Making of a Greener Computer

Toxics Link
Factsheet
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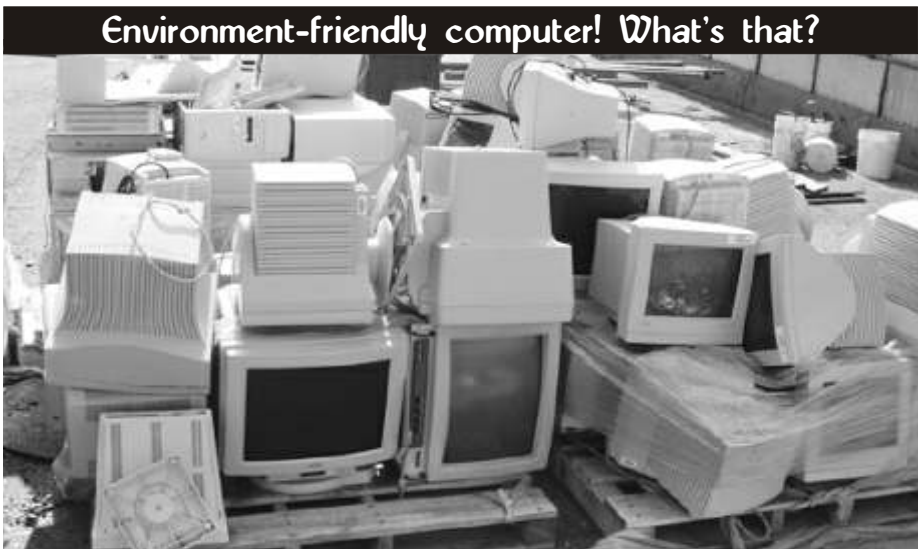
Computers have been a boon to the modern day existence, simplifying lives. It is an advanced tool that helps to create, share information and work more efficiently and effectively. Life is much easier due to the speedy internet service that brings the world home at a touch of a key. But the modern world's greatest tool is also a readily disposable and resource-heavy product. Performance-wise, computer design has progressed stupendously but looking at it from an environment friendly perspective, we are still at a nascent stage.

But what is a green or environmentally friendly computer?

The answer is not very simple. Computers are made up of many complex components. All of these components have associated raw materials, energy and toxics repercussions. That is why, at this stage of technological evolution, it's probably impossible to conceive of a completely green computer. What we can look and talk about are relatively **greener or more environmentally safer computers.**

To term a computer "greener", we have to look at both upstream as well as downstream impacts. This fact sheet takes a look at the manufacturing, operating and disposal processes. A life cycle perspective can give us greater understanding of the product's environmental impact. For example, a study of the supply chain use of energy and chemicals for a 32MB RAM memory chip show that at least 1,200 gms of fossil fuels and 72 gms of chemicals are required to produce a 2 gm memory chip. The amount of environmentally sensitive materials used far belies its tiny size; fossil fuels used for production are some 600 times the weight of the chip. During the production processes, low energy usage and resources used in manufacturing



AT A GLANCE

- **Computers using less energy and resource footprint in manufacturing process using less environmentally hazardous materials are known as green computers.**
- **Occupational health hazards as well as environmental hazards are caused by the release of the toxic materials used in manufacturing process. Plus rudimentary recycling at the end-of-life also causes environmental degredation.**
- **There have been some legal actions in different parts of the globe to move towards greener electrical and electronic equipments, with respect to materials. The two initiatives, which have made a huge impact on the global scenario, are the EU RoHS and China RoHS**

Eco-Labeling

Eco-labels are a primary tool available to tell consumers about the environmental characteristics of products. It can help the consumers in making an informed choice regarding the products that they buy, help them in choosing a green product.

Eco-labeling of computers poses a lot of difficulties because of its complex and rapidly changing nature. But there have been certain initiatives in this direction, covering various issues like energy and content of hazardous materials. Many eco-labels have been introduced over the years; some of them are listed below-

TCO labeling is a quality and environmental labeling system for electronic office equipment, developed and managed by TCO, the Swedish Confederation of Professional Employees. The first TCO labeling started in 1992 with original focus of the label on workplace environment issue such as limiting the electromagnetic radiation from CRT monitors, sound emitted by devices, ergonomics, and electrical safety. It also addresses issues of energy use, ease of recycling, take back programmes and the content of hazardous substances.

The Blue Angel is the first and oldest environment-related label for products and services in the world with about **10,000 products** and services in **80 product categories** carrying the eco-label. The requirements for this German eco-label based for PC are similar to TCO, also stipulate no PBBs, PBDEs or chlorinated paraffins addition to the base material of printed circuit boards and no halogen polymers usage.

Nordic Swan is certification label introduced by the Nordic council of Ministers, and is used in Finland, Iceland, Norway and Sweden. It too has a PC certification label which has similar requirements as TCO. This also focuses on upgradability and disassembly aspects.

E. U. Flower, developed by the European Union also covers personal computers and has similar requirements to TCO.

The Japan Environment Association administers **Japan Eco Mark**. Certification criteria for computers were released in 2000 and include design for recycling, take-back and recycling provision, elimination of hazardous substances, and energy conservation.

Japan's PC Green Label, in addition to the standard criteria talks about the ozone layer depletive substances not to be used in PC final assembling process including OEM product and product repair service to be provided for at least five years after the end of sales date of the product. The labeling programme developed by The Japan Electronics and Information Technology Industries Association stresses on design for reduce, reuse and recycle. Some other countries like Korea, Taiwan also have eco-labeling programme for computers

Energy Star is a joint program of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy. In 1992 the USEPA introduced it as a voluntary labeling program designed to identify and promote energy-efficient products to reduce greenhouse gas emissions. Computers and monitors were the first labeled products. The label is now on major appliances, office equipment, lighting, home electronics, and more. In 2007 new Energy Star specifications were issued for office and imaging equipment. This means it will be more difficult for computers, copiers, fax machines, mailing machines, multifunction devices (MFDs), printers, and scanners to earn the label. The U.S. Environmental Protection Agency's Energy Star program has recently been adopted by Australia, the European Union, Japan and Korea.

Money Isn't All You're Saving

and non-toxic manufacturing processes are critical parameters to judge a computer on its green quotient.

Post manufacturing and till its final disposal, there are other considerations as well. Some of the important criteria for greener computer post manufacturing processes are-

- High operational power efficiency
- Reduction and elimination of hazardous materials
- Design for Environment (DfE)

India is facing a significant energy shortage. Demand for electricity exceeds supply by 70,000 megawatts – for enterprise, government and consumer use – and leaving companies with IT needs having to power their hardware with external diesel generators. This is obviously very expensive and as a result the operating costs can skyrocket. Climate change and the need for energy saving has made energy efficiency of computers of utmost importance. Various reports suggest that the awareness and demand for energy efficient computers in enterprises are on the rise in India.

The use of toxic materials like lead, mercury, beryllium and flame-retardants in computers has been in focus mainly due to two reasons. Firstly, radiations or emissions during usage are still a topic of debate but there has been unanimous recognition of the problem caused due to the release of toxic materials in the recycling processes. Secondly, growing piles of computers in the waste stream, it is not just a concern in terms of the huge quantities to be managed but also the health and environmental hazards caused by them. To address these, we have to look at not just recyclable, upgradable or durable computers but also how to reduce the toxic contents in them.

In this facsheet, we bring some information on certain important aspects of greener computers – related problems, the alter natives and legal frameworks pushing them.

Reducing the toxics

Computers and peripherals are a complex mixture of several hundred materials, many

Women wrestling computer's components apart by hand

of which are hazardous in nature. These include substances like lead, mercury, cadmium, hexavalent chromium, beryllium, brominated flame retardants (BFRs) or PVC. These dangerous substances can cause serious pollution throughout their lifecycle, from the production to the disposal stage. More importantly, at the end of its life, computer hardware if not handled responsibly can result in these toxic substances entering the biosphere. When computers or laptops finish their useful life and are discarded as waste, it ends up in city by-lanes where it is recycled in a most rudimentary fashion. Men, women and even children are seen wresting them its components apart by hand, melting toxic bits in acid baths to recover traces of heavy metals. It is hazardous for all involved in this primitive method of recycling impacting a large number of women and children employed in this homegrown, back- yard industry.

Computer manufacturers control the size, material content, durability, hazardous nature and recyclability of products. Actions such as introducing lead-free solder and reducing PVC content, makes e-waste recycling more sustainable. Avoiding toxic components can remove risks to workers manufacturing the products and to recyclers who manage the disposal of products at the end of life.

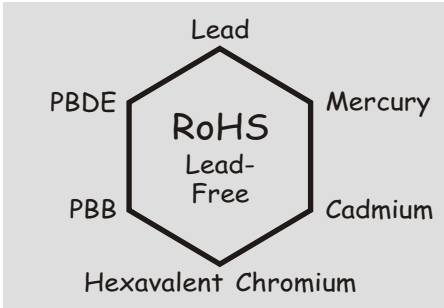
Legal framework to phase out the toxics

There have been some legal actions in different part of the globe to move towards greener electrical and electronic equipment, with respect to materials. The two initiatives, which have made a huge impact on the global scenario, are the EU RoHS and China RoHS.

European RoHS

The Directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment 2002/95/EC (commonly referred to as the Restriction of Hazardous Substances Directive or RoHS) was adopted in February 2003 by the European Union. The RoHS directive took effect on 1 July 2006, and restricts the use of six hazardous materials in the manufacture of various types of electronic and electrical equipment, including computers.

Though globally there is a move to legislate and push for environment friendly computers, but in India there is no legislative mandate to eliminate or restrict the use of hazardous substances. However, the recently issued 'Guidelines for Environmentally Sound Management of Electronic Waste' by Central Pollution Control Board does mention a need for a separate RoHS like legislation in India.



RoHS is often referred to as the “lead-free” Directive, but it actually restricts the use of following six substances:

- Lead • Mercury • Cadmium
- Hexavalent chromium
- Polybrominated biphenyls (PBB)
- Polybrominated diphenyl ether (PBDE)

The maximum permitted concentrations are 0.1% or 1000 ppm (except for cadmium, which is limited to 0.01% or 100 ppm) by weight of homogeneous material. This means that the limits do not apply to the weight of the finished product, or even to a component, but to any single substance that could (theoretically) be separated mechanically.

China RoHS

The People's Republic of China Management Methods for Controlling Pollution by Electronic Information Products, Ministry of Information Industry (MII) Order #39 and Standard SJ/T 11364-2006 Labeling Require-ments for the Control of Pollution from Electronic Information Equipment (also known as China

RoHS) came into effect from March 1, 2007.

While core elements of the European legislation, such as the maximum permitted levels of restricted substances, remain the same, China RoHS contains several unique features, such as,

- Packaging must be non-toxic, biodegradable and recyclable
- Packaging must be marked with material content
- Products must be labeled with
- Names, content levels, and recyclability of harmful materials
- Recyclability (fully, partially and non-recyclable)

Portable RoHS analyzers, also known as X-ray fluorescence or XRF metal analyzers, are used for screening and verification of RoHS compliance.

The Change

Various global manufacturers have taken actions to address these legal requirements. The impacts of these regulations have had their effect on Indian manufacturers as well, specially those who have been supplying to Europe. Most such companies have RoHS compliant product in the market and also plan to phase out PVC and BFR shortly. TBBPA (Tetrabromobisphenol-A) is the leading flame retardant used in circuit boards (95%) and computer chip casings.

The changes have also obviously begun at the component level. Processors manufactured by **Intel Corporation** went 100 percent lead-free from May 2007.

Hical, an Indian company supplying professional grade transformers and other complex wound components worldwide, have all their new products RoHS compliant.

All **Apple** products worldwide comply with European Union's RoHS Directive. Apple also plans to completely eliminate the use of polyvinyl chloride (PVC) and brominated flame retardants (BFRs) in its products, and arsenic in the glass of flat-panel displays by the end of 2008. They have also replaced the CRT displays with LCD, thereby eliminating around 2lbs of lead. Apple also plans to reduce and eventually eliminate the use of mercury by transitioning to LED backlighting for all displays.

A leading Indian brand ***HCL Info system*** initiated the program of phasing out the restricted materials in 2006. With effect from Jan 2008 they have total RoHS compliance for desktops, laptops, workstations, and servers. Further, HCL plans to phase out hazardous chemicals like PVC & BFR by 2009 and 2010 respectively.

Another Indian brand, **Zenith** Computers Ltd. has a target to decrease the amount of lead used to less than 1/3 for new model PCs compared to PCs made earlier. The company also plans to stop using PVC and BFR in its PC models by year 2010.

Wipro also has a RoHS compliant range of desktops and notebooks since June 2007. According to the latest company sources, the company products have now total RoHS compliance and is also estimated to phase out PVC and BFRs by end of 2009.

One of the global majors **Hewlett Packard** has also made changes to comply with the RoHS directive and their future goal is to eliminate all uses of BFRs and PVC from new computing products as technologically feasible alternatives become readily available

These are some of the positive changes, which are happening in material substitution. But there is still a long way to go.

Lead (Pb)-containing solders have been used extensively in micro-electronic applications to form electrical interconnections between packaging levels, to facilitate heat dissipation from active devices, to provide mechanical/ physical support, and to serve as a solderable surface finish layer on printed circuit boards (PCBs) and lead frames. But the European and Chinese legislation, in recent times, have accelerated the transition to Pb-free soldering in the electronic industry. The alternatives that are being used are Tin-silver, Tin-copper, Tin-copper-silver, and Tin silver and bismuth. Studies are still on to see the durability and functionality of these alternatives. Replacements like the Frontrunner, a tin/copper/silver alloy, also require higher melting temperatures, which can affect chip life.

Energy efficiency

Although the recyclability of end-of-life computers and reducing the use of hazardous materials, like lead based solders, has been the topic of various discussions, energy consumption of computers remains a potentially significant part of its overall environmental footprint.

A typical desktop computer uses about 65 to 250 watts. Each part of the computer system with its own power cable requires energy. Inside the computer, the most power-hungry component is the CPU, or central processing unit. Another big source of high-energy consumption is the cathode ray tube (CRT) display. These can burn more than 100 watts by themselves.

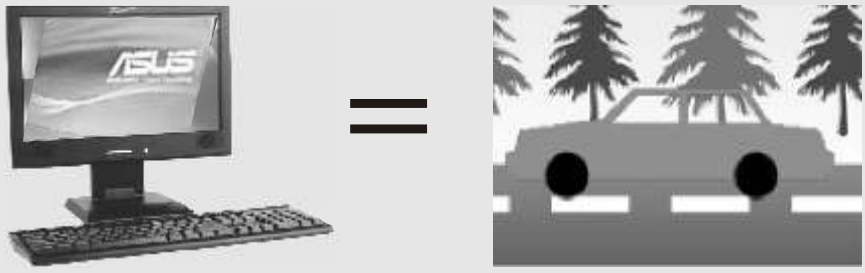
Power requirements and the periods of time that equipment is turned on determine its energy consumption. There are two ways to reduce a product's energy consumption:

I) by using components that require less power, and

II) by using power management software to modulate the energy consumption of these components.

Power requirements of computer have changed drastically over the last two decades. The energy efficiency of computers and monitors has improved over time, which reduces their energy requirements. However, at the same time increased processing power in computers, and higher resolution monitors have increased energy requirements. As a result, newer computers and monitors tend to use more energy when they are active, but they use less energy in low power mode than the older computers and monitors.

Energy management is also another way of looking at saving energy consumption through computer usages. Studies have shown that power management of computers and monitors can significantly reduce their energy consumption. Energy management tools are now standard features in most PCs and are extremely effective in reducing PC energy consumption.



Carbon Dioxide: A typical desktop PC with a 17" flat panel LCD monitor requires about 100 watts – 65 for the computer and 35 for the monitor. Doesn't sound like much? Left on 24/7 for one year, the system will consume a whopping 874 kWh of electricity. That's enough to release 750 lbs. of carbon dioxide into the atmosphere–-the equivalent of driving 820 miles in an average car.

Source: http://www.environment.columbia.edu/docs-wycd/green_guide/Facts.html

In addition to direct PC energy consumption, PCs generate heat, during operation and requires further energy to cool the surroundings. Some studies have estimated that for every 4 kWh consumed by PCs, 1 additional kWh is consumed by cooling and ventilation systems.

Some of the factors that affect energy use

More Energy	Less Energy
Ready to be used	Sleep/Standby
Desktop	Laptop
Faster processor	Slower processor
Older processor	Newer processor
PC	Mac
Heavy use (all drives spinning, processor-intensive task)	Light use (e.g., email, word processing)
On the Internet	Offline

There have also been some initiatives globally in terms of voluntary labeling programmes to address this aspect of computers. **Energy Star** is the widely accepted labeling for energy efficiency for personal computers.

India is also set to launch its energy standards and labeling programme for a range of appliances that will clearly spell out a product's electricity consumption, helping the consumers to choose more energy-efficient models. The Bureau of

Label	Desktop System Unit			Monitor CRT/LCD		
	Idle state (W)	Sleep mode (W)	Off mode (W)	On mode (W)	Sleep mode (W)	Off mode (W)
Energy Star	Category A: ≤ 50.0 Category B: ≤ 65.0 Category C: ≤ 95.0	≤ 4	≤ 2	X < 1 megapixel, then 23; if X > 1 megapixel, then 28X *X is the number of megapixels in decimal form	≤ 2	≤ 1
Korean Ecolabel	—	≤ 5			≤ 2	
TCO' 05	—	≤ 5	≤ 2	—	≤ 4	≤ 3
Blue Angel	Same as Energy star					
EU Flower	Same as Energy Star					
Nordic Swan	Same as Energy Star					

Energy Efficiency (BEE) will start the energy labeling programme, on a voluntary basis, for colour televisions, computer monitors, washing machines, CFL bulbs, LPG stoves, set-top boxes, water heaters, water pumps, uninterrupted power supply systems and battery chargers. At the same time, the bureau has begun the process of making energy labeling mandatory for fluorescent tubelights, airconditioners, refrigerators and motor products that already have a voluntary labeling programme. The standard tactic for the bureau, mandated under the Energy Conservation Act, has been to start with a voluntary system and progress towards a mandatory one.

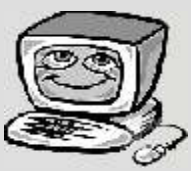
Under the energy standards and labeling programme, BEE will ask manufacturers to get their appliances voluntarily rated for power consumption. On the basis of how much energy the product consumes in its particular category, it will get a "star rating" five stars being granted for being the best and one star for being the worst in its category.

The label will also display information on how much energy the product uses, its efficiency or energy cost. This will make it simpler for consumers to choose the more efficient models and not be swayed merely by the sales pitch of the company.

Screen Savers: Despite common belief, a screen saver does not save energy. In fact, more often than not, a screen saver will not only draw power for the monitor but will also keep the CPU from shutting down.

CRT vs LCD: Energy savings

Monitor type	Power consumption (W)	Usage duration	Total consumption annually (W)	Cost** (Rs)	Saving in electricity bill annually by shifting from CRT to LCD for 1 computer	Saving in electricity bill annually by shifting from CRT to LCD (Rs) for 50 computers#
17 inch LCD	30	10 hrs/day x 5 days a week x 48 weeks	72000 (72 kWh)	360	480	24000
17 inch CRT	70	Same	168000 (168 kWh)	840		



*Average 4 weeks of holidays annually.
**Average cost of electricity consumption in Delhi in industrial/commercial area. Rs 5.00/kWh
#A medium sized office
Source: Toxics link

The Change

In recent years, technology advances have significantly decreased energy consumption, for example, by just replacing the old CRT with a LCD, one can cut power use in half. But a 30-inch LCD can consume as much as 250 watts of electricity more than some computer systems themselves when in use. That means that if you're going green, smaller is definitely better with LCDs.

Computer manufactures across the globe have tried to address many of the problems associated with PC power management. They are not just using components, which are more energy efficient but also are providing computers with energy management options.

Design for Environment

DfE Initiatives have been developed by a number of major equipment manufacturers. Some of the essential components of DfE, besides elimination of hazardous materials are-

- Use of easily identified materials
- Use of secondary raw material in production
- Reduction in the number of individual components used
- Reduction of resource used
- Ease of disassembly and separation
- Standardization and modular design of components
- Extending product life
- Reduction and use of environment friendly material in packaging

In terms of material and recyclability, there have been very few attempts globally. But PCs have a long way to go before they could be called green in this aspect.

Some of the leading brands have incorporated some of these DfE components in their products. As part of HCL's initiatives on recycled materials, the company has adopted a stand to use recycled materials in all the areas applicable. To start with HCL has initiated measures to use recycled plastics in their products and has also implemented measures to recycle/reuse packaging material.

Some of the features established by Apple under DfE are increased utilization of

materials that are easily recycled, utilization of modules, snap-fit designs and connections and minimizations of number of screws used making the products easier to upgrade, service and disassemble.

HP's DfE guidelines recommend that its product designers consider the reduction in number of materials used and also design for disassembly and recyclability by implementing solutions such as the ISO 11469 plastics labeling standard, minimizing the number of fasteners and the number of tools necessary for disassembly.

Some companies like HCL are also looking at packaging material and have the objective to use packaging materials in a way, which has minimum impact on environment.

Some research is also taking place to use recyclable materials. Few are listed below-

Fujitsu, a Japanese company, in 2008, showcased a laptop made out of corn. The inside is a normal PC, but the outside casing is made out of material that is 50 per cent plant-based materials, and 50 per cent regular plastics. The main component is poly-lactic acid, also known as PLA, a resin that comes from the fermentation of the raw biomass from plants. PLA by itself is biodegradable, does not generate dioxin when burnt, or other harmful gases. Fujitsu claims it cuts down on carbon dioxide emissions during the manufacturing process by 15 per cent. What's even more interesting is that Fujitsu sells the corn-based PC for the same price as a regular plastic-encased model, despite the more expensive manufacturing process. From an environmental perspective, the manufacturing process holds a great deal of potential. According to Fujitsu, potatoes and castor oil offer the same energy-saving benefits as corn.

Another innovation has been from a company called **MicroPro**, a company based in Dublin, Ireland. They are supposed to have produced the world's

Annual e-waste recycling event

first 100% biodegradable computer components with eco-friendly computers, keyboards, mouse and flat-panel monitors. The product is named "iameco", and is the brainchild of MicroPro's Managing Director, Paul Maher. According to the company, the computers modular design is what makes them different from other computers: they are updatable, upgradeable, reusable, recyclable and at the end of the life of them the company can replace the main board and start all over again. The life span of these computers is 7-10 years, up to 3 times the lifespan of an average computer. The computers are a third smaller than average computers on the market, requiring less energy to manufacture. They require less energy to run as well. Many of the keyboards, mice and monitors have a wood based frame and are made from the waste product of the pulp industry in Europe. These materials are 100% biodegradable.

The FACTS that one should remember as a consumer when you are buying a new computer:

- Energy ratings and labels (like Energy Star) are good indicators to buy energy efficient computer
- If you are buying an average sized monitor, you should opt for a LCD screen to save energy
- If you don't play advanced 3D games, go with integrated graphics for the lowest power consumption
- Ask for a RoHS compliant computer. These will have restricted use of toxics materials like Lead, mercury, cadmium, BFRs etc.
- Look for a computer and components which can be easily upgradable
- Opt for the latest processor they are more energy efficient
- Check the use of recycled content
- Choose non PVC, BFR machines
- Ask for minimum packaging material

So far products have been innovated and enhanced for efficiency, design and aesthetics with an aim to gain better market and larger consumer accepta-

Material Used

2 LCD = 1 CRT

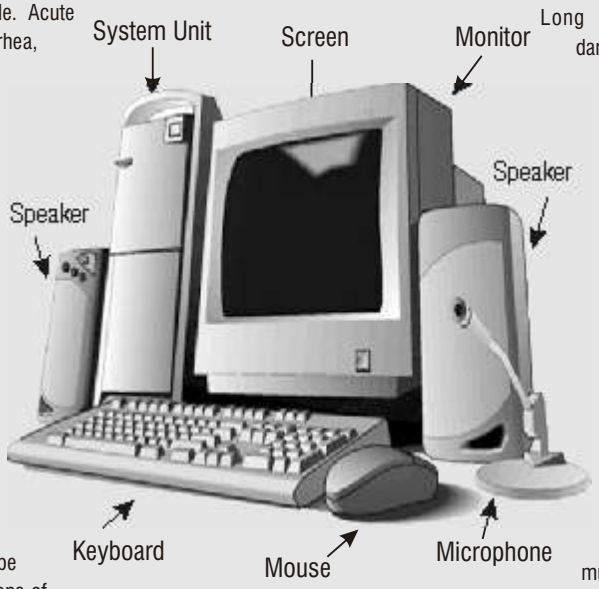
Flat panel display typically uses 40 to 50% less (by weight) materials when compared to conventional CRT screen and requires approximately 60% less energy in use.

Source:http://www.hp.com/hpinfo/globalcitizenship/gcreport/products/materials.html

Lead (Pb): Many older TV and Computer **monitors** can contain up to 4-8 lbs of lead. It is also used in the soldering on the circuit boards. Exposure can cause brain damage, nervous system damage, blood disorders, kidney damage, and developmental damage to fetus. Children are especially vulnerable. Acute exposure can cause vomiting, diarrhea, convulsions, coma, or even death.

Mercury (Hg): Light bulbs in flat panel displays, **LCD screens**, switches, & printed wiring boards all contain mercury. High levels of exposure contribute to brain & kidney damage, harm the developing foetus & can be passed down through breast milk and fish consumption. Exposure through ingestion or inhalation can cause central nervous system and kidney damage.

Plastics & Polyvinyl chloride (PVC): Make up to 14 pounds (about 20%) of an average computer. Dioxin can be formed when PVC is burned. Combinations of plastics, which are difficult to separate and recycle, are used in **printed circuit boards, in components such as connectors, plastic covers & cables**.



Cadmium (Cd): SMD chip resistors, infrared detectors, semiconductors, older types of **cathode ray tubes**, and some plastics contain cadmium. It concentrates in the body & can cause kidney damage & harm to fragile bones. Long term exposure can cause kidney damage and damage to the bone structure. Cadmium is a known cancer causing substance

Brominated flame retardants (BFRs): Used in **plastic casings**, is released when electronics are dumped or incinerated. BFR's likely endocrine disrupters, reduce levels of the hormone thyroxin in exposed animals and can potentially harm the developing foetus in pregnant women.

Barium (B): Used in the front panel of the CRT to protect users from radiation. Short-term exposure to barium can cause brain swelling, muscle weakness, and damage to the heart, liver and spleen.

Beryllium (Be): Found on motherboards and connectors and is a human carcinogen.

bility. But with growing awareness about environmental pollution and its impact on climate change and the concerns of resource depletion, there has been a notable shift in the way the products are designed. Many products are now being developed and designed keeping in mind their environmental impacts or their life cycle impacts and are termed as green products. A computer, which uses cutting edge technology, has been the focus of such innovation. The new age PCs are using less toxic materials and are gradually progressing toward higher energy efficiency and resource minimization. **The future certainly is for greener and more environment friendly technology and products and a green label could be viewed as an USP for these products.** Consumer awareness could perhaps be a major driver to push for such technological advancements of such products. A legislative push from the Government and green procurement policy by major users will also help in driving this change and popularize such products.

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