DESIGN AND ANALYSIS OF A HYBRID POWER CHARGING STATION FOR ELECTRIC VEHICLES AT PATENGA, CHITTAGONG

by

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CERTIFICATE OF APPROVAL

The thesis/project entitled as "**DESIGN AND ANALYSIS OF A HYBRID POWER CHARGING STATION FOR ELECTRIC VEHICLES AT PATENGA, CHITTAGONG**" submitted by **MD Mokarom Hossain Faisal** bearing Matric ID **ET163079** of session **Autumn 2016, Nurul Azam Ayan and MD. Ismail Hossain** bearing Matric ID **ET171085 and ET171058** of session **Spring 2017**, to the Department of Electrical and Electronic Engineering, International Islamic University Chittagong, has been accepted as satisfactory in partial fulfilment of the requirements for the degree of Bachelor of Science in Engineering and approved for the examination held on **22th JULY, 2022**.

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DECLARATION

It is hereby declared that this work has been done by me and no portion of the work contained in this thesis/project has been submitted elsewhere for the award of any degree or diploma.

MD Mokarom Hossain Faisal

Nurul Azam Ayan

MD. Ismail Hossain

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Author

ABSTRACT

As the number of electric vehicles on the road continues to rise, the issue of charging becomes more pressing. It is essential to construct charging stations (CS), which are analogous to petrol stations, in order to meet the demand for recharging and make things more comfortable for drivers. Research on a novel charging station design that makes use of renewable energy sources was conducted for the purpose of this article. In order to deal with the unpredictability, a hierarchical energy management system that is geared toward real-time application has been developed. MATLAB simulation was used in order to establish the appropriate size of the CS by taking into account many objectives, such as economics, the environment, and the degradation of the battery energy storage system. Electric vehicles get their power from their batteries, and these batteries may be charged using either traditional or alternative forms of energy. In this work, the DC Converter for battery charging system for electrical cars that utilize solar is discussed. It is proposed that the Greatest Power Point Tracking (MPPT) algorithm be used to boost the efficiency of the PV system. This would allow for the maximum exploitation of the sun's available energy. Electronics of Power Supply Controlling the process of charging a battery for an electric vehicle may be accomplished with the help of a voltage regulator. The MATLAB/Simulink Simpower Systems are utilized in order to do an analysis on a simulation of the aforementioned system.

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LIST OF ABBREVIATION

WPT	Wireless Power Transmission
NIMH	Nickel Metal Hydride
BAIL	Bangladesh Auto Industries Limited
BEVs	Battery Electric Vehicles
PHEVs	Plug-in Hybrid Electric Vehicles
HEVs	Hybrid Electric Vehicles
GHG	Greenhouse Gas
NDC	Nationally Determined Contributions
HOMER	Hybrid Optimization Model for Electric Renewable
NPC	Net Present Cost
COE	Cost of Equity
MATLAB	MATrix LABoratory
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
PWM	Pulse Width Modulation
SOC	State of Charge

CHAPTER 1

INTRODUCTION

1.1 Introduction

With increased concern about the harmful impact of emissions released to the atmosphere as a result of vehicle and fossil fuel consumption, it is vital to shift to alternate energy sources and place a larger focus on green technology development. The government of Bangladesh, a country with 20 lakhs vehicles and little governance, is under pressure to take actions to decrease CO2 emissions [1].

As a consequence of governments' increasing focus on renewable energy, the automobile industry is aiming to develop and distribute more electric and hybrid vehicles as a method of decreasing carbon emissions. This necessitates the use of appropriate vehicle charging systems. The focus of this research is to build and develop a grid-connected solar-wind hybrid system.

In recent years, the availability of limited fossil fuel reserves, climatic consequences, and greenhouse gas emissions have enforced a turn to renewable energy generation. The focus of this research is to build and develop a grid-connected solar-wind hybrid system. Solar and wind power, rather than hydro, thermal, ocean, and biomass energy, provide for the majority of contributions [2]. Due to recent developments in power electronic storage devices and lowering component prices, solar and wind power have become popular technologies for supplying electrical load in remote and off-grid places. According to reference [3] solar and wind energy are freely available in nature and are more advantageous than other power generation sources. Due to their unexpected and changeable character, the combination of solar and wind energies adds to the complexity, posing technological, environmental, and socio-economic issues [4]. Using mathematical models of diverse components and optimization techniques, a hybrid renewable energy system can be designed [5],[6].

This research is proposed to draw attention to the development of electric vehicle charging stations, as well as hybrid wind-solar power generation systems, in Bangladesh, which has a lot of wind-solar potential. Solar and wind energy potentials will be explored at several geographical locations in Bangladesh as part of this project, which will collect data from various sources. The specified locations will next be analyzed using a software program. The HOMER is a fictional character (Hybrid Optimization Model for Electric Renewable). The program is a micro power optimization model that may be used in a number of applications for both off-grid and grid-connected power systems. A hybrid wind-solar system provides a number of benefits. Combining solar and wind power producing resources boosts system stability and improves energy service, which is one of the benefits.

1.2 Motivation

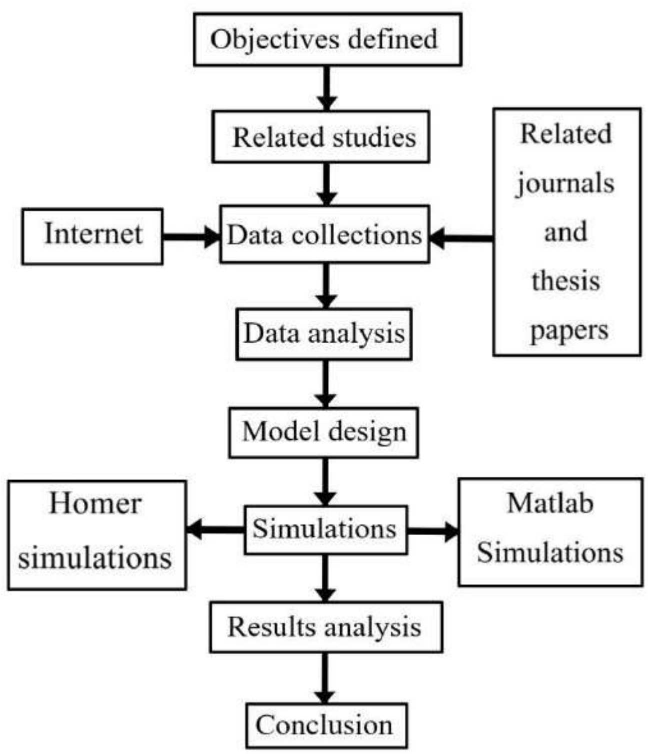
The global vehicle industry is undergoing a paradigm transition, with a trend toward less energy-intensive/clean energy solutions. The transportation sector is the second largest greatest contributor to global Greenhouse Gas (GHG) emissions, accounting for 23% of all man-made CO2 emissions. By 2050, it is widely agreed that CO2 emissions from the transportation sector must be reduced by at least 50%. According to Bangladesh's latest Nationally Determined Contributions, transportation would account for 8.33 percent of total GHG emissions in 2030. (NDC). Bangladesh may choose to refocus its efforts on making the shift to electric vehicles. Globally, electric mobility is on the increase, with more than 10 million electric two/three wheelers on the road as of December, according to the IEA's Global Outlook 2021. Electric two- and three-wheelers are the most common kind of e-mobility in Bangladesh. Bangladesh's electric vehicle sector is still in its infancy. The government is developing regulations to encourage more people to use electric automobiles. In the Mirsarai Economic Zone, Bangladesh Auto Industries Limited (BAIL) is constructing the country's first electric automobile manufacturing. They want to produce a wide range of cars, including two and three wheelers, sedans, hatchbacks, SUVs, and pickup trucks. Nitol Motor is also establishing a "Severe" electric vehicle assembly factory. They plan to build vehicles that can go 200 kilometers in half an hour of charge [7]. Electric cars are divided into three categories. The three categories of electric vehicles are battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs). Bangladesh will produce plug-in hybrid electric vehicles in the future. The lack of charging stations is the most common reason why consumers do not favor electric vehicles. Unlike petrol bunks, charging stations are not accessible everywhere. Only 14 EV charging stations with a total capacity of 278 KW [7] were available in our nation. And each charging station is 26365 km apart. As a result, there is always the concern of what will happen if the vehicle's battery runs out. As a result, we arrive at a method that relies solely on renewable energy to provide a simple and hassle-free charging station for electric vehicles. A universal charging station powers vehicle with diverse charging capacities, boosting demand for electric vehicles while also assuring dependability [8]. In order to pick the most ideal renewable-based charging station, we must first identify a region with abundant solar radiation and high wind speeds, as well as a large amount of generated electricity. We chose Patenga, Chittagong, as the location for this project. This is a significant Bangladeshi city with the highest wind speed and sun radiation.

1.3 Objectives

Main purposes of this work are:

1. To study about EV charging system.
2. To study about EV charging station.
3. To design a Renewable based hybrid power charging station for EV.
4. To simulate and analysis the design of EV charging station.

1.4 Methodology



1.5 Thesis Outlines

This research is proposed to draw attention to the development of electric vehicle charging stations, as well as hybrid wind-solar power generation systems, in Bangladesh, which has a lot of wind-solar potential. Solar and wind energy potentials will be explored at several geographical locations in Bangladesh as part of this project, which will collect data from various sources.

Chapter 1

This chapter includes the introductory discussion such as objective of the work, how the work is done with a superficial representation of the entire work.

Chapter 2

In this chapter extensive study is done on PHOTOVOLTAIC solar panel, wind turbine, converter, battery and different types of Electric Vehicles.

Chapter 3

Location selection, block diagram, HOMER simulation and charging circuit design in MATLAB are deeply discussed in this chapter. A system model also designed in this chapter.

Chapter 4

Detail analysis is done on the output found from the HOMER and MATLAB simulation.
Specific discussions are done on different result.

Chapter 5

Concluded the work by summing the results.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Electric cars (EVs) have gotten a lot of attention in the recent decade because of their vehicle characteristics as well as other benefits that conventional vehicles don't have. A large-scale deployment of electric vehicles can reduce total fossil fuel consumption, lowering greenhouse gas emissions. Furthermore, because they are more energy efficient than traditional internal combustion engines, they have lower operating costs. Recently, value-added uses of electric vehicles have been proposed and implemented, including supplementary grid services and electricity support for specific energy management systems. As a result, electric vehicles' economic performance can be greatly enhanced. The grid integration, particularly the adoption of renewable energy and electric vehicles, has been advocated and discussed well in some literatures. Due to the larger supply side than demand side, fluctuating renewable energy sources such as wind and solar require a fast-response energy buffer to offset their intermittency as well as to store the surplus electricity. Electric vehicles are thought to be the best resource for balancing and storing these renewable energy sources. The batteries in electric vehicles can absorb and release electricity from and to the electrical grid, allowing the system to be balanced quickly.

2.2 Photovoltaic Solar Panel

Photovoltaic (PV) devices use an electronic mechanism that occurs naturally in certain forms and may be integrated in an electrical circuit to generate power directly from sunlight which is shown in **Fig. 2.1**. A photovoltaic module is a group of solar cells that absorb energy and transmit it via a current to any device. These panels are connected to form solar arrays, which supply power to the gadget. This energy is stored in batteries, which allow it to be used whenever it is needed. These panels are joined to create solar arrays, which provide electricity to the device. This power is stored in batteries, which save the energy for usage when needed. Charge regulators govern these batteries, which are filtered by direct or alternating currents and can offer the proper balance for residential equipment that uses electricity. Sun panels must be considered in terms of energy conservation, which is directly proportional to solar irradiation. Depending on whether the circuit device is AC or DC, the energy produced can be preserved in a variety of ways. As a result, the battery that powers each AC or DC circuit is unique to each system. The distinction between AC and DC, which stands for Alternating Current and Direct Current, is vital to understand before attempting to make the greatest use of a stand-alone PV system. The latter produces DC current that is directly fed into an inverter, allowing the circuit's power to be utilized. The main difference is that electrons in a DC electrical circuit travel in one direction, but electrons in an AC electrical circuit alternate back and forth at a tremendously high rate [9]. There are two types of cell used to make photovoltaic solar panel, one is polycrystalline silicon and the other is monocrystalline which is shown in **Fig. 2.2**. Today's scientists and engineers are attempting to transform solar energy directly into useable heat or power. Today, there are two primary types of solar energy systems in use [10].

- Solar photovoltaic
- Solar thermal

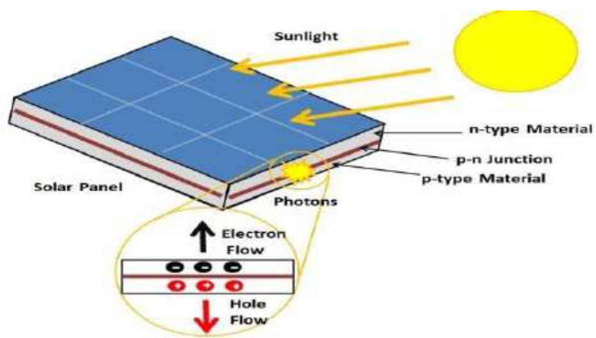


Fig. 2.1 A diagram showing the photovoltaic effect [10].

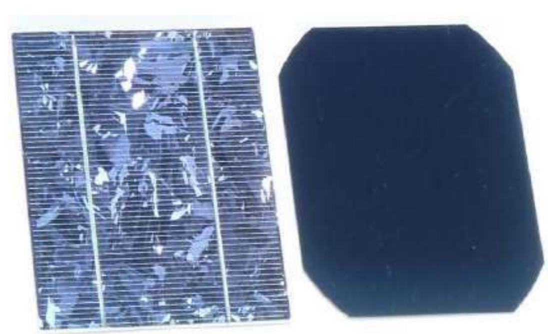


Fig. 2.2 A comparison of a polycrystalline silicon cell on the left and a monocrystalline silicon cell on the right (right) [11].

This contrast makes the AC more efficient since it has fewer losses while transmitting electricity over long distances when compared to DC power. Furthermore, AC voltage is easily convertible, but DC voltage is not. There are two basic solar panel battery technologies that may be used to save energy, but each has its own set of drawbacks. The first is the lead-acid battery, which is common and found in vehicles, and the second is the nickel cadmium battery, which is less common and less energy-efficient. Research has shown that the amount of energy produced by hybrid photovoltaic systems has risen considerably over the preceding decade as a consequence of their successful outputs. One of the assumptions, which many countries ignore, is that its capability is not only valuable for rural regions but will also be the future of metropolitan places [11].

2.3 Wind Turbine

Wind turbines are electric generators that harness the wind's energy and capacity to provide clean, emission-free electricity for farms, residences, and small companies. Individuals may make their own electricity with this simple technique, lowering their energy costs while also helping to safeguard the environment. Small turbines, unlike utility-scale generators, will be suitable for usage on private land in most parts of the nation [12]. Using these technologies in rural locations is simpler than in urban areas, contrary to popular belief, because you may avoid disagreements or concerns with residential communities or local owners associations. On the other hand, open locations apart from trees and buildings are significantly more likely to have a high average wind speed [13]. An American invention suggested by using a simple principle. The output of the wind turbine system is perfectly matched with the utility, so the output is fed into the home through the circuit breaker once the electricity is generated. The wind turbine and the utilities serve the dwelling with energy at the same time. It's vital to keep in mind that if the wind speed is less than 7 mph, the wind turbine won't be able to create any power and will have to rely on the utility for the rest [14]. As wind speed rises, so does turbine production, and the amount of electricity purchased from the utility falls. The extra energy is sold to the utility when the turbine production exceeds the house's demand. This strategy is finished! Modern residential wind energy system Furthermore, although the average house requires 1,0002,000 kilowatt-hours of power every month, the wind turbine cuts utility costs by 50 to 90 percent. A wind turbine with a capacity of 5 to 15 kilowatts may be necessary depending on the usual wind speed in the region. In many regions of the world, even larger wind turbines are now routinely constructed, financially competing with electric utilities in producing affordable, clean power [15]. Wind turbines are divided into two categories [16]. Wind Turbines with a Horizontal Axis (HAWT). Wind Turbines with a Vertical Axis (VAWT). These two types of wind turbines are shown in **Fig. 2.3**.

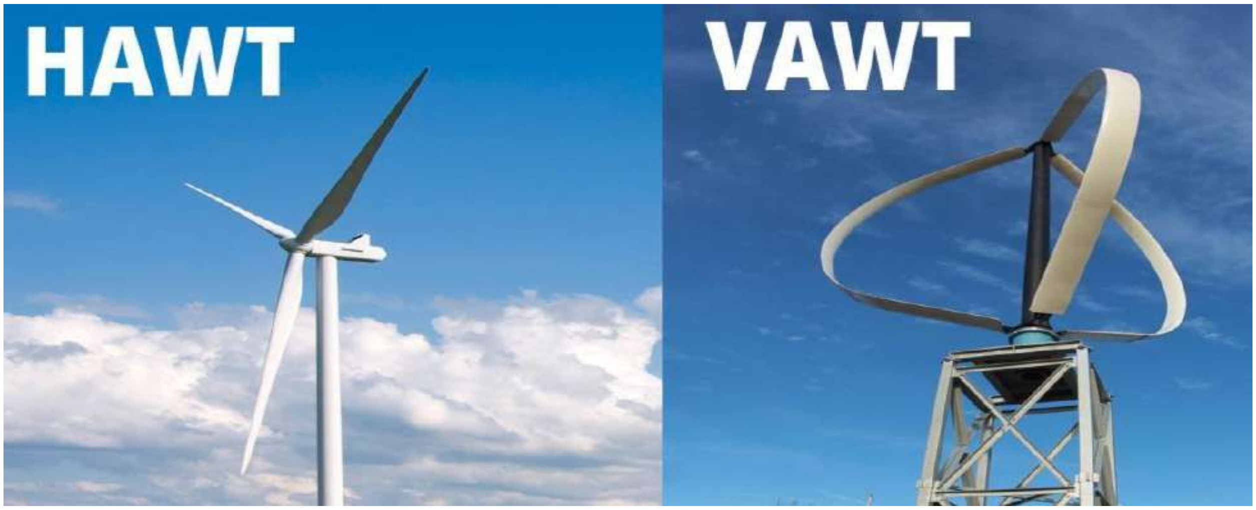


Fig. 2.3 Horizontal axis wind turbine (left) and Vertical axis wind turbine (right) [16]

2.4 Converter

A converter is an electrical device that converts DC to AC during inversion and/or AC to DC during rectification. **Fig. 2.4** shows the AC to DC converter circuit. The inverter capacity, or the maximum amount of AC power that the device can create by inverting DC electricity, is a decision variable that relates to the converter size. The rectifier capacity is a percentage of the inverter capacity, which is the highest amount of DC power the device can create by rectifying AC electricity [17].

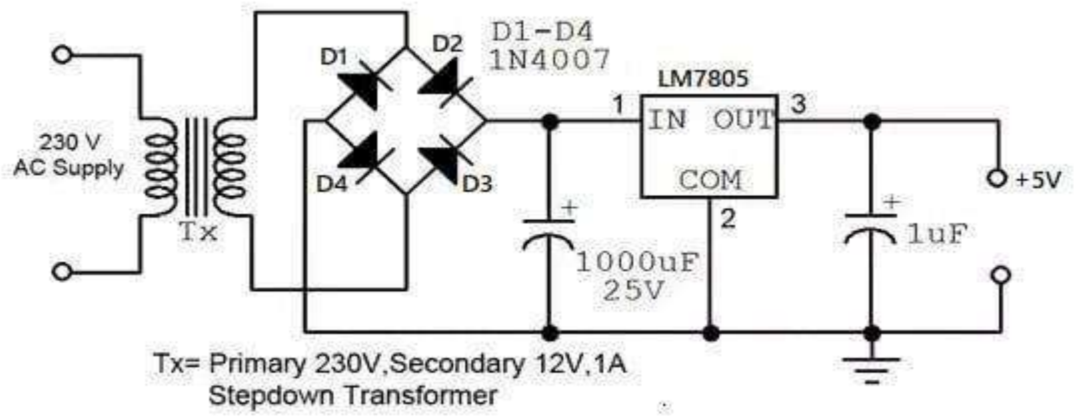


Fig. 2.4 AC to DC converter circuit [17]

The ultimate physical features of the converter are its inversion and rectification efficiency, which are thought to be constant. For this analysis, the inverter and rectifier efficiencies were estimated to be 90% and 85%, respectively. The capacity of the inverter was chosen as 10kW at a cost of 0.30 million dollars and a lifetime of 15 years. The cost of operating and maintaining the inverter is considered to be 1% of the total cost [17].

2.5 Battery

In order to power electric cars, a range of rechargeable batteries are currently accessible on global marketplaces (EVs).Because of its remarkable characteristics and performance, the lithium-ion (Li-ion) battery is the best of all battery kinds and cells. Because of its positive environmental implications and recycling capabilities, lithium batteries have sparked fresh research into creating Li-ion battery technologies. Cost-cutting, safe operation and avoiding negative environmental consequences are all becoming increasingly important issues for advancement. An Electric Vehicle charging station battery is shown in **Fig.2.5**. The state of the art in Li-ion batteries is examined in this article, which includes the basics, architectures, and overall performance of many lithium battery types. A battery management system for Li-ion battery storage in EV applications includes cell condition monitoring, charge and discharge control, state estimation, protection and equalization, temperature control and heat management, battery problem diagnosis, and assessment. Due to price reductions and lightweight with high power density, Li-ion batteries are becoming more widespread in automotive applications. On the other hand, the charging and discharging techniques, CO_2 and greenhouse gas emissions, health ramifications, and recycling and refurbishment procedures have yet to be adequately addressed. As a result, this analysis focuses on the numerous causes, obstacles, and issues, as well as recommendations for future EV battery manufacture. This assessment should result in greater efforts to produce a better Li-ion battery that fits the demands of automotive applications in terms of cost, longevity, specific power, energy density, safety, and performance.

Fig. 2.5 EV charging station battery [18]

Basically, all the electrochemical cells and batteries are classified into two types:

1. Primary (non-rechargeable)
2. Secondary (rechargeable)

These two sorts of batteries are the most fundamental, despite the fact that there are numerous different classes within them. Simply said, Primary Batteries are non-rechargeable and cannot be recharged electrically, but Secondary Batteries can be recharged electrically [19]. Consumers can choose from three different types of batteries. Alkaline, nickel metal hydride (NIMH), and lithium ion are the three types. Each form has advantages and disadvantages. Each has its own position in the technological world [20]. Lithium-ion technology is all the rage in the battery world. They are now a widespread source of power in a variety of daily devices, including computers, cell phones, power tools, and even vehicles. The necessity of dependable portable power is immense and continually increasing as technology improves, focused on speed, large data, and mobility. Rechargeable lithium-ion (Li-on) batteries are becoming more common as a power source for small and big cleaning machines at Tennant. Maintenance, longevity, charging speed, safety, and convenience of charging are the five criteria in which they excel. Before we get into the details, let's define lithium-ion batteries and go over some of the physics underlying them. Lithium-ion batteries can be recharged, but most lithium batteries cannot. Li-ion batteries have a longer life span and may be recharged hundreds of times. They have a higher energy density, voltage capacity, and lower self-discharge rate than traditional rechargeable batteries. A single cell's charge retention is longer than that of other battery types, resulting in improved power efficiency [21].

2.6 Electric Vehicles:

An electric vehicle is a vehicle that is propelled by one or more electric motors (EV). It can be powered by a battery or a collector system that pulls electricity from the car's exterior (sometimes charged by solar panels, or by converting fuel to electricity using fuel cells or a generator). Road and rail vehicles, surface and underwater watercraft, electric aircraft, and electric spacecraft are all examples of electric vehicles [22].

As a consequence of technology advancements and a greater focus on renewable energy, as well as the possibility to reduce transportation's influence on climate change and other environmental problems in the twenty-first century, EVs have experienced resurgence. Electric vehicles are one of the 100 best current climate change mitigation strategies, according to Project Drawdown [23].

Lithium-ion batteries are used in most electric cars (Li-Ions or LIBs). Most other practical batteries have a lower energy density, shorter life duration, and a lower power density than lithium ion batteries. Safety, durability, heat breakdown, and cost are all complicating considerations. Li-ion batteries should be used within safe temperature and voltage limitations to perform safely and effectively [24].

The three categories of electric vehicles are hybrid electric cars, plug-in hybrid electric vehicles, and battery electric vehicles. Although all three types of electric cars use electricity for propulsion, they work differently and have different powertrains and electric ranges. The many advantages of electric cars will be discussed here, along with how they compare to one another.

Hybrid electric vehicles are commonly referred to as "hybrids," and despite the fact that the technology has been known for decades, the Prius was the first automobile to gain significant market share in 1997. In hybrid electric automobiles, a traditional internal combustion engine is paired with an electric propulsion system. The internal combustion engine does the majority of the work, while the electric motor's main goal is to enhance fuel economy.

The most significant difference between a standard hybrid and a plug-in hybrid electric car is that plug-ins have bigger batteries and may be plugged in to charge them. Plug-in electric automobiles can drive for longer periods of time without using the combustion engine since their batteries are bigger as we can see in the labeled diagram of electric vehicle in **Fig.2.6**. Consumers who require or desire greater range may find plug-in hybrids to be a suitable option. A plug-in hybrid provides the option of being able to rapidly fill up with gasoline when charging facilities may not be available for individuals who frequently travel long distances. While owners will want to keep their plug-in hybrids charged as often as possible to get the benefits of driving on electricity, charging the battery is not essential to operate the car.

Electric cars are sometimes referred to as battery electric automobiles. BEVs have a fully electric drivetrain and are powered solely by batteries. In fact, one of the benefits of battery electric cars is their ease of use. A battery electric car has so few moving components that it requires extremely minimal maintenance. Because battery electric cars rely completely on the amount of stored power in their batteries, being able to recharge them fast is much more vital than it is for plug-in hybrid vehicles. As a result, it's critical to select a home charging solution that can fully recharge your BEV as rapidly as possible, allowing you to get the most out of your car [25].

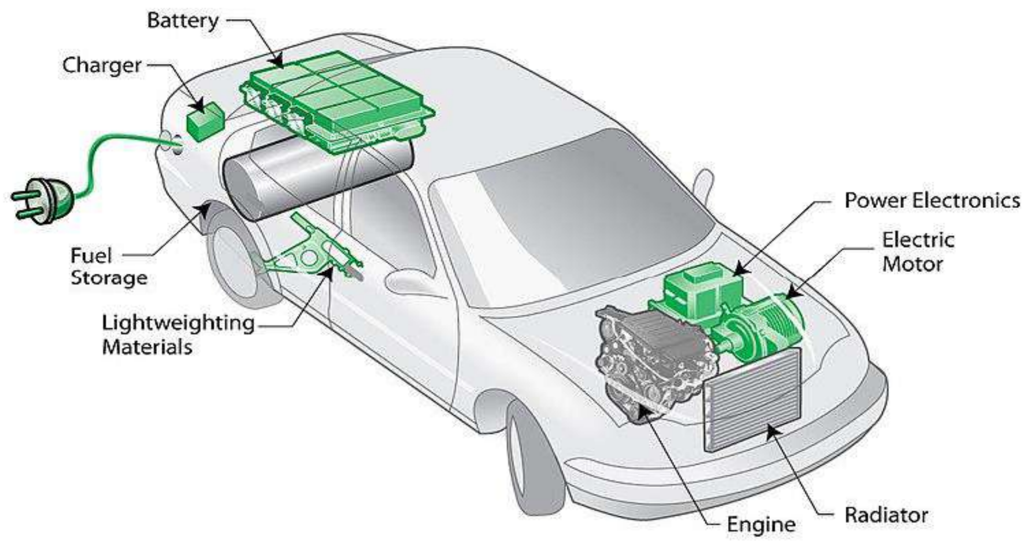


Fig. 2.6 Electric Vehicle [26].

2.6.1 Tesla Model S

Fig.2.7 shows the picture of Tesla Model S. The rechargeable battery of the Tesla Model S Performance has a total capacity of around 103 kWh, according to estimates. 98 kWh is the amount of capacity that utilized (estimate). When the battery is completely charged, there is the potential for a range of around 330 miles. However, the real range will be affected by a number of variables, including weather, topography, the usage of temperature control systems, and driving technique, among others.

It is projected that the Tesla Model S Performance uses around 297 Wh of energy per mile when driving in combination conditions (highway and city). If we compare this level of energy usage to that of a conventional gasoline-powered vehicle, we would get a mileage efficiency of 136 miles per gallon [27].

Fig. 2.7 Tesla Model S [27].

2.6.2 Tesla Model 3

Fig.2.8 shows the picture of Tesla Model 3. It is reported that the Tesla Model 3 Standard Range's battery has a total capacity of fifty kilowatt hours. The capacity that utilized is 40 kWh (estimate). A fully charged battery has the potential to provide a driving range of around 165 kilometers. However, the real range will be affected by a number of variables, including as the weather, the topography, how you drive, and whether or not you have climate control.

The Tesla Model 3 Standard Range has an estimated energy usage of roughly 242 Wh per mile when taking into account both highway and city driving. If we compare this level of energy use to that of a conventional gasoline-powered vehicle, we would get 167 miles per gallon out of it [28].

Fig. 2.8 Tesla Model 3 [28].

2.6.3 Toyota Camry

Fig.2.9 shows the picture of Toyota Camry. Toyota lunch a hybrid model called Toyota Camry which energy is 1.6 kWh. Its engine capacity is 88 kW. For those vehicles Nickel-metal hydride (NiMH) battery are connected in parallel which having 245 V [29].

Fig. 2.9 Toyota Camry [29].

2.6.4 Toyota Prius

Toyota has released a hybrid vehicle known as the Prius. **Fig.2.10** shows the picture of Toyota Prius. which has an energy capacity of 8.8 kWh. The maximum power output of its engine is 53 kW. Lithium-ion (Li-ion) batteries, capable of producing 352 volts when placed in parallel, are used in these automobiles [30].

Fig. 2.10 Toyota Prius [30].

2.6.5 Hyundai sonata

Hyundai manufactures a hybrid vehicle named Hyundai sonata shown in **Fig.2.11** which energy is 1.6 kWh. It has an engine that has a capacity of 38 kW. To power these cars, a lithium-ion (Li-ion) battery of 352 V is used [31].

Fig. 2.11 Hyundai Sonata [31].

2.6.6 Advantages of an Electric Car

1. Electric vehicles run entirely on the electricity you create, so you'll never need to buy gasoline again. Most people charge their cars in the garage, but by installing a few solar panels, you may be able to decrease that cost even more, saving you money on your entire home's energy bill.

2. Electric vehicles are simple to charge, and the best part is that you won't have to stop at a petrol station before getting on the road to do.

3. These automobiles may be fueled for very cheap prices, and many new cars will provide excellent incentives for turning green, such as money back from the government.

4. The most major advantage of an electric vehicle is its low environmental impact. Electric cars are fully environmentally friendly since their engines are powered by electricity. It operates on a clean energy source, thus no harmful gases or smoke is emitted into the atmosphere. They are even better than hybrid cars, because gas-powered hybrids pollute the environment.

5. Electric cars must pass the same fitness and testing requirements as gasoline-powered vehicles. Electric cars are substantially more stable on the road in the case of an accident due to their lower center of gravity.

6. Electric cars do not require lubrication, combustion engine maintenance, or a plethora of other operations that are commonly associated with a gas engine since they employ electrically driven engines.

7. Electric automobiles reduce noise pollution since they are quieter. Electric motors can deliver a smoother ride with more acceleration over longer distances.

8. An electric car's battery is a necessary component. Lithium-ion batteries make up the bulk of electric car batteries, and their prices are dropping year after year. The full capacity of a lithium-ion battery cell should endure 300 to 500 cycles.

9. In the world of automobiles, electric cars provide the most straightforward driving experience. Commercial electric automobiles have a gearbox with only one extremely long gear and do not have the stalling issue that petrol cars experience.

2.6.7 Disadvantages of an Electric Car

Electric fueling stations are still in the early phases of development. There aren't many places you travel on a regular basis that offer electric fueling stations for your vehicle, so if you're on a long journey or visiting family in a rural or suburban region and run out of charge, it could be more difficult to fix.

2.7 Electric vehicle charging station

EVCS is a charging station for electric cars that is equipped with appropriate monitoring and conversion technologies, as well as high voltage and current for rapid charging. The following are some of the most important EVCS terms.

2.7.1 Types of Charging Station:

Household Charging Station: If you want to join the electric vehicle revolution, a domestic charging station might be crucial since it relieves grid stress. Residential auto charging can be done with far less current pulled from the grid, allowing the system to handle the higher power demand during peak load hours. Charging electric vehicles at night is the most cost-effective and has the least impact on the grid, according to [32]. It lowers the per unit cost of power by reducing grid demand during base load hours and charging autos at night. In a home charging station, level 1 charging may easily charge automobiles in 7 to 8 hours.

Parking Charging Station: While charging a car takes time, you may relieve demand on public charging stations and the grid by using that time to park a vehicle. Automobiles are parked at work for about five hours per day, according to the National Household Travel Survey [33]. This function is available at restaurants, shopping malls, libraries, and other establishments that follow charging infrastructure requirements.. Existing parking zones are converted into smart charging parking zones with internet access for slot booking and traffic information [34].

Public Charging Stations: Public charging stations are provided to provide fast charging for autos, although traditional charging takes longer Various charging topologies and rapid charger combinations are used to achieve fast charging. A front-end AC-DC converter and a back-end DC-DC converter are typical components of a charging station. A DC link capacitor connects both converters [35]. MOSFET and IGBT are used in chargers with high frequency switching rectifiers that function on the idea of Pulse Width Modulation (PWM). By keeping the power factor close to unity, the PWM system delivers high-efficiency and accurate power conversion while also managing the output voltage [36]. Due to the existence of power electronics components, charging a car might result in power quality concerns such as harmonics, voltage imbalance, and so on.For this, a high-quality filter is used to connect the charger to the electrical grid, preventing harmonics from affecting the grid and the motor attached to the car [35],[37].

Battery Swapping Station: The Battery Swapping Station (BSS) was created to ease the difficulty of charging time and the acute demand for a charged automobile. In a BSS automobile, a drained battery or battery pack may be replaced with a fully charged one straight away, reducing the amount of time spent waiting for the vehicle's battery to charge. The Battery Management System helps the BSS monitor the battery life (BMS). It determines the energy density of the battery in accordance to its SOC (Stage of Charge) level [38]. There are several challenges to overcome while deploying a BSS. Battery design is one of the primary difficulties that may be solved by constructing the battery pack in such a way that it can be simply and quickly removed from vehicles and re-attached. Another responsibility is to ensure that the battery packs are compatible with each other's brands. Manufacturers may produce interchangeable battery packs for BSS and EVs using a single standard layout. There's also the problem of battery degeneration and ownership, which is the most significant impediment to BSS adoption.

2.7.2 EV Charging System

Based on the power transfer technique, EV charging systems are categorised as conductive charging systems or inductive charging systems.

Conductive Charging: This charging technique uses a cable or connection to create direct contact between the car and the charger. This is the present infrastructure of the charging station. It can be done on-board or off-board, depending on the degree of charge. This sort of charging boosts performance, and almost every electric vehicle manufacturer provides it. The Nissan Leaf, Chevrolet Volt, Mitsubishi i-MiEV, and Tesla Roadster are among the vehicles that use conductive charging systems [39],[40].

Inductive Charging: Inductive charging, often known as wireless charging, is a revolutionary idea in which the car and the charger are not physically connected. Transformers use the same electro-magnetic induction concept [40]-[43]. For wireless transmission charging, the distance between the primary and secondary coils is measured. Power is transported through thin air via a magnetic field. The sole downside is that it is less efficient and less powerful than conductive charging, as well as being costlier [39]. It is, however, useful in that it allows charging without the hassle of connecting and unplugging larger charging plugs. Vehicles may be charged at any location. size and compatibility of the connection Charging strips can be installed on the road to charge vehicles. Charging may also be done while driving. Dynamic is the term for this. Charging without wires Roads with the ability to supply electricity Wireless power transmission to electric automobiles (WPT) is achieved by electric motorways or charging lanes [39]-[42].The charging time will be reduced if you charge while driving. Time spent by vehicles in a stationary position [39]. This method is still being used in a number of countries, with further research being done on how to improve it [43].

Level 1 charger is a kind of charger having 120 V charging outlet which can deliver 12 Amp to 16 Amp current. That means this charger can deliver 1.4 kW to 1.9 kW per hour. Average 26.5 hours will take to charge a vehicle having 50 kW battery power. Level 2 charger is a kind of charger having 208 V to 240 V charging outlet which can deliver 12 Amp to 80 Amp current. That means this charger can deliver 12.5 kW to 19.2 kW per hour. Average 6.5 hours will take to charge a vehicle having 50 kW battery power. Level 3 charger or DC fast charger is a kind of charger having 400 V to 480 V charging outlet which can deliver upto 125 Amp current. That means this charger can deliver upto 90 kW per hour. Average 1.6 hour will take to charge a vehicle having 50 kW battery power[44].

CHAPTER 3

SYSTEM DESIGN

3.1 Introduction

Popularity of Electrical Vehicle mostly depend on the numbers of charging station have. To construct or establish an EV charging station we have to keep in mind about the location, solar radiation and wind speed data of that location. Homer application is the best tool for designing a charging station with a best deal with low cost. An EV charging station should have level 1, level 2 and level 3 chargers to charge all category Electrical Vehicles. In this chapter we will make a charging station model design using Homer Software, as well as we will design circuit diagram of level 1, level 2 and level 3 charger by MATLAB software.

3.2 Location Selection

Renewable charging station is consisting of solar and wind turbine. So, location should be the open place on sea shore side. For our charging station model location is a factor that is important. **Fig. 3.1** shows the map location of Patenga ring road, Chittagong. we are selecting Patenga ring road, Chittagong shown in **Fig. 3.2** as there are a two way four lane big road beside a beautiful sea shore.

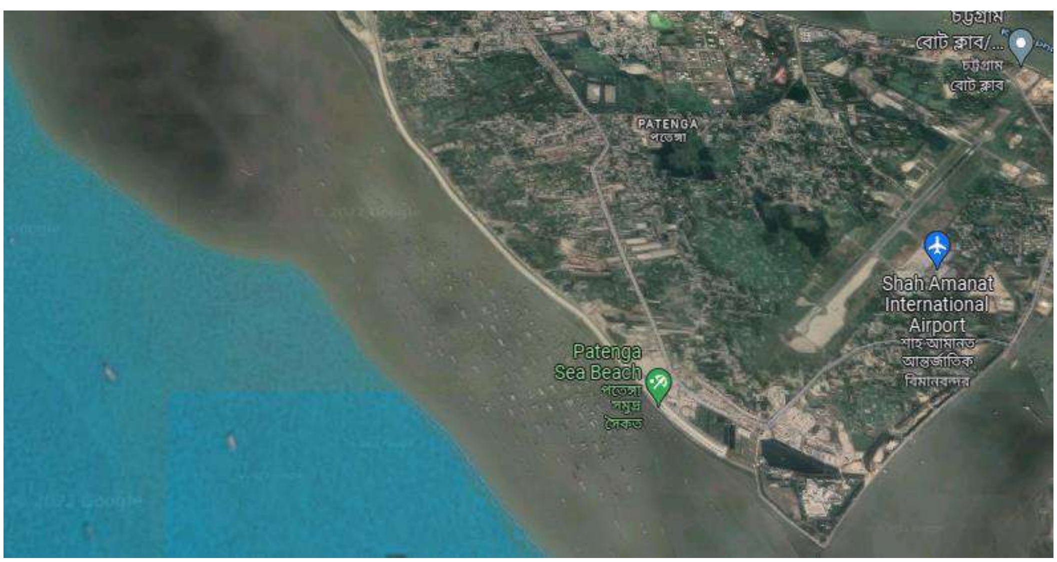


Fig. 3.1 Map location Of Patenga Ring Road, Chittagong

Fig. 3.2 Patenga Ring road, Chittagong [47].

The main purpose of selection of this place because of wide area and open place. The average solar radiation in Patenga, Chittagong is 13.1 W/m^2 shown in **Fig. 3.3.** [46]

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	-BEGIN HEADER-														
2	NASA/POWER CERES/MERRA2 Native Resolution Monthly and Annual														
3	Dates (month/day/year): 01/01/2020 through 12/31/2020														
4	Location: Latitude 22.2583 Longitude 91.7977														
5	Elevation from MERRA-2: Average for 0.5 x 0.625 degree lat/lon region = 34.35 meters														
6	Value for missing model data cannot be computed or out of model availability range: -999														
7	Parameter(s):														
8	ALLSKY_SFC_UVA CERES SYN1deg All Sky Surface UVA Irradiance (W/m^2)														
9	ALLSKY_SFC_UVB CERES SYN1deg All Sky Surface UVB Irradiance (W/m^2)														
10	-END HEADER-														
11	PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
12	ALLSKY_SFC_UVA	2020	9.48	11.84	14.64	14.01	15.15	13.41	14.26	13.3	12.73	12.71	11.38	10.18	12.76
13	ALLSKY_SFC_UVB	2020	0.21	0.29	0.38	0.37	0.42	0.39	0.44	0.41	0.38	0.34	0.27	0.23	0.34

Fig. 3.3 Solar radiation data from Power Data Access Viewer [46].

The average wind speed in Patenga, Chittagong is 13.96 m/s shown in **Fig. 3.4** collected from Power Data Access Viewer. [46]

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	-BEGIN HEADER-														
2	NASA/POWER CERES/MERRA2 Native Resolution Monthly and Annual														
3	Dates (month/day/year): 01/01/2020 through 12/31/2020														
4	Location: Latitude 22.2583 Longitude 91.7977														
5	Elevation from MERRA-2: Average for 0.5 x 0.625 degree lat/lon region = 34.35 meters														
6	Value for missing model data cannot be computed or out of model availability range: -999														
7	Parameter(s):														
8	WS50M_RANGE MERRA-2 Wind Speed at 50 Meters Range (m/s)														
9	-END HEADER-														
10	PARAMETER	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
11	WS50M_RANGE	2020	5.47	6.41	5.97	7.37	13.84	12.28	9.45	12.09	11.62	12.19	5.45	5.6	13.96

Fig. 3.4 Wind speed data from Power Data Access Viewer [46].

3.3 Block Diagram

We are following this block diagram shown in **Fig. 3.5** to create a HOMER simulation Analysis this is a representative image of the flow of energy from solar and wind to storage and load. The storage has a two-way conversion circuit so that it can provide power for loading. With this block diagram in mind, we have tried to move our work forward. This block diagram shows the main path of our work. As shown in this block diagram, a combination of solar and wind is arranged in a renewable power supply, stored in storage as well as supplied at load. We have completed our work following the guidelines shown in the block diagram.

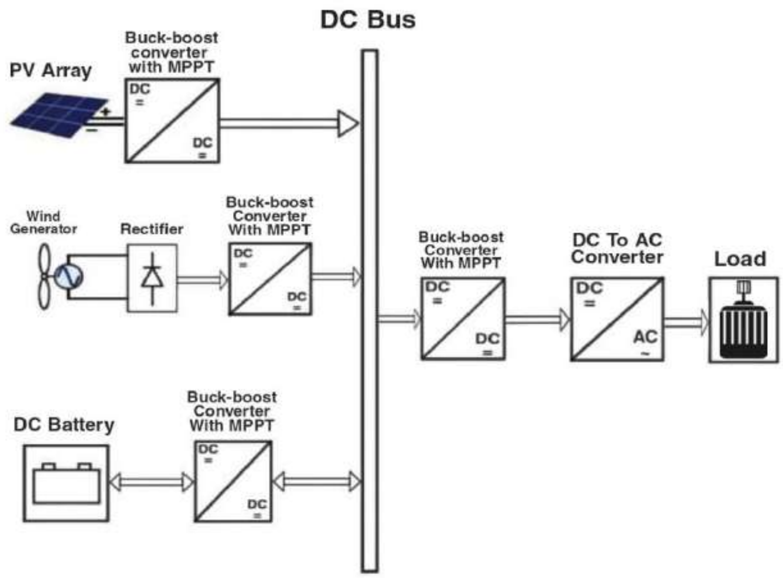


Fig. 3.5 Block Diagram of Electric Vehicles charging Station system

3.4 HOMER Simulation

3.4.1 About HOMER

Homer simulation software mainly used for designing a renewable power generation model and figure out the output comes from the model. Homer Optimizer will find out the best generation capacity model with low cost assets. By selection of proper components Homer simulation software creates a model by Its own. When we runs this model Homer uses internet to find out the price and production power capacity of those components we selected and gives us a proper model with the amount of power should generate from PVs and Wind turbines.

3.4.2 HOMER schematic diagram

The schematic diagram of electric vehicle charging station shown in **Fig. 3.6**. This schematic diagram is the representation of Homer simulation model done by Homer simulation software. In this diagram there are solar panels, wind turbines, converter, battery storage, and load. We are considering load as DC load because Electric vehicle batteries are mainly DC. We are using a AC wind turbine with AC bus and a converter has added between AC bus and DC bus so that it can convert alternating current to direct current. PVs and batteries are connected to DC bus and load as output.

The main operation of this simulation is: PVs and wind turbines will generate electrical power. The power generated from wind turbine is AC will convert into DC through converter. Total power will store in batteries as well as given to the load. When will the power production of wind and solar reduce, batteries will support as the source of power.

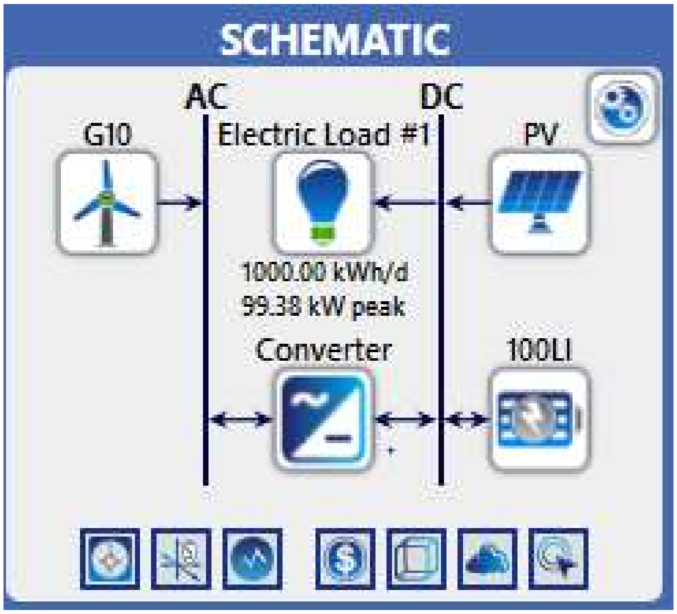


Fig. 3.6 SCHEMATIC Diagram of Electric Vehicle of charging station in HOMER Software.

3.4.3 Location selection in HOMER

At first we need to select our desire location which we have selected for our model. After opening Homer simulation software, we saw a partition with world map. There is a search option to search our desire location. We types "Patenga, Chittagong" in search option and software find it out from world map. Then we have downloaded solar radiation and wind speed data from Resources option shown in **Fig. 3.7**.

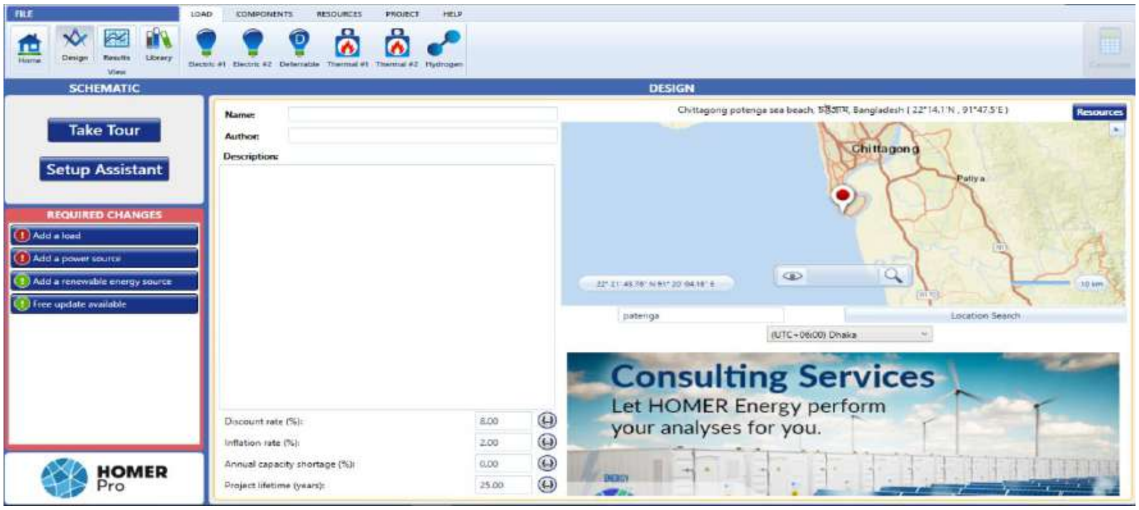


Fig. 3.7 Location selection in HOMER Software.

3.4.4 PV Solar Panel selection

After the selection of Location in Homer, the next step we have taken that is selection of PV solar panel. For this we went in "Design" option, where we found "Component" option. In this option PV is clearly seen to select PVs for the model. We selected Generic Flat Plate PV of 1 KW power generate capacity also choose the HOMER Optimizer radio button so that HOMER can figure out It's cost and derating factor and guaranty by using internet. After doing this entire step we saw in schematic diagram situated in left top side of the screen, a PV module diagram has been added with DC bus in it shown in **Fig. 3.8**.

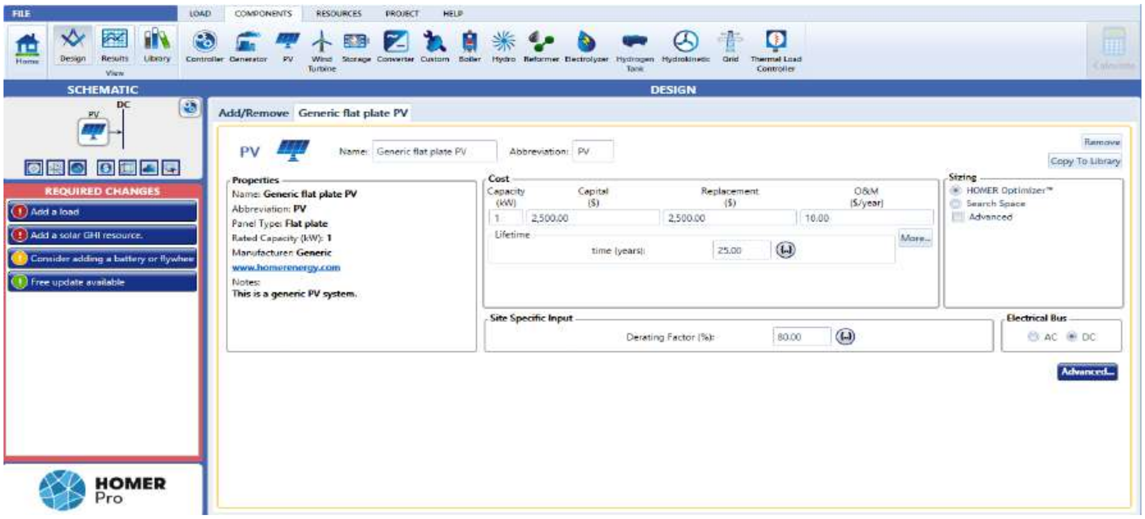


Fig. 3.8 Solar Panel selection in HOMER Software.

3.4.5 Wind Turbine selection

Same process has taken to select wind turbine as we followed to select the PV solar panel. As we are preparing a Electric Vehicle charging Station with renewable energy, only PV solar panel cannot take production to the demand. So wind turbine can support the model to fulfill the demand. We choose Generic 10 KW wind turbine as well as HOMER Optimizer so that the software could find out the actual price, hub size and guaranty of that wind turbine. By doing these steps we saw that a wind turbine module diagram has need added in the schematic diagram with an AC bus shown in **Fig. 3.9**.

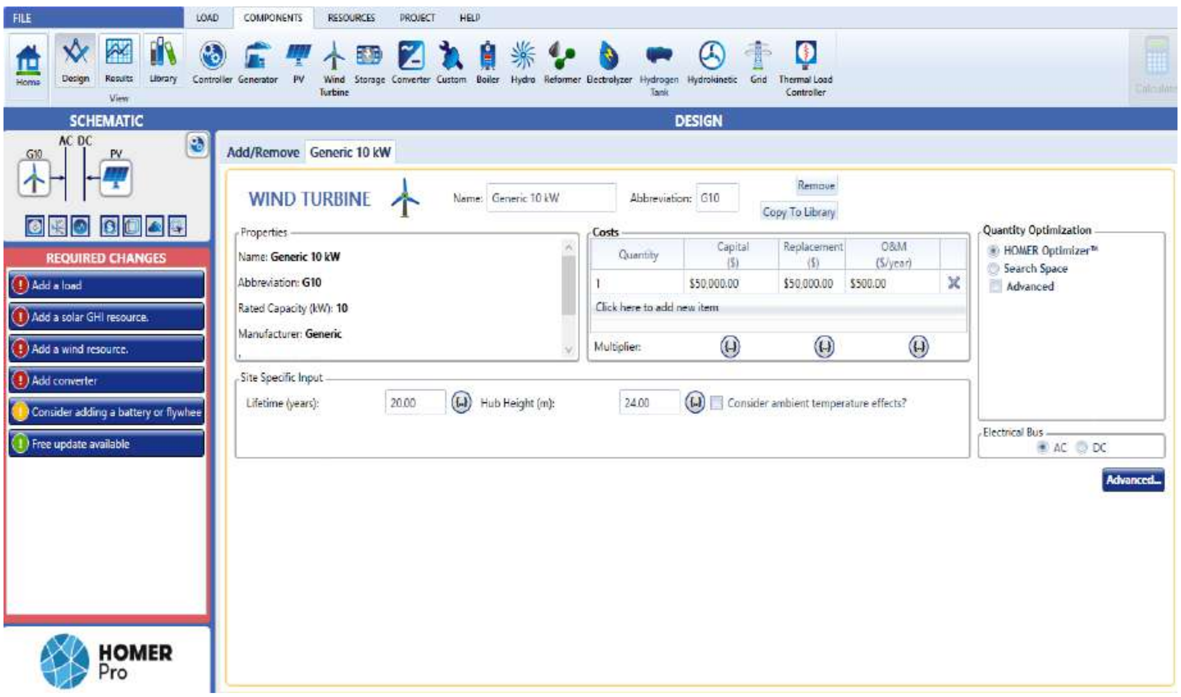


Fig. 3.9 Wind Turbine selection in HOMER software.

3.4.6 Adding Converter

Converter converts alternating current to DC current or direct current to alternating current for the purpose of use. In this model alternating current has to convert in in direct current to store the electrical energy to storage battery. Converter added from the component option in HOMER and used HOMER Optimizer to optimize its price and guaranty time. Converter has been added between AC bus and DC bus in schematic diagram shown in **Fig: 3.10**.

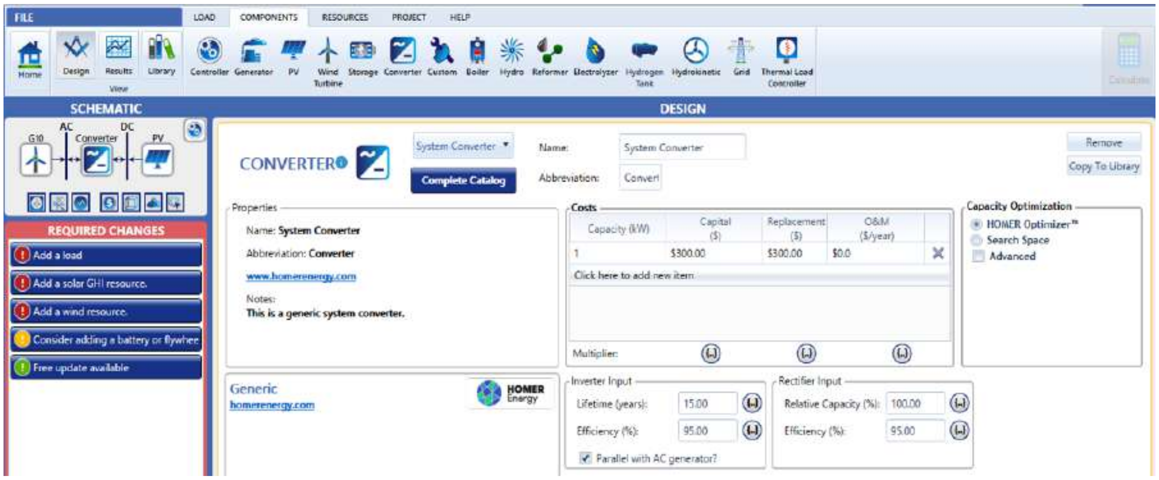


Fig. **3.10** Converter selection between AC bus and DC bus in HOMER software

3.4.7 Storage system

We need to store the power generated from the PV panel and wind turbine to batteries as well as supplying the load. All those power would not be delivered to the load as always. So at some times demand will decrease. At that time we need to store the whole energy to the battery. HOMER suggests adding a battery and we selected with the optimizer option. A battery added to schematic diagram shown in **Fig. 3.11.**

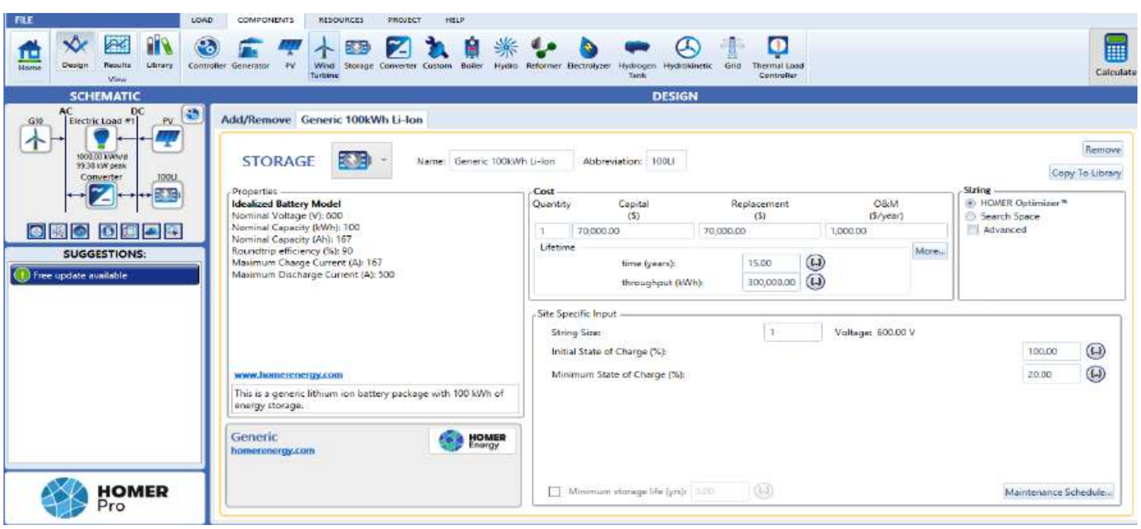


Fig. 3.11 Adding a Storage in HOMER software

3.4.8 Load selection

Load is a main factor of this model. Electric Vehicles batteries are plays the role of load in our model. So we have used DC types load. The time of selection of a load HOMER gives us a option of load type. There are four types of load to choose those are Industrial, Commercial, Residential and None. We have selected Commercial load as Charging Station is a commercial entities. Second step is to determine load demand in every hour of a day. We had to fill a chart with the demand of every hour of a day by the traffic of the location we selected for the model. We did not find any authorized data of the traffic of that road from internet or offline. So we filled the hourly demand chart by the traffic percentage of Chittagong Highway. Amount of vehicles highly increases from 7 p.m. to 1 a.m. So we filled 60 KWh demand from 7 p.m. to 1 a.m. and 50 KWh demand from 3 p.m. to 6 p.m. and 32 KWh from 1 a.m. to 3p.m. Total Annual baseline demand of power is 1036 KWh per day and scaled annual power is 1000 KWh per day. Average power demand per hour is 43.17 KW (baseline) and 41.67 KW (scaled), peak power demand in 102.96 KW (baseline) and 99.38 KW (scaled), load factor is 42% shown in **Fig. 3.12.**

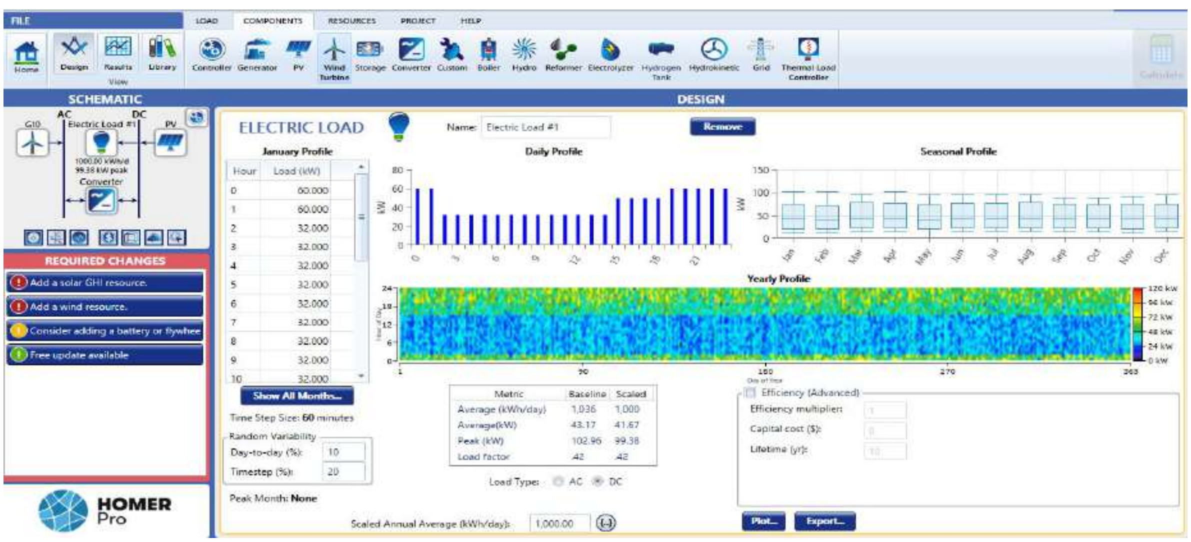


Fig. 3.12 Load selection in HOMER software

3.5 Charging Circuit Design

There are three types of chargers for charging Electric Vehicles. Those are

1. Level 1 charger.

2. Level 2 charger.
3. Level 3 charger.

We have used storage battery of 600v in our charging station model. For this model we are considering Vripple = 0.36v and Iripple = 3A. And these equation are used for calculating the value of capacitance and inductance which are given below:

$$C = Iripple / (8 * Fsw * Vripple).$$

$$L = Vout * (Vin – Vout) / (Iripple * Fsw * Vin).$$

Putting the value of all parameters we found inductance value 24mH, capacitance value 20uF for level 1 charger and for level 2 charger we found inductance value 36mH, Capacitance value 20uF and for level 3 charger inductance value 33mH and capacitance value 20uF we have found.

Fig. 3.13 represents the charging circuit diagram. This circuit works like buck converter during battery charging operation and works like a boost converter during battery discharging. But our main purpose is to charge Electric Vehicles battery that is why we use buck converter circuit for chargers. Buck converter is used for battery charging operation. To charge an Electric Vehicle by level 1, level 2, level 3 chargers, a charging circuit shown in **Fig. 3.13** has design for converting 600v to 120v, 600v to 240v, 600v to 400v. Generally level 3 charger voltage range is 400v to 600v. But we have just design for 400v fast charger not for 600v rapid charger. Here in this circuit we used 600v as input voltage which considering the voltage of charging station battery. Then we add a series RLC branch which is considered as input bus capacitance. After that we add MOSFET. MOSFET is used for controlling the voltage. Again we add two RLC branch first one is considered as the output filter inductor and the second one is considered as the output filter capacitor. We use current measurement block for measure the battery current. After that we add a battery and Goto block. Goto block is used for label the battery current. We add a bus selector with battery and add battery voltage, current and SOC to the bus. After that we add another Goto blocks for label the battery voltage, current and SOC using this block. Which are mention as Vbat, Ibat and SOC. We add constant block where we set the reference value of the required current. Then we add sum block and add the battery current with sum block. We use a PI controller in this circuit to regulate the battery current during charging operation. We also add PWM generator for controlling the power transfer from one component to another by quickly switching. After that we add a logical operator, set the operator types as NOT and add Goto blocks which are considered as PWM1 and PWM2. PWM1 and PWM2 are corresponding connected to gate terminal with MOSFET 1 and MOSFET 2. We add a display for current, voltage and SOC for showing the output result. We also add scope for showing the output waveform of given result. At last we add powergui block and set the simulation type as discrete. The value of different parameters pictures are added in Appendix A.

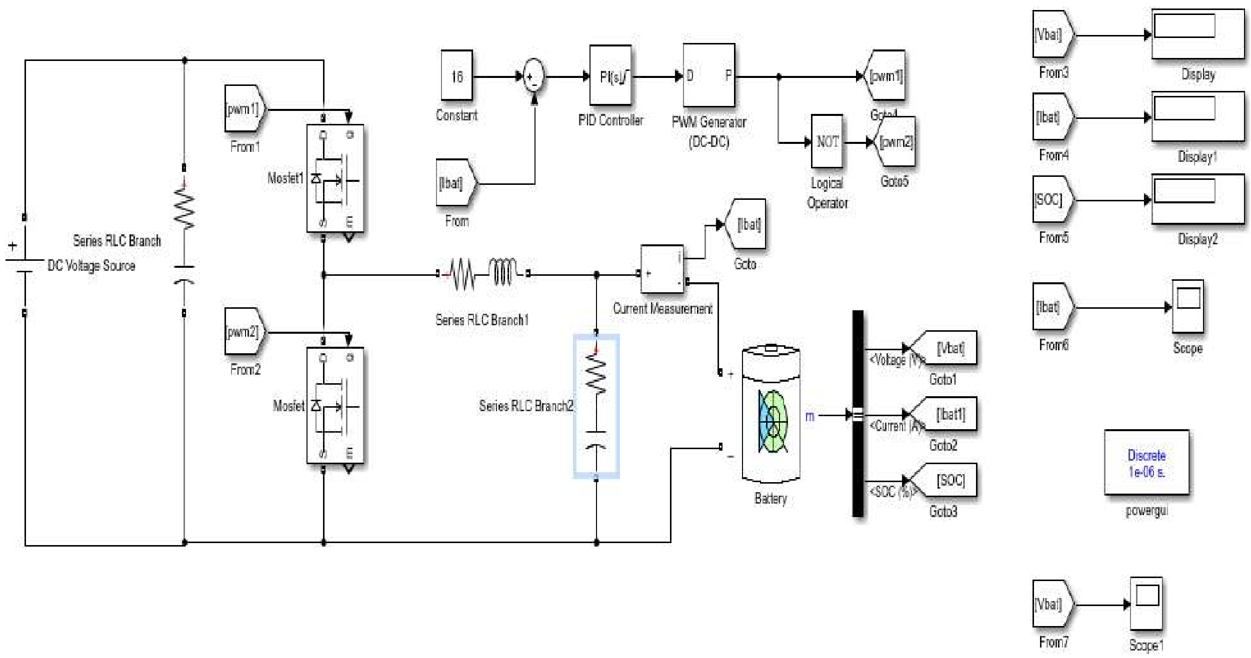


Fig. 3.13 Level 1, Level 2, Level 3 charger circuit design by MATLAB software

CHAPTER 4

RESULT ANALYSIS

4.1 Introduction

Previously we have simulated our desired model in HOMER and MATLAB charging circuit. In this chapter we are going to analyze the output obtained from HOMER and MATLAB. We are taking a discussion for the output obtained from individual PV panel and Wind turbine. We will find out the total power input and output from the renewable source to load and storage and loss of the battery. Cost analysis also an important factor of this model so we will also discuss about total cost analysis. To charge an Electric Vehicle, charger circuit will be also mentioned in this chapter. At the end we will see the amount of Electric Vehicle can charge our model with their Perspective vehicle model.

4.2 Results obtained from HOMER

4.2.1 Power from PV solar panel

Rated capacity 498 kW means to establish a set of PV module which has the ability to generate 498 kW with capacity factor 16.4%. Mean output from PV panel is 1960 kWh per day. Total electrical power production from PV panel is 715295 kWh per year. Total hours of operation of PV module are 4372 hours per year. And cost of generating per kW is 0.142 dollar which is equal to 12.5 taka in BD currency. **Fig. 4.1** representing all about this.

Quantity	Value	Units
Rated Capacity	498	kW
Mean Output	81.7	kW
Mean Output	1,960	kWh/d
Capacity Factor	16.4	%
Total Production	715,295	kWh/yr

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	494	kW
PV Penetration	196	%
Hours of Operation	4,372	hrs/yr
Levelized Cost	0.142	$/kWh

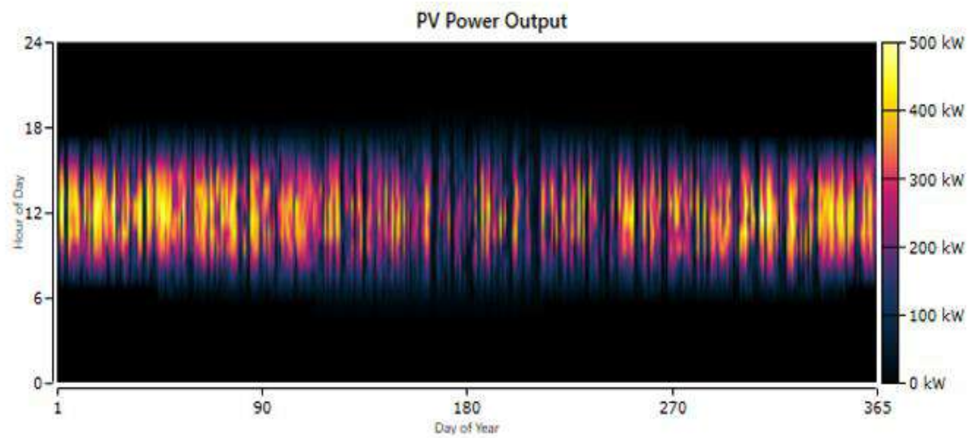


Fig. 4.1 Output result of PV panel by HOMER simulation software

4.2.2 Power from wind turbine

We have used Generic 10 kW wind turbine, given the rated capacity of Wind turbine is 110 kW. So we need 11 wind turbines for this model. Mean output is 16 kW with a capacity factor of 14.5%. Total electrical power production is 139952 kW per year. Hours of Operation are 4392 hours per year. The cost consumption to produce the energy is 0.386 dollars per kW Shown in **Fig. 4.2**.

Quantity	Value	Units
Total Rated Capacity	110	kW
Mean Output	16.0	kW
Capacity Factor	14.5	%
Total Production	139,952	kWh/yr

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	110	kW
Wind Penetration	38.3	%
Hours of Operation	6,821	hrs/yr
Levelized Cost	0.386	$/kWh

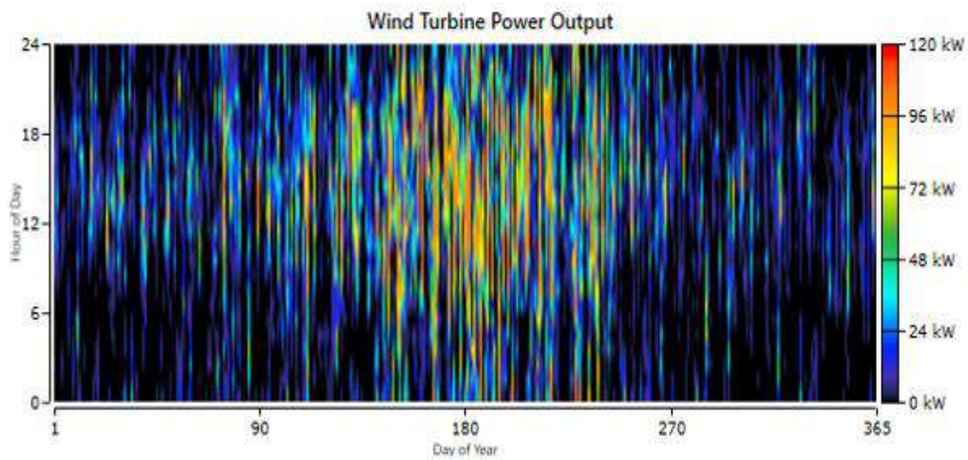


Fig. 4.2 Output result of wind turbine by HOMER simulation software

4.2.3 Total power production and consumption

Total power production is equal to the individual power generation of PV and wind turbine. As we obtained power from PV and wind turbine respectively 715295 kW and 139952 kW. So, total power Production is 855247 kW and consumption by the load is 364763 kW. Percentage of Efficiency is 42.65%. Cost of Equity (COE) is 0.7938 dollars (69.82 taka in BD) and Operating cost 62706 dollars (55 lakhs 14 thousands 9 hundred 93 taka in BD). Total Net Present Cost (NPC) is 3742974 dollars equal to 32 crores 91 lakh 94 thousand 5 hundreds 64 taka almost Shown in **Fig.4.3**.

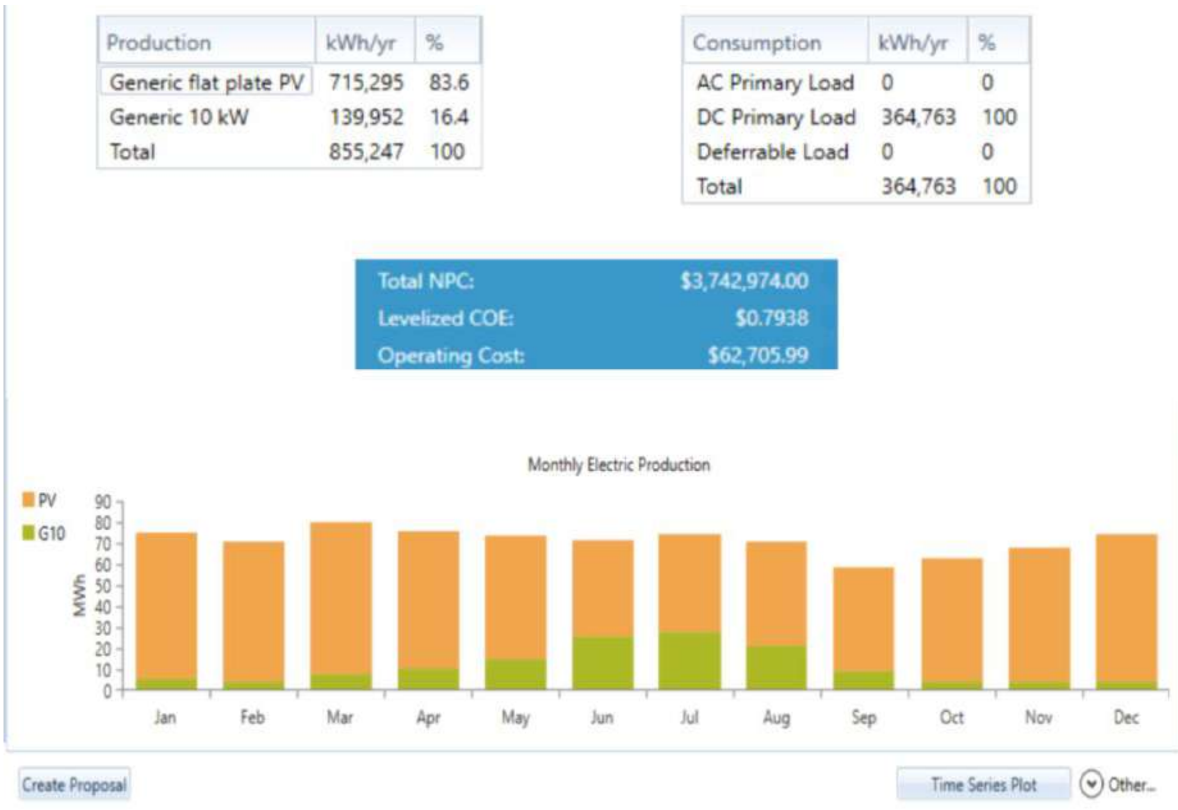


Fig. 4.3 Total power output by HOMER simulation software

4.2.4 System converter's input and output

Converter converts Alternating Current to Direct Current. Though we have used a converter between an AC bus and DC bus, so the converter will convert the turbine's power to DC bus to store in battery or deliver it to load. The rated capacity of the converter is 58.5 kW with a capacity factor of 13%. The hours of operation are 4937 hours per year. Energy out throughout the converter is 66505 kWh per year. Energy inserted into the converter is 70005 kWh per year. Losses energy is 3500 kWh per year shown in **Fig. 4.4.**

Quantity	Inverter	Rectifier	Units
Capacity	58.5	58.5	kW
Mean Output	0	7.59	kW
Minimum Output	0	0	kW
Maximum Output	0	58.5	kW
Capacity Factor	0	13.0	%

Quantity	Inverter	Rectifier	Units
Hours of Operation	0	4,937	hrs/yr
Energy Out	0	66,505	kWh/yr
Energy In	0	70,005	kWh/yr
Losses	0	3,500	kWh/yr

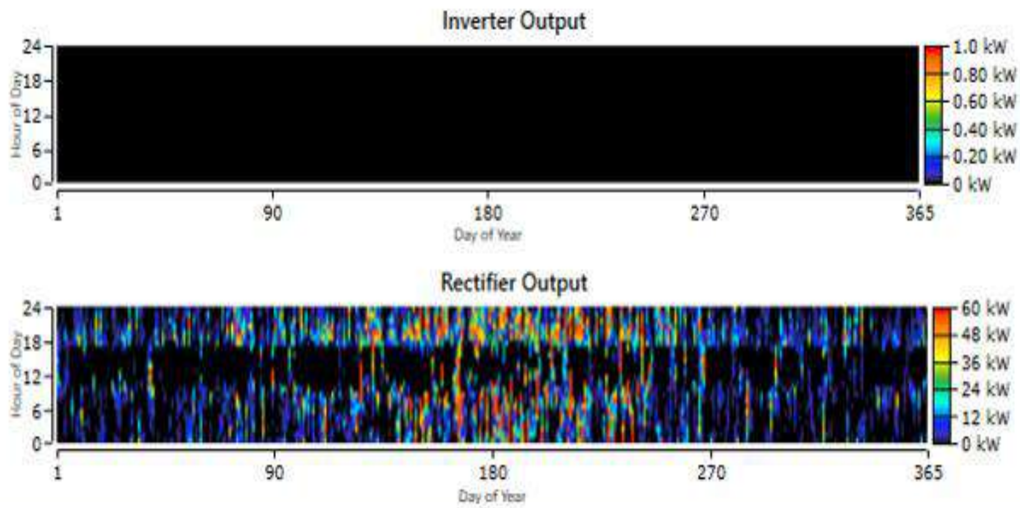


Fig. 4.4 Converter output by HOMER simulation software

4.2.5 Battery's input and output

Batteries are needed as storage for the charging station to store energy generated from PV and wind turbines. **Fig.4.5** is about the batteries of the HOMER schematic model. The output result shows the quantity of barriers should be 16 with string size 1. All of the batteries should be connected in parallel. The voltage of the bus is 600v which means that 600V is the total voltage of the batteries after all of those connecting in parallel. The input and output energies are accordingly 203489 kWh and 183525 kWh per year. The losses of energy from batteries are 20370 kWh per year. Storage depletion is the difference in the storage state of charge at the beginning and end of the year, which shows 406 kWh per year. Annual throughout is 193452 kWh per year.

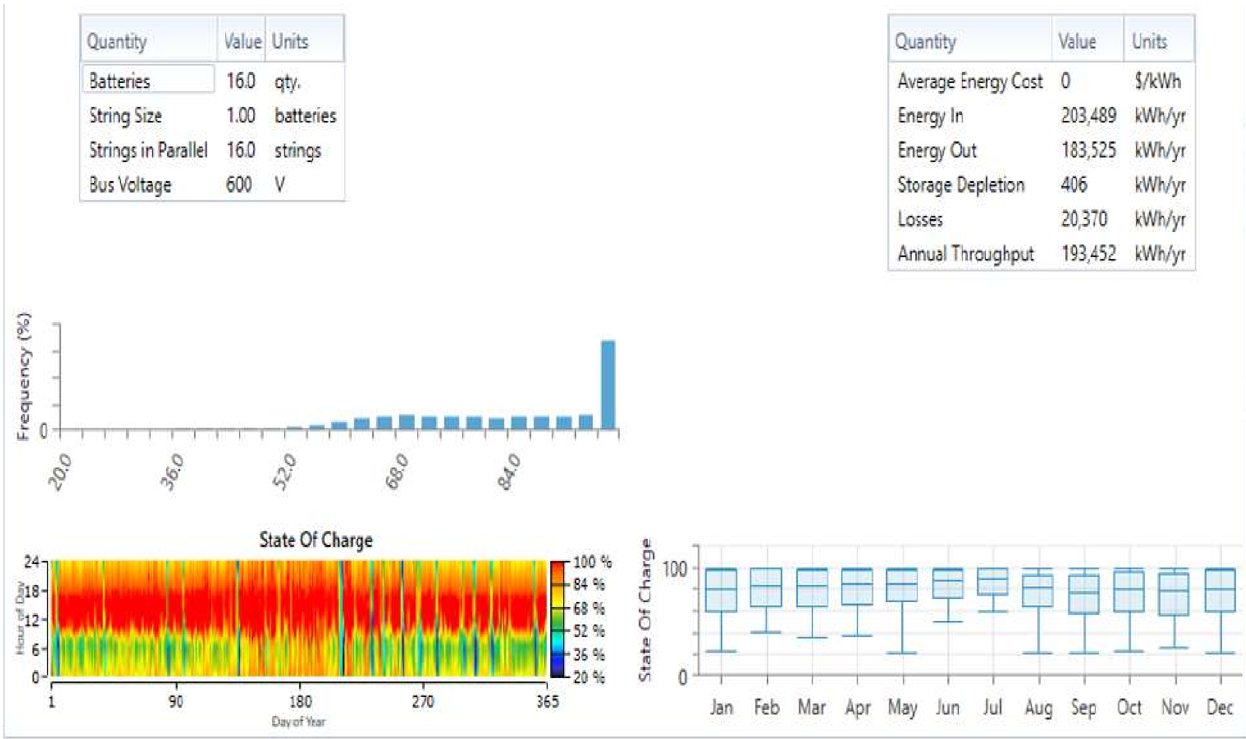


Fig. 4.5 Battery output by HOMER simulation software

4.3 Cost analysis of the model

Installing this model is such a big deal because, to install this model, a huge amount of money is needed. **Fig.4.6** represents the cash flow of this model. As the figure 3,000,000 dollars (263,760,000 taka in BD currency) needs as capital, 62,706 dollars (5514993 taka in BD currency) needs to operate the system. The total cost of this model reaches (NPC) 3,742,974 dollars (329,194,564 taka in BD currency) added replacement cost and salvage. The cost of Equity (COE) is 0.7938 dollars (69.82 taka in BD currency).

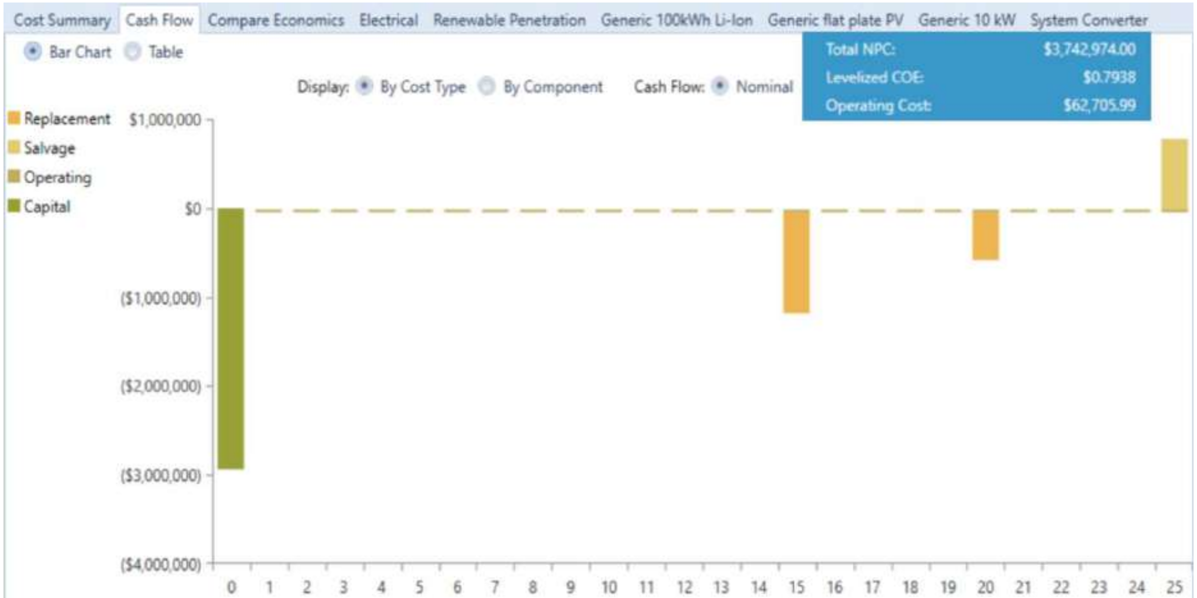


Fig. 4.6 Cash flow

4.4 Charging Electric Vehicles from the produced power

As the total amount energy generated from the 8,55,247 kWh per year. And the load consuming 3,64,763 kWh. Here, loads are refereeing amount of Electric Vehicle changed the charging station. So, we have considered load consumption to figure out the amount of Electric Vehicle can charged from the charging station.

So the total power consumption = 364763 kWh per year

= (364763)/365 kWh per day

= 999.35 kWh per day

The power need to fully charge a Tesla Model S is 103 KW [40].

So, we can charge up to 9 Tesla model S per day.

The power need to fully charge a Tesla Model 3 is 50 KW [41].

So, we can charge up to 19 Tesla Model 3 per day.

The power need to fully charge a Toyota Camry is 88 KW [42].

So, we can charge up to 11 Toyota Camry per day.

The power need to fully charge a Toyota Prius is 53 KW [43].

So, we can charge up to 18 Toyota Prius per day.

The power need to fully charge a Hyundai Sonata is 38 KW [44].

So, we can charge up to 26 Hyundai Sonata per day.

4.5 Results obtained from MATLAB simulation

We have designed a charging circuit for EVs as the variety of power delivery of vehicles chargers. We need to convert 600V to 120V (level 1 charger), to 240V (level 2 charger) and to 400 (level 3 charger). The result of the MATLAB simulation was given in **Fig. 4.7, Fig.4.8** and **Fig.4.9.**

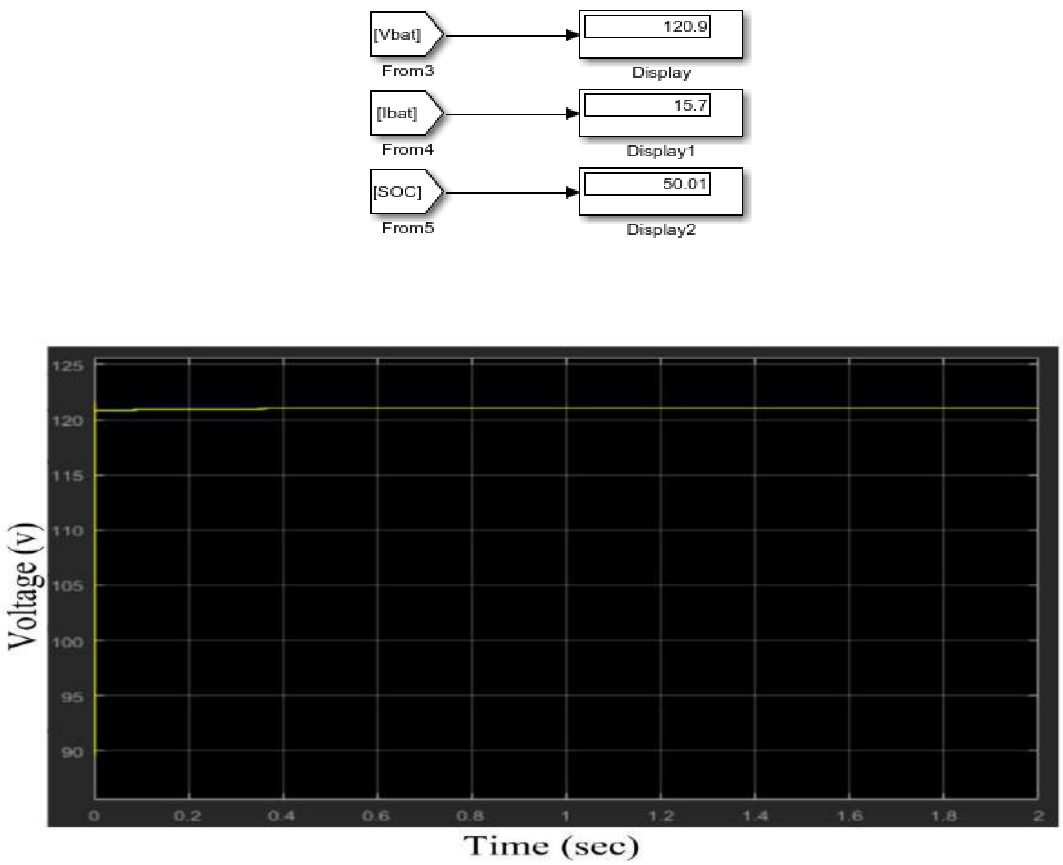
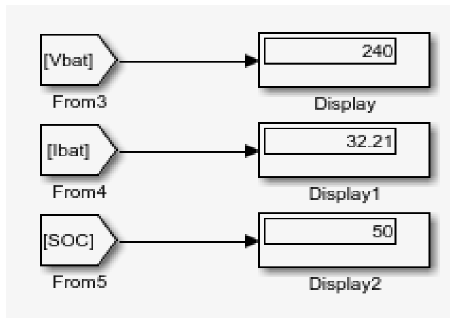


Fig. 4.7 Output result of level 1 charger by MATLAB simulation software (120v)

Fig. 4.7 shows the output voltage of the level 1 chargers and the web form where it is possible to convert the input voltage from 600 volts to the output voltage to 120 volts. A 120 volt charging circuit is called a level 1 charger. So it is a level 1 charger.



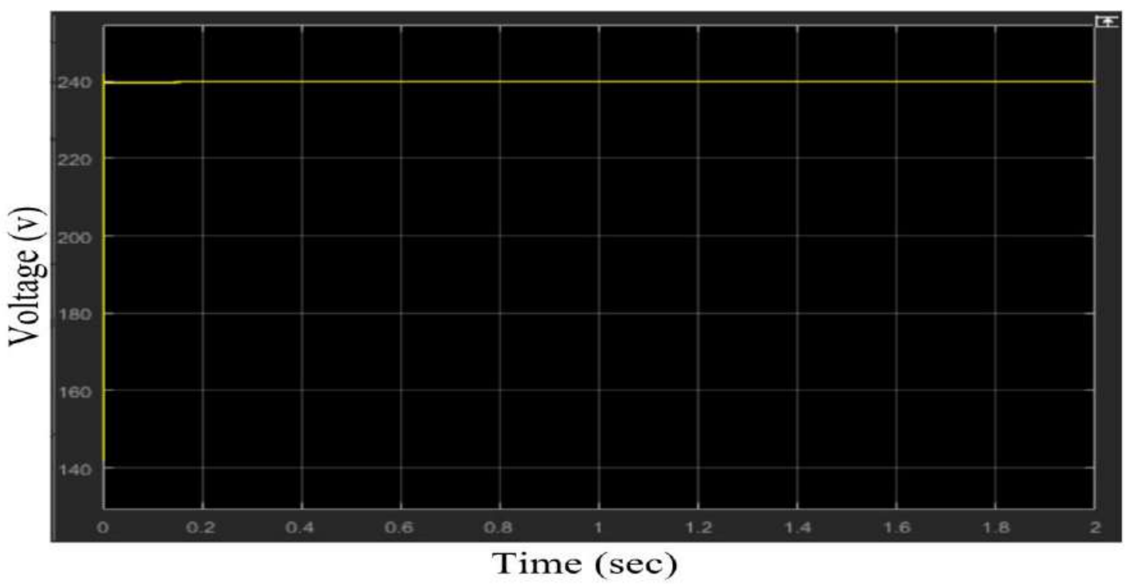
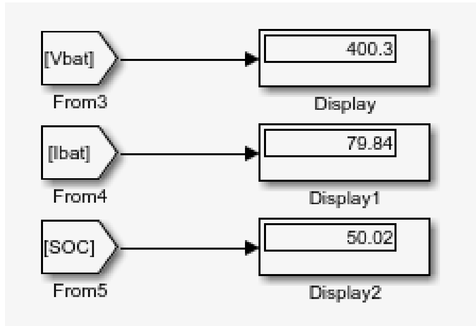


Fig. 4.8 Output result of level 2 charger by MATLAB simulation software (240v)

Fig. 4.8 shows the output voltage of the level 2 chargers and the web form where it is possible to convert the input voltage from 600 volts to the output voltage to 240 volts. A 240 volt charging circuit is called a level 2 charger. So it is a level 2 charger.



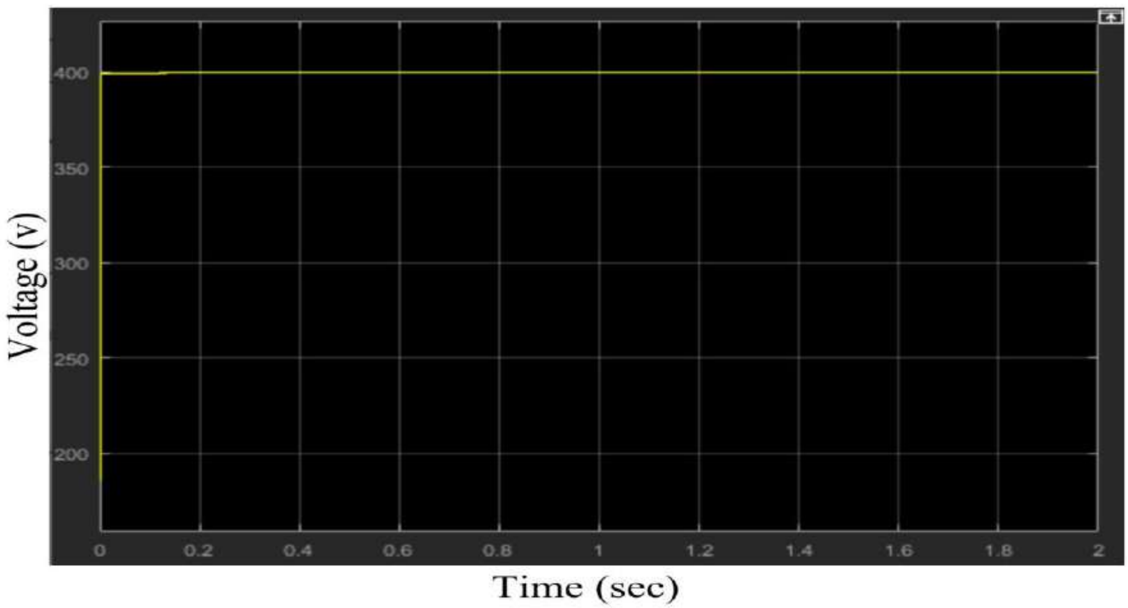


Fig. 4.9 Output result of level 3 charger by MATLAB simulation software (400v)

Fig. 4.9 shows the output voltage of the level 3 chargers and the web form where it is possible to convert the input voltage from 600 volts to the output voltage to 400 volts. A 400 volt charging circuit is called a level 3 charger. So it is a level 3 charger.

CHAPTER 5

CONCLUSION

This chapter will discuss what the main purpose of our work is and what we expected from it, whether it has been fulfilled or not. We will also discuss what the shortcomings of our proposed work are and what are the limitations, whether there is any way to solve them.

5.1 Evaluation

In addition to formulating policies for electric vehicles in Bangladesh, the authorities have also started working on charging policies for imported vehicles. Officials say they expect motor vehicle imports to begin once the policy is finalized. However, apart from the huge number of electric-powered easy bikes that are now available in Bangladesh, there is no time limit on when it will be possible to import other vehicles including private cars. Incidentally, the Bangladesh Road Transport Authority (BRTA) had formulated a draft policy about two years ago to regulate illegally operated electric vehicles, especially easy bikes, across the country. The draft policy stipulates that the life span of electric motor vehicles is ten years for motorcycles, nine years for three wheelers and 20 years for light, medium and heavy vehicles. Can be recharged using approved charging station, own management, solar panel or any renewable energy. The government of Bangladesh is paying close attention to electric vehicles because they are environmentally friendly and fuel efficient. However, looking at the power generation of Bangladesh, a problem arises with the charging of cars. To solve this problem we have worked with a renewable electric charging station. We have designed a model where solar and wind turbines have been used for power generation. It generates electricity by utilizing fully renewable energy sources. This model will not affect the grid of Bangladesh. We had to use Homer simulation software to design this model. In Homer simulation software we select the necessary equipment for the model which is suitable for our model and space. Based on that selected equipment Homer simulation software created a design. Running the given model, we collect different types of data from there and observe them. The model proposed by Homer uses an electric car battery as a load, which is similar to a DC load. The model provided by Homer Software is capable of generating 855247 kWh of power per year. The load from there will consume 364763 kWh of power per year, which stands at 999.35 kWh per day. With this consuming power our charging station is capable of charging 9 Tesla Model S, 19 Tesla Model 3, 11 Toyota Camry, 18 Toyota Prius or 26 Hyundai Sonata. Homer's simulation software provides an idea of the total cost of building a charging station which is about 3742947 dollars which is about 32 crores 91 lakh 94 thousand 5 hundred 84 BDT. The cost per kilowatt of electricity generated is 0.7938 dollar USD or 69.82 BDT. Although the cost of using fully renewable energy is high, it can be used for a long time and it will not affect the grid.

5.2 Limitations and solutions

Our main problem with this model is that it is more effective for the sea side, because the sea side is open space and the wind speed is higher than the city. There is enough space in Chittagong to install this charging station as it is surrounded by sea around Chittagong. But the question remains as to how effective it is for outside Chittagong. The answer depends on the location. Although the number of Electric Vehicles in Bangladesh is still low. Although this charging station is enough to meet the demand for the time being, if the number of vehicles increases after a few years, then the charging station will be greatly affected. Since wind speed and solar radiation are considering the first problems, the grid can be used to set up this charging station inside the city. The second problem is the number of cars. If the number of vehicles increases, it is possible to increase the power generation by increasing the number of wind turbines and solar panels in the charging station. Or it can be done by connecting the grid connection. It is also possible to meet the demand by setting up a few such charging stations.

REFERENCE

[1] Will Bangladesh's new vehicle emissions standards be enforced, 2021 March 22, retrieved from: https://www.google.com/amp/s/www.thethirdpole.net/en/pollution/will-bangladeshs-new-vehicle-emissions-standards-be-enforced/%3famp.

[2] Benefits of Renewable Energy, 2021 March 22, retrieved from: https://mnre.gov.in/knowledge-center/ publication.

[3] M. H. Nehrir et al., "A Review of Hybrid Renewable/Alternative Energy Systems for Electric Power Generation: Configurations, Control, and Applications," in *IEEE Transactions on Sustainable Energy*, vol. 2, no. 4, pp. 392-403, Oct. 2011, doi: 10.1109/TSTE.2011.2157540.

[4] X. Chen, M. B. Mcelroy, Q. Wu, Y. Shu and Y. Xue, "Transition towards higher penetration of renewables: an overview of interlinked technical, environmental and socio-economic challenges," in *Journal of Modern Power Systems and Clean Energy*, vol. 7, no. 1, pp. 1-8, January 2019, doi: 10.1007/s40565-018-0438-9..

[5] W. Zhou, C. Lou, Z. Li, L. Lu and H. Yang, (2010), " Current status of research on optimum sizing of stand-alone hybrid solar–wind power generation systems.", *Applied Energy*. 87. 380-389. 10.1016/j.apenergy.2009.08.012.

[6] A. M. Patel and S. K. Singal, "Off grid rural electrification using integrated renewable energy system," *2016 IEEE 7th Power India International Conference (PIICON)*, 2016, pp. 1-5, doi: 10.1109/POWERI.2016.8077272.

[7] Bangladesh on the road to an electric future, 2021 March 23, retrieved from: https://www.thedailystar.net/ tech-startup/news/bangladesh-the-road-electric-future-2180226.

[8] A. Joshi , K. M. V. Somaiya, A. Tharakram and M. Hussain, " Electric Vehicle Charging Station" in *2021 International Journal of Scientific Research in Science, Engineering And Technology. IEEE access*, v , pp: 122-128, 2021.

[9] G. Léna, (2013), "Rural Electrification with PV Hybrid Systems.", *International Energy Agency Photovoltaic Power Systems Programme*, IEA-PVPS T9:13. 58

[10] Photovoltaic effect and process, 2021 August 24, retrieved from: https://energyeducation.ca/encyclopedia/Photovoltaic_effect.

[11] Comparison solar cell poly-Si_vs_mono-Si, 2021 August 24, retrieved from: https://upload.wikimedia.org/wikipedia/commons/7/71/Comparison_solar_cell_poly-Si_vs_mono-Si.png.

[12] S. Gangwar, D. Bhanja and A. Biswas, (2015). *Cost, reliability, and sensitivity of a stand-alone hybrid renewable energy system—A case study on a lecture building with low load factor*. JOURNAL OF RENEWABLE AND SUSTAINABLE ENERGY. 7. 10.1063/1.4906916.

[13] Electric power production varies with wind speed, 2021 August 27, retrieved from:http://bergey.com/windschool/90-second-expert/windpower-for-remote-homes.

[14] Off-Grid Residential Wind Power, 2021 August 27, retrieved from: https://www.motherearthnews.com/sustainable-living/renewable-energy/home-wind-power-zm0z13amzrob/.

[15] Small Wind Turbines for Homes & Businesses, 2021 August 27, retrieved from:http://bergey.com/windschool/residential-wind-energy-systems.

[16] Types of Wind Turbines (HAWT vs VAWT), 2021 August 28, retrieved from: https://blog.arborwind.com/what-are-vertical-axis-wind-turbines?hs_amp=true.

[17] AC to DC Converters: Features, Design & Applications, 2021 September 03, retrieved from: https://how2electronics.com/ac-to-dc-converters-features-design-applications/.

[18] Portable charging station powered by second-life EV batteries, 2021 September 08, retrieved from:https://chargedevs.com/newswire/portable-charging-station-powered-by-second-life-ev-batteries

[19] What are the different types of battery, 2021 September 09, retrieved from: https://www.electronicshub.org/types-of-batteries/

[20] Three Main Battery Types: Alkaline, NiMH & Lithium Ion, 2021 September 09, retrieved from: https://paleblueearth.com/blogs/news/3-main-battery-types.

[21] What are the Benefits of Lithium-Ion Batteries , 2021 September 09, retrieved from: https://www.tennantco.com/en_ca/blog/2019/11/lithium-ion-battery-benefits.html.

[22] A. Faiz, C. S. Weaver, and M. P. Walsh, *World Bank Book : Air pollution from motor vehicles* , Stand Alone Books. November 1996, ISBN 978-0-8213-3444-7., pp. 18-56

[23] M. R. Ahsan and S. M. I. Rahman. "A Design and Simulation of Vehicle to Home (V2H) Technology to Match Power Demand", *International Journal of Innovative Science and Research Technology*, Vol. 7, Issue no. 2, February 2022.

[24] L. Lu, X. Han, L. Jianqiu, J. Hua, and M. Ouyang. (2013). “A review on the key issues for lithium-ion battery management in electric vehicles”, *Journal of Power Sources*. 226. 272–288. 10.1016/j.jpowsour.2012.10.060.

[25] The Different Types of Electric Vehicles, 2021 October 09, retrieved from: https://evcharging.enelx.com/resources/blog/566-different-types-of-electric-vehicles.

[26] K. Ramesh, C. Bharatiraja, R. Selvaraj, G. Vijayalakshmi and P.L. Sambanthan. (2016). Design and Implementation of Real Time Charging Optimization for Hybrid Electric Vehicles. *International Journal of Power Electronics and Drive Systems (IJPEDS)*. 7. 1261. 10.11591/ijpeds.v7.i4.pp1261-1268.

[27] Tesla Model S Specifications, 2021 October 09, retrieved from: https://ev-database.uk/car/1324/Tesla-Model-S-Performance#:~:text=is%20162%20mph.-,Battery%20and%20Charging,is%2098%20kWh%20 (estimate).

[28] Tesla Model 3 Specifications, 2021 October 09, retrieved from: https://ev-database.uk/car/1060/Tesla-Model-3-Standard-Range#:~:text=The%20battery%20of%20the%20Tesla,is%2040%20kWh%20 (estimate).

[29] Toyota Camry Specifications, 2021 October 09, retrieved from: https://mobile.guideautoweb.com/en/specifications/toyota/camry/hybrid-se/2020/.

[30] Toyota Prius prime 2019 Specifications, 2021 October 09, retrieved from: https://mobile.guideautoweb.com/en/specifications/toyota/prius/prime/2019/.

[31] Hyundai Sonata Specifications, 2021 October 09, retrieved from: https://mobile.guideautoweb.com/en/specifications/hyundai/sonata/hybrid-ultimate/2020/.

[32] S. Divyapriya, Amutha and R. Vijayakumar, "Design of Residential Plug-in Electric Vehicle Charging Station with Time of Use Tariff and IoT Technology," *2018 International Conference on Soft-computing and Network Security (ICSNS)*, 2018, pp. 1-5, doi: 10.1109/ICSNS.2018.8573637.

[33] A. Santos, N. McGuckin, H. Y. Nakamoto, D. Gray, and S. Liss, *Summary of travel trends: 2009 national household travel survey*, 1200 New Jersey Avenue, SE Washington, DC United States 20590, 2011-6, pp. 11-13.

[34] J. Babic, A. Carvalho, W. Ketter and V. Podobnik, "Evaluating Policies for Parking Lots Handling Electric Vehicles," *in IEEE Access*, vol. 6, pp. 944-961, 2018, doi: 10.1109/ACCESS.2017.2777098.

[35] A. S. Varghese, P. Thomas and S. Varghese, "An efficient voltage control strategy for fast charging of plug-in electric vehicle," *2017 Innovations in Power and Advanced Computing Technologies (i-PACT)*, 2017, pp. 1-4, doi: 10.1109/IPACT.2017.8245074.

[36] B. Deng and Z. Wang, "Research on Electric-Vehicle Charging Station Technologies Based on Smart Grid," *2011 Asia-Pacific Power and Energy Engineering Conference*, 2011, pp. 1-4, doi: 10.1109/APPEEC.2011.5748759.

[37] M. D. Paolo, "Analysis of harmonic impact of electric vehicle charging on the electric power grid, based on smart grid regional demonstration project — Los angeles," *2017 IEEE Green Energy and Smart Systems Conference (IGESSC)*, 2017, pp. 1-5, doi: 10.1109/IGESC.2017.8283460.

[38] D. Zheng, F. Wen and J. Huang, "Optimal planning of battery swap stations," *International Conference on Sustainable Power Generation and Supply (SUPERGEN 2012)*, 2012, pp. 1-7, doi: 10.1049/cp.2012.1846.

[39] S. Habib, M. M. Khan, F. Abbas, L. Sang, M. U. Shahid and H. Tang, "A Comprehensive Study of Implemented International Standards, Technical Challenges, Impacts and Prospects for Electric Vehicles," *in IEEE Access*, vol. 6, pp. 13866-13890, 2018, doi: 10.1109/ACCESS.2018.2812303.

[40] F. Zhang, X. Zhang, M. Zhang and A. S. E. Edmonds, "Literature review of electric vehicle technology and its applications," *2016 5th International Conference on Computer Science and Network Technology (ICCSNT)*, 2016, pp. 832-837, doi: 10.1109/ICCSNT.2016.8070276.

[41] M. Yilmaz and P. T. Krein, "Review of charging power levels and infrastructure for plug-in electric and hybrid vehicles," *2012 IEEE International Electric Vehicle Conference*, 2012, pp. 1-8, doi: 10.1109/IEVC.2012.6183208.

[42] Y. J. Jang, "Survey of the operation and system study on wireless charging electric vehicle systems," *Transportation Research Part C: Emerging Technologies*, vol. 95, pp. 844–866, 2018.

[43] N. Shinohara, "Wireless power transmission progress for electric vehicle in Japan," *2013 IEEE Radio and Wireless Symposium*, 2013, pp. 109-111, doi: 10.1109/RWS.2013.6486657.

[44] Electric Vehicle Charging System, 2021 September 15, retrieved from: https://circuitdigest.com/article/electric-vehicle-on-board-chargers-and-charging-stations.

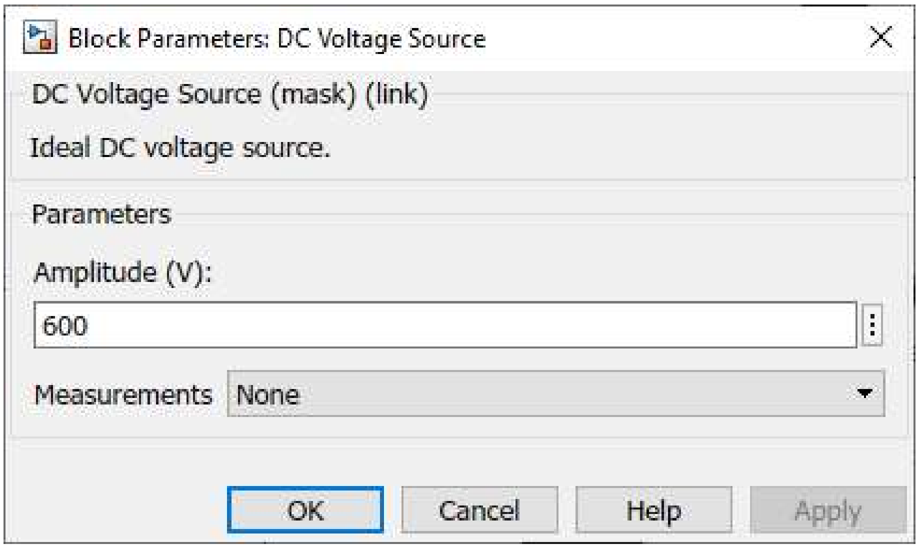
[45] Chittagong City Outer Ring Road, Patenga, 2021 July 22, retrieved from: https://m.daily-bangladesh.com/english/Chittagong-City-Outer-Ring-Road-to-be-launched-in-Dec/51152.

[46] Solar radiation data and wind speed data, 2021 September 17, retrieved from: https://power.larc.nasa.gov/data-access-viewer/.

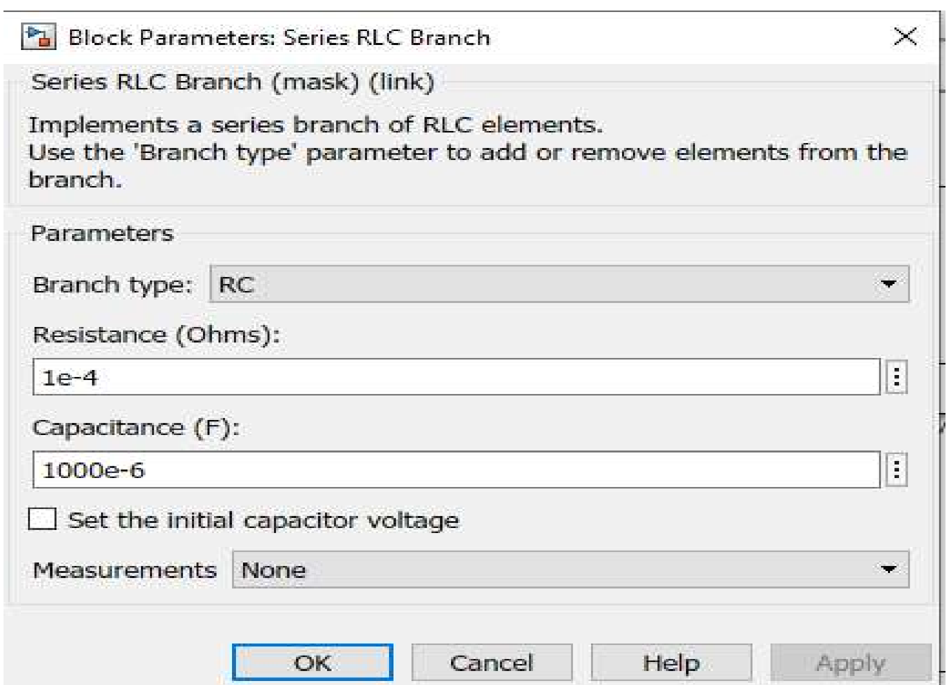
APPENDIX A

Appendix.A:

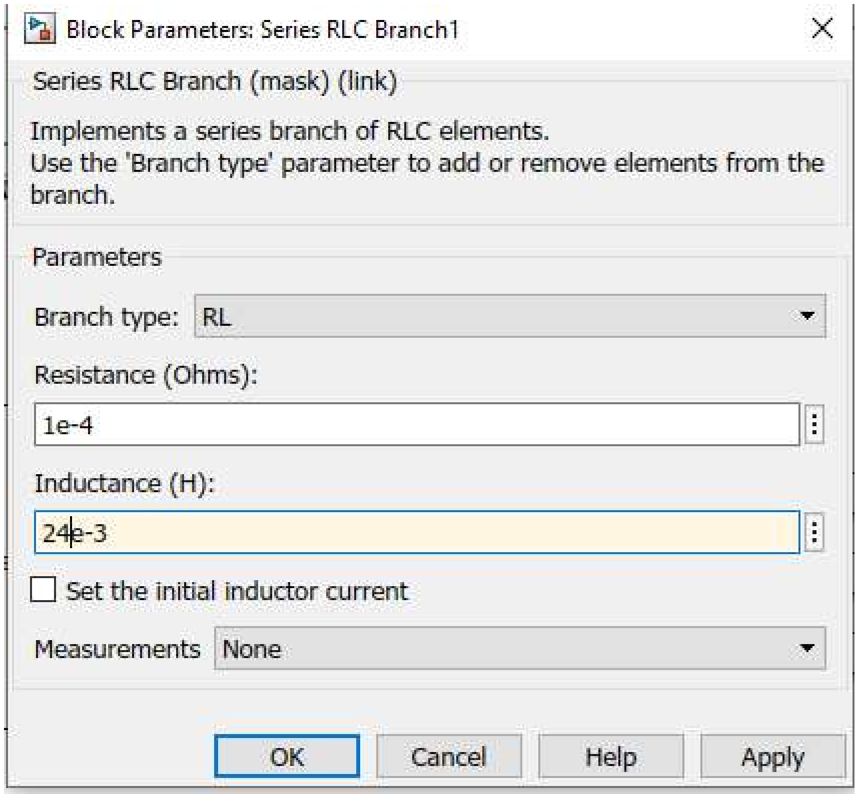
1) **DC input voltage**

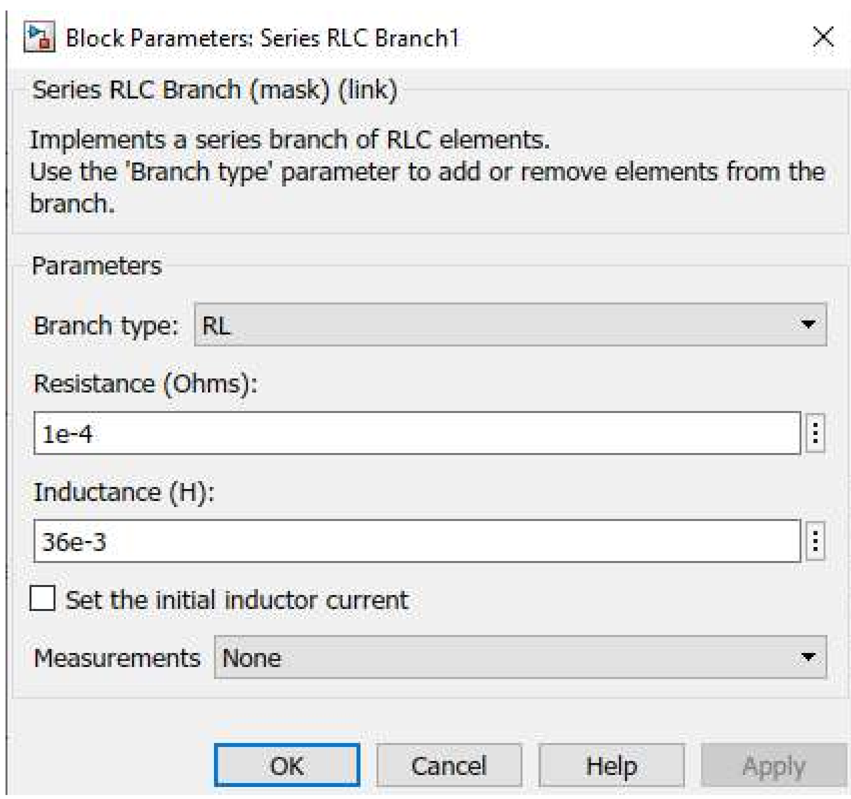


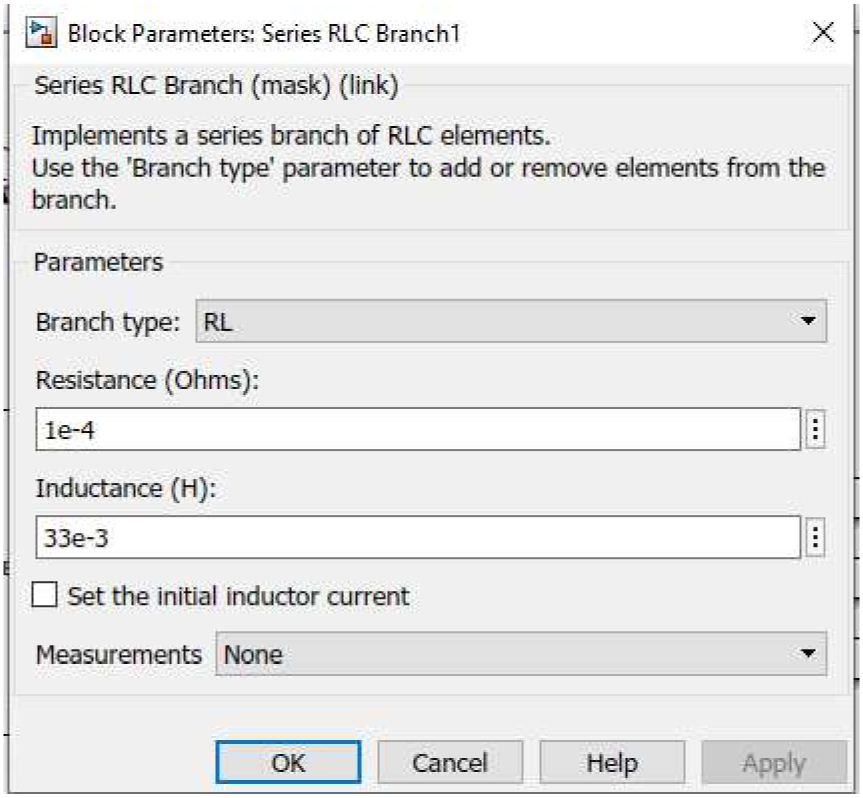
2) **Input bus capacitance**



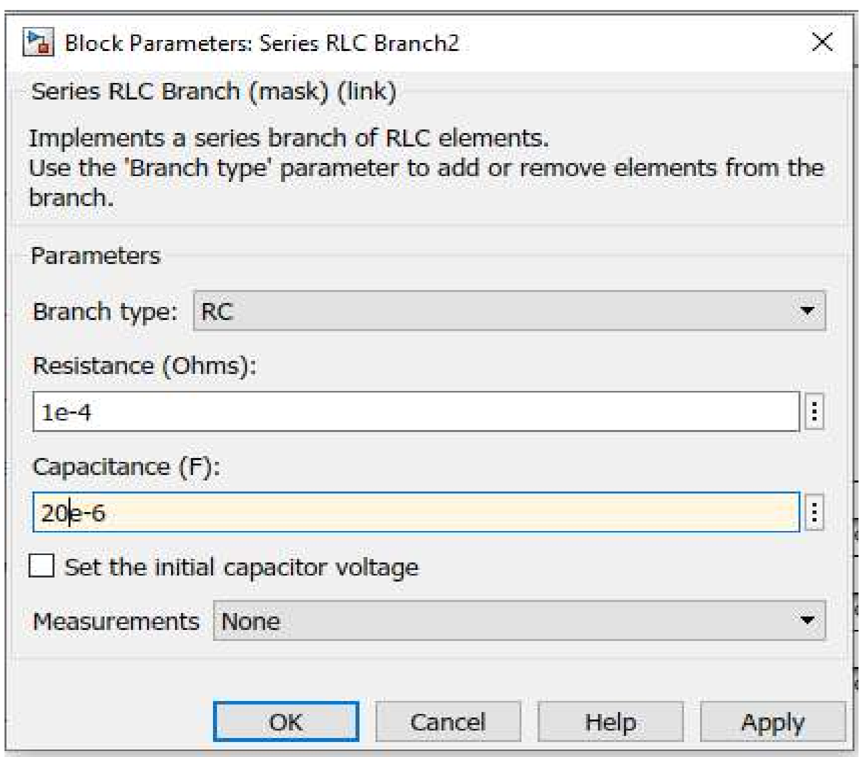
3) Output filter inductor



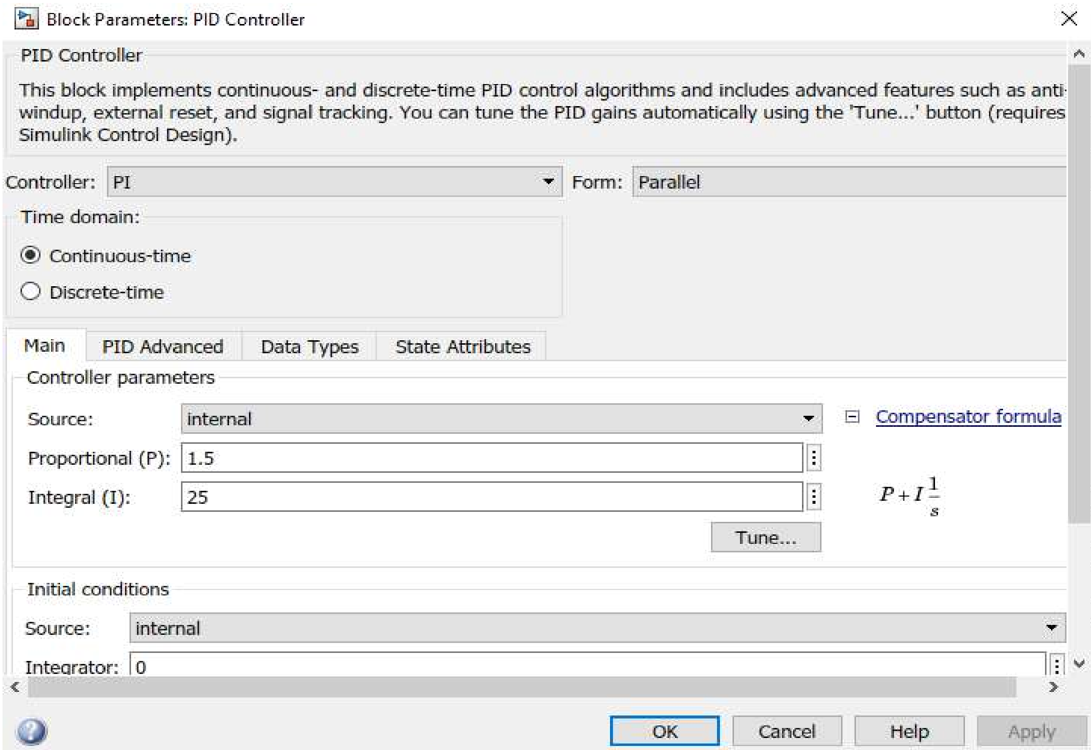




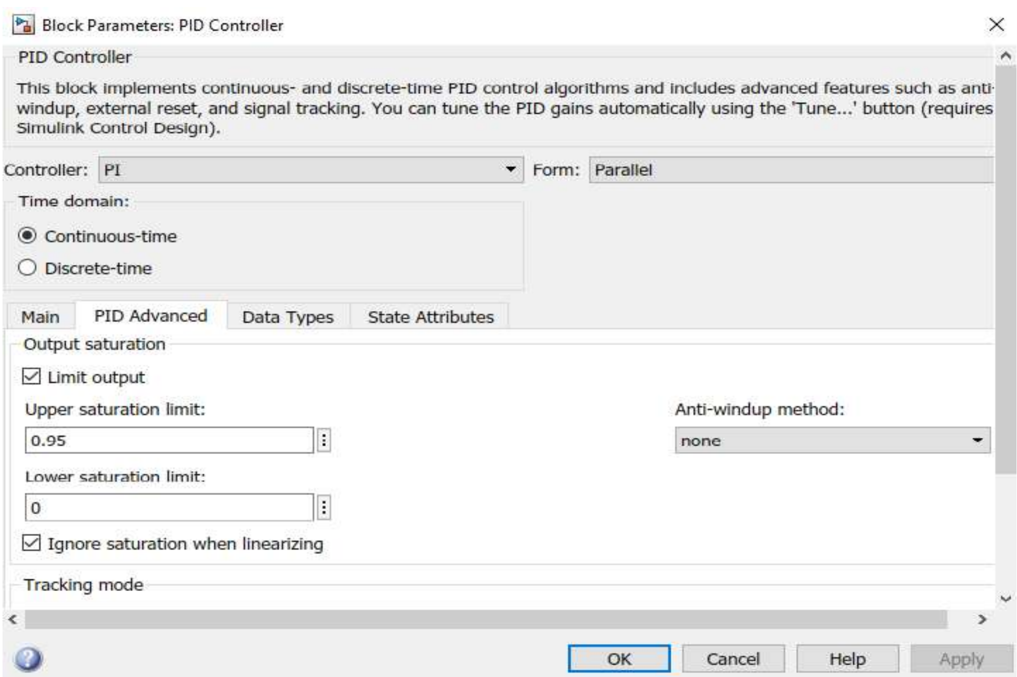
4) Output filter capacitor



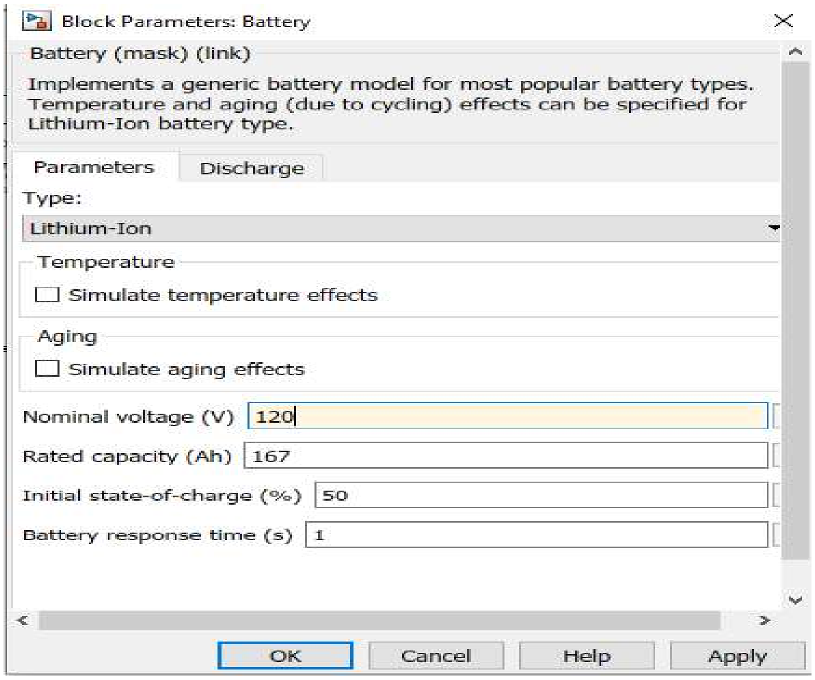
5) PI controller values



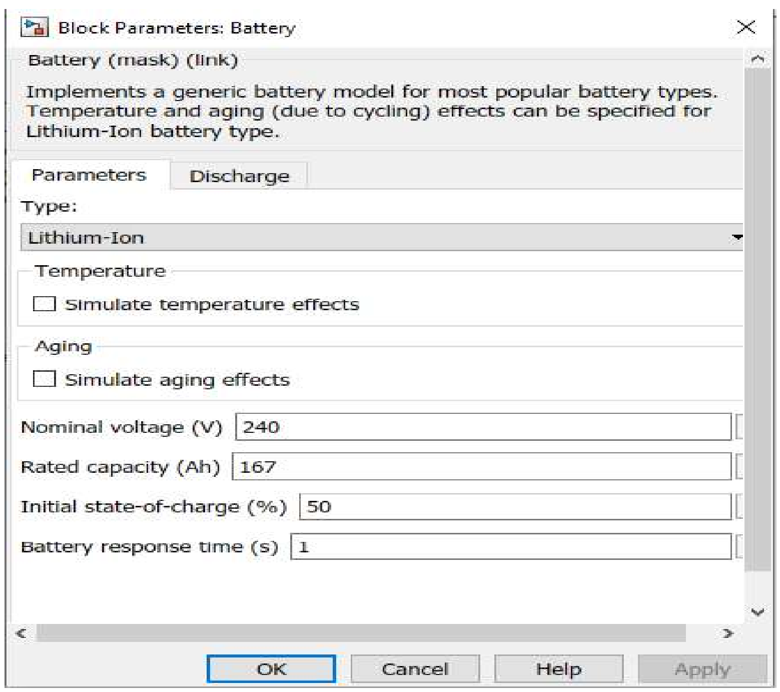
6) PI controller limit values



7) Nominal voltage for level 1 charger



8) Nominal voltage for level 2 charger



9) Nominal voltage for level 3 charger