CS8078 GREEN COMPUTING

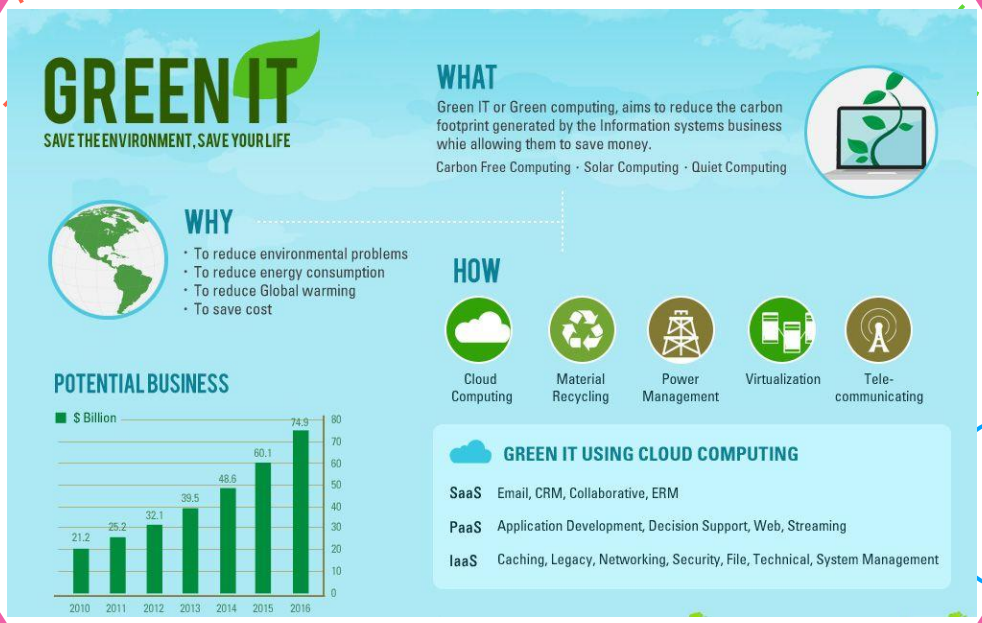
UNIT-I FUNDAMENTALS

Green it Fundamentals: Business, IT and the Environment

Green Computing: Carbon foot print, Scoop on power

Green it strategies: Drivers, Dimensions, and Goals - Environmentally Responsible

Business: Policies, Practices, and Metrics.



INTRODUCTION

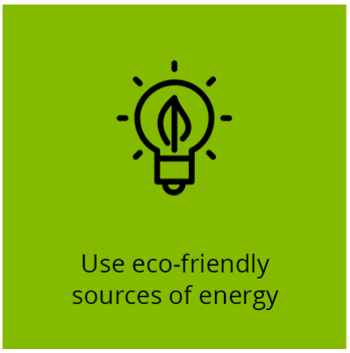
- Green computing is the environmentally responsible and **eco-friendly** use of computers and their resources.
- It is also defined as the **study of designing**, **manufacturing/engineering**, **using** and **disposing of computing devices** in a way that **reduces** their **environmental impact**.
- It is also called as Green IT

HISTORY

- Green computing was Originated in 1992 at the U.S Environmental Protection Agency that launched Energy Star program.
- Shortly after that the term “Green Computing” was coined.

WHY IS GREEN COMPUTING REQUIRED?

- Impact of **Electricity to the Environment**
- Uses **lot of electricity**
- Impact of **Toxic waste to the Environment**



GREEN IT

- Green IT stands for **Green Information Technology**.
- Information Technology is essentially the design, implementation and management of computers that both individuals and businesses use.
- The Green IT is composed of two things:
  - Minimizing the **negative impact of information technology** use on the environment
  - Using information technology **to help solve environmental issues**

WHY GREENS IT ?

- Rising energy demand with a **more limited supply** and increasing utility costs
- Management of **hazardous waste** and electronic equipment disposal (e-waste)
- Increasing **gasoline costs**, which drive up employee commuting costs leading to retention issues
- Increasing **real estate costs**
- Rising **airline ticket costs and travel complexities**
- A stronger **regulatory climate at the federal**, **state** and **local levels**

SOURCES DANGER TO ENVIRONMENT

LEAD	MERCURY	CADMIUM
Used in soldering of printed circuit boards lead can cause damage to the central and peripheral nervous system , blood systems and kidneys	Used in batteries, switches . Mercury spreads out in water transforming into methylated mercury that can cause chronic brain damage	Used in resistors for chips and in semiconductors . Cadmium is classified as toxic, these compounds accumulate in the human body, particularly the kidneys

GREEN SOURCES

BAMBOO	RECYCLABLE PLASTICS	ECO-FRIENDLY FLAME RETARDANT
It is becoming increasingly popular for **making casings** for computers and peripherals	Computers are constructed from non-recyclable plastics. ie, recyclable polycarbonate resin	There are flame retardant **silicone compounds** available that are flame retardant and completely non-toxic

GREEN SOURCES

INVENTORY MANAGEMENT	VOLUME REDUCTION
Reducing the **quantity of both hazardous materials** used in the process and the amount of excess raw materials	Removes **hazardous portion of waste** from non hazardous portion

ENERGY CONSUMPTION

Component	Power Consumption (Watts)
CPU Intel Pentium 4 (Prescott) 3.2 GHz	84
CPU Intel C2D E2140-2220	65
CPU Intel C2D E6750	65
CPU Intel C2Q Q6600	95 or 105
CPU Intel C2D E7200-7300	65
CPU Intel C2D E8200-8600	65
CPU Intel C2Q Q9300-9650	95
CPU Intel Core i7 920	85
CPU Intel Core i7 940	92
CPU Intel Core i7 965 Extreme	100
CPU AMD Athlon 64 3800+ EE	62
CPU AMD Athlon 64 X2 4800+ EE	65

Component	Power Consumption (Watts)
CPU AMD Athlon 64 X2 4800+	89
CPU AMD Athlon 64 X2 6000+	125
CPU AMD Phenom X3	95
CPU AMD Phenom X4 9100e-9350e	65
CPU AMD Phenom X4 9500-9750	95
CPU AMD Phenom X4 9750-9850 Black	125
CPU AMD Phenom X4 9950 Black	140
Hard Drive 2.5"	2 to 6
Hard Drive 3.5"	10 to 30
DVD Drive	5 to 12
Mainboard	20 to 60
1 Memory Module	3

- A **complete desktop** uses an average of **200 Watt/hours** (Wh).
- A **Laptop** uses an average of **100 Watt/hours** (Wh).

ALTERNATIVES

REMOTE WORKING

E-WASTE RECYCLING

USING ENERGY STAR LABELLED PRODUCTS

CLOUD COMPUTING

GREEN COMPUTING

- Green computing is the practice of using computing resources efficiently.
- Designing , manufacturing and disposing Computer, servers with no impact on the environment.
- To reduce the use of Hazardous materials, maximize energy efficiency during product's lifetime.

WHY GREEN COMPUTING?

- Computer energy is often wasteful
  - Leaving the computer on when not in use
- Printing is often wasteful
  - How many of you print out your emails or meeting agendas
- Pollution
  - Due to manufacturing, packaging, disposal techniques
- Toxicity
  - Due to toxic chemicals involved in the manufacturing.

GREEN COMPUTING: CARBON FOOTPRINTS

- Latest research states that by the end of 2020 carbon emission footprints **will increase by 20%.**
- This emission is mainly taking place **due to Data Centers** used to achieve the cloud computing architecture.
- **Data centers and new technology** adoptions are mainly causing this carbon emission.
- These Data Centers uses cloud energy to serve the user generated request and this energy consumption is the basic cause of carbon emission.

GREEN COMPUTING: CARBON FOOTPRINTS

- The **Fusion-io**, which is fastest manufacturer of the **solid state devices** in the world, conducted a case study to reduce the carbon footprint by **replacing their multiple heavy load servers** and **retiring all the extra number of servers** previously in operation.
- The results had shown that total **80% of carbon footprint** was reduced as well as the performance and speed was noticeably optimized than before.

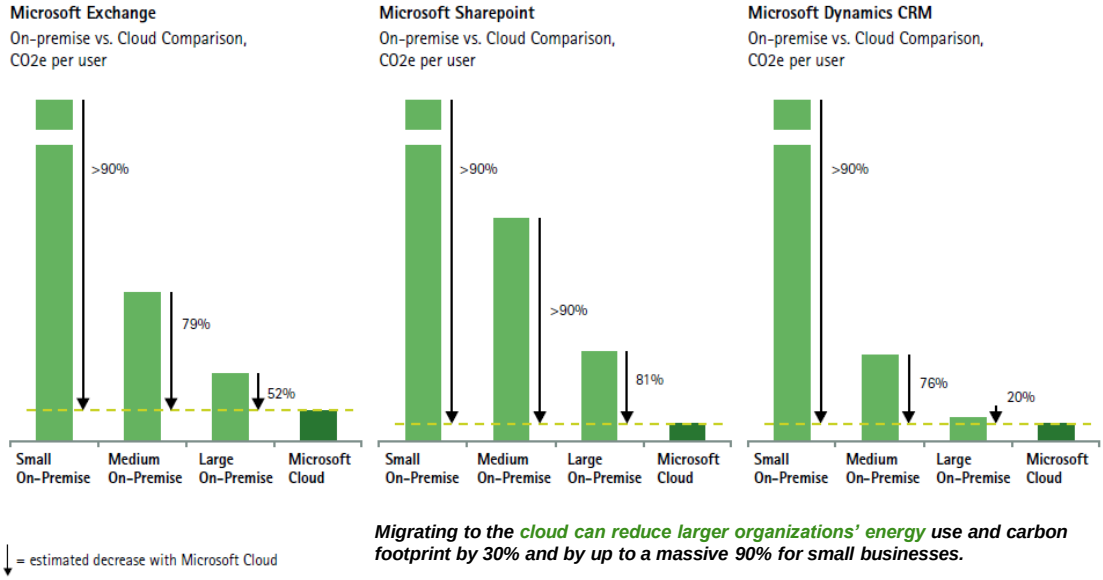
GREEN COMPUTING: CARBON FOOTPRINTS

- As the **hard drives** have become cost effective than earlier the backup and **storage of online data** has been increased which resulted into **more power consumption.**
- Hence, researchers are **focusing on saving the online data in larger arrays** while not compromising on the performance level to reduce the power consumption.
- Replacing **petroleum-based plastics** with **bio-plastics** can reduce the carbon emissions up to a massive level as the bio-plastics generate a lot less toxic emissions.
- Bio-plastics are **plants-based polymers** and they offer less oil and energy consumption.
- The major challenge in using plants-based polymers is that important measures are needed to **obtain a certain temperature for these polymers otherwise they will melt down**.
- The displays that are high power-eaters should be replaced with less power consuming displays i.e. **Organic Light Emitting Diodes (OLED)**.

GREEN COMPUTING: CARBON FOOTPRINTS

- Using **solid state or flash memory** instead of **hard drives** can reduce the energy consumption up to 10% because larger number of moving parts of hard drives can cause larger consumption of energy.

GREEN COMPUTING: CARBON FOOTPRINTS



Migrating to the cloud can reduce larger organizations' energy use and carbon footprint by 30% and by up to a massive 90% for small businesses.

GREEN COMPUTING: SCOOP ON POWER

- Terminal servers
- Shared memory
- Power management
- Storage Management
- Video card
- Display
- Computer multitasking
- Parallel Processing in Computers
- Software Pipeline

GREEN COMPUTING: SCOOP ON POWER

- **Terminal servers**
  - Terminal servers are widely **used to create virtual labs** for the clients for example LTSP and Terminal Services for Windows.
- **Shared memory**
  - Shared memory **minimizes the processing complexity** and also creates ease for computations as there is only one actual copy of the data for all the programs.
- **Power management**
  - The **ACPI** (Advanced Configuration and Power Interface) is the newer version of another old power control standard **APM** (Advanced Power Management) by Intel-Microsoft.
- **Storage Management**
  - Physically **larger hard drive consumes more power** than physically smaller hard drives e.g. 2.5 inches form factor. The larger moving parts may result into higher consumption of power and bigger amount of heat generated.
- **Video card**
  - A **fast GPU** can act like a **most power-hungry** component as compared to the other ones.
  - For efficient power reduction there are a few options available for example:
    - **Say "no"** to video card - Desktop sharing software or a shared terminal can provide the display.
    - **Motherboard video output** – Requires low power but the user has to compromise on 3D performance.
    - The GPU should be **selected on the basis of performance** per watt.

GREEN COMPUTING: SCOOP ON POWER

- Display
  - The power consumption is generally **higher for CRT** monitors and lower for **LCD monitors**.
  - The light emitting diodes (**LED**) use less amount of electricity as compared to the fluorescent bulbs.
- Computer multitasking
  - Multitasking is the **process of executing multiple tasks** while sharing the same set of actual resources at one time.
- Parallel Processing in Computers
  - Parallel processing is the **process of executing a task or more than one task** using multiple processors.
  - Parallel processing is used to optimize the speed as each task is being processed without interfering each other.
- Software Pipeline
  - A pipeline is a **sequence of processing elements** in which the output of one element serves as the input of next element.
  - The information between these elements is conveyed in the form of bits, bytes or records.

GREEN IT STRATEGIES

- Green strategies outline a **long-term and unified approach** of an organization toward environmental responsibility.
- The green strategic approach considers both **internal and external organizational characteristics**, including its **structure**, **dynamics**, **macroeconomic incentives**, **compliance constraints**, and the need to align **corporate social responsibility** with mainstream corporate business.
  - Example, incorporating **RFID** tags in the supply chain will not only help the organization manage its inventories better, but will also open up **opportunities to reduce its carbon footprint due to reduced material wastage.**

GREEN IT STRATEGIES

- Drivers
- Dimensions
- Goals

GREEN IT STRATEGIES: DRIVERS

- Green IT is the systematic application of practices that enable the **minimization of the environmental impact** of IT.
- Maximize efficiency and allow for company-wide **emission reductions** based on technology innovations.
- Green IT is supposed to significantly **decrease the environmental footprint** of the IT industry and to foster environmental innovations in other industry sectors.
- The most important driver for the implementation of Green IT measures is the **reduction of operational costs**.

GREEN IT STRATEGIES: DRIVERS

- The three primary green IT drivers
  1. Reducing operational costs
  2. Being socially responsible
  3. Complying with government regulations

Drivers	Not Important 1	Somewhat Important 2	Important 3	Very Important 4	Rating Average
Reducing operational costs (e.g., energy use).	5%	13%	40%	**42%**	3.2
Socially responsible thing to do.	6%	15%	**43%**	36%	3.1
Government regulations.	8%	17%	35%	**40%**	3.1
Meet organization's overall green initiatives.	12%	19%	**44%**	26%	2.8
Actions of competitors.	28%	29%	**30%**	13%	2.3

GREEN IT STRATEGIES: DRIVERS

Motivation	Driver	Source
Economic opportunities	a) Cost savings b) Revenue growth c) Prevent resource restrictions d) Risk reduction e) Innovation f) Repositioning	Accenture (2009); Bansal & Roth (2000); e-Server-Consortium (2009); Harmon & Auseklis (2009); Hart & Milstein (2003); Info-Tech (2009); Skinner (2009); Zarnekow et al. (2009); Zarrella (2008)
Stakeholder pressure	g) Emission and waste reduction h) Reputation i) Media attention	Accenture (2009); Bansal & Roth (2000); e-Server-Consortium (2009); Esty & Winston (2009); Hart & Milstein (2003); Info-Tech (2009); Nunn (2007); Zarnekow et al. (2009); Zarrella (2008)
Legislation	j) Regulatory compliance k) Legitimacy	Esty & Winston (2009); Harmon & Auseklis (2009); Hart & Milstein (2003); Info-Tech (2009); Zarrella (2008)
Ethical motives	l) Corporate citizenship m)Top management n) Company values	Bansal & Roth (2000); Nunn (2007); Zarrella (2008)

Overview of drivers of Green IT initiatives

GREEN IT STRATEGIES: DIMENSION

- Strategy implies **choice**, **priority**, and **focus** and comes along with trade-off decisions.
- The environmental strategies are subdivided into two dimensions:
  1. **Competitive Advantage dimension**
     - Firms can either pursuit a **low-cost strategy** by **reducing their operational costs through environmental initiatives**, or they can strive for competitive differentiation based on a superior, sustainability-related value proposition.
  2. **Competitive focus dimension**
     - Determines whether the environmental investments are **targeted at internal organisational processes** or at **market-oriented products** and **services**.

GREEN IT STRATEGIES: DIMENSION

		Competitive focus	
		Organisational processes	Products and services
Competitive advantage	Low-cost	*Eco-efficiency*	*Environmental cost leadership*
	Differentiation	*Beyond compliance leadership*	*Eco-branding*

Generic competitive environmental strategies

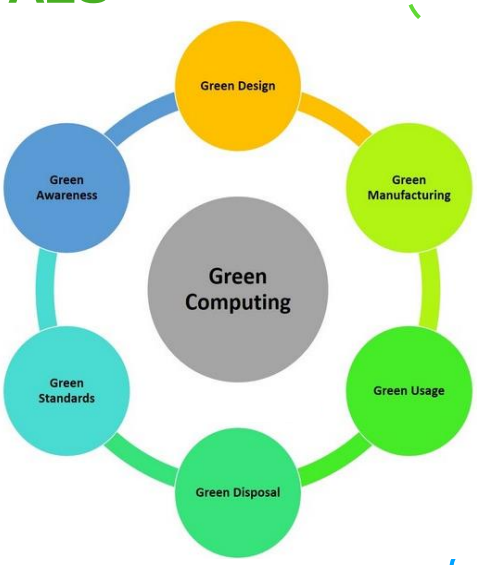
- The **eco-efficiency** strategy aims at the **minimization of waste**, by-products and emissions. In this way, the production efficiency can be enhanced and costs can be reduced.
- Although initiatives that allow for a **reduction of the environmental footprint** and simultaneously come along with cost savings are attractive for virtually every firm, this strategy proves to be particularly appropriate for mass volume producers with intense industrial processing.
- The **beyond compliance leadership strategy** concentrates on **organisational processes** as well, but the competitive advantage is rooted in differentiation rather than in cost reductions.

GREEN IT STRATEGIES: GOALS

- Green IT strategic planning includes due considerations to the **business goals** of the organization, its **demographic characteristics**, its **existing approach** in the context of Green IT as also its **maturity** in terms of Green IT.
- The philosophy behind a green strategy can be
  - **risk, associated with growth;**
  - **social, non-profit;**
  - **careless, without any strategy; and**
  - **the lean-intelligent, balanced one**

GREEN IT STRATEGIES: GOALS

- Two viewpoints need to be treated together.
  1. One is **not exclusive to the other**, although both, in their own right, provide a major insight into the market-driven economies that most of the world is now used to.
  2. Second viewpoint underscores the need for **intelligent utilization of environmental capital** in a way that will result in production of wealth capital.



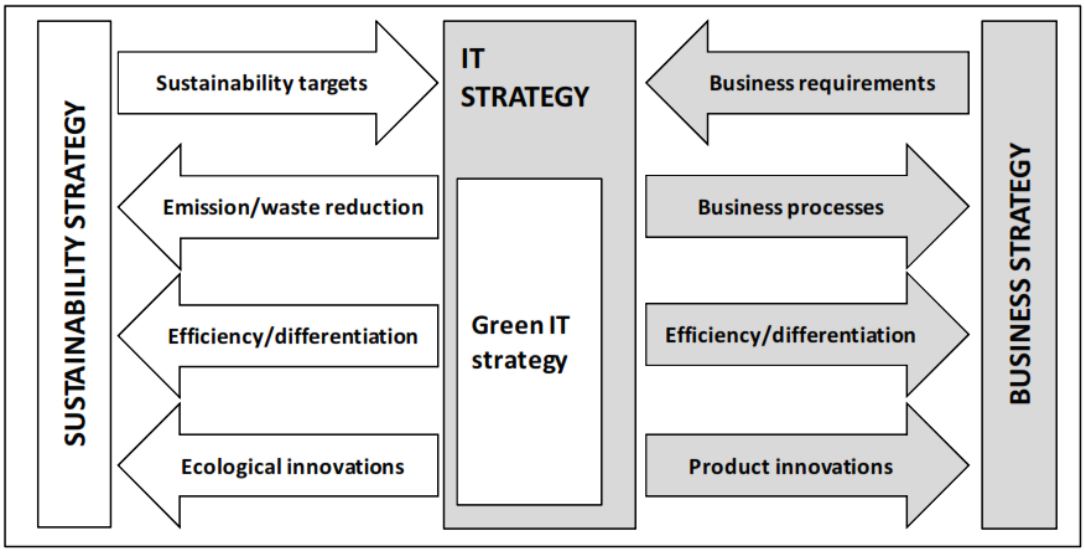
GREEN IT STRATEGIES: GOALS

- IT energy use and whether they set **measurable green IT goals.**
  - (e.g., reduce electrical usage by 25 percent over the next three years).

Does Your Organization Have Measurable Green IT Goals?	
Options	**Percent**
Yes — measurable green IT goals.	15%
We have broad green IT goals, but not specific numbers.	27%
No.	56%

Does Your Organization Monitor IT-related Energy Spending?	
Options	**Percent**
Yes.	36%
No, but we plan to in the near future.	14%
No.	50%

GREEN IT STRATEGIES



ENVIRONMENTALLY RESPONSIBLE BUSINESS: POLICIES

10 Ways to Encourage an Environmentally Responsible Business

1. Implement a recycling program
2. Conserve energy within the office
3. Promote a paperless office
4. Support green vendors
5. Reduce by reusing
6. Invest in office plants
7. Conserve human energy
8. Encourage sustainable transportation
9. Get outside and volunteer
10. Make green thinking a key part of your company culture

ENVIRONMENTALLY RESPONSIBLE BUSINESS: PRACTICES

1. Solar power
2. Encourage a minimalist company culture
3. Grass roofs for insulation
4. Go paperless or use recycled paper
5. Compost bins
6. Cycle to work schemes
7. Endorse remote working
8. Avoid using plastic cutlery
9. Switch your search engine (eg: https://www.ecosia.org/ *Plants a tree for every 45 search*)

ENVIRONMENTALLY RESPONSIBLE BUSINESS: MATRICS

ENVIRONMENTALLY RESPONSIBLE BUSINESS: MATRICS

- Environmental metrics are designed to assess the environmental impact of technology or activity. Such impacts are primarily related to **using natural resources** (lifecycle INPUTS) and generating waste and emissions (lifecycle OUTPUTS).
- The ultimate sustainability goal is to minimize the environmental impacts due to using **non-renewable resources** and **minimizing waste and pollution**.
- Since the complete elimination of these impacts is hardly possible (any technology has its environmental costs!), it is also important to **evaluate the rate at which environment can absorb** the impacts and become remediated.

ENVIRONMENTALLY RESPONSIBLE BUSINESS: MATRICS

Metric	Units*	What it measures
Water use	m^3	Amount of water consumed in the process of extraction, processing, manufacturing, maintenance and use of the product
Land use	acre	Land area required (not available for other needs) for extraction, processing, manufacturing, use, and disposal of the product
Embodied energy (Live energy)	J	Sum of all energy inputs to produce the product. This metric may include both technological and natural transformations.
Total lifecycle energy	J	Sum of all energy spent to produce the product, extract and process the initial materials, use the product, and dispose off the waste

Environmental metrics related to lifecycle inputs

ENVIRONMENTALLY RESPONSIBLE BUSINESS: MATRICS

Metric	Units	What it measures
Global Warming Potential (GWP)	$kgCO_2$	Contribution to global warming due to emissions of greenhouse gases to the atmosphere
Ozone Depletion Potential (ODP)	kgCFC11	Contribution to stratospheric ozone layer depletion
Water/Soil Acidification Potential (AP)	kgSO2	Contribution to acidification of soils and water due to the release of gases such as nitrogen oxides and sulfur oxides
Smog / Tropospheric Ozone Creation Potential (SCP)	$kgNO_2$	Contribution to air pollution, creation of tropospheric ozone (smog) by releasing nitrogen oxides and particulates
Eutrophication Potential (EP)	kg N	Enrichment of the aquatic ecosystems with nutritional elements (nitrogen or phosphorus)
Human Toxicity Potential (HTP)	1,4-DCB	Impact on humans of toxic substances emitted to the environment (health / cancer /non-cancer impacts)

Environmental metrics related to lifecycle outputs

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