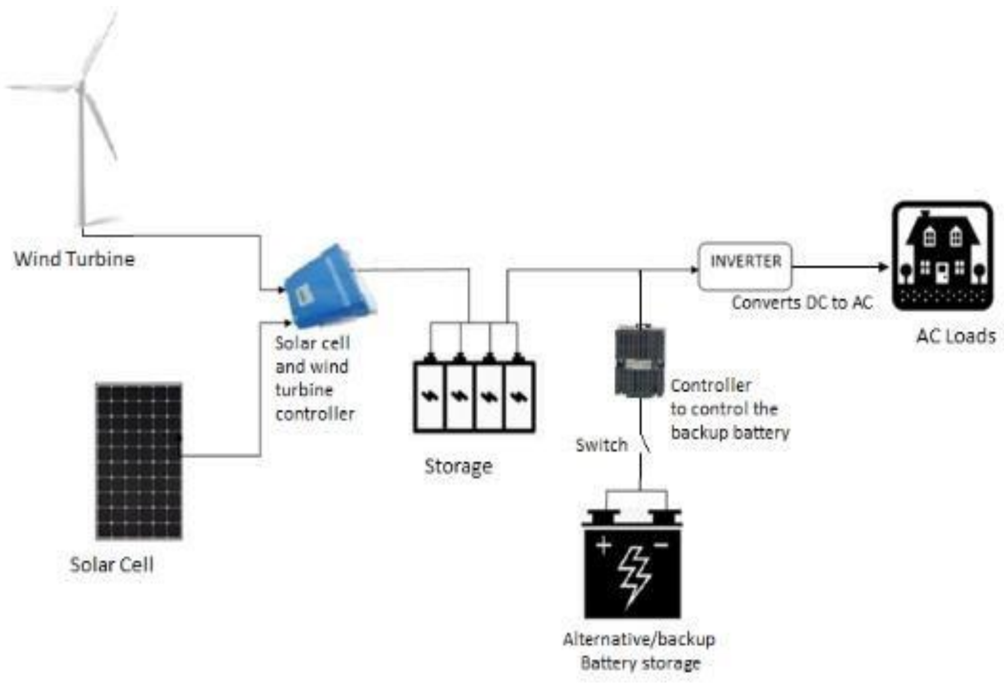

Fig 4.1: Systemic Block Diagram

4.3 Block Diagram:

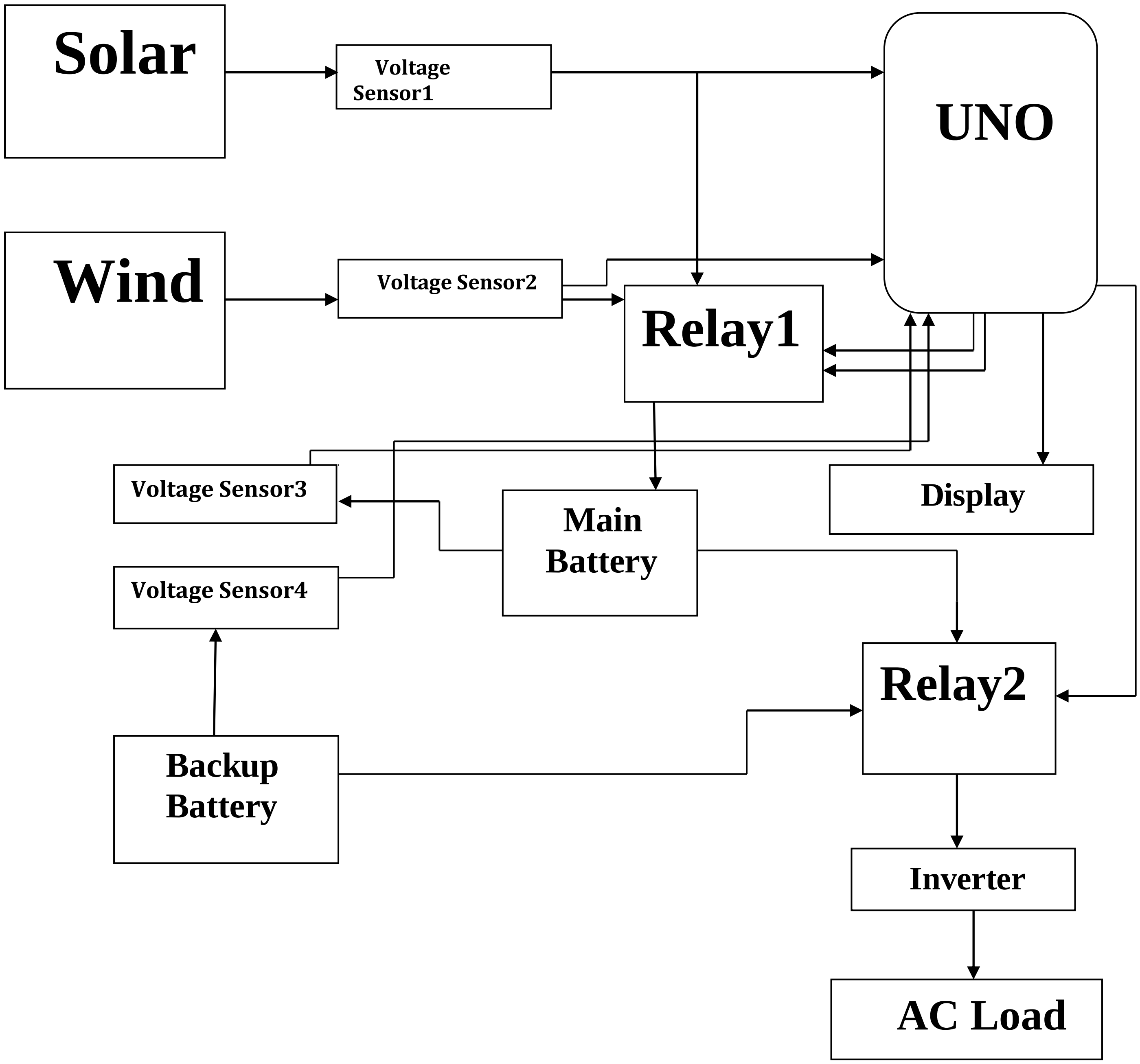

Fig 4.2: Block Diagram

4.4 Flowchart:

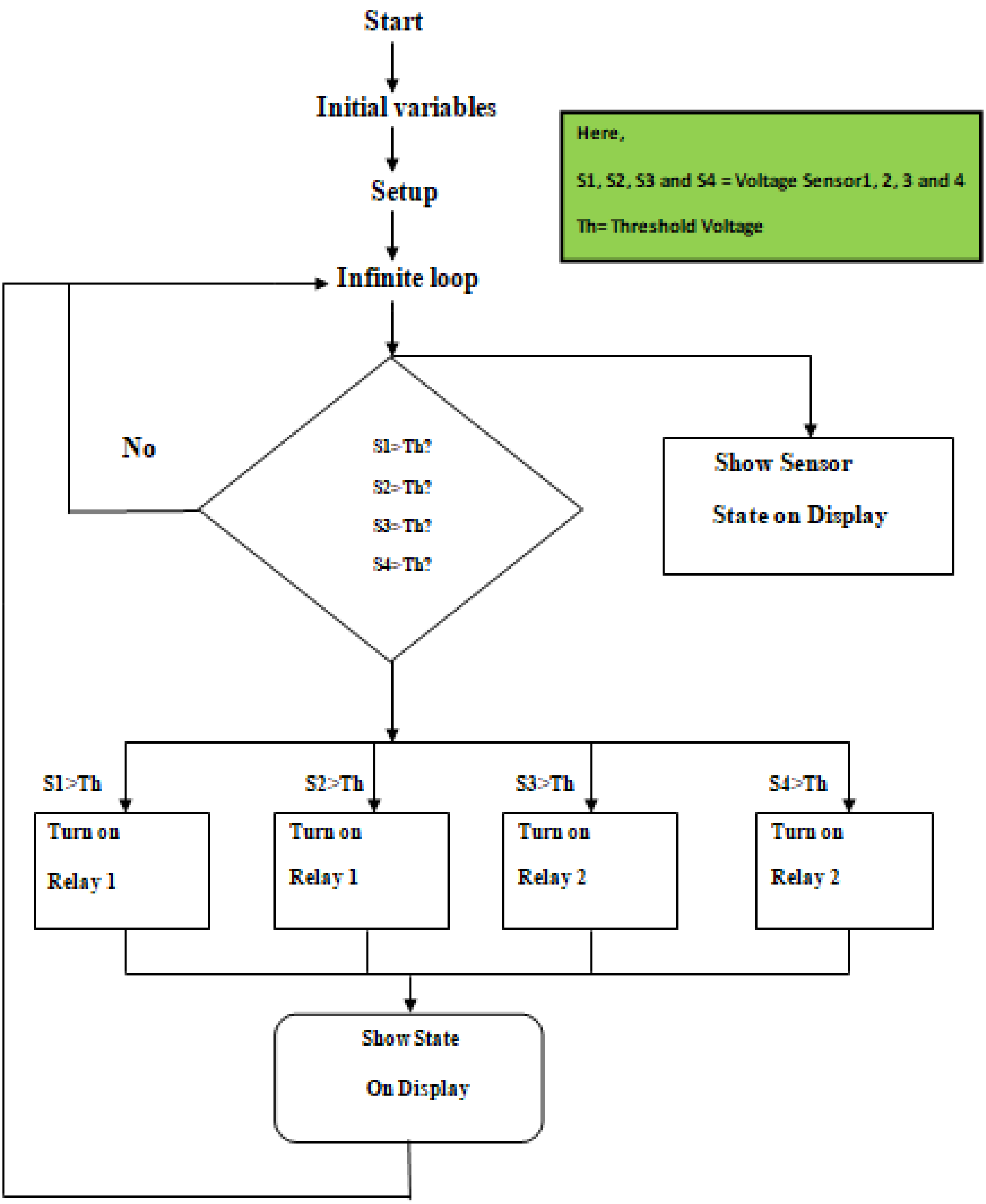

Fig 4.3: Flowchart of the System

4.5 Circuit Diagram (Simulation):

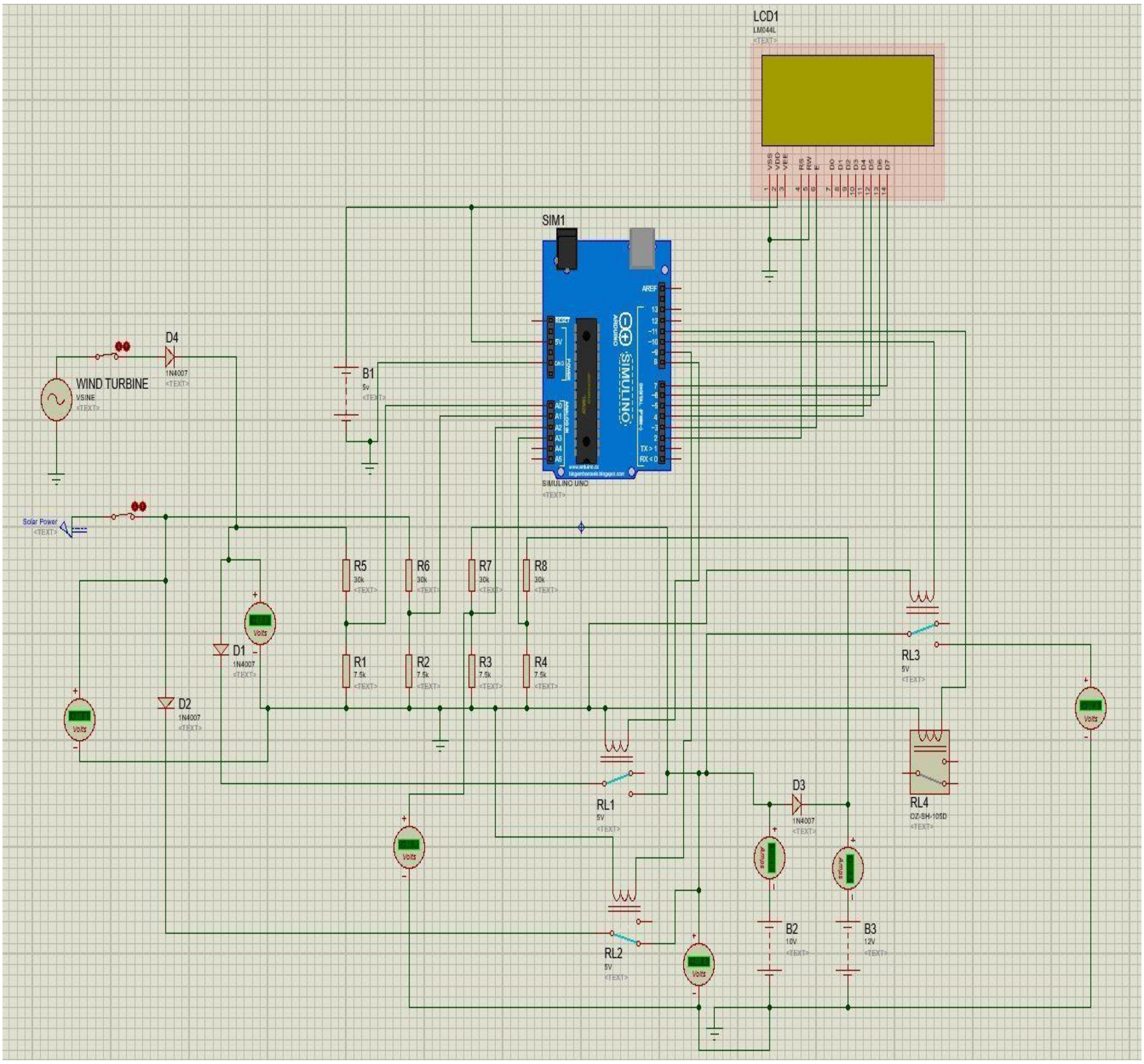

Fig 4.4: Proteus Simulation of Full Circuit

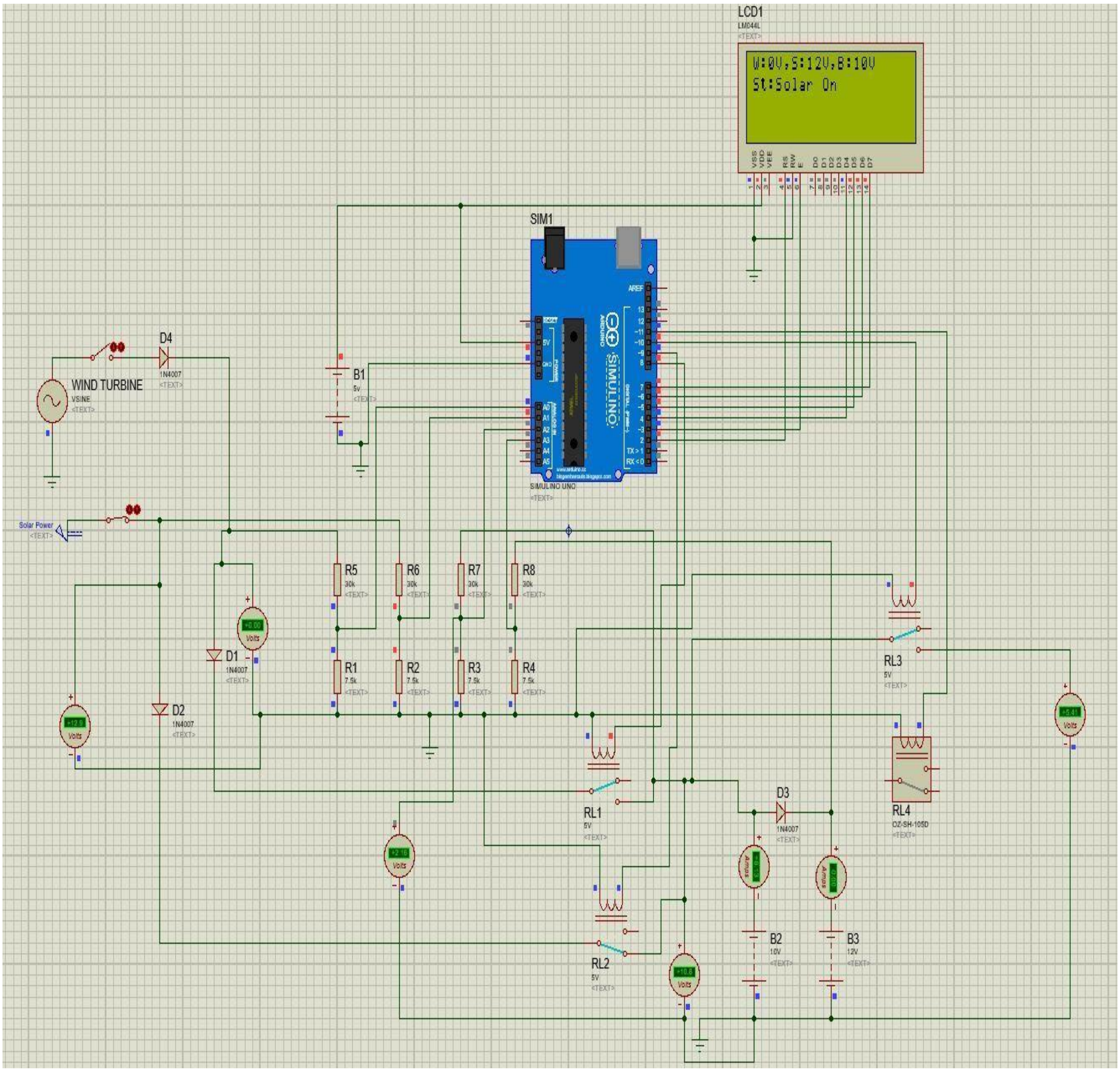

Fig 4.5: Solar Panel ON Mode

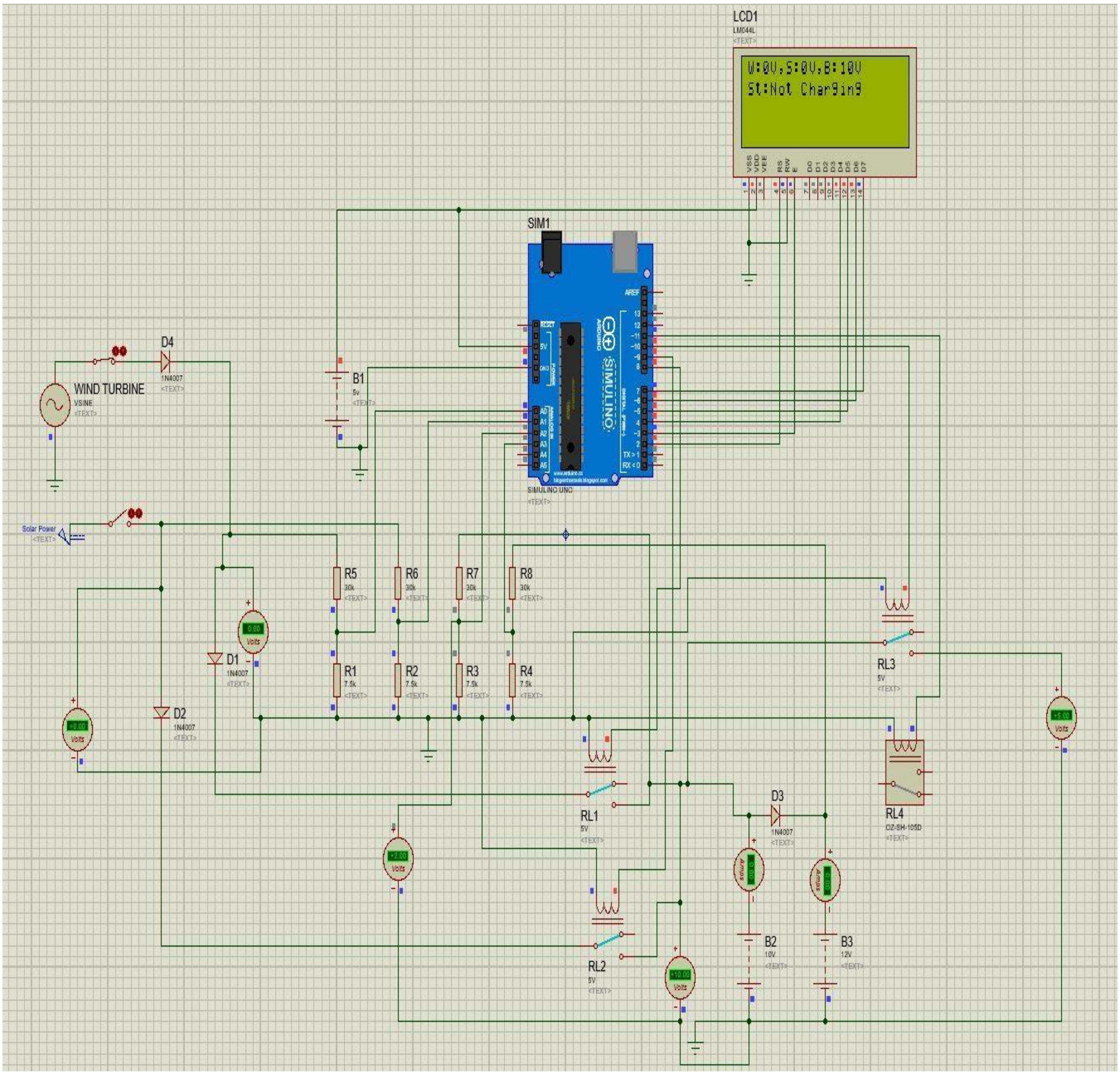

Fig 4.6: Wind Turbine ON Mode

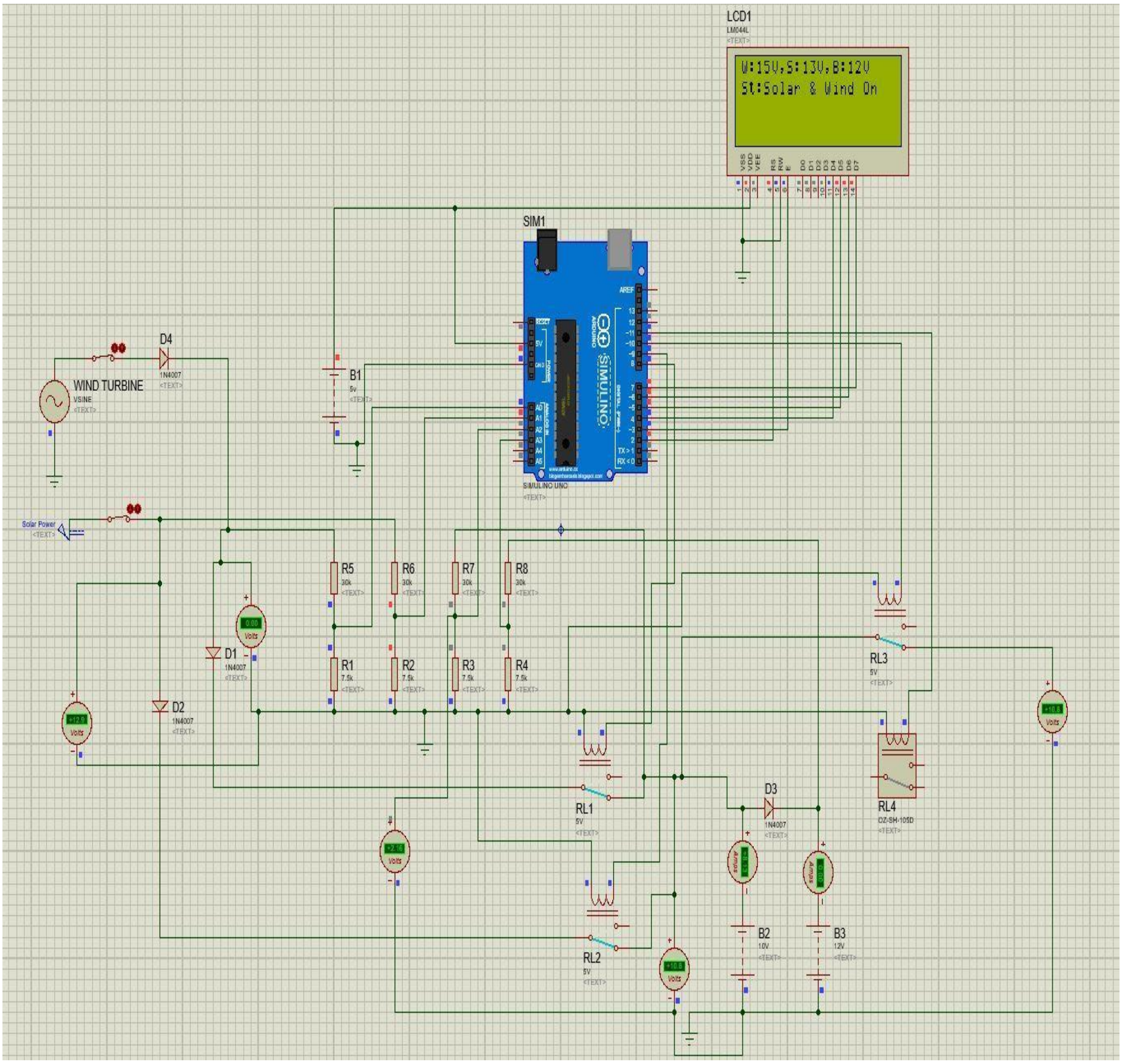

Fig 4.7: Wind Turbine and Solar Panel ON Mode

4.6 Explanation and Implementation:

We wanted to make a renewable hybrid energy system using both wind and solar thus our simulation part begins. At first, we try to make the diagram in proteus simulation with both solar and wind turbine **[12]**. For the simulation part as we want to show our current status for both wind and turbine therefore, we used a lcd display. Furthermore, we used an extra battery as backup in case our main functional battery faces any shortage of power. We used an ammeter with the battery to see if it was charging or not. Now, if we turn on the solar panel, we can see the status ON in the display as well as on the ammeter it will show positive volts which mean our main battery is charging with solar power. Now if we start the wind turbine, we will also see the variation on the ammeter as the voltage we get from the wind is not constant. Finally, if we start both wind and turbine together it will show the status on the display and both of them continuously will charge the battery. We used relay as a switch or charge controller to manage the charging system of the battery for both wind and solar turbine and used voltage sensor1, voltage sensor2, voltage sensor3 and voltage sensor4 with Arduino UNO to show the voltages of battery in the display.

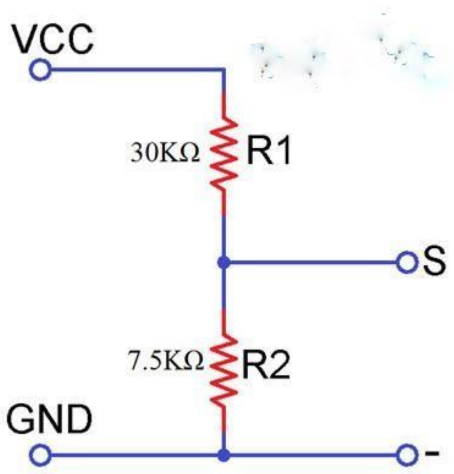

Fig 4.8: Voltage Sensor Circuit Diagram [6]

Vout = (analog Read* 4.092 / 10)

Vin = Vout * (R2/(R1+R2))

After completing the simulation part at proteus, simulation then comes the coding part to run the simulation without any problem. We did our code in Arduino and for the lcd display we used <liquidcrystal.h> library and connected it with Arduino pin (2-7). For solar, wind, main battery and backup battery, we define three int value for relay and connected with Arduino pin 9,8,10,11. Furthermore, for the load section we add a switch with the variable of “sw” and connected it with Arduino pin 12. After that we declare the three relays as output and make them HIGH for primarily turn them off. Now in the loop we used voltage sensor interface to get the Vout value for wind, solar and battery.

Here, the declare variable is-

wind=wind out

solar= solar out

bat1= batt out

bat2= batt1 out

When we started the inverter for the load at first, we turn ON the switch now our main battery is in use and if (bat1>10) than in the display it will show bat1 load is ON or else it gives us the indication that bat1 is low and the backup battery(bat2) need to be active. Furthermore, it will now check if (bat1<9 && bat2>10) bat2 is greater than 10 volts or not. When bat2 is greater than 10 volts than our bat2 load will be on however when both bat1 and bat2 is less than 10 volts bat-relay will be High.

Now, if (wind>=10 && solar<10) wind output is greater or equal than 10 volts and solar output is less than 10 volts that’s mean wind relay will be ON and it will charge the battery.

Again, if (wind<10 && solar>=10) wind output is less than 10 volts and solar output is greater or equal than 10 volts than solar ON will be shown in the display and solar panel is ready to charge the battery.

Again, if (wind>=10 && solar>=10) wind and solar both generate more than or equal 10 volts then both will be able to charge the battery efficiently.

Finally, if both solar and wind failed to generate more than 10 volts than our backup battery will be started as a load.

Chapter 5

Result and Analysis

5.1 Load Profile & Load Calculation

Table 5.1: Solar Panel Rating

Specification	**Value**
Model	T-16P
Maximum watt power	15W
Short circuit current	0.92A
Open circuit voltage	21.8V
Maximum power current	0.83A
Maximum power voltage	18V
Weight of panel	1.4kgs
Irradiance	1000W/m^2

Table-5.2: Wind System Rating

Specification	**Value**
Rotor blade diameter	6.5 inch
Number of blades	3blades/ horizontal axis
Cut in/ cut off wind speed	17m/s
Rated power	24 watts
Rated voltage	220V AC
Input Voltage	12V
Input Current	2 Amps

Table 5.3: Detail Load Calculation

Appliance	**No of units**	**Power consumption of each unit(w)**	**Power (W)**	**Hours of Use**	**Daily Power consumption (Wh/day)**
Light bulb	2	5	10	5	50
Table Fan	1	10	10	3	30
Mobile/Power bank Charger	2	4	8	.5	4
Electric Doorbell	1	2	2	0.0833	0.0167
Electric mosquito killer vaporizer	1	5	5	1	5
Total			**35**	**9.5833**	**89.0167**

5.2 Discussion

We have used a 12V Battery with 1.5 Ah rating, which gives 18-watt power supply per hour. This battery will give backup for 20 hours. In our project we estimated backup time for 10 hours and output 35-watt output as well. We used an inverter which has maximum power output 60 watt. We considered two 5W energy bulbs, a small table fan, power bank & mobile charger, doorbell, Electric mosquito killer vaporizer as load. Details load calculation is given in above mention table tables.

Chapter 6

Conclusions and Future Work

6.1 Conclusion

For remote areas around the world, hybrid systems are considered a viable alternative to utilities or traditional fuel-based electricity. However, the demand for clean energy and improved alternative energy technologies has great potential for the widespread use of such systems. In order to ensure the widespread adoption of this new technology, solar photovoltaic and wind energy technologies need to be further developed and improved to reduce the cost of hybrid power systems.

Firstly, to start the project we need to generate power. For this generation of power, we need to use wind turbine and solar panel. But while looking for a wind turbine, we cannot find it in miniature way so we used a DC Motor as wind turbine. The Arduino is used as a microcontroller that works to trip the circuit on and off. We have also added the load calculations in details from the miniature project that proves we can use the project in bigger format. We have faced some troubles in coding while generating the hex files. Another difficulty we have faced, while using the DC Motor as the wind turbine when the motor rotates, we observed the voltage was fluctuating. For that reason, we increased the threshold voltage a bit in the coding. We have also faced problems in distributing the loads because the load we assumed was so high to overcome the problem for that reason we worked with the limited load that was possible to generate. After overcoming all those problems, we were able to finish the project successfully. We have also briefly discussed below about the upcoming future work as well.

6.2 Future Work:

By enlarging this miniature project into big scale, we want to implement this in any of the coastal areas of Bangladesh like Khulna, Patuakhali, Barisal, Noakhali and Chittagong. In those coastal areas, this project is a good solution to the shelter center's that suffer from power disruption problem for a long time due to natural calamities. Integrated power system (IPS) could be a solution here but if the power disruption is lengthy enough, then the IPS cannot meet the demand for long time power supply. We planned to implement this project in the midst of shelter center's only whereas we are also planning to do this in the educational institutions, hospitals and in other important places in the coastal areas. We are planning about to add hydropower with this smart hybrid renewable energy system where maximum output can be expected.

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Appendix A

(Software Simulation Code)

```
#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("V");

  lcd.print("S:");
```

```
    lcd.print(solar);
     //lcd.print("V");
       lcd.print("B:");
    lcd.print(bat1);
    // lcd.print("V");
    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 (500);
}
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
    (500);
 }
 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();
}
```