International Conference on Mechanical, Industrial and Materials Engineering 2017 (ICMIME2017)
28-30 December, 2017, RUET, Rajshahi, Bangladesh.

Paper ID: ET-06

Energy and Carbon Footprint Analysis of University Vehicles in Bangladesh

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Abstract

Energy availability and environmental threats are the future key challenge for Bangladesh need to overcome. Natural gas and petroleum are the main sources of energy in Bangladesh. Transport sector contributes for 60% of total oil consumption of the country. This study investigated the energy consumption and carbon footprint assessment of transport vehicles operated by fuel oil for sample universities in Bangladesh. Result show that, per capita energy consumption per year for sample technical University is 248MJ where for non-technical University is 277MJ. Annual total CO_2 emission is 80 ton and 627 ton estimated for sample technical and non-technical university respectively where the carbon footprints are estimated to 118 t CO_2 eq and 907 t CO_2 eq respectively. This information reveals that how the university vehicles are contributing on transport sector energy and environmental issues and useful to environmental regulatory team to take appropriate measures to build low energy and low carbon societies as well as low carbon campus.

Keywords: Energy consumption, Carbon footprint, University vehicle, Bangladesh

1. Introduction

Energy is the key requirements for the development of a country. World primary energy consumption increasing at the rate of 1.9% per year and total of 57% will be increased in 2035 compared to 2008's level of which, major contribution will be from developing countries [1]. Distinguish research report shows that, developing countries required significant energy in near future will contribute major share on global energy consumption [2]. Still fossil energy sources are playing a dominant role in global total energy consumption [3]. Limited reserves of fossil energy enforce the researcher's fascination to establish alternative way to meet energy demand in target to avoid fossil sources. On the other hand, environmental pollutions due to combustion of fossil energy are other exciting issues now a day, since increasing trend of global greenhouse gas (GHG) emission will make the problems in human living in future [4]. Moreover, the contribution of developing countries on global carbon emission is 63% pinpointing the significance of controlling and mitigating such issues to make better environment for human living [5]. So, all these concern emphasis to replace or control the fossil energy use in all energy consuming sectors of human activities. Developing country Bangladesh is an impoverished country. The national vision 2021 shows that, energy needs will be four times the present demand in future [6]. Moreover, CO_2 emission in Bangladesh is one tenth of world CO_2 emission in 2006 implies the environmental analysis in all sectors of Bangladesh is important [7].Universities are one of the energy intensive sectors of Bangladesh and transportation is one of the integral sector have significant impact on energy consumption and carbon emission. Such universities have an active role to solve the aforementioned issues through research activities, collaborations, suggestions, adaptations, etc.

Significant numbers of educational institutes in the world are trying to build low energy and low carbon campus as a model for nation. Good examples of some universities namely Yale University, California state University, Carleton college, University of Texas etc. [8]. They reported that, transportation sector is the second energy and GHG emission intensive sectors of the university. Firstly they prepared the research report on energy consumption and GHG emissions. Based on the report they suggested the ways to reduce and control energy consumption and GHG emissions through making the better policies, plan for investment, implementation the measures, raising awareness and monitoring. Such research is also important for developing countries as well as Bangladesh to take initiatives. But the study on transportation sector in Bangladesh taking into account the issues described are unusual. To implement any prospective suggestion, it needs preliminary existing report on

the related issues. The output of the research report on energy consumption and GHG emission in the university transportation sector may contribute to raise the awareness of local and national policy maker to take attempt and implement the prospective ways to mitigate and control the energy crisis and environmental problems.
Hence, a study has been undertaken on transport vehicles of two types University in Rajshahi. The questionnaire and field survey data is used for the analysis. The aim of this study is to analyses the operating energy consumption by the vehicles of two university and corresponding GHG emission as well as carbon footprint comparison.

2. Methodology

Methodology comprises the boundary description and the estimation procedure of energy consumption, GHG emission and carbon footprint for the selected university campus. The details are described as follows:

2.1 Boundary description

The study was conducted in technical and non-technical universities in Rajshahi, Bangladesh. The key features of the selected universities are given in Table 1.

Table 1. Key features of the selected universities

Characteristics	Technical University	Non-technical University
Type	Public	Public
Location	Urban	Urban
Population	3,000 plus	24,000 plus
Energy source	Electricity, Diesel, Petrol	Electricity, Diesel, Petrol
No. of Large Buses	6	25
No. of Mini Buses	2	2
No. of Micro Bus	3	8
No. of Car	3	3
No. of Ambulance	1	4
No. of Jeep	1	2
No. Pickup	1	2

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The features of the universities show that, both are public type and located in urban areas. The population of non-technical university is eight times the technical university. The energy sources are electricity, diesel and petrol. There are significant number of microbus and large bus in non-technical university compared to technical university.

2.2 Estimation procedure

Two students were sent to collect the necessary data to conduct the study. The vehicle conditions, number of vehicle, types of vehicle, daily fuel consumption, no. of trip, distance travel etc. were recorded during the data collection. The specific steps to conduct the study are shown in Figure 1.

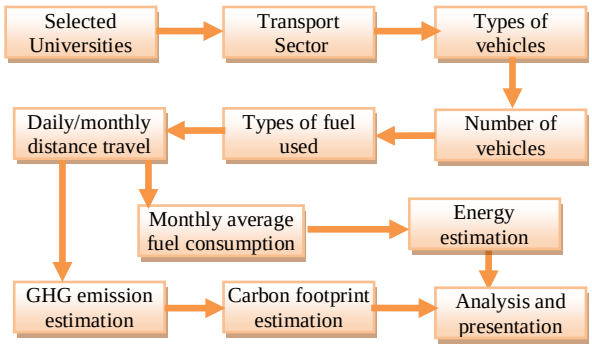

Figure 1. Specific steps to conduct the study

Questionnaire and log book reserved in the transport sector was used to collect the data for two fiscal years. The data was then checked and verified with the annual report and interview with the drivers. The amount of energy estimated by using the quantities fuel used multiplied with the individual heating value of fuel. The GHG emission was estimated by using the national emission factor for the vehicles per km travel [9-10] as in the following equation.

$$Emission = Average\ annual\ \ travel\ (km) \times emission\ \ per\ km\ travel \quad (1)$$

Carbon footprint is the total set of greenhouse gas emissions caused by an individual, product, organization etc. It is usually expressed in terms of carbon di-oxide equivalent (CO_2 eq). Carbon footprint was estimated by multiplying the values of warming effect [11] for each gas with the quantities emitted. The numerical value of warming effect for each gas is shown in Table 2. The total value was estimated by summing up the values for individual vehicles.

Table 2. GHG gases and numerical value of global warming potential

Greenhouse gases	Numerical value of global warming potential (kg CO_2 eq)
CO_2	1
CO	1.57
CH_4	25
NOx	298
SO_2	0.44

The general equation for carbon footprint estimation is shown below

$$Carbon\ \ footpr\,\text{int}\ (CO_2\, eq) = Quantity\ gas\ emitted\ (kg) \times global\ \ war\,\text{min}\, g\ \ potential \quad (2)$$

3. Results and discussion

The detail results of this study are presented and discuss in this section in terms of energy consumption, GHG emissions and carbon footprint. The relative comparison is also presented in the results.

3.1 Energy consumption

Table 3 shows the annual total energy consumption by the transport vehicles of the selected technical and non-technical university in terms of primary fuel.

Table 3. Annual average energy consumption from the transport sector of the selected universities.

Selected university	Annual average oil consumption (litre)	
	Diesel	Petrol
Technical University	26,279	3,766
Non-technical University	1,93,483	15,127

Table shows that, significant quantities of oil are consumed annually by the transport sector of the selected universities. The diesel consumption for technical university is seven times higher than petrol where for non-technical university is thirteen times higher than petrol. It implies that the non-technical university adopted significant number of diesel engine vehicles. The miles of diesel engine is around 50% lower than that the petrol engine though the market price of the diesel is 20% lower than the petrol.

Figure 2 shows the total annual energy consumption per capita by the transport vehicles of technical and non-technical university in terms of kWh.

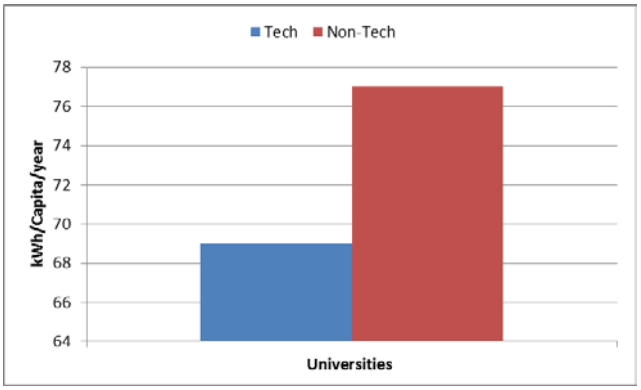

Figure 2. Total annual energy consumption per capita by the transport vehicles

It is seen that, per capita energy consumption for technical university is 69 kWh where non-technical university is 77 kWh estimated. The percentage difference is 10% though the number of population in non-technical university is eight times higher than technical university.
It should be noted that, Bangladesh import significant oil from abroad every year with high price. The natural gas (NG) is available in Bangladesh. In addition, modern engines are fuel efficient. There are NGV vehicles, electric vehicles, hybrid vehicles can play an important role to replace the existing old model engines and save the limited fossil resource. If the vehicles adopted the modern technologies then huge quantities of import currencies could be save. Conversion to NGV vehicles are already established in private sector within the country but such implementation is not well established yet in the public universities as there are significant numbers of public universities within the country. Though, such implementation requires access of natural gas. Hence, better management the transport sector of the university campus is important to rational use of limited energy.

3.2 GHG emissions

The annual GHG emissions by the transport vehicles for the universities are presented in Table 4. It is seen that significant GHG emissions are estimated from the transport vehicles of the universities contributing on local as well as global emissions.

Table 4. Annual GHG emissions from the transport sector of the selected universities.

Selected university	GHG emissions				
	CO_2 (ton)	CO (kg)	CH_4 (kg)	NOx (kg)	SO_2 (kg)
Technical University	80	94	9	126	84
Non-technical University	627	604	52	931	687

The magnitude of CO_2 emission is significantly higher than that the other emissions. The magnitude of CO and NOx emissions are tends to similar. The CH_4 and SO_2 emissions are found lower in magnitude compared to other GHG emissions.
Figure 3 shows that, the magnitude of GHG emissions for non-technical university is significantly higher than that of the technical university.

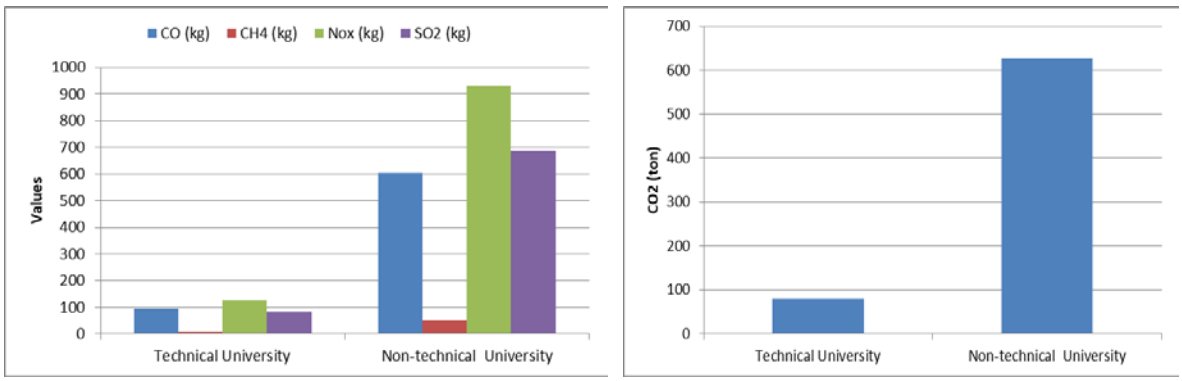

Figure 3. Total annual GHG emission for the transport vehicle of the selected universities

The annual CO_2 emissions from the transport vehicles for the technical and non-technical university are estimated to 80 ton and 627 ton respectively. NOx emission is responsible for acid rain in the earth and found to significant in magnitude compared to other GHG gases except CO_2 emission.

3.3 Carbon Footprint

Figure 4 shows the annual carbon footprint estimated from the transport vehicles of the selected universities. It is seen that, the total annual carbon footprint for the technical and non-technical universities are 118 and 907 ton CO_2eq respectively.

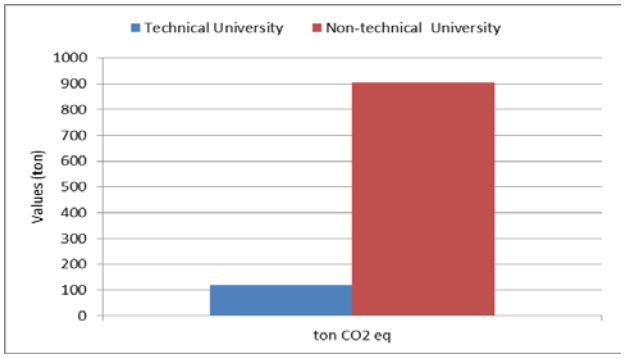

Figure 4. Total annual carbon footprint for the transport vehicles of the selected universities

These values provide the useful information regarding the magnitude contribution of carbon footprint on global value for a particular sector of the educational institution in a developing country.
Figure 5 shows the estimated annual per capita carbon footprint for the selected universities. The per capita carbon footprint for the non-technical university is 0.03 ton where the technical university is 0.02 ton. Hence, per capita environmental impact is higher for non-technical university implies that better management of transport vehicles and rational use of limited fossil energy is important for non-technical university transport sector in this study.

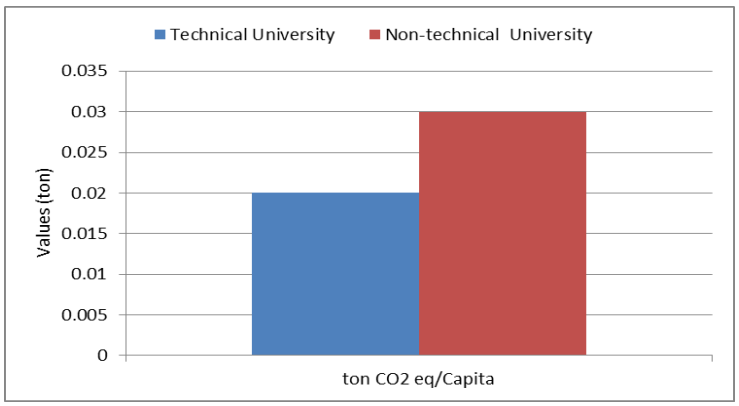

Figure 5. Total annual carbon footprint per capita for the transport vehicles of the selected universities

4. Conclusions

Energy consumption, GHG emission and carbon footprint analysis of two type's university transport vehicles is done in this study. The following conclusion can be drawn from the analysis:

1. Non-technical university transport sector is the energy and GHG emission intensive compared to technical university in spite of having more population in the non-technical university.
2. Per capita energy consumption for technical and non-technical university is estimated to 248 MJ and 277 MJ respectively.
3. Estimated annual oil consumption for technical and non-technical university is 189 barrel and 1312 barrel respectively.
4. The GHG emission for non-technical university is significantly higher than technical university. The dominant GHG gases are CO_2, CO and NOx have the major contribution on total GHG emission. CH_4 and SO_2 have the lower impact on total GHG value.
5. Carbon footprints for the technical and non-technical universities are estimated to 118 and 907 ton CO_2eq respectively.

The estimated values tell us about the intensity of energy consumption, intensity of GHG emissions and their impacts on local as well as global environment. These lead to highlight the importance of energy and GHG emission research in the transportation sector of a university campus to take initiatives for better management, better environmental regulations and adaptation the modern technology in the transportation vehicles in target to contribute on global energy crisis as well as to mitigate and control the environmental problems. Moreover, fuel

switching, better selection the mode of transport, fuel blend etc. could help to reduce the fossil energy consumption and contribute on global GHG emission mitigation.
In Bangladesh there are 40 public universities. Government has taken initiatives in the transportation sector to improve the energy status and air quality within the country but implementation of such initiatives in the university transportation sector is not well established. Hence, such issues could highlight in frontline of the policy maker through this paper to contribute build low energy and low carbon university campus.

Acknowledgments

Authors would like to thanks the Department of Mechanical Engineering of RUET for providing the appropriate platform to conduct the study. Thanks are also extended to the staffs and officer of the corresponding sector of the universities for providing the data. Authors also would like to acknowledge the ongoing Higher Educational Quality Enhancement Project (CP 3615) in the Department of Mechanical Engineering for technical support to prepare this manuscript.

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