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Studies of Energy Use, Green IT Practices and the Role of Entrepreneurship in Higher Engineering Education in Nigeria

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***Abstract*— Africa is a home to diverse sources of natural energy (solar, geothermal, oil and gas, etc.). But it remains an established fact that the continent is still referred to as the Dark Continent due to little or not enough energy generation necessary for economic development and sustained growth. To address the concerns of global rising energy cost there has been global move to implement more efficient Information Technology (IT) resources; this is approached by using IT resources in an effective and economic way. Entrepreneurship and the use of green IT and promotion of awareness thereof through education are employed. Report has it that a reasonable amount of capital can be saved when businesses adopt efficient measures. In order to achieve this, development of a sustainable Green IT plans are required; such as energy conservation, green procurement, recycling, virtualization, governmental regulations, optimization of the IT infrastructures as well as proper awareness strategies are necessary. There is a need for inclusion of entrepreneurship in engineering curriculum and a review of green IT practices across different nations in the continent. This paper focuses on Nigeria and examines approaches to energy use, green IT practices and role of entrepreneurship in promoting innovation and creativity in higher engineering education and research. We investigate the various challenges posed by poor or inefficient IT practices, the role of entrepreneurship in engineering education and practice as well as explore sustainable strategic IT approaches to overcoming Greening Issues, which could have potential impact on economy. A survey of data from diversity of studies show that capitals saved through the various measures could facilitate the implementation of solutions to address some of the existing problems related to green IT issues for improved efficiency and sustainability. Inclusion of entrepreneurship in current engineering education curriculum would prepare the graduate engineers to be employable globally whilst contributing to the nation's economic and sustainable development.**

Keywords—Engineering Studies, Entrepreneurs, Greening Issues, Green IT.

I. INTRODUCTION

Engineering studies and technological research establishes the fact that energy efficiency remains the most cost effective way to reduce energy use. According to *Walter George and Anne Arundel of County Public Schools: "*Anyone who does not have an energy efficiency program is being fiscally irresponsible". To actualize this objective; procurement of green IT infrastructures, recycling of used materials, virtualization, optimization of the IT infrastructures as well as proper organizational policies are necessary. With all these put together; entrepreneurs can achieve high rates of efficiency with minimal risk and a large potential payback. Unfortunately, few entrepreneurs in Nigeria have started these implementation.

Being the fastest growing segment responsible for high energy consumption; Information Technology (IT) industry are looking for strategies to offset rising costs and to use technology in ways that reduce their environmental impact; a term known as Greening Issues. To address this, the need for green IT practices have been attracting attention and interest amongst IT infrastructure manufacturers, suppliers and service providers. Green IT is used here to describe the study and practice of using computing resources in ways that help reduce energy and operating costs, enable sustainable business practices and reduce the environmental impact of IT practices in the larger community [1].

This paper presents the issues emanating from current IT infrastructures and resources usage as related to entrepreneurs in Nigeria, and establishes a dialogue of solutions on how to optimize performance and move forward in a balanced and efficient way that preserves the society through green IT practice. We also present our recommendations as evidenced by reports and a survey of data from diversity of studies for suggested solutions and recommendations for adoption.

II. ENERGY USE AND GREENING ISSUES

High consumption rate of energy by electrical and electronic equipments is one of the major source of greening issues around the world today; due to the rapid uptake of information technology around the world. An average client Personal Computer infrastructure of a 5,000 desktop enterprise, assuming PCs and LCD monitors left in idle state, consumes power at a rate equivalent to the emission of over 4.65 million

lbs of CO_2 per year. Average business desktop consumes 717.44 kWh at 1.297 lbs CO_2 per kWh emitted as a result of electricity generation multiplied by 5,000 PCs. A survey carried out by Forrester research indicated that only 13% of organizations surveyed had an enterprise-wide power management program, while another 18% had begun implementing a program but it was not intended for all PCs [2].

Most IT Infrastructure equipments used by entrepreneurs and firms in Nigeria appear to be 'power-hungry'. The infrastructures found in most data centers include chillers, power supplies, storage devices, switches, pumps, fans, and network equipment. In some cases, these equipments are already at the end of their useful lives, and as such become inefficient. Such data centers typically use 2 or 3 times the amount of power overall as used for the IT equipment, mostly for cooling [3]. Hence, there is a need to explore and investigate the extent to which maintenance engineering could be of use.

Most countries in Africa including Nigeria [4] have neither a well-established e-waste management system for re-cycling of obsolete electrical and electronics product. Available research suggests that the volume of used electronics is large and growing. In a report by GAO [5], some data suggest that over 100 million computers, monitors, and televisions become obsolete each year and that this amount is growing. These obsolete products in most cases are probably stored while they have the potential to be recycled or re-used. These e-wastes contain valuable resources such as copper, gold, and aluminum that are lost if ultimately abandoned or disposed in landfills.

A cumulative effect of these practices does not only result in economic shortfall but also in environmental pollution of the society as a whole.

III ENTREPRENEURSHIP, ENERGY EFFICIENCY AND GREEN IT PRACTICE

To overcome Greening Issues by any entrepreneur, appropriate green initiatives have to be in place, effectual in the design of organizational policies. We explore the concept of energy conservation**,** green procurement, recycling, virtualization and optimization of the IT infrastructures as initiatives towards the practice of Green IT. Touching on the issue of procurement, making environmentally sound purchase decisions by organizations is a major step towards solving greening issues. This is better achieved through the procurement of EPEAT (Electronic Product Environmental Assessment Tool) registered products. EPEAT is a system which helps purchasers in the public and private sectors evaluate, compare and select desktop computers, notebooks and monitors based on their environmental attributes. In Nigeria, EPEAT also provides a clear and consistent set of performance criteria for the design of products, and provides an opportunity for manufacturers to secure market recognition for efforts to reduce the environmental impact of its products [6].

A. Energy Conservation and Virtualization

Implementation of energy management strategies and technologies has the potential to greatly reduce energy consumption. Desktop power management is a critical parameter of any Green IT computing strategy that can be adopted by an organization. The Advanced Configuration and Power Interface (ACPI) specification is an important component of PC power management, which is used to define power management and monitoring.

Use of computers for the control of equipment has been observed to contribute to reduction of costs in terms of managing and running resources in industries. Operating Systems such as Windows 7 leverage ACPI controls as well as additional advanced hardware power management functionality to reduce overall power consumption. A research report released by Mindteck's Advanced Smart Energy Laboratory indicated that the use of Windows 7 operating system can help organizations save on energy costs. The result shows that cost savings of up to $40.44 (84.46% reduction an equivalence of 6,800 in Nigerian currency) per client per year, not including LCD consumption, can be realized by ensuring that desktop PCs or laptops automatically enter sleep states during working hours [7].

Virtualization is the efficient use of computing resources for collaboration that reduces travel time and cost, increases organizational efficiency, and addresses environmental concerns. In a virtualized system two or more logical computer systems runs on one set of hardware. Through the practice of virtualization; organizations lowers power and cooling consumption, by reducing the number of machines and servers it needs.

Cloud computing, Intranet mailing system such as Lotus Notes, E-Learning, teleconferencing and video conferencing virtualization technologies can be explored to minimize the travel costs personnel spend to attend meetings. On the other hand, technologies such as that of the mobile, IP, web and video-based can be adopted as substitutes. The use of web enabled voice and video conferencing using meeting-ware products to provide presentation sharing and discussion capability are additional Green IT strategies for organizations to cut down expenditures.

B. Recycling and IT Infrastructure Optimization

Recycling of waste materials goes a long way in saving the society economic shortfalls. Facts gathered by Tree Hugger reported that: 44,000 trees will be saved if every household in the United States replaced just one roll of virgin fibre paper towels (70 sheets) with 100 percent recycled ones. One ton of scrap from discarded computers contains more gold than can be produced from 17 tons of gold ore. 9 cubic yards of landfill space can be saved by recycling one ton of cardboard [8]. Organizations policies should be devised on how e-wastes should be managed. There are many manufacturers recycling programs that could be adopted such as HP's Planet Partners

recycling service [9]. Although Nigeria being a developing country is considered still backward in putting in place adequate e-waste management schemes, the services of some few available ones can still be explored. A case study is the "Maintenance System Consultants; commissioned by the Lagos State Environmental Protection Agency on Thursday, 21st January, 2010 [10]. The objective was aimed at joining the concerted efforts of the Lagos State Government, private businesses and environmental advocates by establishing in Lagos State a recycling plant for e-wastes. This project opened up a channel for the segregation of e-wastes from the general wastes stream and brought these potentially hazardous wastes into controlled disposal and recycling.

Significant cost savings are realized by ensuring that all PC hardware and software components are optimized. Green IT practice involves a number of strategies to optimize the efficiency of data center operations in order to lower costs and to lessen the impact of computing on the environment. One obvious strategy for data centers operational on obsolete equipments is to invest in new ones that are designed to be energy efficient.

Worthy of consideration is the efficiency of algorithms used for any given computing function operational on computing resources. Although the impact is minimal compared with other approaches, it is still an important consideration. Algorithms can be used to route data-to-data centres where electricity is less expensive. Researchers from MIT, Carnegie Mellon University, and Akamai have tested an energy allocation algorithm that successfully routes traffic to the location with the cheapest energy costs. The researchers project up to a 40 percent savings on energy costs if their proposed algorithm were to be deployed [1].

III. DATA ANALYSIS OF SURVEYS, RESULTS AND DISCUSSION

The present study involved the gathering of data from engineering practitioners, firms and entrepreneurs in the sectors. Survey questionnaires were administered and interviews conducted. Some of the participating organizations included computer and IT Training Institutes and Technology based Businesses. Aptech Computer Education and NIIT Nigeria are the two notable entrepreneurs of IT education in Nigeria indentified for this purpose. The report is as shown in Table 1.

Table 1: Survey Questions Used in to Gather Data from IT Training Institutes

Survey Questions	Aptech Computer Education	NIIT Nigeria
Average total number of computers	400	1200
Total number of centres	14	24
Number of daily hourly use	8	10
Weekly working days	7	7
Total staff capacity	210	480
Staff numbers sent on training to India yearly	6	20
Common type of computers used	Pentium IV	Pentium IV
Computers replaced per annum	20	45

In our study, the following were details utilized to elucidate relevant information in relation to the configuration of the computers used: The cost of one unit (KWh) of electricity, C_ε, cost is ₦11.94 [11]. Intel Pentium IV with the minimum peripheral devices has an energy consumption value, $E_{pc,}$ of 260Watt; 19 inches flat screen monitor has an energy consumption value, E_m, of 36Watt; Power consumption by each set of computer, $P_{pc,}$ is 296Watt on average; Each organization operates 7days per week with a total of 28days in a month; Quantity of Gold in Pentium IV CPU, M_{au}, is 0.05g [12]. 1g of gold bar costs ₦6591.44 [13]; It is assumed that the cost of IT infrastructures used for the Green IT practices is seen as part of capital investment. These figures used in the computation were those available at the time of this research.

The cost of electricity for each firm is calculated using the expression:

$$C_{\varepsilon\,(annual)} = (P_{pc}x1000)x\, C_\varepsilon\, x\, N_{pc}\, x\, T_w\, x\, D_w\, x\, M_y \qquad (4.1)$$

where N_{pc} is the total number of computers in the firm, T_w is Apteh number of hours worked in a day (8.5 hours), D_w is the number of days worked in a week (7 days), M_y is the number of months worked in a year (12 months) and all the other symbols have their usual meaning.

Estimates of the cost for staff training which constitutes continuing professional development, whereby staff were sent to India for a week were calculated for each of the two firms studied, which comprised Aptech Computer Education Institute (A) and NIIT Computer Centre (B). Expenses incurred for stationeries used traditionally for communications such as sending memos and letters were computed and compared to expenses incurred utilizing video conferencing and the use of inter-office communication purpose. The results are shown on Tables 2 (traditional expenses without use of IT) and Table 3 (expenses with green IT practices employed). On Table 4 are the estimated saved cost by each of the firms showing the amount saved as a result of introducing green IT practices in the process and activities of the firms including virtualization.

Table 2: Estimate of Costs of Resources under traditional mode of operation.

Company (firm)	Electricity Cost $C_{\varepsilon\,(annual)}$ (₦)	Staff training cost in India for a week (₦)	Cost of stationeries for communication (₦)
A	4,037,515.78	2,210,952.00	960,000.00
B	14,250,055.68	₦7,369,840.00	2,880,000.00

Table 3: Estimate of Costs of Resources under digital mode of operation incorporating Green IT practice

Firm	With ACPI enabled Electricity Cost $C_{e\ (annual)}$ (₦)	Staff training cost in India for a week through video conferencing and virtualization per annum (₦)	Cost of inter-office communication with Intranet virtualization per annum (₦)
A	3,087,512.06	2,210,952.00	960,000.00
B	11,400,044.554	7,369,840.00	2,880,000.00

Table 4: Amount Saved by Each Firm

Firm	Amount saved through Energy Conservation with ACPI enabled (₦)	Amount saved through virtualisation : video conferencing (₦)	Amount Saved through Virtualization: Intranet mailing system (₦)	Worth of Gold recoverable through Recycled of scrapped Computers (₦)	Total (₦)
A	950,003.71	2,210,952.00	960,000.00	6,591.44	4,127,547.15
B	2,850,011.13	7,369,840.00	2,880,000.00	14,830.74	13,114,681.87

The analysed data above shows clearly that there is huge saving from implementing green IT practice in firms. From the interviews, it was also clear that firms would want to adopt the green IT approach to conduct of business. However there are few obstacles that contribute to them not being able to do. Some of these obstacles include intermittent power supply and in some cases no power at all which makes them resolve to the use of generators. The lack of adequate means of record keeping and available information to help business sector engage in planning and understanding market operations guided by statutory policies constitute a major hurdle to jump over too. As an emerging economy now ranked number one in Africa, it is important to have a solid structure to assist in consolidating most of the systems for marketing and business. Entrepreneurship should be embedded in all levels of higher education to create the awareness of opportunities and allow the students irrespective of their subjects disciplines begin to engage with creativity and innovation before leaving the tertiary level of education.

The findings of our study points to the fact that both firms have earned considerable savings on cost through Green IT practices, which they can reinvest into their respective businesses. Going green and reducing the carbon footprint minimizes high-energy consumption. This has the potential to facilitate increased awareness for all, greater market activities, profit maximization for entrepreneurs, which could benefit everyone globally.

IV. CONCLUSION

We believe the issues raised and covered in this paper is applicable not only in Nigeria but also in some other developing countries in Africa and around the world. It is important that the level of interaction between the public, private and voluntary sectors be well supported and level of accountability be established. Entrepreneurship should be embedded in the curriculum of diverse disciplines in higher education including science, engineering and technology. Executives of firms as well as managements in higher engineering education institutes should seek to enforce these policies and incorporate it into academic curriculum as a form of training for the future generation of leaders of the sectors. We conclude that green skills are increasingly vital for economy and development of society. The insights presented help to shed light on the emerging trends in green computing and the need to have a commonly agreed approach to the development of policies, utilization and implementation of computing resources to make for an efficient and cost effective way. There should be cooperation and joined up approaches developed by the sectors (statutory, business and voluntary) relating to greening issues embedded in engineering education and research, which should link demand and practice with legislation to create conditions for development, progress and sustainability.

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