A Study to Set up Hybrid Recharging Station for E-Vehicles

As

Bangladesh perspective

By

Raktim Mitra

&

Syed Bahauddin Ahmed

A Thesis

Submitted as partial fulfillment for the degree of

B.SC. IN ELECTRICAL & ELECTRONIC ENGINEERING

In the department of

Electrical & Electronic Engineering

INTERNATIONAL ISLAMIC UNIVERSITY CHITTAGONG

BANGLADESH

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CANDIDATES DECLARATION

It is hereby declared that the work presented in this thesis is done by us under the supervision of Engr.Md.Ahsanul Hoque, Lecturer, Department of Electrical & Electronic Engineering, IIUC. We also declare that, all information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

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RECOMMENDATION

This is to certify that Raktim Mitra & Syed Bahauddin Ahmed, students of International Islamic University Chittagong under the department of Electrical & Electronic Engineering had carried out the thesis on “A Study to Set up Hybrid Recharging Station for E-Vehicles As Bangladesh perspective”, under my supervision.

Signature of the supervisor

……………………….

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First of all we want to thank our Almighty creator for giving us opportunity to complete this thesis paper properly. It has been a great and wonderful experience to conduct this study. We have learned a lot during the process. Also we really have strong passion for energy. We hope this study provide some useful ideas for the readers and stimulate further research in this area.

It gives us much pleasure to express our deepest sense of gratitude and sincere thanks to our highly respected sir Engineer Md. Ahsanul Hoque, Lecturer of EEE Department, IIUC, for his guidance throughout our dissertation work. We can't say thank him enough for his tremendous support and help. It was real pleasure to work under his guidance. We feel motivated and encouraged every time we attend his meeting.

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We express our indebtedness of our friends for their help and valuable suggestions to complete this paper work and also for tolerating our mistakes and immaturity.

At last but not least, we are also thankful to those who have directly or indirectly helped us and encouraged us to complete this thesis.

September, 2014 Authors

DEDICATED TO………

ALL THE MOTHERS OF THE WORLD

ABSTRACT

Renewable energy resources can play an important role in a developing country like Bangladesh. In Bangladesh the electric vehicles powered by rechargeable batteries are becoming popular day by day but it is a matter of great regret that a big amount of power is being used daily to recharge their batteries at the recharging stations. As Bangladesh faces acute power crisis this is a big challenge. This paper has proposed a PV based recharging station for electric vehicles and made a detail analysis on it.

Keywords: Solar System, Wind turbine, Hybrid Recharging Station, Power System.

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CHAPTER 1

INTRODUCTION

1.1 Electric Vehicles

The electrical vehicles are relatively new concept in the world of the automotive industry. The distinguishing feature of an electric vehicle is that it is propelled by one or more electric motors rather than by an internal-combustion engine. Electric vehicle can be separated into three groups based on the how and where the electricity produced.

- Vehicles relying on continuous electric supply from an off-board generation system. These include trolley buses supplied by overhead wires as well as most electric transportation systems. Because of their dependence on continuous electric supply. These vehicles are suitable only for very limited niches.
- Vehicles relying on stored electricity from an off-board generation system. These include battery- electric vehicles as well as vehicles using other energy storage media such as flywheels. These are frequently referred to as zero-emission vehicles but this is true only if emissions from the off-board power generation system are ignored.
- Vehicles relying on on-board electric generation to supply their needs. These includes series electric hybrids in which a small engine drives an electric generator while the wheels are provided exclusively by an electric motor in which both the engine and the electric motor can drive the wheels and fuel cell electric vehicles.

1.2 Advantages of electrical vehicles:

- The number one advantage of an electric vehicle is that no gas is required.
- The most obvious advantage of electric car batteries is that they don't produce the pollution associated with internal combustion engines. However, they still have environmental costs.
- The important advantage of battery-powered motors over gas-powered engines is the lower cost of the fuel.
- Developing electric vehicles is important in reducing greenhouse gas emissions. Electric vehicles are 100 percent eco-friendly as they run on electrically powered engines. It does

not emit toxic gases or smoke in the environment as it runs on clean energy source. They are even better than hybrid cars as hybrids running on gas produce emissions. You'll be contributing to a healthy and green climate. American vehicles are responsible for almost half of the green house gas emitted by vehicles globally but make up 30 percent of cars in use according to report by Environmental Defense.

- We can plug the car into any outlet of the proper voltage and charge the car. Electricity is much cheaper than gas and the savings will be dramatic.
- Safety is a big concern with these vehicles. However, the fluid batteries actually take impact better than a fully made gas car and can help even more in the event of an accident.
- Electric vehicles run on electrically powered engines and hence there is no need to lubricate the engines. Other expensive engine work is a thing of past. Therefore, the maintenance cost of these vehicles has come down. We don't need to send it to service station often as we do a normal gasoline powered vehicle.
- Electric vehicle put curb on noise pollution as they are much quieter. Electric motors are capable of providing smooth drive with higher acceleration over longer distances.

1.3 Problem Statement:

- The speed of electrical motor rickshaw is not suitable with their body structure. That's why causing a lot of accidents.
- The roads of Bangladesh are not suitable for such kind of E-vehicles.

1.4 Importance of electric vehicles as Bangladesh perspective:

Air pollution has become a matter of great concern for us in recent years. In the recent year public repression has increased to a great extent due to this problem. Those who are living in cities in Asian countries including Dhaka have already realized how seriously air pollution has been poisoning life and degrading the environment. People living in major towns of Bangladesh experience the problems of air pollution in varied degrees.

Diesel & petrol run vehicles contribute a lot to air pollution. Industrialization and mechanized vehicles are two major sources of air pollution in any country. The number of automobiles has been increasing in Bangladesh at the rate of at least 10 per cent annually which has been contributing to air pollution on the one hand and traffic congestion on the other.

The main pollutants from gasoline powered internal combustion engines are carbon monoxide, hydrocarbons, nitrogen oxides, sulphur dioxide particulates of lead compound and unburned carbon particles. Emissions from diesel engines are smoke, carbon monoxide, unburned carbon, nitrogen oxides and sulphur dioxide. Air pollution seriously affects the respiratory tract and causes irritation, headache, asthma, high blood pressure, heart ailments and even cancer. If this trend of air pollution continued, those living in major cities including the metropolis will become exposed to these ailments and also other complications. The mental faculty of children will be adversely affected by lead pollution which can also affect the central nervous system and cause renal damage and hypertension. This problem can be solved if we use electric vehicles which are not depending on petrol and diesel. In future, petrol and diesel will be finished. So, at those times, we will have to depend on electricity to run vehicles.

But, we will not be able to depend on grid line power for running electric vehicles because of shortage of power. That’s why; we can depend on Renewable energy. In the next chapter, we have proposed a Renewable energy based Hybrid charging station for electric vehicles. Currently two types of electric vehicles are available in our country. These are Electric Motor Rickshaw and electric taxi (locally called tom-tom). We have proposed our hybrid charging system based on these two types of vehicles.

1.5 Chapter overview

In the first chapter, we have discussed about E-vehicles as Bangladesh perspective.

In the second chapter, we have given a proposal to set up Hybrid charging station for E-vehicles. We discussed here about total system output and required cost. We also have shown here software simulation of total system output. Hope that, our proposed thesis will be helpful for Bangladesh. Finally in the third chapter, we have added the conclusion.

CHAPTER 2

Hybrid Recharging Station for E-Vehicles

Day by day pollution is overwhelming all major cities of our country. The main reasons are the air and noise pollution caused by transport vehicles and a significant part comes from petrol and diesel-powered motorbikes and three-wheelers. Electric vehicle is totally friendly with environment and free from pollution.

Currently two types of electrical verticals are running in our country. One is locally called “Tom Tom”. It looks closely like traditional CNG based auto rickshaw except its run on battery. The second one is two seated rickshaw. Both of them are energy efficient and environment friendly being popular in the world as well as Bangladesh.

Fig.1: Motor driven rickshaw.

Fig.2: Easy bike (Tom-Tom).

Battery-run rickshaws And Easy bike could be a low-emitter complementary transport for the low-income people, who suffer most from a lack of transport facility. Though, these types of vehicles are getting popularity day by day but motor driven rickshaw and tom-tom consume a lot of power every day. For finding the number of motor driven rickshaw in Chittagong city, we had contact with Chattagram Motor Rickshaw Malik Somiti, Chattagram Mohanogori Auto Rickshaw Malik Somiti, Chattagram Auto Rickshaw Malik Chalok Kollan Somiti, Chittagong Metro Auto-Rickshaw Malik Somiti. They Said Approximately 1,50,000 motor driven rickshaw are in Chittagong city [1]. Each EMR consumes 0.5 kW of electricity during off-peak hours to recharge the batteries [2] and 1, 50,000 Rickshaws consume at best 75000 KW and monthly it’s become 2250000kW. It’s a big amount of electricity consumed by Electrical motor rickshaw monthly. This causes lots of load shedding in Chittagong city.

To realize the amount of loss, we had made a survey in different Thana of Chittagong city to find out the number of motor driven rickshaw which is given charge from garage or household connection.

Table 1: Loss of electricity of different areas caused by electrical motor rickshaw

No	Name of Thana	Number of Rickshaw	Number of rickshaw ×0.5 kW	Amount of consumed power
1	Panchlaish Thana	11370	11370× 0.5 kW	5685 kW
2	Double mooring Thana	9570	9570× 0.5 kW	4785 kW
3	Kotowali Thana	14590	14590× 0.5 kW	7295 kW
4	Bandar Thana	19340	19340× 0.5 kW	9670 kW
5	Patenga Thana	11478	11478× 0.5 kW	5735 kW
6	Karnafuly Thana	13788	13788× 0.5 kW	6894 kW

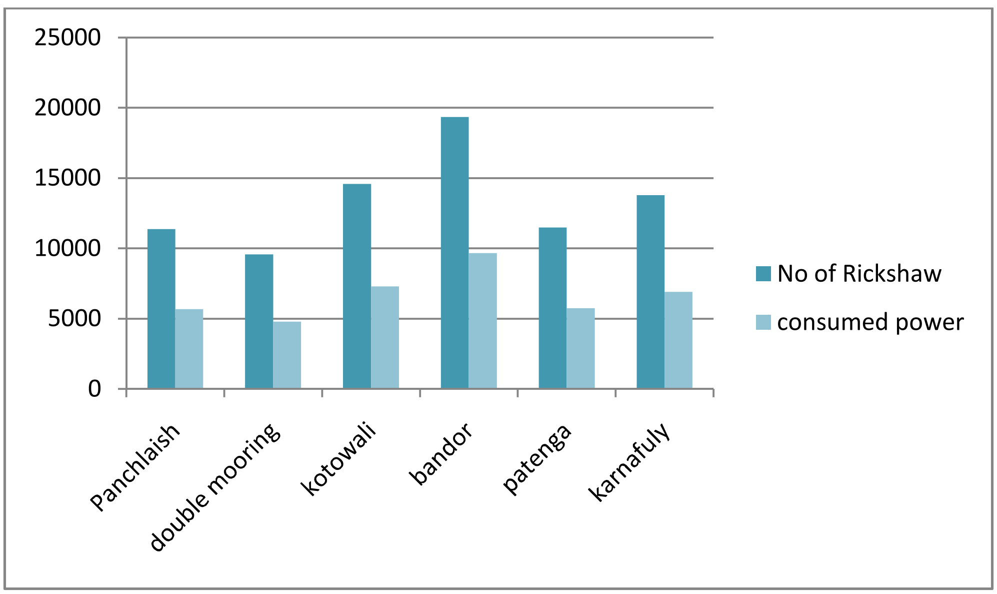

Fig.3: Day electricity loss caused by electrical motor rickshaw/easy bike of different areas.

We have shown the power loss graphically of various Thana of Chittagong city areas. The amount of loss will be more for all over the country because the amount of electrical rickshaw is increasing day by day. In Chittagong, the power station cannot maximize production due to gas shortage. As a result load shedding is increasing day by day. Charging of electrical motor rickshaw and easy bike plays a role to increase load shedding. The number of electrical motor rickshaw is increasing day by day and these are found everywhere in Chittagong and whole Bangladesh. This will create more force for becoming load shedding.

A 48V, 500W, 13.5A, 500rpm rated brushless DC (BLDC) gear motor used in the system. Four 12V, 20Ah rechargeable batteries were used in series to provide 48 Volts to the BLDC motor. These were lead-acid batteries each weighing 7.1 Kg and 181 X 77 X 171 mm in dimension. The batteries were accommodated inside the seats[3]. Controller is essential for BLDC motors because of complicated electronics connection and charger for charging battery shown in below:

Fig.4: Motor, charger & controller.

Currently there is no recharging station for charging them as it consumes lots of power from Grid. So here we propose a hybrid electrical vehicle Recharging station.

2.1 Proposed Design of hybrid charging station: There are a lot of CNG stations in our country. We have proposed here a hybrid charging station for electrical vehicles. Our proposed hybrid system has been discussed below:

Fig.5: CNG station.

Solar and wind energy will be used here as hybrid system. This process can run alongside the Normal CNG filling station or petrol pump, as the solar panels would be mounted on top of it and wind turbine will be at 40m height. This method can work in almost every part of Bangladesh as the whole country face almost same solar insulation and wind speed, which is enough to produce required electrical energy. In the solar side, The PV modules can be accommodated on the roof of fuel filing stations. Generally the roof is plain as a result there is no problem to set up but for maximum efficiency. That is why; no extra space will not require for setting up hybrid charging station. PV modules are tilted with an angle which depends on the location of the installation. For Bangladesh the optimum tilt angle is around 23°[4].Capacity of the PV module should be selected taking in consideration the rooftop size for accommodating the panels and the desired output. For making our system hybrid, we will use here a wind turbine to increase the production. Any types of wind turbine can be used here. The wind generation module is constituted by a windmill, a generator, a rectifier, and a dc/dc converter. The converter commands the voltage on the generator terminals, indirectly controlling the operation point of the wind turbine and consequently its power generation. Solar modules will be connected to the dc bus via a dc/dc converter. The control sections control the whole system which is connected or interfaced with the output devices or a Personnel Computer. There will also be a meter which continuously measures the electrical supply and the data is sent to displaying unit. This unit may be a Personnel Computer or other display unit. If it is PC, there is an advantage that the data will be gathered .As the battery is DC powered there is no need to attach with any inverter.

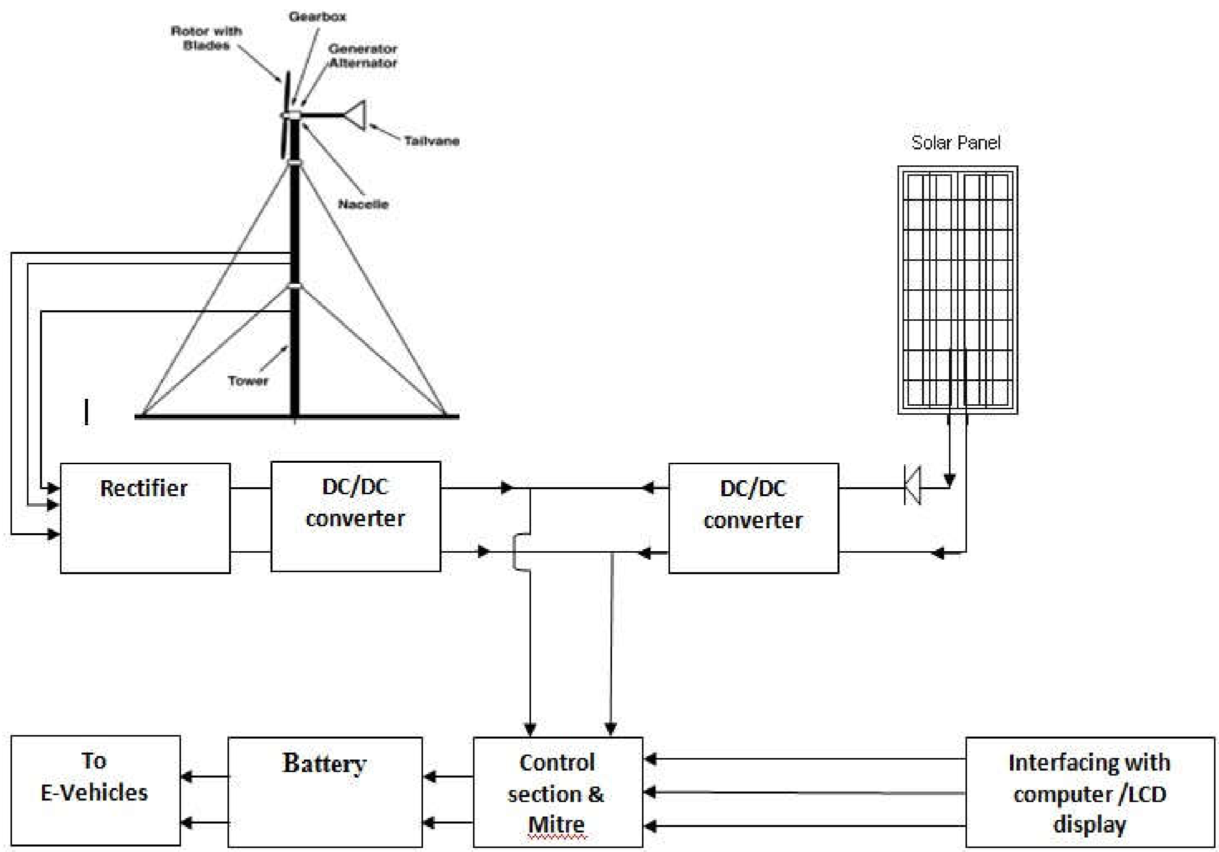

Fig.6: Block diagram of total hybrid system.

Here rectifier has been used here for converting AC to DC. The DC/DC converter is used for converting a source of DC current from one voltage level to another. The cost of our proposed hybrid station components may be varied depending on its brand, quality, place and quantity.

For solar energy, our estimated capacity is 8kW per day. So, considering overall efficiency 55%, total input power = 8/0.55 = 14.55 kW. If we choose 230W solar panel each, the number of solar panels will be= (14.55x1000)/230 =63.24 ≈ 63. So, here we have taken 15kW solar panel each of 230W. Maximum output would be greater when the solar radiation is high.

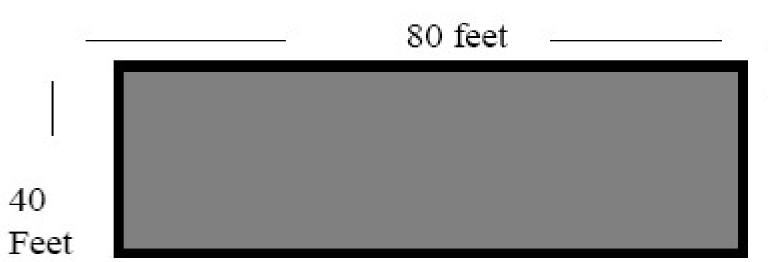

Fig.7: Length & width of total solar panel area.

In our proposed system, the length of the total solar panel is around 80 feet and the breadth is around 40 feet.

So , Area = (80 x 40) square feet

= 3200 square feet

= 975.36 m^2.

Total Solar panel Area will be 975.36 m^2

In our proposed system, we will use one 10kW wind turbine which start up wind speed will be $2ms^{-1}$ and its diameter will be 8 miters. We should use that kind of wind turbine which has high lifetime with cost efficiency. The specification of wind turbine which we proposed to use in our hybrid system is given below:

Table 2: Specification of wind turbine of proposed hybrid system

Company name	Hikochi electronics limited,China (mainland)
Product	Wind turbine
Product ID	FD8.0-10000
Rated power(w)	10KW
Rated Voltage	240V
Rotor Diamitre	8m
Start up wind speed	$2ms^{-1}$
Rated wind speed	$12ms^{-1}$
Security wind speed	$60ms^{-1}$
Generator work way	Magnetic saturation
Generator material	Steel
Blade material	Fiber glass
Blade quantity	3
Tower Height	12m
Matched inverter type	Sine wave
Price	8210.53 USD

2.2 Calculation of Annual solar output:

Global formula to estimate the electricity generated in output of a photovoltaic system is:

E = **A** x **r** x **H** x **PR**

Here,

E = Energy

A = Total solar panel Area (m^2)

$$r = \frac{\text{electric power of one solar panel in KW}}{\text{Area of one solar panel}}$$

H = monthly average solar radiation on tilted panels (shadings not included)

PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9).

Example of losses details that give the PR value (depend on the site, the technology, and sizing of the system):

- Temperature losses.
- DC cables losses.
- Shadings (specific to each site).
- Losses weak radiation.
- Losses due to dust, snow.
- Other losses.

In our system,

A = 975.36 m^2

$$r = \frac{\text{electric power of one solar panel in kW}}{\text{Area of one solar panel}} = \frac{0.23\ kW}{15.48} = 0.015$$

[Electric power of one solar panel is 230 W. So, it is 0.23 in kW and we will use 63 solar panels which total Area is 975.36 m^2. So, Area of one solar panel is 15.48 m^2]

H = month wise solar radiation in selected place.

PR = 0.9 [range between 0.5 to 0.9]

The solar resource input for the various months throughout the year was obtained from the internet via HOMER software by providing the latitude, longitude and time zone information.
Location of the site: Latitude $22^0 33'$ North, Longitude: $91^0 59'$ East

The averages solar radiation data for various months throughout the year of Chittagong is shown below.we have got it by setting Chittagong in HOMER as input parameter.

Table 3: The average solar radiation data of Chittagong

Month	Daily radiation
January	4.59
February	5.12
March	5.63
April	5.76
May	5.78
June	4.33
July	4.04
August	4.22
September	4.08
October	4.72
November	4.40
December	4.39
Average	4.75

(i)Power available per day from solar PV system in January: E = **A** x **r** x **H** x **PR**

= 975.36 m^2 x 0.015 x 4.59 x 0.9

= 60.45 kW

Total power production of January = 60.45 kW x 31 days = 1873.60 kW

(ii) Power available per day from solar PV system in February: E = **A** x **r** x **H** x **PR**

= 975.36 m^2 x 0.015 x 5.2 x 0.9

= 68.47 kW

Total power production of February = 68.47 kW x 28 days = 1917.16 KW

(iii) Power available per day from solar PV system in March : E = **A** x **r** x **H** x **PR**

= 975.36 m^2 x 0.015 x 5.63 x 0.9

= 74.14 kW

Total power production of March = 74.14 kW x 29 days = 2150.06 kW

(iv) Power available per day from solar PV system in April : E = **A** x **r** x **H** x **PR**

$= 975.36\ m^2 \times 0.015 \times 5.76 \times 0.9$

$= 75.85$ kW

Total power production of April = 75.85kW x 30 days = 2275.5 kW

(v) Power available per day from solar pv system in May : E = **A** x **r** x **H** x **PR**

$= 975.36\ m^2 \times 0.015 \times 5.78 \times 0.9$

$= 76.10$ kW

Total power production of May = 76.10 kW x 31 days = 2359.1 kW

(vi) Power available per day from solar PV system in June : E = **A** x **r** x **H** x **PR**

$= 975.36\ m^2 \times 0.015 \times 4.33 \times 0.9$

$= 57.01$ kW

Total power production of June = 57.01 kW x 30 days = 1710.44 kW

(vii) Power available per day from solar PV system in July : E = **A** x **r** x **H** x **PR**

$= 975.36\ m^2 \times 0.015 \times 4.04 \times 0.9$

$= 53.20$ kW

Total power production of July = 53.20kW x 31 days = 1649.2 kW

(viii) Power available per day from solar PV system in August : E = **A** x **r** x **H** x **PR**

$= 975.36\ m^2 \times 0.015 \times 4.22 \times 0.9$

$= 55.57$ kW

Total power production of August = 55.57 kW x 30 days = 1667.1 kW

(ix) Power available per day from solar PV system in September : E = **A** x **r** x **H** x **PR**

$= 975.36\ m^2 \times 0.015 \times 4.08 \times 0.9$

$= 53.73$ kW

Total power production of September = 53.73 kW x 30 days = 1611.9 kW

(x) Power available per day from solar PV system in October : E = **A** x **r** x **H** x **PR**

$= 975.36\ m^2 \times 0.015 \times 4.72 \times 0.9$

$= 62.15$ kW

Total power production of October = 62.15 kW x 31 days = 1926.65 kW

(xi) Power available per day from solar PV system in November : E = **A** x **r** x **H** x **PR**

$= 975.36\ m^2 \times 0.015 \times 4.40 \times 0.9$

$= 57.95$ kW

Total power production of November = 57.95 kW x 29 days = 1680.55 kW

(xii) Power available per day from solar in December : E = **A** x **r** x **H** x **PR**

$= 975.36\ m^2 \times 0.015 \times 4.39 \times 0.9$

$= 57.80$ kW

Total power production of December =57.80 kW x 31 days = 1791.8 kW

So, Total annual output from solar PV system = [1873.60+ 1917.16 + 2150.06 + 2275.5 + 2359.1 + 1710.44 + 1649.2 + 1667.1 + 1611.9 + 1926.65 + 1680.55 + 1791.8] kW

= 22613.06 kW

2.3 Calculation of Annual wind turbine output:

The kinetic energy (KE) of an object (or Collection of objects) with total mass M and velocity V is given by the expression:

$$KE = ½ * M * V^2 \text{...} (1)$$

Now, for purposes of finding the kinetic energy of moving air molecules (i.e. wind), it has the geometry of a collection of air molecules passing though the plane of a wind turbine blades (which sweep out a cross-sectional area A), with thickness (D) passing through the plane over a given time. The volume (Vol) of this parcel is determined

by the parcel's area multiplied by its thickness:

$$Vol = A * D$$

Let ρ (the greek letter 'rho') represent the density of the air in this parcel.

Note that density is mass per volume and is expressed as:

$$\rho = M / Vol$$

and a little algebra gives:

$$M = \rho * Vol$$

Now let's consider how the velocity (**V**) of our air parcel can be expressed.

If a time T is required for this parcel (of thickness **D**) to move through the plane of the wind turbine blades,

then the parcel's velocity can be expressed as V = D / T

and a little algebra gives D = V * T.

Let's make some substitutions in expression no. 1 ($KE = ½ * M * V^2$)

Substitute for M (= ρ * Vol) to obtain: KE = ½ * (ρ * Vol) * V^2

And Vol can be replaced by A * D to give: KE = ½ * (ρ * A * D) * V^2

And D can be replaced by V * T to give: KE = ½ * (ρ * A * V * T) * V^2

Leaving us with: KE = ½ * ρ * V3* A * T

Now, power is just energy divided by time, so the power available from our air parcel can be expressed as:

$$\begin{aligned} \text{Power} &= KE / T \\ &= (\tfrac{1}{2} * \rho * V^3 * A * T) / T \\ &= \tfrac{1}{2} * \rho * A * V^3 \end{aligned}$$

So, the equation of power of wind is

$$P = \tfrac{1}{2} \times \text{Air density} \times \text{swept rotor area} \times (\text{wind speed})^3$$

Here , wind speed of Chittagong according to patenga weather station (Chittagong) is given below :

Table 4: Wind speed of Chittagong according to patenga weather station[5]

Month	Wind speed
January	3.25 ms^{-1}
February	2.66 ms^{-1}
March	3.13 ms^{-1}
April	2.88 ms^{-1}
May	4.96 ms^{-1}
June	5.83 ms^{-1}
July	5.67 ms^{-1}
August	5.13 ms^{-1}
September	3.36 ms^{-1}
October	3.2 ms^{-1}
November	2.61 ms^{-1}
December	2.97 ms^{-1}
Average	3.8 ms^{-1}

According to German scientist Albert Beiz, 59.3% electric energy can be found from total wind energy[6]. It is called Beiz's law and was first formulated on 1919. Our target is to produce 40% electricity. Rest power is considered as loss.

Rotor swift Area of wind turbine= $\pi \times$ (4m) ^{2} =50.26 m^2

[Rotor diameter=8m, so, radius =$\frac{8m}{2}$ =4m]

Air Density = 1.16kg/m^3 at 30^{o} C

Energy equation, P = $\frac{1}{2}\times$Air Density × Rotor Swift Area × (Air Speed) ^{3}

(i) In January, per day power production will be = $\frac{1}{2}\times 1.16\times 50.26\text{m}^2\times (3.25\text{ms}^{-1})^3$ =1.00069 kW

Generation according to German scientist Albert Beiz = 1.00069 ×40% = 0.4003 kW

[According to German scientist Albert Beiz , 59.3% electric energy can be found from total wind energy. Our target is to produce 40% electric energy from wind]

Generation in January (744 hours)= 0.4003 kW x 744 hours = 297.82 kWh

(ii) In February, per day power production will be = $\frac{1}{2}\times 1.16\times 50.26\text{m}^2\times (2.66\text{ ms}^{-1})^3$ =0.55 KW

Generation according to German scientist Albert Beiz = 0.55 ×40% = 0.219 KW

Generation in February (672 hours) = 0.219 kW x 672 hours = 147.5 kWh

(iii) In March, per day power production will be = $\frac{1}{2}\times 1.16\times 50.26\text{m}^2\times (3.13\text{ ms}^{-1})^3$ = 0.89 kW

Generation according to German scientist Albert Beiz = 0.89 kW ×40% =0.357 kW

Generation in March(696 hours) = 0.357 kW x 696 hours = 248.85 kWh

(iv) In April, per day power production will be = $\frac{1}{2}\times 1.16\times 50.26\text{m}^2\times (2.88\text{ ms}^{-1})^3$ = 0.69kW

Generation according to German scientist Albert Beiz = 0.69 ×40% = 0.27 kW

Generation in April (720 hours) = 0.27 kW x 720 hours = 200.54 kWh

(v) In May , per day power production will be = $\frac{1}{2}\times 1.16\times 50.26\text{m}^2\times (4.96\text{ ms}^{-1})^3$ =3.55 kW

Generation according to German scientist Albert Beiz = 3.55 ×40% = 1.422 kW

Generation in May (744 hours) = 1.422 kW x 744 hours = 1058.60 kWh

(vi) In June, per day power production will be= $\frac{1}{2}\times 1.16\times 50.26\text{m}^2\times (5.83\text{ ms}^{-1})^3$ = 5.77 kW

Generation according to German scientist Albert Beiz = 5.77 ×40% =2.31 kW

Generation in june (720 hours) = 2.31 kW x 720 hours = 1663.60 kWh

(vii) In July, per day power production will be= $\frac{1}{2}\times 1.16\times 50.26\text{m}^2\times (5.67\text{ ms}^{-1})^3$ = 5.31 kW

Generation according to German scientist Albert Beiz = 5.31 ×40% = 2.13 kW

Generation in July (744 hours) = 2.13 KW x 744 hours = 1581.36 kWh

(viii) In August, per day power production will be= $\frac{1}{2}\times 1.16\times 50.26m^2\times (5.13\ ms^{-1})^3$ =3.94 kW

Generation according to German scientist Albert Beiz = 3.94 ×40% = 1.57 kW

Generation in August (720 hours) = 1.57 kW x 720 hours = 1133.43 kWh

(ix) In September, per day power production will be= $\frac{1}{2}\times 1.16\times 50.26m^2\times (3.36ms^{-1})^3$ =1.10 kW

Generation according to German scientist Albert Beiz = 1.10×40% =0.44 kW

Generation in September (720 hours) = 0.44 kW x 720hours = 318.46 kWh

(x) In October, per day power production will be= $\frac{1}{2}\times 1.16\times 50.26m^2\times (3.2\ ms^{-1})^3$ =0.95 kW

Generation according to German scientist Albert Beiz = 0.95 ×40% = 0.38 kW

Generation in October (3.2 hours) = 0.38 KW x 744 hours = 284.27 kWh

(xi) In November , per day power production will be= $\frac{1}{2}\times 1.16\times 50.26m^2\times (2.61\ ms^{-1})^3$ =0.51 kW

Generation according to German scientist Albert Beiz = 0.51 ×40% = 0.20 kW

Generation in November (696 hours) = 0.20 KW x 696 hours = 144.29 kWh

(xii) In December , per day power production will be= $\frac{1}{2}\times 1.16\times 50.26m^2\times (2.97\ ms^{-1})^3$ =0.76 kW

Generation according to German scientist Albert Beiz = 0.76 ×40% = 0.305 kW

Generation in December (744 hours) = 0.305 kW x 744 hours = 227.27 kWh

Total Yearly production from wind turbine = [297.8 + 147.5 + 248.85 + 200.54 + 1058.60 + 1663.60 + 1581.36 + 1133.43 + 318.46 + 284.27 + 144.29 + 227.27] kWh

= 7305.97 kWh

2.4 Total Annual output from our proposed hybrid E-vehicles charging station:

According to our calculation, we will be able to produce 22613.06 kW from solar PV system.
And, from wind turbine we will get 7305.97 kW electricity.
So, total production will be = [22613.06 + 7305.97] kW = 29919.03 kW per year

2.5 Simulation by HOMER: Here, by the HOMER software the simulated peak demand of primary load is 7 kW and total energy consumption is 48kWh/day. Simulated result is almost equal to calculated result as we given balanced input load to the HOMER software of different hours of a day.

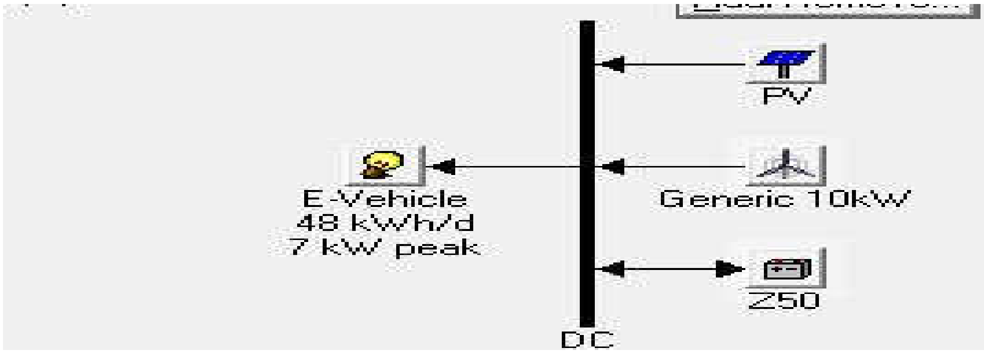

Fig.8: Model of hybrid system in HOMER software.

2.5.1 Daily load profile: For calculating daily load curve in HOMER software, we have considered various loads for different times of a day (24 hours). Each E-vehicle of our country (motor rickshaw & easy bike) consume 0.5 kW per day. According to it, we have calculated the load. We have selected every different hours of a day as charging time. From 2am to 5am charging station will be closed. That's why; load will be zero at that time. We given balanced input load to the HOMER software of different hours of a day.

Table 5: various loads for different times of a day (24 hours)

Timeline	(kW)
12am-1am	3
1am-2am	3.5
2am-3am	0
3am-4am	0
4am-5am	0
5am-6am	3.5
6am-7am	4
7am-8am	3
8am-9am	2.5
9am-10am	2
10am-11am	1.5
11am-12pm	1
12pm-1pm	2.5
1pm-2pm	3
2pm-3pm	2.5
3pm-4pm	2
4pm-5pm	1.5
5pm-6pm	1

6pm-7pm	1
7pm-8pm	1.5
8pm-9pm	1.5
9pm-10pm	1.5
10pm-11pm	2
11pm-12am	3.5
Average	1.98

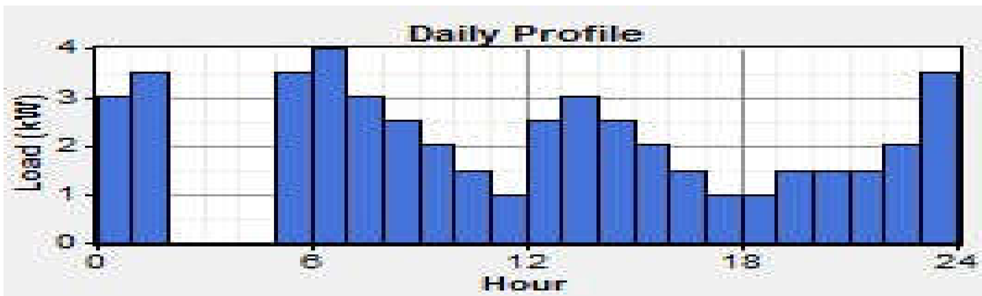

Fig.9: Daily load curve in HOMER software.

From 2am to 5am, our proposed charging station will be kept close. That's has been shown in the daily load curve.

2.5.2 Generation cost: Its need to be noted that the price listed in table are taken as a unit price of the equipments used in our system rather than the whole system as a input parameter. It's done by collecting data from local and foreign market for the individuals and HOMER software calculated it.

Table 6: Generation cost of Hybrid system

Component	Capital ($)	Replacement ($)	Operation & maintenance ($)	Total ($)
PV	19688	1228	5113	25341
Wind turbine (10KW)	8211	0	2876	11087
Battery (Zess 50)	3000	522	767	4126
System	30899		8757	40554

According to homer calculation, total system setup cost will be 40554 ($). In our country BDT, it will be 32, 44,320 BDT.

2.5.3 Cash flow summary: Simulated cash flow summary has been shown here.

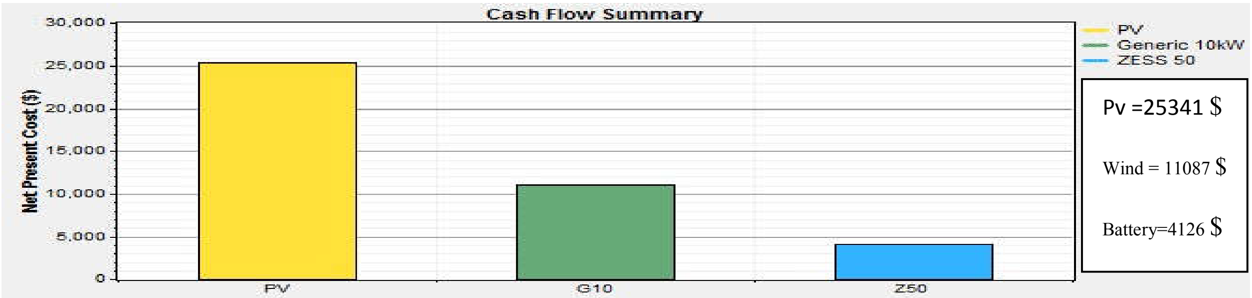

Fig.10: Cash flow summary of hybrid system in HOMER.

2.5.4 Simulated Output from Solar PV system: Simulated output from solar pv system is 22634 KW per year. Simulated result is almost equal to calculated result. Graphical Simulated PV output has been shown here. In 1st six hours (12am to 6am) and last six hours (6pm to 12am) of a day, we don't get any sunlight, that's why, no power will be produced at that time.

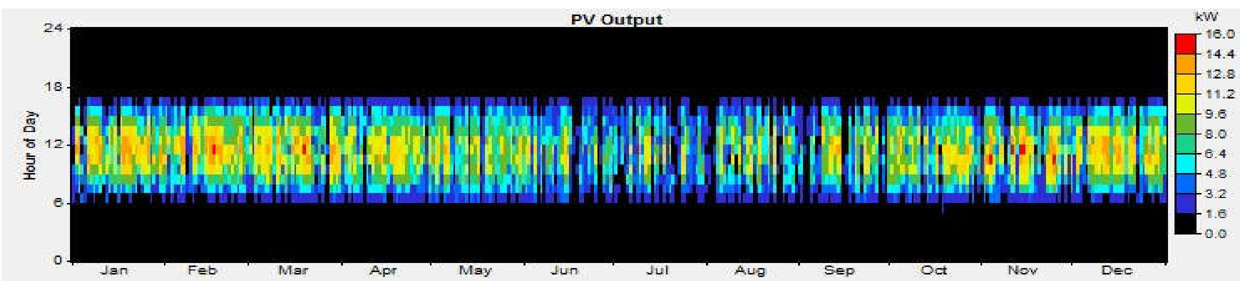

Fig. 11: Simulated output of solar pv system in HOMER.

2.5.5 Simulated Output from wind turbine: Simulated output from wind turbine is 7131 kW per year. Simulated result is almost equal to calculated result. Graphical Simulated wind turbine output has been shown he

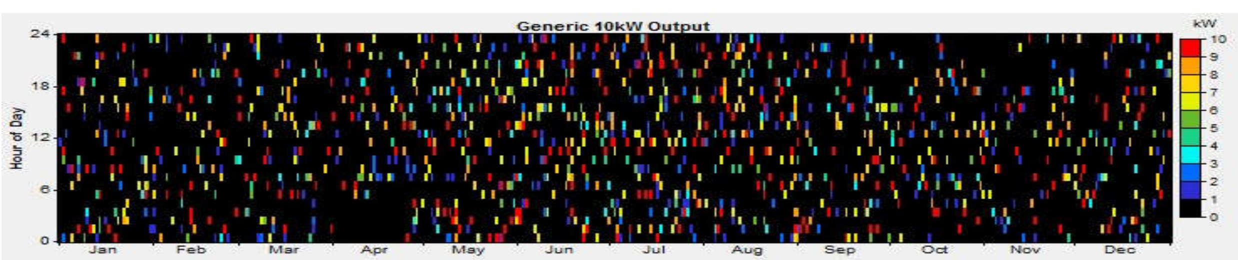

Fig. 12: Simulated output of wind turbine in HOMER.

2.5.6 Monthly average electric production from our hybrid system : Simulated graph of monthly average electric production from our hybrid system is shown below. From the graph, we can see that, PV output is greater than wind turbine output.

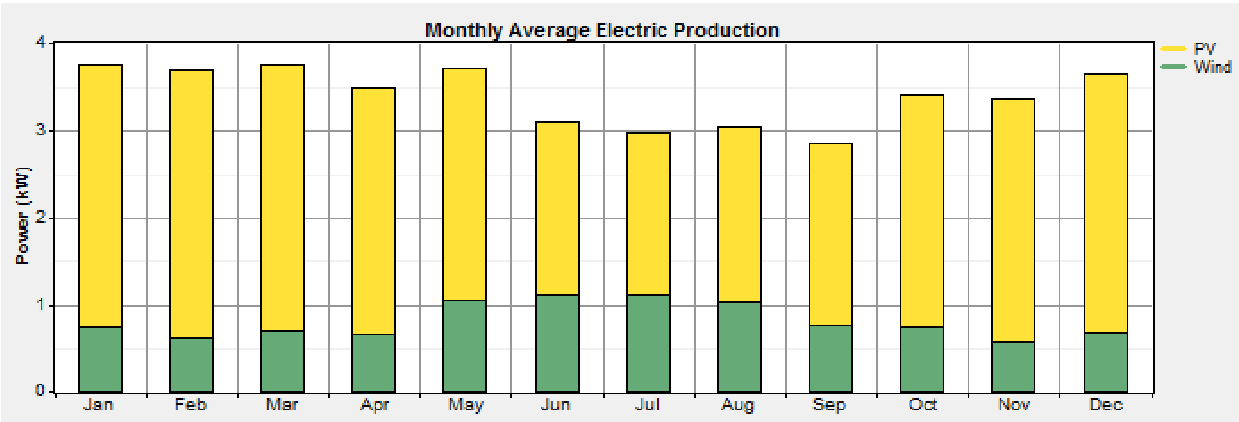

Fig.13: Monthly average electric production from our hybrid system.

2.5.7 Simulated yearly production result in hybrid E-vehicles recharging station: Simulated yearly production result in hybrid E-vehicles recharging station is shown below. This result is almost same as our theoretical calculated result.

Production	kWh/yr	%
PV array	22,634	76
Wind turbine	7,131	24
Total	29,765	100

Fig.14: Simulated yearly production result.

2.6 Comparison between theoretical and simulated output: In our theoretical calculation we have got total 29909.03kW per year from our hybrid system. In simulation by HOMER software, we can see that total production is 29765 kW per year. So, we can see that, simulated result is almost equal to calculated result.

2.7 Payback duration analysis: The payback period means that the number of years required recovering the cost of the investment and for cost benefit analysis of our system it is needed.

If annual production is 29765 kW per year, it will be approximately 81.54 kW per day. If per rickshaw and E-vehicles consumes 0.5 kW per day, we can recharge 163 electrical motor rickshaw/easy bike per day.

Normally motor rickshaw and easy bike puller have to pay 70-90 BDT to charge each e-vehicle. If we take 40tk to recharge per E-vehicles, our daily income will be 6523 BDT and yearly income will be 2380968 BDT.

So, payback duration in year $= \dfrac{\text{cost of setting Hybrid station system}}{\text{annual income}}$

$$= \frac{40554\,\$ \times 80\ bdt}{2380968\ bdt}$$

$$= \frac{3244320}{2380968}$$

$$= 1.3 \text{ years}$$

So, if we will set up such kind of recharging station for Electric vehicles, we will get back our investment within 1.3 years.

CHAPTER 3

CONCLUSION

Although the Electric vehicle has some limitations, its environment friendly nature has made it popular to all over the world. So, it is clear that our proposed system could be an effective one due to its necessity in the power crisis context. Though our proposed system is designed for Chittagong city and costs are calculated with respect to Chittagong city, this system is implemented anywhere in Bangladesh. And it is also said that this proposed system is economically and geographically feasible to Bangladesh.

3.1 Opportunities and Benefits: The opportunities and benefits are given below:

1. The existing fuel stations can be used. No other site is needed to be selected.
2. The payback time is estimated and lesser than other system.
3. No extra labour cost and maintenance cost is needed.
4. Extra power can be used for the recharging station itself
5. This system becomes one of the factors to increase the income of the owners of fuel filling stations.
6. Proper utilization of solar energy.
7. Dependence on fossil fuels such as Diesel, Petrol and Gas etc is decreased.
8. It is a pollution free process.

3.2 Challenges and Limitations: The challenges and limitations are given below:

1. Initial cost is high for the owner of the fuel filling stations.
2. The design must be perfect.
3. Lack of knowledge about proper maintenance of Solar based technologies.
4. During night and insufficient solar radiation the system is not work properly.
5. For fully recharging the battery pack can take 3 to 4 hours.
6. Lack of knowledge about clean renewable energy technologies.
7. Lack of awareness of future development.
8. During nighttime and in insufficient solar radiation the solar PV system will not work and during slow wind speed, we will get poor output from wind turbine.

An enormous amount of energy is extracted, distributed, converted and consumed daily in the present world. The energy demand in the whole world is increasing day by day. So, we can say that, our proposed system is helpful for Bangladesh perspective to solve power crisis.

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