American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-4, Issue-7, pp-112-122
www.ajer.org
Research Paper Open Access

Carbon Emission Management in the Construction Industry – Case Studies Of Nigerian Construction Industry

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ABSTRACT : *Climate change is a global concern. The effect is seen all over the globe and man's anthropogenic activities is a major contributor. This study evaluates the management of carbon emissions in the Nigerian construction industry by measuring the amount of carbon being emitted from constructional activities within selected organizations. At present, there is no standard of measuring greenhouse gas emissions that is acceptable internationally for all countries so the UK Department for Environment and Rural Affairs (DEFRA) methodology of emission monitoring and measurement was used to evaluate the extent of carbon dioxide emissions in these organizations. This methodology was adopted for this study because there was no known national methodology for emission measurement and monitoring within Nigeria. Case studies were undertaken and questionnaires were applied in some construction organizations within Nigeria and the responses from these questionnaires were evaluated and it was found that though there was significant emissions from the Nigerian construction industry, the provision for emissions monitoring and management was lacking, the general awareness regarding carbon emissions and environmental issues across the various organizations evaluated was poor and the construction organizations had no singular person directly in charge of carbon or environmental issues.*

Keywords - Climate change, Global warming, DEFRA Methodology, Greenhouse gases, Carbon emission management, Construction industry.

I. INTRODUCTION

There is a general consensus that global warming is as a result of climate change. Climate change is one out of many global pressures that the present generation needs to attend to in order to ensure that the quality and prosperity of life is preserved [1]. The earth's climate has varied significantly in the past with variations as a result of natural emissions like volcanic eruptions and greenhouse gas emissions. The concentration of carbon dioxide, a major greenhouse gas has increased in recent years. This increase in carbon dioxide emission has been attributed to anthropogenic activities of man. In 1997, an agreement was reached in Kyoto where about 38 developed countries committed themselves to the reduction of their annual carbon dioxide emissions [2]. The global climate will continue to change as long as man inhabits this planet and with the predictions on global temperature continuing to rise, there is an expected change in the global climate that will lead to changes in weather patterns for each locality with impact varying according to local conditions and vulnerability. The 2007 fourth assessment report from the Intergovernmental Panel on Climate Change (IPCC) stated that there is a 90 per cent likelihood of man-made greenhouse gas emissions causing most of the observed global temperature rise since pre-industrial era [3].

Addressing the threat posed by carbon emissions ultimately require behavioral changes in the global consumption and utilization of energy especially fossil fuels. The ultimate objective to address climate change by the United Nations Framework Convention on Climate Change (UNFCCC) as clearly stated by the body is to stabilize atmospheric greenhouse gas concentrations at safe levels that would prevent dangerous anthropogenic interference with the climate system. To achieve this goal, net carbon emissions must be substantially reduced over the course of this century and must be virtually eliminated in the future [4]. Progress towards achieving this will require a long chain of actions performed over time though there are growing suggestions that these steps alone will not be enough to reduce or stabilize the global atmospheric carbon dioxide concentrations [5].

Carbon management is the concept of managing carbon dioxide emissions from anthropogenic activities so as to minimize its effects on global climate. The techniques include among others carbon dioxide capture and storage, geochemical carbon cycling to enhance transformation of carbon dioxide gas into dissolved

or solid phase carbon, biological mechanisms of enhancing carbon contents of soils and physical mechanisms such as formation of carbon dioxide lakes, and confinement of Carbon dioxide gas in underground formations [6]. Tackling carbon emission is a local issue that will depend on the individual country's emissions status and vulnerability to climate change. It will therefore require management strategies that are locally adaptive since sources like energy (availability, alternatives or mixes and demand), carbon sinks and other factors vary widely globally. In developed and developing countries, the largest sources of carbon dioxide are from fossil fuel while in less-developed countries like Nigeria, most of the carbon emissions are from sources such as fossil fuel consumption in the transport sector, industrial sector including the construction industry, deforestation, gas flaring as a result of oil exploration and land use.

Managing carbon emissions successfully will require the development of different types of options which will include the followings:

- greater efficiency in the production and use of energy;
- greater use of renewable energy technologies;
- technologies for removing carbon from hydrocarbon fuels and sequestering it away from the atmosphere;
- a mixture of behavioural and operational changes in forestry, agricultural, industrial and land use practices; and
- Other approaches, some of which are currently very controversial, such as nuclear power and carbon capture and storage [7, 8].

The population of the world as a whole will continue to grow in the coming decades, because though populations in some parts of the world have stabilized, in developing countries like Nigeria, the population is growing and will continue to grow. The desire for development will also continue among developing countries and this will definitely lead to an economic development that will continue to result in growing energy demand, even if the global energy efficiency can be significantly increased.

The Clean Development Mechanism (CDM) is a market mechanism under the Kyoto Protocol targeted at reducing GHG emissions in a cost effective way and still maintain sustainable development in host countries by encouraging energy-efficient, capital and technology transfer into those countries. CDM is an important mechanism that is designed to link the gap between industrialized countries which are responsible for most of the past greenhouse gas emissions and the developing world which is expected to be the major source of future emissions. Article 12 of the Kyoto Protocol provides for the clean development mechanism. Through the CDM, countries with emission targets can invest in emission control projects in developing countries with no targets, thus earning credits for the reductions in GHG emissions in the host country [9, 10].

The greenhouse gas benefits of each CDM project will be measured according to internationally agreed methods and will be quantified in standard units, to be known as 'Certified Emission Reductions' (CERs), expressed in tonnes of CO_2 emission avoided. CDM projects should be based on voluntary participation by each Party. In providing a mechanism for this exchange, CDM through emissions trading reduces the cost of meeting the Kyoto targets on one hand and provides a new source of export earnings on the other [11].

Nigeria is a Party to the UNFCCC, which it signed on June 13th 1992 and ratified in August 1994 and ratified the Kyoto Protocol in 2004 and the Protocol came into force in the country in 2005. The Federal Ministry of Environment which is responsible for carbon emissions and climate change is one of the relevant authorities for CDM in Nigeria. Recently, the FGN introduced another authority named the Presidential Implementation Committee on CDM (PIC CDM) as the entity to organize CDM activities in Nigeria. The PIC CDM has been named the Designated National Authority (DNA) as required by the UNFCCC. In this capacity, the PIC CDM has complete responsibility for CDM activities, especially in areas where government intervention and activities are expected. Stakeholders include the government, the general public and the private sectors [12, 13].

As far back 2007 CDM projects commenced activities and they are at various stages currently. Gas Flare Reduction Partnership (GGFR) in Nigeria has undertaken a series of actions in gas flare reduction strategies mechanisms to achieve its objectives. GGFR's stated objective in Nigeria is to reduce key barriers to flared gas utilization [12, 14, and 15].

Construction industry accounts directly and indirectly for an estimated 40% of the material flow entering the world economy and in the developing countries it accounts for around 50% of the total energy consumption. Materials used in construction have widely varying amounts of greenhouse gases associated with their extraction, refining, manufacture or processing and delivery. As new buildings become more energy efficient, the emissions associated with materials make up a greater proportion of their total climate change impact. Planners, developers, architects and builders are becoming more aware of the climate change impacts of construction materials and are increasingly including climate change considerations in their selection of materials and construction techniques for building projects [16, 17].

In global terms, the Nigerian construction industry is very small with global construction estimated to be about $4 trillion in 2008, the value of the Nigerian construction industry was estimated at $3.15 billion (0.2% of the global total estimate). Its impacts on the environment is considerably huge and is therefore the largest exploitation of natural resources with transformations that are irreversible sometimes being the end result on the environment. The impacts on the environment as a result of exploitation are particular in energy use, air and water pollution, depletion of natural resources loss of agricultural land, natural reserves, forests, soil degradation etc [18-20]

The Nigerian population is growing at an alarming rate with growth rate estimated at 1.999% thereby increasing the need for housing and urbanization. Urbanization with huge movement of people especially, the youth from the rural areas to urban centers is creating so much constructional activities in the industry [21].

Nigeria was the 4th highest emitter of Carbon dioxide in Africa as far back as in 2004, producing an estimated 31.1 million metric tonnes of Carbon dioxide emissions per capita and fossil fuel use and gas flaring was identified as the major sources of this carbon emission [22]. In 1995, the total Carbon emissions from Nigeria was 21.42 million metric tonnes – from the little data available, there has been a gradual increase in the annual national carbon emissions inventory. The main sources of Carbon emission in Nigeria were identified to be from the combustion of fuels, agriculture, and fugitive emissions due to gas flaring [23, 24]. Each sector of the economy has its own contribution to the carbon emission in the country. To be able to manage these emissions, it is very important to have an effective inventory of carbon emissions from the various sectors.

The Nigerian economy presently is one that is driven by Oil. Hence, the activity surrounding its exploration, exploitation, generation and production account for a certain percentage of Carbon dioxide emission particularly through gas flaring. In 2000, studies showed that over 3-5 billion standard cubic feet of associated gas was produced and more than 70 per cent was burnt off (flared). This made Nigeria the world's largest country with flared gas which amounted to about 2 billion standard cubic feet a day being flared. The economy is gradually picking up as well as the fact that the population is growing rapidly [25]. These both have effect on the extent of emissions from the transport, industrial, services and the agricultural sectors.

In Nigeria, harvesting of wood to be used as fuel by about 50% of the population is a major source of deforestation and is estimated to be at a rate of about 400,000 hectares per year. If this trend continues the country's forest resources could be completely depleted by 2020. Use of wood as an energy source can also contribute to the accumulation of carbon dioxide, the main greenhouse gas, both because burning wood produces carbon dioxide, and because deforestation destroys an important carbon dioxide sink [26, 27].

The objectives of this study are to estimate the energy consumed in direct construction activities, estimate the direct emissions of carbon as a result of construction activities, and the analysis of the two points above, with recommendations and a conclusion drawn concerning ways of managing carbon emissions from construction activities. In other words, this work aims at exploring the rate of emissions of carbon dioxide in the construction industry, the level of awareness and how this emission is managed within the Nigerian construction industry.

II. MATERIALS AND METHODS

2.1 Case studies

Three case studies involving construction organizations of different sizes and in different locations in Nigeria were taken for consideration. The names of these construction organizations were not used directly in this project for security purposes. These case studies were selected randomly based on the volume of work each was involved in and its perceived size. Emissions from construction activities were evaluated through the energy being consumed for such activities.

Case Study 1 was indigenous, carries out building and civil construction activities all over the country, has branches in six states with its national headquarter located in the northern part of the country. At the time of the study a branch located in the Middle Belt of the country was the respondent. Case Study 2, at the time this study was conducted was one of the leading constructional organisations in Nigeria and had handled a sizeable number of both building and civil construction works all over Nigeria. The head office, located within the Federal Capital Territory and is partly handled and owned by expatriates and indigenous Nigerians. It was responsible for most of the construction projects carried out in the present Federal Capital Territory before it took off as a national capital and are still responsible for most of the construction projects being handled by the Nigerian Government. The questionnaire was answered and filled from one of the branches within the Federal Capital Territory. Case study 3 was a civil construction organisation that was involved in road construction work in some states within the country. This organisation like case study 2 was had a combination of both expatriates and indigenes working together. The questionnaire was handled by a branch of the organisation that was handling a civil construction work in the Middle Belt of the country.

This evaluation was carried out by considering the energy consumption through the use of electricity, fuel consumption and the fuel types and the DEFRA methodology [28] of carbon emissions conversion tool used to convert from fuel consumption to carbon equivalent. This method of measurement/conversion was used because it was simple, available to all and will be ideal for Nigeria where there are no known laid down regulations regarding measurements and conversion factors. Also, Nigeria already recognizes the British Standard and combines the British Standard with its own code of practice within the construction industry. The general awareness of the construction industry's employees and the management of each industry were also considered.

Questionnaires were applied in the construction industries and the responses from these questionnaires were evaluated to arrive at a conclusion concerning the status of the Nigerian construction industry with regards to emissions. The issues tackled in the questionnaire include type of energy used, yearly consumption and transport emissions. The data collected through this questionnaire contained all information needed to establish how the Nigerian construction industry was handling emissions and management of carbon. The questionnaire sought for contact details of the company and most importantly the identification of a person responsible for carbon issues within the organization. The DEFRA 1999 reporting guidelines suggest that the identification of a 'greenhouse gas champion' is the first step to take when attempting to report on greenhouse gas emissions [29]. This person should have the authority to collect data and draw up a strategy for managing and reporting on emissions, and should liaise with the relative consultative and statutory bodies. A number of questions were asked to establish the presence of this greenhouse gas champion or a carbon information manager within the organization and also to establish the availability of a carbon emission or an environmental policy within the organizations. Using the DEFRA methodology for estimating Carbon dioxide emissions from energy consumption based on the carbon content of the fuels and the fuel types supplied to the organizations, different activities like combustion of fuel from plant and equipment usage, transport, electricity consumption were considered [28].

The Questionnaire was devised to help gauged the staff awareness as regard carbon emission and management, energy consumption and energy data collation including bills logging and documentation. Questions 1, 2, and 3 were all general questions designed to get a feel about the size of the construction company and questions 4, 5, 6, 7 and 8 were designed to measure the awareness of environmental issues especially carbon emissions and its management within the organization. Question 5 specifically asked for the presence of a "green champion" or a carbon information manager. This is an individual that is wholly responsible for carbon issues or environmental issues within an organization and who would also be responsible for a proper logging and documentation of all energy bills, consumption and types. Finally, the respondents were also given the opportunity to offer suggestions or comments regarding carbon emissions and management within their various organizations. The following section is a sample of the questionnaire that was sent to the various respondents.

2.2 Data analysis

2.2.1 Carbon emission measurement

Direct and indirect carbon emissions from construction activities or what is called scope 1 and scope 2 emissions were the identified emission sources for this research. Direct emissions are emissions from onsite heating (or electricity generation), onsite industrial use or manufacturing process and from owned transportation fleet while indirect emissions included emissions from energy purchased, usually split by fuel type or generation method. Putting the above into scope 1 and scope 2 emissions, scope 1 emissions were the direct carbon emissions from sources that the organizations owned or controlled (e.g. emissions from combustion of boilers, generating plant, air conditioning units, vehicles; and emissions from any on site production activities) while scope 2 emissions were carbon emissions from the generation of electricity, heat or steam that were used by the construction organization and have been brought in from elsewhere. The activity data or the energy consumption data were collected in litres of petrol consumed and kWh of electricity consumed as shown below for scope 1 and scope 2 emissions:

- Scope 1: purchased quantities of commercial fuels (oil, gas, etc.) using data from meters and/or utility bills. Common units of fuel consumption were converted into CO_2 emissions using the standard published emissions factors.
- Scope 2: purchased quantities of electricity consumption using data from meters and/or electricity bills. Electricity consumption was converted into CO_2 emissions using the UK grid average conversion factors created by DEFRA [28].

2.2.2 Tool and data conversion factor

The annual electricity consumed for the various activities were calculated using the kWh of electricity consumed per week for twelve months, and the activity data converted into the emissions data using the UK DEFRA greenhouse gas conversion factors for companies. Once the activity data was collected, the next step was the application of the above conversion factors using the UK guidance. The data from each activity was calculated and then a combined total of carbon dioxide emissions from the various fuel and energy consumption obtained and an overall emission for each organization arrived at. The DEFRA data conversion tool [28] provides that

- Emissions from grid electricity was converted into carbon dioxide equivalent using annex 3 of the conversion factor; while
- Emissions from the use of fuels was converted into carbon dioxide equivalent using annex 1;

The quantity of carbon dioxide (kg) emitted from each constructional activity is given by (1):

$$Activity\ Data \times Emission\ Factor = Carbon\ dioxide\ content \quad (1)$$

The process used in the determination of carbon emission and its management for the various case studies is summarized in fig. 1 below:

2.3 Data quality and limitations

Due to the distance between Nigeria (the case study) and the UK where this study was carried out, the collection of data was systematic. Data were collected using a third party to get to the various respondents through the internet services and through telephone communications. These media of communication placed a time constraint on the data collection and the research as a whole as it was difficult getting the required data from Nigeria. Data documentation within the various organizations was a little bit difficult as discussed.

III. RESULTS

3.1 Case study findings

The results and findings obtained from the various case studies are summarized under the following headings:

(i) The size of the construction organisation;
(ii) The availability of a carbon information/policy manager;
(iii) The availability of an organisational carbon or environmental policy; and
(iv) Energy and fuel consumptions data.

These issues were handled primarily by the first 6 questions on the questionnaire and the responses for the 3 case studies are presented in Table 1. Each case study was considered separately based on the response received from the questionnaire that was administered to it. Tables 2 to 6 show details of energy consumption for the past 12 months by the case studies. Case Study 3 did not state weekly cost of energy consumed for various construction activities.

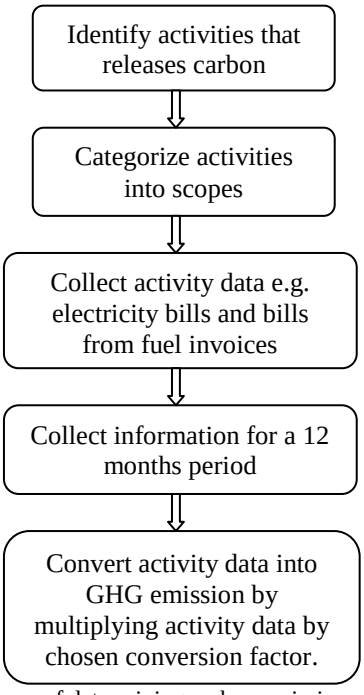

Fig. 1: Process of determining carbon emissions and its management (Source: [28]).

Table 1: Responses to the First 6 questions by the Case Studies

Issue	Case Study 1	Case Study 2	Case Study 3
Position of Respondent	Site Engineer	Engineer	Project Manager
Number of Employees	> 150	> 150	> 150
Presence of Carbon Emission/other Environmental Policy	No	No	Unsure
Presence of a Personnel in charge of Environmental issues	No	No	No
Presence of day to day log of Energy bills and consumption based on fuel types	Yes	Yes	Yes
Presence of method for CO_2 Emissions assessment	No	No	No

Table 2: Annual Energy consumption by Case Study 1

Fuel type	Annual units consumed (kWh/tonnes or litres)	Total annual cost (₦)
Grid electricity	1,040,250 kWh	10,090,425
Natural gas	-	-
Gas diesel oil	800,000 litres	92,000,000
Heavy fuel oil	-	-
Any form of renewable energy	-	-
Coal or coking	-	-

Table 3: Annual Energy consumed for transport by Case Study 1

Fuel type used	Total units consumed annually (l or kg)	Total amount spent annually (₦)
Petrol	156,000litres	10,140,000
Diesel	-	-
Petroleum gas	400,000litres	46,000,000
Natural gas	-	-
Others	-	-

Table 4: Annual Energy consumed for Construction activities by Case Study 2

Fuel type	Annual units consumed (kWh/tonnes or litres)	Total annual cost(₦)
Grid electricity	3120000 kWh	-
Natural gas	1456kg	-
Gas diesel oil	520000 litres	-
Heavy fuel oil	-	-
Any form of renewable energy	-	-
Coal or coking	-	-
Others	-	-

Table 5: Annual Energy consumed for various construction activities by Case Study 3

Fuel type	Annual units consumed (kWh/tonnes or litres)	Total annual cost(Naira)
Grid electricity	52,000 kWh	-
Natural gas	1344kg	-
Gas diesel oil	370000 litres	-
Heavy fuel oil	480000litres	-
Any form of renewable energy	-	-
Coal or coking	-	-
Others	-	-

Table 6: Annual Energy consumed for transport by Case Study 3

Fuel type used	Total units consumed annually (l or kg)	Total amount spent annually (₦)
Petrol	137,480litres	8,650,000
Diesel	-	-
Petroleum gas	520,000litres	46,000,000
Natural gas	-	-
Others	-	-

3.2 Carbon measurement and conversion from the case studies

Tables 7 to 9 below show the energy and fuel consumption with their conversion factor for the various case studies.

Table 7: Conversion of emissions from energy consumption for construction activities to carbon equivalent for case study 1

Fuel type	Quantity consumed	Emission factor(kg CO_2/unit)	Total CO_2(kg)
Gas diesel oil	800,000 litres	2.6413	2113040.00
Petrol	156,000litres	2.3018	359080.80
Natural gas	40,0000litres	2.0230	80920.00
Grid electricity	1,040,250kWh	0.50076	520915.59
Total			3073956.39

Table 8: conversion of emissions into carbon dioxide equivalent for case study 2

Fuel type	Quantity used	Emission factor (kg CO_2/unit)	Total kg CO_2
Gas diesel oil	520000litres	2.6413	1373476.00
Petrol	-	2.3018	-
Natural gas/other petroleum gas	1456kg (1.456 tonnes)	2894.0	4213.66
Grid electricity	3120000kWh	0.50076	1562371.20
Total			2940060.86

Table 9: Conversion of emissions into carbon dioxide equivalent for case study 3

Fuel type	Quantity used	Emission factor (kg CO_2/unit)	Total (kg CO_2)
Gas diesel oil	370000litres	2.6413	977281.00
Petrol	137480litres	2.3018	316451.46
Natural gas	125000litres	2.0230	252875.00
Grid electricity	1135000kWh	0.50076	568362.60
Total			2114970.06

IV. DISCUSSION

From the responses given by the various case studies, the analyses of each organization's status regarding carbon management were discussed under the following sub sections.

4.1 Carbon information/policy manager

The Carbon Information Manager is responsible for carbon emission, management and all that pertains to environmental issues, and should have a level of detailed understanding of every activities and operations within the construction organization. This manager will ensure that:

(i) Emission data like energy bills, fuel consumption invoices are properly kept and updated from time to time;
(ii) Policies and regulations regarding carbon emissions are maintained;
(iii) A general awareness about carbon issues is created within the organisation;
(iv) A link between the organisation and the government including the general public as regard carbon emission and its management is maintained.

From Table 1, the responses of 2 of the case studies were negative on this issue while case study 3 was unsure. From the number of employees recorded by them, they were between medium and big in size. The absence of a carbon or environmental issues Manager shows the level of importance placed on emissions of greenhouse gases from construction activities by the organization or its understanding of carbon emissions and this raised some suspicion as to the validity and consistency of the data supplied. Given the volume of work Case study 2 was involved in, the number of employees it has and its exposure to the Federal Government's economical policies some meaningful information regarding carbon emission issues, awareness about climate change, the effect of carbon emissions on climate change and possibly the availability of a form of environmental policy was highly expected from it. This response from this case study also shows a lack of understanding or interest regarding carbon emissions and management. Case Study 3 was unsure as touching the presence of a person in charge of any form of carbon issues. The respondent was a project manager within the organization and if he/she is unsure of a carbon information manager then there is a need to query his competence, the general awareness across the organization regarding environmental issues and also the validity of other information supplied within the questionnaire by the respondent.

Based on the responses given by all the case studies on this issue, there is the need for the creation of awareness and/or a policy within the Nigerian construction organizations on the provision for a Carbon Information Manager who will be able to control some aspects of carbon emissions as well as stimulating other aspects that might be susceptible only to influence, rather than direct control. For instance, while an organization has direct financial control over energy consumption, having an effective energy policy that relies on influencing employee behavior rather than controlling its energy consumption will go a long way.

4.2 Carbon issues and environmental policy

Table 1 also shows that the 3 case studies all answered in the negative on the issue of a carbon emissions/other environmental policy within the various organization. An environmental policy stating organizational objectives, targets and means of achieving these targets is very important if the emissions of greenhouse gases are to be monitored within an organization. The absence of one shows the level of awareness within the various construction organizations. The Table also shows the calibre of the persons who responded on behalf of the case studies and for them not to know would be very unfortunate. This also speaks of the national attitude towards environmental or carbon emission issues within the construction industry and within the nation as a whole in Nigeria. The fact that there was a general carefree attitude towards emission or environmental issue could be because Nigeria was classified under the countries with little emissions and do not need any emission reduction target for now. With the current population, the rate the population is growing coupled with some national emission problems like gas flaring, deforestation and emissions from agricultural processes, carbon emissions within the country will keep growing in all sectors of the economy and there is a need to lay down ways for these emissions to be monitored and managed.

4.3 Carbon dioxide emissions from the various case studies

Tables 7 to 9 show the carbon emissions from the constructional activities of the various case studies. The total computed carbon dioxide emission from case study 1 was 3073956.39kg (approximately 3073.96 tonnes of CO_2). The total carbon emission calculated from this case study was 2940060.86kg (approximately 2940.06 tonnes CO_2). This result was however inconclusive as the figure for petrol consumption was missing. It was either this organization was not using petrol for its construction activities or there were some discrepancies in the documentation of energy consumption for those activities. The carbon emissions from the construction activities for case study 3 was calculated as equal to 2114970.06kg of CO_2 (approximately 2114.97tonnes of CO_2). The figures that were calculated from these emissions individually were minimal but when combined from the entire construction sector and other sectors of the economy, this will become significant.

The status of the Nigerian construction industry concerning carbon emissions and management can be seen from the responses which were generally negative. There is an absolute absence of awareness regarding carbon emissions and management. For carbon to be well managed and monitored through proper measurement, it is important that energy consumption be properly documented and logged at the appropriate time according to quantities consumed, the types and the amount spent in acquiring the energy with everything shown in the right order with the right units.

4.4 Ways of reducing carbon emissions within the construction organizations

Countries like the UK have put in place policies and regulations that have helped in the reduction of its carbon emissions. Incorporating some of these policies into the Nigerian environmental policies will go a long way in helping Nigeria to monitor its greenhouse gas emissions and also manage it successfully. The Nigerian construction industry and the Nigerian Government could reduce its carbon emissions by adopting the UK Low

Carbon Transition Plan strategies for built environment. These strategies involve the followings will go a long way in the reduction of carbon if incorporated into the Nigerian policies.

(a) Clean energy cash-back schemes: Payments if low carbon sources are used to generate heat or electricity;
(b) A target to generate a percentage of total national electricity consumption from renewable sources; and
(c) The government encouraging industries and household with the provision of smart meters so that the public will understand its energy use and maximize opportunities for saving energy thereby reducing the emissions as a result of energy consumption and by doing that also saves energy bill.

UK energy supply comprises of natural gas, coal, petroleum, nuclear power and renewable energy. Policies involving the introduction of different energy mixes had helped in the reduction of emissions within the UK. The Nigerian energy policy needs to be upgraded if different energy mixes will be encouraged in the national mix. Every sector of the economy and everyone need to play a part in making these changes. Nigeria will then have a better quality of life, improved long-term economic health, new business opportunities in a fast-growing global sector, reduced reliance on fossil fuels, greater security of future energy supplies and fewer emissions into the atmosphere [30].

South Africa is another good example of an African country that is trying to do something tangible about the reduction of its carbon emissions. In December 2009 just before the convention in Copenhagen, the South African government announced national greenhouse gas emissions reductions by 34% by 2020 and 42% by 2025. South Africa which has a dirty economy due to its historical dependence on cheap coal to generate electricity, on a per capita basis have a greenhouse gas emission that is close to that of the UK and Germany despite its smaller economy. Two processes were agreed on by the South African government to help in the reduction of its carbon emissions. These were:

(i) The compilation of a climate change green paper which will lead to legislation and policies in support of carbon management; and
(ii) The compilation of the second Integrated Resource Plan (IRP2) by the department of energy, which will determine what South Africa's energy mix will be for the next 25 years [31].

In terms of sensitivity to environmental issues and shifts in awareness and policy, there is much that the Nigerian government and the Nigerian construction industry need to learn from South Africa. In 2009, there was a conference in South Africa called the Green Building Council of South Africa (GBCSA) , which launched the 'Green Star" rating tool that was based on the Australian Green Star rating system and since then the Council has been hard at work translating the meaning of 'Green' building into something that is practical. The objectives of the Green Star South African rating tool were given as:

(i) The reduction of the environmental impact of development;
(ii) The establishment of a common language for green building;
(iii) The setting of benchmarks and standards of measurement;
(iv) The promotion of integrated whole building design; and
(v) To raise awareness of green building benefits.

The South African government now has new or reprioritized considerations which taken into account during construction includes skills transfer, local procurement, suppliers, eco-design and sustainability.

There are a number of complementary ways the Nigerian construction industry and the Nigerian government can learn from what the UK and the South African government has done to 'make a difference' and, in so doing, will begin to address the issues of carbon emissions and management within the construction industry and the nation at large. Whether this means using products made from renewable resources or recycled material, choosing products with low energy, opting specifically for non-toxic products or changing to technology to harness renewable energy sources for example the harnessing of solar energy, will help in the creation of a built environment that is environmentally friendly and a Nigeria that is environmentally sustainable [32]

V. CONCLUSIONS AND RECOMMENDATIONS

Three construction organizations within the Nigerian were considered as case studies for this study and the organizational size, availability of a carbon information manager, availability of carbon policy or methods of assessing carbon emission and available energy consumption data were considered. From these considerations, the following conclusions were drawn:

- The figures (3073.96, 2940.06 and 2114.97 tonnes of CO_2) obtained from the various case studies represent significant amount of carbon dioxide emissions.
- There were some elements of doubt regarding the validity of the data collected as the basis for the calculations of these carbon emissions. These were observed in the way the questionnaires were filled as there were some important parts that were left vacant. For carbon to be properly managed there is a need for a proper documentation and logging of energy use, fuel types, quantity consumed and duration

of consumption. This does not however invalidate the results obtained because the missing information would have been an addition to the values above.

- There were no particular persons responsible for carbon management or emission monitoring in all the case studies undertaken and this probably is the situation in the Nigerian construction industry.
- There was no carbon or environmental policy in place in all the case studies considered and there was no form of carbon assessment in any of the organisation. This also is likely the situation across the industry.

To manage carbon emissions within the Nigerian construction industry effectively, the followings are recommended:

- The presence of a carbon management department with an information manager within the individual construction organisations.
- The need for the various construction organisations to develop their own ways of collecting energy data and they can do this by starting from a blank sheet of paper and a pile of energy bills.
- An organisational objectives stating a carbon management strategy that will benefit the organisation, the economy as well as the environment;
- Communicating across each construction organisation about carbon management and the creation of awareness regarding carbon emissions, the effect of the emissions on the environment especially climate change, the stand of the organisation and its objectives regarding carbon management issues;
- The creation of a general awareness regarding employees behaviour and energy consumption;
- Setting of targets regarding organisational objectives and decide on the carbon emission measurement criteria to be used;
- Prioritising the areas of carbon emissions that need to be controlled and target areas where reduction in emissions will have a high impact on the overall measure e.g. energy consumption; and
- Considering monitoring carbon emissions for a period before setting targets.

In this study, time limitations and distance restricted the amount of data collected and the amount of research carried out as regard emissions from the construction activities. Research was carried out via the internet and telephone services due to the distance between the UK and Nigeria. Carbon dioxide emission was the only greenhouse gas considered for this study and the method for measurement and calculation of data used was the UK DEFRA methodology. The use of this methodology for carbon emission within the Nigerian construction industry is not ideal because the emission scenarios within the two countries are different. The DEFRA conversion factor was however adopted because there was no national emission factor for Nigeria to be used and the measurement of carbon emissions probably gives an indication of the Nigeria situation.

In this work all the research were carried out using questionnaire via the internet and telephone services. It is therefore recommended that a further work be carried out where research can be possible by being involved in the construction activities directly and having a firsthand knowledge about the energy being consumed, where it is consumed and also monitor how these emissions can be measured and managed by considering the following:

- Determining the general awareness of the employees and the whole construction industry as regard the effects of carbon emissions within the construction industry;
- Determine the effect of employees' behaviour on energy and fuel consumption;
- Development of a database for emission issues within the construction industry through a proper energy consumption and carbon inventories;
- The consideration of the other greenhouse gas emissions as this is vital for a proper greenhouse gas emission inventories.

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