**Birla Institute of Technology, Mesra**

# Green Computing: Green Manufacturing

# Project

*Submitted*

## Under the Guidance

## Of

## Dr. (Mrs.) Aruna Jain

**(Associate Professor, Computer Science and Engineering)**

**by**

# Nabh Choudhary

*(BE/10398/15)*

# Bachelor of Engineering

*In*

# Information Technology

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# Abstract

In today's world the driving force of computing has shifted from faster analysis, speedier calculations and solving of more complex problems to achieving energy efficiency, minimization in consumption of electronic equipment, minimization of e-waste and use of non-toxic materials in preparation of electronics. The practice of using computing resources efficiently is gaining serious momentum and thus the goals of reducing the use of hazardous materials, maximizing energy efficiency during the product's lifetime, and promotion of recyclability or biodegradability of defunct products and factory waste are being realized. This radical change in perspective amongst the developers has led to a revolution in the field of computing technology and this revolution has been coined as green computing. Green computing is basically the study and practice of efficient and eco-friendly computing which will help a typical organization to reduce their energy footprint while maintaining required levels of computing performance.

Global carbon emissions attributable to ICT have been estimated at 2% to 2.5% of world totals - about the same as the airline industry - and as high as 5-6% of developed nation totals. McKinsey forecasts that the ICT sector's carbon footprint will triple during the period from 2002 to 2020.

For office buildings, ICT typically accounts for more than 20% of the energy used, and in some offices up to 70%.

Although energy costs typically comprise less than 10% of an overall IT budget, in a few years they could rise to more than 50% according to a 2006 Gartner report. Many large organizations - such as Google - already claim that their annual energy costs exceed their server costs.

In this project an attempt has been made to focus on the methods to solve these issues using *Green Computing: Green Manufacturing.* What Green Manufacturing means, how it works, what are its advantages and what are the products developed to promote this idea.

# Introduction

Bill Gates predicted many years ago of a PC in every home. He was widely considered to be simply promoting an unlikely scenario with the aim of boosting Microsoft's profits. However, how right he truly was. Not just at home but also virtually every commercial organization of any size is heavily reliant upon IT.

But this advancement was never free. We lost a lot of our natural resources in form of energy, which is non-renewable.
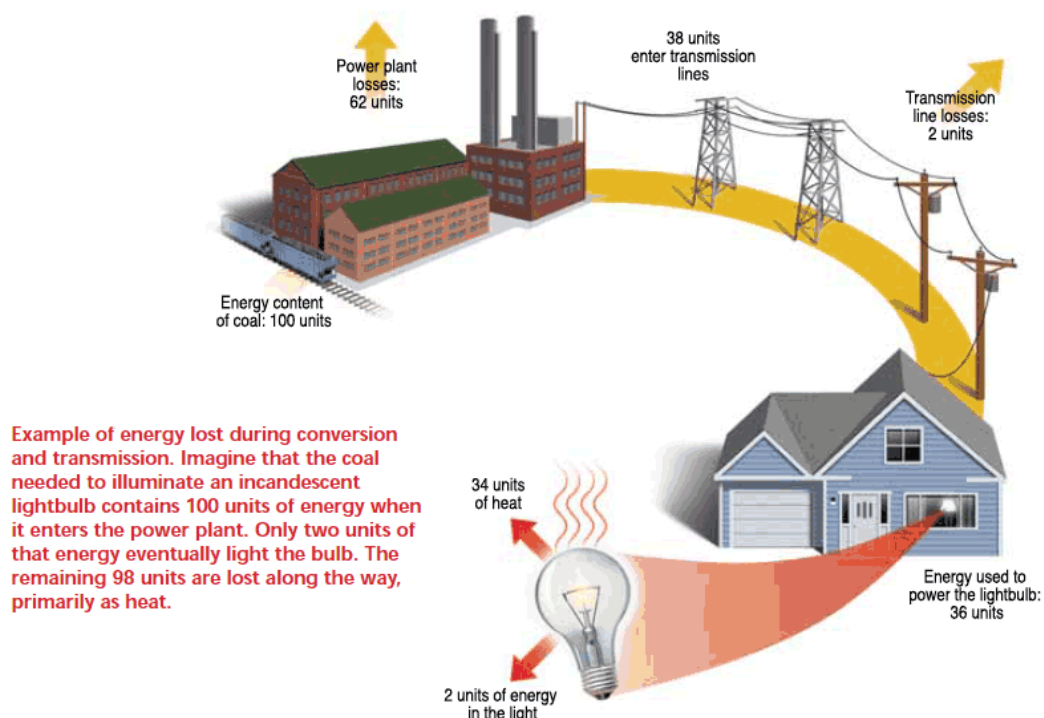


Thus, 100 units of input only give 2 units of output. This is not only loss of energy but also loss of capital. In addition to the factors of energy loss in process of converting it into electrical energy and its transportation, a huge amount of energy is loss by the electronics we use.

**IT Contribution:**

- Computers systems and Data centres together contribute to the most of the energy used by the IT sector. In 2014 , these two factors together consumed more energy than aviation industry.

- A **desktop** uses an average of 200 W/hour when it is being used (loudspeakers and printer included). A computer that is on for eight hours a day uses almost 600 kWh and emits 175 kg of $CO_2$ per year.
- A **laptop** uses between 50 and 100 W/hour when it is being used, depending on the model. A laptop that is on for eight hours a day uses between 150 and 300 kWh and emits between 44 and 88 kg of $CO_2$ per year. In **stand-by mode** the power consumption of both a desktop and a laptop falls to about a third. This contributes to the 'vampire draw' of your household.
- Generation Of heat by the systems has to be handled by proper cooling systems, which indeed produce harmful green-house gases.
- A huge amount of toxic and carcinogenic waste is produced when the components of computer system like silicon chips, microcontrollers and other computer components are disposed in the environment.
- It's no secret that data centers, the massive but bland, unremarkable-looking buildings housing the powerful engines that pump blood through the arteries of global economy, consume a huge amount of energy. US data centers consumed about 70 billion kilowatt-hours of electricity in 2014, the most recent year examined, representing 2 percent of the country's total energy consumption, according to the study.
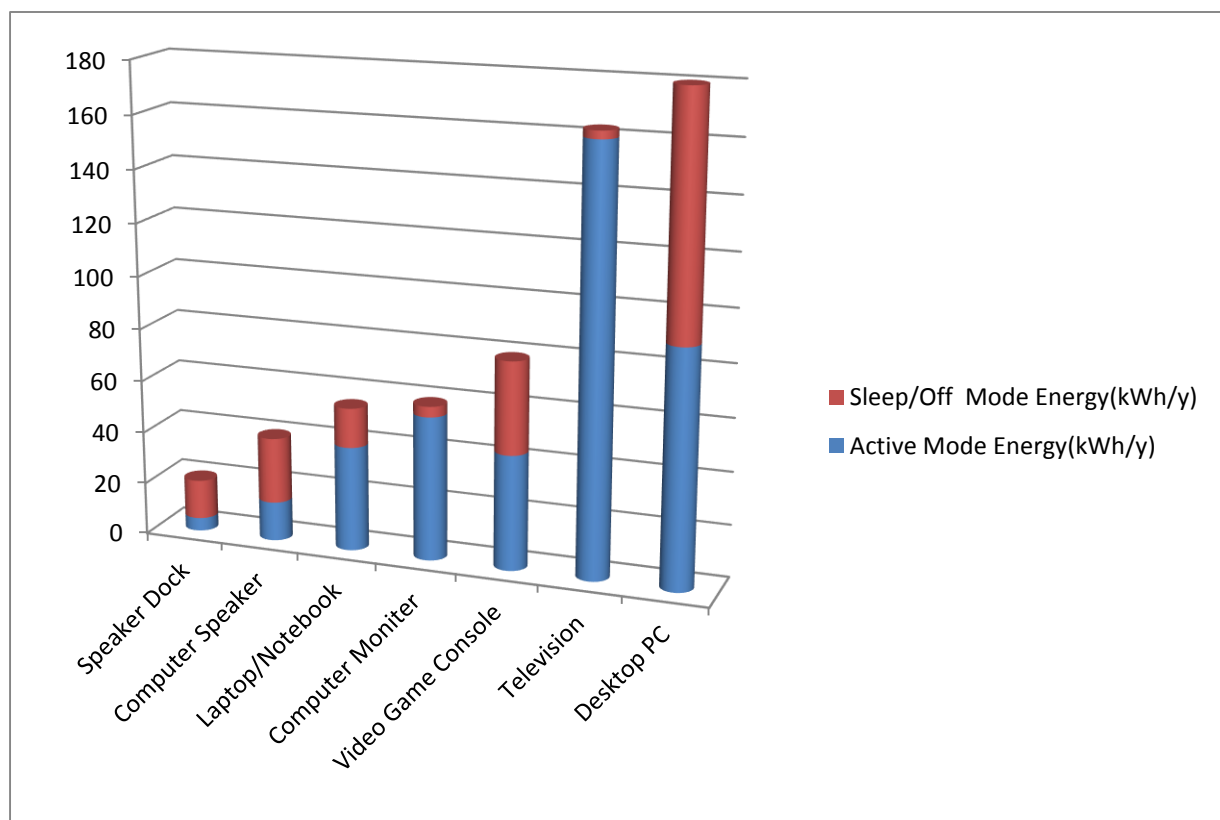
Environmental and energy conservation issues have taken centre stage in the global business arena in recent years. The reality of rising energy costs and their impact on international affairs coupled with the increased concern over the global warming climate crisis and other environmental issues have shifted the social and economic consciousness of the business community.

As we now know that the IT industry has long been a significant contributor to global warming, but there is a strong and growing trend that seeks to reverse that impact and it is called **Green Computing**.
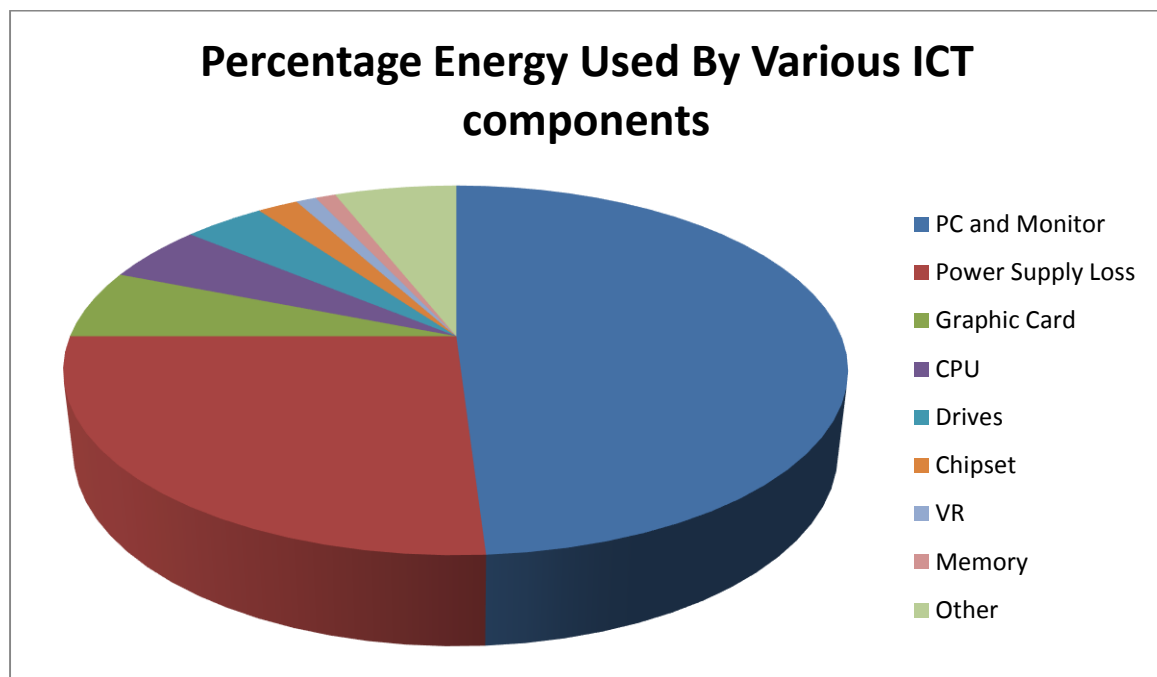


### Introducing Green Computing:

**Green Computing** or **Green IT** refers to environmentally sustainable computing or IT. It is "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. Green IT also strives to achieve economic viability and improved system performance and use, while abiding by our social and ethical responsibilities. Thus, green IT includes the dimensions of environmental sustainability, the economics of energy efficiency, and the total cost of ownership, which includes the cost of disposal and recycling. It is the study and practice of using computing resources efficiently.

The goals of green computing are similar to green chemistry; reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, and promote recyclability or biodegradability of defunct products and factory waste. Green computing researchers look at key issues and topics related to energy efficiency in computing and promoting environmentally friendly computer technologies and systems include energy efficient use of computers, design of algorithms and systems for environmentally-friendly computer technologies, and wide range of related topics.
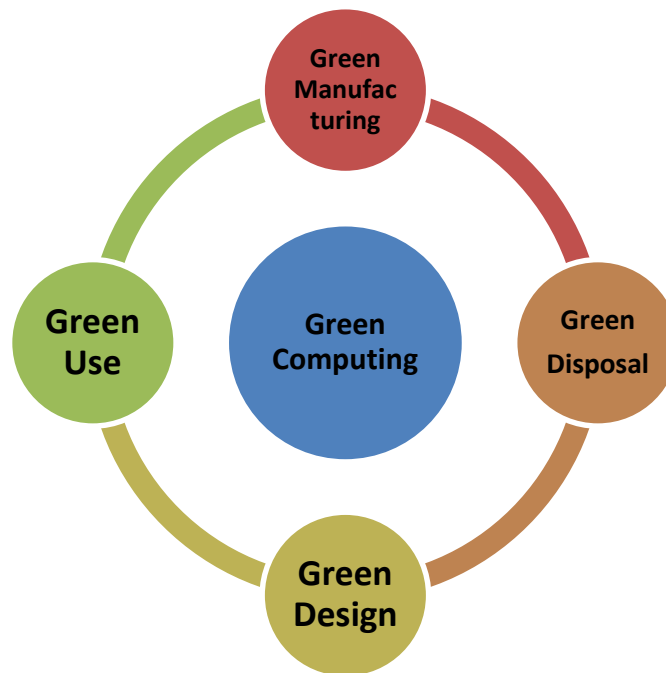


## Roads To Green Computing:

Nowadays in order to achieve social awareness and promotion of green technology solutions, main four complementary approaches are employed:

• **Green Use**: Reducing the power consumption of computers, information systems and their peripheral subsystems in environmentally friendly manner.

• **Green Disposal**: Refurbishing and reusing existing old computers and other electronic associated devices. Recycling unwanted used computers and other electronic-waste by IT vendors using their "take back" policy in order to take responsibility for the full lifecycle of products they produce.

 • **Green Design**: In broader aspect connecting companies, government agencies and environmental organizations in order to develop inventive management, business and regulatory processes that can improve environmental quality while enhancing economic development. In narrow and practical aspect designing power efficient and eco-friendly computers and its subsystems like servers and cooling equipment.

 • **Green Manufacturing**: Process of production of computers and associated devices include methods of manufacturing and biodegradable components for

minimal or no impact on environment. This approach allows providing improvements.



In this project I am going to explore one of these roads towards and Green Computing and towards a greener and better world-"**Green Manufacturing**", how it is implemented, how it is advantageous, and how it can be improved further.

# What do you mean by Green Manufacturing?

In a 2008 article San Murugesan, Editor in Chief, IEEE IT Professional, 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*" . Murugesan 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 manufacturing is a method for manufacturing that minimizes waste and pollution. These goals are often achieved through product and process design.***

In the not-too-distant future, environmentally benign manufacturing will become one of industry's greatest strategic challenges, not only from an engineering perspective, but also from a business and marketing perspective. Many large, multinational companies are cognizant of impending overseas (Europe & Japan) environmental regulations and growing consumer demand for a new generation of environmentally friendly products, and they are beginning to formulate their response. Some have embraced the notion that green products and green production techniques are a competitive weapon.

The **centre for Green Manufacturing at the University of Alabama** defines the goal of green manufacturing as:

"***To prevent pollution and save energy through the discovery and development of new knowledge that reduces and/or eliminates the use or generation of hazardous substances in the design, manufacture, and application of chemical products or processes.***"

In order to achieve goals set by the idea of ICT sustainability whole process of creating ICT infrastructure should be taken into account. Minimal impact on the environment should be one of the key assumptions for IT manufacturers during the process of design and production of all ICT components. Major IT companies are already applying green standards to their own operations in order to: gain new revenue opportunities and promote social and environmental responsibility influencing customers and market competition. Main areas in green manufacturing of computers are:

• *Eco-friendly design*: the design of computing resources that meet the stringent restriction of e.g. Energy Star enabling further utilization with determined power supply and power management requirements (including special modes and allowances). "The Energy Star devices can be programmed to power-down to a low electric state when they are not in use, helping to save energy and run cooler which helps them last even longer.

• *Use of bio-products*: biodegradable and renewable materials often require less energy to produce in comparison to traditional toxic materials. Manufacturers' use many different types of plastic in computers, which makes is very changeling do recycle. What are more computers contain hazardous contaminants for environment like: cadmium, lead, mercury or chromium. Use of harmful power-demanding materials can be replaced by efficient and recyclable elements e.g. displays made of OLED's (Organic Light-Emitting Diode) - in manufacturing mercury is not used, making them more environmentally friendly.

## *Industry Initiative towards Green Manufacturing:*

The ICT sector industry have now felt the use of Green Manufacturing processes and have now taken significant step in this direction. IT sector companies including the giants like Apple, Microsoft, Toshiba, Nokia and Dell have changed their production process significantly to incorporate Green Manufacturing in it.
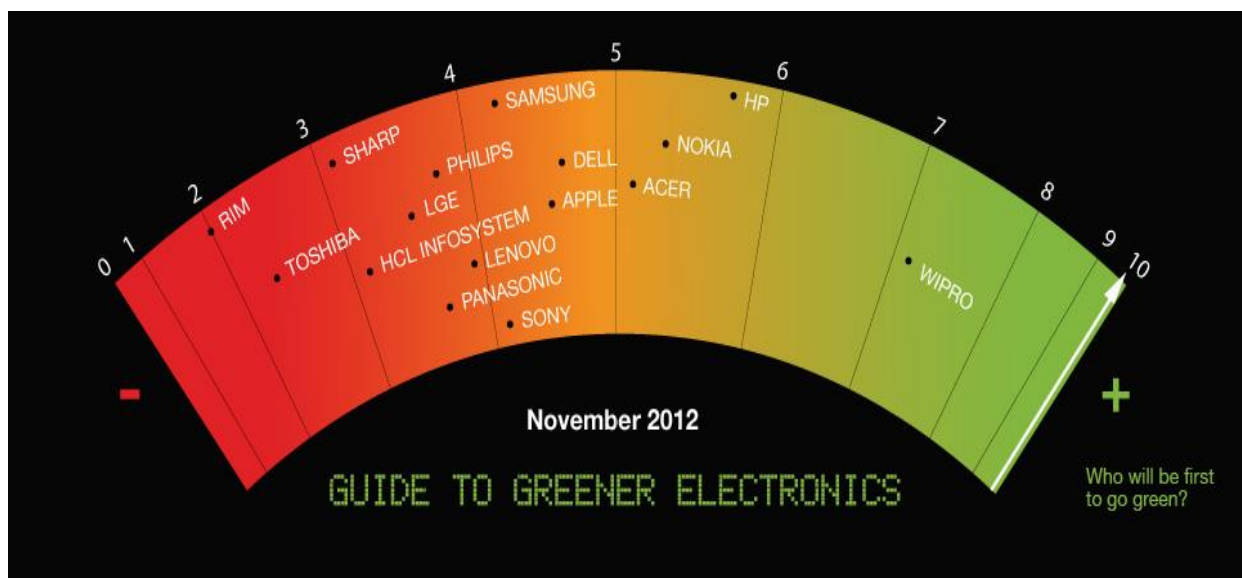
### *Green Peace Index:*

Every day, more people around the world rely on laptops, phones and tablets to make their lives more productive and fun. Electronic gadgets can make our lives

better, but the rate at which we purchase and discard these devices is having a serious impact on our planet.

Consumers have expressed their desire for greener electronics, and the industry has shown that improvements are possible, but only if leading electronics companies apply the sector's know-how and innovative spirit within the sustainability arena.

The **Green Peace Index** evaluates leading consumer electronics companies based on their commitment and progress in three environmental criteria: Energy and Climate, Greener Products, and Sustainable Operations. The Guide scores companies on overall policies and practices – not on specific products – to provide consumers with a snapshot of the sustainability of the biggest names in the industry.



Higher the Green Peace Index betters the companies' initiative towards green manufacturing.

## *Energy Star:*

**Energy Star** is an international standard for energy efficient consumer products originated in the United States. It was created in 1992 by the Environmental Protection Agency and the Department of Energy. Since then, Australia, Canada, Japan, New Zealand, Taiwan, and the European Union have adopted the program. Devices carrying the Energy Star service mark, such as computer products and peripherals, kitchen appliances, buildings and other products, generally use 20–30% less energy than required by federal standards. In the United States, the Energy Star label is also shown on Energy Guide appliance label of qualifying products.

Energy Star specifications differ with each item, and are set by either the Environmental Protection Agency or the Department of Energy.

**For Computers:**

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.

**For Servers:**

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.

Higher the "*Energy Star*" of an equipment better greener is its use environmentally.

### *Recent Steps toward Green Manufacturing:*

#### *1) 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 catalogue of green products from its member organizations and information for reducing PC power consumption. It was started on 2007-06-12.

#### *2) 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.

#### *3) 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.

#### *4) The Green Grid:*

It is a global consortium dedicated to advancing energy efficiency in data centres and business computing ecosystems. It was founded in February 2007 by several key companies in the industry – AMD, APC, Dell, HP, IBM, Intel, and Microsoft, Rack able Systems, Spray Cool, 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 centre efficiency.

# Case Study on Blackle

## *Background:*
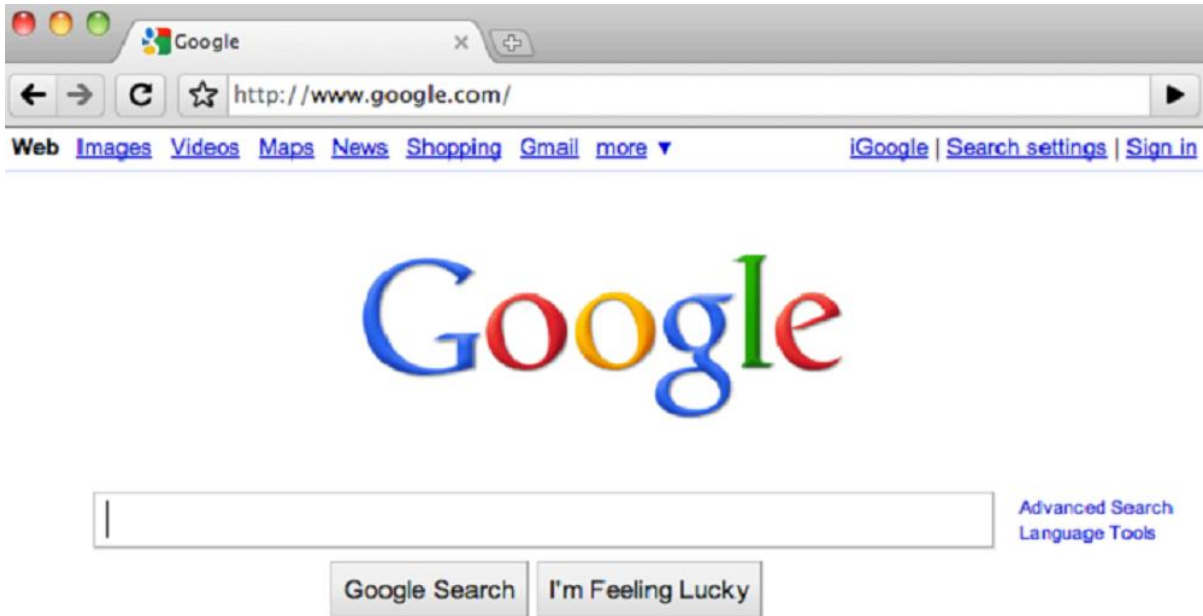


## *One Google search is equal to turning on a 60W light bulb for 17 seconds.*

Several scientists and researchers tried to find the Carbon Footprints of Google Search and conclusion which they made was enough to straighten the eyebrows of us all towards it. Here's what the Times Online said over the weekend in summarizing these estimates:
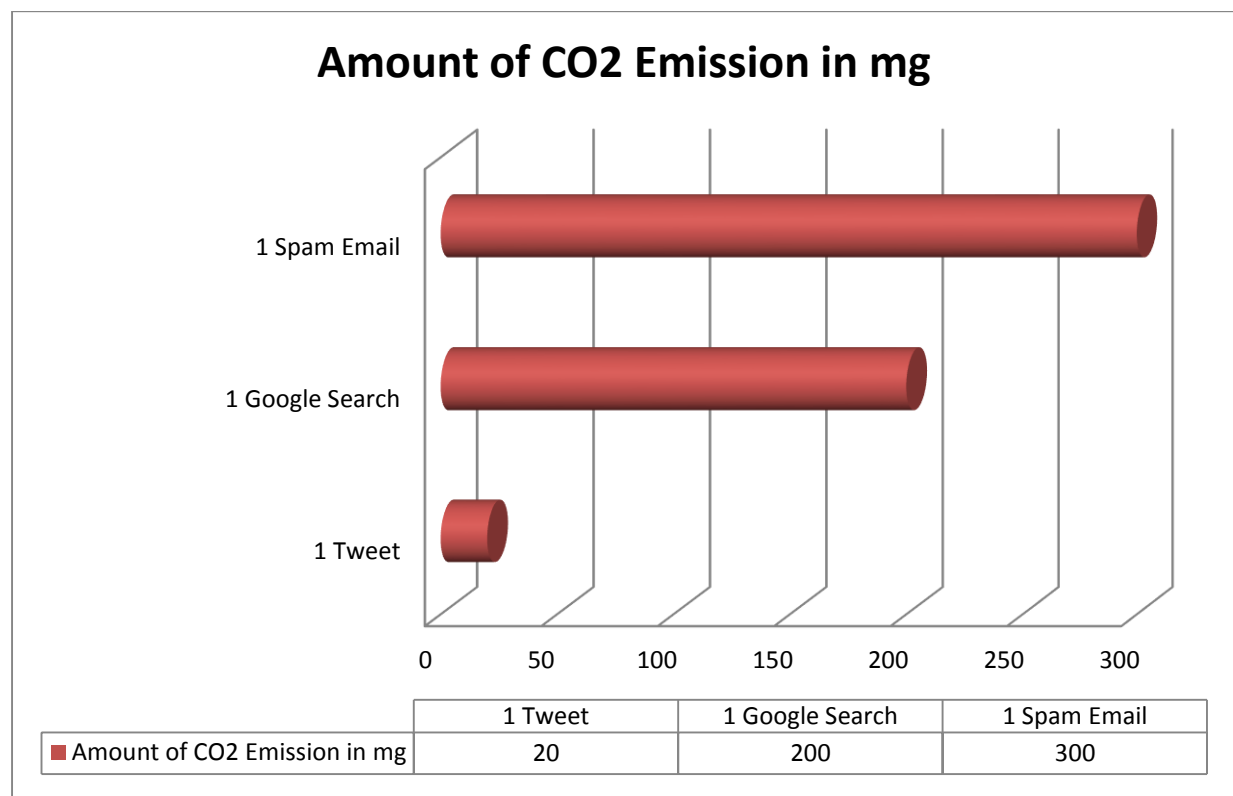
"*Performing two Google searches from a desktop computer can generate about the same amount of carbon dioxide as boiling a kettle for a cup of tea, according to new research.*"

While millions of people tap into Google without considering the environment, *a typical search generates about 7g of $CO_2$* Boiling a kettle generates about 15g. "Google operates huge data centres around the world that consume a great deal of power," said Alex Wisner-Gross, a Harvard University physicist whose research on the environmental impact of computing is due out soon. "*A Google search has a definite environmental impact.*"
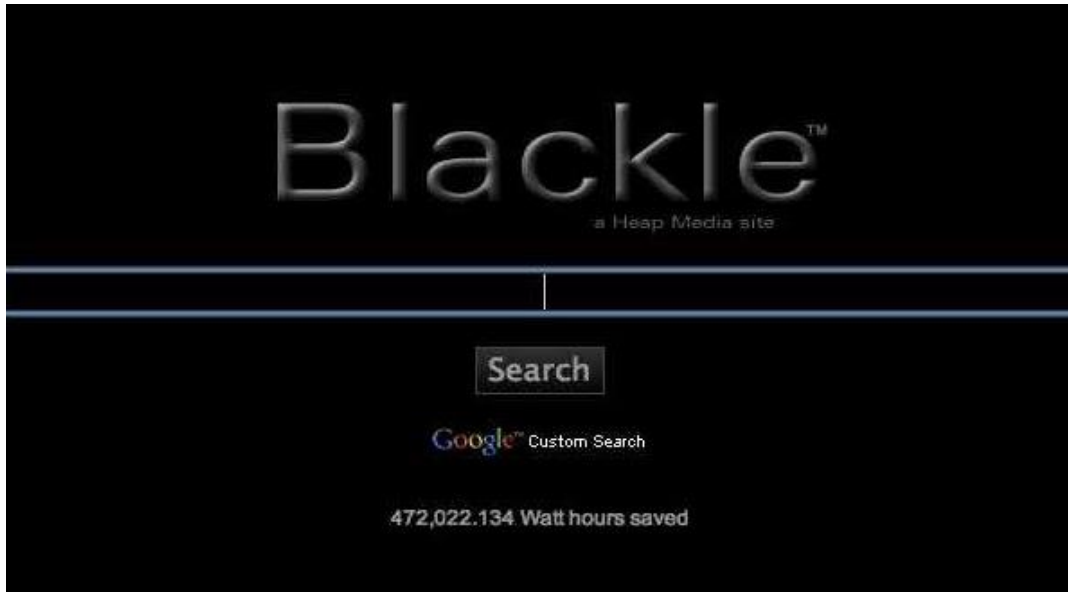
Now consider that people conduct over 1 billion searches a day, and you've got a massive energy footprint of roughly **12.5 million watts.**

The issue is how much energy is used by Google's data centres, which process search queries from all over the globe. There's another estimate in the piece, which is more favourable for Google:

A separate estimate from John Buckley, managing director of carbonfootprint.com, a British environmental consultancy, puts the $CO_2$ emissions of a Google search at between 1g and 10g, depending on whether you have to start your PC or not. Simply running a PC generates between 40g and 80g per hour, he says. Of $CO_2$ Chris Good all, author of Ten Technologies to Save the Planet, estimates the carbon emissions of a Google search at 7g to 10g (assuming 15 minutes' computer use).

## Amount of CO2 Emission in mg

| | 1 Tweet | 1 Google Search | 1 Spam Email |
|---|---|---|---|
| ■ Amount of CO2 Emission in mg | 20 | 200 | 300 |

## *Alternative: Blackle*



## *What Is Blackle?*

Blackle is a search-engine site powered by Google Search. Blackle came into being based on the concept that when a computer screen is white, presenting an empty word or the Google home, and one's computer consumes 74W. When the screen is black, it consumes only 59W. Based on this theory if everyone switched from Google to Blackle, mother earth would save 750MW each year. This was a really good implementation of Green Computing. The principle behind Blackle is based on the fact that the display of different colours consumes different amounts of energy on computer monitors.

## *How Does It Work?*

Blackle saves energy because the screen is predominantly black. "Image displayed is primarily a function of the user's colour settings and desktop graphics, as well as the colour and size of open application windows; a given monitor requires more power to display a white (or light) screen than a black (or dark) screen."

In January 2007 a blog post titled Black Google Would Save 750 Megawatt-hours a Year proposed the theory that a black version of the Google search engine would save a fair bit of energy due to the popularity of the search engine.

In 2016 the majority of monitor sales are LED backlit LCD's which do not light up the parts of the screen that are black. Some older CCFL LCD monitors

worked by wastefully backlighting the entire screen. Since 2005 manufacturers have moved away from CCFL's.

The Black Manufacturers believe that there is value in the concept because even if the energy savings are small, they all add up. Secondly they feel that seeing Blackle every time we load our web browser reminds us that we need to keep taking small steps to save energy.

Blackle was created by *Heap Media* and is powered by *Google Custom Search*.
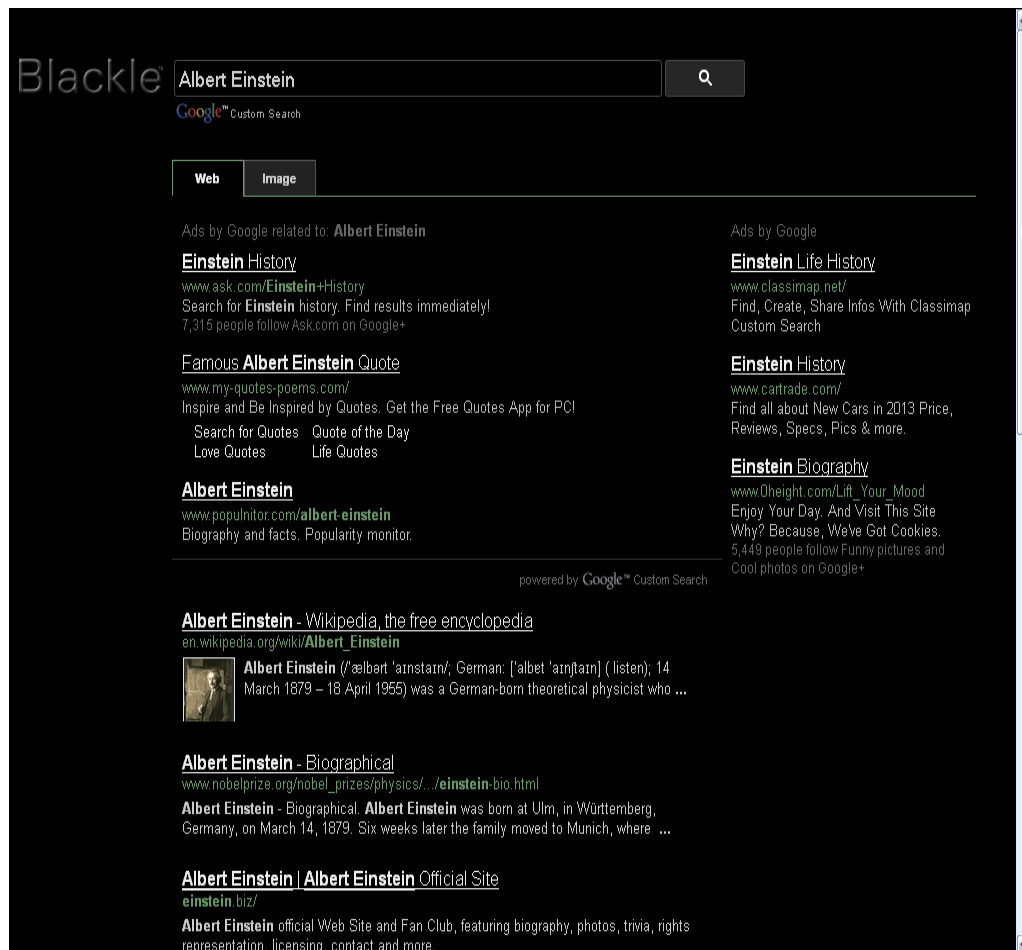


*Darker shades seem to influence the power draw from monitors the least.*

Independent studies and experiments carried out by various websites and organisation drive our attention towards dark shades screens for less energy consumption.

One of such researches was done by website PCSTATS.com where they hooked up an *EXTECH POWER ANALYSER* to a 19inch CRT and a 19 inch LCD.

Blackle's claims appear to hold water, although the difference is just 17.7W and 3.8W for CRT and LCD respectively. What that adds up to over the course of a year, for every second you spend doing a search on Google is massive.

*The resulting monitor power consumption to display a webpage fluctuated as shown below:*
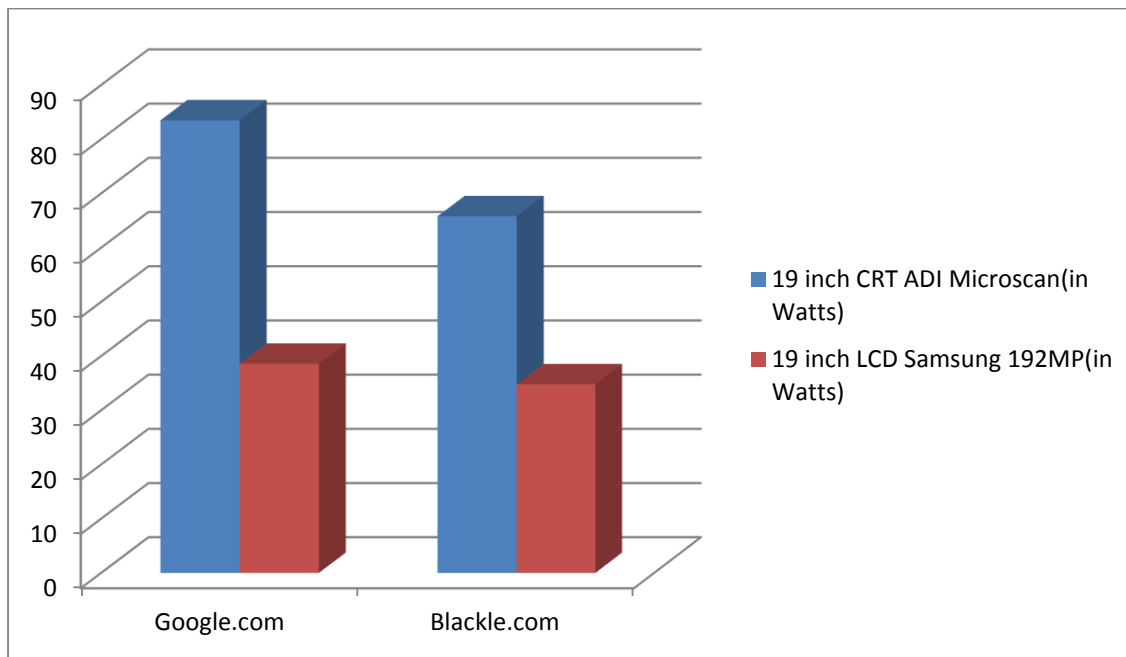


Before comparing Google and Blackle another important aspect of energy saving depends on **colour scheme of website and its web design**. The brighter colours used in a web page increases energy used in its access. This assumption was proved by the study of State University of St.Petersberg which said that **"Energy consumed by monitors having Solid colours was much higher than those having Grey scales colours"**

| Monitor Power Consumption - Solid Colours (Full screen, solid colour) | | |
|---|---|---|
| Colour | 19" CRT ADI Microscan | 19" LCD Samsung 192MP |
| (red) | 72.2W | 37.2W |
| (yellow) | 78.9W | 38.7W |
| (green) | 69.9W | 37.6W |
| (cyan) | 74.9W | 38.9W |
| (blue) | 68.5W | 37.4W |
| (magenta) | 77.4W | 38.2W |

| Monitor Power Consumption - Greyscales (Full screen, solid colour) | | |
| --- | --- | --- |
| Grey | 19" CRT ADI Microscan | 19" LCD Samsung 192MP |
| | 84.9W | 40.0W |
| | 76.8W | 39.3W |
| | 70.8W | 38.9W |
| | 69.8W | 38.5W |
| | 66.3W | 38.1W |
| | 63.5W | 35.5W |

The above table justify that method proposed by Blackle of using grey scales colours would be more eco-friendly as compared to current situation of using solid colours.

What is the carbon footprint of some of the most popular websites out there? How about websites those focus on environmentally friendly design, products, lifestyles and energy sources? Are there websites which disseminate this timely and important information using a power sensitive color scheme?

Blackle answers all these questions successfully.
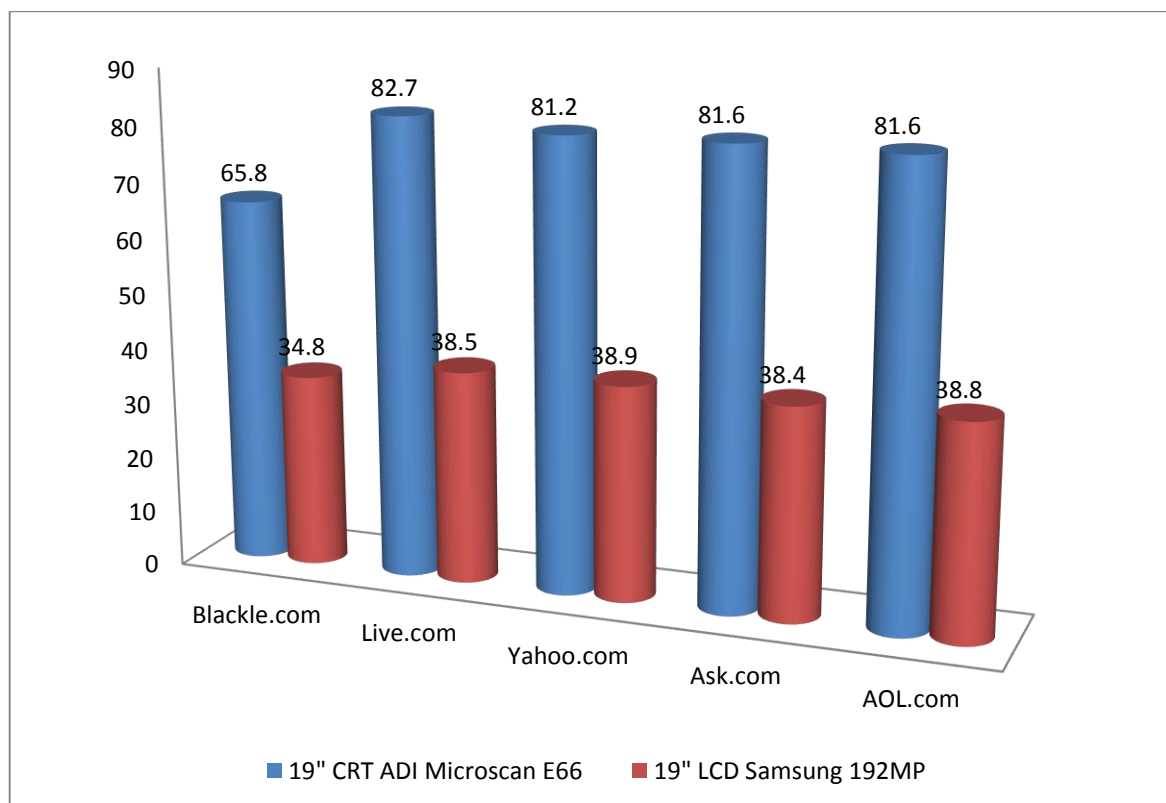
From all these comparisons and research work it is clear that Blackle can be considered as a greener alternate to Google but on the other side of the coin, a lot of claims made by Blackle are still controversial and a number of organisations are questioning their method of calculating energy utilised.

So, further study is required on Blackle before it can be used on larger scale.
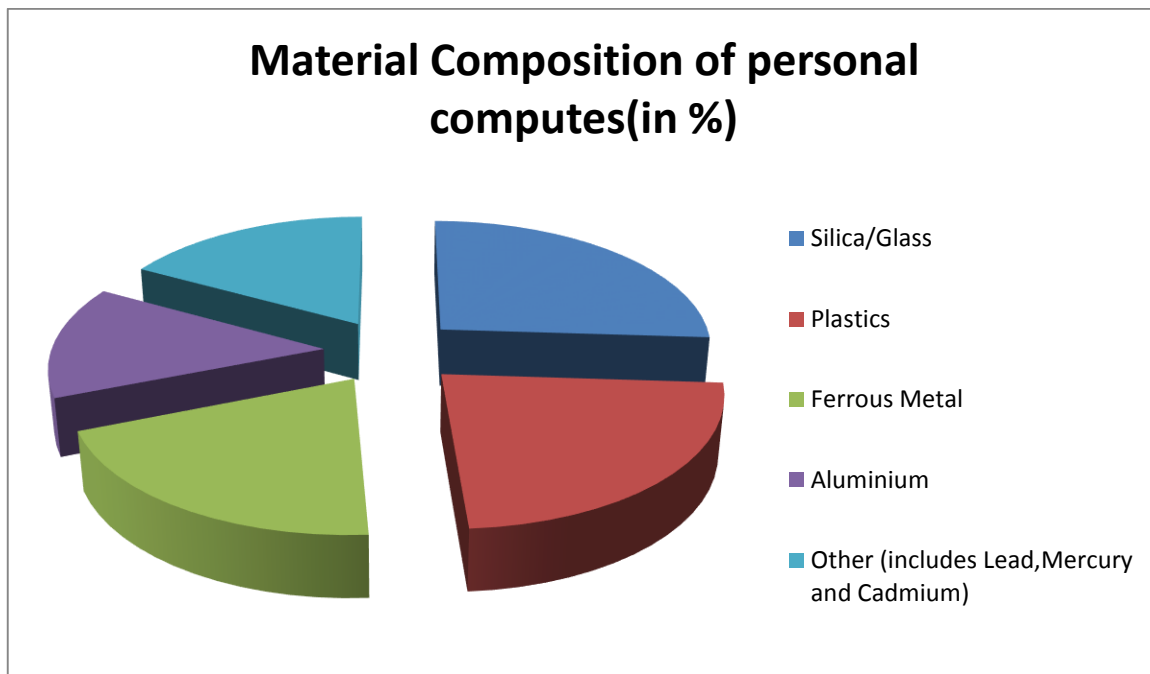
# Case Study on Zonbu Computers

*Background:*
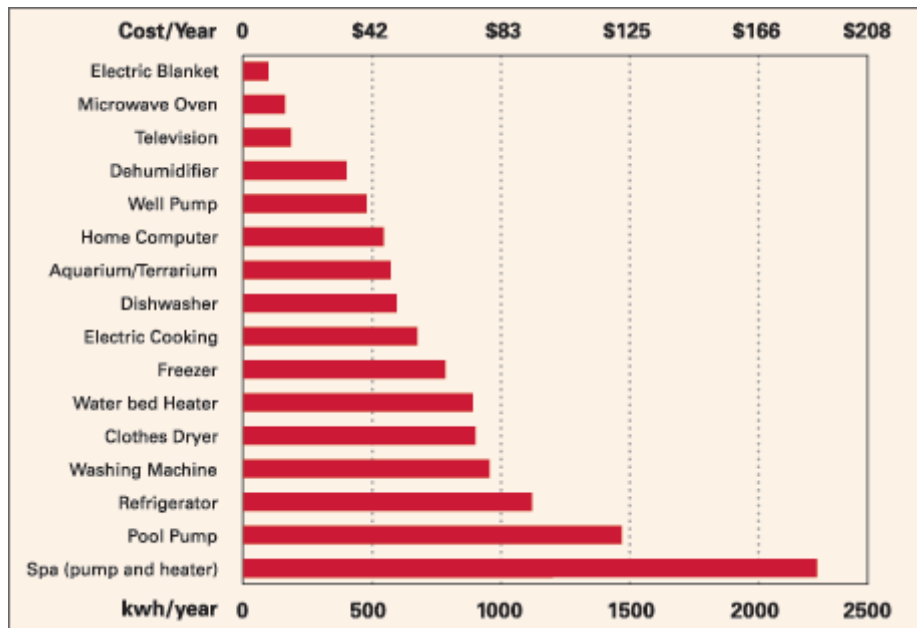


Normal home computers use 550kwh/year energy. However from environmental point of view home pc which we use about 24*7 is actually harming the environment.



- *They generate **1.8 million metric** ton of **e-waste**.*
- *They emit **118 million metric** ton of $CO_2$ each year.*

- *Computer products often contain hazardous and toxic materials that pose environmental risks if they are landfill or incinerated.Like the following:*

  1. *Computer monitor use cathode ray tubes (CRTs), which have major amounts of lead.Lead can cause damage to the central and peripheral nervous system, blood systems and kidneys.*
  2. ***Printed circuit boards** contain primarily plastic and **copper**, and most have small amounts **of chromium, lead solder, nickel, and zinc.***
  3. *In addition, many computers have **batteries** that often contain **nickel, cadmium, and other heavy metals.** Mercury and Cadmium are classified as toxic. Mercury spreads out in water bodies transforming in methylated mercury that can cause chronic brain damage.*

## Material Composition of personal computes(in %)

- Silica/Glass
- Plastics
- Ferrous Metal
- Aluminium
- Other (includes Lead,Mercury and Cadmium)

## Alternative:

## Zonbu Computers:

Zonbu is a technology company that markets a computing platform which combines a web-centric service, a small form factor PC, and an open source based software architecture. The Zonbu subscription plans include online storage (using Amazon S3), automatic upgrades, online support and remote file access. The Zonbu OS is a customized version of Linux based on the Gentoo distribution using the Xfce desktop environment. It is geared towards non-

technical users, and the user interface focuses more on simplicity than advanced features.

The file system architecture combines a transparent overlay file system (pioneered by Linux Live Distributions) with an on-line back-up service. User data is locally cached on Compact Flash Card, then transparently encrypted with 128-bit encryption and transferred to remote storage servers at Amazon S3.



### *What makes Zonbu a product of Green Manufacturing?*

 The Company has made a commitment to create products that are not only affordable, but environmentally responsible as well. The Desktop Mini was the first EPEAT Gold certified consumer desktop based upon meeting stringent environmental criteria and compliant with ENERGY STAR 4 and RoHS standards (Reduction of Hazardous Substances). The Notebook obtained the EPEAT Silver status.

Not only is Zonbu energy efficient, but it is manufactured with the environment in mind.

*"At just over two pounds, Zonbu device consumes at least four times fewer chemicals and fossil fuels during manufacturing than conventional desktop PCs. Moreover, the Zonbu manufacturing process complies with the high standards of the European RoHS Directive. This restricts hazardous substances in electronic equipment, including cadmium, mercury, lead, hexavalent chromium and certain brominated flame retardants."*

According to the Company, the use of a Zonbu Desktop Mini reduces your carbon footprint by 1 ton each year, and could save you as much as $10 a month in electricity. Additionally, to eliminate any further carbon footprint of your device, the Company buys regulatory grade carbon offsets from Climate Trust, a top-ranked provider.

*Recycling:* When you are ready to upgrade your computer, you can send it back to the Company. Try and resend it in its original packaging. Not only will they *recycle* the old packaging, they will dismantle the old device, and properly recycle its parts. No more electronic waste piling up in our landfills or hazardous chemicals leaching out of them.

| Criteria | Standard PC | Zonbu Device |
|---|---|---|
| *Average Energy Use* | 175W | 15W |
| *CO2 Emission* | 2071 pounds | 177 pounds |
| *Energy Consumption* | 1534 kWh/year | 131 kWh/year |
| *Emission after Carbon Offset* | 2071 pounds | 0 pounds |
| *Equivalent gallons of gasoline used* | 107 gallons | 0 gallons |

*Table based on study conducted by website [www.pcstats.com](www.pcstats.com).*

Zonbu produce only public use computers to get "GOLD" certification by EPSEAT among all the 530 computers certified by the organisation. "No one has developed a greener alternative for consumers," said Jeff Omelchuck, executive director of the Green Electronics Council, which manages the EPEAT program. "In addition to meeting or exceeding most of our environmental criteria, Zonbu consumes a fraction of the power of most desktops."

However, there are many perceived drawbacks to using a Zonbu system in lieu of a traditional personal computer. Obviously, the prospect of storing one's files online may alarm the security-conscious, as anyone with access to the file server can access the files. Additionally, while failure of the home user's Zonbu machine would not result in data loss, failure or even unavailability of the file server would mean that one could not access their data. Even a simple Internet connection problem would result in data isolation. As of

summer 2007, no information is provided on Zonbu's website regarding their policy of data retention and access should a user default on their monthly payments, or unsubscribe from the service altogether. This has caused concerns regarding data hijacking and subsequent ransom.

# Case Study on SunRay Thin Client

The background on *Zonbu* computers of energy wastage, high power usage and e-waste also hold for SunRay Thin Clients. These PC systems also try to fulfil above mentioned requirements in their own way.



Oracle's Sun Ray Clients are simple, ultra-reliable, low-power devices that are ideal for displaying server-hosted virtual desktops. Sun Ray Clients are designed for secure, cost-effective virtualized desktop environments and don't require a local operating system or management, eliminating the complexity, expenses, and security vulnerabilities associated with other thin client and PC solutions.

The *Sun Ray Client architecture* consists of two major components: *the Sun Ray Client device* and *Sun Ray Software*.

**Sun Ray Clients** are simple, low-cost, low-power consumption devices that require no desktop administration. Sun Ray Clients differ from complex PCs and other thin clients with embedded operating systems because they have no local operating system (such as Windows XP Embedded or Windows CE) to manage, administer, or create vulnerabilities. This also eliminates the need to upgrade the client when new applications are introduced or more computing power is required. For maximum convenience and security, every Sun Ray Client contains an integrated smart card reader, enabling a user to simply insert

their smart card into any available Sun Ray Client and instantaneously accesses their existing session over a local or wide-area network (LAN or WAN).

**Sun Ray Software** provides user, client, and server authentication, firmware updates, as well as user session management across the environment. User sessions are load balanced across the servers in the group to optimize performance for users.

Environmentally Responsible Computing the Sun Ray 3i Client is one of the most eco-friendly clients on the market, offering the following benefits:

• Consumes less power than most thin clients and a fraction of a typical PC, earning it the ENERGY STAR 5.0 Category A qualification.

• The Sun Ray 3i Client is an EPEAT Silver registered product. EPEAT is operated by the non-profit Green Electronics Council and used by corporations and government to identify greener products.

• Compact and light, which means reduced costs and energy for transport.

• Negligible heat emission results in reduced cooling costs and no requirement for fans.

• 98% recyclable, and free from many environmentally hazardous materials, with minimal waste in assembly and packaging, and less production materials than typical PCs.

• Dramatically reduces e-waste with a significantly longer product life expectancy than a typical PC, with dramatically fewer desktop refreshes.

## *How does the Sun Ray help the environment?*

- *Lower power and cooling usage*. 4-7 watts vs. over 100 for the typical PC.
- *Reduced waste.* A Sun Ray has no disk drive, DVD drive or fans. When discarded it has a significantly smaller circuit board, enclosure and power supply than a typical PC. Our basic Sun Ray 2 weighs less than one pound.
- *Improve real estate usage*. At Sun we have reduced our real estate significantly because of the "hot-desking" feature of the Sun Ray thin client. We can allocate 2-3 mobile workers to one cube. This reduces waste, power, cooling and other factors.
- *Improved resource utilization*. Processors can be shared among users. No longer is a 3 GHz processor locked up in a box in the cube next to you

while that person is out of the office or on vacation.  In this shared environment, many users can be allocated to a small number of processors.

### *The Sun Ray thin client also helps to control costs in a number of ways:*

- No patching required.
- No local software installation on each device.
- No reason to replace it every three years.  We have Sun Ray devices over 7 years old.  Think of it as a VT100 terminal on steroids.
- Reduced system administration costs through centralized management.
- Upgrades for hardware (CPU, Memory, and Disk) and Software (Word processing, mail etc.) occur in a centralized location rather than on the desktop.  A single a central Sun Ray server provides additional power to all of its users.
- Reduced cost to move an employee.  Simply pull out your smart card and switch to any cubicle available.
- Reduced data loss and backup issues.  All data is kept in centrally managed and backed up data centres by professionals.
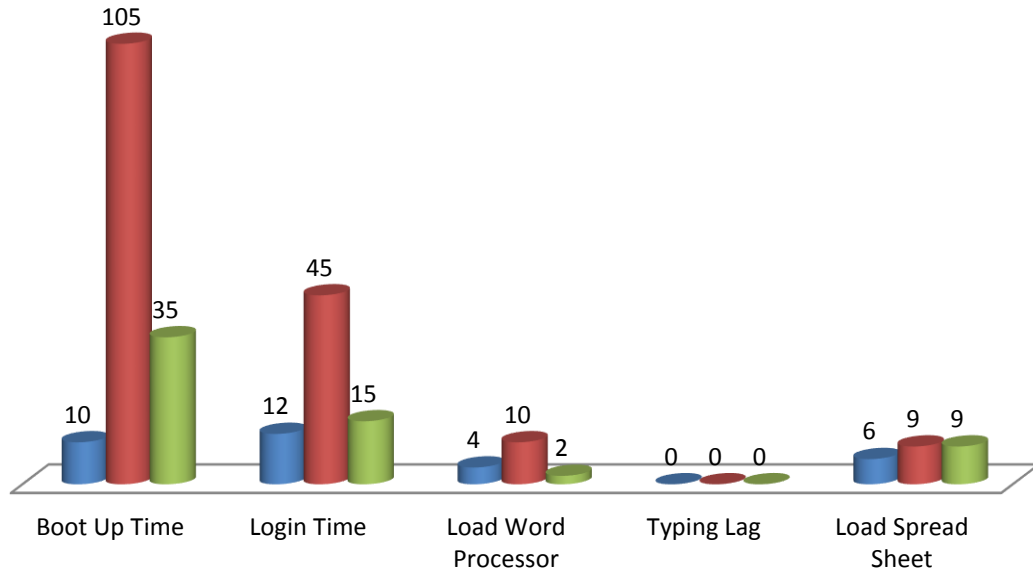
The above made claims were also confirmed by a number of  IT giants including Apple, Google and Verizon who used SunRay thin clients.

Verizon CIO John Hinshaw confirmed a juicy green nugget of data in a recent interview: He said the wireless giant has reduced energy consumption by 30% since replacing PCs with Sun Ray thin clients in the company's call centres.  That will translate to a savings of $1 million per year for Verizon, once the company rolls out thin clients (or some "desktop-less" variants) in its remaining data centres.

Sun Ray 3 Series Clients were honoured by the Industrial Designers Society of America (IDSA) for their 'concept-through-production' focus on eco-friendliness in the design, materials, packaging, power consumption, weight/shipping, and carbon footprint; human factors such as no moving parts and a touch-sensitive power switch; and the consistency of features throughout the product line.

# Time Used By Various PCs

■ Thin Client  ■ Managed PC (Lean)  ■ Desktop PC(Compact)

| | Boot Up Time | Login Time | Load Word Processor | Typing Lag | Load Spread Sheet |
|---|---|---|---|---|---|
| Thin Client | 10 | 12 | 4 | 0 | 6 |
| Managed PC (Lean) | 105 | 45 | 10 | 0 | 9 |
| Desktop PC(Compact) | 35 | 15 | 2 | 0 | 9 |

*All time in seconds. Results based on office work conducted by Verizon Wireless.*

# Conclusion

The reason for a development in the sector of green computing specially that of green manufacturing has been many but to name a few we can say that

- *Because* the world's appetite for energy is outpacing production of renewable and non-renewable resources.
- *Because* that the world is too densely populated to escape the effects of Greenhouse gas emissions, electronic waste disposal and toxic production methods.
- *Because* ICT is both part of the problem and a key to the solution.
- *Because* to thrive requires combining social responsibility, smart resource use and technological innovation.

Green Manufacturing is like a boon in this situation. It simply refers to method of manufacturing that minimises waste and pollution. There have been a lot of developments and groups in this sector of industry like *Climate Savers Computing Initiative, Green Computing Impact Organization Inc., Green Electronics Council, etc.* ,which works in improving the output of this sector.

Not only e-waste but also the energy consumption of existing technology is the driving force towards Green Manufacturing. New more eco-friendly products are required to make the world a green place. The have been a lot of development in this sector which we can see in form of Blackle, Zonbu Computers and SunRay thin client.

Although we have covered a lot distance in this sector but in order to balance the damage already done, more effort and participation is required.

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