A

Seminar report

On

Green Computing

Submitted in partial fulfillment of the requirement for the award of degree
of Bachelor of Technology in Computer Science

SUBMITTED TO:
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Acknowledgement

I would like to thank respected Mr…….. and Mr. ……..for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

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Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

Preface

I have made this report file on the topic **Green Computing**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to ……..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

Introduction

Green computing is the study and practice of using computing resources efficiently. The primary objective of such a program is to account for the "triple bottom line**" (**People, Planet, Profit**),** an expanded spectrum of values and criteria for measuring organizational (and societal) success. The goals are similar to green chemistry; which is trying to reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, and promote recyclability or biodegradability of products and factory waste. Modern IT systems rely upon a complicated mix of people, networks and hardware; as such, a green computing initiative must be systemic in nature, and address increasingly sophisticated problems. Elements of such as solution may comprise items such as end user satisfaction, management restructuring, regulatory compliance, disposal of waste, telecommuting, virtualization of server resources, energy use, thin client solutions, and return on investment (ROI).

Virtualization and Server Based Computing reduces emissions, by utilizing fewer servers, power and cooling and providing a low-power/low-cost thin client on the users desktop. All while centralizing and streamlining administration and providing high availability. Computers overall now account for about 2% of worldwide energy usage. By the end of 2008, according to Gartner, Inc. analysts, half of the world's datacenters won't have enough energy capacity to meet the power and cooling requirements of the latest high-density computing equipment, such as blade servers. In addition, Gartner estimates that energy bills, which traditionally have accounted for less than 10% of an overall IT budget, soon could account for more than half. In the U.S., for example, consumption of electricity by IT has doubled since 2000 and now comprises 3% of total electricity consumed nationally. Electrical power for datacenter servers is only part of the problem. Non-IT devices also consume datacenter power, including transformers, uninterruptible power supplies, power wiring, fans, air conditioners, pumps, humidifiers, and lighting

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1.0 CHAPTER I

1.1 History of Green Computing

In 1992, the U.S. Environmental Protection Agency launched Energy Star, a voluntary labeling program which is designed to promote and recognize energy-efficiency in monitors, climate control equipment, and other technologies. This resulted in the widespread adoption of sleep mode among consumer electronics. The term "green computing" was probably coined shortly after the Energy Star program began; there are several USENET posts dating back to 1992 which use the term in this manner. Concurrently, the Swedish organization TCO Development launched the TCO Certification program to promote low magnetic and electrical emissions from CRT-based computer displays; this program was later expanded to include criteria on energy consumption, ergonomics, and the use of hazardous materials in construction.

When it comes to PC disposal, it is necessary to know everything there is to know in order to be involved in green computing. Basically, the whole green aspect came about quite a few years back when the news that the environment was not a renewable resource really hit home and people started realizing that they had to do their part to protect the environment.

Basically, the efficient use of computers and computing is what green computing is all about. The triple bottom line is what is important when it comes to anything green and the same goes for green computing. This considers social responsibility, economic viability and the impact on the environment. Many businesses simply focus on a bottom line, rather than a green triple bottom line, of economic viability when it comes to computers. The idea is to make the whole process surrounding computers friendlier to the environment, economy, and society. This means manufacturers create computers in a way that reflects the triple bottom line positively. Once computers are sold businesses or people use them in a green way by reducing power usage and disposing of them properly or recycling them. The idea is to make computers from beginning to end a green product.

1.2 Regulations and Industry Initiative

1.2.1 From the Government

Many governmental agencies have continued to implement standards and regulations that encourage green computing. The Energy Star program was revised in October 2006 to include stricter efficiency requirements for computer equipment The European Union's directives 2002/95/EC (RoHS), on the reduction of hazardous substances, and 2002/96/EC (WEEE) on waste electrical and electronic equipment required the substitution of heavy metals and flame retardants like PBBs and PBDEs in all electronic equipment put on the market starting on July 1, 2006. The directives placed responsibility on manufacturers for the gathering and recycling of old equipment (the Producer Responsibility model).

5.2.2 From the Industry

- **Climate Savers Computing Initiative :** CSCI is an effort to reduce the electric power consumption of PCs in active and inactive states. The CSCI provides a catalog of green products from its member organizations, and information for reducing PC power consumption. It was started on 2007-06-12.
- **Green Computing Impact Organization, Inc. :** GCIO is a non-profit organization dedicated to assisting the end-users of computing products in being environmentally responsible. This mission is accomplished through educational events, cooperative programs and subsidized auditing services. The heart of the group is based on the GCIO Cooperative, a community of environmentally concerned IT leaders who pool their time, resources, and buying power to educate, broaden the use, and improve the efficiency of, green computing products and services
- **Green Electronics Council :** The Green Electronics Council offers the Electronic Products Environmental Assessment Tool (EPEAT) to assist in the purchase of "green" computing systems. The Council evaluates computing equipment on 28 criteria that measure a product's efficiency and sustainability attributes. On 2007-01-24, President George W.

Bush issued Executive Order 13423, which requires all United States Federal agencies to use EPEAT when purchasing computer systems.

- **The Green Grid :** It is a global consortium dedicated to advancing energy efficiency in data centers and business computing ecosystems. It was founded in February 2007 by several key companies in the industry – AMD, APC, Dell, HP, IBM, Intel, Microsoft, Rackable Systems, SprayCool, Sun Microsystems and VMware. The Green Grid has since grown to hundreds of members, including end users and government organizations, all focused on improving data center efficiency.

2.0 CHAPTER II

2.0 The Demons behind Green Computing

- **Power supply:** Desktop computer power supplies (PSUs) are generally 70–75% efficient, dissipating the remaining energy as heat. An industry initiative called 80 PLUS certifies PSUs that are at least 80% efficient; typically these models are drop-in replacements for older, less efficient PSUs of the same form factor. As of July 20, 2007, all new Energy Star 4.0-certified desktop PSUs must be at least 80% efficient.

- **Storage:** Smaller form factor (e.g. 2.5 inch) hard disk drives often consume less power than physically larger drives. Unlike hard disk drives, solid-state drives store data in flash memory or DRAM. With no moving parts, power consumption may be reduced somewhat for low capacity flash based devices. Even at modest sizes, DRAM based SSDs may use more power than hard disks, (e.g., 4GB i-RAM uses more power and space than laptop drives). Flash based drives are generally slower for writing than hard disks.

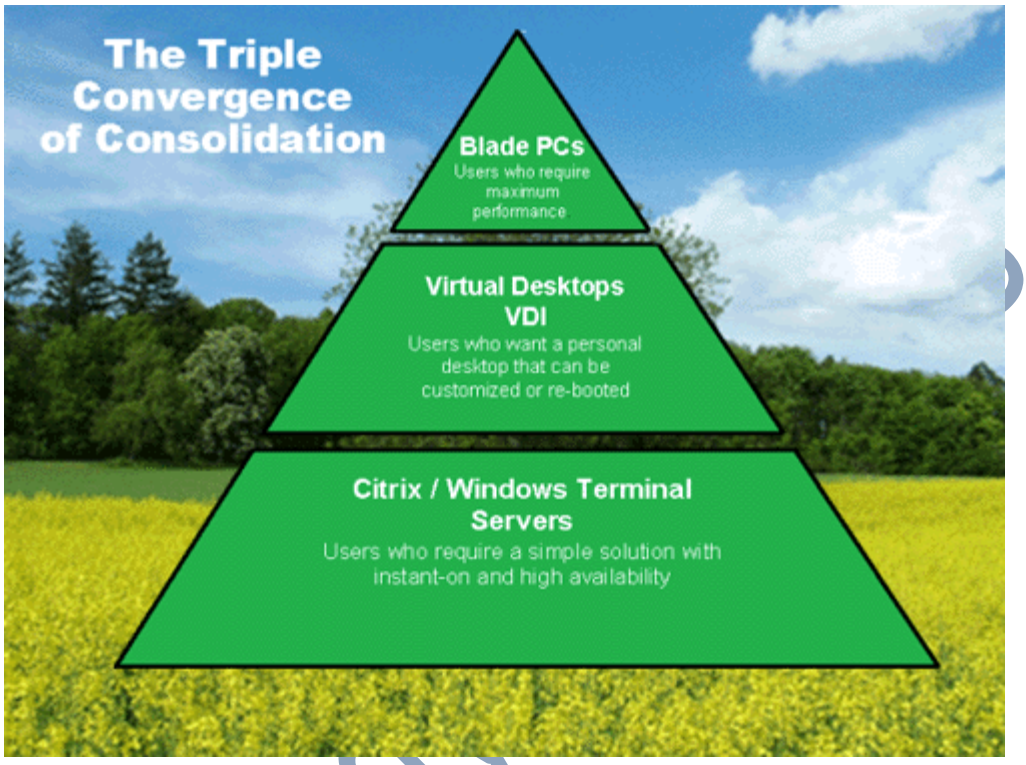
    - **Video card:** A fast GPU may be the largest power consumer in a computer. Energy efficient display options include: No video cards used in a shared terminal, shared thin client, or desktop sharing software if display required.
    - Use motherboard video output - typically low 3D performance and low power.

- Reuse an older video card that uses little power; many do not require heat sinks or fans.
- Select a GPU based on average wattage or performance per watt.

- **Materials:** Computer systems that have outlived their particular function can be repurposed, or donated to various charities and non-profit organizations. However, many charities have recently imposed minimum system requirements for donated equipment. Additionally, parts from outdated systems may be salvaged and recycled through certain retail outlets and municipal or private recycling centers. Recycling computing equipment can keep harmful materials such as lead, mercury, and hexavalent chromium out of landfills, but often computers gathered through recycling drives are shipped to developing countries where environmental standards are less strict than in North America and Europe. The Silicon Valley Toxics Coalition estimates that 80% of the post-consumer e-waste collected for recycling is shipped abroad to countries such as China, India, and Pakistan. Computing supplies, such as printer cartridges, paper, and batteries may be recycled as well.
- **Display:** LCD monitors typically use a cold-cathode fluorescent bulb to provide light for the display. Some newer displays use an array of light-emitting diodes (LEDs) in place of the fluorescent bulb, which reduces the amount of electricity used by the display.
- **Chilling of data:** To keep servers at the right temperature, companies mainly rely on air conditioning. The more powerful the machine, the more cool air needed to keep it from over heating. By 2005, the energy required to power and cool servers accounted for about 1.2 % of total U.S electricity conception. By 2010, half of the Forbes Global 2000 companies will spend more on energy than on hardware such as servers.

2.1 Approaches to Green Computing

2.1.1 Virtualization



Computer virtualization refers to the abstraction of computer resources, such as the process of running two or more logical computer systems on one set of physical hardware. The concept originated with the IBM mainframe operating systems of the 1960s, but was commercialized for x86-compatible computers only in the 1990s. With virtualization, a system administrator could combine several physical systems into virtual machines on one single, powerful system, thereby unplugging the original hardware and reducing power and cooling consumption. Several commercial companies and open-source projects now offer software packages to enable a transition to virtual computing. Intel Corporation and AMD have also built proprietary virtualization enhancements to the x86 instruction set into each of their CPU product lines, in order to facilitate virtualized computing.

In case of server consolidation, many small physical servers are replaced by one larger physical server, to increase the utilization of costly hardware resources such as CPU. Although hardware is consolidated, typically OS are not. Instead, each OS running on a physical server becomes

converted to a distinct OS running inside a virtual machine. The large server can "host" many such "guest" virtual machines. This is known as Physical-to-Virtual (P2V) transformation.

Virtual machine can be more easily controlled and inspected from outside than a physical one, its configuration is also more flexible. This is very useful in kernel development and for teaching operating system courses.

A new virtual machine can be provisioned as needed without the need for up-front hardware purchase. Also, virtual machine can be easily re-located from one physical machine to another as needed. For example, a sales person going to a customer can copy a virtual machine with the demonstration software to its laptop, without the need to transport the physical computer. At the same time and error inside a virtual machine does not harm a host system, so there is no risk of breaking down the OS in said laptop.

2.1.2 Material management

- **RoHS**

: In February 2003, the European Union adopted the Restriction of Hazardous Substances Directive (RoHS). The legislation restricts the use of six hazardous materials in the manufacture of various types of electronic and electrical equipment. The directive is closely linked with the Waste Electrical and Electronic Equipment Directive (WEEE), which sets collection, recycling, and recovery targets for electrical goods and is part of a legislative initiative that aims to reduce the huge amounts of toxic e-waste**.** Driven by these directives, VIA implemented a set of internal regulations in order to develop products that are compliant with these accepted policies, including the use of nonhazardous materials in its production of chipsets, processors, and companion chips. In 2001, they focused on lead-free manufacturing, introducing the Enhanced Ball Grid Array (EBGA) package for power efficient VIA processors and the Heat Sink Ball Grid Array (HSBGA) package for their chipsets. In traditional manufacturing processes, lead is used to attach the silicon core to the inside of the package and to facilitate integration onto the motherboard through tiny solder balls on the underside of the package. VIA's lead-free manufacturing technologies do not require a lead bead, and the solder balls now consist of a tin, silver, and copper composite.

However, not everyone is satisfied with this new objective. Howard Johnson of the online *EDN* magazine says that the move toward lead-free devices is not only unhelpful but actually worse for the environment. “The additional tin mining required to produce high-purity tin alloys, plus the mining of other precious metals required to alloy with tin in substitution for lead, is a poor trade for the use of existing lead, much of which comes from recycled products,” Johnson writes. He also believes that lead-free assembly is less reliable than lead-based assembly, partially due to the increased growth of tin whiskers — small, hair-like metallic growths that naturally emerge from the surface of solid tin. On lead-free tin surfaces, these whiskers can grow to a length sufficient to short an electronic circuit to another, leading to product failure.

- **Energy efficient Computing**

  - Do not leave your computer running overnight and on weekends. Also, wait until you are ready to use it before you turn it on.
  - A modest amount of turning on and off will not harm the computer or monitor. The life of a monitor is related to the amount of time it is in use, not the number of on and off cycles.
  - Try to plan your computer-related activities so you can do them all at once, keeping the computer off at other times.
  - Do not turn on the printer until you are ready to print. Printers consume energy even while they are idling.
  - Do not print out copies of email unless necessary.
  - If you spend a large amount of time at your computer, consider reducing the light level in your office. This may improve CRT (cathode ray tube) screen visibility as well as save energy.
  - Most computer equipment now comes with power management features. If your computer has these features, make sure they are activated.
  - The best screen saver is no screen saver at all - turn off your monitor when you are not using it. This option is second best only to turning off your computer all together.
  - Use "paperless" methods of communication such as email and fax-modems.

- When typing documents, especially drafts, use a smaller font and decrease the spacing between lines, or reformat to keep your document to as few pages as possible, especially when typing drafts.
- Review your document on the screen instead of printing a draft. If you must print a draft, use the blank back side of used paper.
- Use a printer that can print double-sided documents. When making copies, use double-sided copying.
- Always buy and use recycled-content paper. Look for papers with 50-100% post-consumer waste and non-chlorine bleached. Also, recycle your paper when done.
- Buy a monitor only as large as you really need. Although a large monitor might seem more attractive, you should remember that a 17-inch monitor uses 40 percent more energy than a 14-inch monitor. Also, the higher the resolution, the more energy it needs.
- Ink-jet printers, though a little slower than laser printers, use 80 to 90 percent less energy.
- Request recycled / recyclable packaging from your computer vendor.
- Buy vegetable (or non-petroleum-based) inks. These printer inks are made from renewable resources; require fewer hazardous solvents; and in many cases produce brighter, cleaner colors.

- **Recycling**

Obsolete computers are a valuable source for secondary raw materials, if treated properly, however if not treated properly they are a major source of toxins and carcinogens. Rapid technology change, low initial cost and even planned obsolescence have resulted in a fast growing problem around the globe. Many materials used in the construction of computer hardware can be recovered in the recycling process for use in future production. Reuse of tin, silicon, iron, aluminum, and a variety of plastics – all present in bulk in computers – can reduce the costs of constructing new systems. In addition, components frequently contain copper, gold, and other materials valuable enough to reclaim in their own right. Electronic devices, including audio-visual

components (televisions, VCRs, stereo equipment), mobile phones and other hand-held devices, and computer components, contain valuable elements and substances suitable for reclamation, including lead, copper, and gold. They also contain a plethora of toxic substances, such as dioxins, PCBs, cadmium, chromium, radioactive, and mercury.

Whole computers and pieces of electronic equipment are shredded into smaller pieces to be more manageable and facilitate the separation of the constituent components. Leaded glass from cathode ray tubes is sold to foundries for use as a fluxing agent in the processing of raw lead ore. Other valuable metals, such as copper, gold, palladium, silver and tin are sold to smelters for metal recycling. The hazardous smoke and gases generated by these processes are captured, contained, and treated to ensure that they do not become a threat to the environment. These methods allow for the safe reclamation of all the valuable materials used in computer construction.

2.1.3 Telecommuting

Telecommuting, e-commuting, e-work, telework, working at home (WAH), or working from home (WFH) is a work arrangement in which employees enjoy flexibility in working location and hours. In other words, the daily commute to a central place of work is replaced by telecommunication links. Many work from home, while others, occasionally also referred to as nomad workers or web commuters utilize mobile telecommunications technology to work from coffee shops or myriad other locations. Telework is a broader term, referring to substituting telecommunications for any form of work-related travel, thereby eliminating the distance restrictions of telecommuting. All telecommuters are teleworkers but not all teleworkers are telecommuters. A frequently repeated motto is that "work is something you do, not something you travel to". A successful telecommuting program requires a management style which is based on results and not on close scrutiny of individual employees. This is referred to as management by objectives as opposed to management by observation. The terms *telecommuting* and *telework* were coined by American Jack Nilles in 1973.

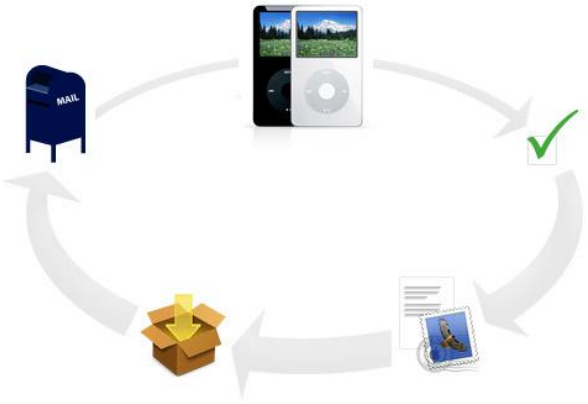
Long distance telework is facilitated by such tools as virtual private networks, videoconferencing, and Voice over IP. It can be efficient and useful for companies as it allows staff and workers to communicate over a large distance, saving significant amounts of travel time and cost. As broadband Internet connections become more commonplace, more and more workers have enough bandwidth at home to use these tools to link their home office to their corporate intranet and internal phone networks.

2.1.4 VoIP

Voice over Internet Protocol (VoIP) is a general term for a family of transmission technologies for delivery of voice communications over the Internet or other packet-switched networks. The reduction in telephone wiring will obviously lead to decreasing costs because of Voice-Over-Internet protocol. Voice over IP (VoIP) reduces the telephony wiring infrastructure by sharing the existing Ethernet copper, thus reduce the use of metallic waste. VoIP and phone extension mobility also made Hot-desking and more practical.

2.2 Role of IT vendors

- **Apple**



Four areas of particular attention are product and packaging design, materials, energy efficiency, and recycling. Each aspect of the design cycle provides significant challenges, yet our efforts in these areas have resulted in some impressive results.

Product design: It all begins here. Reducing the environmental impact of our products starts with the product design phase. Design dictates the quantity of raw materials as well as the type and recyclability of materials used. It also determines how much energy is consumed during manufacturing and product use. For example, the amazingly slim 20-inch iMac is made from highly recyclable glass and aluminum and it is so energy efficient it consumes about the same amount of power as a standard light bulb when on.

Materials: Apple helps to safeguard the environment - as well as consumers' safety - by restricting the use of environmentally harmful compounds in our materials and manufacturing processes. In addition to the substances that have already been restricted or eliminated, Apple is removing elemental forms of bromine and chlorine from our products, not just polyvinyl chloride (PVC) and brominated flame retardants (BFRs). The new MacBook family also uses mercury-free light-emitting diode (LED) displays, with arsenic-free display glass.

Energy efficiency: A devices greatest contribution to greenhouse gas emissions comes from its consumptions of energy over time. Apple has made great strides in recent years to optimize the energy efficiency of our hardware and created tools, such as the Energy Saver feature in Mac OS X, that allow consumers to manage the power consumption of their computers. Since 2001, Apple desktop computers, portable computers, and displays have earned the ENERGY STAR rating.

Recycling : Apple's holistic, lifecycle approach to recycling includes using highly recyclable materials in products in addition to providing extensive take-back programs that enable consumers and businesses to safely dispose of used Apple equipment. Since our first take-back initiative began in Germany in 1994, we have instituted recycling programs in 95 percent of the countries where our products are sold - diverting over 53 million pounds of electronic equipment from landfills worldwide. Apple is on track to eliminate toxic chemicals from our products. In the2008 Environmental Update Steve Jobs provides an overview on Apple's progress to eliminate mercury and arsenic from displays and Brominated Flame Retardants (BFR's) and Polyvinyl Chloride (PVC) from internal components. Steve Jobs also talks about Apple's policy on climate change, steps taken to improve product energy-efficiency as well as overall recycling performance during 2007.

- **Wipro**

Wipro Limited, a leading player in Global IT and R&D services, is committed towards environmental sustainability by minimizing the usage of hazardous substances and chemicals which have potential impact on the ecology. It has joined hands with WWF India, one of the largest conservation organizations in the country, to directly deal with issues of climate change, water and waste management and biodiversity conservation.

- **Green Lighting Solutions**
  - Complete range of Brightness Management Products for Green Buildings
  - Ability to integrate lighting and lighting management systems for Green Building performance standards
  - Role of Lighting for GREEN buildings: 17% – 20% of the overall building's energy usage
  - Optimize Energy Performance
    - High efficiency luminaries design
    - High efficiency light sources - Compact Fluorescent Lamp, LED, etc.
    - Lighting controls
    - High efficiency control gear
    - Personalized controls through task lighting Intelligent lighting systems
- **Green IT Solutions Applications**
    - e-Freight – An innovative application for the Air Cargo industry that enables efficient, multi-format & paperless interaction between Airlines, Freight Forwarder and Customs
  - Emission Compliance Management System
    - An application developed for manufacturing companies

    - Helps them to control pollution & reduce carbon monoxide emissions
  - Energy Efficiency Solution
    - A process & technology application that accommodates the functionality requirements of an end-to-end energy efficiency solution
    - It is a framework that is designed to help customers to use their energy requirements in the most-cost effective manner
- **Products**
  - Wipro Green ware
    - RoHS Compliant (Restriction of Hazardous Substances)
    - Energy star certification
    - Energy Conservation mechanism in electronic components
    - Compliant with environment & safety standards and statutory regulations
    - Recyclable & degradable packing materials
    - MPR II certified radiation free monitors
    - Wipro WEEE Statement
    - Part of 'Quick Start Guide' shipped with all systems from factory
    - WEEE – Waste from Electrical and Electronic Equipment
- **Services**
  - e-Waste Disposal Service
    - Offering a facility to collect retired computers, laptops & servers from willing customers and to dispose them off in a responsible manner
  - Eco-friendly Product Engineering Designs
    - Eco-friendly Engineering Designs that are RoHS compliant & energy efficient

- For Telecom & Embedded solution customers
- With state-of-the-art labs for environmental testing

- Green Data Center Energy consumption & Cost are the drivers due to:

  - Increase in computing demand
  - Changing cost dynamics
  - Data Centre Life Cycle Mismatch
  - Wipro's service offering – Build / upgrade into a Green Data Centre:

- **Manage IT Infrastructure**
  - Optimize server operations & reduce floor footprint
  - Implement remote monitoring for increased efficiency and improved management
- **Green Testing Lab**

  - Wipro has set up a hardware lab in its Sarjapur campus that will exclusively test products to confirm that they are "green" compliant
  - The idea is to maintain & uphold the environmental standards by the Government & Society
  - Virtualization Of Testing
  - Server Consolidation

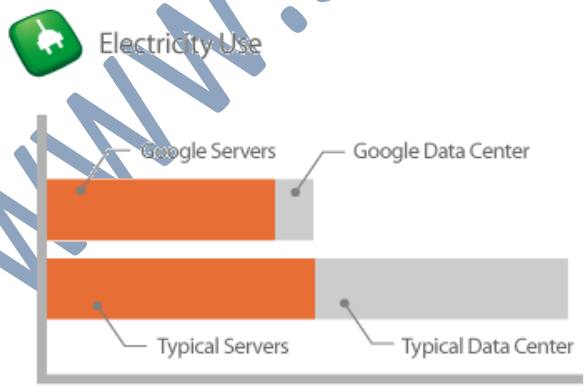
    - Allows to run multiple heterogeneous operating systems OR versions of same operating systems simultaneously on a single server —without partitioning or rebooting. It consolidates workload of several under-utilized servers to fewer machines, perhaps a single machine
    - Reduces Cost
    - Reduces cost involved in hardware resources, power, cooling, commercial space & maintenance
    - Reduces Testing Time
    - Simplifies & reduces testing effort

- **Shared Service Consulting**
  - A practitioner's perspective
    - Wividus - A shared service organization
    - Supports 80000+ employees; handles 4000+ transactions per day
    - Conserving resources – paper (95% electronic transactions) & energy
    - Sharing service resources across Wipro businesses
    - Applying Six Sigma & Lean Concepts

- **Google**

Google's mission is to organize the world's information and make it universally accessible and useful. Hundreds of millions of users access our services through the web, and supporting this traffic requires lots of computers. We strive to offer great internet services while taking our energy use very seriously. That's why, almost a decade ago; we started our efforts to make our computing infrastructure as sustainable as possible. Today we are operating what we believe to be the world's most efficient data centers.

The graph below shows that our Google-designed data centers use considerably less energy - both for the servers and the facility itself - than a typical data center. As a result, the energy used per Google search is minimal. In fact, in the time it takes to do a Google search, your own personal computer will use more energy than we will use to answer your



query.

But sustainability is about more than electricity, so we've gone beyond just reducing our energy consumption. Before the end of 2008 two of our facilities will run on 100% recycled

water, and by 2010 we expect recycled water to provide 80% of our total water consumption. We also carefully manage the retirement of our servers to ensure that 100% of this material is either reused or recycled. Finally, we are engaging our users and peers to help build a clean and efficient energy future. This broader impact could be significant; if all data centers operated at the same efficiency as ours, the U.S. alone would save enough electricity to power every household within the city limits of Atlanta, Los Angeles, Chicago, and Washington, D.C.

Sustainability is good for the environment, but it makes good business sense too. Most of our work is focused on saving resources such as electricity and water and, more often than not, we find that these actions lead to reduced operating costs. Being "green" is essential to keeping our business competitive. It is this economic advantage that makes our efforts truly sustainable.

Google's five step plan

1. Minimize electricity used by servers
2. Reduce the energy used by the data center facilities themselves
3. Conserve precious fresh water by using recycled water instead
4. Reuse or recycle all electronic equipment that leaves our data centers
5. Engage with our peers to advance smarter energy practices

- **VIA**

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.

- **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) 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.

- **Solar computing:** Amid the international race toward alternative-energy sources, VIA is setting its eyes on the sun, and the company's Solar Computing initiative is a significant part of its green-computing projects. For that purpose, VIA partnered with Motech Industries, one of the largest producers of solar cells worldwide. Solar cells fit VIA are power-efficient silicon, platform, and system technologies and enable the company to develop fully solar-powered devices that are nonpolluting, silent, and highly reliable. Solar cells require very little maintenance throughout their lifetime, and once initial installation costs are covered, they provide energy at virtually no cost. Worldwide production of solar cells has increased rapidly over the last few years; and as more governments begin to recognize the benefits of solar power, and the development of photovoltaic technologies goes on, costs are expected to continue to decline. As part of VIA's "pc-1" initiative, the company established the first-ever solar-powered cyber community center in the South Pacific, powered entirely by solar technology.

- **Lead-Free and RoHS computing:** In February 2003, the European Union adopted the Restriction of Hazardous Substances Directive (RoHS). The legislation restricts the use of six hazardous materials in the manufacture of various types of electronic and electrical equipment. The directive is closely linked with the Waste Electrical and Electronic Equipment Directive (WEEE), which sets collection, recycling, and recovery targets for electrical goods and is part of a legislative initiative that aims to reduce the

huge amounts of toxic e-waste**.** Driven by these directives, VIA implemented a set of internal regulations in order to develop products that are compliant with these accepted policies, including the use of nonhazardous materials in its production of chipsets, processors, and companion chips. In 2001, they focused on lead-free manufacturing, introducing the Enhanced Ball Grid Array (EBGA) package for power efficient VIA processors and the Heat Sink Ball Grid Array (HSBGA) package for their chipsets. In traditional manufacturing processes, lead is used to attach the silicon core to the inside of the package and to facilitate integration onto the motherboard through tiny solder balls on the underside of the package. VIA's lead-free manufacturing technologies do not require a lead bead, and the solder balls now consist of a tin, silver, and copper composite

- **IBM**

In May 2007, IBM unveiled Project Big Green -- a re-direction of $1 billion USD per year across its businesses to increase energy efficiency. New products and services are expected to reduce data center energy consumption and transform clients' technology infrastructure into "green" data centers, with energy savings of approximately 42 percent for an average data center. As part of Project Big Green, IBM is building an $86 million green data center expansion at its Boulder, Colorado location and will consolidate nearly 4,000 computer servers in six locations worldwide onto about 30 refrigerator-sized mainframes running the Linux operating system.

Project Big Green outlines a five-step approach for data centers that is designed to improve energy efficiency:

1. Diagnose: evaluate existing facilities -- energy assessment, virtual 3-D power management and thermal analytics.
2. Build: plan, build or update to an energy efficient data center.
3. Virtualize: Virtualize IT infrastructures and special purpose processors.
4. Manage: seize control with power management software.
5. Cool: exploit liquid cooling solutions -- inside and out of the data center.

By investing in systems that deliver better performance per watt, businesses can make significant long-term savings and reduce their carbon footprint. Project Big Green invests in delivering

continual advances in power-performance for each new generation of its server and storage technologies, enabling clients to run the same business workload at lower cost and with reduced environmental impact

- **Sony**

Sony has developed an environmentally friendly prototype battery that runs on sugars and can generate enough electricity to power a music player and a pair of speakers, the Japanese company said. The bio battery's casing is made of a vegetable-based plastic. It measures an inch and a half along each edge and works by pouring sugar solution into the unit; where enzymes break it down to generate electricity. Test cells had an output of 50 mill watts. Sugar is a naturally occurring energy source produced by plants through photosynthesis. It is therefore regenerative, and can be found in most areas of the earth, underlining the potential for sugar-based batteries as an ecologically friendly energy device of the future

2.4 Green Computing Tips

- Use LCD monitors instead of CRT monitors, which consume a lot more electricity. LCD monitors uses three times less when active, and ten times less energy when in sleep mode.
- Use laptops instead of desktop computers, also cuts down on energy usage. The Everex Step Note NC1501 is touted as the world's most energy efficient notebook computer, using only 12W peak power. By comparison, a desktop model uses 200-400 watts.
- If a laptop is not feasible, look for the Energy Star label when purchasing a computer. New US government regulations make this more important than it's been for the past fifteen years.
- Disable your screen saver. Burn-in is not an issue with modern monitors, and screen savers can prevent your monitor and computer from going into idle/sleep mode.

- Enable the power management features on your computer, to turn off components such as the monitor, fans and hard drive when idle. On Windows, go to Control Panel / Power Options. On OS X, go to System Preferences / Energy Saver.
- Switch off the monitor, printer, scanner and other peripherals when not in use.

➢ Tips for Green Home Computing:

- Don't check your email on a PC as far as possible – use a mobile device
- Never leave your PC switched on at the wall, or on standby
- Take that CRT monitor to the recycling centre
- Always switch off speakers, modem, monitor at the wall socket if not using
- Use natural ventilation in the computer room
- Only connect to the internet when you know you will use the connection
- Get all family members to log on to the WiFi network at the same time
- Consider buying a newer, more energy efficient computer or low power notebook
- Surf at cafes where they only have a single WiFi modem

➢ Tips for Green Office Computing:

- User blade servers that run very low temperature chips to save cooling
- Tell employees to switch everything off at night
- Use smart thermostats in the server room to save cost
- Use low power thin client PCs that use on-demand applications
- Switch to LCD screens to cut power usage
- Only buy Green label PCs and hardware that can be completely recycled.
- Recycle all internal paper, and reprint on the back of used single side waste

3.0 CHAPTER III

3.1 Future is Green

India Inc is already facing an energy crisis. Today most large Data Centers (DC) consume 10-100 times more energy per square foot than a typical office building and most of these data centers have become chillers (over cooled), which again eats into power needed to cool them. Now, emerging high density computer systems and consolidation of IT resources into fewer DCs are stretching the limits. That is why one would witness that DCs are evolving at a faster rate due to which customers have to modify or redesign their DC every five years. Customers are looking for solutions that adapt to the changing needs of the data center without needing additional investment. The existing scenario for DC includes reviewing installed power sources and finding any technical solutions that can reduce the energy demand. For DCs that are in the design stage, it is vital to provision for such devices, or to use the latest power conditioning equipment. One should not go only by the specifications; it is a good idea to measure the power output from a sample device and monitor it. A deep study on the efficiency of the devices being used can prove helpful. Even a one or two percent drop in power consumption can result in substantial cost savings in the long run. It is this scenario that is forcing many IT departments to evaluate their DC power consumption and find ways to become more energy-efficient. In today's 24x7 world of information availability, on-demand services, and round-the-clock commerce sites, companies increasingly are adding high-performance servers, storage and other equipment to their data centers to satisfy user and customer demand. As a result, companies find that they need more and more power to run and cool this equipment. At the same time, the cost of electricity is on the rise. Many companies are trying to be good corporate citizens by becoming green (or at least greener).

Large DCs are looking at pocketing more green into their pocket. It is primarily because they want to minimize the risk in the DC as heat generation goes higher, leading to greater power consumption. So DCs need to go in for optimization of power as well as cooling. There is a

strong possibility that organizations will look at green technologies to reduce their data center costs without even knowing it and that because most of the bigger and multiple

One thing that each and every DC manager agrees upon is that power and cooling are the two important factors required for the smooth functioning of a DC. Data center power and cooling go hand-in-hand. And it will be right to say that based on the requirement per rack, the cooling and power management must be designed at the rack level to avoid any wastage of energy within a data center. Today cooling contributes nearly 35 to 40% of total DC energy consumption and if we see the distribution of IT servers within a rack in a data center, we will find that the loads are unequally distributed. This means that there may be a few racks that generate 3/4 kW to 15 kW per rack of heat load. The racks with more than 10 kW load are the extreme density racks and are required to be cooled for reliability within the DC. Since the temperature in the room is not evenly distributed, it needs supplemental cooling at the source where the heat is being generated. Several trends are driving up DC power requirements significantly. First, most companies need more computing power to run their Web sites and business and financial applications, for which servers often must run round-the-clock. Second, newer computers use higher performing processors that consume more electricity. And third, there is a trend to physically consolidate servers by moving to high-density rack and blade servers, packing more processing power into smaller spaces within data centers.It have been noted that up to 40% of the operating costs of a building that houses a DC could be power- and cooling-related expenses. If nothing changes, power and cooling issues (and costs) are likely to get worse in the future. That's because the price of electricity is expected to rise, and many newer systems are expected to require more power. Faced with growing power consumption requirements to run and cool DC equipment, companies are looking for ways to reduce electrical usage and costs. To figure out where to focus attention on energy, one must understand what contributes to power consumption.

DCs are very different today than they were a few years ago. Equipment that used to fill an entire room is now contained in a single rack, concentrating extreme power and heat densities-a situation that must be addressed to assure reliability. This has caused a shift in focus from "Watt per square foot" to "KW per rack" when creating cooling solutions. The DCs are

expected to operate at a maximum of 125 watts per square foot and a significant amount of cost and energy is spent in order to keep these solutions up and running 24x7.

To meet the requirements and limitations on power and cooling for each data center, it is important to consider the thermal footprint of each DC or server room by figuring how much critical load can you power; how much can you cool before you start to have problems like downtime or failure; and how much computing capacity you need vs. power/cooling capacity you can not exceed before you incur the expense of overhauling the data center. Unfortunately, many data centers are now stuck in a heat loop. Creating heat by powering cooling to offset heat dissipated by servers entails creating new heat to get rid of existing heat. This is a problem irrespective of the platform being used be it rack, tower, blade; all data centers have to address it. In fact, a Google engineer warned that, if the performance per watt of today's computers does not improve, the electrical costs of running them could end up exceeding the initial hardware price tag.

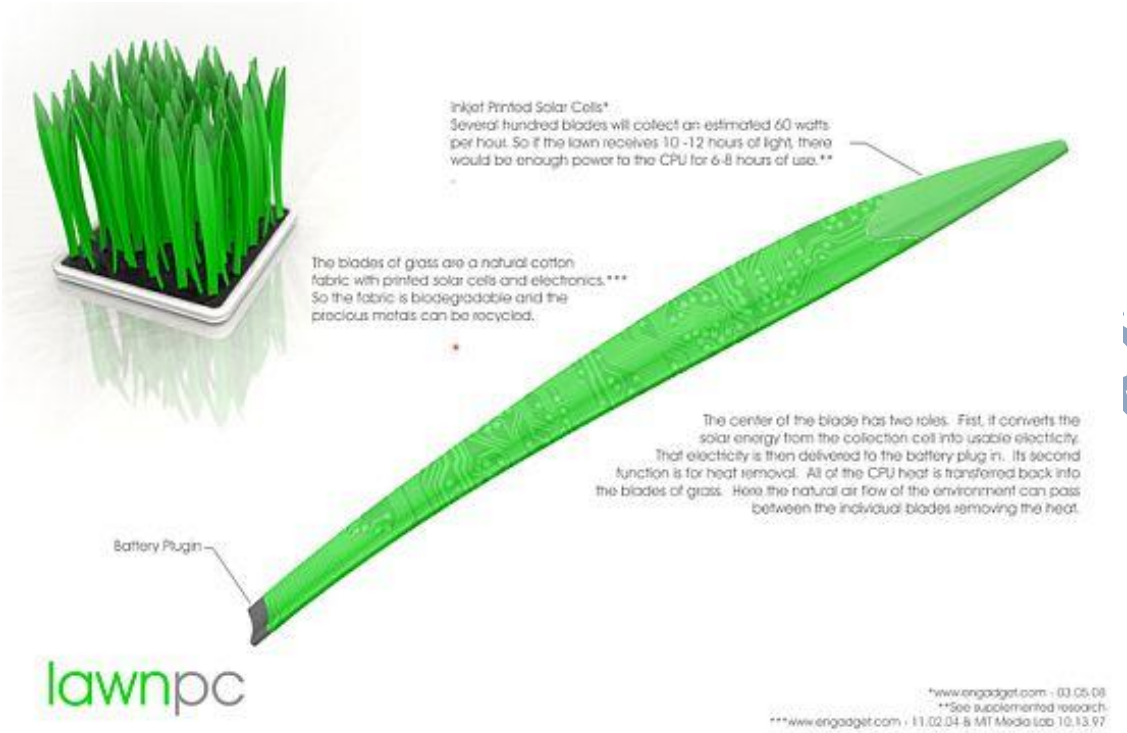
Today many a large DC is looking at including liquid cooling as an option as many companies are running out of room to ventilate racks. The next step is to put liquid cooling next to the rack. Improved energy efficiency is just one of the many benefits that this technology brings to the table and it's a lot easier to pump liquid, than air, to where it's needed. Liquid cooling is not new; it's been used from the days of the mainframe. Mainframes generated a lot of heat. So much so that it was too much for air cooling to handle. Air cooling is not as effective as liquid cooling for the same volume. As computers and servers become smaller and their density goes up, at some point we will not be able to cool data center racks with air anymore. They will have to be cooled with liquid directly. That's what happened in the case of the mainframes where vendors were forced to resort to liquid cooling. A migration from air to direct liquid cooling is being used to address surging DC energy costs and allow the power densities of servers to continue to increase into the next decade. Some DC managers may not fully grasp the problem, because over the past eight years, server performance has increased by a factor of 75 while performance per watt of power has increased 16 times and the data centers are using more number of processors than ever. Meanwhile, the power density of equipment has increased to the point where power and cooling plays a critical role. That creates two problems. First, energy costs are spiraling upward. Many DC managers don't see that today, because their power use

isn't metered separately and isn't part of the IT budget. There is no hard and fast rule as to which technology to use to optimize DC. What is important is to undertake a full exercise to see the hot zones and chill zone and then use appropriate technologies to reduce the operational cost of DC.

3.2 Lawn PC

Technology isn't always on the same page with sustainability. Still when green innovation transforms the trajectory, even we find ourselves inclining towards the novelty. Such is the LawnPC, which visions to transform computing in the near future. The concept PC from David Veldkamp is powered by the solar cells attached to the grass like lawn on the PC, made from natural cotton fabric these blades transfer the generated 60 watts of energy down to the plug-in button at the bottom each blade. The concept requires no cooling fans, just put it where natural light and air are readily available and then leave rest on this wirelessly functional device that'll give you the cleanest computing all the time.

Renewable energy is the need of the hour and the form in which it has been used here is simply stunning. 60 Watts of solar energy per hour gets a thumb up from our side. Geeks like us on that side wouldn't be satisfied with the concept we know, but then guys, just give Designer David Veldkamp the breather to have initiated in making something with a likely future.



4.0 Conclusion

Green Computing is on the radar screens of CIOs, but its not primarily motivated by eco-friendlyness," says Jim Noble, CIO of Altria, parent company of Philip Morris and Kraft Foods. "The primary motivation is technology's cost". The good news for Mother Earth is that there are a lot of money-saving, eco-friendly steps just waiting for IT execs to take

5.0 Glossary

CIO : Chief Information Officer

DC : Data Centre

LCD : Liquid Crystal Display

RoHS : Restriction of Hazardous Substances Directive

WEED : Waste Electrical and Electronic Equipment Directive

BFR : Brominated Flame Retardants

WAH : Working At Home

WFH : Working From Home

EBGA : Enhanced Ball Grid Array

HSBGA : Heat Sink Ball Grid Array

PVC : Polyvinyl Chloride

LED : Light Emitting Diode

VoIP : Voice over Internet Protocol

EPEAT : Electronic Products Environmental Assessment Tool

CSCI : Climate Savers Computing Initiative

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