Green Computing: Techniques and Challenges in Creating Friendly Computing Environments in Developing Economies

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Abstract: **The adoption of ICT's has currently realised advancements in technologies such as faster internet connectivity has changed the way we live, work, learn and play , it is affecting our environment in several ways. Today use of ICT has enabled and created many opportunities for employment round the globe, as the computer literacy becomes a prerequisite condition for sustenance in almost every sector. Besides this, ICT has impacted both positively and negatively on our environment. To grow awareness about environmental impact of computing, green technology is gaining increasing importance. Green ICT as a concept has been popularized to achieve energy efficiency and minimize consumption of energy by e-equipment. Climate change is one of the main environmental concerns being addressed globally; our environment has been changing thus posted more worrying because it is impossible to predict exactly how it will develop and what the consequences will be. Globally and even developed nations have been using various approaches to manage our environment. Green Computing is among the key techniques being implemented. The approaches required to achieve green computing as a technique includes both efficient hardware implementations and improving software methodologies of the various researchers. This paper aims to present green computing techniques and challenges, their impact on environment and creating a friendly computing environments in developing nations. The paper concludes by providing future directions of research.**

Keywords: **Green computing, Techniques, Approaches, Environment friendly, Energy efficient, Energy consumption, developing economies.**

I. INTRODUCTION

Green computing is the study and practice of minimizing the environmental impact of computer system and related resources effectively and eco-friendly (Sidhu, 2016). It is an emerging concept towards reducing the hazardous material and save our environment from the harmful impacts of the computer, CPU, servers and other electronic devices. Green computing first discussed in the year 1990 by the US environment protection energy while launching an approach to energy reduction called the Energy Star Program. Energy star is a program label awarded to computers and other electronic devices. The label is used to minimize the use of the energy and maximize the efficiency of the product/device (Sidhu, 2016). The labeling program was designed to promote and recognize the energy efficiency in monitors, climate control equipment and other technologies. Due to the adoption of the technique, most electronic consumers have implemented their devices to run on sleep mode (Sidhu, 2016).

This concept of green computing can be used in environmental science to offer economically possible solutions for conserving natural resources. Green computing is designing, manufacturing, using and disposing of computers and its resources efficiently with minimal or no impact on environment) (Sidhu, 2016). The goals of Green computing are to manage the power and energy efficiency, choice of eco-friendly hardware and software, and recycling the material to increase. Green computing, also called green technology, is the environmentally sustainable use of computers and related resources like - monitors, printer, storage devices, networking and communication systems - efficiently and effectively with minimal or no impact on the environment. Green computing has come up as a boon for the IT industry whose goals are to reduce the use of hazardous and toxic materials, maximize energy efficiency during the product's lifetime, and promote the recyclability or biodegradability of defunct products and factory waste.

According to (Griffins, 2005), Green Technology is a set of practical measures designed to ensure that Information Technology is developed, delivered and used in a way that is environmentally friendly, sustainable and energy efficient. This methodology was adopted in order to ensure that the usage of energy is done efficiently, to promote recycling of waste products. Most organisations have implemented their environmental concerns through use of the Green IT to reduce power consumption and thus lowering costs (Griffins, 2005).

Green computing efficiency can be emphases on minimalizing hazardous environmental impact in with achieving economic viability and improved system performance (Skłodowska, 2015). The field of green technology covers a board spectrum of subjects – from alternative energy-generation and electricity consumption techniques and use of eco-friendly, recyclable materials to implementing sustainable digital services (Skłodowska, 2015). The Computer manufacturers and vendors contribute directly to pollution, whereas the IT industries have a hidden impact on environmental pollution caused by unconscious consumption of power and inefficient use of hardware devices (Agarwal, Datta & Nath, 2014, pg.

5). The efficiency of electronic devices will depend on the amount of energy used. In this paper Energy efficiency refers to using less energy to produce the same amount of services or useful output (Patterson, 1996).

Energy consumption has been regarded as one of the main causes of climate changes in both developed and developing economies, changes in energy consumption and its structure may greatly affect any climate change strategy achievement goals (Santamouris, 2019).Energy consumption can be influenced by many social and economic factors and drivers. For example in less developed economies, the tremendous increase of the population as well as the expected significant increase of domestic GDP may result in a significant increase in energy consumption thus affecting the climate change (Santamouris, 2019). A reported by ExxonMobil (2018), the world's population is expected to reach 9.2 billion people by 2040, compared to nearly 7.4 billion today. Most of the new population will be in developing economies. The impact of such changes to environment will definitely affect our climate hence the need to introduce Green IT as a technique to reduce the changes (Santamouris, 2019).

The ICT industry is responsible for about 2% to 2.5 % of all world's greenhouse gas emissions. Although it is not a large percentage, very disturbing is fact that the rate of ICT consumption is increasing by 20% a year so if nothing is done the contribution to global greenhouse gas emission is projected to nearly double – to about 4% - in 2020. Hence, there is a necessity to balance the dramatic growth of utilizing computing resources with green technology to reduce environmental impact at the same time maintaining overall development (Skłodowska, 2015). The need for green computing is obvious, if world is determined to pursue the assumptions of sustainability. Modern IT systems are based on a complex mixture of people, networks and hardware. Green computing initiative must be structured in nature and turn in the direction of the increasing number of sophisticated computational problems.

Currently, data volumes are doubling every 18 months, and enterprises want to keep more data online and provide access to more users ((B.Sc, 2010). The impact is huge increases in the amount of hardware infrastructure needed, resulting in corresponding increases in power, cooling and data center space needs. The recycling of old computers raises an important privacy issue. The old storage devices still hold private information, such as emails, passwords and credit card ((B.Sc, 2010). Green Growth is a good development it is about quality of growth, ensuring that it achieves development objectives while striving to manage the developing nation's resources sustainably and minimize waste, pollution, and Build resilience ((B.Sc, 2010). For many developing countries near term, emphasis may need to be placed more on managing local rather than global environmental issues. However, implications of development choices need to be considered when these are likely to be irreversible over the medium to longer-term (Sperling).

The African continent is also one of the most vulnerable regions to climate changes. These global changes interact with local environmental issues, such as land degradation, the depletion of natural resources, air and water pollution (Umamaheswari, 2015). Growing populations and urbanisation rates further underline the urgency of strengthening resilience of livelihoods and sustainably managing essential ecosystem goods and services (Resources). In recent years, companies in the terms of both reducing cost and public relations are going green in the best interest realize to come in computer industries (Umamaheswari, 2015).

Globally environmental challenges caused by IT related products have been a serious issue and must be resolved. Most developed economies have put in place working initiatives to manage environmental challenges that effect our climate, this is not the same for Developing Economies since there still a gap in initiatives towards green computing environment friendly (Umamaheswari, 2015).. Techniques and approaches started towards green computing which have seen the energy consumptions reduce. There are still key challenges that have been experienced in implementing green computing techniques and have been affecting the implementation of these techniques by some firms. To address this matter, this paper aims to present green computing techniques, approaches and challenges, their impact on environment and creating a friendly computing environments in developing economies (Umamaheswari, 2015)..

II. RELATED LITERATURE

Green computing has been explained and discussed to show its main function to relate to our environment, which must be friendly. According to San, (2010) defined green computing as the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems such as monitors, printers, storage devices, and networking and communications systems efficiently and effectively with minimal or no impact on the environment (Curry et al., 2012) lays out four paths along which he believes the environmental effects of computing should be addressed: Green use, green disposal, green design, and green manufacturing. Green computing can also develop solutions that offer benefits by "aligning all IT processes and practices with the core principles of sustainability, which are to reduce, reuse, and recycle; and finding innovative ways to use IT in business processes to deliver sustainability benefits across the enterprise and beyond" Modern IT systems rely upon a complicated mix of people, networks, and hardware; as such, a green computing initiative must cover these areas as well ((B.Sc, 2010).

To clearly put emphasis on green technology, our environment needs immediate recoup from pollution. This can be done through the help of this technology where one can reduce pollution and improve the cleanliness as well. Today developed as well as developing countries are turning to green

technology to secure the environment from negative impacts. As explained earlier the technology gives an indication that messing up of the environment is higher due to human intrusion and the important need to slow down and adopting healthier ways towards life. By adopting green technology wisely, the earth can be protected against environmental pollution (Kumar).

Using green technology will become not only important but also mandatory too in the coming years. With the earths' energy resources depleting fast, we have to rely on alternative sources of energy. Green technology encourages the concept of cleanliness, freshness as well as promotes new dimensions. The sooner we realize the importance of using green technology, the better it will be for our planet and its environment (Kumar).

Data Center is a big contributor to the eco-footprint. It is common for ICT to account for 25% or more of the total electricity consumption. The Green House Gas (GHG) footprint from the manufacture, operation and disposal of ICT equipment is a significant part of the total for non-manufacturers. Just as big are the opportunities to make sizeable reductions in the enterprise's eco-profile by implementing programs which reduce space, energy and waste by launching programs for virtualization, power management and other proven methods (Griffins, 2005)..Among the issues most commonly reported, and those that appear to be fueling the Green IT movement, are the following; Rising energy demand with a more limited supply and increasing utility costs (Griffins, 2005)., Management of hazardous waste and electronic equipment disposal (e-waste),Increasing gasoline costs, which drive up employee commuting costs leading to retention issues, Increasing real estate costs, Rising airline ticket costs and travel complexities • A stronger regulatory climate at the federal, state and local levels (Griffins, 2005).

The need to take action to address this growing list of business and environmentally linked issues is driving a wide range of thinking and problem-solving activities. New initiatives are reported from all segments of the industry, including businesses government, computer manufacturers and service providers. Global enterprises also are being driven by toughening regulations adopted by the European Union (Griffins, 2005). As a result, many IT organizations are looking at Green IT programs to achieve objectives that include improving energy efficiency and power management practices, increasing hardware utilization, reducing life- cycle costs and looking for ways to cut down on computer waste (Griffins, 2005).

Today, technological advancements in mobile phones and computers has led to increased use of Internet, ICT has consistently delivered innovative products and services and thus becomes an integral part of our everyday life (Raza, 2013). Despite the benefits derived from such technologies , Use of ICT related devices such as computers and mobile phones has immensely contributed to environmental problems such as global warming and climate change (Raza, 2013). ICT is participating roughly 3% of global electricity usages and carbon dioxide emission, and if same trends continues, it is predicted to be 6% by 2020. A recent Internet Data Center (IDC) report estimated the worldwide spending on enterprise power and cooling to be more than $30 billion and likely to even surpass spending on new server hardware (Raza, 2013).

Wang and David (2008) expressed that the Green computing or sustainability is not merely the operational energy consumption of computing apparatus. Green computing must take the product life cycle into consideration, from production to operation to reprocess. Previous studies introduced to achieve overall carbon footprint reduction for personal and business computing environments, the devices will be factored under various operational conditions and environments whereby two phases production and operations of the manufactured goods must be considered (Umamaheswari, 2015).

III. GREEN COMPUTING TECHNOLOGIES AND APPROACHES

Use of computer system and IT services has made one's life easier and more comfortable. It also increases the processing speed and power consumption (Rina Mishra, 2015). This large amount of power consumption increases the emission of greenhouse gases and increases the pollution as well. Energy consumption is also increasing due to, leaving the system on even when they are not being used. (Rina Mishra, 2015) Along with this a large amount of energy wasted in IT, because data centers needed lots of power and matching cooling capacity, when it is not available then it causes environmental pollution. Green computing deals with the concept of reducing energy consumption, recycling eliminate hazardous elements but it also deals with reduce in the business travel sharing the resources (cloud computing) and optimization. Green Computing technologies are the approaches or fundamental techniques that can be used to significantly decrease the power consumption and impact on environment (Rina Mishra, 2015).

Hardware and Firmware level techniques are applied at the manufacturing time of a machine (Sonu, 2014). These techniques contain all the optimization methods that are applied at the time of designing at the logic, circuit, architectural and system levels (Choudhary, 2014), Operating System level techniques include methods that take care about programs at operator level. Power management techniques as the core level manages all the levels for power management (Choudhary, 2014). Other related green computing power management techniques are discussed in this paper.

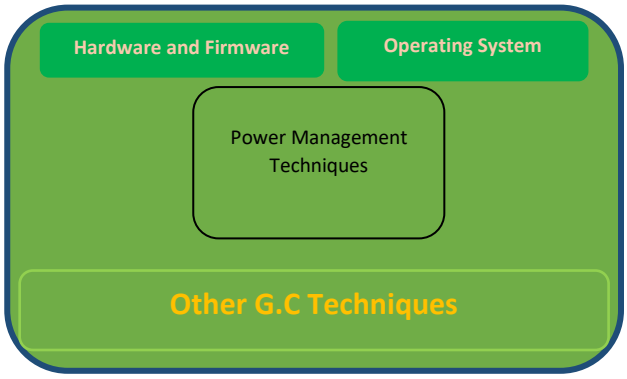

Fig.3.1 Enhanced Power Management Techniques in Green Computing – Source Researcher

A. Virtualization

The term virtualization came into existence only because of the need for saving the excessive use of individual systems. Virtualization refers to a technology for creating cloud computing platform, the strength of cloud computing and the use of hardware and software virtually without knowing the need of resources available originally (Pallavi Mohindru, 2015). The virtualized environment is known as the virtual machine (VM). It lets one to run multiple virtual machines on a single server (physical machine), where each virtual machine shares the resources of single physical server across multiple environments (Pallavi Mohindru, 2015). Different virtual machines can run on different operating systems and various applications on the same physical computer. Thus with this virtualization key technology, effective and ecofriendly utilization of resources are more desirable feature of cloud computing. As many virtual machines can run on a single (Pallavi Mohindru, 2015). The virtualization is one such sort of technology, which is giving provision for the users in accessing the servers from a remote area (Joe, 2015). The helpful factor regarding this is that the individuals can combine many physical systems into a single integrated system and hence the original hardware and system can be unplugged resulting in reducing power and cooling consumption. Instead of setting a server and a cooling system for that, it will be better to access a big system server in a virtualized manner (Green Computing, 2013) (Joe, 2015).The concept of virtualization is best suitable in the Green computing area because it can save power and can also cut costs breaking the link between the applications, application components, system services and storage systems (Joe, 2015).

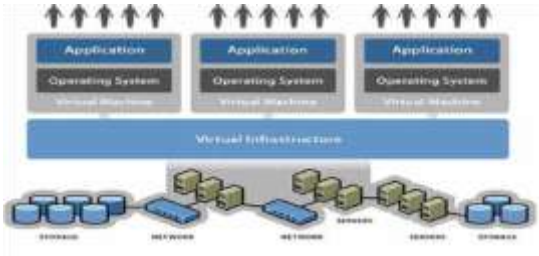

Figure 3.2 Virtualization Processes (Pallavi Mohindru, 2015)

The main challenge with Virtualization as a technique is that it has many security issues and limited security capabilities that must be addressed before cloud technology is affected by them. However there was a proposed new security architecture in a hypervisor-based virtualization technology in order to secure the cloud environment, this architecture has not been tested so there is no evidence to prove this (Sabahi, 2012).

B. Sleep Proxies

In modern operating systems, the use of features using which the individuals can make a system to automatically switch to its sleep mode when the system is left idle (Joe Vijesh, 2015). This is one of the greatest ideas that can be used as a powerful management tool in the industry (Energy benchmarks: a detailed analysis, 2006). There are certain IT departments which will disable these features in the system so that they can easily make patching, maintenance and backup in a much easier manner with no interruption (Joe Vijesh, 2015). It needs to be avoided to achieve green computing. Sleep proxies always resides on the host in the same LAN and will intercept the packets targeted to a sleeping host (Joe Vijesh, 2015).

C. Telecommuting

Telecommunications-related technologies, such as teleconferencing, also are often implemented in green computing initiative (Pazowski, 2015). "Technological advancements in communications devices and with the aid of computer networking systems have made it possible for people to work from remote locations and for telecommuting to become an ever-more feasible option for many companies. Telecommuting increased satisfaction between the two parties, reduction of greenhouse gas emissions related to travel, and increased profit margins because of lesser costs for workplace space, heat, lighting and many more. This technology is currently running in taking green computing initiatives" (Lama, Sharma, Goyal & Singh, 2014, p. 972). Through IT/IS systems telecommuting can also be used for remote administration, group document management and cooperative knowledge management (Pazowski, 2015). It is estimated that one-fifth of all travel is associated with commuting. Thus, the wider use of teleworking would greatly reduce the negative impact on the environment (Pazowski, 2015). Unified Communications leads to an increase in the level of cooperation between employees. Video solutions enable real-time collaboration that are most important environmental initiatives in the business environment (Pazowski, 2015).

D. Green Cloud Computing

The Gartner report from May 2009 defines cloud concept as "a style of computing where scalable and elastic IT capabilities are provided as a service to multiple customers using Internet technologies" (Pazowski, 2015). The 1856 use of the potential of cloud computing model interacts with the concept of sustainable development, understood in three

dimensions: economic, environmental and social (Pazowski, 2015).Clouds merge environment, saving power, cooling, space and money (Pazowski, 2015).Cost savings and flexibility of operations are among the most frequently mentioned benefits associated with a decision to adopt the cloud computing solution. Fixed costs related to the investment in infrastructure (which in the traditional business model increases with time and the need to update the software) are reduced, as well as energy costs feeding the infrastructure (Pazowski, 2015). Traditional costs related with the licenses, a number of users, equipment, operation, repairs and applications are replaced for payment for functionality that is actually used by the company or other organization that also get access to the latest technology. This solution allows adjusting supply to demand, eliminating incurring unnecessary costs associated with the overestimation or underestimation of customer needs. At the same time, it affects the reduction of occurrence of lost sales opportunities risk and cost of incorrect demand forecasting and company's supply planning (Pazowski, 2015).

Some aspects of cloud's ICT infrastructure allow identifying the model as the one providing green benefits. The basic features of the model allow you to specify several environmental benefits that can be achieved by migrating the IT resources to the cloud. These aspects may include:

- Dynamic provisioning and multi tenancy: lower energy consumption and associated carbon emissions than the traditional approach of over-provisioning (Pooja Kallange, pg. 27). Automatic processing of computing environment supports user needs, operating under the cloud may acquire or release the resources (instances) where it is appropriate (according to the demand). Dynamic resource allocation is done automatically, thus datacenters maintain active servers according to current demand. With virtualization technology, which allows connecting disparate resources in one great set of resources it is possible to release them more selectively to all customers at the same time increasing the level of their use. Without virtualization cloud computing would never arise. The entire pool is shared by many customers of a one supplier, in the way of dynamic allocation and releasing precisely defined portion of virtual resources. Level of use of the pool is proportional to changes in demand for computing resources (Pazowski, 2015)..
- Optimal server utilization: traditionally, many servers remain idle of 85-95% of the time using nearly as much power as they do when they are active. Virtualization technology enables hosting of multiple applications through one server. The number of active servers is reduced and the power consumption is lower.
- Energy-efficient client devices: the public cloud model reduces the number of energy consuming clients through small energy-efficient devices (e.g. thin clients)

E. Carbon Aware Green Cloud Architecture

Green cloud architecture is one of the latest developments of green computing idea. The aim of this unified solution is to deliver both users and providers, high-level architecture for supporting energy- efficient service allocation that is based on cloud technology. Cloud providers, being profit oriented are looking for solutions that can lower their electricity bills without losing their market share. The goal of satisfying the demand for high-level computing services on the user's side and saving energy on the provider's side can now be achieved by implementing the green cloud infrastructure (Atrey, Jain & Iyengar, 2013, pg. 96) and carbon footprint.

F. Deployment Optimization: Energy Efficient Algorithm

Design and development as well as its proper use are mainly useful for reducing energy cost as much as possible (Pau, 2012). Many tool, computers, devices need higher energy and power, and for better green computing mechanism we need to use deployment optimization (Pau, 2012).Windows 7 may be a wonderful example for this. Practically windows 7 along with office 2010 package needs near about 70 times more RAM than that of office 2000 or earlier version like windows 98 (Pau, 2012).

G. Resource Allocation

Resource allocation is another important name in green computing. Through the intelligent algorithm energy consumption is possible even in route direction (Pau, 2012). In this case data can reach its appropriate address without consumption of time, the information networks and system can use this for resource allocation (Pau, 2012).

H. Material Cycling: Material Cycling

Emerging concepts of Green Computing and technology (Pau, 2012). Time by time we need material cycling because electronic garbage today is a big challenge to our environment as much harmful material like- lead, mercury, and chromium are released from this garbage (Pau, 2012). The new technology and discovery and development of computing devices increase the awareness about material cycling (Pau, 2012).

I. Product Longevity

Gartner maintains that the Personal Computer manufacturing process accounts for 70% of the natural resources used in the life cycle of a Personal Computer (Thomas, 2015). More recently, Fujitsu released a Life Cycle Assessment (LCA) of a desktop computer that show that manufacturing and end of life accounts for the majority of this desktop's ecological footprint. Therefore, the biggest contribution to green

computing usually is to prolong the equipment's lifetime (Thomas, 2015).

J. Super-Computers

Today a new supercomputer, L-CSC from the GSI Helmholtz Center, Made in Germany emerged as the most energy-efficient (or greenest) supercomputer in the world (Thomas, 2015). The L-CSC cluster was the first and only supercomputer on the list to surpass 5 gigaflops/watt (billions of operations per second per watt). L-CSC is a heterogeneous supercomputer that is powered by Dual Intel Xeon E5-260 and GPU accelerators, namely AMD FirePro™ S9150 GPUs (Thomas, 2015). It marks the first time that a supercomputer using AMD GPUs has held the top spot. Each server has a memory of 256 gigabytes. Connected, the server via an Infiniband FDR network (Thomas, 2015).

K. Carbon-free Computing

One of the VIA Technologies_ ideas is to reduce the "carbon footprint" of users — the amount of greenhouse gases produced, measured in units of carbon dioxide (CO^2) (Umamaheswari, 2015). The main aim of VIA is offering the PC products which certified carbon free by their responsibility for taking the amounts of CO^2 emit (Umamaheswari, 2015).

Lead-Free and RoHS computing In February 2003, the constraint of dangerous substance directive (RoHS) is adopted by the European combination. Manufacturing of a variety of types of electronic and electrical equipment by the legislation restricts the use of six hazardous materials (Umamaheswari, 2015). The directive is closely linked with the Waste Electrical and Electronic Equipment Directive (WEEE). The aspire is to reduce the huge amounts of poisonous electronic-waste by which sets collection, recycling, and recovery targets for electrical goods and is part of a legislative initiative) (Umamaheswari, 2015).Lifetime of device is calculated the electricity for environmental experts in industries works. . Starting this data, one can bring to a close how much carbon dioxide the device will emit into the atmosphere during its process (Umamaheswari, 2015). A server is an indicator of this estimation and company will pay regionally for offsetting of the emissions (Umamaheswari, 2015).

L. Power Management Tools

Power management is proving to be one of the most valuable and clear-cut techniques in near future to decrease energy consumption (Kaur, 2019). IT departments with a focus on saving energy can decrease use with a centralized power management tool (Kaur, 2019). Compiling data from Energy Star case studies for seven deployments of 11,000 - 499,000 machines, it was found that sleep scheduling could save between $10.75 and $95 per computer per year. These deployments used a combination Windows built-in sleep function, group policies, different software systems, such as PC Power-down, EZ GPO, Tivoli systems, BigFix (Kaur, 2019).

M. Leveraging Unused Computer Resource

One of the exiting areas where Green Computing can grow is the share and use efficiently the unused resources on idle computers (Kaur, 2019). Leveraging the unused computing power of modern machines to create an environmentally proficient substitute to traditional desktop computing is cost effective option (Kaur, 2019). This makes it possible to reduce CO2 emissions by up to 15 tons per year per system and reduce electronic waste by up to 80% (Kaur, 2019).

N. The State of Electronic Use and Disposal in Developing Economies

In Developing Economies such as Africa due to rapid increase in technology, electronic products are used for short span and older products are dumped frequently, this is not the case for developed nations since proper measures have been initiated in disposing the products (S.Taruna1, 2014). The replacement of electronic products is much cheaper than repairing. If dumped in unused lands then the toxic chemicals produced by these electronic products either release in the atmosphere or get mix into soil and water (S.Taruna1, 2014). In European countries measures have been taken to prevent such type of electronic waste disposing (S.Taruna1, 2014).By burning chemicals like lead, mercury, cadmium-ashes are mixing in air which is so much harmful that it ill effect food chain. As, while burning PVC plastic present in making computer and in many electronics components produces dioxins and furame which again is hazardous (S.Taruna1, 2014).

Another method followed by developing countries these days is to export their e-waste to developing countries. Recycling which is taking place over this electronic waste is a good thing, but more that the disappointing point is the way the raw materials from these products are processed and handled, which can harm the workers who are handling these products while recycling as well as is harmful to environment (S.Taruna1, 2014).

The difference between the recycling process in developed economies and developing economies is that, in developed economies like Europeans parts, some e-waste like plastics are not reprocessed to evade brominated furans and dioxins being released (S.Taruna1, 2014). In developing economies it is estimated that about 475 metric tons of e-waste was to be exported illegally. In the UK alone, approximately 23,000 metric tons of E-waste was illegally shipped to India, Africa and China. This is a major concern and a violation of international law (S.Taruna1, 2014).

It is cheaper to have the hard labour of pulling apart and melting down pieces done put side the country even if that means the useless scraps and other hazardous materials will litter that area. (S.Taruna1, 2014) In addition, in developing economies unlike developed economies laws are inadequate. People are taking jobs in their scrap yards because it gives them decent wages to live and often children are taking up their jobs, which are very dangerous for their health.

Environment in developed countries is paying more focus on priority over the profit drawing specially in industry and economy, and innovation in own native land than enforcement of laws. It is not better to ship developed countries electronic waste to other countries for disposal –rather than-proper methods should be made to recycle maximum components used in manufacturing and usage of minimum hazardous chemicals and last even if to dispose their e-waste , disposal should be complete 100% ecofriendly way. It will be better to use different chemical composition for new discovery so that single chemical will not reside in atmosphere in abundance, because the abundance presence of a particular element can cause major dangerous effects (S.Taruna1, 2014).

IV. MAJOR CHALLENGES FACING GREEN COMPUTING

Green computing adoption has been experiencing some challenges during its implementation. Previous researches focus was on computing efficiency and cost associated to IT equipment's and infrastructure services that were considered low cost and available (Kaur, 2019). Currently infrastructure is becoming the bottleneck in IT environments and the reason for this shift is due to growing computing needs, energy cost and global warming (Kaur, 2019). The environmental concerns have made many shifts by the industries this immediate shift has generated serious challenges for IT industry. More study is required to counter the up-coming challenges thus currently studies are being done with a focus on cooling system, power and data center space (Kaur, 2019).

When it comes to the choice of what infrastructure or equipment will drive the firm , most firms will require and ensure they have computers with higher processing power that is important to business while some firms will go for higher drive capacity , the firms have to balance between meeting the limitations and managing the challenges in order to realise an f environment friendly system. Green Computing challenges are not only for IT equipment's users, but also for the IT equipment's Vendors. Several major vendors have made considerable progress in this area, For example, Hewlett-Packard recently unveiled what it calls "the greenest computer ever"—the HP rp5700 desktop PC (Kaur, 2019). The HP rp5700 exceeds U.S. Energy Star 4.0 standards, and has an expected life of at least five years, and 90% of its materials are recyclable. Dell is speeding up its programs to reduce hazardous substances in its computers, and its new Dell OptiPlex desktops are 50% more energy-efficient than similar systems manufactured in 2005, credit goes to more energy-efficient processors, new power management features, and other related factors (Kaur, 2019) . IBM is working on technology to develop cheaper and more efficient solar cells plus many other solutions from IBM to support sustainable IT. Green Computing has the following few prominent challenges today (Kaur, 2019).

- Equipment power density / Power and cooling capacities
- Increase in energy requirements for Data Centers and growing energy cost;
- Control on increasing requirements of heat removing equipment, which increases because of increase in total power consumption by IT equipment's;
- Equipment Life cycle management – Cradle to Grave; and
- Disposal of Electronic Wastes

As Green Computing technology records challenges the techniques has several benefits. Green Computing technology can help us to secure and have a safe place for all globally (Masood Anwar, 2013). If everyone tries to save the environment then our surrounding will be the best for survival. Some of the benefits of green computing includes; Reduce the amount of pollution in air, reduce power consumption and decreases the amount of heat which evolved the products, reduces the pressure on paper industry which is a main issue, Renewable resources are encouraged to recycle, Green computing helps to promote the effective utilization of natural resources and lastly It helps as to avoid hazardous products that can destroy environment (Masood Anwar, 2013).

Other benefits of green computing includes ; Reduced energy usage from green computing techniques translates into lower carbon dioxide emissions (Choudhary, 2014), stemming from a reduction in the fossil fuel used in power plants and transportation, Conserving resources means less energy is required to produce, use, and dispose of products ,Saving energy and resources saves money, Green computing even includes changing government policy to encourage recycling and lowering energy use by individuals and businesses ,Reduce the risk existing in the laptops such as chemical known to cause cancer, nerve damage and immune reactions in humans (Choudhary, 2014).

V. RECOMMENDATIONS

The use of modern approaches and techniques such as green computing has a vital effect on daily operations of a given firm. The paper therefore gives the following as key recommendations. Developing Economies should encourage all firms to implement and draft laws to adopt green IT approaches to realise an environment friendly. Organisations should purchase and only use green IT hardware's. Firms to ensure that it is cost-effective to recycle large amounts of computer equipment and this will impact positively on the environment. Climate changes which are being exhibited globally because of poor disposal of electronic related products which affect our environment negatively. Countries should enact laws to ensure that organisations contact the manufacturers and make agreements key areas of the equipment with regards to recycling and training of staff. There exist companies that specialize in corporate computer disposal services both offer disposal and recycling services in compliance with both international and local laws and

regulations. Such companies frequently also offer secure data elimination services.

VI. CONCLUSIONS

We can therefore conclude that, green computing is the key to better environmental friendly society. Most Developing Economies have adopted green computing approaches from other developed nations. Developing Economies will still experience serious challenges in realizing environmental friendly due to the slow pace at which the laws and regulations are being implemented. The important key to remember is that while all of these technologies are beneficial in some way, the most beneficial to existing corporations are those that directly affect their processes and IT infrastructures. It is important to note that reducing the number of servers using virtualization as a technology is a great way to consolidate but in order to get the maximum benefit the corporation must reorganize its datacenter infrastructure and in addition, rethink processes and procedures that utilize these resources from the user's standpoint.

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Lastly, allow me to acknowledge the various sources that I have cited as key sources in this paper. For I accept a lot has been done but still we need to fix the gaps as highlighted in this paper.

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