Volume 5, Issue 10, October-2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Green Solutions: A Pilot Study on Green Technology and Green Computing

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Abstract- Green Technology(GT) and Green Computing now-a-days are most two important issues in the present IT scenario. Green Computing primarily concerned about efficient use of computer power management, minimum discharge of carbon dioxide and to recycle e-waste to make the environment sustainable. Green Technology is one step above Green Computing where the people much more concerned about how to minimize any kind of technology related hazards and to make this globe safe for the use of coming generations. In the present study the authors concentrate on the need for Green Technology and to make this globe sustainable for the coming years. Due to the alarming degradation of the overall environmental situations over the whole world, it is very much needed that the researchers should propose some environmental technical solutions in more or less all fields of technology. Such technical solution are proposed to substitute the traditional high-cost , pollution prone strategies. These are basically known as Green Solutions(GS). Not only it is bounded in only IT and Electronics ,it is even in turn responsible for sustainable development of socio-economic condition in developing countries. This paper analyses these Green Solutions along with their specific area of application. This study also includes what are the relative advantages and pitfalls. Finally the authors also explore the current trend in Green Computing and how it is successfully adopted is thoroughly discussed in subsequent sections.

Keywords— Holoprojector, Holodisc, Blackale, E-waste, VIA Technology ,Energy Star

I. INTRODUCTION

The term "Green" is strongly coupled with environment. So when we talk about "Green Computing",then it is quite obvious that we are finding some solutions ,rather than strategies to build software products efficiently with minimum impact on environment .Developing a software product is not only bound to writing it`s core code, but also it includes several phases starting from planning to maintenance. If we want to build energy efficient green software, we have to make the whole process "Green".

Global warming is a serious issue today ,probably the most worrying threat to our planet at the present time is global warming. Green computing and the use of energy efficient green technologies can reduce this scaring impact of global warming. All we know the continuous use of non-recyclable energy resources can lead us to the dead end of the civilization.

The predominant factors resulting in the warming of the earth are the emissions of CO_2 and deforestation. CO_2, which damages the ozone layer, comes from several sources, but the most problematic are those coming from the burning of fossil fuels from power plants. This releases thousands tons of CO_2 into the atmosphere every year. Another cause of these emissions is the burning of gasoline for transportation, which continues to increase because of our demand for cars and also our increasing worldwide consumption, resulting in an increasing need to transport goods. Also, forests store large amounts of carbon, so deforestation is causing larger amounts of CO_2 to remain in the atmosphere. Nevertheless, there are potential ways to solve these problems, or at least reduce the effects. Firstly, governments need to reduce our dependence on fossil fuels and promote alternatives. Plant-derived plastics, bio-diesel, wind power and solar power are all things that are a step in the right direction. But these things merely represent solutions in a fuzzy manner. So brief discussion is strongly needed in order to enforce the application of these strategies in modern real life scenario. More precisely, we need to mention the specific areas with corresponding remedies. However, in this paper the authors concentrate on only one such field- The modern IT and Electronics Industry and here an attempt is made to analyze different green strategies that is applicable in this particular area.

In order to make this green movement a big success, governments need to take some initiatives such as use of electronic documents in governments sectors rather using paper documents, because all we know paper production industry is totally based on forest removal program, this could be dangerous for environment. Moreover the maintenance of paper documents is a highly tedious job and security issue is also a matter. All these problems can be solved by the use of e-documents(such as Electronic Forms, PDF documents ,Electronic Mails).This is very useful both in terms of cost and effort. Government can launch the environment awareness program in school ,colleges to ensure the efficient use of energy resources.

Not only any governing body ,but also individuals can play a part by making lifestyle changes. People should try to buy cars with the best fuel economy, and only use their car when really necessary. They can also switch to energy companies

that use renewable energy rather than fossil fuels. Finally, small things like buying energy efficient light bulbs, turning off electricity in the house, and planting trees in the garden can help.

To conclude, although global warming is a serious issue, there are steps that governments and individuals can take to reduce its effects. If we are to save our planet, it is important that this is treated as a priority for all concerned.

The following few sections will describe the probable remedies to make green and energy efficient software in addition with some statistical information.

- What is Green Technology?
- Some green strategies along with their specific application field.
- Few words about the Electronic waste management.

A. Green Technology

What is green computing? Green computing is a practice of using computer resources efficiently. It also ensures designing , manufacturing and disposing computer, servers with no impact on the environment. Some other issues are related with such rudimentary terms. When a green software ensures minimum or no destructive impact on environment ,in turn it solves some other problems such as it tries to eradicate the use of non recyclable energy sources like coal ,petroleum oil and gas etc. It also reduces the effect of toxic materials, maximizes the energy efficiency by the efficient and optimal use of resources.

If we start to think from very basics, we will realize that practice of green computing in hand is not very tough at all. Roughly, we often make the computer turn on when it is not in use, this may cause a huge energy loss. Since this energy means electrical energy, so such practices lead us to the wasteful use of non recyclable energy resources. Apart from this printing is often wasteful. Use of digital documents instead of using paper documents can be a remedy. To make the computers and other peripheral devices in factory we can reduce the use of plastic and poly carbonated materials. We should start use of flame retardant silicon compounds in circuit board designing which are flame retardant and completely non-toxic. There are some other promising green solutions which are described in next few paragraphs.

B. Some promising Green Solutions

1) Use of Ultra-Low Voltage VLSI circuits: The need for green computing and nearly-minimum energy operation is continuously pushing VLSI circuits and systems toward lower voltages. From this perspective, sub-threshold and near-threshold operation have become very attractive under low to moderately high performance targets.But this concept is associated with some other questions too, such as ultra-low voltage operation poses many challenges related to (*i*) Reliable operation despite of variations and transient errors, (*ii*) Reduction of the energy/performance penalty due to uncertainty and design margining (*iii*) Energy scalability and adaptation to a wide range of operating conditions, (*iv*) Efficient modeling and design exploration, (*v*) Reduction of cost associated with design.

2) Use of proper software development model: Choice of proper software development model is strongly associated with green computing. In many IT industries ,no specific model is used actually to develop a software. Though they develop quite good software ,but some questions arise due to the choice of improper software development model and it`s impact on the environment. All we know there are some very primitive type of software development models are available like Iterative Waterfall Model, Spiral Model, Evolutionary Model ,Prototype Model etc. But we just can not use any of these for any project in a random manner. All these models are not well suited for all software development both in terms of technical aspects and environmental issues. Suppose id we choose Evolutionary Model or Prototype Model in order to develop a very small and simple software with no as such complex GUI and specific customer need, then it could cause havoc. In that case Iterative waterfall Model is the right choice. The fact is that during software development too much interactions and change of designing do not guarantee Eco-friendly software development. We can take another example also, in some projects where the client`s need is mono-changing or the developer`s idea is not clear, Spiral Model or Prototype Model is good solution instead of choosing Waterfall Model.

3) Elimination of Recursion: In terms of green computing, recursion is not a good practice in programming. All we know that when we use recursion in our programs ,then the compiler need to maintain internal stacks to execute programs. Sometimes this technique takes a lot of space and time causing degradation of performance as well as extra energy consumption .Some compiler converts recursion into iteration. This technique may save time and energy in some cases .

4) Resource Hibernation and Sleep Mode: Hibernation is the process of using low power mode.An idle resource can be kept in hibernate state but switching to and from this state can be wastage of precious resources and time.This mode saves energy and protects your work by copying system data to a reserved area on your hard drive and then completely turning off your computer.

Another important term is “Sleep Mode”.It is also known as Standby Mode.Sleep or Standby mode conserves energy by cutting off power to your display, hard drives and peripherals. After a pre-set period of inactivity, computer switches to a low power state.

5) Dynamic Power Management: Power consumption in Complementary Metal-Oxide Semiconductors (CMOS) is categorized into static and dynamic. Power consumption is dynamic when circuit is in operating state and no power leakage occurs. Whereas power consumption is static, when circuit will not be in running form but it is still powered. Dynamic power management system sets the power of its hardware in true time without degradation in performance to decrease probable power waste. Dynamic Voltage and Frequency Scaling (DVFS), Dynamic Process and Temperature (DPT) compensation and idle time prediction are some power aware software that can drive hardware power saving

mechanisms.Use of those software in some specific fields like Green Compiler design and Real time system development can optimize the energy consumption in very brilliant manner.

6) Use of energy aware data structure: Data structures have significant effect in execution of a program and energy conservation as efficient data structure is more energy conservative. Research shows that merge sort consumes less energy with array data structure whereas it consumes more energy in the case of link list data structure. Furthermore, compilation of various data structures APIs such as linked list, arrays etc. with some energy conservative compiler make these data structure energy aware and use of them in program may leads energy conservation.

7) Distributed Green Compiler: Distributed Green Compiler formulates an energy conservative executable by applying several green techniques to reshape source code during intermediate code conversion. A classic green compiler requires more time to compile the source code for energy conservative executable. It applies green strategies in compilation hence leads to degradation of performance.Distributed Green Compiler decreases compilation time by distributing source code over a network of physical or virtual machines. However, software developer also has the option to compile program on a single machines. Compiler cannot reshape all source code in energy conservative executable, for example recursion elimination, use of register operands. Distributed Green Compiler provides green suggestions for software developers by highlighting the areas of source code, which cannot be reshaped by compiler for energy optimization during intermediate code conversion. Distributed Green Compiler gives energy consumption statistics of program after compilation that tells programmer how much energy can be conserved in a produced executable.

8) Blackale: Blackle is a website powered by Google Custom Search and created by Heap Media, which aims to save energy by displaying a black background and using grayish-white font color for search results. Blackle saves energy because the screen is predominantly black. Setting Blackale as our browser homepage will somehow be able to reduce energy consumption.

9) Concept of Energy Star: One of the first manifestations of the green computing movement was the launch of energy star program back in 1992 by the Environmental Protection Agency and the Department of Energy..Energy Star served as a kind of voluntary label awarded to computing products that succeeded in minimizing use of energy while maximizing efficiency. Energy Star applied to products like computer monitors, television sets and temperature control devices like refrigerators, air conditioners, and similar items. Device carrying the Energy Star service mark, such as computer products and peripherals ,kitchen appliances ,building or other products generally use 20-30% less energy than required by federal standards, In the United States the Energy Star label is also known as the Energy Guide appliance label for qualifying products.

Energy Star specifications differ with each item, and are set by either the Environmental Protection Agency or the Department of Energy. The following highlights product and specification information available on the Energy Star website.

The concept of Energy Star rating for Computers .Servers, Appliances and Home Electronics is discussed briefly in next few paragraphs.

Energy Star 4.0 specifications for computers became effective on July 20, 2007. The requirements are more stringent than the previous specification and existing equipment designs can no longer use the service mark unless re-qualified. They require the use of 80 Plus Bronze level or higher power supplies. Energy Star 5.0 became effective on July 1, 2009.

The EPA released Version 1.0 of the Computer Server specifications on May 15, 2009. It covers standalone servers with one to four processor sockets. A second tier to the specification adding active state power and performance reporting for all qualified servers, as well as blade and multi-node server idle state requirements is expected in 2013.

As of early 2008, average refrigerators need 20% savings over the minimum standard. Dishwashers need at least 41% savings. Most appliances as well as heating and cooling systems have a yellow Energy Guide label showing the annual cost of operation compared to other models. This label is created through the Federal Trade Commission and often shows if an appliance is Energy Star .While an Energy Star label indicates that the appliance is more energy efficient than the minimum guidelines, purchasing an Energy Star labeled product does not always mean one is getting the most energy efficient option available. For example, dehumidifiers that are rated under 25 US pints (12 L) per day of water extraction receive an Energy Star rating if they have an energy factor of 1.2 (higher is better), while those rated 25 US pints (12 L) to 35 US pints (17 L) per day receive an Energy Star rating for an energy factor of 1.4 or higher. Thus a higher-capacity but non-Energy Star rated dehumidifier may be a more energy efficient alternative than an Energy Star rated but lower-capacity model.The Energy Star program's savings calculator has also been criticized for unrealistic assumptions in its model that tend to magnify savings benefits to the average consumer.

Energy Star qualified televisions use 30% less energy than average. In November 2008, television specifications were improved to limit on-mode power use, in addition to standby power which is limited by the current specifications. A wider range of Energy Star qualified televisions will be available. Other qualified home electronics include cordless phones, battery chargers, VCR s and external power adapters, most of which use 90% less energy.

10) Cloud storage: Cloud storage plays an vital role in green computing. Cloud computing is very important energy-efficient method we have to address the ever accelerating demand for computation and data storage .Although the architecture of cloud computing is an order of magnitude more efficient than traditional on-premises server solutions ,the promise of truly green cloud computing lies with locating cloud data centers near clean ,renewable sources of energy. Policy decisions that encourage the consumption of green energy sources will balance cloud computing providers` need for affordable energy with the need to reduce the overall environmental impact of cloud computing and will ensure that cloud computing is none other than green computing.

11) Virtual displays and Holograms: The modern era of visual technology is also trying to devise some green

approaches ,those are going to become emerging technologies in near future. Examples of such technologies include 3D Holograms and Screen less virtual displays It deals with the display of several things without the use of screens using projector. It involves the following 3 different working principles. The Visual image, Virtual retinal display, Synaptic interface. Holograms were used mostly in telecommunications as an alternative to screens. Holograms could be transmitted directly, or they could be stored in various storage devices (such as holodisc) the storage device can be hooked up with a holoprojector in order for the stored image to be accessed.Apart from this,virtual reality goggles (which consist of two small screens but are nonetheless sufficiently different from traditional computer screens to be considered screen less) and heads-up display in jet fighters (which display images on the clear cockpit window) also are included in Visual Image category. In all of these cases, light is reflected off some intermediate object (hologram, LCD panel, or cockpit window) before it reaches the retina. In the case of LCD panels the light is refracted from the back of the panel, but is nonetheless a reflected source. The new software and hardware will enable the user to, in effect; make design adjustments in the system to fit his or her particular needs, capabilities, and preferences. They will enable the system to do such things as adjusting to user`s behavior in dealing with interactive movable type. The main use of the screen less displays are used for the development of the mobile phones which are mainly used by the old and blind people. This type of the invention of the screen less displays was first done on the mobile phone named OWASYS 2CC. This model is very useful for the old, blind, and even for the people with less vision power. Screen less display's major working principle can also be implemented in the emerging of the new screen less TV's. Imagine that watching the TV picture that seems to be magically appearing in the thin air. The picture just floats on in front of the viewer; this would be a latest emerging technology in the future.

The rationale behind this concept is that it also is a green technical solution ,since the concept of physical display monitors and screens are omitted, so it is quite obvious fact that it will also eliminates the need of a huge amount of power consuming electrical and electronics devices, chips, those are used to design monitors and screens.

C. Electronic waste or E-waste

In this decade ,the most important environmental issue is to save our earth. Though there are so many different causes which are hampering the stability of nature, one of them is Electronic waste. Now the obvious question is that what is Electronic waste? Electronic waste or e-waste describes discarded electrical or electronic devices. Used electronics which are destined for reuse, resale, salvage, recycling or disposal are also considered as e-waste. Informal processing of electronic waste in developing countries may cause serious health and pollution problems.

Electronic scrap components, such as CRTs, may contain contaminants such as lead, cadmium, beryllium, or flame retardants. Even in developed countries recycling and disposal of e-waste may involve significant risk to workers and communities and great care must be taken to avoid unsafe exposure in recycling operations and leaking of materials such as heavy metals from landfills and incinerator ashes.

Display units (CRT, LCD, LED monitors), processors (CPU, GPU, or APU chips), memory (DRAM or SRAM), and audio components have different useful lives. Processors are most frequently out-dated (by software no longer being optimized) and are more likely to become "e-waste", while display units are most often replaced while working without repair attempts, due to changes in wealthy nation appetites for new display technology. This problem could potentially be solved with Modular Smartphones.These types of phones are more durable and have the technology to change certain parts of the phone making them more environmentally friendly. Being able to simply replace the part of the phone that is broken will reduce e-waste.An estimated 50 million tons of E-waste are produced each year. The USA discards 30 million computers each year and 100 million phones are disposed of in Europe each year. The Environmental Protection Agency estimates that only 15-20% of e-waste is recycled, the rest of these electronics go directly into landfills and incinerators. According to a report by UNEP titled, "Recycling - from E-Waste to Resources," the amount of e-waste being produced including mobile phones and computers could rise by as much as 500 percent over the next decade in some countries, such as India. The United States is the world leader in producing electronic waste, tossing away about 3 million tons each year. China already produces about 2.3 million tons (2010 estimate) domestically, second only to the United States. And, despite having banned e-waste imports, China remains a major e-waste dumping ground for developed countries.

Now in order to control the damages caused by E-waste some green strategies are used to recycle E-wastes. Such strategies are often known as E-waste management. The following few lines will describe this in a brief manner.

1) Recycling: One of the major challenges is recycling the printed circuit boards from the electronic wastes. The circuit boards contain such precious metals as gold, silver, platinum etc. and such base metals as copper, iron, aluminum etc. One way e-waste is processed is by melting circuit boards,burning cable sheathing to recover copper wire and open pit acid leaching for separating metals of value .Conventional method employed is mechanical shredding and separation but the recycling efficiency is low. Alternative methods such as cryogenic decomposition have been studied for printed circuit board recycling and some other methods are still under investigation.

2) Consumer awareness: The U.S. Environmental Protection Agency encourages electronic recyclers to become certified by demonstrating to an accredited, independent third party auditor that they meet specific standards to safely recycle and manage electronics. This works to ensure the highest environmental standards are being maintained.

3) Processing techniques: In many developed countries, electronic waste processing usually first involves dismantling the equipment electronics,recycling can be postponed and value gained from device use.This approach sometimes could be useful.

II. LITERATURE SURVEY

A. Why Green Computing?

In a world where business is transacted 24/7 across every possible channel available, companies need to collect, store, track and analyze enormous volumes of data—everything from click data and event logs to mobile call records and more. But this all comes with a cost to both businesses and the environment. Data warehouses and the sprawling data centers that house them use up a huge amount of power, both to run legions of servers and to cool them.

Here we present some notable areas of research in green computing:

1) New Optimization Techniques in Performance-Energy-Temperature aware Computing: The exponential growth in computing activity and the rising concern for energy conservation have made energy efficiency in computers a technological issue of prime importance. The trade off between Performance-Energy-Temperature has to be made for so that the maximum benefits can be obtained. Designing techniques that are optimal with respect to performance, energy, and temperature are utmost requirement as far as green computing research challenges are concerned.

2) Information Resource Tier Optimization: The information resource tier represents important data base management systems in the global computation world. General paradigms include databases, directories, file-systems, and flat files. It also includes the integration of different database structures so that different databases can be analyzed irrespective of their storing mechanisms and data
structure.

3) Reduce architectural complexity: The research area is open to reduce the number of tiers and component dependency to reduce maximum system use. Intel‘s core 2 duo is a mechanism which uses power to run only those components which are necessary at any computation.

4) New high-efficiency data center design: Bigger data centers can be made much more energy efficient than smaller data centers. Standards are emerging for measuring this, such as the concept of Power Usage Effectiveness (PUE). PUE is defined as the ratio of total facility power divided by IT equipment power. Thus, it is a measure of how much of the power being consumed by the facility is actually being used to power the IT equipment itself rather than all the other things. Therefore it will quiet be a challenge to make the bigger data center power efficient.

5) Developing Green Maturity Model: Full equipment life cycle is the main area for green maturity model, with energy reduction as the best measure of ―greenness. The need of maturity models for equipment, IT organizations, computing techniques is an issue which has been addressed by some researchers but is limited to specific areas. Green maturity model for virtualization depicts that each level describes the degree of green characteristics.

6) Wireless Sensor Network for Data Center Cooling: Data center cooling is a major issue as far as power consumption is concerned. Data centers are backbone of any computing organization and must be reliable and available at every point of time. Measuring the data center effectiveness and maintaining the baseline is an issue. Wireless sensors could play a big role for managing data centers power management.

7) Green Software: Recently, green software movement has become a research subject for most of the software developers companies because of need for sustainable development. Most of the research has been done on the characterization, metrics and technical answer for green software, but few have addressed green software from the business perspective. Business organizations are moving towards green software‘s and still some considerable steps need to be taken.

The following table represents how the VIA technology is used in different practical fields to ensure green computing and their relative success rates.

TABLE I APPLICATION AREAS OF VIA TECHNOLOGY AND RELATIVE SUCCESS RATES

Technology Used	How the technology work?	Success Rate
VIA Technology	Green computing VIA Technologies, a Taiwanese company that manufactures motherboard chipsets, CPUs, and other computer hardware, introduced its initiative for "green computing" in 2001. With this green vision, the company has been focusing on power efficiency throughout the design and manufacturing process of its products. Its environmentally friendly products are manufactured using a range of clean computing strategies, and the company is striving to educate markets on the benefits of green computing for the sake of the environment, as well as productivity and overall user experience.	70%
VIA Technology	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 (CO2). Greenhouse gases naturally blanket the Earth and are responsible for its more or less stable temperature. An increase in the concentration of the main greenhouse gases — carbon dioxide, methane, nitrous oxide, and fluorocarbons — is believed to be responsible for Earth's increasing temperature, which could lead to severe floods and droughts, rising sea levels, and other environmental effects, affecting both life and the world's economy.	77%

VIA Technology	Quiet computing A central goal of VIA's green-computing initiative is the development of energy-efficient platforms for low-power, small-formfactor (SFF) computing devices.	63%

III. RESULTS

1. After the 1997 Kyoto Protocol for the United Nations Framework Convention on Climate Change, the world has finally taken the first step in reducing emissions. The emissions are mainly a result of fossil-fuel-burning power plants.(In the United States, such electricity generation is responsible for 38 percent of the country's carbon dioxide emissions.)
2. VIA aims to offer the world's first PC products certified carbon free, taking responsibility for the amounts of CO2 they emit. The company works with environmental experts to calculate the electricity used by the device over its lifetime, generally three years. From this data, one can conclude how much carbon dioxide the device will emit into the atmosphere during its operation. This estimate will serve as an indicator, and the company will pay regional organizations for the ―sequestering, or offsetting, of the emissions. Offsetting carbon dioxide can be achieved in different ways. One way is to plant trees that absorb CO2 as they grow, in the region in which the processors were purchased. The necessary amount of trees per processor is represented by VIA's TreeMark rating system. VIA promotes the use of such alternative energy sources as solar power, so power plants wouldn't need to burn as much fossil fuels, reducing the amount of energy used.

Steps to Green Computing

1. Develop a sustainable green computing plan. Discuss with the business leaders the elements that should be factored into such a plan, including organizational policies and checklists. Such a plan should include recycling policies, recommendations for disposal of used equipment, government guidelines and recommendations for purchasing green computer equipment. Green computing best practices and policies should cover power usage, reduction of paper Consumption, as well as recommendations for new equipment and recycling old machines. Organizational policies should include communication and implementation.
2. Discard used or unwanted electronic equipment in a convenient and environmentally responsible manner. Computers have toxin metals and pollutants that can emit harmful emissions into the environment. Never discard computers in a landfill. Recycle them instead through manufacturer programs such as HP's Planet Partners recycling service or recycling facilities in your community. Or donate still-working computers to a non-profit agency.
3. Make environmentally sound purchase decisions. Purchase Electronic Product Environmental Assessment Tool registered products.
4. If we think computers are nonpolluting and consume very little energy we need to think again. It is estimated that out of $250 billion per year spent on powering computers worldwide only about 15% of that power is spent.
5. Computing- the rest is wasted idling. Thus, energy saved on computer hardware and computing will equate tons of carbon emissions saved per year.
6. The plan towards green IT should include new electronic products and services with optimum efficiency and all possible options towards energy savings.
7. Power supplies are notoriously bad, generally as little as 7% efficient. And since everything in a computer runs off the power supply, nothing can be efficient without a good power supply. Recent inventions of power supply are helping fix this by running at 80% efficiency or better.
8. Mobile phones are better than computers – green computing. They have faster processors, more ram, faster.
9. Wireless Internet connectivity and larger memories. Mobile Phones consume very low power.
10. Purchase LCD's monitors which consume less energy than CRT's screen and LCD's is also not harmful for the eyes.

IV. CONCLUSION AND FUTURE SCOPE

Green computing represents a responsible way to address the issue of global warming. By adopting green computing practices, business leaders can contribute positively to environmental stewardship—and protect the environment while also reducing energy and paper costs. Global warming and the problem of minimizing environmental impact from fossil-fuel emissions have raised to the top of global public policy agenda. As a result, businesses and consumers alike have started to embrace environmentally sustainable products that offer low carbon solutions that can not only reduce their global greenhouse gas (GHG) emissions, but can do so by more efficient energy consumption and lower costs.

ACKNOWLEDGMENT

The authors are very much grateful to Department of Computer Science for giving opportunity to work in the field of Green Computing and Green Technology. Two authors SA and AN also grateful to Fr. Dr. J. Felix Raj for encouraging to do research work in the area of Green Computing and Green Technology.

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