

**Study on Power Consumption and Social Aspects of Battery Operated Auto-rickshaw***Md. Zulkefa Rian<sup>1</sup>, Dr. A. N. M. Mizanur Rahman<sup>2,\*</sup>*<sup>1</sup>UG student, Dept. of Mechanical Engineering, Khulna University of Engineering & Technology, Khulna-9203<sup>2</sup>Professor, Dept. of Mechanical Engineering, Khulna University of Engineering & Technology, Khulna-9203**ABSTRACT**

For short distances 3-wheelers dominate our transportation sector but several disadvantages force us for better means of transportation. Battery operated auto-rickshaw, which are now common in transport sector, consumes a considerable amount of electricity during charging of their batteries and thereby causes of load shading. At the same time, they reduce the unemployment problem partly. This paper found out the feasibility of battery operated auto-rickshaw as an alternative transport by analyzing power consumption, effects on national electricity supply, reduction of unemployment and socio-economic aspects of people involved with it and finally the environmental aspects of these vehicles. A questionnaire was developed and information was collected by interviewing the auto-rickshaw drivers of different areas of Khulna city. It also predicts the emission of polluting gases from different power plants. The study revealed that battery operated auto-rickshaw reduces unemployment problems to some extent, as well as improve their socio-economic condition. Average power consumption of a battery operated auto-rickshaw is about 8 - 11 kWh per day. Also, there is less emission of polluting elements provided the discharges of the batteries are performed in a systemic way. The operating cost of battery operated auto-rickshaw is less than that of a fuel operated 3-wheelers. So, from national point of view and considering the social impact for short distances battery operated auto-rickshaw is more suitable.

Key Words: Battery operated auto-rickshaw, Easy bike, Economic aspects, Social impacts, Air pollution.

**1. Introduction**

Battery operated auto-rickshaw popularly known as 'Easy-bike' is newly added to the transportation sector of Bangladesh. It has been playing a significant role as a means of transport for short distances as well as an income generating source for unemployment people since the introduction of this. From the start, it is being used as popular transportation means especially for lower, lower-middle, even middle income people in urban areas. It involves relatively lower travel cost as well as provides much more comfort and safety. It is convenient to the users during travel compared to other public transport system. So, urban employment generation largely depends on it.

Easy-bikes are operated by rechargeable lead-acid batteries as their sources of power. These batteries are charged with electricity taken from the domestic or commercial lines which indirectly burdens the national grid. At present electricity seems to be a low cost power source for these vehicles as compared to commercial fuels like petrol or diesel. The operating cost of Easy-bike seems to be low as compared to commercial fuel operated 3-wheelers. As petrol is burned in 3-wheelers engines, these vehicles also emit pollutants as exhaust gases while Easy-bikes have almost no pollutants. Thus, Easy-bikes can play an important role in the transportation sector. At the same time, because of significant amount of electricity is used for charging the batteries of these vehicles, so, the country is experiencing tremendous shortage of electricity. As a result load shading is very common today. These electrically charged vehicles run almost

all over the cities and districts of Bangladesh. So, huge number of Easy-bikes enhanced the load shading problem. Bangladesh Power Development Board (BPDB) claims that these electrically charged vehicles consume approximately 4 MWh of electricity every day for charging their batteries. But there is no authentic data for this claim. At the same time since the socio-economic condition of some low income people is improving with the inclusion of these vehicles. Therefore, an exclusive comparative study is necessary to decide whether electricity will be used to recharge the batteries or not. Also, question arises whether these vehicles should continue or they should be banned is a big question.

To cope up the problem a survey was conducted in Khulna city with a questionnaire. The objectives were to find out the real consumption pattern of electricity, the socio-economic condition of the stakeholders, the environmental issues and some other parameters.

**2. Overview of Battery operated Auto-rickshaw and Fuel operated 3-wheelers**

Batteries have advantages of being quick responsive, useful in a wide range of power levels, efficient, simple to install and easy to maintain. The Easy-bikes are built on small chassis and three small wheels. The chassis is generally made from mild steel and the body is with GI pipes. The front face is slightly aerodynamic shape, the overall dimensions are 287×105×178 cm depending on different manufactures. The space is suitable for 5 passengers. A water-proof dc motor, powered by lead acid batteries, is used as source of power and the output

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of the motor is about 1000-1250 watts. The cost of Easy-bike ranges from BDT 130,000 to 160,000 [1]. Generally, 5 batteries of 12 volts in some case 4 or 6 batteries of 12 volts of totaling 60 volts and 140 amps are used. Batteries need approximately 8 hours for charging at new condition but it need 10-12 hours after using 8-12 months. Each battery costs about BDT 12,000–13,000 [1]. The various models of Easy-bikes are now present in Bangladesh. The common models are: XINGE, DOWEDO, JET FIGHTER, MAINBON GROUP, GANGCHILL, XINGEBANG and JT TRICYCLE. The photographic view of two models of Easy-bike is shown in Figure 1 and 2.



Figure 1: Model: JET FIGHTER

For short distances fuel operated 3-wheelers are popular transport medium in many cities of Bangladesh from seventy's and these vehicles are run by petrol. These are 2-stroke SI engines [2]. These vehicles generally travelled a distance of 30 km to 35 km per liter of petrol. Number of passengers of these vehicles is also five. The cost of such a vehicle is approximately BDT 350,000. The various gases emitted from these 3-wheelers pollute the environment.

There are other disadvantages of 2-stroke SI engines. It has more fuel consumption, bad emission of harmful gases; noisy sound etc. Its engine oil is relatively expensive and this creates smoky emission. 2-stroke engines do not use fuel efficiently as the lubrication system is not efficient. The consumption of lubricating oil is large in a 2-stroke engine because of high operating temperature. These engines produce lot of pollution [2]. They emit significant amount of unburnt hydrocarbons, CO<sub>2</sub>, CO, NO<sub>x</sub> and so many harmful gases to the environment.

### 3. Electricity Consumption and No. of Easy-bike

About four lakh Easy-bikes are running across the country which consumes approximately 4 MWhr of electricity per day for charging their batteries as reported by BPDB on May 2014 [3].

The owners of the Easy-bike charge the batteries either from domestic power connections or from vendors.

Sometimes the vendor's connections are illegal resulting in a loss of electricity and also create an unexpected pressure on the national grid. An Easy-bike needs on an average 8 - 11 kWh of electricity per day which is not negligible.



Figure 2: Model: XINGE BANG

The number of battery operated auto-rickshaw running all over country (including all districts and urban areas under these various divisions) as reported in the literature [3 - 5] are presented in Table 1.

Table 1: Approximate No. of Battery operated Auto-rickshaw running on divisional areas:

Name of Division	Number of Easy-bikes (Approximated on May, 2014)
Dhaka	67,753
Chittagong	63,580
Khulna	60,820
Rajshahi	54,342
Sylhet	56,885
Barisal	47,740
Rangpur	43,642

Source: The New Age, 7 November, 2013

### 4. Power Scenario of Bangladesh

In Bangladesh various types of resources are available to generate electricity. Mainly natural gas is used; but coal, furnace oil, diesel, hydropower etc. are also used to generate electricity. Table 2 and Table 3 show the present electricity generation capacities on the basis of type of fuels and type of resources respectively [6].

Table 2: Present Generation Capacity by Type of Fuel as on 2013

Sl. No.	Type of Fuel	Capacity (MW)	Total (%)
01.	Coal	200	2.34
02.	Furnace Oil	1876	21.97
03.	Natural Gas	5730	67.12
04.	Diesel	511	5.99
05.	Hydro	220	2.58
	<b>Total</b>	<b>8537</b>	<b>100</b>

**Table 3:** Present Generation Capacity by Type of Resources as on 2013

Sl. No.	Type of Plant	Capacity (MW)	Total (%)
01.	Hydro	220	2.58
02.	Steam Turbine	2193	25.69
03.	Gas Turbine	1295	15.17
04.	Combined Cycle	1455	17.04
05.	Reciprocating Engine	3374	39.52
	<b>Total</b>	<b>8537</b>	<b>100</b>

Source: <http://www.bpdb.gov.bd/annual report 2013>

The zone-wise production of electricity is shown in Table 4. This also shows the differences between the installed capacities and the actual generations [7].

**Table 4:** Summary of Present Electricity Generation of Bangladesh Zone-wise

Sl. No.	Name of Zone	Installed Capacity (MW)	Present Capacity (MW)	Actual Generation (MW)
01.	Dhaka	3894	3664	2403
02.	Chittagong	1207	1127	827
03.	Comilla	1392	1297	1125
04.	Mymensingh	232	219	163
05.	Sylhet	760	746	630
06.	Khulna	1609	1510	990
07.	Barisal	73	65	55
08.	Rajshai	837	819	688
09.	Rangpur	337	287	227
	<b>Total</b>	<b>10341</b>	<b>9727</b>	<b>6962</b>

Source: <http://www.bpdb.gov.bd/total generation report May, 2014>

### 5. Emission of CO<sub>2</sub> Gas from Power Plants

Although, the majority of electricity produced in Bangladesh is from natural gas but still the emission of CO<sub>2</sub> and other polluting gases have been rising in the power sector due to use of different kinds of oils and coals to produce the same. The rising trends of carbon emissions in the power sector is ultimately the result of using coal and petroleum oils like diesel and furnace oil as these produce more carbon dioxide while combustion. The emissions will be even more, if coal-based power plants are introduced more in the country as coal is considered to be the dirtiest fuel for power generation. In contrast there is no emission of CO<sub>2</sub> in hydro-electric or nuclear power plants but their uses are still not prospective. The total electricity generation capacity in the country as on May, 2014 is around 10,341 MW against a maximum demand of over 7,500 MW and the actual generation was 6,962 MW. Of the total production approximately 67% comes from natural gas, 26% from petroleum oils while the remainder is from coal and hydro-power.

In the country there is a mix of power plants that use different energy sources such as furnace oil, HSD, coal, natural gas and hydro power. Each kWh of electricity can be produced by using different energy sources and each source is characterized by a factor that indicates the amount of CO<sub>2</sub> released into the atmosphere to produce each kWh electricity. CO<sub>2</sub> gas in the atmosphere is the main cause of global warming, which directly affects the increase of earth's temperature and affects greatly the change of climate. Table 5 shows the emission of CO<sub>2</sub> from various sources [8, 9].

**Table 5:** CO<sub>2</sub> Emission to produce each kWh of electricity by different types of fuel

Sl. No.	Type of Fuel	CO <sub>2</sub> Emissions gm/kWh
1.	Coal	800 to 1050
2.	Natural Gas	469 to 600
3.	Diesel	570 to 650
4.	Furnace Oil	640 to 765
	<b>Average Total</b>	<b>592.61</b>

Source: <http://en.wikipedia.org/Greenhouse gas/Carbon dioxide emissions/power plants;>  
<http://www.sunearthtools.com>

### 6. CO<sub>2</sub> Emission from Fuel Operated 3-wheelers

In the country the number of 3-wheelers has grown rapidly, as a result, pollution levels have been increased which is a serious threat for the environment. 3-wheelers are running by petrol and the exhaust gases from these create heavy smoke which contains various harmful gases mostly CO<sub>2</sub> and NO<sub>x</sub>. They also create sound pollution. The CO<sub>2</sub> emission is approximately 153.78 gm per km distance travelled by a 3-wheeler [10]. Figure 3 shows the photographic view of CO<sub>2</sub> emission from a fuel operated 3-wheeler.



**Figure 3:** Photographic view of emission of various harmful gases from a 3-wheeler.

### 7. Survey and Collection of Data

A questionnaire has been developed to collect information from both the Easy-bike drivers and fuel operated 3-wheelers in Khulna city. In this study 200 Easy-bike drivers were interviewed. Some information were collected from the fuel operated 3-wheeler drivers and their Union office. The information regarding the

charging was taken from the field survey as well as in the Laboratory. Finally the data were analyzed.

All data's regarding the economic and social aspects of the stake holders were collected from Easy-bike drivers by interviewing and closely observing them. These information broadly include: (i) General and personal, (ii) Vehicular, (iii) Energy requirement and related, (iv) Economic related, (v) Overall financial, (vi) Problems, social or other related and many more. Some information was collected from internet as well as various newspapers and social media.

## 8. Results

### Socio-economic condition

The analysis of data revealed that the socio-economic condition of the Easy-bike drivers and their families are improving day by day. More than 80% of the drivers agree with the increase in their daily income and remainder 20% disagree with this. More than 50% agree that this vehicle brought prosperity in their economic condition. Most of the drivers think that, it is a comfortable job than their previous jobs and its change their life style. Table 6 shows the average daily and monthly income of the Easy-bike drivers.

**Table 6:** Daily and Monthly Income of Drivers

Daily Income Range BDT.	%	Monthly Income Range	%
> 500	07	> 5000	12
500-600	10	5000-6000	08
600-700	51	6000-7000	07
700-800	12	7000-8000	16
800-900	09	8000-10000	14
1000 <	11	10000 <	43

Source: Survey data from Khulna City, 2014

### Electricity Consumption

Although, the consumption of electricity for charging the batteries are taken during the survey but the same were also measured in the laboratory for three vehicles for seven days. From the laboratory data it is seen that battery operated auto-rickshaw consumed on an average 8 - 11 kWh of electricity per day during charging their batteries. Table 7 shows the result of 7 days observations while the batteries were fully charged.

### Cost Calculation

A Battery operated auto-rickshaw generally consumed 8 to 11 kWh of electricity during their charging. The price of 1 kWh of electricity is BDT 7.42 [12] for commercial rate at off-peak time and BDT 13.20 as on IPPs [12]. The cost for running per km distance travelled per person is calculated based on data from ten vehicles.

Fuel operated 3-wheelers are usually driven by petrol and small amount of mixture of lubricants. These vehicles generally travelled a distance of 30 to 35 km per liter of petrol. The cost for travelling per km per person is also calculated for these.

**Table 7:** Charging Information of Battery operated auto-rickshaw.

Day	Energy Consumption in kWhr			Remarks
	Vehi-cle-1	Vehi-cle-2	Vehi-cle-3	
1	10.27	8.86	10.05	Vehicle-1 is relatively old; Vehicle-2 is new & vehicle-3 is medium aged.
2	11.72	10.09	10.09	
3	10.05	9.41	8.40	
4	11.63	8.70	10.66	
5	10.55	9.53	10.38	
6	10.45	8.58	9.08	
7	11.78	10.04	9.84	
<b>Avg.</b>	<b>10.92</b>	<b>8.15</b>	<b>9.79</b>	

### Cost Comparison per passenger per km

For battery operated auto-rickshaw the average cost per person per km is about BDT 0.1365 and for fuel operated 3-wheelers the same per person per km is about BDT 3.74, which is thirty times higher than battery operated auto-rickshaw.

### Comparison of CO<sub>2</sub> emission

Power plants produce 592.6412 gm of CO<sub>2</sub> per kWh of electricity. The amount of energy consumed by the battery operated auto-rickshaw is near about 8 to 11 kWh per charging. It can travel an average distance of 60-70 km per charging. The total amount of energy consumed per km is 0.143 kWh. So, to produce 0.143 kWh, the amount of CO<sub>2</sub> emission from the power plant is near about 84.67 gm. The actual emission in gm/km by fuel operated 3-wheelers is about 153.78 gm. So, the emission of CO<sub>2</sub> from a battery operated auto-rickshaw is less than that of a fuel operated 3-wheelers.

## 9. Discussion

The socio-economic condition of battery operated auto-rickshaw drivers are improving with the inclusion of this vehicle.

The battery operated auto-rickshaw is directly related to electrical power consumption of the country because it consumes electricity during charging their batteries. The data shows that four lakhs such vehicle consumes about 4 MWhr of electricity every day.

The transportation cost of battery operated auto-rickshaw is lower than fuel operated 3-wheelers as well as no direct emission of harmful gases from battery operated auto-rickshaw. Fuel operated 3-wheelers are also noisy which causes sound pollution.

It is also envisioned that the power plants emit various harmful gases which cause serious pollution of the environment as well as health hazard. The coal-based plants are the largest contributors of these pollutants.

Proper handling of discharges of batteries in a systematic way has no adverse effect on the environment. Sometimes it creates traffic jam in a narrow road. Auto-rickshaws are being parked in the busy road as well as foot path and traffic jams are the consequence of this mismanagement. Excessive number of battery-operated auto-rickshaws is increasing this traffic jam. So, it should be controlled in a right way to reduce traffic jam.

While collecting the data from the survey there was little problem to get the accurate information such as some of the drivers could not give the answers to all of the questions fully and sometimes their information was not fully correct, some data which were far away from them these data were neglected. So it seems to be difficult to find the real data.

#### **10. Conclusion**

From the analysis of the data obtained from the survey the following conclusions can be made.

- The inclusion of battery-operated auto-rickshaw improves the socio-economic condition of many poor unemployed people.
- The interest of lower-middle income people in this transportation system is more in short-distance because of lower travel cost than rickshaw and 3-wheelers.
- The transportation cost of battery-operated auto-rickshaw is less than fuel-operated 3-wheelers.
- A battery-operated auto-rickshaw seems apparently non-polluting and a very silent transport system for urban and rural areas of the country.
- It is apparently a cost-effective vehicle as it is an environment-friendly vehicle.
- The fuel-operated 3-wheelers emit CO<sub>2</sub> and other polluting gases. Indirectly this is true for battery-operated auto-rickshaw as electrical power plants generate CO<sub>2</sub>.
- Pollutants from disposal of batteries could be reduced by proper disposal of the same.
- Although, these vehicles consume electricity from the national grid but considering the economic and social improvement of the families of battery-operated auto-rickshaw, it is more advantageous than fuel-operated 3-wheelers.

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