

Green computing

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Abstract:

Green computing, Green ICT as per IFG International Federation of Green ICT and IFG Standard, green IT, or ICT sustainability, is the study and practice of environmentally sustainable computing or IT. San Murugesan notes that this can include "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."^[1]

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 the recyclability or biodegradability of defunct products and factory waste. Green computing is important for all classes of systems, ranging from handheld systems^[2] to large-scale data centers.^[3]

Many corporate IT departments have green computing initiatives to reduce the environmental impact of their IT operations

In 1992, the U.S. Environmental Protection Agency launched Energy Star, a voluntary labeling program that 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. 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.

Keywords: Green computing, Green certifications .

1. Introduction

What is green computing?

Green computing, also called green technology, is the environmentally responsible use of computers and related resources. Such practices include the implementation of energy-efficient central processing units (CPUs), servers and peripherals as well as reduced resource consumption and proper disposal of electronic waste (e-waste).

One of the earliest initiatives toward green computing in the United States was the voluntary labeling program known as Energy Star. It was conceived by the Environmental Protection Agency (EPA) in 1992 to promote energy efficiency in hardware of all kinds. The Energy Star label became a common sight, especially in notebook computers and displays. Similar programs have been adopted in Europe and Asia.

Government regulation, however well-intentioned, is only part of an overall green computing philosophy. The work habits of computer users and businesses can be modified to minimize adverse impact on the global environment.

Here are some steps that can be taken:

Hybrid cloud command and control

- Power-down the CPU and all peripherals during extended periods of inactivity.

- Try to do computer-related tasks during contiguous, intensive blocks of time, leaving hardware off at other times.
- Power-up and power-down energy-intensive peripherals such as laser printers according to need.
- Use liquid-crystal-display (LCD) monitors rather than cathode-ray-tube (CRT) monitors.
- Use notebook computers rather than desktop computers whenever possible.
- Use the power-management features to turn off hard drives and displays after several minutes of inactivity.
- Minimize the use of paper and properly recycle waste paper.
- Dispose of e-waste according to federal, state and local regulations.
- Employ alternative energy sources for computing workstations, servers, networks and data centers.

Perhaps the most talked about aspect of green technology is the promise of alternative energy sources. Sun, wind, water, sugar — we've heard about them all. However, scientists are working on other aspects of the problem as well, testing building materials and studying chemical processes to reduce the use and generation of hazardous substances. Nanotechnology is also being used in an attempt to manipulate materials at the nanometer scale; scientists are hoping it can transform manufacturing on a

global level, from government purchasing to a technological revolution.

The huge amount of computing manufactured worldwide has a direct impact on environment issues, and scientists are conducting numerous studies in order to reduce the active nonhazardous materials in the products' manufacturing process.

VIA Technologies 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.

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. 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.)

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

negative impact of computing technology on our natural resources. Companies are addressing e-waste by offering take-back recycling programs and other solutions, with lower energy consumption and less wasted hardware. A central point of research is testing and applying alternate 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.

In addition, 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. Wetlands also provide a great service in sequestering some of the carbon dioxide emitted into the atmosphere. Although they make up only 4 to 6 percent of the Earth's landmass, wetlands are capable of absorbing 20 to 25 percent of the atmospheric carbon dioxide. VIA is working closely with organizations responsible for preserving wetlands and other natural habitats, and others who support extensive recycling programs for ICT equipment. The amount paid to these organizations will be represented by a proportion of the carbon-free product's price.

Carbon-emissions control has been a key issue for many companies who have expressed a firm commitment to sustainability. Dell is a good example of a company with a green image, known for its free worldwide product-recycling program. Dell's Plant a Tree for Me project allows customers to offset their carbon emissions by paying an extra \$2 to \$4, depending on the product purchased. AMD, a global microprocessor manufacturer, is also working toward reducing energy consumption in its products, cutting back on hazardous waste and reducing its eco-impact. The company's use of silicon-on-insulator (SOI) technology in its manufacturing, and strained silicon capping films on transistors (known as "dual stress liner" technology), have contributed to reduced power consumption in its products.

Solar Computing



Fig. 1 Solar powered 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's 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.

Figure 2 : how to be green with gadgets.

Software and deployment optimization

Algorithmic efficiency

Main article: [Algorithmic efficiency](#)

Further information: [Analysis of algorithms](#)

The efficiency of algorithms has an impact on the amount of computer resources required for any given computing function and there are many efficiency trade-offs in writing programs. Algorithm changes, such as switching from a slow (e.g. linear) search algorithm to a fast (e.g. hashed or indexed) search algorithm can reduce resource usage for a given task from substantial to close to zero. A study by a physicist at Harvard, estimated that the average Google search released 7 grams of carbon dioxide (CO₂). However, Google disputes this figure, arguing instead that a typical search produces only 0.2 grams of CO₂.

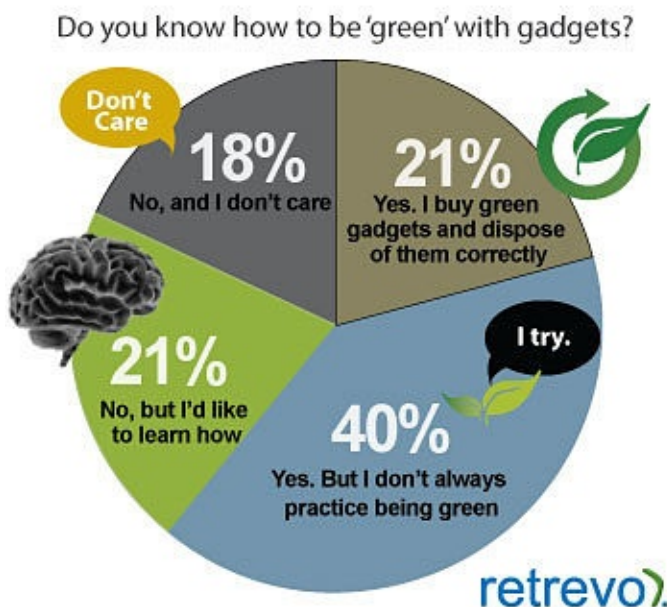
Resource allocation

Main article: [Resource allocation](#)

Algorithms can also be used to route data to data centers where electricity is less expensive. Researchers from MIT, Carnegie Mellon University, and Akamai have tested an energy allocation algorithm that successfully routes traffic to the location with the cheapest energy costs. The researchers project up to a 40 percent savings on energy costs if their proposed algorithm were to be deployed. However, this approach does not actually reduce the amount of energy being used; it reduces only the cost to the company using it. Nonetheless, a similar strategy could be used to direct traffic to rely on energy that is produced in a more environmentally friendly or efficient way. A similar approach has also been used to cut energy usage by routing traffic away from data centers experiencing warm weather; this allows computers to be shut down to avoid using air conditioning.^[27]

Larger server centers are sometimes located where energy and land are inexpensive and readily available. Local availability of renewable energy, climate that allows outside air to be used for cooling, or locating them where the heat they produce may be used for other purposes could be factors in green siting decisions.

Approaches to actually reduce the energy consumption of network devices by proper network/device management techniques are surveyed in. The authors grouped the



approaches into 4 main strategies, namely (i) Adaptive Link Rate (ALR), (ii) Interface Proxying, (iii) Energy Aware Infrastructure, and (iv) Energy Aware Applications.

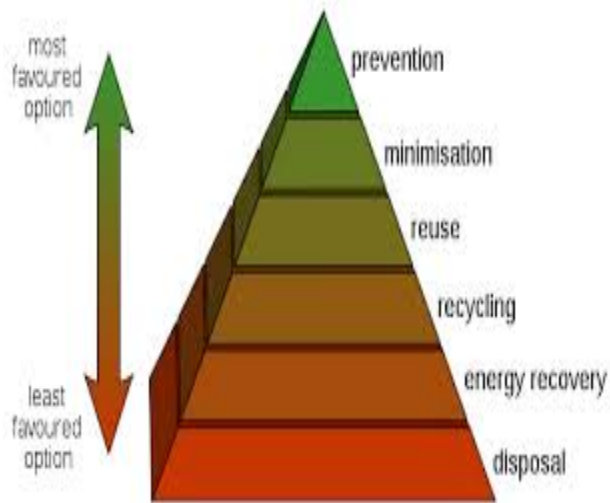


Figure 5 :options most and least favoured in Green computing.

Virtualizing

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. Virtualization can assist in distributing work so that servers are either busy or put in a low-power sleep state. 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 virtual computing.

Terminal server

Terminal servers have also been used in green computing. When using the system, users at a terminal connect to a central server; all of the actual computing is done on the server, but the end user experiences the operating system on the terminal. These can be combined with thin clients, which use up to 1/8 the amount of energy of a normal workstation, resulting in a decrease of energy costs and consumption.^[citation needed] There has been an increase in using terminal services with thin clients to create virtual labs. Examples of terminal server software include Terminal Services for Windows and the Linux Terminal Server Project (LTSP) for the Linux operating system.

Power management

The Advanced Configuration and Power Interface (ACPI), an open industry standard, allows an operating system to directly control the power-saving aspects of its underlying hardware. This allows a system to automatically turn off components such as monitors and hard drives after set periods of inactivity. In addition, a system may hibernate, when most components (including the CPU and the system RAM) are turned off. ACPI is a successor to an earlier Intel-Microsoft standard called Advanced Power Management, which allows a computer's BIOS to control power management functions.

Some programs allow the user to manually adjust the voltages supplied to the CPU, which reduces both the amount of heat produced and electricity consumed. This process is called undervolting. Some CPUs can automatically undervolt the processor, depending on the workload; this technology is called "SpeedStep" on Intel processors, "PowerNow!"/"Cool'n'Quiet" on AMD chips, LongHaul on VIA CPUs, and LongRun with Transmeta processors.

Data center power

Data centers, which have been criticized for their extraordinarily high energy demand, are a primary focus for proponents of green computing. Data centers can potentially improve their energy and space efficiency through techniques such as storage consolidation and virtualization. Many organizations are aiming to eliminate underutilized servers, which results in lower energy usage. The first step toward this aim will be training of data center administrators. The U.S. federal government has set a minimum 10% reduction target for data center energy usage by 2011. With the aid of a self-styled ultraefficient evaporative cooling technology, Google Inc. has been able

to reduce its energy consumption to 50% of that of the industry average.

Operating system support

Microsoft Windows, has included limited [PC power management](#) features since Windows 95. These initially provided for stand-by (suspend-to-RAM) and a monitor low power state. Further iterations of Windows added hibernate (suspend-to-disk) and support for the [ACPI](#) standard. Windows 2000 was the first NT-based operating system to include power management. This required major changes to the underlying operating system architecture and a new hardware driver model. Windows 2000 also introduced [Group Policy](#), a technology that allowed administrators to centrally configure most Windows features. However, power management was not one of those features. This is probably because the power management settings design relied upon a connected set of per-user and per-machine binary registry values, effectively leaving it up to each user to configure their own power management settings.

This approach, which is not compatible with Windows Group Policy, was repeated in Windows XP. The reasons for this design decision by Microsoft are not known, and it has resulted in heavy criticism. Microsoft significantly improved this in Windows Vista by redesigning the power management system to allow basic configuration by Group Policy. The support offered is limited to a single per-computer policy. The most recent release, Windows 7 retains these limitations but does include refinements for [timer coalescing](#), [processor power management](#), and display panel brightness. The most significant change in Windows 7 is in the user experience. The prominence of the default High Performance power plan has been reduced with the aim of encouraging users to save power.

There is a significant market in third-party [PC power management](#) software offering features beyond those present in the Windows operating system. Most products offer [Active Directory](#) integration and per-user/per-machine settings with the more advanced offering multiple power plans, scheduled power plans, anti-insomnia features and enterprise power usage reporting. Notable vendors include [IE NightWatchman](#), [Data Synergy PowerMAN \(Software\)](#), [Faronics Power Save](#), [Verdiem SURVEYOR](#) and [EnviProt Auto Shutdown Manager](#)

Power supply

Desktop [computer power supplies](#) (PSUs) are in general 70–75% efficient,^[47] dissipating the remaining energy as heat. A certification program 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.

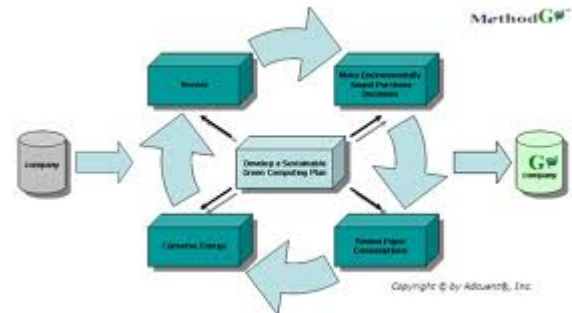


Figure 6 Green computing method.

Storage

Smaller form factor (e.g., 2.5 inch) [hard disk drives](#) often consume less power per gigabyte 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.

In a recent case study, [Fusion-io](#), manufacturer of solid state storage devices, managed to reduce the energy use and operating costs of [MySpace](#) data centers by 80% while increasing performance speeds beyond that which had been attainable via multiple hard disk drives in Raid 0. In response, MySpace was able to retire several of their servers.

As hard drive prices have fallen, storage farms have tended to increase in capacity to make more data available online. This includes archival and backup data that would formerly have been saved on tape or other offline storage. The increase in online storage has increased power consumption. Reducing the power consumed by large storage arrays, while still providing the benefits of online storage, is a subject of ongoing research.

Video card

A fast [GPU](#) may be the largest power consumer in a computer.^[56]

Energy-efficient [display](#) options include:

- No video card - use a shared terminal, shared [thin client](#), or [desktop sharing](#) software if display required.
- Use motherboard video output - typically low 3D performance and low power.

- Select a GPU based on low idle power, average wattage, or [performance per watt](#).

Display

[CRT monitors](#) typically use more power than LCD monitors. They also contain significant amounts of lead. [LCD monitor](#) 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. Fluorescent back-lights also contain mercury, whereas LED back-lights do not.

Materials recycling

Recycling computing equipment can keep harmful materials such as lead, mercury, and hexavalent chromium out of [landfills](#), and can also replace equipment that otherwise would need to be manufactured, saving further energy and emissions. Computer systems that have outlived their particular function can be re-purposed, 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. Computing supplies, such as [printer cartridges](#), [paper](#), and [batteries](#) may be recycled as well.

A drawback to many of these schemes is that computers gathered through recycling drives are often 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](#) and [Pakistan](#).

In 2011, the collection rate of e-waste is still very low, even in the most ecology-responsible countries like France. In this country, e-waste collection is still at a 14% annual rate between electronic equipment sold and e-waste collected for 2006 to 2009. The recycling of old computers raises an important privacy issue. The old storage devices still hold private information, such as emails, passwords, and credit card numbers, which can be recovered simply by someone's using software available freely on the Internet. Deletion of a file does not actually remove the file from the hard drive. Before recycling a computer, users should remove the hard drive, or hard drives if there is more than one, and physically destroy it or store it somewhere safe. There are some authorized hardware recycling companies to whom the computer may be given for recycling, and they typically sign a non-disclosure agreement.

Cloud computing

Cloud computing addresses two major ICT challenges related to Green computing – energy usage and resource consumption. [Virtualization](#), [Dynamic provisioning environment](#), multi-tenancy, green data center approaches are enabling cloud computing to lower carbon emissions and energy usage up to a great extent. Large enterprises and small businesses can reduce their direct energy consumption and carbon emissions by up to 30% and 90% respectively by moving certain on-premises applications into the cloud.

Telecommuting

[Teleconferencing](#) and [telepresence](#) technologies are often implemented in green computing initiatives. The advantages are many; increased worker satisfaction, reduction of greenhouse gas emissions related to travel, and increased profit margins as a result of lower overhead costs for office space, heat, lighting, etc. The savings are significant; the average annual energy consumption for U.S. office buildings is over 23 kilowatt hours per square foot, with heat, air conditioning and lighting accounting for 70% of all energy consumed.^[69] Other related initiatives, such as [hotelling](#), reduce the square footage per employee as workers reserve space only when they need it. Many types of jobs, such as sales, consulting, and field service, integrate well with this technique.

[Voice over IP \(VoIP\)](#) reduces the telephony wiring infrastructure by sharing the existing Ethernet copper. VoIP and phone extension mobility also made [hot desking](#) more practical.

Telecommunication network devices energy indices^[edit]

The information and communication technologies (ICTs) energy consumption, in the USA and worldwide, has been estimated respectively at 9.4% and 5.3% of the total electricity produced. The energy consumption of ICTs is today significant even when compared with other industries. Some study tried to identify the key energy indices that allow a relevant comparison between different devices (network elements). This analysis was focused on how to optimise device and network consumption for carrier telecommunication by itself. The target was to allow an immediate perception of the relationship between the network technology and the environmental impact. These studies are at the start and the gap to fill in this sector is still huge and further research will be necessary.

Supercomputers

The inaugural Green500 list was announced on November 15, 2007 at SC107. As a complement to the TOP500, the unveiling of the Green500 ushered in a new era where supercomputers can be compared by performance-per-watt.

The [TSUBAME-KFC-GSIC Center](#) by Tokyo Institute of Technology, Made in Japan was with a great advantage to the second, the Top 1 Supercomputer in the World with 4,503.17 MFLOPS/W and 27.78 Total Power (kW)++

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

Conclusions:

[Green computing](#) and green technology refers to the environmentally responsible use of computers and any other technology related resources. Green computing includes the implementation of best practices, such as energy efficiency central processing units ([CPUs](#)), [peripherals](#) and [servers](#). In addition green technology aims to reduce resource consumption and improve the disposal of electronic waste ([e-waste](#)).

[Green IT](#): How to deliver value to your business

As more IT professionals are put under pressure to ensure their IT investments are made in all the right places, a common goal is to review and possibly reallocate resources elsewhere. This mini guide reveals how to deliver green computing, improve energy efficiency, and measure the sometimes elusive value of green IT.

Green technology offers network managers [cost-reduction and operational benefits](#)

Reducing your [carbon emissions](#) and taming energy efficiency is no longer just an option. It is now an inevitable future of the 21st century business landscape.

[Green computing tips and best practices](#)

Learn about the latest green computing expert advice, news and tips, in this UK mini guide to [greening](#) your IT. Learn how to implement new green technology to enhance energy efficiency rates.

[Green data storage technology survey](#): Green storage a priority for European storage professionals

Green data storage is at the top of the IT managers' priorities list, according to our energy efficiency technology survey. Read what European [storage professionals](#) are implementing in terms of green technology.

[Green storage essentials](#): Addressing power, cooling and space issues

In this guide to green storage you'll find power-saving tips and storage energy efficiency metrics. This green technology learning guide explains how to tackle [cooling, power and space](#) issues within your storage infrastructure.

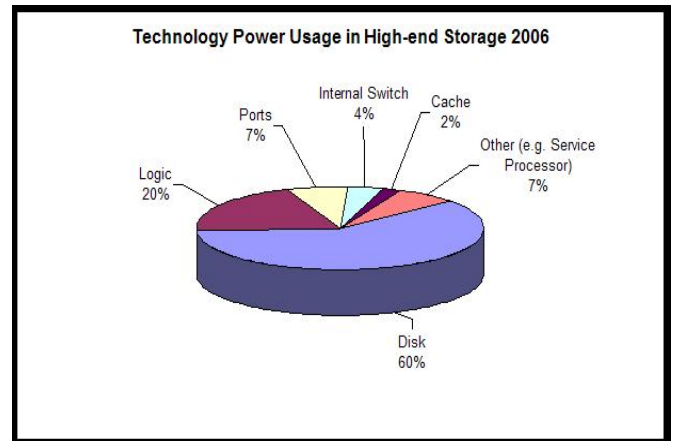


Figure 7 : Technology power usage .

Government legislation

The [Carbon Reduction Commitment](#) (CRC) scheme is designed to reduce carbon emissions, in the UK, by 1.2 tonnes by 2020. Through the use of green technologies the mandatory UK standard aims at [improving energy efficiency](#) through cutting UK carbon emissions 80% by 2050. The CRC covers all forms of energy – electricity, gas, fuel and oil – with the exception of transportation fuels.

[CRC legislation](#) drives demand for green IT skills

Companies will soon be forced to hire new staffs that are [skilled in green technology](#) due to the mandatory Carbon Reduction Commitment (CRC) scheme brought in recently. The scheme encourages companies to improve their energy efficiency levels.

Knowing which [carbon compliance scheme](#) you fall under

You might find this flow chart useful for finding out whether you will be affected by the Carbon Reduction Commitment (CRC) scheme, the [Climate Change Agreement](#) (CCA) or the European Union Emission Trading Scheme (EU ETS). With more and more carbon compliance schemes, being introduced, it is important for

businesses to look in to using green technologies for better energy efficiency rates.

CRC Energy Efficiency Scheme tutorial

There was industry spread confusion when the [Carbon Reduction Commitment \(CRC\) was introduced recently](#). For those that are still confused about energy efficiency, or those that are yet to read up on how the CRC may affect you, get the latest green technology, advice, news and tips here.

Will you lose profit through the [CRC Energy Efficiency Scheme](#)?

According to this [data centre management](#) consultancy these practical energy efficiency steps, will aid you in finding out how the Carbon Reduction Scheme (CRC) will affect you. Find out new green technologies, under the scheme, and how you can make the most of it.

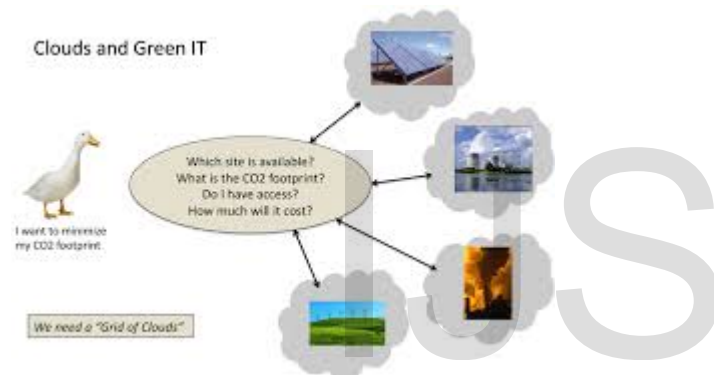


Figure 8: clouds and Green IT

Improving energy efficiency

In Europe we have a voluntary initiative aimed at reducing the environmental impact of data centres through the use of more green technology. The [EU Code of Conduct on Data Centres' Energy Efficiency](#) focuses on two areas for improving energy efficiency; IT load (The amount of IT capacity available for the power that's consumed) and the facilities load (equipment/systems that support the load, e.g. PDUs, UPSs) and cooling systems.

Service providers battle to [reduce carbon footprint](#) as data centres expand

According to the director of Verdantix, very few businesses have set themselves targets to boost energy efficiency levels. His paper suggests that suppliers offset their energy usage by purchasing [renewable energy certificates](#) from

companies that provide green energy, such as wind and solar power. This looks like the company has reduced its carbon emissions on paper, without having to purchase any green technology.

GE goes Platinum with [pioneering green data centre](#)

GE's data centre is one of the first in the world to be awarded the Leadership in Energy and Environmental Design (LEED) Platinum Certification. The award is presented by the US Green Building Council for IT projects that go beyond standing codes, implement green technology, and create [energy efficient buildings](#).

Energy saving tips: [Reduce energy consumption](#) with hot and cold aisles

These [hot and cold aisle](#) energy efficiency tips aim to help you reduce your energy consumption within the data centre. Take a look to see if you're using a cooling technique that is wasting energy rather than saving it.

How to optimise [CRAC units for best energy efficiency](#)

[CRAC units](#) need to be a part of any energy efficient data centre plan. Read our tips on how to match the facility to the needs of the IT estates, select the right green technology, and optimise your CRAC units.

MAID 2.0 and disk spin down [reduce energy costs](#)

MAID 2.0 and disk spin down are prime technologies for improving energy efficiency and cutting your overall costs of storing your persistent data. Find out how this green technology can save you money and [reduce your carbon footprint](#).

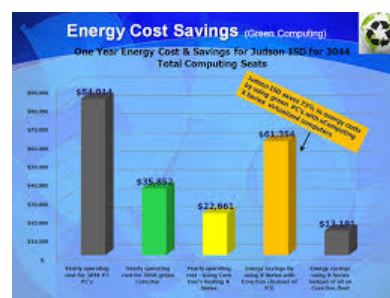


Figure 9 :Energy cost savings due to Green computing.

More on green computing and improving energy efficiency

[Green-energy technologies](#) a priority across all IT operations

Consolidation, compliance pushing demand for a [green data centre](#)

[Going green](#) with enterprise asset management systems

[Green data centre](#) guide for managers

[Power management technology](#) for the green data centre

computing? Be sure to let us know in the comments and share your eco-experience.

- The first result of green computing research resulted in the Sleep mode function for computer monitors. This function allows the computer to enter standby mode after a pre-set period passes without any user activity. After this, various concepts like energy cost accounting, thin client solutions, eWaste, and [virtualization](#) were developed.

- **Green IT**

Green computing is commonly referred to as Green IT. The idea is to ensure the least human impact on the environment. Apart from this, it aims to achieve environmental sustainability.

In simple language, green computing is the scientific study of efficient and effective designing, manufacturing, using, disposing, and recycling of computers and computer related products like servers, network systems, communication systems, monitors, USBs, printers, etc. The study uses science to create technologies that help to preserve natural resources and reduce the harmful impact on the environment.

- These four pathways focus on various activities such as:

Power Management - This feature means conservation of power used by all electrical appliances. Many appliances now come with a power saving/management feature as well. Devices with this feature automatically turn off the power or switch the appliance to a low power state when not being used.

Energy Efficient Computing - Computers have a fan / heater-like component inside them. The energy waste of computers is increasing by the day. Unfortunately, not many people are aware of this. Energy waste is leading to a climatic change from burning coal and oil. [Learn how to buy an energy-efficient computer.](#)

Remediation of Environmental Pollutants - This deals with reducing and removing pollution or contaminants from groundwater, soil, surface water, or sediments.

Virtualization - This is popularly known as VPS and is commonly used to split the server. The idea is to use one server which connects to many individual computers. This

development has been seen in software, technology, and other types of architecture virtualization.

Sewage Treatment - This wastewater treatment involves removing of contaminants from waste water and sewage. Various chemical and biological processes are used to remove chemicals and other contaminants.

Efficient Disposal/Waste Management - This is the collection, processing, recycling, and disposal of waste materials.

Efficient Recycling - Reusing products is much better than letting them stay in landfills.

Regulatory Compliance - A strategy must be designed by governments, which would offer rules for curbing waste management, reducing pollution, and stringent penalties for non compliance.

Recycling and Water Purification - This is the process of removing all unneeded materials and contaminants from water. The water is then used for drinking or fulfilling specific requirements for medical, chemical and other uses.

Green Metrics and Methodology - It is important to quantify sustainability and environmental performance to help reach our goals.

Renewable Resources - Use of [renewable sources](#) of energy such as solar power and wind to serve purposes like heating, cooking, etc.

Eco-Labeling of IT Products - More companies should design their products so they receive the eco-label. Consumers must check for the eco-label before investing their resources in a particular IT product.

Thin Client Solutions - Thin client is also known as a lean client solution, and requires computers to depend on another computer or server to function.

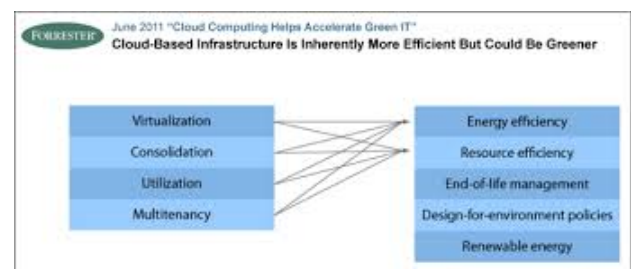


Figure 10: cloud computing helps accelerate Green IT.

- **Going Green at Work**

Organizations all over the world are beginning to understand their corporate social responsibility toward the environment. Most companies now believe in conserving energy and power and using environmentally friendly products that help in reducing their carbon footprint. In fact, in many organizations, the need for green computing

is put at the top of the agenda. Nowadays, it is imperative for all sized organizations to implement aspects of green computing in their daily workings.

Organizations must follow these simple steps for creating the green computing awareness in their workplaces.

- Announcing green intentions to all employees.
- Setting up a committee to form a green IT plan.
- Centralization of all desktops.
- Using efficient computer applications.
- Power management tactics.
- Business performance enhancement.

The most common actions organizations have undertaken are:

- **Virtualization:** Virtualization is the consolidation of servers and systems to reduce power consumption and energy utilization. It leads to usage of more than one system on a single piece of physical hardware. This allows for minimum power consumption and maximum cooling.
- **Power Saving:** Industry standards like ACPI design and manufacture computer components in such a way that they result in power controlling and saving.
- **Telecommuting:** Employees working from home reduce the fuel emission created during commuting by vehicles. Moreover, there is reduction in overhead costs on utilities, etc. All of these initiatives result in increased power and energy savings.
- **VoIP:** VoIP stands for Voice over Internet Protocol and results in less telephone wiring and lower costs.

Green computing is extremely popular. It is not only seen as an organizational responsibility but is also the responsibility that must be undertaken by all computer users. Home computer owners must also resort to green computing practices to make the environment more sustainable.

Future trends are also using computers and Living Machines such as the one developed by Worrell Water Technologies, where entire buildings and even municipalities can recycle wastewater for continuous use - all controlled by specially designed computers with a goal toward saving on another precious resource: water!

Check out Bright Hub's [five-part series on green computing](#), which covers everything from electronic waste to green grids to VoIP and more.

Green computing programs

Degree and postgraduate programs that provide training in a range of information technology concentrations along

with sustainable strategies in an effort to educate students how to build and maintain systems while reducing its negative impact on the environment. The [Australian National University](#) (ANU) offers "ICT Sustainability" as part of its information technology and engineering masters programs.^[73] [Athabasca University](#) offer a similar course "Green ICT Strategies",^[74] adapted from the ANU course notes by Tom Worthington.^[75] In the UK, [Leeds Beckett University](#) offers an MSc Sustainable Computing program in both full and part-time access modes.^[76]

Green computing certifications

Some certifications demonstrate that an individual has specific green computing knowledge, including:

- Green Computing Initiative - GCI offers the Certified Green Computing User Specialist (CGCUS), Certified Green Computing Architect (CGCA) and Certified Green Computing Professional (CGCP) certifications.^[77]
- [CompTIA](#) Strata Green IT is designed for IT managers to show that they have good knowledge of green IT practices and methods and why it is important to incorporate them into an organization.
- [Information Systems Examination Board](#) (ISEB) Foundation Certificate in Green IT is appropriate for showing an overall understanding and awareness of green computing and where its implementation can be beneficial.
- [Singapore Infocomm Technology Federation](#) (SiTF) Singapore Certified Green IT Professional is an industry endorsed professional level certification offered with SiTF authorized training partners. Certification requires completion of a four-day instructor-led core course, plus a one-day elective from an authorized vendor.^[78]
- [Australian Computer Society](#) (ACS) The ACS offers a certificate for "Green Technology Strategies" as part of the Computer Professional Education Program (CPEP). Award of a certificate requires completion of a 12-week e-learning course designed by Tom Worthington, with written assignments.^[79]
- International Federation of Green ICT and IFG Standard - promotes two basic green programs, IFG standard towards Green business and Green Government, and a program designed for professional Green IT certification by IFG.

It's becoming increasingly easier to make your PC setup more eco-friendly, thanks to a wide range of both software and hardware solutions available to help you go green.

The green-computing movement, which began with [the Energy Star program](#) back in 1992, strives to ensure that the computer industry adopts various environmentally sustainable practices, such as creating more environmentally sound products and ensuring that those products' manufacturing processes, overall design, everyday use and eventual disposal have as small an environmental impact as possible.

It's no secret that not every manufacturer is as eco-centric as they could be, but with the help of [certain product makers](#) and a handful of selected software, you can do your part.

Bad Eco-Design

One example of poor eco-design comes courtesy of the new USB Eco Button.

Saving some money on your energy bills is one thing, but saving the entire planet is a much more admirable goal. Unfortunately the [recently released USB Eco Button](#), which promises to save both the planet and your wallet, fails on both counts, adding to the ever-growing list of [useless gadgets](#).

The [device](#), which is essentially a USB-powered plastic button, puts any Windows based machine, except those running Windows 7, into a [low-power energy saving mode](#). Once activated, the included software will then monitor your computer's power usage, in addition to recording how much CO2 the Eco Button has saved.

The problem? The Eco Button is largely unnecessary, since such low-power modes can be implemented via software-only fixes. Considering the materials and energy used to manufacture it, the Eco Button could be doing more harm than good. The final icing on this not-so-green cake? The [\\$14 'Eco Button'](#) seems to be a second-rate imitation of another [previously released--and trademarked--'Eco button'](#).

That said, there are numerous other ways to green up your OC.

Lowering your CO2 emissions ([and in turn, your bills](#)) by reducing your power consumption can be achieved by turning to more environmentally friendly products and services. Francine Kizner looks at how you can [make your office more green](#) with this run-down of eight handy eco-gadgets, but for those more concerned with [going green at home](#) be sure to read over the following tips:

Now that we've established that you do not need a plastic button to put your computer to sleep, here are a number of programs that can do the job by putting your PC into the deepest sleep possible without compromising your session:

In addition to the various software solutions, the major OSes all have built-in power-saving modes, such as OS X's Energy Saver and Windows' Power Options control panel and sleep mode, which my colleague Jason Cross [discusses in greater detail here](#).

Changing your PC's various components, amongst other gadgets, to greener alternatives is another way to reduce your environmental impact. Apple is well-known for its recent green efforts, even [managing to please Greenpeace this year](#) and moving up a place in their rankings. Sony Ericsson has also been getting in on the eco-act this year with [greener cell phones](#). Unfortunately due to the economic downturn the interest in [tweaking products to be green has decreased](#), but some companies are still offering ecological hardware options:

By using some of the products mentioned above, along with various other alternatives, you can save yourself some money over time, while doing your bit for Planet Earth.

References

- Worrell Water Technologies - [How Living Machines Work](#)
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