Data Centres: A Prescriptive Model For Green And Eco-Friendly Environment In The Cement Industry In Nigeria

Wilson Nwankwo, Kingsley E. Ukhurebor

Abstract: Data centres are important facilities in modernization of cement production industries across the world. In the last two decades, Nigeria has witnessed an amazing cement manufacturing and production reforms. Consequent upon these reforms is a marked reduction in the importation of bagged cement from other countries thereby reducing capital flights and boosting the gross domestic product. A typical cement plant in Nigeria produces an average of 6000 metric tonnes of bagged cement per day. Of vital importance to the instrumentation of local cement production and distribution plants is high technology computing infrastructure. These cement plants deploy sophisticated IT infrastructure that are driven by large diesel powered generators owing to the unstable mains power supply across the country. The effect is increased environmental pollution and degradation in the hosting environments as chemical, gaseous emissions, electronic wastes, and noise are consistently present. In some facilities, there are often more than one data centre with each supporting a definite suite of production processes. This paper is an attempt to proffer solution to the traditional problems of environmental pollution arising from poor data centre operations. Accordingly, a carefully articulated integrated that would enable enforcement agencies, and control experts reduce the localization and pollution issues associated with scattered data centres, is proposed. It is believed that adherence to the proposed innovative model would reduce drastically the pollution associated with data centres in cement factories in Nigeria.

Index Terms: Environmental pollution control, Green computing, Data centre, Production operations

1. INTRODUCTION

All over the world, cement is one of the most essential ingredients in domestic and industrial construction of various infrastructure like buildings, roads, bridges etc. In Nigeria, the production of cement is perceptible to the pre and the instantaneous post-independence epoch which witnessed the introduction of development strategies and import substitution strategy that had influenced on the cement necessity for development of various infrastructure of the country [1]. Records have showed that cement production in Nigeria started in full scale around 1957. As at that time three cement plants were established one in each of the three regions by the governments in these regions; Northern, Eastern and Mid-Western regions respectively. Afterwards, other cement production companies like West African Portland Cement Company (WAPCO), Ashaka Cement, Cement Company of Northern Nigeria (CCNN) and Benue Cement Company (BCC) were established [2]. Presently, there are ten notable cement industries in Nigeria with plants located in different parts of the country. Some of these companies include: Ashaka Cement Company Plc, West African Portland Cement Company Plc (WAPCO) now Lafarge Cement WAPCO Nigeria Plc, Benue Cement Company Plc (BCC), Dangote Cement Plc, Cement Company of Northern Nigeria Plc (CCNN), Calabar Cement Company Limited, Edo Cement Company Limited, Ibeto Cement Company Limited, Eastern BulkCem Company Limited, United Cement Company Limited, Nigeria Cement Company Plc(NigerCem). Table 1 shows the various cement plants, location and ownerships in Nigeria.

Table 1. *Cement plants in Nigeria*

S/N	Plant Name	Location	Cement Company	State
1	Ashaka	Gombe	Ashaka	Gombe
2	Benue	Gboko	Dangote	Benue
3	Bundu Ama	Bundu Ama	Ibeto	Rivers
4	Edo Okpella	Okpella	Edo	Edo
5	Effium	Effium	Ibeto	Ebonyi
6	Ewekoro 1/2	Ewekoro	Lafarge/WAPCO	Ogun
7	Ibeshe	Ibeshe	Dangote	Lagos
8	Kalambaina	Kalambaina	BUA	Sokoto
9	Mfamosing	Calabar	United Cement	Cross River
10	Obajana	Obajana	Dangote	Kogi
11	Obu	Okpella	BUA	Edo
12	Sagamu	Sagamu	Lafarge/WAPCO	Ogun
13	Sokoto	Sokoto	CCNN	Sokoto
14	Nkalagu	Nkalagu	NigerCem	Ebonyi

As a result of the inherent challenges faced by these industries, local production has persistently remained at approximately 50% capacity rate with an estimated annual growth rate of 3%. Despite the effort of the Federal government in respect of enhancement of local market competition, the price of cement has constantly increased by more than 300% since the late 1990s as a result of supply deficiency. Presently, a 50 kg bag of cement is sold for about three thousand Naira compared to six hundred

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Naira only in 2002, the Compound Annual Growth Rate (CAGR) is about 30%.

The Nigerian clement industry is faced with the following major challenges:

a. High Initial Setup Costs
b. High Distribution Costs
c. Contention with environmental challenges posed by production operations
d. Inauspicious Government Policies
e. Inadequate Local Capacity
f. Unreliable Power Supply
g. Technological Inadequacies

Notwithstanding the challenges, the Nigerian clement industry has the potential to contribute to greatly to the economy. They play a main role in the economic growth and development generally due to the fact that the industry is labour intensive, consequently a major employer of labour. The industry also has a substantial contribution to the country's Gross Domestic Product (GDP) as well as a means of Foreign Direct Investment. There has be increasing demand for cement ever since the commencement of cement production in 1957. According to existing data, from 2001 to 2011, the estimated annual demand for cement has grown from about ten million metric tonnes to twenty-five million metric tonnes, representing a CAGR of 30% [3]. And this is expected to continue in the near future as the economy increases and purchasing power progresses. The main composites for the manufacture of cement are limestone, shale, red alluvium and gypsum, which are basically raw materials. Apart from gypsum, which occurs only in limited quantities, Nigeria is copiously gifted with all the other main composites. Limestone, which is the foremost composite occurs in different parts of the country but at different proportions. Apart from the main composites (raw materials), the other main requirements for the manufacture of cement are energy [1-2] and technological infrastructure. As regards energy to drive production operations, Nigeria is bountifully blessed with various sources of energy such as petroleum, coal and even other alternative fuel[4-6]. The demand for cement is derived from the rising demand for residential and non-residential construction. The cement industry in Nigeria has witnessed enormous growth over the past few decades. With an estimated population of about 180 million and a growth rate of approximately 3% annually, the production, distribution and consumption of cement is expected to upsurge ([1]). In order to boost supply of cement, it is believed that certain intrinsic challenges within the system have to be tackled effectively. Like in other subsectors, the cement industry is not without some environmental implications. The pollution from the production, distribution and consumption of clement especially is a cause for concern especially as the world is witnessing climate change. However, there are limited literature on the assessment of cement- associated activities in Nigeria in relation to how the operators of such companies have fared in the area of promoting safe environment consistent with substantive laws and policies on environmental protection. This again affirmed the report that the limited experimental studies have led to the dependence on descriptive reviews of previous conference/seminar documents, lecture notes, among other available documents in the area of cement-associated activities in Nigeria [1].

1.1 Data centres in Cement Production and Distribution plants

Over the years, data centres have become indispensable component of the technological infrastructure required for cement production and distribution plants owing to their roles in automation. They have been considered as modernization facilities across the world [7-12]. In the last two decades, Nigeria has witnessed an amazing cement manufacturing and production reforms. Consequent upon these reforms is a marked reduction in the importation of bagged cement from other countries thereby reducing capital flights and boosting the gross domestic product. A typical cement plant in Nigeria produces an average of 6000 metric tonnes of cement per day. Of vital importance to the instrumentation of local cement factories is high technology computing infrastructure. These cement plants deploy sophisticated IT infrastructure that are driven by large diesel powered generators owing to the unstable mains power supply across the country. The effect is increased environmental pollution and degradation in the hosting environments as chemical, gaseous emissions and noise are consistently present notwithstanding the initial environmental impact assessment (EIA) done by the environmental protection regulatory agency, NESREA [13-17]. In some plants, there are often more than one data centre with each supporting a definite suite of production processes.

1.2 Increasing Data centre emissions and pollution

Notwithstanding their indispensable position in the today's manufacturing and production industries, data centres have been identified as sources of greenhouse emissions, environmental pollution and climate change [18-25]. Cement factories and plants are culprits as they are driven by huge computing infrastructure. In this study, an attempt is made to resolve the traditional complications in the form of environmental pollution/emission arising from the production, and distribution operations of cement plants especially as it affects the high capacity data centre facilities on which most of the production and distribution processes depend upon. Consequently, we will propose a carefully articulated cohesive model that would enable enforcement agencies, instrumentation and control experts and other regulators reduce the localization and pollution issues associated with scattered data centres. It is believed that adherence to the proposed innovative model would assist in mitigating the environmental pollution associated with the production, distribution and consumption of cement in Nigeria substantially.

2. Materials and Methods

This study is informed by the authors' residual and experiential knowledge on the operations of cement factories in Nigeria having worked and overseen ICT facilities in the production and distribution operations in one of the ICT-driven cement factories in Nigeria. The materials utilized include: a functional Microsoft Windows 10-powered HP Elitebook 820 series computer system installed with Microsoft Visio 2013 and Microsoft Excel 2016 software

respectively; Tecno G9 android Tablet for note-taking. The methodology employed is a design science approach. The enhanced design science approach is considered very suitable due to the fact that the nature of this study requires a survey of operator's perspectives on green practices in data centres in the local cement factories, knowledge of local environmental protection laws and regulatory policies, as well as the creation of a model that would provide a guide to the deployment of improved systems that readily resolves issues and challenges that may exist in such data centres and related infrastructure in promoting ecofriendly environments.

2.1 Research Design

As noted earlier, this study adopted a design science approach complemented by survey of opinions of operators and users in a given cement factory in Nigeria. The survey constituted the bedrock on which the design science routines leaned. A purposive sampling was done and one cement plant was selected and this is justified by authors' experience in the common practices in the cement industries in Nigeria. The location of the study is Port Harcourt(see Figure 1), a riverine capital city of the oil-rich Rivers State located near the Atlantic Ocean South-South of Nigeria. The city plays host to a number of terminals of popular cement companies in Nigeria though only one of companies has a functional installed production plant.

Figure 1. *Port Harcourt, Rivers State (source: WorldAtlas, 2019)*

Population

Quota sampling was used to select the actual participants in an opinion survey. The quota comprises seventy-seven persons who are knowledgeable in production and distribution operations in the cement plant. The various positions/portfolios of the persons are presented in Table 2.

Table 2*. Population sample*

Respondent's position	Number
General Manager(Operations)	2
IT Manager	1
System analysts	4
System operators	15
Weighbridge operators	10
Instrumentation and control operators	15
Site Maintenance engineers	5
Safety officers	10
Truck operators	10

2.2 Data collection and analysis

A structured questionnaire was used to augment systematic observation and past experiences of the authors. The questionnaire is divided into different segments: biodata, opinions on environmental regulatory policies, level of awareness on measures to be employed to sustain good environmental safety index, preventive and control measures already implemented, evaluation programs put in place, periodicity of re-evaluation, certifications from relevant regulatory/certification authorities, infrastructure/equipment evaluated/certified, etc. A total of ten questions were framed in respect of the opinions of the participants.

Data analysis was done using Microsoft Excel 2016.

2.2 Design of analytic and prescriptive process models

Here, analytic and prescriptive models of processes that interact in the production environment and distribution environment were created to reflect the relationships that exist in the production and distribution chain especially where energy consumptions and operation of equipment result to generation of emissions. Prescriptive models are very important in any scenarios where orderliness and structured measurable approaches are advocated. Emphasis is made to identify the areas of concern as it affects regulatory/certification authorities. The last phase was the design of a prescriptive model that reflect how data centres in cement industries could be acquired and/or designed and implemented with emission checks to reduce environmental problems.

3. Results and Discussion

3.1 Opinion analysis

Table 3 shows the demographics of the population of study.

Table 3*. Population demographics*

	Men	Women	Total
Primary certificate only	1	0	1
Secondary certificate only	20	5	25
Diploma	38	15	53
HND/Degree	47	10	57
Masters	5	1	6

Figure 2-3 present the clustered trend chart and whereas Figure 3 shows the clustered column chart on opinions of study population.

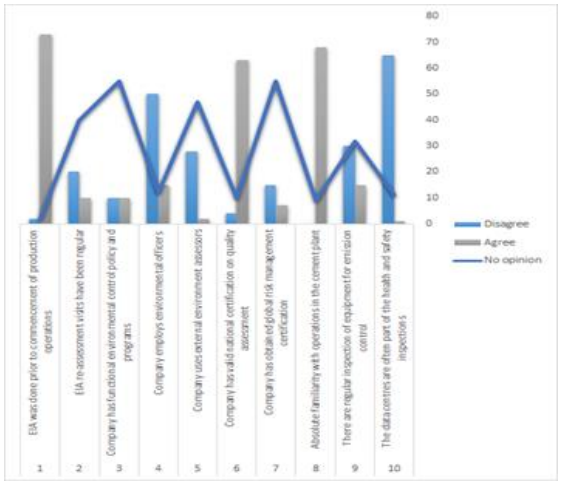

Figure 2: *Clustered trend chart on opinion of respondents*

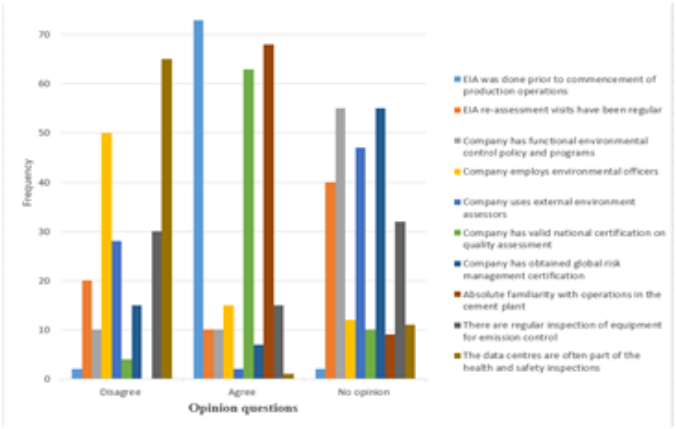

Figure 3: *Clustered column chart*

In the clustered column chart, the collective opinions of all participants on each of the survey questions are grouped to show how the responses vary across board. It is instructive to note that the data centres were not usually considered as facilities that require health, safety and environment inspections as against the other operating machineries in the cement plant. This is found to be consistent with traditional practices in data centres in other sectors such as telecommunications and financial services where massive data centres are built with less care about their contributions to the greenhouse emissions.

3.2 Model of Traditional Data Centre in Cement plants in Nigeria

Figure 4 shows the model of traditional data centres in many cement plants in Nigeria. Usually, there is one main data centre with a backup facility of similar infrastructure. The main data centre supports two main outlets: weighbridge and truck inlet/outlet plant, and the bagging lines. The weighbridge and truck inlet/outlet plant is powered by sophisticated ICT solution such as the SAP R3/HANA, etc. installed on the data centre servers but accessed through distributed servers in the mini data centre that supports weighbridge and job order processing as well as truck sequencing operations. The bagging lines are also driven by similar distributed servers to ensure redundancy should there be failure of one or two servers in the distribution chain. The implication of the existing model is increased power consumption rates due to the computing hardware and associated heating ventilation and air-conditioning equipment. In many of the plants, electric power crisis often leads to the use of backup server hardware that have reached end of life. These consume more power though the operators are neither conscious of the differences in power consumption nor the higher greenhouse gases generated owing to the server uptime often maintained at 98% or thereabout.

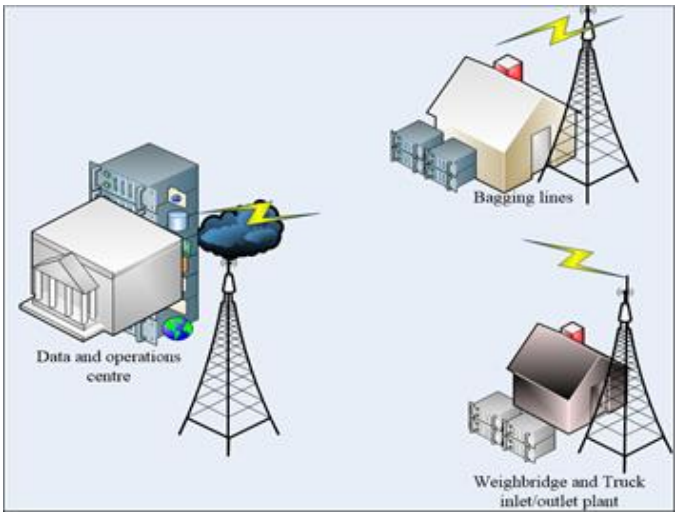

Figure 4: *Model of the Traditional Data Centres in Cement Plant*

3.3 Model of Improved Data Centre Instrumentation and Emission Control System

Figure 5 shows a prescriptive model of an improved data centre with improved features. The prescriptive model incorporates among others: collapsed or condensed server hardware stack into a virtual private cloud with a hybrid storage area network with capacity for large volume data compression, automated and thin provisioning. Other features proposed in the model are: server hardware assessment (HA) prior to deployment, integrated compliance system (ICS) and an emission control system (ECS). With respect to HA, Nigeria's principle cybercrime legislation empowers the Computer Professionals Registration Council of Nigeria (CPN) to assess every acquired computer hardware for compliance in quality, safety and technical suitability for use in Nigeria hence the CPN as an agency of the Government can exercise its statutory powers in determining the nature of equipment that may be used in any cement production plant to support its operations[26-28]. Every assessment would be logged to a centralized integrated compliance system which is accessible to other regulatory agencies such as NESREA. Every data centre would install an emission control system which would be placed online and linked to a remote monitoring-enabled ICS structured in such a way that emissions beyond threshold limits registers a negative entry in the system. The relevant regulatory agencies can monitor and take decisions on erring cement plants.

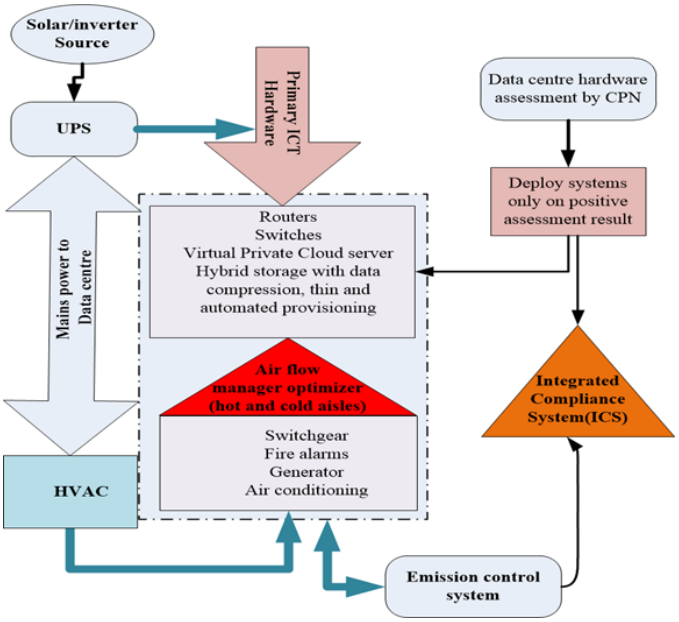

Figure 5: *Prescriptive model of a Data Centre with emission control and Integrated Compliance System*

4. CONCLUSION

In this paper, an attempt is made to bring to bear the implications of data centres in cement plant in Nigeria and the underlying gaps as to the neglect of data centres which pose concerns to health, safety and environmental inspections in cement production and distribution plants in Nigeria. The study took a swipe on the need to deploy environmentally friendly data centres as against the traditional practices whereby little or no attention is paid by the operators of such plants. The environmental regulators and law enforcement agencies are not left out as the survey revealed that regulatory agencies rarely pay periodic visits to cement plants to re-evaluate the stance of those plants as regards their consistent adherence to environmental laws and policies. In conclusion, the paper develops a prescriptive model that defines the procedures that are to be taken by cement company operators and environmental protection agencies in Nigeria towards ensuring that data centres in cement plants operate in tandem with laid down policies and global best practices.

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