Determination of Carbon Footprint for Climate Change Mitigation: A Green IT Practice

(A Case Study of Babcock University, Ilishan-Remo, Ogun State, Nigeria)

Adegunle A. A., Kuyoro Shade O., Awodele O.
Department of Computer Science
Babcock University, Nigeria
e-mail: adegunleadebola@gmail.com, afolashadeng@gmail.com, delealways@yahoo.com

Abstract— **The growing concern about changing weather patterns and global climate change has led to an upsurge in the popularity of green computing and green IT (Information Technology) lately. This study focused on determining the carbon footprint of Babcock University (BU) and also makes available the benefits of green computing and green IT practices. A carbon footprint conceptual framework was designed and the emission-factor based calculation approach was used in the estimation of BU's carbon footprint, using Microsoft excel for the analysis of results. A greenhouse gas inventory was taken using interview method to get all the needed data for the computation of carbon emissions. The total carbon footprint of BU for the year 2013/2014 was discovered to be 33,017.89 tons of carbon dioxide equivalent (CO_2e) with electricity, Information and Communication Technology (ICT), generator use and Faculty, staff and student commuting contributing 46%, 23%, 11% and 11% respectively for the base year.**

Index Terms **– Green computing, Green IT, Carbon footprint, Carbon dioxide (CO_2), Greenhouse gases.**

I. INTRODUCTION

The green computing concept began in 1992 when the United States (U.S.) Environmental Protection Agency (EPA) launched Energy Star; a voluntary labeling program to promote and recognize energy-efficiency characteristics of electronic equipment such as monitors, climate control equipment and other technologies [1][2]. This led to a widespread adoption of sleep mode among consumer electronics [2]. According to an estimation given by the U.S. EPA, inclusion of sleep mode in computers reduces their energy consumption by 60 to 70 percent (%) [3]. Green computing refers to the practice of maximizing the efficient use of computing resources in order to minimize environmental impact. These include the goals of controlling and reducing the environmental footprint of a product by minimizing the usage of water, energy, hazardous materials and other scarce resources, in addition to minimizing waste from production and throughout the supply chain [4].

Green IT (Information Technology) denotes ecologically sound IT which refers to the study and practice of the design, manufacture, use and disposal of computers, servers and related subsystems resourcefully and efficiently with little or no impact on the environment. Green IT serves as benefit to the environment by improving energy efficiency, encouraging reuse and recycling, using less harmful materials and lessening greenhouse gas emissions [3].

Greenhouse gases (GHGs) are polyatomic molecules which include: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), water vapor (H_2O), Ozone (O_3), and Chlorofluorocarbons (CFCs); the ozone depleting chemicals [5]. A greenhouse gas is any gas that traps heat in the atmosphere via greenhouse effect [6].

Carbon footprint refers to "the measure of the amount of greenhouse gases, measured in units of carbon dioxide, produced by human activities". A carbon footprint for an individual or an organization can be measured which is usually given in tons of carbon dioxide equivalent (CO_2e) per year [6]. A Gartner study reports that Information and Communication Technology (ICT) presently accounts for approximately 0.86 metric gigatonnes of carbon dioxide (CO_2) emissions yearly, or just about 2% of global carbon emissions in addition to greenhouse gas (GHG) emissions and e-waste, which are some of the effects of ICT to mention a few on environmental sustainability [7].

This study accounts for two of the main greenhouse gases (GHGs) which are carbon dioxide and nitrous oxide.

II. PROBLEM STATEMENT

Information Technology (IT) has contributed a lot to the improvement of human lives, offering convenience alongside several other benefits. However, IT has been identified to be a major contributor to environmental problems such as global warming, enhanced greenhouse

effect and climate change [3]. Considering the fact that educational institutions are prominent in the developing countries and lots of CO_2 emission emanates into the atmosphere through these media, the effort in mitigating climate change has been greatly hampered. It is thus necessary to present a standardized means of calculating carbon footprint as well as devise means of alleviating CO_2 emissions in the atmosphere. Evaluating the carbon footprint of Babcock University, a focal point of activities and a representative of educational institutions in developing countries, would serve as a benchmark for the actual carbon footprint value and the greenhouse gas emissions obtainable. This will in the long run serve as a baseline for measuring the extent of CO_2 emissions and ways of alleviating it.

III. METHODOLOGY

A conceptual framework that clearly characterize all the activities that give off CO_2 emissions on campus was designed by adopting and making improvements on an existing conceptual framework. The three (3) scopes stated in the GHG protocol by the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) was employed [8].

The emission factor-based calculation approach given by the WRI and WBCSD was used to determine the carbon footprint from each emission source. The needed data were collected via personal interviews with the departments in charge of keeping such records.

The analysis of the carbon footprint obtained from each emissions source were represented using numerical values in units of kilogram (kg) of carbon dioxide equivalent (CO_2e) and tons of CO_2e respectively and also with the use of pie and bar charts.

The emission estimation method that was employed in this study is the emission factor-based calculation approach which is given in the Equation 1 below:

$$E = A * EF. \quad (1)$$

Where E denotes Emissions.

A denotes Activity data: It has to do with the activity that produces an emission, such as amount of electricity used in terms of Kilowatt Hour (Kwh).

EF denotes Emission Factor, it is the amount of CO2 that is used up for each unit of activity data. An instance is an emission factor for electricity which is expressed in kilogram of carbon dioxide per kilowatt hour (kg CO_2 / kWh) [9].

For the calculation of Babcock University's carbon footprint, a Microsoft Excel workbook was used. For the purpose of this study, the fiscal year for the calculation of carbon emissions was set to be 2013/2014.

A. Organizational Boundary

The organizational boundary of this study covered both Ilishan and Iperu campuses of Babcock University, Ogun State, Nigeria. The Ilishan campus consists of Babcock University Teaching Hospital (BUTH), Babcock University High School (BUHS), Babcock Guest House (BGH), administrative buildings, residential buildings, cafeteria and various faculties that is, Schools. While the Iperu campus houses the School of Law and Security Studies and residential buildings.

B. Operational Boundary

Specifically for the purpose of this study, the operational boundary was grouped into the following sources of emissions:

1) Scope 1 Emissions

These emissions consist of all direct emissions from sources that are owned and/or controlled by Babcock University (BU) that are associated with on-campus stationary sources which include:

- Production of electricity from the campus co-generation power plant specifically, generators (diesel and petrol).
- University vehicle fleet fuel consumption (diesel and petrol).
- Babcock University shuttle (petrol).
- Student Union vehicle (petrol).
- Agricultural emissions in the form nitrous oxide emissions resulting from fertilizer application on the School farm, carbon dioxide emissions due to the use of tractors and the use of lawn mowers for horticultural purposes.

2) Scope 2 Emissions

Scope 2 emissions are indirect emissions which arise from sources that are neither owned nor operated by Babcock University but whose products are directly linked to on-campus energy consumption. They are the result of imported/purchased electricity from the local utility provider, Power Holding Company of Nigeria (PHCN) measured in Kilowatt Hour (KWh).

3) Scope 3 Emissions

These emissions include all other indirect emissions that occur as the result of outsourced activities. They arise from sources that are neither owned nor operated by Babcock University but which are either directly financed or linked to the campus through encouragement or influence which include:

- Emissions associated with Faculty and Staff commuting in personally-owned vehicles to and from the University campus.
- Emissions associated with student commuting on campus in University shuttles.

C. Conceptual Framework for Babcock University (BU)

The designed conceptual framework includes ICT as one of its categories; it is an improvement on the work of [10], University of Cape Town (UCT) carbon footprint methodological framework.

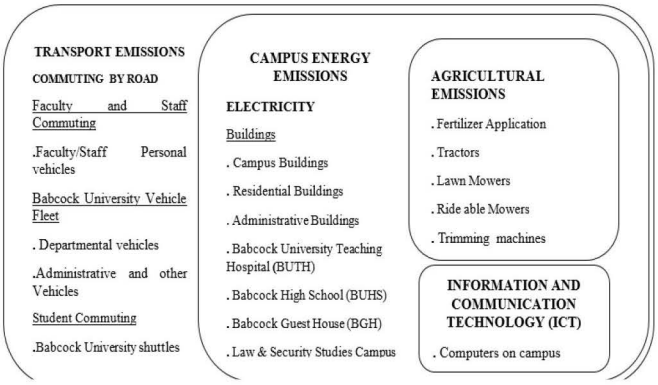

Fig.1. The Conceptual Framework for Babcock University (Adapted from Letete et al., 2011).

The conceptual framework above clearly portrays the sources of emissions envisaged to contribute considerably to BU's carbon footprint. It was used for the determination of the school's carbon footprint regarding the sources of emission on campus to collect activity data from for BU's carbon footprint computation. The conceptual framework categorizes BU's carbon emissions as follows:

1) Transport Emissions

This category covers emissions from Faculty and Staff commuting to and from BU and also those emissions from vehicles owned by University departments and the Student body - Babcock University Students Association (BUSA). Also, emissions from BU Ventures Shuttle fleet, which provides commuting services for the University community within the University campus are also included.

2) Campus Energy Emissions

This segment encapsulates all GHG emissions that originate from direct energy consumption on the University campuses (Ilishan and Iperu). This is primarily divided into contributions from the consumption of electricity namely; campus buildings, administrative buildings, residential buildings, Babcock University High School (BUHS), Babcock University Teaching Hospital (BUTH), Babcock Guest House (BGH) and the Law and Security Studies Campus located at Iperu, Ogun State.

3) Agricultural Emissions

This section comprise emission of nitrous oxide from nitrogen fertilizer application on the school farm, carbon dioxide emissions given off as a result of using tractors, lawn mowers, rideable mowers and trimming machines for horticultural purposes.

4) Information and Communication Technology (ICT)

This category entails the total number of computers that connect to BU's network.

IV. RESULTS

In this study, GHG calculations were done by multiplying activity data from various emission sources on campus with relevant emission factors.

A. Scope 1 Emission Sources

1) Generators

Babcock University has a total of ten (10) generators that are used to supply electricity when there is power outage from the mains supplied by Power Holding Company of Nigeria (PHCN). The head of the electrical unit at the Facilities management department made it known that the generators are used averagely for four (4) hours a day because electricity supplied by PHCN is available on an average of twenty (20) hours a day. The total CO_2 emissions by generators owned by BU at these three locations namely; main campus, Iperu campus and BUTH was 3,780,000Kg CO_2, equivalent to 3704.4 tons of CO_2e.

The pie chart below shows the emissions by Babcock University's generators and the percentage of emissions given off by each location. It is observed from fig. 2 that the main campus accounts for the highest amount of carbon emissions from the use of generator, which is 48% of the total carbon emissions in this category.

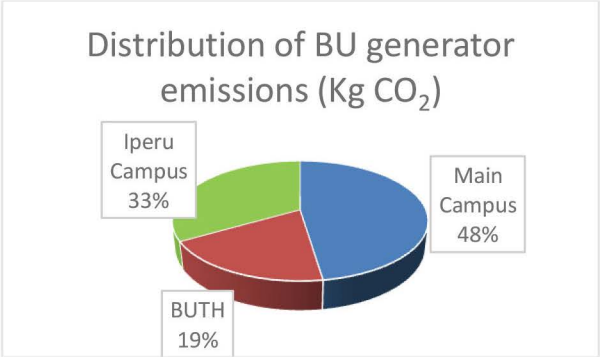

Fig. 2. Pie chart showing distribution of BU generator emissions.

a) Generators of Banks Located on Campus

There are a total of five (5) Banks located on campus, each having one diesel generator. Each Bank was visited to get the activity data (litres of diesel used by their generators). The total carbon emissions from all Banks located on campus for the year 2013/2014 was 94.4328 tons of CO_2e.

b) Private Business Generators

Owners of Stalls on campus were interviewed to get the activity data regarding the litres of fuel used to power their generators. It was discovered that a total of five (5) petrol generators are used for business, four (4) belonging to the photographers and one (1) owned by the Cobbler. Depending on how much work needs to get done, during peak time, 8 litres of petrol is used daily while 5 litres of petrol is used for 3 days during off-peak period by the photographers. It was assumed that all photographers use the same quantity of fuel daily and that 5 working days

make a week. Therefore, total carbon emissions by private business owners on campus (Photographers and the Cobbler) was 17,692.8Kg CO_2, which is equivalent to 17.3389 tons of CO_2e.

c) Agricultural Emissions

The Farm manager was able to give the type of fertilizer used on the school farm to be Nitrogen Phosphorus Potassium (NPK), specifically NPK 15:15:15. The quantity given was 50 bags of 50 kilogram (kg) of NPK yearly. There are two tractors owned by BU with only one functional as at the time this study was carried out. The functional tractor was said to consume 400 litres of diesel monthly at peak period.

The percentage of Nitrogen in an NPK 15:15:15 fertilizer is 15%. The activity data was multiplied by the emission factor to give the amount of nitrogen used which was then multiplied by its Global Warming Potential (GWP) in order to convert the value to its carbon dioxide equivalent (CO_2e) value. Nitrous oxide emission for the fiscal year due to use of NPK (synthetic fertilizer) was 284.813 tons of CO_2e.

2) Farm Machineries

The Grounds department was able to provide the quantity of trimming machines, lawn mowers and rideable mowers for both Iperu and Main campus. Total CO_2 emissions from the use of all farm machineries was 32,140.8kgCO_2 which is equivalent to 31.5 tons of CO_2e. The pie chart in fig. 3 gives a pictorial representation of carbon emissions from farm machineries. The use of tractor accounts for the largest percentage of carbon emissions in this category.

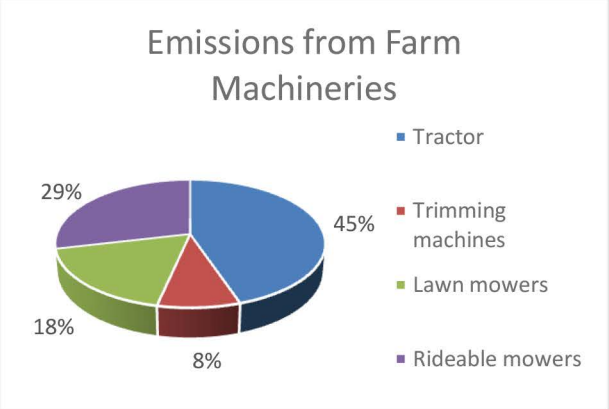

Fig. 3. 3-D Pie chart representation of farm machineries.

3) University Vehicle Fleet

The transport department gave the total number of University's vehicle fleet which included cars, buses, trucks, jeeps and Pick-Ups to be seventy (70) which are used for administration and their fuel consumption rates. The total carbon emissions from University vehicle fleet was 2,632,896kgCO_2, equivalent to 2,580.24 tons of CO_2e.

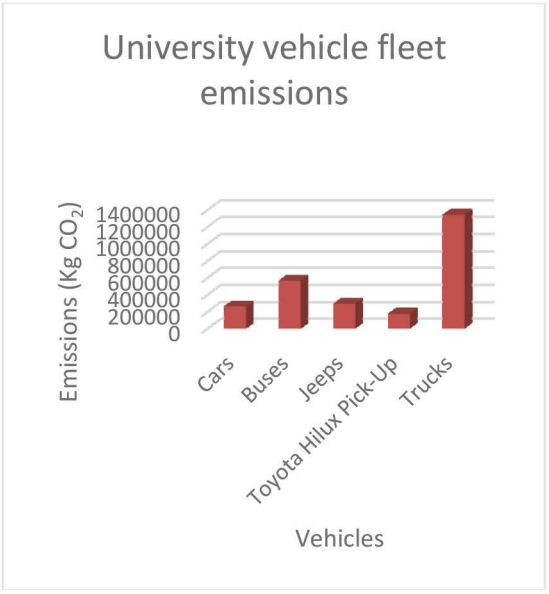

Fig. 4. 3-D bar chart showing University vehicle fleet emissions.

B. Scope 2 Emission Sources

Babcock University purchases electricity from the Power Holding Company of Nigeria (PHCN). The records from January to March 2014 and also for May to July 2013 were provided by the electrical unit, Facilities Management. The emission factor used for purchased electricity was that peculiar to Nigeria which is 0.486277966 per Kilowatt Hour (KWh) of electricity consumed [11]. Total carbon emissions from purchased electricity for the fiscal year 2013/2014 was 15,370,948kgCO_2, equivalent to 15,063.53 tons of CO_2e. The chart in fig. 5 shows the trend of electricity consumption at Babcock University for the fiscal year 2013/2014.

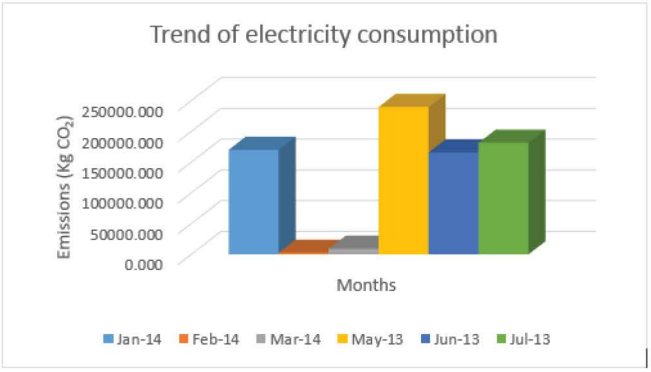

Fig. 5. Trend of electricity consumption.

C. Scope 3 Emission Sources

1) Faculty and Staff Commuting

For the number of personally owned vehicles by Faculty and Staff for the purpose of commuting, the head of Transport operations gave the figure to be 765 vehicles both at Ilishan and Iperu campus. It was assumed that each Faculty and Staff that commutes to and from the campus in personally owned cars daily uses 40 litres of petrol weekly and that there are five (5) working days in a week, 4 weeks in a month and 12 months in the fiscal year. The carbon emissions from Faculty and Staff commuting for the fiscal year were 3,525,120kgCO_2, equivalent to 3,454.618 tons of CO_2e.

2) Student Commuting (University Shuttles)

The distance of the farthest Hall of residence to the school area was given to be three-quarter of a kilometer or maximum of one kilometer. Information about University shuttles was provided by a shuttle operator on campus; there were nine (9) functional shuttles when this study was conducted and the daily fuel usage was assumed to be ten (10) litres of petrol. The total carbon emissions from shuttles for the fiscal year were 62,208kgCO_2e. The total carbon emissions from Scope 3 that is, Faculty, Staff and Students commuting in the fiscal year were 3,587,328kg CO_2 which is equivalent to 3,515.581 tons of CO_2e.

D. Carbon Emissions of BU's Information and Communication Technology (ICT)

The director of ICT, Babcock University gave the number of workstations that connect to the school's network to be about 400 computers. For the total number of users who connect via wireless fidelity (Wi-Fi) using personal laptops, it was assumed that 80% of the entire student population which comprise undergraduates and postgraduates own a laptop. This implies that about 7,298 students own laptops which makes a total of 7,698 computers with the figure given by the ICT director inclusive. According to [3], each Personal Computer (PC) in use generates about a ton carbon dioxide yearly which is equivalent to 1016.04642kg (UK, long ton) [12]. This implies that the total carbon emissions from BU's ICT for the fiscal year were 7,821,525.3kg CO_2, equivalent to 7,665.0948 tons of CO_2e.

E. Total Carbon Footprint of Babcock University (BU)

University activities for year 2013/2014 led to the release of about 33,017.89 tons of CO_2 equivalent (CO_2e) emissions into the atmosphere, with about 46% of those emissions coming from the consumption of electricity alone (see fig. 6). The use of computers (ICT), generators and Faculty, Staff and Student commuting were the second, third and fourth most carbon-intensive activities at the university in 2013/2014 with contributions of 23%, 11% and 11% respectively.

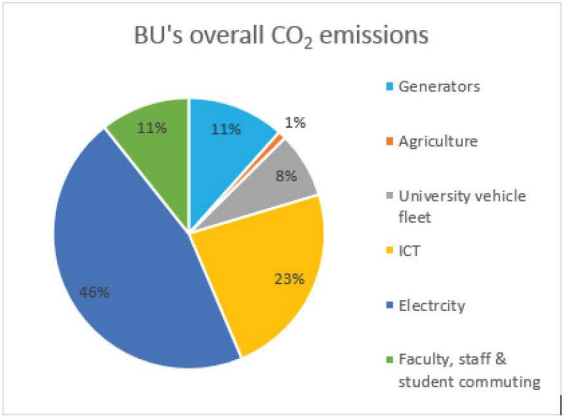

Fig. 6. 2-D pie chart showing BU's overall CO_2 emissions.

Fig. 6 is an overview of the carbon footprint of Babcock University, highlighting only the most significant contributors (greater than 0.5% contributors). Fig. 7 shows the contribution of various University activities.

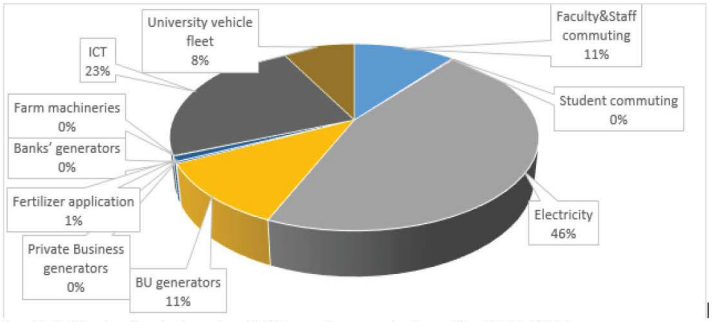

Fig. 7. 3-D pie chart showing BU's carbon emissions for 2013/2014.

V. DISCUSSION AND CONCLUSION

The aim of this study was to determine the carbon footprint of Babcock University (BU) and also to design a carbon footprint conceptual framework which was adopted in the measurement of the carbon footprint of BU. The total carbon footprint of BU for the year 2013/2014 was discovered to be 33,017.89 tons of carbon dioxide equivalents (CO_2e). In the year under review, 46% of BU's carbon footprint resulted from the use of electricity next to ICT, the use of generator and Student and Staff commuting which accounted for 23%, 11% and 11% respectively.

In view of the fact that the Information and Communication Technology (ICT) industry is responsible for approximately 2% of global carbon emissions and ICT solutions have the potential of being the driving force to lessen a considerable part of the lingering 98% of total CO_2 emitted by non-ICT industries [13], it is recommended that Babcock University should include green computing and green IT as a part of the University curriculum and also sensitization workshops should be conducted for Faculty and Staff in the fields of green computing and green IT.

Carbon sequestration which is the removal of carbon dioxide from the atmosphere; its permanent storage which can be achieved by planting crops or trees that absorb carbon dioxide from the atmosphere through photosynthesis and its storage in their ecosystem as wood, roots, or soil organic matter can be adopted [14]. The use of alternative source of electrical energy can also be introduced such as the use of solar energy, windmills, amongst others.

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