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UNIT - 1

Green IT : An Overview

Introduction

Information technology has fundamentally altered our work and life and improved our productivity, economy and social well-being. It has a new role to play to create a greener, more sustainable environment.

IT has been contributing to environmental problems people do not realize. Computers & other IT infrastructure consume significant amounts of electricity, which is increasing day by day, placing a heavy burden on our electric grids and contributing to greenhouse gas emissions (CO_2).

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 and communication systems efficiently and effectively with zero or minimal impact on the environment. IT support, assist and leverage other environmental initiatives and help to create green awareness.

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Green IT benefits the environment
→ By improving energy efficiency
→ lowering GHG emissions
→ using less harmful materials
→ encouraging reuse and recycling
Green IT includes the dimensions of
→ environmental sustainability.
→ the economics of energy efficiency
→ The total cost of ownership which includes the cost disposal & recycling
→ Increasing in demand for green it products solution and services.
→ Increased awareness of the harmful effects of GHGs & Environment emissions.
→ Electronic waste disposal practices.

1.2 Environmental concerns and sustainable Development

The GHG is changing the world's climate & weather patterns, creating droughts floods and pushing global temperatures slowly higher. Global data shows that storms, drought & weather related disasters are growing more severe and frequent

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Global warming is an average increase in the temperature of the atmosphere near the Earth's surface which can contribute to changes in global climate patterns

It can occur from variety of causes both natural & human

It often refers to warming that can occur due to increased GHG emissions from human activities which trap heat. This phenomenon is called the greenhouse effect.

The common characteristics of them are they can absorb thermal infrared radiation which is emitted from the earth and then re-emit it, increasing the earth's temperature

The most significant constituents of GHGs are carbondioxide CO_2, methane, nitrous oxide and chlorofluorocarbon [CFC] gases.

Electricity is a major source of GHGs as it is generated by burning coal or oil which releases CO_2 into the atmosphere

Reducing electric power consumption is a key to reducing CO_2 emission.

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1.2.1 The Inconvenient Truth

climate change presents a new kind of risk, its impact is global and long term and the damage it causes is eventually irreversible

Controversies exist concerning the causes of global warming, and these are scientific, political & or social in nature. & the scientific community in support of human caused warming.

Global warming is mainly caused by human activity and will continue if GHG emissions are not reduced

Governments, enterprises and people all have roles in combating global warming and building a sustainable environment

1.2.2 Sustainable Development

Sustainability is all about meeting needs and seeking a balance between people, the environment & the economy.

The development that meets the needs of the present without compromising the ability of future generation to meet their needs.

Sustainable development comprises economic environmental & social dimensions.

1.2.3 Why should you go green ?

The reasons for going green are manifold

→ increasing energy consumption and energy prices.
→ growing consumer interest in environmentally friendly goods & services
→ Higher expectations by the public on enterprises
→ Environmental responsibilities & emerging stricter regulatory and compliance requirements
→ when making purchasing, leasing or outsourcing decisions many customers now take into consideration the company's environmental records and initiatives
→ Investors are increasingly placing their money on initiatives that are green or that develop and promote green products & services.
→ Companies with the technology & vision to provide products & services that address environmental issues.

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1.3 Environmental Impacts of IT.

IT affects our environment in several ways.

1) Each stage of a computer's life from its production, through its use and to its disposal presents environmental problems.
2) Manufacturing computers and their various electronic and non electronic components consume electricity, raw materials, chemical and water and generate hazardous waste.
3) Total electrical energy consumption by servers, computers, monitors, data communication equipment and data center cooling systems is steadily increasing.
4) This increase results in greater GHG emissions as most electricity is generated by burning fossil fuel like coal, oil and gas.
5) Computer components contain toxic materials.
6) The increased number of computers & their use, along with their frequent replacement.
7) Increasing pressure on the IT industry, business and individuals to make IT environmentally friendly throughout its life cycle, from birth to death to rebirth.
8) Social & corporate responsibility to safeguard our environment.

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1.4 Green IT

Green IT is an umbrella term refers -ing to environmentally sound information technologies and systems, applications and practices.

It encompasses 3 complementary IT-enabled approaches to improving environ -mental sustainability

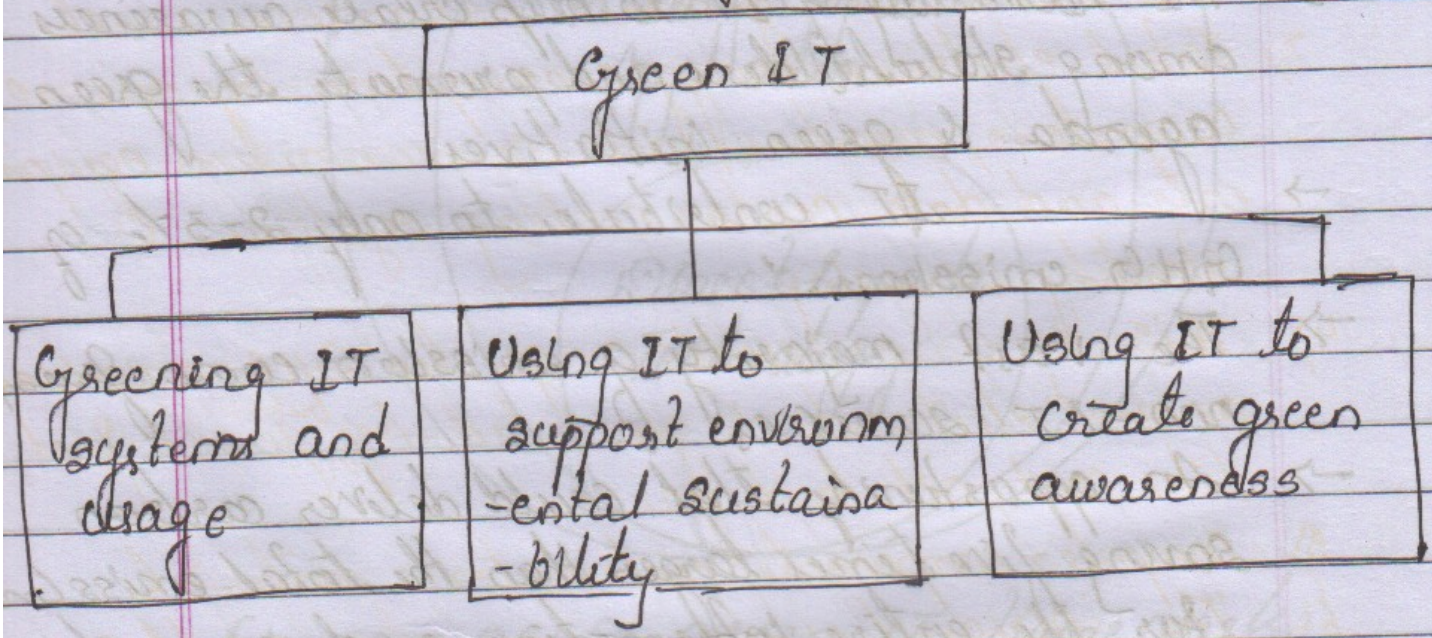

Fig 1.1 Green IT dimensions

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1 The efficient and effective design, manufacture, use & disposal of computer hardware software and communication systems with no minimal impact on the environment

2 The use of IT and information system to empower i.e, support, assist and leverage - other enterprise wide environmental initiatives.

3 The harnessing of IT to help create awareness among stakeholders and promote the green agenda & green initiatives.

→ IT contributes to only 2-3% of GHG emissions.

→ The vast majority of emission come from non-IT sources

→ An opportunity that could deliver carbon saving five times larger than the total emission for the entire information and computer technology

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

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1.4.1 OCED Green IT Framework

The organisation for economic coperation and Development has proposed a green IT framework consisting of 3 analytical levels

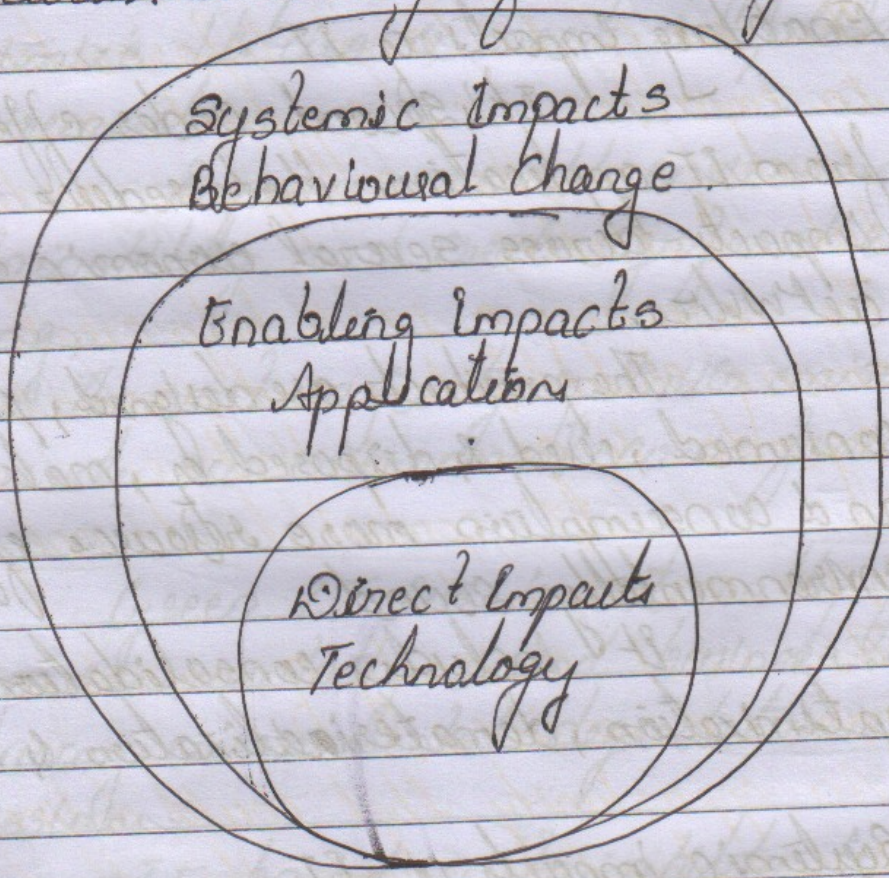

Fig 1.2. OCED green IT framework

1) Direct impacts of IT:

It is a first order effects on the environment and include both positive and negative impacts due to the physical existance of IT goods and services and related proceu.

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IT manufacturing and services firms, including intermediaries and goods producers and final consumers and users of ICT's

2) Enabling impacts of IT

It is second order effects that arise from IT applications that redefine environmental impacts across several economic & social activities.

The products are designed, produced, consumed, used & disposed of, making production and consumption more resource efficient & environmentally sound

It includes consolidation, integration optimization, dematerialization & substitution

3) Systemic impacts of IT

It is third order effects based on impacts and their application on the environment.

It involve behavioural change, process and other non technological factors

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1.4.2 Green IT 1.0 & 2.0

Green IT 1.0 was internally focussed on reengineering IT products and process to improve IT's energy efficiency, maximize its use & meet compliance requirements.

Improve overall environmental sustainability and create significant energy saving.

The vast majority of GHG emissions that degenerate our environment come from non IT.

Green IT 2.0 is externally focussed on environmentally sound business transformation reducing environmental degradations and GHG emissions

IT based sustainability innovation, enterprise wide sustainability

IT can help to create sustainability environment by

→ co-ordinating, reengineering, optimizing the supply chain, manufacturing activities & organizational workflows. to minimize their environmental impact

→ Making business operations, building and other system energy efficient
→ Helping decision making by analysing, modelling & simulating environmental effects
→ providing platforms for eco-management and emission trading
→ Auditing, reporting energy consumption and saving
→ Offering environmental knowledge management system and decision support system.

1.5 Holistic Approach to Greening IT

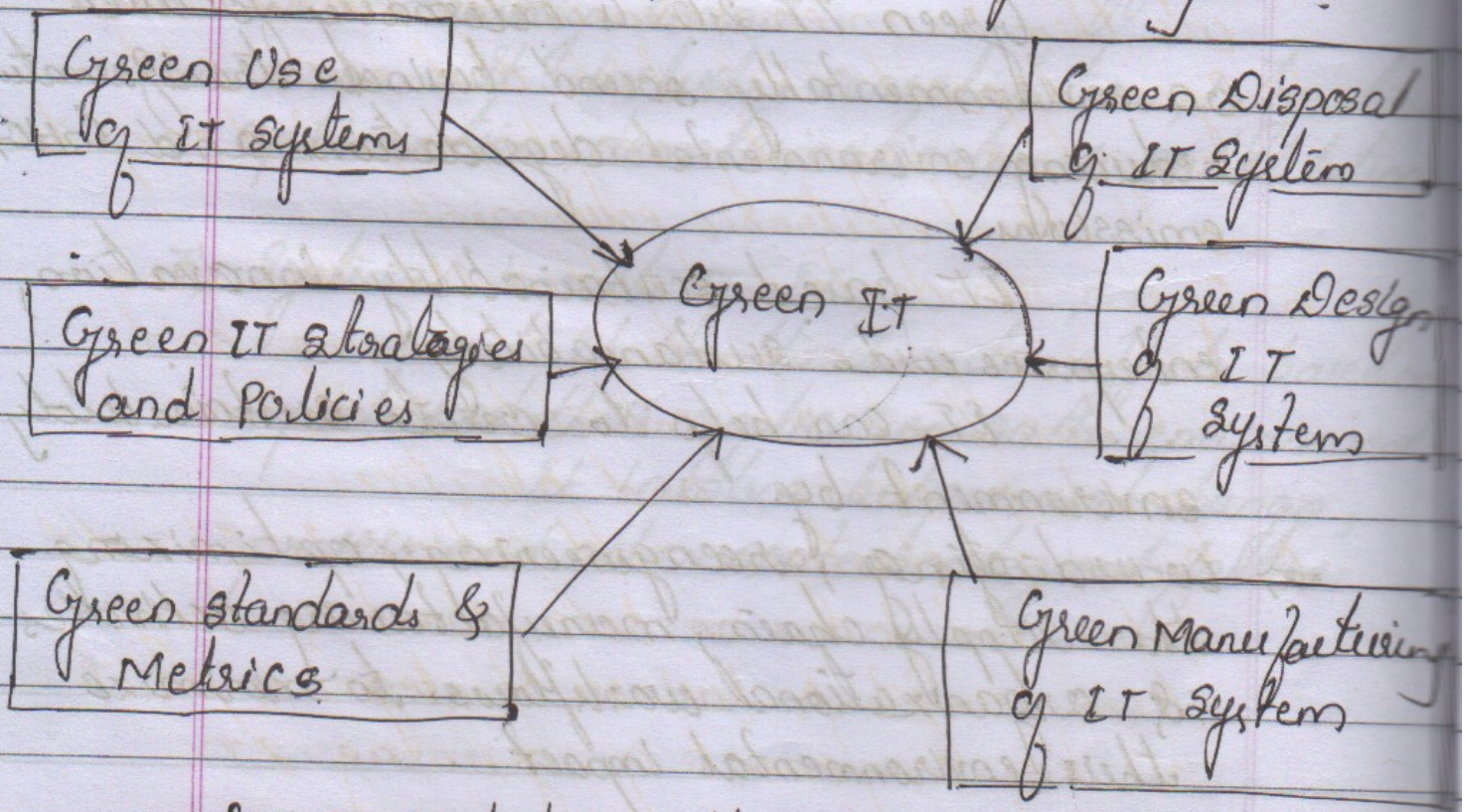

Fig 1.3 Holistic, Multipronged approach to greening IT

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- A holistic approach that addresses the problems along these six complementary directions

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 sub-systems 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, properly recycle unwanted computers and other electronic equipment
5 Green standards and metrices :- These are required for promoting, comparing and benchmarking sustainability initiatives products services and practices
6 Green IT strategies and policies :- It add value and focus on both short & long term benefits. & business strategies & practices are key components of greening IT.

1.5.1 Greening Computer's Entire Life Cycle

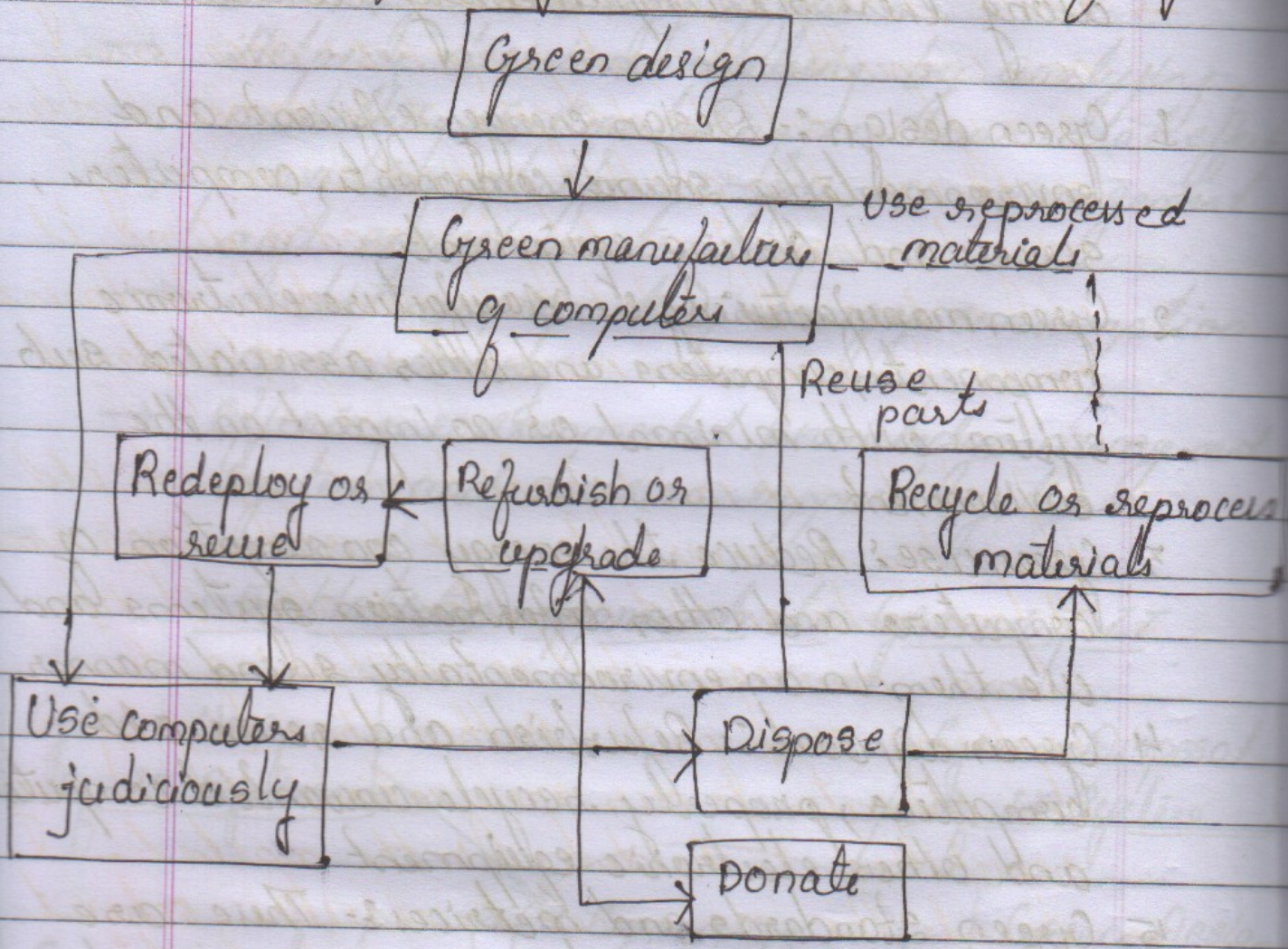

fig 1.4 Greening computer's entire life cycle

Server and Storage system could be made greener, reducing their GHG emission and carbon footprint and minimizing or eliminating toxic materials used or released to the environment.

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1.5.2 The Three Rs of Green IT

→ Reuse :- Many organizations and individuals buy new computers for each project or once every 2-3 years and should give it to someone who could use it in another project or unit. By using hardware for a longer period of time it can reduce the total environmental footprint caused by computers manufacturing & disposal.

→ Refurbish :- It can refurbish and upgrade old computers & severs to meet our new requirements
- It can make an old computer & other IT H/w almost new again by reconditioning & replacing some parts. Rather than buying a new computer to our specifications it can buy refurbished IT hardware in the market.

→ Donate the equipment to charities, school or someone in need or it can trade the computers

→ Recycle :- It cannot be refurbish or reuse computers by depositing them with recognized electronic recyclers or electronic waste collectors E-waste discarded computers & electronic goods is one of the fastest growing waste types

The united Nations Environment program estimates that 20-50 million tons of e-waste are generated worldwide each year. This is increasing.

IT hardware contains toxic materials like lead, chromium, cadmium and mercury. If they bury IT hardware in landfills, toxic materials can leach harmful chemicals into water ways & the environment, if burned they release toxic gases into the air we breathe.

Waste electrical and electronic equipment regulations aim to reduce the amount of e-waste going to landfills, increase recovery & recycling rates.

Bans on the export & import of e-waste, & gets into developing countries for recycling as the cost of recycling is lower.

E-waste is handled informally in unofficial recycling markets by manual, crude, hazardous means of to extract metals & other valuables.

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1.6 Greening IT

The key among them are PCs, notebooks and servers, data centres and cloud computing, software, storage systems, networking and communication systems and protocols.

1.6.1 Green PCs, Notebooks and Servers

→ Reduce energy consumption by making small changes to the ways in computers

→ users ones computers leave them on, wasting electricity

→ computers generate heat & require additional cooling, which add to the total power consumption & cost

→ It can reduce PC energy consumption by adopting several measures

- Enabling power management features of - without sacrificing performance, program computers to automatically power down to an energy saving state when they are not using
- Turning off the system when not in use. Basic energy conservation strategy for system

- Using screensavers :-
  A blank screensaver conserves more power than a screensaver that displays moving images, which continually interact with the CPU
- Using thin client computers :-
  Users can choose to employ thin client computers, which draw about a fifth of the power of a desktop PC.

1.6.2 Green Data Centres

The modern engine rooms that power the Internet & corporate computing are growing in their number, capacity & power consumption. Data centres are one of the fastest-growing users of power. The carbon footprint of data centres has been increasing dramatically as they consume much energy to power their IT system and cooling system.

The continued rise of Internet and web applications is using the rapid growth of data centres and an increase in energy use.

To use more transactions in less time, to process, store more data, business process, enterprises are installing

Energy price, data centre's, operational costs, critical observation or examinations increases and Data centre efficiency is a major issue facing to IT department.

The cost, the availability of electrical power is becoming a critical issue for many companies who data centres have expanded continuously. Energy suppliers need to design, build & supply the huge amount of electrical power demanded by data centres.

The IT departments uses how to reduce, energy consumption by data centres.

A green data centre is one of in which IT system, air conditioning systems, electrical & mechanical systems, Buildings that house the data centre are designed, operated for maximum energy efficiency, low carbon footprint.

The data centres using cooling, heating & IT system to reduce power consumption to processing & operational needs.

The data centres saved by energy consumption includes servers, storage & network virtualization, the use of blade servers, servers

clustering and consolidations, energy efficient power supply is used.

The EU code of conduct on Data centres,

Energy efficiency is a voluntary initiative aimed at reducing the environmental, economic & energy supply security.

The scope of the code of conduct encompasses both the equipment & system level focusing on two primary areas:

1) IT load
2) Facilities load

IT load is used for the capacity available for the power consumed

Facilities load used the equipment & the systems support the IT load such as cooling system, power distribution units & uninterruptable power supply.

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1.6.3 Green cloud computing

Cloud computing is a transition from computing as a product to computing as a service, which is shared and scalable on demand.

The benefits of cloud computing offers
→ businesses, educational institutions, governments individual in both developed & emerging markets
→ use is growing, created huge demands on data centres
→ services, vendors use large scale data centres
→ Infrastructure with thousand of servers ~~hosting~~ uses cooling, storage and communications thus
→ Increasing energy consumption by data centres

Cloud computing is a green solution as cloud infrastructure embraces two critical elements of a green IT:

→ resource efficiency & energy efficiency

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1.6.4 Green Data Storage

Data and information storage requirements keep growing forcefully

→ Data centres consume significant amount of power & cooling

→ It consumes anywhere between 24% & 40% of total power usage & biggest power hogs

→ several approaches including

a) MAID [Massive Array of Idle Disks]

(1) It involves data migration

(2) It tries to copy files based on temporal locality

(3) It uses a small subset of disks

(4) MAID system is able to achieve energy saving

→ Spin down disk spin down

(1) It is also known as MAID

(2) It can reduce power consumption

b) → Tiered storage

(1) It is the alignment of different categories of data to various types of storage media to reduce total storage cost

(2) Based on performance, availability & recovery requirements

(3) The higher tiers of storage are sql server, oracle, DB2, Mysql

c) SSD → Solid state drives
(1) It uses solid state memory to store persistant data
(2) it have lower access time & power consumption
(3) It has rapidly increased in popularity as the primary data storage
(4) It offers small size, low weight, low power high shock resistance & fast performance.
d) System level approaches.
↳ Storage virtualization
(1) It is a key strategy for reducing storage power consumption, storage H/w cost & energy cost
(2) it helps users for data centre storage
(3) It also increases storage utilization
e) Thin provisioning (TP)
(1) It is a method of storage resource management and virtualization
(2) It operates by allocating disk storage space in a flexible manner among multiple users
(3) NetApp, EMC, Dell EqualLogic are TP systems
f) Data de-duplication
(1) It is the elimination of coarse-grained redundant data to improve storage utilization

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(2) It may occur in line, data are flowing as post process after data have been written
(3) It reduces the storage capacity, data that must be sent across a network for remote backups, replication & disaster recovery
(4) It can compression ratio. from 3:1 to 10:1

Tiering is used for data & files & allocate various data & files to the most efficient layer of storage available.

1) Tier 1 → on demand data
2) Tier 2 → data critical but still timely
3) Tier 3 → archival data.

1.6.5 Green software

Green software is environmentally friendly software that helps improve the environment.

Green software can classified into four broad categories

- software is, greener → consumes less energy to run
- Embedded software that audit other things in going green

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- sustainability repeating software as carbon management software
- software for understanding climate change, assessing its implications & forming suitable policy response.

Sustainable software development refers to creating software addressing environmental requirements & perspectives
→ Development related attributes such as modifiability, reusability, & portability.
→ performance attributes as computational time, efficiency, usability.
→ Dependability influence s/w's environment.

Using open source methodologies for application development is expected to result in energy saving as collaborative development process. tend to be more efficient than traditional process

Organization are manage thereby carbon footprint
→ The amount of GHGs produce.

IT system can measure, analyse, & manage carbon emissions in a cost effective & efficient manner called as carbon management system.

A number of carbon management systems are Carbonview [www.carbon.view.com] Carbon planet [www.carbonplanet.com] Greenstone [www.greenstonecarbon.com/software.php) Emissions Logic [www.cenasus.com/cens/emissions_logic] are available in the market CMS is also integrated with ERP software from vendors like SAP, Oracle and Microsoft.

1.6.6 Green Networking and Communication

Networks and communications facilitate data transfer and sharing information, shop learn and socialize online

The demands on communication nlws wired & wireless, have been constantly increasing & the energy consumption also increased

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Green networking refers to ways of minimizing networks impacts on the environment using energy efficient networking technologies, protocols & products & minimizing resource use.

Green networking practices includes

- Using newer, more energy efficient techniques technologies & products
- Upgrading older equipment with newer, greener networking gears
- Employing smart systems, users management & energy conservation across IT networks to increase energy efficiency
- Substituting telecommuting, remote administration & video conferencing for travel

1.7 Applying IT for Enhancing Environmental Sustainability

IT can be a key driver in greening several industries & activities and a positive force towards environmental sustainability initiatives

IT contributes only about 3% of GHG emissions and come from non-IT sources, which can realize enhanced energy efficiency and minimize this environmental pollution

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IT becoming green, it is very helpful enabler & to create better environment.

The opportunities are.

→ software tools for analysing, modelling, & simulating environmental for risk management
→ platforms for eco-management, emission trading & ethical investing
→ Tools for auditing, reporting energy consumption saving & monitoring GHG emissions
→ Transfer of environmental knowledge, decision support, collaborative environments, environmental ontologies.
→ Environmental information system engineering includes geographic information system, environmental data standards.
→ Urban environment planning tools & systems
→ Technologies & standards for interoperable environmental monitoring nws, smart in situ sensor networks
→ Integration & optimization of existing environmental monitoring networks, easy plugin new sensors, sensor co-operation & nws
→ Tools & system for optimizing organizational workflows

To reduce their carbon footprint, organisation can dematerialise their product & activities embracing IT.

Dematerialization refers to the transformation of physical goods to information goods in digital form "turning atoms to bits".

Organisation can use electronic billing music and videos, e-books, electronic documents, & video conferencing. etc.

1.8 Green IT standards and Eco-Labelling of IT.

The Green IT standard are

- EPEAT [Electronic product Environmental Assessment Tool.]

It is a popular, easy to use assessment tool to help organization compare computers desktops, laptops & monitors.

EPEAT-registered products are classified as bronze, silver or gold

They have reduced levels of cadmium, lead and mercury.

It can be more efficient, & easy to upgrade & recycle.

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RoHS [Restriction of Hazardous Substances Directives]

The use of certain hazardous substances in electrical & electronic equipment

WEEE [Waste Electrical Electronic Equipment]

→ It is placed on manufacturers

→ global IT manufacturers each member state implement different types of WEEE systems

LEED [Leadership in Energy and Environmental Design]

It consists of a suite of rating system for the design, construction & operation of high performance green building, homes

Energy star

A global labelling program that segregates computers, monitors, printers & servers are used as many other electrical & electronics goods based on energy efficiency.

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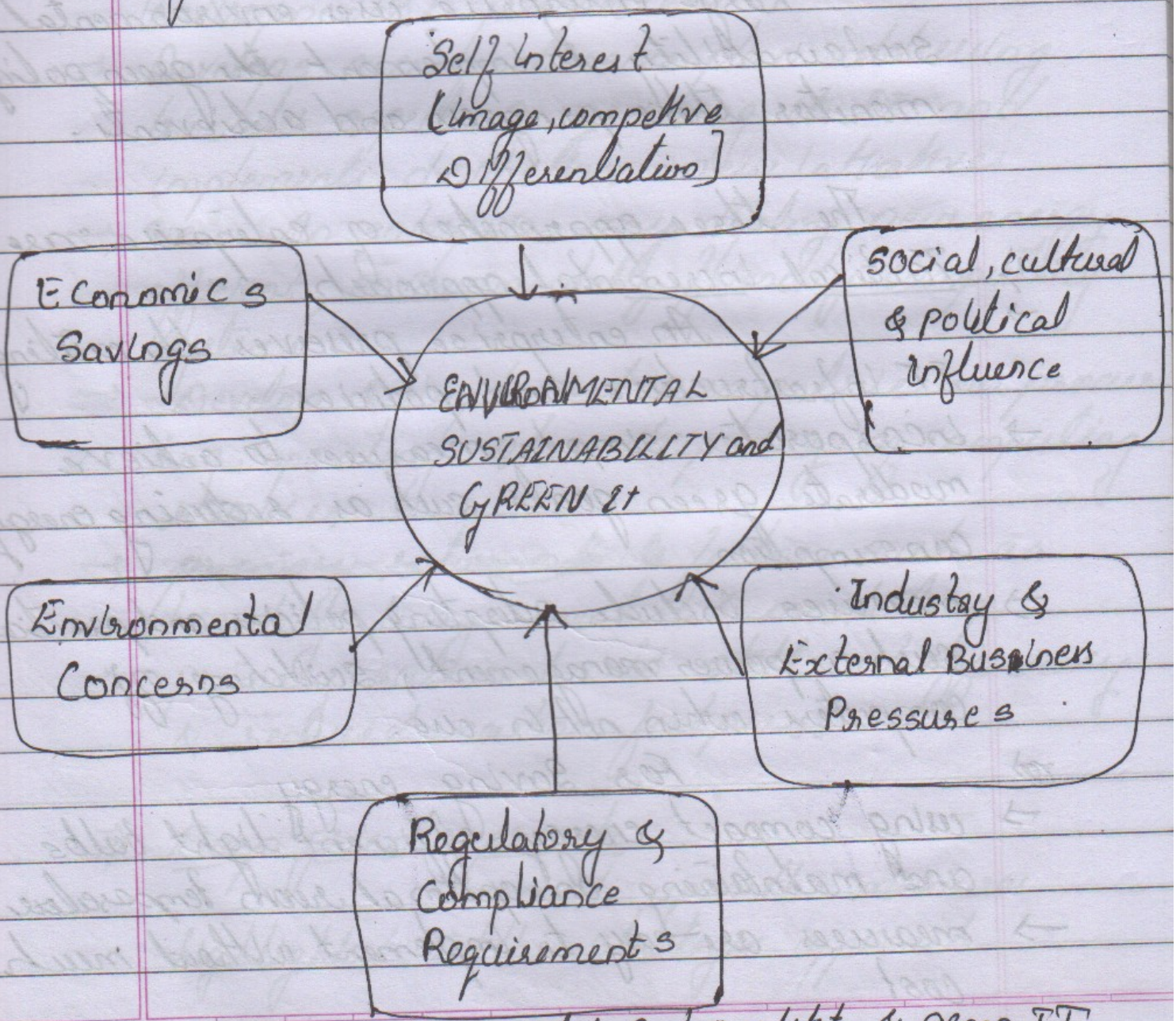
1.9 Enterprise Green IT strategy

Green IT and green initiatives are becoming a key for enterprises & govt. By several on-going developments as concerns about climate change, government regulations, peer pressure & influence.



Drivers of environmental Sustainability & green IT.

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Each enterprise must develop a holistic, comprehensive green IT strategy, enterprise wide green strategy.

IT policy outlining aims, objectives, goals, plans & action & schedules.

Large enterprise uses environmental sustainability to implement the green policy, monitor their progress and achievements.

The three approaches of enterprise are

1) Tactical Incremental approach.

→ An enterprise preserves the existing IT infrastructure and policies

→ Incorporates simple measures to achieve moderate green goals such as reducing energy consumption

→ measures include adopting policies and practices such as power management, switching off computers when not in use.

For saving energy

→ using compact energy-efficient light bulbs and maintaining an optimal room temperature

→ measures are easy to implement without much cost

→ Enterprises should work towards these measures only as short term, adhoc solutions

2) Strategic approach

→ An enterprise conducts an audit of its IT infrastructure and its use from an environmental perspective

→ Develops a comprehensive plan addressing broader aspects of greening its IT and implements distinctive new initiatives

→ Ex:- An enterprise may deploy new energy efficient, environmentally friendly computing systems

→ Develop & implement new policies on procuring, operating & for disposing of computing resources

→ ~~primary rationale~~ & factors such as branding, image creation & marketing

→ primary rationale is still cost efficiency & reduced carbon footprint.

3) Deep green approach

Expands upon the measures highlighted in the strategic approach

→ Enterprise adopt additional measures such as implementing a carbon offset policy to neutralize GHG emissions including planting trees, buying carbon credits from one of many carbon exchanges or using green power generated from solar or wind energy.

1.9.1 Green Washing

→ The practice of organizations exaggerating their green credentials, environmental sustainability attributes, & making untrue claims

→ Green washing is an amalgam of the terms green and white wash.

→ Socially irresponsible, unethical practice misleads customers & the public regarding the company's environmental practices or the environmental benefits of its product or services.

→ A marketing ploy to establish an eco-friendly image to consumers, investors, businesses & regulators.

→ uses indefinite claims regarding products or services of ~~enterprise~~ environmental impacts

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1.10 Green IT : Burden or Opportunity

In general, the 'go green' movement & green demands on corporate IT.

→ Do ~~do~~ not excessively or unduly burden IT systems, corporate IT departments or function - al units.

→ These initiatives provide an opportunity to revisit, ~~revisit~~ examine our IT systems & their operations in terms of energy efficiency and resources utilization.

→ Enable us to go lean on IT, minimize IT's energy consumption & save on energy bills.

→ primarily focussed on meeting their functional & performance requirements.

→ very little attention was paid to aspects such as energy consumption, effective utilization of IT resources,

→ IT's operational cost or IT's negative impact on environments at the stages of design, manufacturing, use, reuse and disposal

→ IT's is required to go green.

→ It is good for IT, businesses & the entire planet.

→ Initially going green as a burden, a closer examination of green philosophy reveals.

→ It includes improving energy efficiency, resource utilization, reducing waste, promoting recuse & recycling

Not going green ?

→ cost a lot in the context of emerging stricter environmental regulations, stakeholders demands competitiveness, brand or corporate image, and social responsibility.

A holistic & objective view of green IT

greening of IT and greening by IT

→ Both are economic & environmental imperatives
→ Business that reduce their environmental footprint can also reduce costs & improve their public image
→ IT professionals, CIOs and IT support staff are being called upon to deliver environmentally sustainable IT solutions
→ Green IT understanding across companies, IT professionals, students & IT users.
→ Green initiatives revisit & examine our IT systems, operations in terms of energy efficiency & resource utilization & reduce energy bills.

→ It's energy consumption, effective use of resources, operational costs & Negative environmental impacts during manufacturing, use & disposal

→ Smart companies will adopt an environmental strategy to innovate, create value & build a competitive advantage

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Assignment questions

1) Briefly describe climate change, global warming greenhouse gases and green house effect
2) Define Green IT and list the benefits of Green IT
3) Explain how the software impact the environment & the energy consumption of computing system
4) Describe different dimensions for directions of green IT
5) Mention six holistic approaches that address Green IT
6) Discuss whether Green IT is burden or opportunity
7) Explain the 3 Rs of green IT
8) What are the key subsystems of IT that could be made greener? Briefly explain
9) Why there is growing demand & need for greening data centers
10) What is meant by green washing? Explain with examples
11) Write a short note on Green data storage
12) What is meant by dematerialization in the context of environment sustainability?

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UNIT-2.

Green Devices and Hardware

2-1 Introduction

Electronic devices have become ubiquitous and are an intrinsic part of our lives. while these devices provide the convenience of faster, better access to people, information, services & their negative effects available resources & environment.

The threat of global warming looming large, prudent use of these devices, usage patterns & ways to minimize the impact

The number of computers & other electronic devices in use has been increasing exponentially and newer more powerful devices continue to replace older version.

Development efforts were focused primarily on improving processing speed, increasing device density & reducing the cost of production

During earlier days of digital revolution manufacturers gave concentration on speed & cost of electronic devices. with advent of battery powered devices such as notebooks of computers & mobile phones, power consumption is important.

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2.2 Life Cycle of a Device or Hardware

Each stage of the cycle has varying levels of impact on the environment. In the following section each stage of computer device and green considerations will discuss.

The typical life cycle of a device

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

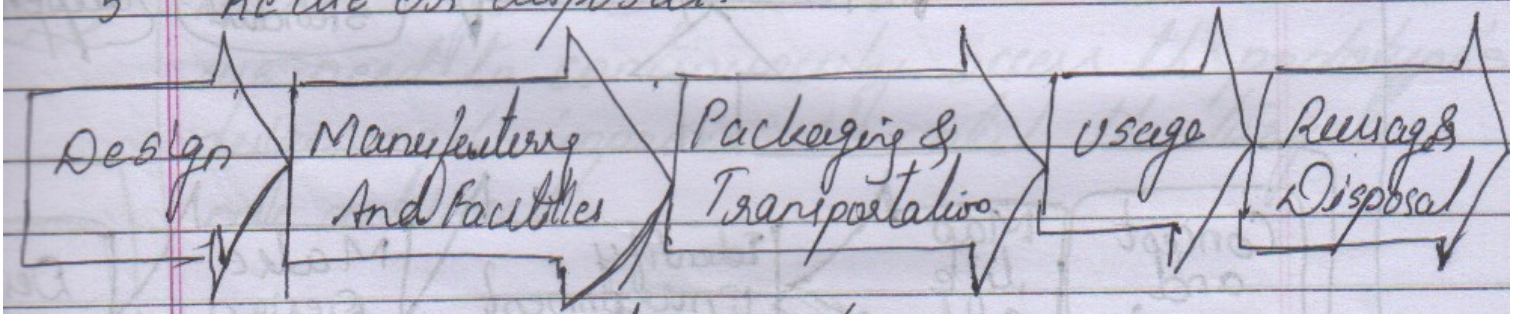

Fig. Life cycle of a device

2.2.1 Design

In this stage, the idea about the device is designed, prototyped and tested. and it involves the decisions regarding architecture, constituent components, material and layout have a huge effect on the environment. to design devices while meeting performance & other requirements

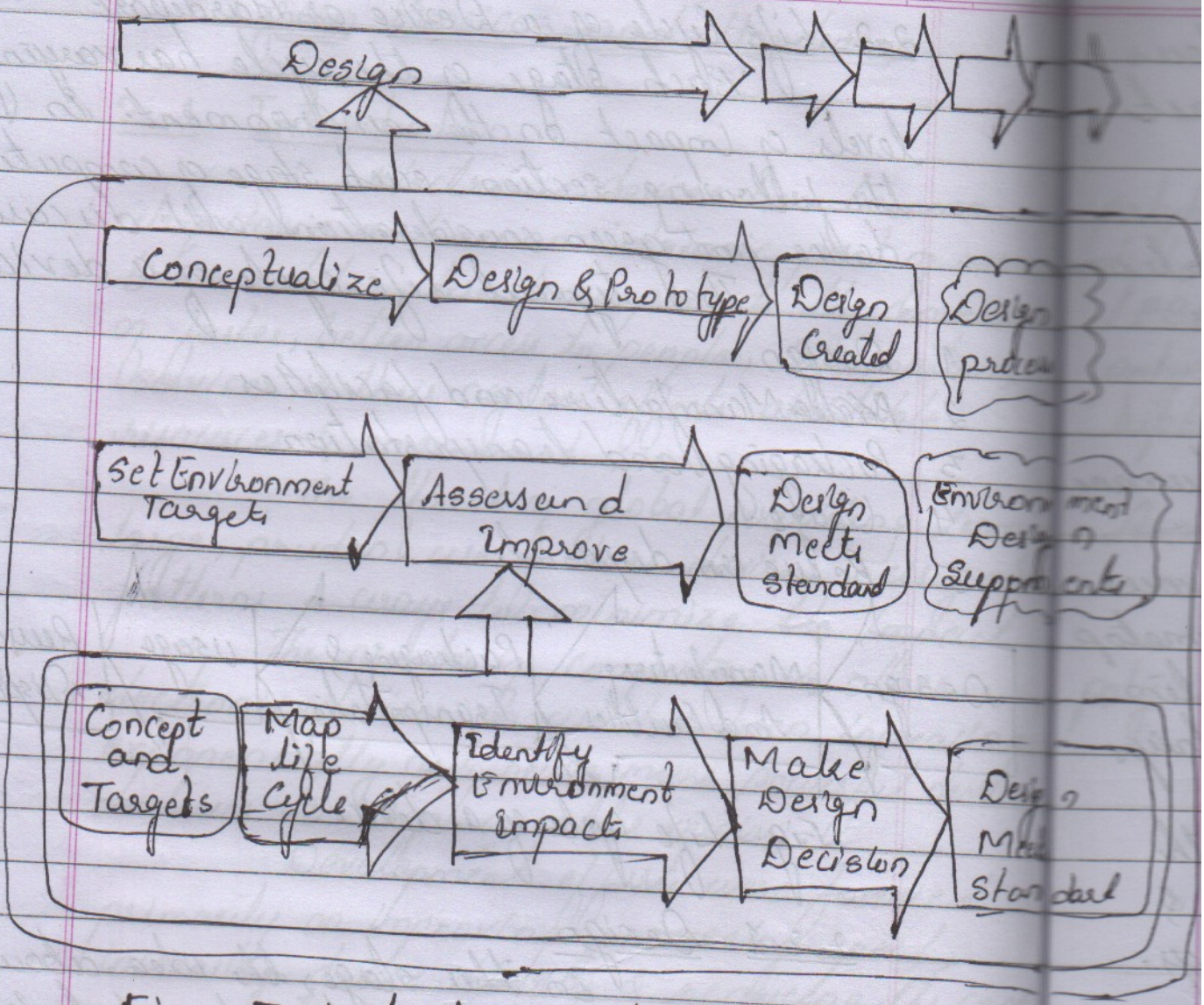

Fig: Typical steps in design a device

when a device gets into the design stage. Environmental targets should be done in parallel to conceptualization & can be derived from the device environmental objectives and impact assesment reports. These targets should act as a benchmark and should help with decision making while design the device.

As the device is being prototyped one of the goals should be to meet all environment targets have been set. To achieve this we need to continuously assess the prototype's design and improves it until the targets are achieved.

2.2.2. Manufacturing

The manufacturing process is one of the main sources of environmental impacts in the life cycle of a device. ~~The~~ processes consumes a lot of raw materials, water & energy and this process produces lot of waste toxic materials

Manufacturing electronic device uses some of the hazardous chemicals substances which are very dangerous to human beings

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This table shows the list of hazardous substances chemicals and their impact on human being

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

chemical	Used in	Effect on human
Lead	circuits, motherboard and glass monitors	Affects nervous system, hematopoietic system and kidneys
cadmium	Low-temperature soldering, plating for corrosion protection, colorant in plastics & contact buttons in relays	Affects the liver & kidneys,
Mercury	Monitors and batteries	Affects immune system, alter genetic & enzymes system

		damages the nervous system
polybromenated diphenyl ethers (PBDEs) and polybromenated biphenyls (PBBs)	Flame retardants	Extremely toxic
Arsenic	Manufacture of semiconductor	Affects cellular longevity
polyvinyl chloride	Manufacture of computer parts	Carcinogen & also has effect on the human reproductive system.

It is very important to minimize the use of environmentally sensitive substances & reduce the amount of harmful waste.

The EPEAT (Electronic Product Environmental Assessment Tool, n.d.) rating system is used to know the greenness of the devices. It grades electronic devices & computer system into three grades bronze, silver and gold helps customes how green a device is & to make informed choices.

The rating system takes into account the following aspects

- Reduction or elimination of environmentally sensitive material
- Material selection
- Design for end of life
- Device longevity or life extension
- Energy conservation
- End of - life management
- Corporate performance
- packaging

2.2.3 Packaging and Transportation

It contribute to the carbon footprint in a device's life cycle

The two main contributors in this segment are

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> Materials used for packaging
> Carbon footprint of vehicles used in transportation.

The packaging should be done in such a way that it minimizes the amount of material used while ensuring the integrity and security of the device.

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

The following are general recommendation for designing suitable packaging.

1. Packaging materials should be recyclable
2. Minimum 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 & tabs instead.
5. All the additives, coating & inks are used for package should be eco-friendly
6. Printed documentation can be avoided and device documentation must be provided with the web pages.

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7 The devices must be as small as possible. so that they can be transported with less number of vehicles.

2.2.4. Use

→ Electronic devices consumes a lot of energy when we used them. and a devices carbon footprint increases, & thus result impacts on the environment. and the amount of CO_2 as green house gases released

→ The Energy star rating system helps customers choose the most energy-efficient devices and reduce their energy consumption and cost.

→ The manufacturer provide guidelines on its best usage practices from environmental and energy perspectives.

→ kill a watt is a device is plugged between the device & the power socket. the amount of energy consumed over time & with different or optimum configuration that consumes least energy.

→ Reduce energy usage in notebook computer desktop computers, servers, mobile devices & other special devices.

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2.2.4.1 Notebook Computer

Notebook Computers are designed and power consumption could be reduced and or optimized

It can be rechargeable battery, & life time of a battery is short and runs on solar power also.

The monitors & CPU consume the largest share of power that is utilized by the laptop

Reducing the power consumption are as follows

1 Reduce the brightness of the monitor to an appropriate level

2 when some background task is running on the computer there is no need to use the monitor

3 computer Operating system provide power saving profiles.

The higher the speed at which a processor runs, the more energy is consumed to reduce the energy use a lower frequency processor. This is done by BIOS setup

The spinning of the hard disk results in higher energy usage. Lessening the speed of the hard disk results in lower energy consumption.

Defragmenting the hard disk reduces the speed of the hard disk.

Solid state drives are known to consume less energy.

Notebook computers can operate two ideal power modes.

① Standby
② Hibernate

Standby mode, the laptop's internal devices and optical drives are powered off.

Hibernate mode makes the laptop completely shut down while still retaining the powered-on-state, thus reducing the start up time

2.2.4.2 Desktop Computer

Desktop are PC use from a single location & are not portable

The architecture and physical configuration of desktop support upgrading & replacing individual defective subunits & parts

Desktop users are home users who are not fully aware of disposal mechanisms

Desktop are left on 24/7 even during holidays. Sometimes most of time desktop remains idle & waste a lot of energy.

Advanced Micro Devices and several other companies came together to develop the magic packet technology to accomplish this when the computer is sleep state, the Ethernet network interface controller is left powered on.

Tools like Night Watchman, the Energy Detective, emonitor & conserve Insight help managers in assessing the power usage trends of many of their desktop & presenting the data in the form of a dashboard.

Dashboard helps the desktop power usage patterns & set power conservation targets which will make the company greener.

These tools allow enterprise to securely, remately & centrally power down desktop & to apply power schemes at different times in multiple locations, globally from a single console, maximizing power saving without impacting user.

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2.2.4.3 Servers

Servers computers run one or more services that will be used by other computers in the network

Ex mail servers, database servers, file servers, etc

It provides increased reliability redundant servers.

A large amount of heat due to their large power consumptions & they require better cooling mechanisms.

2.2.4.4 Mobiles Devices.

Mobile devices comprise mobile phones, personal digital assistant & other smart devices that people use around. devices are small in size, rechargeable battery, external chargers for their batteries.

The power efficiency of the chargers is low, & most & consumes power when not charging a battery & hence waste power.

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2.2.4.5 Specialized Devices

Specialized Devices are designed for a specific purpose, such as set-up-boxes, play station & medical equipment like X-ray machines & computerized tomography scanners

It consumes power ~~dres~~ when not in use, ideal power could be as much as about two thirds of the power the devices consumes when it is used.

2.3 Reuse, Recycle and Dispose

One way to reduce waste is to increase the lifespan of the devices & saves life cycle energy & resources & reduces the amount of hazardous materials ending up in landfills

~~Electronic devices~~

once the devices become old we don't ~~waste managers~~ use them, this leads to accumulation of more e-waste

Due to lack of sufficient knowledge about toxicity of the chemicals, lack of regulations, to-date recycling, recycle methodologies leading to health hazards and pollutions

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Reuse :-

Reusing a computer is 20 times more effective at saving life cycle energy recycling

- once the devices gets older, instead of throwing them we must use them in some other places like educational institutions
- copy the information that has been stored in the device to a backup device.
- wipe off personal or sensitive information in the device
- Another way to increase the life span of a device is by upgrading the various parts.

(1) The device should be modular
(2) Each part of the device should be easy
(3) The device should be easy to disassemble & reassemble

Recycle :-

whenever a device can't be reused we can go for recycle

- Recycling is a process in which parts of older devices are used as a raw material for new devices.

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- An electronic device consists of various materials which take quite a lot of energy to extract from ores
- Materials like gold, silver, copper & plastic can be recovered & reused
- The cost of extracting these materials from the ore will be eliminated
- The problem with recycling process is that lack of knowledge, bad recycling methodologies and old techniques
- Recycling also creates health problems. & not required to wear protective clothing
- To adopt healthy e-waste recycling process:

Dispose.

when recycling and refurbishing are effective techniques for the end of life management of electronic devices.

- Some of the e-waste disposal technique used now a days are incineration, chemical decomposition and landfills.
- Depending on type of device & material we will do different technique suitable for disposal

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> Incineration is a waste treatment process that involves the combustion of organic substance contained in waste materials.
> It may result in the release of toxic gases and can produce a hazard.
> If the device is non biodegradability of material used in electronics. Then we can go for chemical decomposition
> chemical decomposition can be executed in a managed manner.
> The material which are biodegradable can be disposed by using landfill technique.

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Assignment

1. Discuss the impacts of various chemicals used in manufacturing process.
2. Explain the various E-waste disposal techniques & which is the most effective among them & why?
3. Explain the life cycle of a device as hardware with a diagram
4. Describe Reduce, Recycle & Disposal methods of an electronic device.

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Green Software

3.1 Introduction

A green IT infrastructure is incomplete without green software. software plays an important role in overall platform energy efficiency.

The characteristics of green software & the software design considerations & methodologies to improve software energy efficiency.

A computing platform is a combination of hardware, software & other technologies that allow software to run.

The techniques used all types of platforms including embedded platforms, smart phones, tablets, netbooks, notebooks, desktops, data centre servers & super computers.

A big concern for data centres is the cost of electricity to run the servers & air conditioning units to keep the room & servers cool.

To make the green IT infrastructure it is very important to create a software which allows the hardware to run with less power.

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3.1.1 processor power states

CPU is busy it consumes more power and when it is idle processing information as performing computations, it should be consuming minimal energy

CPU has two energy states called C-states and P-states which indicates the different energy consumption of a CPU

C-states

C-states are power states that define the degree to which the processor is sleeping. C0, the processor is active and executing instructions. while C0, the processor can operate at various frequency levels,

Higher the C-state the CPU becomes idle & some part of CPU is turning off & the energy is saved. Deeper sleep period leads to greater energy saving.

Even if the sleep period is only 10ms, a considerable amount of energy can be saved over time.

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3.1.1.2 P-States

P-states define the frequency at which the processor is running.

Different processor brands showcase their P-states as features, such as Speedstep in Intel processors, powernow!

Lower P-state number represents higher speed & hence higher power consumption.

P_0 → maximum power & frequency

P_1 → less than P_0, voltage or frequency scaled down.

P_n → Low power and frequency than P_{n-1} state.

P-states were developed to save energy overall & deliver the performance you need ~~you need~~ it.

P-states save energy by studying the following equation.

$$P = CV^2f$$

P → power required to run a CPU

C → the product of the capacitance

f → frequency

V → Voltage

An end user can actually control the P-state of the processor by setting the platform power policy.

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3.2 Energy-Saving Software Techniques

Energy saving features in the platform are transparent to the software developer and applications have very little direct control, the behaviour of the software has significant influence on whether the energy saving features can inhibit - s ~~the~~ are effective and leads to lower battery life and higher energy costs.

A third mechanism might be to use an alternate audio decoder when the system is running on battery power, one that may sacrifice a small bit of quality for longer battery life.

Software Energy Efficiency

- **Computational Efficiency**
  - Algorithms
  - Multithreading
  - Vectorization
  - μArch tuning
- **Data Efficiency**
  - Asynchronous I/O
  - Buffering
  - NUCA
- **Context Awareness**
  - AC/DC
  - Thresholds
  - Power policies
- **Idle Efficiency**
  - C-states
  - Timer resolution
  - Background Activity

3.2 Software energy efficiency techniques

The distinction between active and idle software.

Active software is s/w that is fulfilling its intended purpose such as by compiling a spreadsheet, playing music or a movie, uploading photos to a website or browsing the internet. there is a workload that the CPU or GPU 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, Idle Efficiency & context awareness.

3.2.1 Computational Efficiency

CE means getting the workload done quickly with minimal energy consumption

It is required to develop a s/w that saves not only time but also energy.

Computational Efficiency of algorithm can be increased by.

a) Efficient algorithm b) Multithreading
c) Vectorization d) Arch tuning (processor Architect ect Tuning)

a) Efficient Algorithms.

It is clear from computer science theory that the choices of algorithms and data structures can make a vast difference in an application's performance.

An algorithm that computes a solution a solution in $O(n \log n)$ time is going to perform better than one that does the job $O(n^2)$ time.

A stack may be better than a queue & a B-tree may be better than a binary tree or a hash function

The best algorithm or data structures to use depends on many factors, ~~which to select~~ can lead to an application that delivers better performance.

3.2.1.2 Multithreading

Multithreading the software delivers better performance and better energy efficiency

Many threading methodologies and libraries such as OpenMP, OpenCL and Thread Building Blocks

The energy consumed to complete a job in single threaded application is always

more compared to running the same job in multithread application. The added advantage is that the eight thread run was completed in about one-fourth the time and the processor is available for other computations and hence consumes 25% less energy.

3.2.1.3 Vectorization

Another method to achieve better computational efficiency is by vectorization the code instead of using scalar C-code.

→ By using advanced instruction such as Single-Instruction multiple data for instruction level data parallelism.

→ Using a method we have to turn the AVX features on & off, it will measured both the performance & the average power of an audio decode workload.

→ It completes the task faster and hence saves energy

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3.2.2 Data Efficiency

Data Efficiency reduces the amount of data which is moving across the different components [like hard disk, RAM, CPU]. It reduces the energy consumption of the devices & this process is called Data efficiency.

Data efficiency can be achieved by designing

- software algorithm that minimize data movement
- Memory hierarchies that keep data close to processing elements
- Application software that efficiently uses cache memories.
- It includes Disk I/O, using block read, native command queuing, file fragmentation, disk I/O with multithreaded code as well as prefetching & caching

3.2.2.1 Managing Disk I/O

The performance of any hard disk drives are depends on the rotational speed, seek time, rotational latency & the sustainable transfer rate and actual

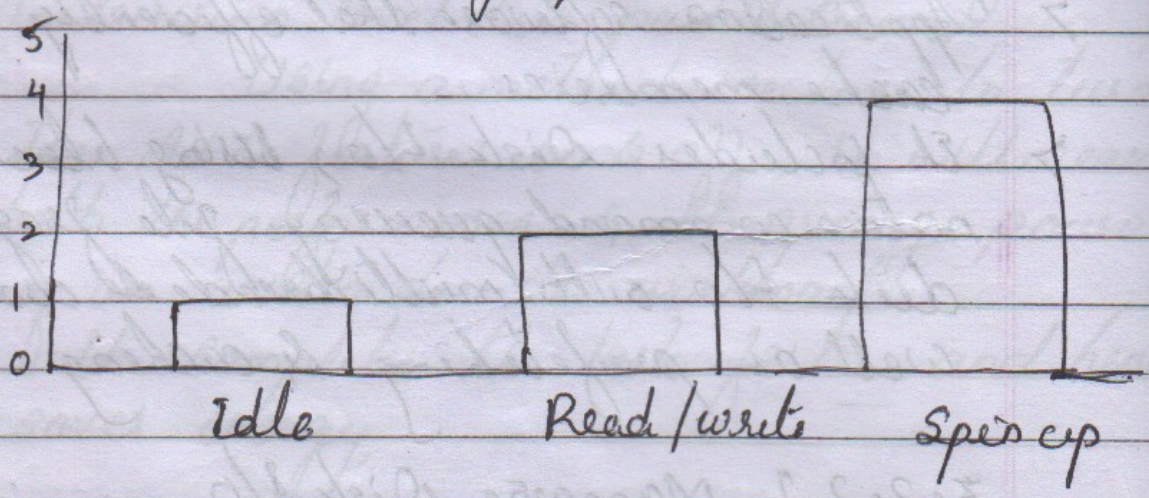
location of data on disk

HDD performance data

Average seek time (ms)	Average latency time (ms)	Spindle start time (ms)
12	5.56	4000

This table shows the relative time (ms) involved in the operation based on the theoretical specification of the serial advanced technology attachment (SATA) drive

HDD Average power (W)



The figure shows the average consumed during idle, read/write & spin up.

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The Harddisk consumes more energy when it is spinning, if we can reduce the spinning of the harddisk then we can save a lot of power.

The energy usage techniques of harddisk drives.

1 Impact of block size on sequential reads
Instead of reading a large volume of sequential data, reading the data in larges chunks requires lower processor utilization & less energy

2 Native command queuing on random reads.
Effective use of asynchronous I/O with native command queuing improves performance & save energy.
Application which deal with random I/O or I/O with multiple files should use asynchronous I/O.

3 Buffering during multimedia playback.
For multimedia playback, reading ahead & caching media content will save energy.

when MP3 file of 4MB is reading in 2KB chunks & played directly, the HDD has to be active till all 4MB file is played so it consumes more power.

If we use buffering technique for the same 4MB MP3 file. the energy consumed by the hard disk

If this buffering entire file can be read & stored in buffer & hard disk go idle, then next content can be played from buffer space.

4 Impact of fragmentation

The performance & energy cost to read a fragmented file are greater than those of a contiguous file

A programming language which has the option for defragment disks of memory periodically can save energy.

5 Disk I/O multithreaded code

The performance & energy cost of multithreading can be reduced by co-ordinating access to shared data.

3.2.2.2 Prefetching and Caching

It can save energy during DVD playback.

The power consumption of three different DVD playback software applications with the multiple out of box configuration available while taking power measurements

① primarily power saving mode
② no power saving mode.

Ex:

3 guidelines emerge that can help to save energy during DVD playback.

1) Buffering

It can reduce DVD power consumption by 70% & overall platform power consumption by about 10% compared to other techniques

2) Minimize DVD device use:-

Reduce DVD spin-up, spin-down & read accesses in order to save energy.

3) Let the OS manage the CPU frequency

Design the OS to set different P-state to adjust the CPU frequency. From this energy can be saved

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3.2.3 Context Awareness

Context Awareness in computers means that they can sense the environment in which they are operating and softwares can be designed to react to changes in the environment.

Example of context awareness behaviours

1) A PC or smartphone warns about low battery
2) Responds to change from AC to DC power supply automatically dimming the display by notebook PC
3) A tablet or smartphones adjust display brightness
4) A handheld device writes cached data to flash memory when battery is low.

The use of sensors is growing rapidly in smartphones & tablets & includes light sensors, gyros, accelerometer, GPS receivers, near field communication.

context awareness makes our devices 'smarter' & the behaviour of applications can be passive or active.

A passive response to a change in context would be to ask the user what action to take

A active response would be to take actions automatically either is built in feature or user configurable option

3.2.3.1 Awareness of power source

it is very beneficial for the application to know the source of power.

Ex If a notebook PC is plugged into a AC power source or operating on battery.

- In windows you can achieve this by querying a unique GUID called GUID_ACDC_POWER_SOURCE
- when the power status changes system should indicates this with a notification
- To get notifications, your application must register for the event
  - → switch from AC to DC Power
  - → reaching a battery threshold.

3.2.3.2 Platform Power Policies

The operating system provides built in power - High performance, Balance and power saver mode.

This give the system user the option between better performance, battery life

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Application software can use power policies in the following ways.

1) Adjust application behaviours based on the user's current power policy.
2) change application behaviours in response to a change in power policy
3) change the power policy to suit the application behaviours.

3.2.3.3 Other Context-Aware Behaviours

The component on the platform & use that information for intelligent application behaviours & energy savings.

Ex: network cards, bluetooth, Wi-Fi, USB devices & monitors, LAN, radios.

Network increases energy consumption not just because the LAN card uses energy for transmitting & receiving data.

The SENS APIs distributed with the platform Software Development Kit, provide for checking the network is alive and another will ping a specified address for you.

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3.2.4 Idle Efficiency

It is defined as the power consumed when the system is running but not executing any workload

- whenever the system is idle state the process - as will be in higher C-state (C6, or C7). so it will not executing the workload
- By improving application idle efficiency which lead to a significant increase in battery life

The following 3 methods can be used to decrease the idle time of the system.

3.2.4.1 Deep C-state Residency

One of the key requirements for achieving idle efficiency is to keep the platform in deeper C-state for longer time.

If the processor transition between the different C-state (C0 to C6) is high then lot of power consumption happens without any workload execution.

To reduce C-state transition in application & services, it is recommended not to split a task between process & threads per core parallel execution can occur.

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3.2.4.2 OS Times Resolution

→ Every operating system has default system wide time resolution. In windows it is 15.6ms.

→ Each time when a times resolution expired the OS receives the interrupt & the OS has to handle this interrupt. This leads to energy

→ windows performs two main actions

⇒ It updates the times tick count if a full tick has elapsed & it checks whether a scheduled times object is expired.

→ Many application call TimeBegin Period with a value of 1 to increase the times resolution to the maximum of 1ms to support graphical animations, audio playback & video playback.

→ when the application is active and then returns the times to its default state

→ High resolution times effect the performance of the OS, it is recommended to develop an Application which uses low resolution times

→ windows 7 comes with a command line utility called PowerCfg.

→ powercfg increases timer resolution & show the entire call stack for the request.
→ If the application use high resolution periodic timer. when power saving power plan is active.

3.2.4.3 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 macroscale such as disk defragmentation, antivirus scans & others are also important for power.
→ UBPM is used to minimize the power impact from background activities:
→ It Hides scheduling of services & task is transparent to users, it provides existing APIs
→ It enables the triggers-start services based on environmental changes

To minimize frequent idle activity are

→ Elimination of transmission control protocol distributed program call times on every system times interrupt
→ Reduction in frequency of USB driver maintenance timers
→ Intelligent times tick distribution
→ Timer coalescing

3.3 Evaluating and Measuring Software Impact to Platform power

To improve the energy efficiency of application software & to optimize power on mobile platforms it is important to understand the impact on power consumption of the different hardware functional units.

→ To provide a high level power consumption of a particular platform &
→ To more accurate and invasive method to measure power is to use data acquisition tool where specific hardware components are instrumented & granular power measurement can be logged.

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3.3.1 Fluke NetDAQ [Networked Data Acquisition Unit]

It is one of a class of DAQ tools that can be used to measured platform power consumption while running different application on the system.

The Details of a NetDAQ setup are as follows

→ The target PC has a special motherboard with built in sense resistors.
All sense resistors are wired at both ends before being connected to a module attached to the NetDAQ unit

→ The NetDAQ modules attached with individual wires to the target PC & measures voltage & current

→ The host PC can be any IA32 system NetDAQ logger s/w installed on it

3.3.2 Software Tools

Tools are important for tuning s/w for performance & energy efficiency

To help diagnose energy problems with the application & system & provide a starting point towards creating energy

efficient apps & platforms.

3.3.2.1 windows 7 powercfg

powercfg is a command line tool that lets user control these system's power management setting.

Users can use powercfg to view & modify power plans & to detect common energy efficiency problems when system is idle.

Typical diagnostics are generated & following issues are reported.

→ processor utilization
→ power policy setting
→ platform timer resolution requests
→ Outstanding power request
→ platform capabilities
→ Battery capacity
→ USB devices selective suspend issue.

3.3.2.2 PowerInformer

It is a tool developed by Intel ~~developed~~ to provide basic power relevant statistics to a developer.

Developers can use these statistics to optimize their applications against battery life constraints

power Inforemer features includes.

→ Battery & power states Indicators
→ processor detection
→ percentage time & and Average residency of C_1, C_2 & C_3 states of the system & of all logical processors
→ percentage time of the P-stages of the system
→ System calls per second
→ Interrupt rate of the system
→ Disk I/O & File I/O operations [access, control, read & write] rates

3.3.2.3 Energy Checker

The Intel Energy checker SDK was developed to help software developers measures software energy efficiency & write energy aware software.

Energy aware software should be capable of measuring & reporting dynamically its energy efficiency metrics.

It provides the function required for exporting & importing counters from an application.

The core API consists of five functions to open, reopen, read, write & close a counter.

API exposes metrices of useful work done by an application through easy software instrumentation.

The Energy checker SDK provides a way for the software developer to determine what measures of useful work are important for that application & expose those metrices through a simple API.

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UNIT-3

Green Enterprises and the Role of IT

3-1 Introduction

Enterprises are becoming greener & IT plays major roles in greening an enterprise. An overview of various green initiatives within and between organisation. Based on the value chain perspective and focusing on various organisational functions.

The general greening strategies; practices, policy & process characteristics across the internal & external value chains set the stage for evaluating & integrating IT considerations. The application of IT tools & S/w for greening purposes, various green value chain dimensions, inbound logistics, purchasing production & outbound logistics, design & marketing intra organizational relationship & reverse logistics (closing the loop) are addressed.

Organization can complete with various greening policies such as environmental management systems [EMS], green procurement design for the environment, life cycle analysis, green marketing & green logistics and transportation

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For planning and controlling each of the value chain functions of organization. IT can effectively be used.

Ex IT could be harnessed for life cycle assessment environmental management system, environmental performance measurement system and design for environment & even green supplier & customer management

Green IT means that purchasing greener technologies, using IT in service setting, manufacturing these system or managing the end of life of IT equipment all have implications for greening the enterprises

E-commerce business practices which are heavily dependent on IT, have significant inter organizational implications. Replacing physical goods such as printed books with information goods, also called dematerialization, can eliminate significant waste & reduce the carbon footprint with physical product manufacturing delivery & management.

Reduction in inventory, warehousing return of product & obsolescence can be improved with effective Information Technology & information system that can be used for

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design, planning & implementing value chain activities

The roles of IT & IS in greening the enterprise will be detailed

13.2 Organizational and Enterprise Greening

Organizations have been experiencing various pressures from a variety of stakeholders that require them to address their environmental impacts & contribute to environmental sustainability by greening their enterprise

There are 4 business value dimensions for enterprise greening

- Cost reduction
- Revenue generation
- Resiliency or business continuity
- Legitimacy (its right to do business)

(1) Elimination or reduction of waste reduces the cost, consumption of executive resources such as energy & paper essentially means there is inefficiency & increased cost.

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Ex cost reduction is less energy usage & paperless office

(2) Organizations may realize extra revenue through green IT & IS practices By product and former waste products may find alternative uses instead of non-value adding disposal to landfills. IT products and materials that are returned may be recycled, remanufactured & resold, potentially as green products. This leads to revenue generator or profit centre for organizations

(3) Business continuity having the resources to remain in business & deliver products or services to customers, making sure your organizat-ions & partners are resilient. Organization can manage supply chains in a sustainable way, such as by making sure that hazardous materials are not in IT products, it is more likely that long term continuity will occur.

(4) Organizations need to develop their right to do business to operate effectively & with little stakeholder conflict. This value-adding dimension is related to furthering the reputation &

legitimacy of organizations that have green IT and green IS practices in place. Extending the life of IT products by donating to charity can also improve an organization's image and reputation.

Table 3-1 provides a summary of these business value dimension that can help organizations manage their green IT & IS practices

Cost reduction	Revenue generation	Resiliency	Legitimacy & image
Decrease the cost of production by selling returned & recycled material from IT equipment. Reuse collected material in production which drives down production cost	Lengthen the life of an IT product by reselling & reusing older system to location that cannot afford newer systems.	An organization may lose its license to operate or become less profitable if the IT product it manufacturers do not later back but left to entis other markets	Having IS system that are green will help to improve organization & product image.

Reduce energy usage	Develop new information system that allow for managing of an enterprise environmental processes & practices	The lack of information related to environmental performance may cause business shutdown.

3.2.1 The Green Enterprise : A value chain perspective.

Figure 3.1 describes activities and operations within an organisation value chain. Within the system perspective of the organizations, activities begin with procurement and the 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 & delivery services are central issue for purchasing agents. Thus the selection of material, services & suppliers become a critical for purchasing

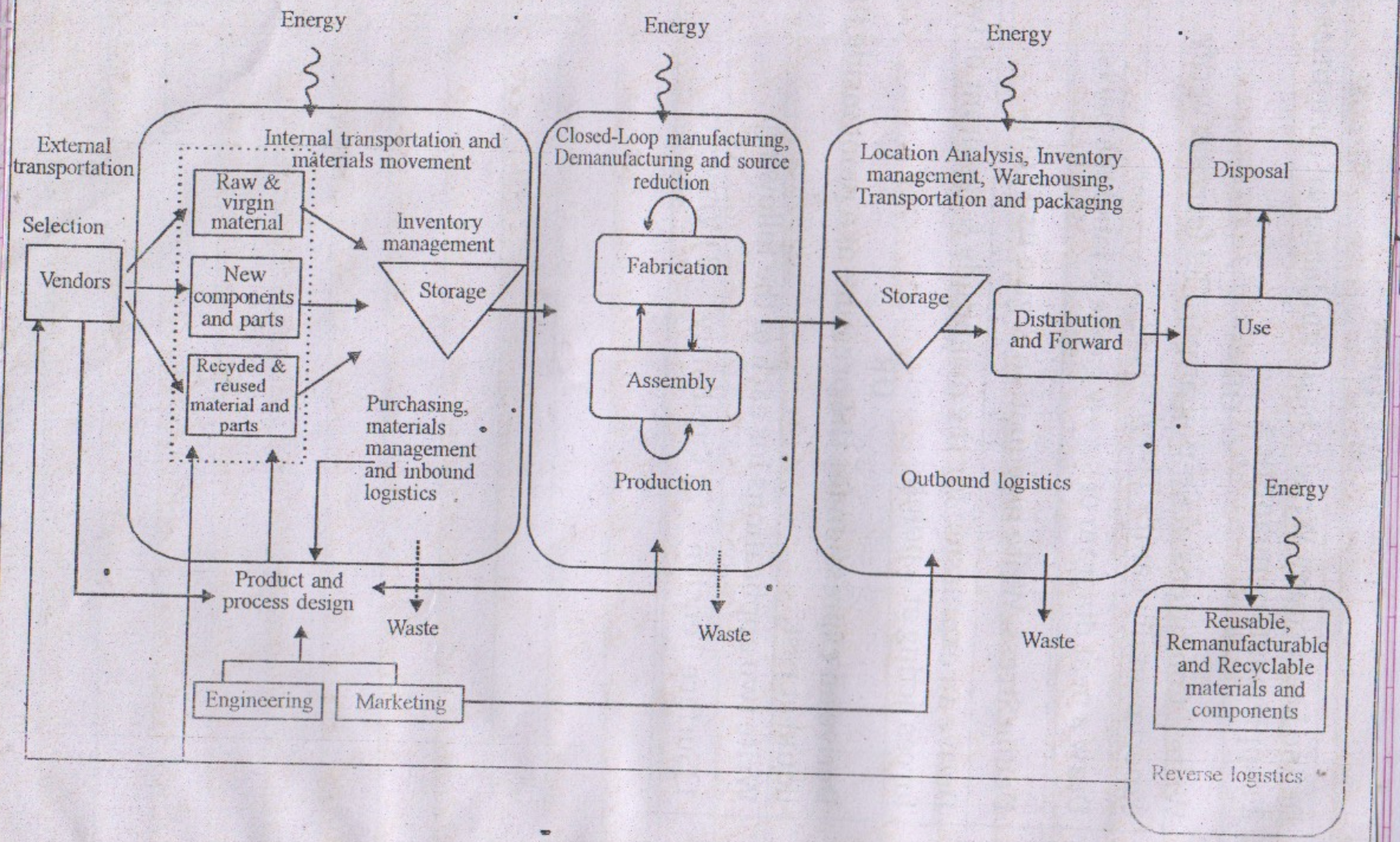
Energy
Energy
Energy
External transportation
Selection
Vendors
Internal transportation and materials movement
Raw & virgin material
New components and parts
Recyded & reused material and parts
Inventory management
Storage
Purchasing, materials management and inbound logistics
Closed-Loop manufacturing, Demanufacturing and source reduction
Fabrication
Assembly
Production
Location Analysis, Inventory management, Warehousing, Transportation and packaging
Storage
Distribution and Forward
Outbound logistics
Disposal
Use
Energy
Reusable, Remanufacturable and Recyclable materials and components
Reverse logistics
Product and process design
Engineering
Marketing
Waste
Waste
Waste

Fig. 3.1

function to help guarantee the environmental performance of this supply chain & material.

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

The design of product & processes is an important strategic activity for an enterprise and it is a major function influenced. Design should address new ecological themes as life cycle analysis & design for the environment.

The production function in a typical manufacturing organization composed of assembly and fabrication. This function, environmental issues such as closed-loop manufacturing, total quality environmental, de-manufacturing and source reduction making some forms of value-adding contributions.

Outbound logistics includes activities as transportation determination, packaging location analysis, warehousing & inventory

management. Activities such as using recycled containers & green fleets, efficiency designing, managing warehousing & inventory play roles in managing an enterprise ecological footprint.

Marketing role is important for organisational functions. Green marketing is a effective component of green enterprise for many organizations & it can be focus on the green products & greening of processes. & it is a critical to the management of an enterprise green image & reputation.

The 'use' external activity is the actual consumption of the product. At this stage, field servicing may occur, but from an environmental perspective the product or material may be disposed or returned to the supply chain through the reverse logistics channel. This step of the process is known as closing the loop & the closed-loop supply chain.

The reverse logistics function may feed directly back to an organization's internal supply chain or to an external vendor, starting the cycle again.

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Supply chain activities consumes energy & generates some waste, reduction in energy usage & waste generation that need to addressed throughout the supply chain.

3.3 Information System in Greening Enterprise

Organizational IS can be separated into four majos categories of system

1. Transaction processing system
2. Decision Support System
3. Management Information system
4. Executive support system.

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

MIS and DSS are typically focused at the middle management level of an organization.

MIS's role is to summarize & aggregate in reporting & communication of operational information.

DSS are typically analytical tools that help middle level managers make relatively routine decision & use information from various level of the organization.

ESS focus on the needs & requirements of upper management & aid their focus on strategic management of the organization.

Environmental management information system [EMIS] that helps to manage the environmental aspects is emerging.

Table 3.2 using this DSS categorization, summarizes the various roles of the levels and system types for a new enterprise function as examples

Table 3.2

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 success	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 .

Finance	Daily transactions of green house gas emissions permits	Financial environmental budget reports	Capital budgeting DSS tools integrating environmental factors	Shareholder value percentage for socially responsible funds.
Accounting	Daily recording information on environmental accounting data	Internal and external environmental audit information	Environmental balanced scorecard system	Social and environmental report structure and standards.
Human resources	Updating material safety data sheets (MSDSs)	Environmental training records	Personnel selection of environmental programmes	Environmental and safety requirements in union negotiations.

3.3.1 Environmental Management Information systems

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

The focus on software & system that are used to manage an organization's environmental & greening activities. The usage of system extends to intra-enterprise activities

3.2.2 Software and Databases

Environmental software programmes cover everything from auditing & managing emission to catalysing energy & minimizing waste.

Traditional environmental software as part of EIS has focused on internal practices

Software system include the utilization of LCA which goes beyond organizational boundaries.

Design for environment databases also plays a role & helps integrate suppliers & vendors data & processes.

A summary of the major software and database system are shown in Table 3.3.

Table 3.3

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.
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. Focuses 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	Focuses on government environmental, health and safety regulations, workplace assessments, health and safety project management, illness records and injury statistics. 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. 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. 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 . The larger IT framework could be Web based. Enterprise resource planning systems may contain these modules.

An integrated enterprise resource planning (ERP) system, as shown in figure 3.2 can cover many of the environmental management IS software types, databases types and organizational functions.

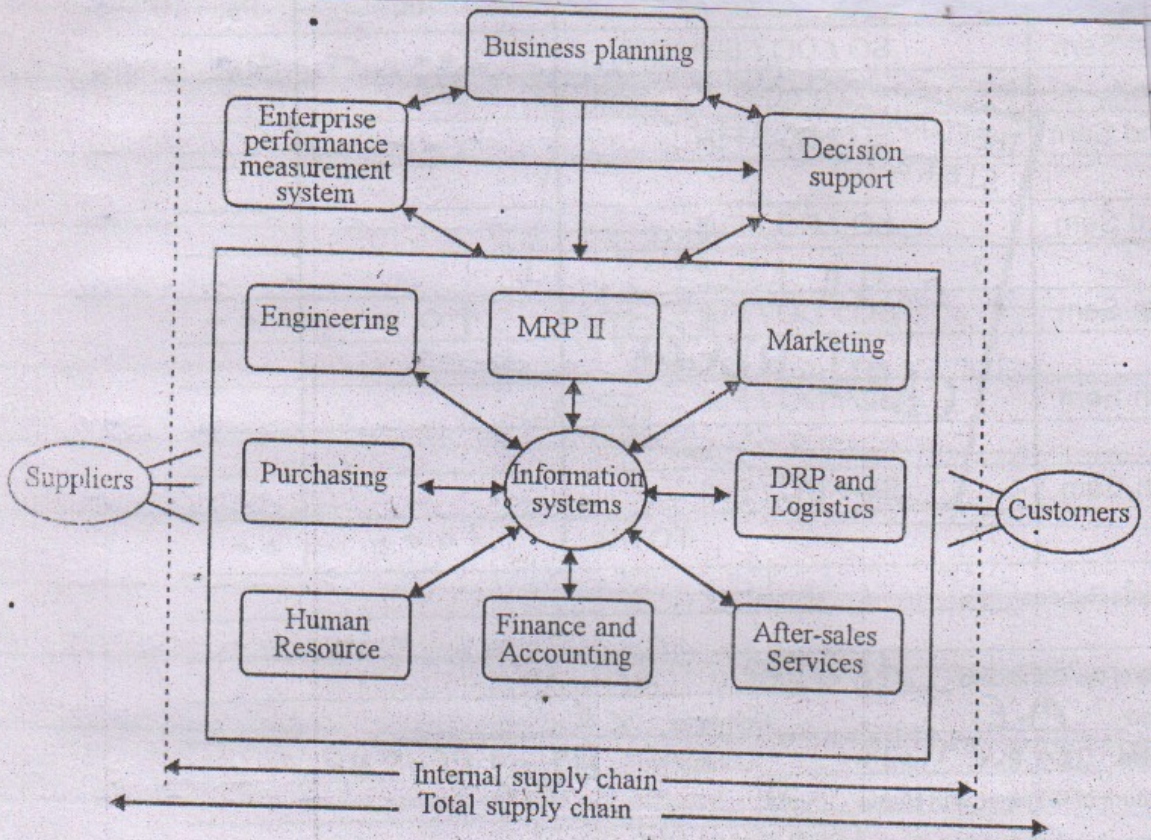

Fig. 3.2

3.3.3 ERP EMISs

ERP system offer a multitude of data with environmental relevance, but mainly focus on substance classifications, hazardous material & disposal criteria.

Data could not be used for monitoring & controlling material, energy and water consumption or material as energy flows.

The integration of ERP system with more advanced environmental IS tools helps to address this limitation.

EMIS have been designed as stand-alone, isolated, software tools such as waste administration Packages.

Integration of ERP functionality requires an emphasis in their common base. is the physical flow model.

physical flows entering and leaving the production process. and it is important for imposed to specific cost like taxes, tariffs and levies.

The essential units for EMISs are physical ones.

mass units (kg) and energy units (MJ) are measured over a definite unit of time. The time unit depends on the availability of data, & scope (Instrumental, operational, tactical & strategic) is used.

other operational units are volume, surface, number of items etc.

The other unique aspects of environmental information & IS Design is the need to use multiple stakeholders.

Supply chain partners, regulatory authorities, consumer organizations, unions, insurance companies & the community

EMIS waste & emission data would require similar controls & accuracy.

Standard information would be available from ERP system for LCA includes material & product information, process and work flow information, supply chain information and information about waste.

~~3.1 3.2 3.3~~ ERP EMIS informations

3.1 1) Materials and products information
3.2 2) process and work flow information
3.2 3) Supply chain information
3.4 4) Information about waste.

3.3.3.1 Materials and product Informatio

Material & product data are available through a bill of material (BOM) BOM and supporting inventory control system provide some insight into the composition of materials flows is not sufficient from an environmental point of view

The product and material information is on technical aspects, quality & product specification

Environmentally relevant data, partially overlap the BOM & Material requirements planning (MRP) data

BOM material & product composition can be represented on different levels & different ways.

These levels may include elements compounds, material & parts & components assemblies.

A BOM usually includes no weight & components or only incomplete information on weight.

components are reported & not materials or substances as needed for LCA inventory. Supporting processing materials are also not included in BOM.

Ex:- A printed circuit board is listed as a components, this would include data on the supplier, type number, dimension & functionality which can be obtained from a BOM.

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Regulatory policy is Restriction on Hazardous Substances (ROHS), manufacturers are required the prohibited substance in their products.

BOM represents a single product or assembly, or group of products which can aid recognition of any RoHS restricted substances in the final product.

Integrating a BOM with a material safety data sheet is one way of both environmental & product information.

3.3.3.2 process and work flow Information

process flow charts are part of ERP systems. This information may be used to describe the material & energy flows in an LCA.

~~Components~~ waste orders may contain a relatively complete data set about material components, required resources & the job table order.

process flow charts can be generated to track production related data for resources & energy use.

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3.3.3.3 Supply Chain Information

Transportation & logistics type information could be useful for environmental management.

Supplies information can be used to calculate the transportation effort to the company.

Transportation method within a company can be obtained from the work order.

Distribution method within a company can be obtained from the Sales & Distribution functionality of an ERP system.

3.3.3 Information about waste.

Information includes types & quantity of waste & the product that generated the waste.

Logistics & procurement-scheduling modules may also provide valuable information from an environmental perspective.

Transportation planning will identify weights, modes of transport, distances & other information that can be used to evaluate

the carbon footprint of the organization's logistics function?

3.3.4 ERP Challenges and Deficiencies with Respect to EMIS.

Integrating ERP with EMIS System raises a number of managerial & technological challenges & issues.

- No one ERP system exist that meets the needs of companies with diverse and multi dimensional EMIS requirements within the same industry
- Data are at highly aggregated levels
- There is only partial registration of the BOM's components

registration of components & their weights but not material or substances

- There is no integration of energy use, wastes use, or emission into water, air & land.
- The entire life cycle is not included, & recycling & reuse are not considered
- There is no capability to generate reports for EMS or LCA
- Units are in batch or lot sized operational control - type units

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3.3.5 Integrating Environmental and LCA Information with ERP

ERP system have environmental, health & safety (EH&S) modules

Ex the SAP R/3 system has an integrated EH&S module & provides operational solutions for hazardous substance management, product safety, dangerous good management & waste management.

Structural system models that shows a more extensive linkage between EMIS, LCA & ERP.

The functionality of an ERP system should include various managerial & function-al decision levels. using the managerial decision making hierarchy link.

Other ERP systems integration of mass & energy flow models for effective integration

Business process models are required for system analysis & design approaches for implementating enterprise-wide IS.

An exchange format between ERP & EMIS system is to be a two-way integration

ERP data are useful for EMIS and EMIS can be used for ERP such as in cost accounting modules.

3.3.6 Electronic Environmental and Sustainability Reporting

Environmental communication and environmental & sustainability corporate reporting are tools to communicate a company's performance, demonstrate its management system & present its responsibility & other items.

An environmental data are continuously dynamic & growing the report may have to be a living document.

proders need to be in place to gather the information & put in appropriate format to be reported.

The most common language used for communication & reporting standardization is Extensible Markup Language (XML).

Many EMS are currently under design to arrive at the corporate report.

XML based documents have a precisely defined structure

XML can be seen as a large family of technologies & language that permits structuring document contents, formatting document & transforming document into other document or function.

XML document have a strict structure, flexibility needed for the presentation of various kinds of informations required in the reporting process.

XML based reports suitable tools for internet & cross-media reporting

3.4. Greening the Enterprise:

IT Usage and Hardware:

The adoption of environmentally friendly materials, procedures & practices in the design, manufacturing & delivery of IT system.

The environmental implications of H/w production are quite extensive. Electronic product require significant 'clean' requirements higher purity requirements for energy & materials.

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Ex A 2g memory chip may require 1.3 kg of material resource input, while an average PC, cathode ray tube monitor requires 10 times its weight of water, fossil fuels & chemicals as material & resource input

Large quantities of energy, material & chemicals are used for production phase.

Modern electronics & computing equipment consists of toxic materials which includes lead, cadmium in computer circuit boards, lead oxide & barium in the monitor's CRT.

Mercury in switches & flat screens,

3.4.1 Environmental Information Technology Standards

The major effort towards greening IT product is the Electronic Product Environmental Assessment Tool [EPEAT] Identify green computer & other electronic equipment.

It is a powerful tool for enterprise sustainability performance.

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EPEAT is a three-tiered, point-based system. There are 23 required criteria to meet the lowest level of EPEAT certification which is EPEAT Bronze. This criteria covers the entire life cycle of a product, from a reduction of the toxic materials used in production to the energy it uses while in operation and the recyclability of its materials at the end of life.

product that meet all 23 criteria receive Bronze certification

14 or 21 → optional criteria silver or gold certification.

Table 3.4 categories for the 23 EPEAT required criteria

Table 3.4 EPEAT required (mandatory) criteria for IT equipment

- **Reduction and elimination of environmentally sensitive materials**
  1. Compliance with provisions of European RoHS directive upon its effective date.
  2. Reporting on amount of mercury used in light sources (mg).
  3. Elimination of intentionally added short-chain chlorinated paraffin(SCCP) flame retardants and plasticizers in certain applications.
- Materials selection
  1. Declaration of postconsumer recycled plastic content (%).
  2. Declaration of renewable or bio-based plastic materials content (%).
  3. Declaration of product weight (lbs.).
- Design for end of life
  1. Identification of materials with special handling needs.
  2. Elimination of paints or coatings that are not compatible with recycling or reuse.
  3. Easy disassembly of external enclosure.
  4. Marking of plastic components.
  5. Identification and removal of components containing hazardous materials.
  6. Minimum 65% reusable or recyclable.
- **Product longevity or life cycle extension**
  1. Availability of additional three-year warranty or service agreement.
  2. Upgradable with common tools.

- Energy conservation
  1. Energy Star.
- End-of-life management
  1. Provision of product take-back service.
  2. Provision of rechargeable battery take-back service.
- Corporate performance
  1. Demonstration of corporate environmental policy consistent with IS 14001.
  2. Self-certified environmental management system for design & manufacturing organizations.
  3. Corporate report consistent with the EPA's Performance Track or Global Reporting Initiative (GRI).
- Packaging
  1. Reduction or elimination of intentionally added toxics in packaging.
  2. Separable packing materials.
  3. Declaration of recycled content in packaging.

3.4.2 Green Management of Data Centres

The most critical energy user within an enterprise with around the clock usage is the data centre.

File servers and centralized data storage devices are predominant

The management of these centres is critical to the overall greening of IT whether it is service or manufacturing.

A number of strategies & practices to make data centres greener especially from an energy saving perspective.

3.5 Inter-organizational Enterprise Activities and Green Issues

Inter-organizational Enterprise activities can be made greener by leveraging IS and technologies.

3 activities are gaining growing

1) Electronic commerce and purchasing
2) Reverse logistics and demanufacturing operations
3) Eco-Industrial parks.

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3.5.1 Electronic Commerce and Greening the Extended Enterprise.

It is the process of buying and selling goods and services electronically through computerized or mobile communication system using various technologies as Internet, the world wide web, and electronic data interchanges.

E-commerce can occur between business and consumers (B2C's) business and other businesses (B2B's) consumers and consumers (C2C).

There are environmental implications and issues for all these types of transaction and greening implications occurs from all these areas.

The Internet and WWW has helped reduce information asymmetry. It is one party has more information for a transaction than another party.

Environmental information whether it was for reactive purpose or proactive purposes was not easily available to all parties

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The reduction in information asymmetry necessitates organizations becoming more environmentally sound, from a social legitimacy perspective & Information based policy instruments.

The role of e-commerce as a conduit of environmental information is best ~~exemplified~~ typical example by the preparation and delivery of environmental reports.

By implementing e-commerce, firms are likely to better manage their inventories through better information sharing.

E-commerce makes it possible for companies to directly do B2C business, reducing the need for retail shops and other intermediary services along the supply chain. consumers can quickly gather price and product information through the Internet & base their buying decision on these attributes. consumers & companies can have products delivered from centralized locations versus driving to from individual outlets.

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3.5.2 Demanufacturing and Reverse Logistics.

Extending the life of IT product or materials, a system will allow for the management of IT hardware as it needed.

Managing and incorporating a reverse-logistics channel is necessary that may not only voluntary but also to regulatory requirements such as Waste Electrical & Electronic Equipment (WEEE) regulations in Europe, Japan & china.

Managing & closing the loop across enterprise for production & materials is imp.

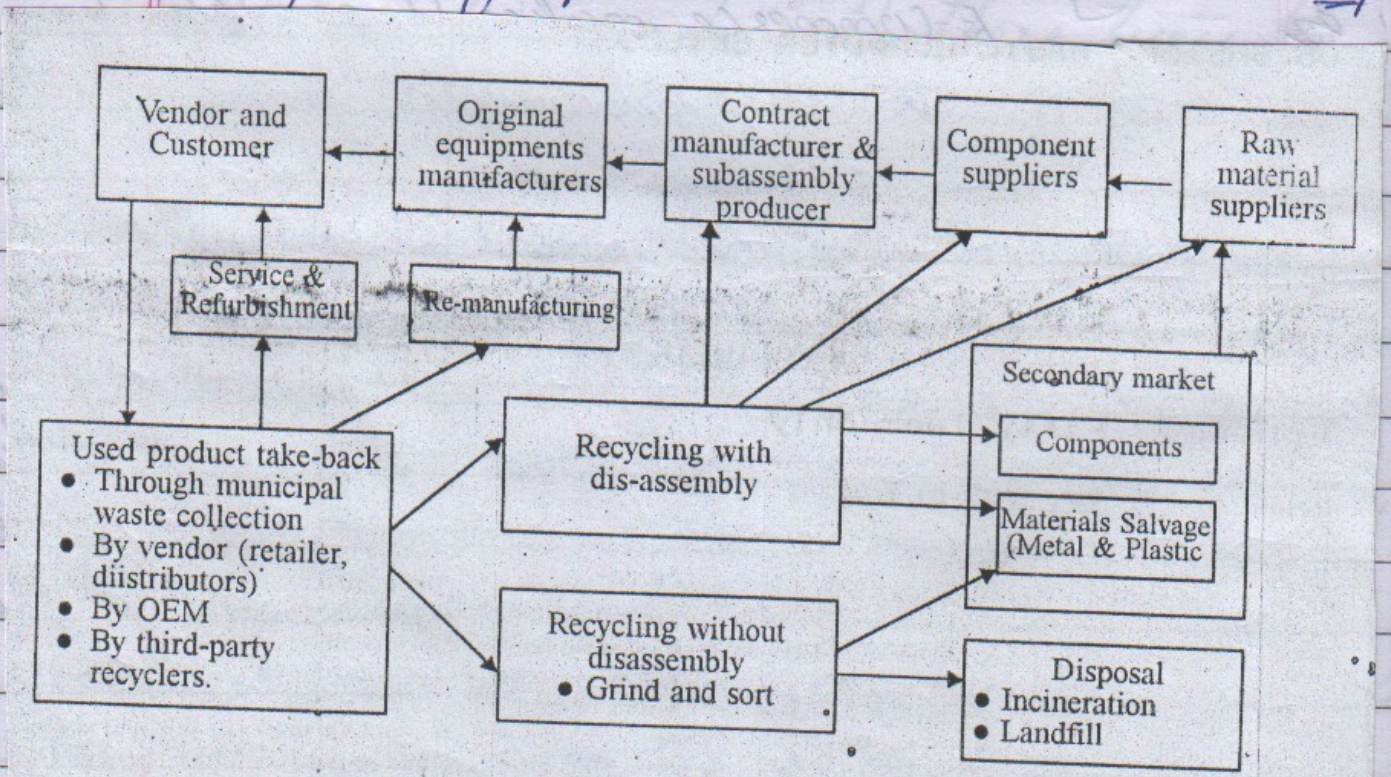

Fig. 3.3 A closed-loop system for IT products and materials.

Figure 3.4 summarizes the various input sources and types of output of this facility

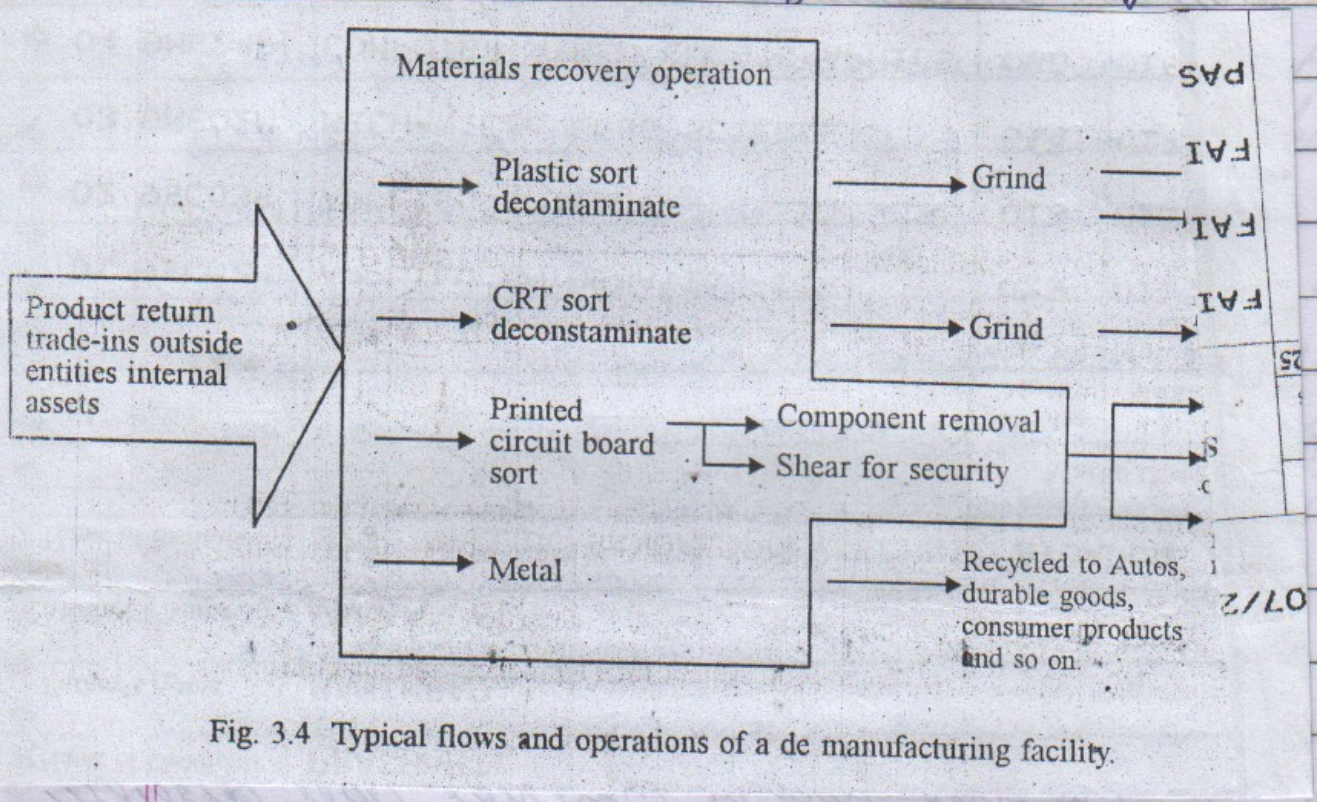

Fig. 3.4 Typical flows and operations of a de manufacturing facility.

Computer & electronics components form the overwhelming material that is processed within an asset materials recovery operation [AMRO]

→ Office furniture & office based products & material arrive for processing.
→ intact parts are removed, tested & stocked as spares.
→ precious metals are extracted & resold
→ plastics, glass & other material are recycled.
→ 1% material ends up in landfills.

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3.5.3 Eco-Industrial Parks and Information System

Eco-Industrial parks are formed by physically or virtually locating organisations whose by-products may be utilized by other organisations within the park.

Environmental information plays an important roles in the planning, design, construction, management & retrofit of eco-industrial parks, in symbiosis & in by-product exchange network synthesis.

One of the key approaches to improve environmental performance & production management efficiency is to integrate members environmental information into a park management system.

Software and development system for eco-industrial parks have been developed.

The major purposes of the system are

1) opportunity identification
2) opportunity assessment
3) barrier removal
4) commercialization and adaptive management
5) Documentation, review and publication

Eco-industrial parks are across dimension :

Eco-Industrial parks within a larger community working together in a broader system may have eco-symbiotic relationship at many levels or mutually beneficial manner.

open source and distributed system can communicate at many levels.

The Internet, e-commerce & other relationship of different organization will share knowledge, expertise & data

Adaptive and dynamic IS can evaluate & link their organization at multiple levels,

IS and mobile technologies can prove useful in managing the organization

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3.6 Enablers and Making the case for IT and the Green Enterprise.

Greening an enterprise by harnessing IT through business process reengineering investment requires thoughtful evaluation and justification by management.

Solution such as the policy of favouring the purchase of greener equipment is easy to implement.

It may require significant investment and justification as greening full data centres with latest technologies.

There are four major categories of enablers for green IT

1) Strategy definition
2) Organizational Support
3) Motivation
4) Traceability.

Strategy definition

A clear target definition for sustainability is required. Supporting corporate strategic measures need to focus beyond economic metrics, towards inclusion of values associated

with economic and greening responsibilities
Thus introducing business case measures for environmental issues can show substantive top management support.

2) Organizational Support:
The main organizational enablers for the succesful adoption of any sustainable practices are top management support.
The top management support having the commitment from two chief executives
CEO (chief Executive officers)
COO (chief Operating officers)
ensures strategic commitment & support for making organizational change

3) Motivation :-
According to self determination theory, extrinsic and intrinsic motivational factor play a role in adopting new business programmes.

Intrinsic motivation is more effective for greening & important personal characteristics to achieve bottom up support

Extrinsic motivation will require more formal procedures and rewards

4) Traceability

The sense of transparency and measurement, also important enablers for greening IT.

IT plays a important process role since measurement system are heavily reliant on software and IS.

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UNIT-4

MANAGING GREEN IT

4.1 Introduction

Green computing is the study and practice of using computing resources efficiently with minimal impact of green IT.

Greene computing is the process of designing, engineering, manufacturing using recycling and disposing computing devices in sustainable way.

Green computing reduce the use of hazardous materials, minimizing use of non renewable resources, enchancing recyclability recycling maximizing energy efficiency & reducing the hazardous waste at all the levels.

Management is the process of organization and co-ordinating activities in order to achieve desired goal.

Management is the process of incorporating green solution into IT to make the organization environment responsibilities.

Managing IT with a focus on environmental sustainability is a wide strategic decision IT Managers and users can make a difference

This chapter begins with strategic planning, leadership skills and demonstrated valued added by green initiatives.

4.2 Strategic Thinking

Green computing involves innovations cost / time trade off and risk.

To successfully plan and practices green IT are

1) Strategic Thinking
2) Strategic planning
3) Strategic Implementation
4) Enterprise Architecture planning

Strategic Thinking

Managing involves planning, coordinating staffing and budgeting, but when it comes to managing green IT which involves innovations and associated risk the manager needs strategic thinking.

Strategic thinking is same as strategic planning

Strategic thinking is the action taken

→ prior to strategic planning, ~~prior to~~
→ prior to the development of requirements

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Strategic planning is a formal process of defining the requirements for delivering a green IT programme.

Strategic thinking is a distinctive activity whose purpose is to discover novel, imaginative green strategies that offer value

It is proactive rather than reactive in nature. The focus is always on a greener future state in relational to where the company is today

Strategic thinking is to enchance the organization position and purpose towards green initiatives specially the area of IT.

The goal is to formulate effective strategies consistent with a business and competitive strategy.

Strate thinking is a mental process arising from personal & managerial experience.

Managers can strategically plan & develop the requirements & process needed to attain the vision of the program utilizing green IT components & systems

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4.2.2 Strategic planning

Strategic planning is the process of defining its strategy or direction and making decisions on allocating its resources to pursue. including capital & people.

Strategic planning defines objectives and goals through mission and vision

mission statement tells you the fundamental purpose of the organisation

vision statement outlines what the organisation wants to be or how it wants the world in which it operates to be.

Every IT department should have its own strategic plan that support the company. In this mission statement & visions the move towards green IT should be prominent.

A company management at the highest level must support the move towards green IT

The CEO & CIO must together do authoritatively mandate the acceptance of changes & must persist and accept the changes

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Difference between

	Strategic Thinking	Strategic planning
1) Vision of the future	only the shape of the future can be predicated	The future is predictable and specifiable in details
2) Strategic Formulation and Implementation	Formulation and Implementation are interactive rather than sequential and discrete	The roles of formulation and Implementation can be neatly divided.
3) Managerial Role in Strategy Making	Lower level managers have a voice in strategic thinking	Senior executives obtain the needed information from lower level managers & then use it to create plans.
4) Control	Relies on self reference	Asserts control through measurement systems assuming that organizations can measure

		and monitor important variables both accurately & quickly
5. Managerial Role in Implementation	All managers understand the large system	Lower level managers need only know their own roles well
6. Strategy making	Finding new strategic options & implementing them successfully is more important than evaluating them	The challenge of setting strategic direction is primarily analytic
7. process & outcome	The planning process is a critical value adding element	The creation of the plan is the ultimate objective

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4.2.3 Strategic Implementation

IT should be recognized as a strategic resource, one that makes a difference & actively support the company.

This should be done by IT Manager as part of strategic implementation. The increased visibility then allocate the IT manager to demonstrate how green IT can have positive value impact for the company.

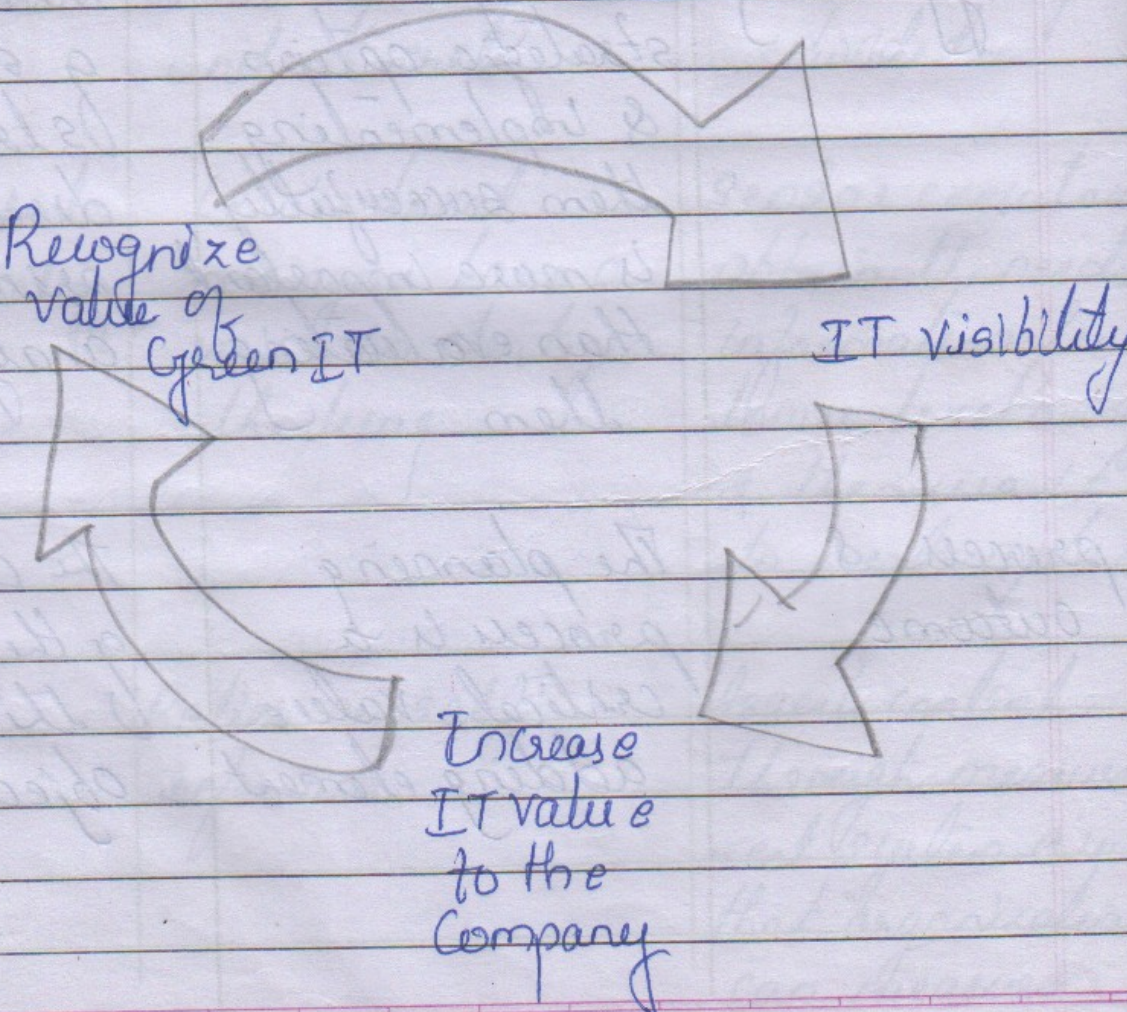

figure 4.1 change the process by understand-ing the process & procedures currently in use and the habit of the IT community & users and customers.

Ex Turning off computers and power strips at the end of the day prevent patches from being automatically pushed.

New habit need to be developed that produce both real & perceived value, which means a new set of rules for IT management.

4.2.4 Enterprise Architecture

Strategic planning, the architecture is needed to support the green initiatives to maximize their impact & support their implementation.

EA is a methodology for developing a series of architectural frameworks i.e current intermediate and target based on mitigation plan.

These frameworks detail all relevant structure within the organisation, including business, application, technology & data.

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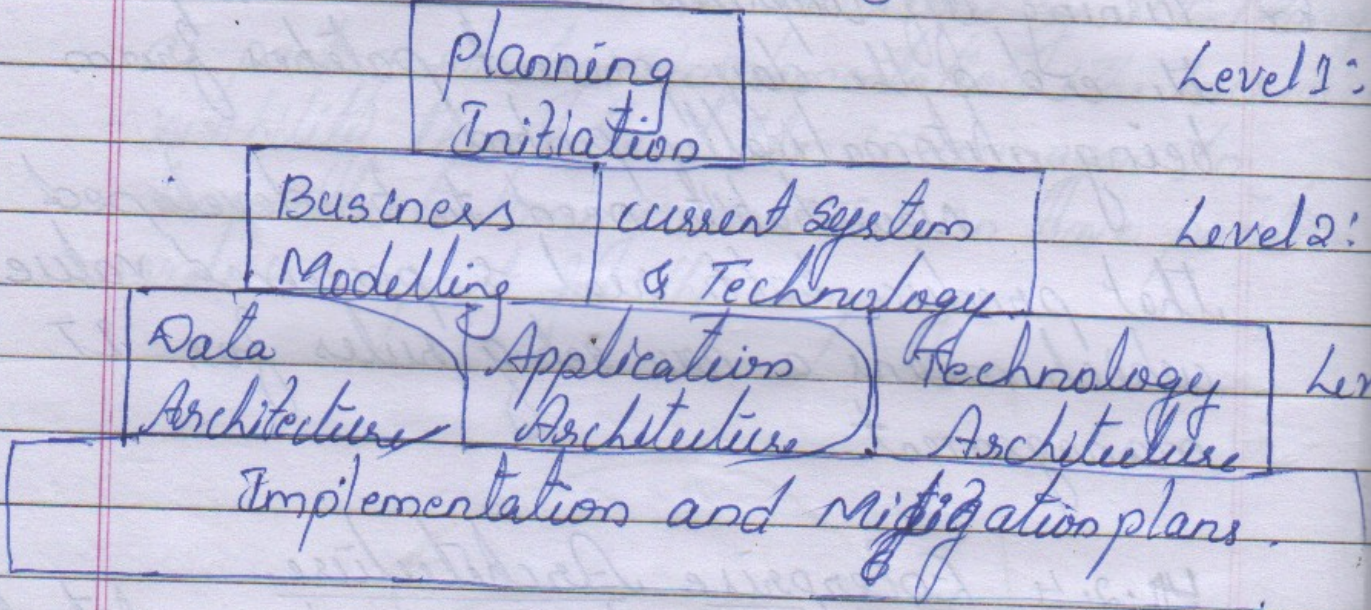
Enterprise architecture planning is the process of defining architecture for the use of information in support of the business & the plan for implementating architecture.



4.2. Enterprise architecture plann

Figure 4.2 represents the layers are implemented in order from top to bottom.

EAP takes a data-centric approach to provide data quality, access to data, adaptability to changing requirements, data interoperability & sharing & cost containment

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etting Started

here we are today

: Future Vision

evel 4: How to get There.

ing levels.

There are four layers critical to succesful ERP.

→ Layer 1 → getting started.
planning initiation leads to producing an ERP workplan and includes decision methodolo-gies & the allocation of resources

Level 2 - Vision of where we are today?

This layer provides a baseline business model along with the compilation of knowledge base for supporting business process.

It also contains current system and technology.

Level 3 The vision of where we want to be:

This layer consists of data architecture which defines major kinds of data needed.

Application architecture defines the major kind of application needed to manage the data & technology needed for support the applications.

Level 4 - How we plan to get there:

The implementation and migration plans defines the sequence for implementing applications,

A cost benefit analysis and a clear path for migration

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4.3 Implementation of Green IT:

Initiating green IT management involves four key components

1 Adopt a bottom up or top down Approach.

If you are working in the company undermanagement team, initiate start discussions with them & start engaging with the users & taking suggestions with quickly demonstrate the value of green initiatives

2 Understand the complexities and interdependencies of how products, architecture 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.

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4.3.1 Return on Investment

Management involves budgeting and financing the basic metrics which measures financial prudence is return on investment.

Every business entity will be trying to maximize the returns on its investment.

IT Managers manage well & help business play the role in making good decisions that produce operational and financial improvements in business performance.

IT managers by developing ways to describe value added is responsible for convincing the top management to invest in green IT Ex more energy efficient desktop reduce energy consumption

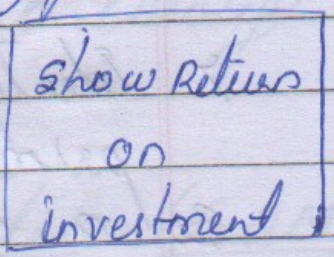
The reduction in the use of energy reduces the cost of running the building, Supported by the managers.

It has advantage of getting promoted by government policies and International Organization promotions.

The IT manager should consider all explaining return on investment or green initiatives to get the project clearance through finance team.

This becomes process and helps in realizing next IT initiatives.

The process is shown in figure 4.3.



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4.3.2 Metrics

Metrics are the methods, techniques and process used to scale the benefits of introducing green IT into the system.

Metrics programe is the process of designing and developing a comprehensive metrics or measurement methods

Metrics programe Includes.

- Identifying objective and goals both primary and secondary

Ex a goal may be to reduce energy cost.

- Identify and collecting supporting data

ex how much energy is consumed by the current desktops & the energy usage of a green in the data centre.

- Designing a model to present this data toward decided objectives

- presenting the model to the management...

It provide management with their answers to their questions based on the metrics analysis.

Metric programs are based on raw data and measurement collected from multiple sources.

The model should be realistic enough to consider only impacts which can be categorically proved.

Data collection becomes core of the metric program and made efficient through automation.

4.3.3. The Goal-Question Metric (GQM) Paradigm

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

The GQM paradigm consists of 3 steps

1) Generate a set of goals based upon the needs of the organization.

It helps to determine the target and the area of consideration.

2) Derive a set of question

The number of possible question which when answered satisfy goals are generated and to make metrics program more realistic.

3) Develop a set of metrics which provide the information needed to answer the question.

The set of metrics and data which could answer the question are identified and collected.

The collected data are analysed & presented to way to answer question which inturn qualify the desired goals.

4.4 Information Assurance [IA]

Information assurance is the practice of managing risk related to use, processing storage and transmission of information as data and the system and processes used for there purposes.

The IA process typically begins with examination and classification of the information.

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Risk management plan that involves mitigation, eliminating, accepting or transferring the risk and consider prevention, detection and response.

Recycling IT component is a great way to improve the IT footprint when managing a classified environment.

4.4.1 Risk Management

Risk is the probability of occurence of a problem. Risk management is the process of assessing, analysing, reducing and avoiding risk.

Risk have two characteristics

1) uncertainty: An event may or may not happen
2) loss: An event may have unwanted consequences or losses.

The objectives of the risk management are

- Identify the potential risks, before they occur
- Communicate the probability of risk
- Allocate resources to risk management
- plan for risk mitigation
- Focus on the project objective and quality while dealing with risks

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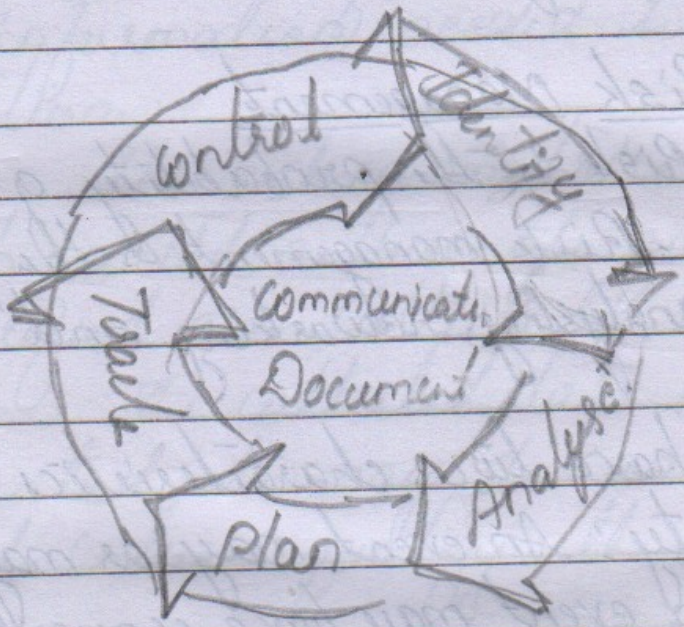
7 Involve the people @ all level
7 Document the risk management as lesson learnt.

The framework for Risk management is shown in figure



Six steps of Risk assessment are

1) Identify: The process include identifying risks and including them in the project plan.

2) Analyse: Analysing risk comprises 3 basics activities: evaluating the attributes of the risk, classifying the risks & prioritizing or ranking the risks

a) Impact: The loss or negative effect on the project should the risk occur
b) Probability: The likelihood the risk will occur
c) Timeframe: The period in which you must take action in order to mitigate the risk.

3 Plan: The develop mitigation strategies based on current knowledge of project risk. The purpose of this plan is to
a) Make sure the risk's consequences & sources are known;
b) Develop effective plan.
c) plan effectively
d) Produce, overtime, the correct set of actions that minimize risk impacts of cost & schedule while maximizing opportunity & value.
e) plan important risk first

4 Track: Track the process by which risk status are acquired, compiled and reported.
The purpose of tracking is to collect accurate, timely & relevant risk information
Tracking status information becomes critical to performing the next function the continuous risk management paradigm control

5) Control: controlling risks involves analysing the status, reports deciding how to proceed & then implementing the decisions

6 Communicate and document: are essential to the success of all other functions within the paradigm and are critical for managing risks.

4.5 Communication and Social Media

Communication to stakeholders and stakeholder participation are keys to the success of green initiatives

Social media can be used for communicating among stakeholders green initiatives and authority for starting green IT projects.

IT Management could pertain to a large society about awareness of green IT initiatives along with creating values.

IT Management should start mass communication by creating separate departments as social authority experts which can influence both employees & customer towards the need of green IT solutions.

There is always good chance of loosing authority due to errors in the communication The social authority expert should manage social media without error.

No project can be succesful without comprehensive communication to all levels within the company.

Everyone must support the move to green IT, in order to support it.