# 1. GREEN IT : AN OVERVIEW

## 1.1 INTRODUCTION

Over the years, **information technology** (IT) has fundamentally altered our work & life and given benefits like improved our **productivity, economy** and **social well-being**. But IT has been contributing to environmental problems. Computers and other IT infrastructure consume significant amounts of **electricity** and contributing to **green house gas** (GHG) emissions. IT **hardware** poses environmental problems during both its **production** and its **disposal**. IT is both a solution and a problem for environmental sustainability.

Green IT also known as Green Computing is " the study and practice of designing, manufacturing and using computers, servers, monitors, printers, storage devices and networking & communications systems efficiently and effectively, with zero or minimal impact on the environment "

Green IT is also about using IT to support, assist and start environmental initiatives and to help create green awareness. Green IT benefits the environment by **improving energy efficiency, lowering GHG emissions, using less harmful materials and encouraging reuse and recycling**.

## 1.2 ENVIRONMENTAL CONCERNS AND SUSTAINABLE DEVELOPMENT

The growing accumulation of GHGs is changing the world's climate and weather patterns, creating droughts in some countries and floods in others and pushing global temperatures slowly higher, posing serious worldwide problems.

**Global warming** is an average increase in the temperature of the atmosphere near the Earth's surface. Global warming can occur by both natural and human induced. *Global warming* often refers to warming that can occur due to increased GHG emissions from human activities which trap heat. This phenomenon is called the **green house effect**.

GHGs they can absorb thermal infrared radiation (heat) which is emitted from the Earth and then re-emit it, increasing the Earth's temperature. The major constituents of GHG are carbon dioxide (CO2), methane, nitrous oxide and chlorofluorocarbon (CFC) gases. Electricity is a major source of GHGs. Reducing electric power consumption is a key to reducing CO2 emissions and their impacts on our environment and global warming.

### 1.2.2 SUSTAINABLE DEVELOPMENT

Sustainable development is the 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Sustainable development comprises economic, environmental and social dimensions.

### 1.2.3 WHY SHOULD YOU GO GREEN?

- Increasing energy consumption & energy prices.
- Growing consumer interest in environmentally friendly goods and services.

- Higher expectations by the public on enterprise's environmental responsibilities.

## 1.3 ENVIRONMENTAL IMPACTS OF IT

IT affects our environment in several different ways. The increased number of computers and their use, along with their frequent replacements impacts our environment. Each stage of a computer's life, from its production, through its use and to its disposal creates environmental problems.

Manufacturing computers and their various electronic and non-electronic components consume electricity, raw materials, chemicals and water, and generate hazardous waste. All these directly or indirectly increase carbon dioxide emissions and impact the environment.

Total electrical energy consumption by servers, computers, monitors, data communications equipment and data centre cooling systems is steadily increasing. This increase results in greater GHG emissions.

Computer components contain toxic materials. Consumers likely to discard a large number of old computers, monitors and other electronic equipment 2–3 years after purchase, and most of this ends up in landfills, polluting the Earth and contaminating water.

## 1.4 GREEN IT

IT has a new role to play in creating a greener, more sustainable environment. The three IT- dimensions to improving environmental sustainability are

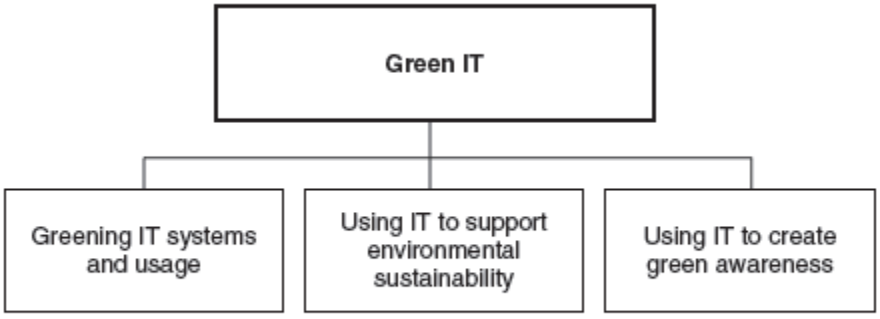



**Figure 1.1** Green IT dimensions.

1. The efficient and effective design, manufacture, use and disposal of computer hardware, software and communication systems with no or minimal impact on the environment
2. The use of IT and information systems to empower – that is, support, assist other enterprise-wide environmental initiatives.
3. The harnessing of IT to help create awareness among stakeholders and promote the green agenda and green initiatives.

Green IT is not just about creating energy-efficient IT systems (hardware, software and applications) but it is also about the application of IT to create energy-efficient, environmentally sustainable business processes & practices, transportation and buildings.

IT can support, assist and leverage environmental initiatives in several areas and also help create green awareness.

IT can help organizations to minimize their environmental impacts in areas such as GHG emissions, toxic contamination and energy and water consumption.

## 1.5 HOLISTIC APPROACH TO GREENING IT

The six holistic approach that addresses the environmental problems are

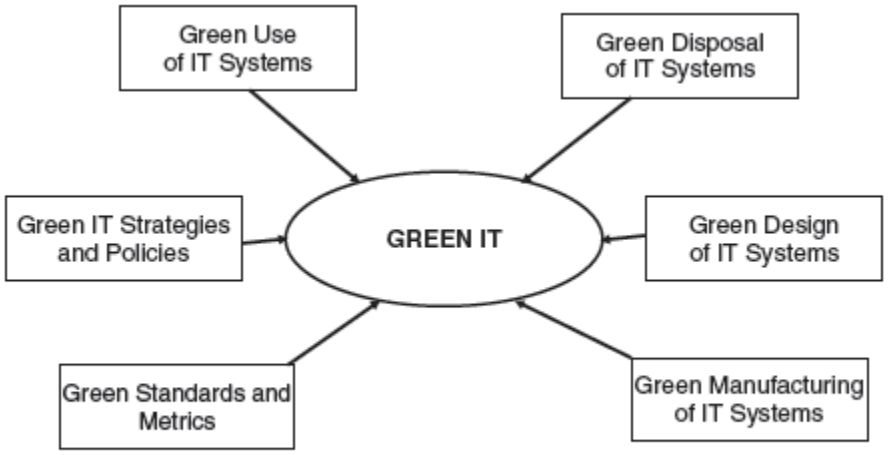



**Figure 1.3** Holistic, multipronged approach to greening IT.

1. **Green design.** Design energy-efficient and environmentally sound components, computers, servers and cooling equipment.
2. **Green manufacturing.** Manufacture electronic components, computers and other associated subsystems with minimal or no impact on the environment.
3. **Green use.** Reduce the energy consumption of computers and other information systems and use them in an environmentally sound manner.
4. **Green disposal.** Refurbish and reuse old computers and properly recycle unwanted computers and other electronic equipment.
5. **Green standards and metrics.** These are required for promoting, comparing sustainability initiatives, products, services and practices.
6. **Green IT strategies and policies.** These effective strategies and policies add value and focus on both short- and long-term benefits.

### 1.5.2 THE THREE RS OF GREEN IT

Unwanted computers, monitors and other hardware should not be thrown away as rubbish, as they will then end up in landfills and cause serious environmental problems. Instead, we should refurbish and reuse them or dispose them in environmentally sound ways.

***Reuse***, ***refurbish*** and ***recycle*** are the three 'Rs' of greening unwanted hardware.

- **Reuse.** Many organizations and individuals buy new computers for each project or once every 2–3 years. Instead, we should make use of an older computer if it meets our requirements. Otherwise, we should give it to someone who could use it. By using hardware for a longer period of time, we can reduce the total environmental footprint caused by computer manufacturing and disposal.
- **Refurbish.** We can refurbish and upgrade old computers and servers to meet our new requirements. We can make an old computer and other IT hardware almost new again by reconditioning and replacing some parts. Rather than buying a new computer to our specifications, we can also buy refurbished IT hardware in the market. If these options are unsuitable, we can donate the equipment to charities, schools or someone in need, or we can trade in our computers.
- **Recycle.** When we cannot refurbish or otherwise reuse computers, we must dispose of them in environmentally friendly ways by depositing them with recognized electronic recyclers or electronic waste (e-waste) collectors. E-waste is one of the fastest-growing waste types and poses serious environmental problems.

## 1.6 GREENING IT

Every subsystem and peripheral of IT can be greened. The key among them are

### 1.6.1 GREEN PCS, NOTEBOOKS AND SERVERS

We can significantly reduce energy consumption by making small changes to the ways we use computers. We can reduce PC energy consumption by adopting several measures.

- Enabling power management features.
- Turning off the system when not in use.
- Using screensavers. A blank screensaver conserves more power
- Using thin-client computers**.**

### 1.6.2 GREEN DATA CENTRES

A green data centre is one in which IT system, air-conditioning systems, electrical and mechanical systems and the buildings that house the data centre are designed and operated for maximum energy efficiency, low carbon footprint and minimum environmental impacts.

### 1.6.3 GREEN CLOUD COMPUTING

Cloud computing represents a paradigm shift. It is a transition from computing-as-a product to computing-as-a-service, which is shared and scalable on demand. Cloud computing is a green solution as cloud infrastructure embraces two critical elements of a green IT: resource efficiency and energy efficiency.

### 1.6.4 GREEN DATA STORAGE

Data de-duplication is the elimination of redundant data to improve storage utilization. De-duplication reduces the required storage capacity since only the unique data are stored.

Filtering out unnecessary data & files and allocates business data & files to the most efficient layer of storage available.

### 1.6.5 GREEN SOFTWARE

Software plays an important role in determining overall energy consumption and computational efficiency. Green software is environmentally friendly software that helps to improve the environment. Green software can be classified into four broad categories:

- Software that is greener – consumes less energy to run;
- Embedded software that assists other things in going green (smart operations);
- Sustainability reporting software, or carbon management software (CMS);
- Software for understanding climate change, assessing and forming suitable responses.

### 1.6.6 GREEN NETWORKING AND COMMUNICATIONS

Green networking refers to ways of minimizing networks' impact on the environment using energy-efficient networking technologies, protocols and products and minimizing resource use whenever possible. Green networking practices include the following:

- Using newer, more energy-efficient techniques, technologies and products;
- Upgrading older equipment with newer, greener networking gears;
- Employing smart systems, user management and energy conservation across IT networks to increase energy efficiency;

## 1.7 APPLYING IT FOR ENHANCING ENVIRONMENTAL SUSTAINABILITY

- Software tools for analysing, modelling and simulating environmental impacts.
- Software tools for environmental risk management;
- Platforms for eco-management;
- Tools for auditing and reporting energy consumption and savings and for monitoring GHG emissions;
- Environmental information systems engineering, including geographic information systems;
- Urban environment planning tools and systems;
- Integration and optimization of existing environmental monitoring networks, easy plug-in new sensors, sensor cooperation and networks;

## 1.8 GREEN IT STANDARDS AND ECO-LABELLING OF IT

To promote and adopt standardization, a number of green IT standards have emerged. Key among them are EPEAT (Electronic Product Environmental Assessment Tool), RoHS (Restriction of Hazardous Substances Directive), WEEE, Energy Star, LEED (Leadership in Energy and Environmental Design), the ISO14001 core set of standards for designing and implementing an effective environmental management system and the EN 16001 Energy Management System.

EPEAT is a popular, easy-to-use assessment tool to help organizations compare computer desktops, laptops and monitors based on their environmental attributes. EPEAT-

registered products are classified as bronze, silver or gold (www.epeat.net) and they have reduced levels of cadmium, lead and mercury to better protect human health. They are more energy efficient and easier to upgrade and recycle. In fact, manufacturers of EPEAT products must offer safe recycling options for their products when they are no longer usable.

### 1.9 Green IT: Burden or Opportunity?

The green philosophy, the 'go green' movement and green demands on corporate IT are not burden on IT systems and corporate IT departments. In fact, Green initiatives provide an opportunity to revisit and examine our IT systems and their operations in terms of energy efficiency and resource utilization and thereby enable us to go lean on IT, minimize IT's energy consumption and save on energy bills.

Until recently, IT primarily focussed on meeting their functional and performance requirements. Very little attention was paid to aspects such as energy consumption, effective utilization of IT resources, IT's operational costs or IT's negative impact on environments at the stages of design, manufacturing, use, reuse and disposal. But now focus is shifted as they are now important for safeguarding our environment.

IT is required to go green. It is good for IT, businesses and the entire planet. Though initially some might view going green as a burden, a closer examination of green philosophy reveals that it includes improving energy efficiency, improving resource utilization, reducing waste, promoting reuse and recycling and more such benefits.

Greening IT efforts reveal that businesses that reduce their environmental (carbon) footprint can also reduce costs and improve their public image. Smart companies will adopt an environmental strategy to innovate, create value and build a competitive advantage. So green IT is not burden to IT but it is an opportunity.

# 2. GREEN DEVICES AND HARDWARE WITH GREEN SOFTWARE

## 2.1 GREEN DEVICES AND HARDWARE

Electronic devices have become an intrinsic part of our lives. These devices provide the convenience of faster and better access to people, information and services, the downside is their negative impact on available resources and our environment. The number of computers and other electronic devices in use has been increasing exponentially and newer more powerful devices continue to replace older versions. This has led to a very short useful lifetime of devices, leaving behind a trail of obsolete devices.

## 2.2 LIFE CYCLE OF A DEVICE OR HARDWARE

A green device can be built by concerted effort at every stage of the device life cycle – from the moment the device is conceived, to its development, to the time when it is used and recycled or disposed.

The typical life cycle of a device, shown in Figure 2.1, consists of five stages:

1. Design.
2. Manufacture and facilities.
3. Packaging and transportation.
4. Usage.
5. Reuse or disposal.


**Figure 2.1** Life cycle of a device.

### 2.2.1 DESIGN

In the design stage, the idea is conceptualized and the device is designed, prototyped and tested. Above figure shows the typical steps in the design process. When a device gets into the design stage, set environment targets and should be done in parallel to conceptualization. Targets act as a benchmark and helps in decision making.

As the device is being prototyped, we need to continuously assess the prototype's design and improve it until the targets are achieved. Design changes have to be implemented and the prototype has to be assessed again for environmental impact. This process should go on until the device meets the environmental targets set for the device.

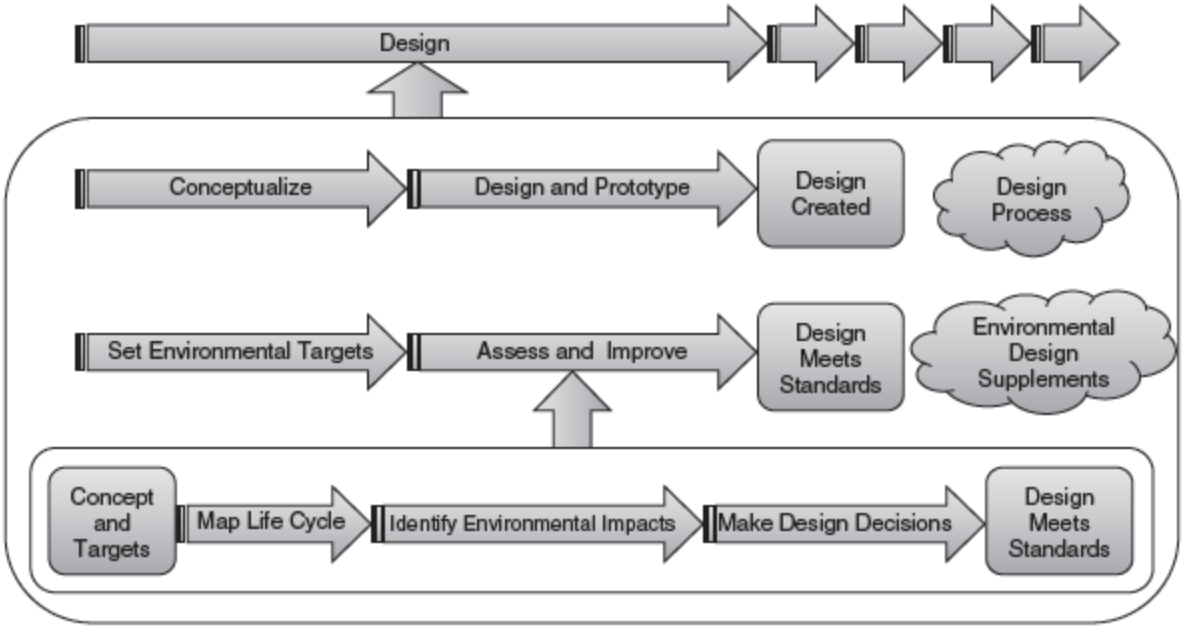



**Figure 2.2** Typical steps in design of a device.

### 2.2.2 MANUFACTURING

The manufacturing process is one of the main sources of environmental impact in the life cycle of a device. Manufacturing processes consume a lot of raw materials, water and energy; they create many different categories of waste, some which are toxic. It is important to reduce, if not eliminate, these materials both in the device and in its manufacturing process.

Electronic devices may contain hazardous and environmentally sensitive materials like Lead (Pb), Cadmium (Cd), Mercury (Hg), Poly Brominated Biphenyls (PBBs), Poly Brominated Diphenyl Ethers (PBDEs), Arsenic and Poly Vinyl Chloride (PVC).

**Table 2.1** Summary of hazardous chemicals used in the manufacturing of electronic devices

| Chemical | Used in | Effect on humans |
|---|---|---|
| Lead | Circuits, motherboards and glass monitors | Affects nervous system, hematopoietic system and kidneys |
| Cadmium | Low-temperature soldering, plating for corrosion protection, colorants in plastics and contact buttons in relays | Affects the liver and kidneys |
| Mercury | Monitors and batteries | Affects immune system, alters genetic and enzyme systems and damages the nervous system |
| Polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBBs) | Flame retardants | Extremely toxic |
| Arsenic | Manufacture of semiconductors | Affects cellular longevity |
| Polyvinyl chloride | Manufacture of computer parts | Carcinogen and also has effect |

- **Lead** is used in printed circuit boards and in glass monitors. They affects nervous system, hematopoietic system and kidneys. Excessive exposure to lead (Pb) results in clinical toxicity.
- **Cadmium** is used in low-temperature soldering, plating for corrosion protection, colorants in plastics and contact buttons in relays. Cadmium when ingested affects the liver and kidneys.
- **Mercury** is mainly used in monitors and batteries. Mercury is a well-known pollutant and it affects the immune system, alters genetic and damages the nervous system.
- **PBDEs and PBBs** are used as flame retardants. These materials are environmental pollutants; they are extremely toxic.
- **Arsenic** is used in glasses and in manufacturing semiconductors. Arsenic interferes with cellular longevity.
- **PVC** is the most commonly used plastics worldwide. It is used in the manufacture of computer parts. Vinyl chloride of PVC is a carcinogen and also affects the human reproductive system.

### 2.2.3 PACKAGING AND TRANSPORTATION

Packaging and transportation also contribute to the carbon footprint in a device's life cycle. They are the materials used for packaging and the carbon footprint of the vehicles used in transportation. The amount of material used for packaging needs to be kept at a minimum.

The size of the device has an effect on the amount of packaging required, so at design stage, effort must be made to make the device as compact as possible. Eco-friendly materials

like recycled paper, potato starch and recycled card board can be used as packaging materials and soy ink can be used for printing.

The following are general recommendations for designing suitable packaging

1. Packaging materials should be recyclable.
2. The amount of packaging materials should be kept at a minimum.
3. Various materials used in packaging should be easily separable to ease the recycling process.
4. Adhesive use should be reduced by using folds and tabs instead.
5. All the additives, coatings & inks that get added to the package should be eco-friendly.
6. Printed documentation can be avoided wherever possible.

In addition, transportation leads to a lot of carbon emission. Along with making the transport system efficient, the design of the device should facilitate smarter transportation. For example, the smaller the device, the more of them can be transported in a given space, thus reducing the number of vehicles required to transport them.

### 2.2.4 USE

Significant amount of energy is consumed by devices when they are being used. This increases a device's carbon footprint and impact on the environment. The energy efficient devices reduce energy consumption and cost. People should learn the usage pattern of devices results in optimal energy consumption.

#### 2.2.4.1 NOTEBOOK COMPUTERS

Strategies that help in reducing their power consumption include the following:

1. Reduce the brightness of the monitor. A brighter screen consumes more energy.
2. Switch off the monitor when some background task is running on the computer.
3. Use power-saving profiles which reduce the amount of energy consumed.
4. Do Multitasking.
5. Keep the minimum number of processes at start-up.

#### 2.2.4.2 SERVERS

Servers are computers designed to serve the needs of other computers. Servers generate a large amount of heat due to their large power consumption and hence they require better cooling mechanisms.

#### 2.2.4.3 MOBILE DEVICES

Mobile devices comprise mobile phones, personal digital assistants (PDAs) and other smart devices. These devices are produced in large numbers and are designed for operation with low power consumption. Chargers consume power even not changing a battery and hence waste power. So chargers should be switched off or unplugged when they are not charging, or disconnected from mobile devices.

#### 2.2.4.4 SPECIALIZED DEVICES

Specialized devices are designed for a specific purpose, such as set-top boxes, play stations and medical equipment like X-ray machines and computerized tomography (CT) scanners. Devices like set-top boxes and play stations consume power even when they are not in use (idle). It is important to switch off the devices so that they do not consume (waste) power when not in use.

### 2.3 REUSE, RECYCLE AND DISPOSE

One way to reduce waste is to increase the lifespan of the devices. Increasing the lifespan of devices saves life cycle energy & resources and reduces the amount of hazardous materials ending up in landfills. **Reus**ing an old computer is a great way to increase its lifespan. Reusing a computer is environmentally friendlier than recycling. Send the computer for **reuse** to some other place like an educational institution. Another way to increase the lifespan of a device is by **upgrad**ing its various parts.

Wherever reuse is not a better option, the next best option is to **recycle**. In the process of recycling, most of the original device's materials are reused as raw materials for a new device, thus resulting in less waste. For recycling, collect back the old devices from customers. E-waste is not properly recycled in developing countries. There recycling simply burn off the e-waste or dump the waste into rivers.

The last option is **disposal**. The techniques of waste disposal are **incineration, chemical decomposition** and **landfill**. Techniques are applied based on the materials used. Incineration is combustion of organic materials in waste materials. It results in the release of toxic gases and can pose a hazard. On the positive side, the heat generated may be used in generating electricity. If non biodegradable materials used, we can go for chemical decomposition and will have to be executed carefully. If biodegradable materials are used then we can go for landfills. Safe disposal is a major problem and the solution depends on the specific material used in manufacturing the device.

### 2.4 GREEN SOFTWARE

A green IT infrastructure is incomplete without green software. Software plays an important role in overall platform energy efficiency. A computing 'platform' is a combination of hardware, software and other technologies that allow software to run. Every device runs software and every one of them requires energy to do it.

#### 2.4.1 PROCESSOR POWER STATES

For software developers, central processing unit (CPU) is the most important factor. CPUs have defined energy states. If the CPU is not actively processing information or not performing computations, it consumes minimal energy. The CPU has C-states and P-states.

#### 2.4.1.1 C-STATES

C-states are core power states that define the degree to which the processor is 'sleeping'. In state C0, the processor is active and executing instructions (tasks) and it is performing that task at a frequency (P-state).

C-states are referred to as sleep states. With each deeper sleep state (Cn), some new part of the CPU is turned off and more energy is saved. Deeper sleep leads to greater energy savings.

#### 2.4.1.2 P-STATES

P-states are performance states that define the frequency at which the processor is running. P-states were developed to save energy and deliver the required performance when we need it. Typical P-states are as follows:

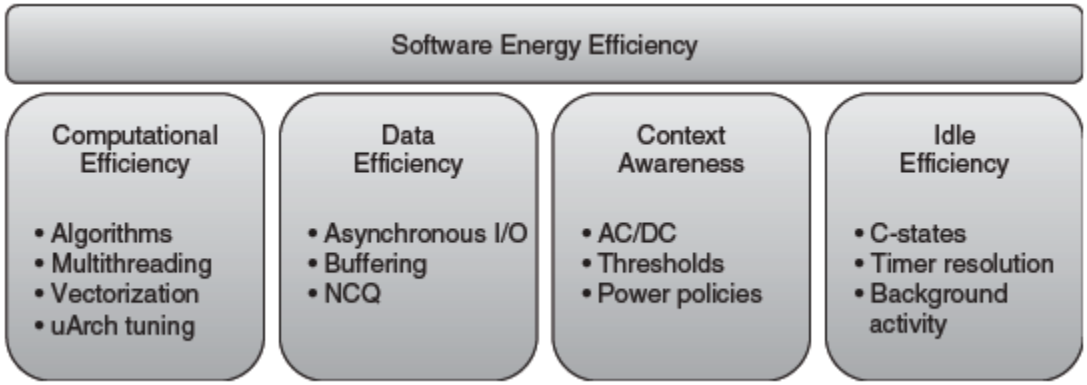
- P0; maximum power and frequency.
- P1; less than P0; voltage or frequency scaled down.
- Pn; lowest rated voltage and/or frequency.

### 2.5 ENERGY-SAVING SOFTWARE TECHNIQUES

Well-behaved software allows the energy saving features to work. If not leads to lower battery life and higher energy costs.

Active software is software that is fulfilling its intended purpose. There would be a workload that the CPU is busy working on. Idle software is software that is essentially running but waiting for an event to make it active.

Software energy efficiency can be improved by improving computational efficiency, data efficiency and idle efficiency and by enhancing context awareness.




### 2.5.1 COMPUTATIONAL EFFICIENCY

Computational efficiency means getting the workload done quickly, with minimal energy consumption. The software performance saves not only time but also energy. The faster we can complete the workload and get the computer back to idle, the more energy we can save.

Computational efficiency can be achieved by efficient algorithms, multithreading, vectorization and uArch tuning are used.

#### 2.5.1.1 EFFICIENT ALGORITHMS

The choice of algorithms and data structures affects the application's performance. For a particular problem, a stack may be better than a queue and a B-tree may be better than a binary tree or a hash function.

The best algorithm or data structure to use depends on problem study and consideration of the architecture, design, algorithms and data structures.

### 2.5.1.2 MULTITHREADING

Software with multi threading feature has better performance and also better energy efficiency. Multi-threading takes advantage of the multiple cores available in modern compute platforms. A well-balanced multithreaded workload is more energy efficient than running the same workload with a single thread.

### 2.5.1.3 VECTORIZATION

Computational efficiency is achieved by vectorizing the code instead of using scalar code. In vectorization technique, advanced instructions such as single-instruction multiple data (SIMD) used. SIMD works with instruction-level data parallelism and completes the task faster and hence save energy.

### 2.5.2 DATA EFFICIENCY

Data efficiency reduces energy costs by minimizing data movement across different components and delivers performance benefits. Data efficiency can be achieved by designing:

- Software algorithms that minimize data movement;
- Memory hierarchies that keep data close to processing elements;
- Application software that efficiently uses cache memories.

Methods for achieving data efficiency are

### 2.5.2.1 MANAGING DISK I/O

Performance of hard disk drive depends on rotational speed, seek time, rotational latency. Hard disk consumes more energy when it is spinning. If spin time is reduced, energy can be saved. Below are the energy usage techniques.

- Impact of block size on sequential reads: When reading a large volume of sequential data, reading the data in larger chunks (blocks) requires lower processor utilization and less energy.
- Impact of native command queuing (NCQ) on random reads: Asynchronous I/O with native command queuing (NCQ) improves performance and saves energy.
- Buffering during multimedia playback: For multimedia playback, reading ahead and caching media content will save energy.
- Impact of fragmentation: The performance and energy costs to read a fragmented file are greater than those of a contiguous file.
- Disk I/O in multithreaded code: The performance and energy costs of multithreading can be reduced by coordinating access to shared data.

### 2.5.2.2 PRE-FETCHING AND CACHING

Three guidelines emerge that can help save energy during DVD playback are

- **Buffering:** Apply buffering techniques, which can reduce DVD power consumption by 70% and overall platform power consumption by about 10.
- **Minimize DVD drive use:** Reduce DVD spin-up, spin-downs and read accesses in order to save energy.

- **Let the OS manage the CPU frequency:** Allow the OS to set the appropriate P-state, adjusting the CPU frequency as needed.

### 2.5.3 CONTEXT AWARENESS

Context awareness in computers means that they can sense the environment in which they are operating and software can be designed to react to changes in the environment. Embedded systems are particularly context aware. Examples of context-aware behaviour are as follows:

- A PC or smart phone warns you when your battery has reached a low-energy state.
- A notebook PC responds to a change from AC to DC power by automatically dimming the display.
- A tablet or smart phone responds to ambient light level and adjusts display brightness.

#### 2.5.3.1 AWARENESS OF POWER SOURCE

It is beneficial for the application to know its source. For example, if a notebook PC is plugged into an AC power source or operating on battery. When power status change, system should indicate this with a notification. Event notifications include the switch from AC to DC power and battery reaches threshold etc.

#### 2.5.3.2 PLATFORM POWER POLICIES

Microsoft Windows provides built-in power policies – High performance, Balanced and Power saver. They give the user the option to choose between better performance and better battery life.

Application software can use power policies in the following ways:

- Adjust application behaviour based on the user's current power policy.
- Change application behaviour in response to a change in power policy.
- Change the power policy to suit the application behaviour.

### 2.5.4 IDLE EFFICIENCY

Idle Power is defined as the power consumed when the software applications and services in the system are running but not actively executing workloads. In this state, there is minimal background activity.

#### 2.5.4.1 DEEP C-STATE RESIDENCY

One of the key requirements for achieving idle efficiency is to keep the system in deeper C-states for as long time. a duration as possible. Software should aim to keep the number of C-state transitions coming and going out of deep C-state as low as possible. Frequent C-state transitions from C6/C7 to C0 are not energy efficient. When the C0 (active) duration is very small, the latency to transition in and out of the C-states may result in net energy loss.

#### 2.5.4.2 OS Timer Resolution

The default system-wide timer resolution in Windows is 15.6 ms ie OS receives a clock interrupt from the system timer hardware. When the clock interrupts fires, OS has to handle interrupt and leads to energy loss. High resolution timers (timer resolution less than 10 ms)

effect the performance. Hence to use the application which use low resolution timer (more than 10 ms).

Applications and services should use the lowest timer resolution possible that meets the performance requirements of the application. If the application (audio, video, graphics) requires a high-resolution periodic timer, increase the timer resolution only when the application is active and then return the timer to its default state after the application exits.

### 2.5.4.3 Background Activity

Frequent periodic background activity increases overall system power consumption. It impacts both the processor and chipset power. Long-running, infrequent events also prevent the system from idling to sleep. Background activity on the macro scale (e.g. minutes or hours) such as disk defragmentation, antivirus scans and the like are also important for power. Windows 7 has introduced a unified background process manager (UBPM) to minimize the power impact from background activities.

# 3. GREEN ENTERPRISES AND THE ROLE OF IT

## 3.1 INTRODUCTION

Enterprises are becoming greener and IT plays major roles in greening an enterprise. For planning and controlling each of the value chain functions of organization, IT can effectively be used. E-commerce business practices are heavily dependent on IT.

## 3.2 ORGANIZATIONAL AND ENTERPRISE GREENING

The greening of IS and IT consists of these efforts for gaining business value. ***Green IS*** refers to improving the flow and management of information and ***Green IT*** *refers* more to the hardware and other infrastructure that can be better managed and designed from an environmental perspective.

The four business value dimensions for enterprise greening: *cost reduction, revenue generation, resiliency or business continuity and legitimacy ('the right to do business').*

Elimination or reduction of waste reduces the cost. Consumption of excessive resources such as energy and paper essentially means there is inefficiency and increased costs.

Organizations can generate extra revenue through green IT and IS practices. By-products and former waste products are re-used instead of disposal to landfills. IT products and materials that are returned may be recycled, remanufactured and resold as 'green' products.

Business continuity - means having the resources to remain in business and deliver products or services to customers, making sure your organization and partners are resilient. By removing hazardous materials in IT products, helps in long-term continuity.

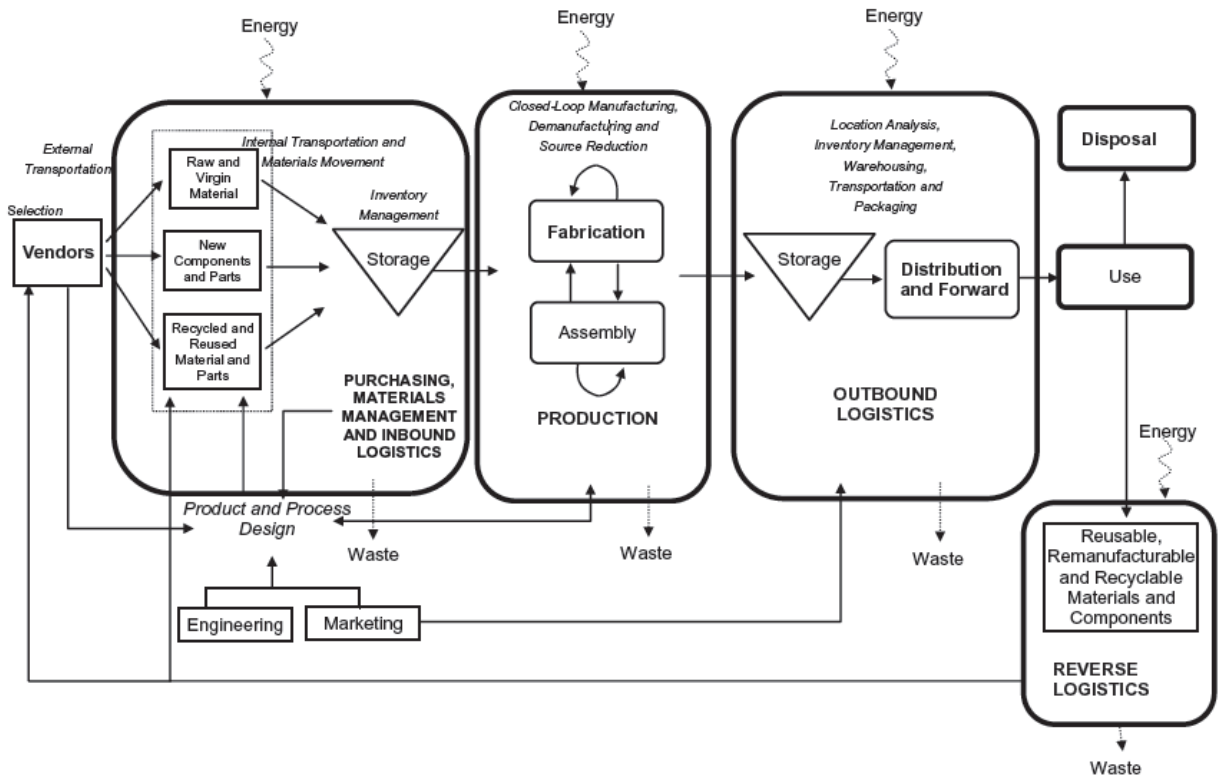
To operate effectively and with little stakeholder conflict, organizations need to develop their 'right to do business'. It is related to reputation and legitimacy of organizations that have green IT and IS practices in place. Industries or companies that are viewed as socially irresponsible will have greater barriers and thus difficulty when attempting to complete their business activities and also in business expansion.

### 3.2.1 THE GREEN ENTERPRISE: A VALUE CHAIN PERSPECTIVE

Figure describes activities and operations within an organization's value chain. The activities begin with procurement and inbound logistics functions that introduce materials and services into the organizational system. These materials are transported from various vendors.

The policies for selection of vendors, including transportation and delivery services, are a central issue for purchasing agents. Thus, the selection of material, services and suppliers may become critical for the purchasing function to help guarantee the environmental performance of their supply chain and materials.

Relationships with suppliers including environmentally oriented selection, development and supplier management are needed for effectively greening the procurement function. These materials are then stored or the services are utilized and may be managed under the auspices of the purchasing function.




## 3.3 INFORMATION SYSTEMS IN GREENING ENTERPRISES

Organizational IS can be separated into four major categories of systems: the transaction processing system (TPS), decision support system (DSS), management information system (MIS) and executive support system (ESS). In addition to these, recently a new category of IS, environmental management information system (EMIS) that helps to manage environmental aspects is emerging.

TPS are focussed at the operational level of an organization and deal with real-time and very short-term information requirements..

MIS is focussed at the middle management (tactical-planning) level of an organization. MIS's role is to summarize and aggregate in reporting and communication systems the company's operational information.

DSS is also focussed at the middle management level of an organization. DSSs are typically analytical tools that help middle-level managers make relatively routine decisions and use information from various levels of the organization.

ESSs focus on the needs and requirements of upper management and aid their focus on strategic management of the organization. Information is aggregated from the lower level systems and summarized.

**Table 12.2** Summary of various information system categories and environmental activities by organizational function

| Managerial decision level | Operational level | Management level | | Strategic level |
|---|---|---|---|---|
| Functional area | Transaction processing systems (TPS) | Management information systems (MIS) | Decision support systems (DSS) | Executive support systems (ESS) |
| Engineering and design | New product requirements, and environmental liability | Economic justification models for designs, and design for environment (DFE) decision tools | LCA inventory data | Environmental product and process performance |
| Procurement | Updating inventory of environmentally sensitive material | Reports concerning environmental performance of suppliers | Supplier selection decision models with environmental factors | Due diligence merger information, and superfund liability information |
| Manufacturing and production | E-mail reminders of permit thresholds | Daily and weekly levels of hazardous wastes generated from processes for Toxics Release Inventory (TRI) reporting | Disassembly production planning tools | Global, yearly emissions changes, and environmental technology information |
| Sales and marketing | Daily sales of environmentally sensitive materials | Information on different green promotion successes | Forecasting tools for green product requirements | Green consumer data |
| Logistics | Amount of packaging returns for day and scheduling of reclaimed materials | Reports on daily and weekly fuel usage | Simulation tools for transportation and energy planning and network design | Long-term data and plans for transportation fleet |

### 3.3.1 ENVIRONMENTAL MANAGEMENT INFORMATION SYSTEMS

EMISs include hardware, software, people, procedures and tasks that manage environmental information and support environmental and other managers in managing environmental issues within and between organizations.

### 3.3.2 SOFTWARE AND DATABASES

Environmental software programmes cover everything from auditing and managing emissions to analysing energy and minimizing waste. A summary of the major software and database systems are shown in Table.

| Type | Description |
|---|---|
| Mass flow and process flow software | Software enabling the construction of full mass flow input and output at different company levels. Helps the user develop a process or mass flow diagram that depicts the sequence of operations for all products. Narrow focus on environmental data. |
| Life cycle software | Link environmental interaction to environmental impact, and assess these aspects for the whole product life cycle. Assist managers in assessing the environmental impacts of each stage of the life cycle of a product, from raw material extraction through transport, design, development, sale and return. |
| Environmental risk and impact assessment software | Identifies and assesses risks and impacts associated with activities at the site level. Focusses on specific events and calculates vulnerability, probability, frequency and potential consequences. Assesses direct and indirect impacts of an activity. |
| Environmental cost assessment software | For use in identifying and assessing costs associated with various environmental activities including clean-up, remediation and process changes due to environmental considerations, related to environmental risk and impact assessment software. |
| Application, modelling and simulation software | Enables the user to construct models of processes and sites. Helps managers visualize impacts, and how they interact or react in different scenarios. Geographic information systems are usually elements of this software. |
| Regulatory software | Focusses on government environmental, health and safety regulations, workplace assessments, health and safety project management, illness records and injury statistics. Text of environment-related laws and regulations with guidance and comments also exists. |
| Waste management software | Manages data for hazardous and solid waste – from profiling and manifesting to calculating, monitoring and tracking at the operational level |
| Permit management and MSDS software | Provides management, processing, tracking and reporting support for permit, submission and monitoring compliance status. Also provides immediate information on materials in production chain. May be related to life cycle and other information software. Databases containing knowledge of chemical substance characteristics, international standards for hazard labelling and so on. |

| | |
|---|---|
| Environmental management system software | These packages contain tools for facilitating the implementation of an environmental management system. Some also contain the documentation for ISO 14001 and the European Union's EMAS. Used for implementation of environmental management standards – for example, ISO 14001 or EMAS. Tracking, managing documents, scheduling and monitoring tasks for each element and aspect of these standards may be included. |
| Integrated and modular software | A system that combines a number of the modular software types mentioned in this table. The larger IT framework could be Web based. Enterprise resource planning systems may contain these modules. |

### 3.3.3 ERP EMIS

Many ERP systems have a multitude of data with environmental relevance but they mainly focus on substance classification, hazardous material and disposal criteria. An integrated enterprise resource planning (ERP) system, as shown in Figure can cover many of the environmental management IS software types, database types and organizational functions.

Much of these data could not be used for monitoring and controlling material, energy and water consumption or material or energy flows.

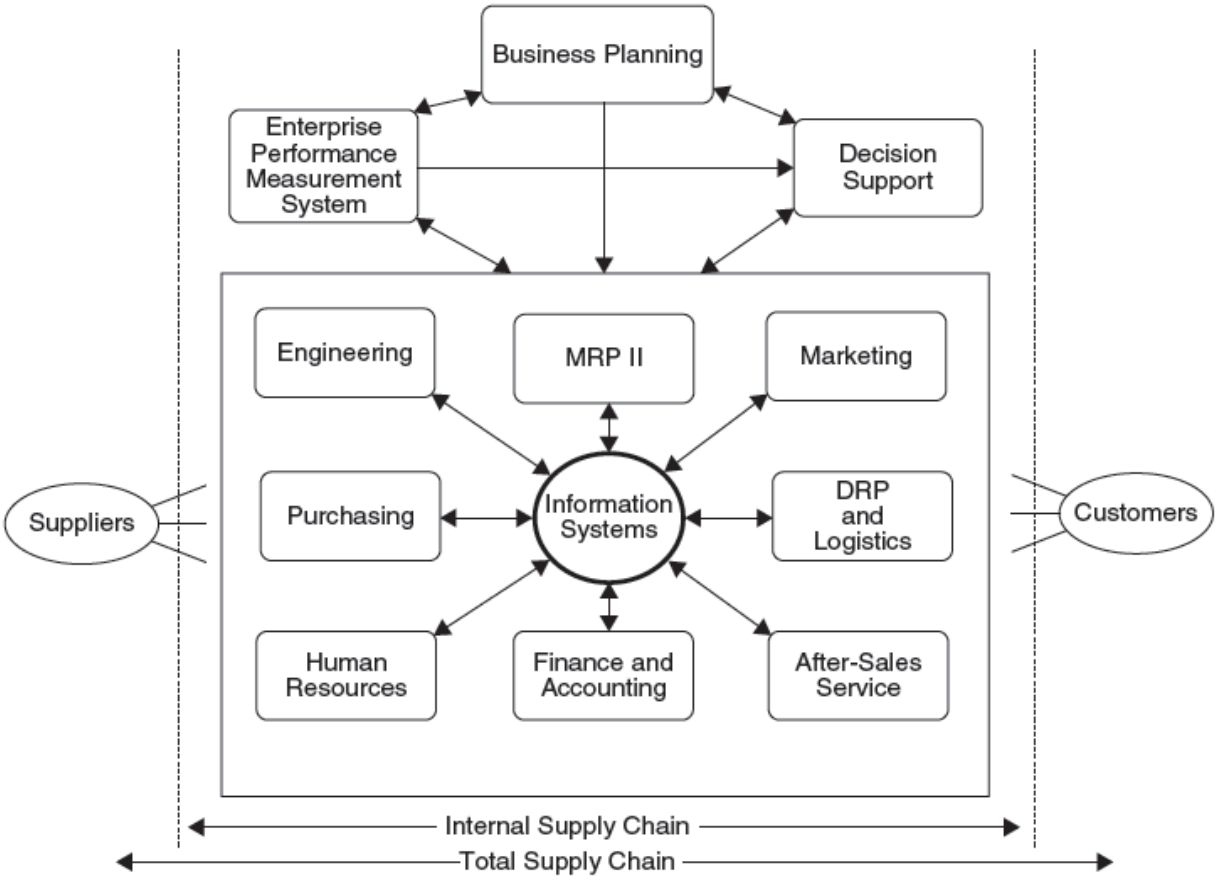



Figure - ERP systems with modules and relationship

EMIS is designed as stand-alone, isolated, software tools. The **physical flow model** - environmental harm directly connected to production is related to physical flows entering and

leaving the production process. From a costing point of view, physical flows are important. The essential units for most EMISs are **physical ones**: mass units (kg) and energy units (MJ).

The relationship between physical data and environmental data is usually dependent on industry and accounting of materials. Another unique aspect of environmental information and the IS design is **supply chain partners** (i.e. suppliers and customers).

### 3.3.3.1 MATERIALS AND PRODUCTS INFORMATION

Material and product data are available through a bill of material (BOM) and usually is not sufficient from an environmental point of view. This product and material information is on technical aspects, quality, product specifications but partial information about environmentally relevant data and material requirements planning (MRP) data.

A BOM usually includes number weight of components or only incomplete information on weight.

### 3.3.3.2 PROCESS AND WORK FLOW INFORMATION

Process flow charts are part of ERP systems and used to describe the material and energy flows in an LCA. Using work orders information, process flow charts can be generated to track production related data for resource and energy use.

### 3.3.3.3 SUPPLY CHAIN INFORMATION

Transportation and logistics-type information could be useful for environmental management reasons. Supplier information can be used to calculate the transportation effort to the company. Transportation methods within a company can be obtained from the work order. The distribution methods from a company can be obtained from the sales and distribution functionality of an ERP system.

### 3.3.3.4 INFORMATION ABOUT WASTE

This information includes types and quantity of waste and the product that generated the waste. Transportation planning will identify weights, modes of transport, distances and other information that can be used to evaluate the carbon footprint.

## 3.3.4 ERP CHALLENGES AND DEFICIENCIES WITH RESPECT TO EMIS

A number of issues are related to the difficulty of integrating the two systems:

- No one ERP system exists that meets the needs of companies with diverse and multidimensional EMIS requirements
- Data are usually at highly aggregated levels.
- There is only partial registration of the BOM's components: registration of components and their weights but not materials or substances.
- There is no integration of energy use, water use or emissions into water, air or land.
- The entire life cycle is not included. Recycling and reuse are not considered.
- There is no capability to generate reports for EMS or LCA.

## 3.4 GREENING THE ENTERPRISE: IT USAGE AND HARDWARE

Enterprise can be greened by the adoption of environmentally friendly materials, procedures and practices in the design, manufacture and delivery of IT systems. Electronic

products require significant 'clean' requirements. Higher purity requirements mean a greater need for energy and materials. For example, a 2 g memory chip may require 1.3 kg (1300 g) of material resource input. Large quantities of energy, materials and chemicals are consumed during the production phase, not all of which will be contained in the final products.

Green IT standards such as Electronic Product Environmental Assessment Tool (EPEAT), RoHS (Restriction of Hazardous Substances Directive), WEEE (Waste Electrical & Electronic Equipments), Energy Star, LEED (Leadership in Energy and Environmental Design) are helps identify greener computers and other electronic equipment.

EPEAT most powerful tools which is a three-tiered, point-based system. There are 23 required criteria to meet the lowest level of EPEAT certification, which is EPEAT Bronze. These criteria cover the entire life cycle of a product from a reduction of the toxic materials used in production to the energy it uses in operation and the recyclability of its materials at the end of life. Products that meet all 23 criteria receive Bronze certification. Those that meet an additional 14 receive Silver and those who meet additional 21 receive Gold certification.

### 3.5 INTER-ORGANIZATIONAL ENTERPRISE ACTIVITIES AND GREEN ISSUES

Three activities that are gaining growing interest: electronic commerce and purchasing, reverse logistics and de-manufacturing.

#### 3.5.1 ELECTRONIC COMMERCE

Electronic commerce (e-commerce) is the process of buying and selling goods and services electronically through computerized or mobile communication systems using Internet, the World Wide Web and electronic data interchanges.

E-commerce can occur between business and consumers (B2Cs), businesses and other businesses (B2Bs) and consumers and consumers (C2C). By implementing e-commerce helps to better manage their inventories through better information sharing. This contributes to less waste and obsolete products which are fundamental factors for green, ecologically friendly practices.

Consumers can quickly gather price and product information through the Internet and male buying decision. The convenience of home shopping is one major reason behind the popularity of e-commerce. That is, consumers and companies can have products delivered from centralized locations versus driving to and from individual outlets. Less or no packaging is required for information products that can be delivered online.

Some experts believe that e-commerce, rather than making the supply chain more effective may increase transport distances resulting in increased pollution.

#### 3.5.2 DEMANUFACTURING AND REVERSE LOGISTICS

To help extend the life of IT products or materials managing and incorporating a reverse-logistics channel is necessary.

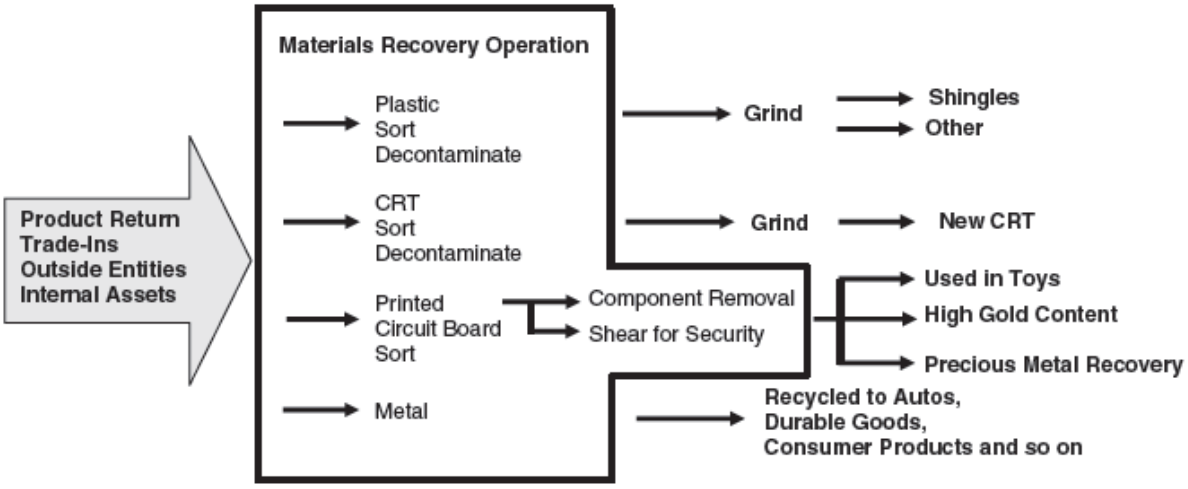
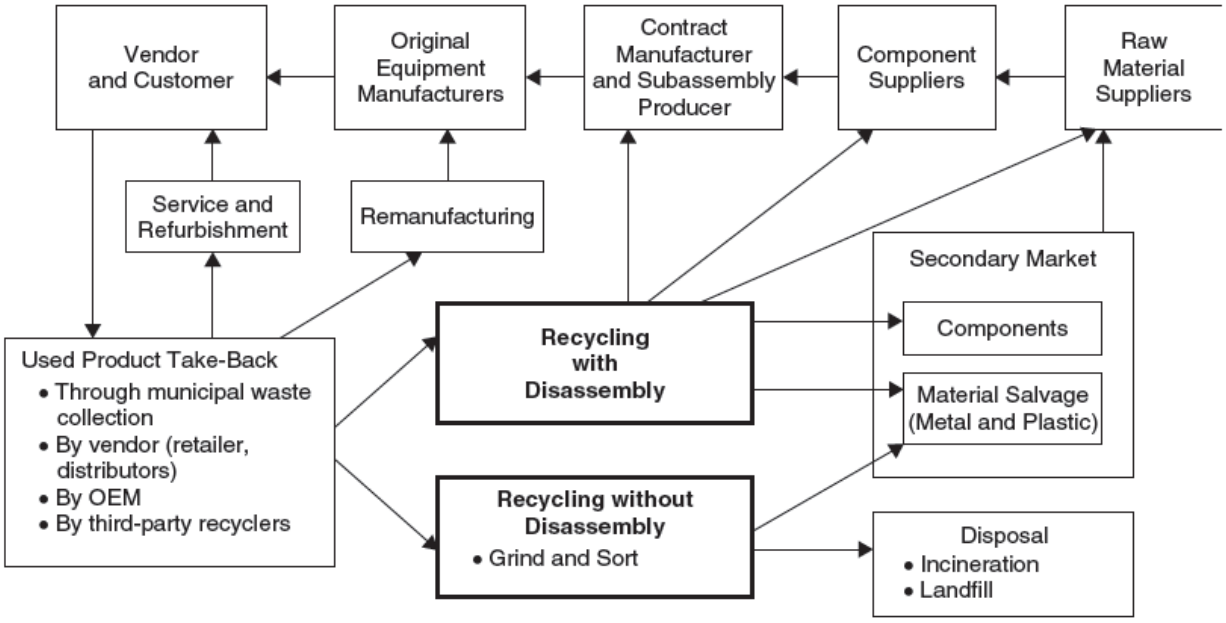



**Figure 12.4** Typical flows and operations of a demanufacturing facility.

Figure provides a summary design of a closed - loop system.




There are multiple loops including immediate reuse back to the consumer market, remanufacturing of equipment around a core, disassembly and recycling with removal and reuse of various parts and recycling without disassembly through destruction of the original equipment and material.

Markets exist for each of these dimensions, and the value of each would need to be determined. The materials are recovered by acquisition of products and materials. The first flow of material goes directly to the disassembly portion of the facility. The second flow of material goes to a sorting section to determine the category of material.

Material which needs some simple 'remanufacturing' or needs to be disassembled for recovery of reusable components or recyclable materials are done. Depending on the material some material will require little processing and others will require a high processing.

### 3.6 ENABLERS AND MAKING THE GREEN ENTERPRISE

There are four major categories of enablers for green IT are: strategy definition, organizational support, motivation and traceability.

- **Strategy definition:** A clear target definition for *sustainability* is required. Corporate strategic measures need to focus beyond economic metrics, towards inclusion of values associated with economic and greening responsibilities.
- **Organizational support:** The main organizational enablers for the successful adoption of any sustainable practices are top management support. With regard to top management support, having the commitment from chief executives – CEO and COO – ensures strategic commitment and support for making organizational change. Bottom-up support may be equally important.
- **Motivation:** Both extrinsic and intrinsic motivational factors play a role in adopting new business programmes. Intrinsic motivation is more effective and is an important personal characteristic to achieve bottom-up support. Extrinsic motivation will require more formal procedures and rewards.
- **Traceability:** This is in the sense of transparency and measurement, also important enablers for greening IT. IT also plays an important process role since measurement systems are heavily reliant on software and IS.

# 4 MANAGING GREEN IT

## 4.1 STRATEGIZING GREEN INITIATIVES

Successfully formulating, implementing and managing green initiatives calls for strategic thinking, strategic planning and strategic implementation.

### 4.1.1 STRATEGIC THINKING

We need a strategy to green your IT or enterprise. Many managers with previous experience in a technical field tend to dive right into the plan without strategically thinking where the plan should lead.

Formulating and implementing green IT initiatives require strategic thinking prior to strategic planning and prior to the development of those requirements. Strategic thinking is a distinctive activity whose purpose is to discover green strategies that offer value.

Strategic thinking is a mental process that arising from personal and managerial experience – that must be enhanced as part of professional development.

### 4.1.2 STRATEGIC PLANNING

Strategic planning is a formal process of defining the requirements for delivering a green IT programme – identifying what and how green system and equipment can be achieved.

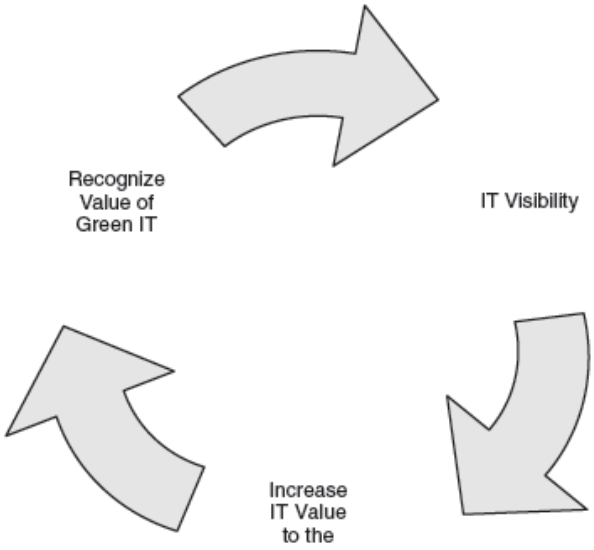
Strategic planning is an organization's process of defining its strategy and making decisions on allocating its resources (people & money) to pursue this strategy. It is the process for determining where an organization wants to be in the short term and in the long term.

Strategic planning starts with a prior mission statement and a vision and leads to the formulation of goals and objectives.

The mission statement tells you the fundamental purpose of the organization. A vision statement tells what the organization wants to be and it concentrates on the future as a source of inspiration and provides clear decision-making criteria.

### 4.1.3 STRATEGIC IMPLEMENTATION

IT is recognized as a strategic resource. It is the responsibility of IT manager to recognize IT as a resource. This increase IT visibility and allows the manager to demonstrate how green IT can have a positive value impact for the company.



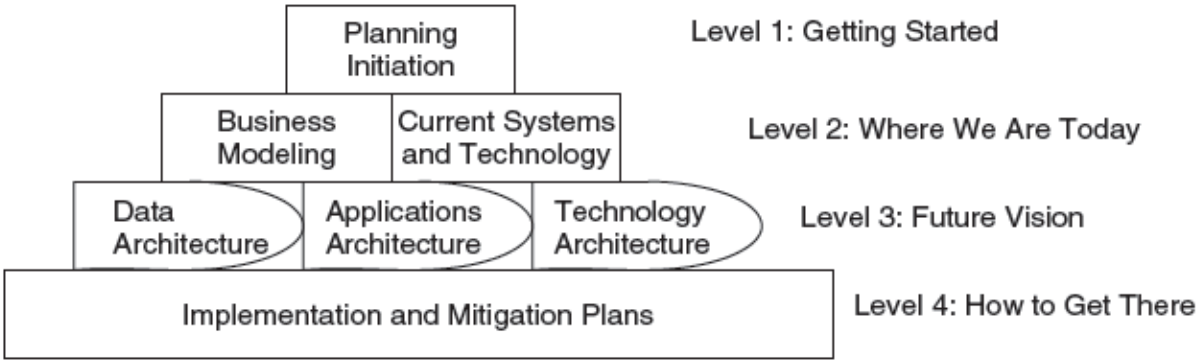
Green IT implementation example such as turning off computers is encouraged. New habits need to be developed that produce both real and perceived value.

To build a green environment you must modify or abolish many old and familiar ways of doing business.

### 4.1.4 ENTERPRISE ARCHITECTURE PLANNING

EA is a method for developing architectural frameworks. Enterprise architecture planning (EAP) is the process of defining architectures for the use of information in support of the business and the plan for implementing those architectures.

The business is the primary mission, followed by the data required to satisfy the mission, then the applications are built using those data, finally followed by the technology to implement these applications.




EAP activity is represented in Figure in which the layers are implemented from top to bottom. There are four layers critical to successful EAP:

- **Layer 1 – getting started:** This planning initiation layer leads to producing an EAP work plan and stresses the high-level management to support and provide resource.

  It includes decisions on which methodology to use, who should be involved, what other support is required and what toolset will be used.
- **Layer 2 – the vision of where we are today:** This layer provides a baseline for defining the architecture and the long-range migration plan.

  It consists of business process modelling, which is a knowledge base about the business functions and the information for various businesses.

  It also consists of current systems and technology, a definition of current application systems and supporting technology platforms.
- **Layer 3 – the vision of where we want to be:** This layer includes the data architecture defining the major kinds of data needed, applications architecture defining the major kinds of applications needed to manage that data and technology architecture defining the technology platforms needed to support the applications.
- **Layer 4 – how we plan to get there:** The implementation and migration plans define the sequence for implementing applications, a schedule for implementation, a cost–benefit analysis and a clear path for migration.

## 4.2 IMPLEMENTATION OF GREEN IT

Initiating green IT management involves four key components:

1. Adopt a bottom-up or top-down approach. If you are part of the company's management team, initiate discussion.
2. Understand the complexities and interdependencies of how products, architectures and operating procedures impact green initiatives.
3. Understand the trade-offs, the architecture and what will be required.
4. Use point solutions associated with comprehensive plans and sound architectures.

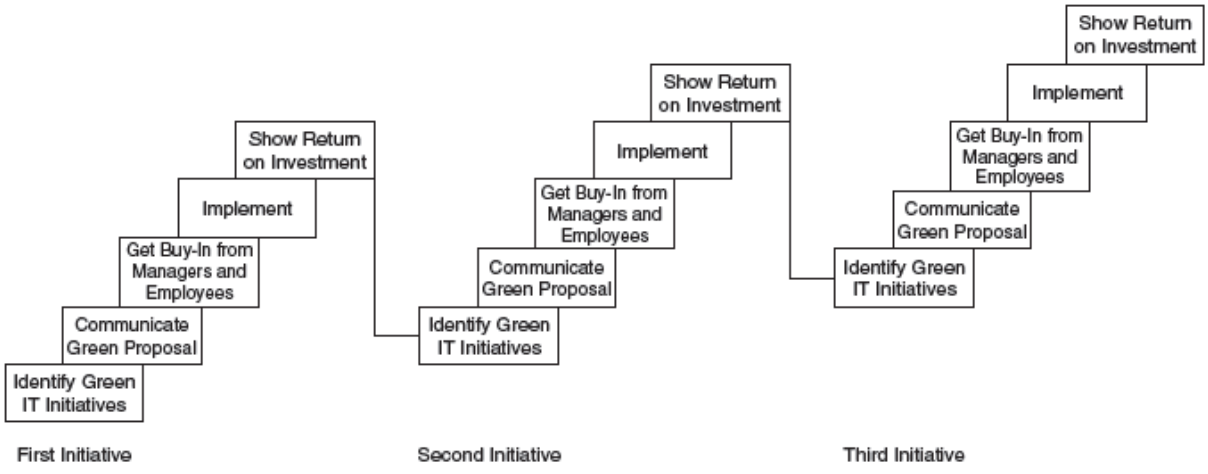
Computers and the IT infrastructure consume significant amounts of electricity and contribute to greenhouse gas emissions. Simple actions such as turning off power strips are easily done by the employees both at work and at home. By educating employees and encouraging these actions, the company benefits as do the employees through the reduction in energy costs. Also educate and convince employees by providing them with relevant information and demonstrating the value of the proposed initiatives. In order to be successful, users must be active participants. Educate employees on how to save energy, and get them involved. Seek employee's feedback, address their concerns and encourage them to participate.

### 4.2.1 RETURN ON INVESTMENT

It is the responsibility of the IT manager to identify and deliver value, and then communicate to management what value has been added. How that value is determined is the responsibility of the technical staff.

For example, assume that an IT manager is upgrading a data centre. As the equipment is purchased, show the value added by the new equipment (e.g. it is made of X% recyclable material). This comparison is necessary to make sure that upper management understands the value of the change.

At the next step, the first installation, which is always the hardest and where unexpected problems are found, should address problems as quickly as possible. At the end of the project announce how the new green IT equipment has made a difference to the environment and energy consumption. This process is demonstrated in Figure.



### 4.2.2 METRICS

Metric programmes are initiated to demonstrate the improvements or benefits of green initiatives. The first step in developing a metrics programme is to identify the program's goals or objectives. Next define the attributes that are to be measured. The final step is to provide management with answers to their questions based on the metric analysis. The key to continued success of a metrics program is immediate, visible benefits.

### 4.2.3 THE GOAL–QUESTION–METRIC (GQM) PARADIGM

The goal–question–metric (GQM) paradigm is a simple mechanism that provides a framework for developing a metrics program by formalizing the characterization, planning, construction, analysis, learning and feedback tasks.

The GQM paradigm consists of three steps:

1. **Generate a set of goals based upon the needs of the organization**- Determine what it is you want to improve
2. **Derive a set of questions**: The purpose of these questions is to quantify the goals.
3. **Develop a set of metrics which provide the information needed to answer the questions**. In this step, the actual data needed to answer the questions are identified and associated with each of the questions.

## 4.3 INFORMATION ASSURANCE (IA)

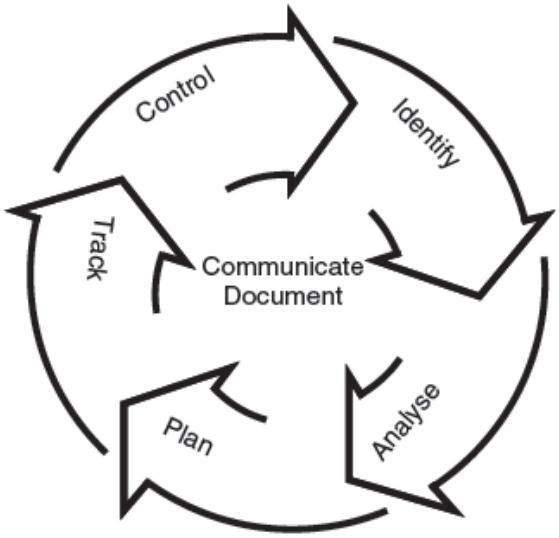
IA is the practice of managing risks related to the use, processing, storage and transmission of information and the systems and processes used for those purposes.

### 4.3.1 RISK MANAGEMENT

Risk management helps avoid disasters, rework and overkill. It also stimulates win–win situation. The objectives of risk management are to identify, address and eliminate risk items before they become threats to the success of implementing green initiatives.

Risks have two characteristics: (i) **uncertainty**: An event may or may not happen and (ii) **loss**: An event may have unwanted consequences or losses.

Risk assessment is a continuous process and involves the following six steps:



1. **Identify:** Consider risks before they become problems and add this information to project management process.
2. **Analyse:** Examine the risks in detail to determine the risks, how they relate to each other and which ones are the most important. Analysing risks comprises three basic activities:
   (a) **Impact:** The loss or negative effect on the project.
   (b) **Probability:** The occurrence of risk.
   (c) **Timeframe:** The period in which you must take action in order to mitigate the risk.
3. **Plan:** Decide what should be done about a risk and develop mitigation strategies based on current knowledge of project risks. The purpose of this plan is to
   (a) Make sure the risk's consequences and sources are known;
   (b) Develop effective plans;
   (c) Plan efficiently.
4. **Track:** Track the process by collecting accurate relevant risk information. Tracking status information becomes critical to performing the next function - control.
5. **Control:** Make effective decisions regarding risks and their mitigation plans. This process needs tracking status information and decides exactly what to do based on the reported data. Controlling risks involves analysing the status reports, deciding how to proceed and then implementing those decisions.
6. **Communicate and document:** Ensure *all* personnel understand the risks of mitigating to green. Communication and documentation are essential to the success of all other functions within the paradigm and are critical for managing risks.

## 4.4 COMMUNICATION AND SOCIAL MEDIA

Communication to stakeholders and stakeholder participation are keys to the success of green initiatives. Among other channels, social media can be used for communicating among stakeholders green initiatives, their progress and their benefits as well as to get their feedback and to engage and involve them.

Start by establishing the IT department as the social authority expert in the field of green IT. By becoming the social authority, you become the influencer and have the opportunity to pull other employees outside the IT department into the push towards green IT. Be careful in your conversations. Always back up your statements with clear facts. Build trust slowly but continually. The most effective marketing approaches revolve around honestly convincing people and providing valuable and accurate information.

# 5. REGULATING GREEN IT: LAWS, STANDARDS AND PROTOCOLS

## 5.1 INTRODUCTION

Organizations in the electrical, electronics and information and communication technology (ICT) sectors are confronted with diverse regulations and its purpose is to make their products environmentally friendly.

The term *green IT* refers to information technologies that have minimum direct effects on the environment in that they (i) consume low amounts of electrical energy in operation and standby modes, (ii) contribute minimally to greenhouse gas (GHG) emissions when in use, (iii) are designed for the environment and are therefore in compliance with regulations on hazardous and restricted substances.

The green IT–based applications typically perform one or more of the following functions:

1. Monitor and report on GHG emissions.
2. Control and report on waste, toxic and hazardous materials use.
3. Manage energy-consuming facilities such as offices, manufacturing facilities.
4. Enable design for environment (DfE).
5. Help redesign business processes to make them energy efficient.
6. Enable energy-efficient logistics and transport throughout the supply chain.
7. Enable dematerialization of travel and other physical carbon-intensive artefacts.
8. Integrate with existing IT-based platforms to make them energy efficient.

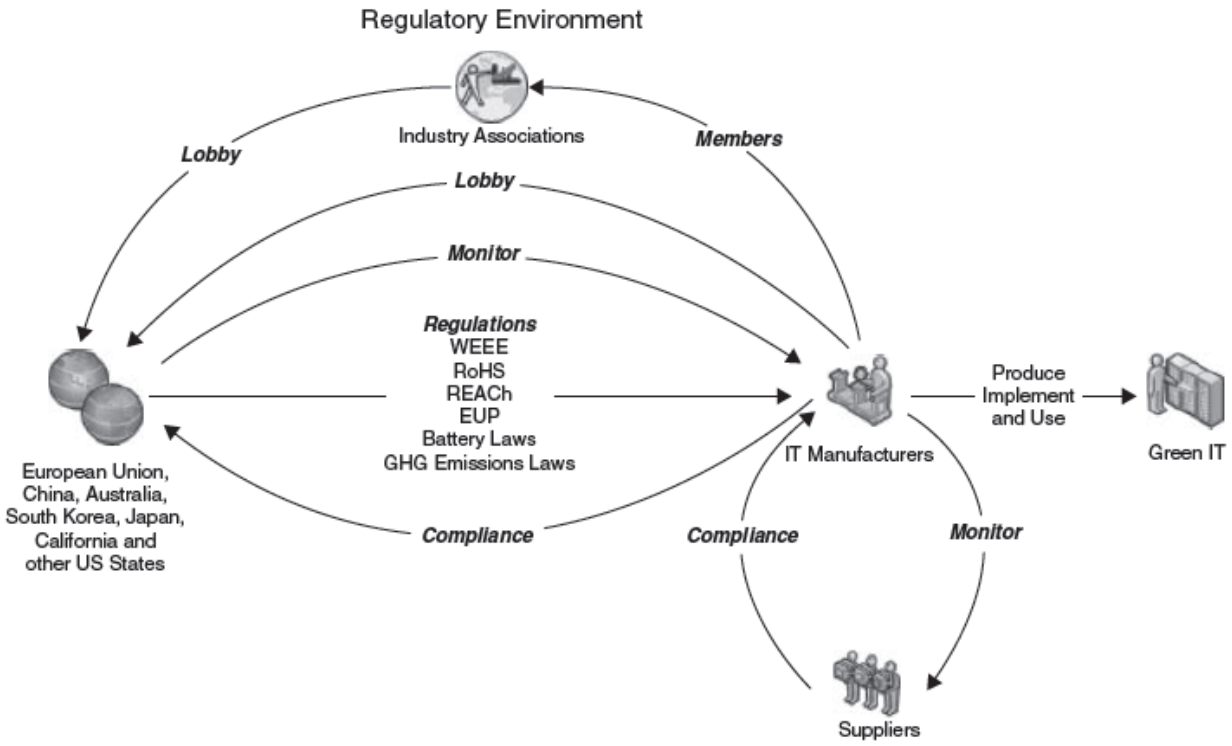
## 5.2 THE REGULATORY ENVIRONMENT AND IT MANUFACTURERS

Electrical, electronics and IT manufacturers face a significant challenge in maintaining compliance with global regulations on environmental issues. Manufacturers are not consumers but they are lobby regulators. Manufactures shape current and future environmental laws that govern their processes and products.

European Union (EU) is regulating environmental laws based on the Restriction of Hazardous Substances (RoHS) Directive, the Waste Electrical and Electronic Equipment (WEEE) Directive, the Registration, Evaluation and Authorisation of Chemicals (REACh) Regulation, the Eco-Design for Energy Using Products (EuP) Directive. These laws have been emulated from China to California, and from Canada to Australia.

These laws have designed for all electrical, electronics and IT manufacturers. RoHS, REACh and the Battery Directive impact the design and manufacture of IT, while EuP focus on the power consumed during use; WEEE addresses the take-back, recycling and disposal of each artefact.

Industry Associations like IEEE, dominant corporations Dell, IBM, HP were consulted when such laws were being drafted.




### 5.2.1 RoHS - Restriction of Hazardous Substances

The RoHS Directive was instituted by the European Union in February 2003 and came into force on 1 July 2006. The RoHS Directive restricts the use of hazardous materials in products that cause environmental pollution during the disposal and recycling of electrical, electronic and IT equipment.

The substances currently targeted by RoHS are mercury, lead, cadmium, chromium, polybrominated biphenyls(PBBs), polybrominated diphenyls (PBDEs). A maximum concentration value of 0.1% by weight in homogeneous materials is tolerated.

Later included nickel plating, polyvinyl chloride (PVC), arsenide, liquid crystals, cobalt. A maximum concentration value of 0.01% weight in homogeneous materials for cadmium is tolerated.

Eliminating these substances will pose a significant challenge for manufacturers. Exemptions were made cover medical devices and monitoring and control instruments. Computer servers and IT networking equipment were exempted until 2010.

### 5.2.2 REACh - Registration, Evaluation and Authorisation of Chemicals

The introduction of the REACh Regulation in June 2007 for IT manufacturers to declare the possible dangers associated with chemical combinations in their products both in use and on disposal. REACh also places disclosure requirements to the extent that customers and organizations like Greenpeace have access to information on regulated substances in use.

Manufacturers have to register with the European Chemicals Agency (EChA) substances of very high concern (SVHC) contained in IT equipment in volumes of over 1 tonne per annum or in concentrations above 0.1%, will result in exclusion of the equipment from the European Union.

SVHCs are carcinogenic, mutagenic, toxic for reproduction. In 2008, REACh listed 15 SVHCs. and it is likely to reach 135.

### 5.2.3 WEEE - Waste Electrical and Electronic Equipment

The WEEE Directive, which was instituted in February 2003, establishes collection, take-back and recycling of IT equipment and categories of electrical and electronic devices. The responsibility for the take-back, disposal, recycling and reuse of WEEE is placed on manufacturers. With EU WEEE, the producer is responsible – physically and financially – for their products. Equipment producers provide the collection centres for take-back.

### 5.2.4 The EC EuP - Eco-Design for Energy Using Products

Legislating for GHG emissions & energy use of it equipment is EC EuP Directive established in 2005. It focuses on energy efficiency in electrical, electronic and IT products. This law sets challenging targets for energy savings of up to 9% in the majority of electrical, electronic and IT products.

IT manufacturers to make compliance declarations on the energy used in the design, packaging, delivery and recycling of products across supply chains, in addition to the energy consumed during use.

This regulation aims to reduce the power consumption of electronic devices and IT device.

## 5.3 NONREGULATORY GOVERNMENT INITIATIVES

Governments across the world have reshaped the IT manufacturing industry through environmental laws. The United States, the European Union and Japan have also initiated and supported several industry standards and adopted wider non regulatory initiatives.

Industry initiatives aimed at achieving energy savings and GHG emissions reductions through the direct and enabling effects of green IT.

| Sl No | Regulation or Policy making body | Law, regulation or policy standard |
|---|---|---|
| 1 | European Union | Eco label standard - environmental impact analysis be conducted on products or services throughout their life cycle. |
| 2 | Germany | German Sustainability in the Information and Communication Technologies initiative. |
| 3 | United Kingdom | Greening of Government ICT Strategy: |
| 4 | Denmark | Action Plan for Green IT. |

## 5.4 INDUSTRY ASSOCIATIONS AND STANDARDS BODIES

The industry associations includes Electronic Industries Alliance (EIA), the Consumer Electronics Association (CEA), the Storage Networking Industry Association (SNIA), the Green IT Promotion Council and the Information Technology Industry Council (ITI). These organizations promote green IT among industry members.

Some of these bodies are also associated with environmental movements such as the Climate Savers Computing Initiative and the Global e-Sustainability Initiative (GeSI). World Wildlife Fund (WWF) plays a key role in both of these industry movements.

The GeSI is encouraging sustainable development in the IT and telecommunications sectors. GeSI advocates programmes to reuse and recycle IT equipment in addition to the promotion of green IT applications that enable smart buildings and smart transportation systems.

The Climate Savers Computing Initiative promotes the use of green IT and its direct effects in lowering GHG emissions. Climate Savers Computing members commit to deploying energy-efficient personal computers and servers and to apply available power management features to reduce emissions.

### 5.5 GREEN BUILDING STANDARDS

The enabling effects of green IT could make a significant contribution in environment-oriented, green IT–enabled building design and management. There are two rival standards in use globally: the US Leadership in Energy and Environmental Design (LEED) Standard, which is a green building rating system developed by the US Green Building Council and the United Kingdom's BREEAM (BRE Environmental Assessment Method), which is most widely used standard globally. LEED and BREEAM standards implement best practice in sustainable design.

### 5.6 GREEN DATA CENTRES

The Green Grid is industry association promotes user-centric models and metrics, energy efficiency standards, processes and efficient technologies for use in data centres. It use of the Power Usage Effectiveness (PUE) and Data Centre Efficiency (DCE) metrics for benchmarking energy efficiency.

### 5.7 SOCIAL MOVEMENTS AND GREENPEACE

Environmental concerns voiced by citizens and consumers gave rise to various social Movements. The most visible is the NGO Greenpeace. NGOs have been driving organizations towards environmental sustainability. Social movements such as Friends of Earth, Greenpeace and the WWF regularly target companies that are not environmentally responsible.

Social movements such as the WWF and Greenpeace also have direct and indirect effects on individual organizations. The WWF is participating in the Global e-Sustainability Initiative and the Climate Savers Computing Initiative. Greenpeace directly monitors the processes and products of leading IT corporations.

Three categories of ranking criteria are employed by Greenpeace to evaluate IT and consumer electronics manufacturers: toxic chemicals, e-waste and energy. An elaborate scorecard was developed from this to score each organization's performance on a scale of 0-10.