PREFACE

UNIT I - FUNDAMENTALS

This unit introduces the notion of Green Computing with its motivation. This also speaks about the necessity of Green IT in imparting sustainable environment. The unit mainly focus on changing the perspective of the industries by including Green IT asone of their business strategic policy. A briefing about the metrics to quantify the intensity of greening is also discussed here.

UNIT II - GREEN ASSETS AND MODELING

This unit briefs about the assets of Green IT. The transformation process from conventional IT to Green IT at various operational levels are discussed elaborately in this unit. Green architecture, design and development of models for implementing greenness and external factors like supply chain management are also focused.

UNIT III - GRID FRAMEWORK

This unit speaks about the benefits of virtualization and its impact on Green IT. A brief discussion on the utilities, communication and other amenities in an industry which tends to contribute to carbon emissions are explained here. Green data centre and the Green Grid framework and best practices to achieve Green IT are explained in this unit.

UNIT IV - GREEN COMPLIANCE

This unit deals about the public perception of Green IT, various compliance standards, protocols etc. The Green IT's audit process is given a special mention. The later part of the unit discuss the technologies and the future roadmap to achieve Green IT.

UNIT V - CASE STUDIES

This unit starts with Environmentally Responsible Business Strategies. Various case studies and a detailed description about each scenario such as hospital, packaging industry and telecom industry is given in this unit.

SYLLABUS

CS8078-GREEN COMPUTING

UNIT I - FUNDAMENTALS 9

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.

UNIT II - GREEN ASSETS AND MODELING 9

Green Assets: Buildings, Data Centres, Networks, and Devices – Green Business Process Management: Modeling, Optimization, and Collaboration – Green Enterprise Architecture – Environmental Intelligence – Green Supply Chains – Green Information Systems: Design and Development Models.

UNIT III - GRID FRAMEWORK 9

Virtualization of IT systems – Role of electric utilities, Telecommuting, teleconferencing and teleporting – Materials recycling – Best ways for Green PC – Green Data centre – Green Grid framework.

UNIT IV - GREEN COMPLIANCE 9

Socio-cultural aspects of Green IT – Green Enterprise Transformation Roadmap – Green Compliance: Protocols, Standards, and Audits – Emergent Carbon Issues: Technologies and Future.

UNIT V - CASE STUDIES 9

The Environmentally Responsible Business Strategies (ERBS) – Case Study Scenarios for Trial Runs – Case Studies – Applying Green IT Strategies and Applications to a Home, Hospital, Packaging Industry and Telecom Sector.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Bhuvan Unhelkar, ―Green IT Strategies and Applications-Using Environmental Intelligence, CRC Press, June 2014.

2. Woody Leonhard, Katherine Murray, ―Green Home computing for dummies, August 2012.

REFERENCES:

1. Alin Gales, Michael Schaefer, Mike Ebbers, ―GreenData Centre: steps for the Journey, Shroff/IBM rebook, 2011.

2. John Lamb, ―The Greening of IT, Pearson Education, 2009.

3. Jason Harris, ―Green Computing and Green IT- Best Practices on regulations & industry, Lulu.com, 2008

4. Carl speshocky, ―Empowering Green Initiatives with IT, John Wiley & Sons, 2010.

5. Wu Chun Feng (editor), ―Green computing: Large Scale energy efficiency, CRC Press

CONTENTS

Unit-1

FUNDAMENTALS

1.1 GREEN IT FUNDAMENTALS: BUSINESS, IT, AND THE ENVIRONMENT

What is Green IT?

Green IT is learning and preparation of manufacturing, designing, consuming and ordering of computers, servers, storage devices and other peripheral devices commendably and competently with minimal or no impact on environment. In other words Green IT is the branch of study that aims at using computers and its associated resources effectively.

Green IT is composed of dimensions of environmental support, the economics of energy efficiency and the total cost of disposal and recycling of the same.

History of Green Computing/ Green IT

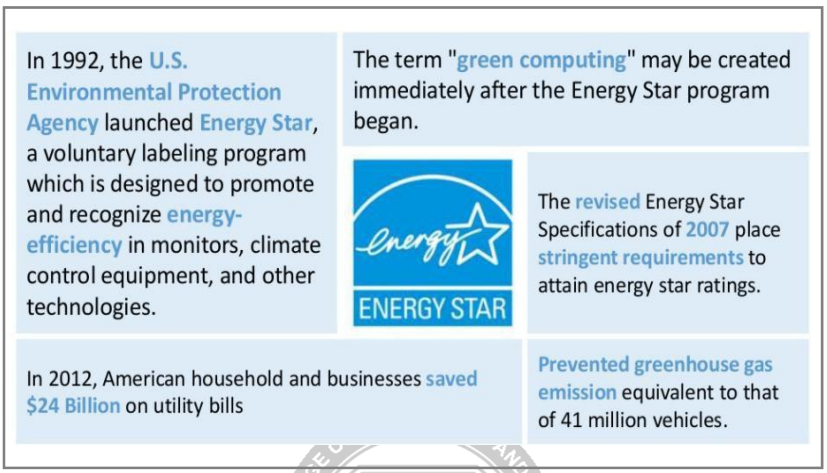

Figure 1.1 – History of Green IT

A brief history of Green IT is provided in the Figure 1 shown above.

How Computing Harm Environment

- Cost of Spam
  - Trillions of spam messages since 2014
  - 0.3 grams of carbon dioxide per message
  - Annual spam energy usage accounts to terawatts which is equivalent to the electricity usage in 2.4 million homes per year.
- Carbon dioxide emitted by device in sleep mode is equal to $1/7^{th}$ of the CO_2 emitted by an automobile.
- Increase in power, cooling and space for storage of data in data centre

- Hazardous materials inside computers like cadmium – damage kidneys, Mercury – neurological damage, Lead – disrupt brain neurotransmitters.

Need of Green IT

- Carbon efficiency is considered one of the major reasons behind efficiency and effectiveness of any organization.
- Reducing carbon consumption reduces the cost is the promising condition for achieving the mantra of Lean Organization is the one that looks for increasing value by reducing cost.
- Green IT aims at attaining the goal of reduced cost by adapting right individual attitude and working life style, thus reframing the rules and regulations of business.
- The need to Green and sustainable ICT is required to collaborate technologists, developers, politicians, researchers and consumers.
- The focus on climate change is also a reason for the development of Green IT.
- The need for an environmentally-efficient business.
- The rising cost over the past year in manufacturing/ production house and in consumer end in case of computers.
- Greenhouse gases and increase in legislation surrounding energy efficiency as well as toxic materials

Green IT Vision

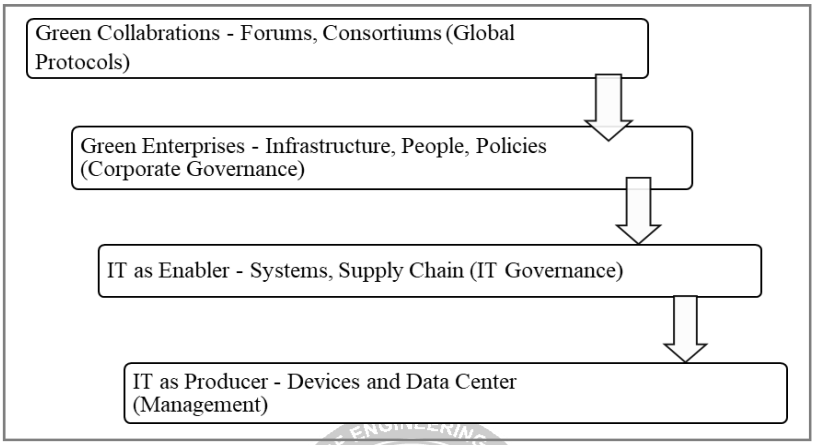

Figure 1.2 – Green Enterprises a vision beyond Green IT

The above figure shows the four stages of a complete Green It vision of an enterprises. They are as follows:

- **IT as a producer** – This addresses the emission produced by the gadgets, it is based on end user as well as from data centres.
- **IT as an Enabler** – Reduction of carbon emission in all areas of the enterprises, the IT governance also plays a major role in controlling the purchase and disposal of the equipment.
- **Green Enterprise** – Deals with infrastructure and buildings, people and their attitude, legal and standards as well as manufacture and sales.
- **Green Collaboration** – Collaboration of all enterprises that belong to a single market vertical.

The major aim of Green Computing is

- To reduce the use of hazardous materials so as to improve the climate change and help preserve nature.
- Maximize energy efficiency during the product's lifetime.
- Promote the recyclability or biodegradability of defunct products and factory waste.
- Computing cost reduction
- Reliability of power – energy efficient systems are in high demand to meet the energy demand as well preserve healthy power supply.
- Save amount spent on power, components and devices.

Approaches to Green Computing

In order to gain the environmental sustainability and efficient use of energy through computing there are four main paths to be taken.

Green Use – Using the computers and other related products in an efficient manner where the energy consumption is minimized.

Green Disposal – Reusing old computers, properly disposing and recycling other unwanted products.

Green Design – Designing energy efficient and environmentally friendly computers and accessories.

Green Manufacturing – Manufacturing computers and other related equipment in a way that they have a minimal effect to the environment.

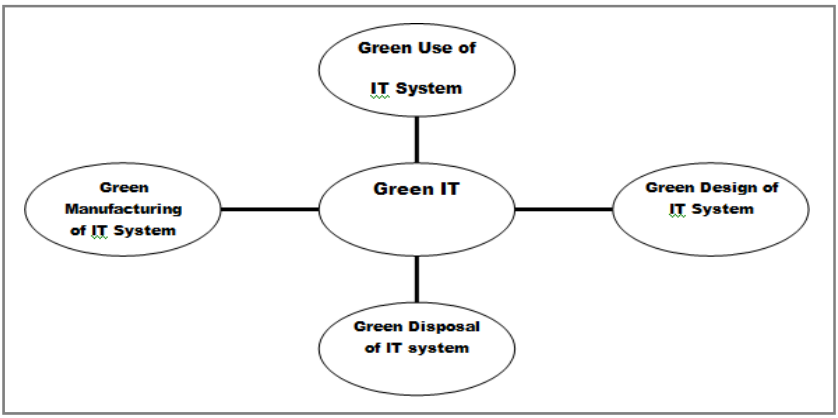

Figure 1.3 – Path way to Green IT

How to apply Green IT in any Organization

Green IT isn't just about energy efficiencies but also about operational efficiencies that can improve the organization. In most of the organizations, Green IT is practiced because of the explicit business drivers such as cost and the availability of the energy, cost of the equipments, cost of the data centres, business process optimization and performance and efficiency. When focusing on business optimization, few areas can be targeted which energy demand can be reduced and growth can be increased with the help of IT.

- Reducing environmental waste
- Improving energy efficiency
- Green IT purchasing

Reducing Environmental Waste

- By reducing office waste in the form electronic components and how to dispose them.

- The old desktop or laptops in office could be used to replace parts needed for hardware repairs or could be donated to families who can use them thus keep them out of landfills.

Improving Energy Efficiency

- This could be achieved in any IT sector by encouraging energy consumption thus company money is also saved to large extent
- The computers which are left turned on in any IT sector for a year, emits carbon which equal emission produced by over 2,000 cars a day.
- The use of standby mode or hibernate mode could also enhance energy consumption.

Green IT Purchasing

- By controlling purchase of new equipment.
- By choosing LCD monitors which uses less energy.
- By choosing Laptop or tablets over desktop which consumes more power.
- By purchasing devices which goes to standby or hibernation mode when not in use.
- Paperless system.

The execution of Green IT approaches in any business environment is based on various stages of complexity with in department and user clusters. The entire business organization is divided into many small chunks and then the approaches are applied. Green IT is not for a specific department or level or complexity rather it is for entire organization. An individual

chuck can become Green by applying its own strategy to attain that state.

Ways to Adopt Green IT

How are some companies addressing green IT?

Printing: this is a movement which involves the use of low- VOC inks, recycled paper, energy-efficient printers, re manufactured toner cartridges & ink cartridges, paperless data distribution, and implementing a pull printing system.

Supply Chains: Companies are altering their supply chain and cutting ties with companies that do not adopt the same green IT goals and practices as them

Data Centres: Data centres are using massive amounts of electricity generated using fossil fuels. Companies recognizethis are looking for renewable energy sources to power data centres and maximize efficiency.

IT Department: The IT department is integral to the success of green IT due to their energy consumption, device management, and data collection.

Green Information Strategy

Under Green Information Strategy, the ways of managing and retaining information has been defined. The ways of collecting, classifying and archiving information are introduced in Green Information Strategy.

It involves several key steps:

- ❖ Understanding the requirements for information retention and availability.
- ❖ Determining infrastructure requirements.

- ❖ Conducting continual strategic planning to meet economic and business conditions and demand.
- ❖ Measuring progress and adjusting the strategies.

Information Lifecycle Management is a set of concepts which helps organizations to build processes and implement best practices for creating, storing, archiving, and dispose data. A variety of technologies and methodologies can be used in order to optimize the storage utilization. Then the amount of storage required and the energy used to power will be reduced.

Green Computing Strategies Points

- ✸ Minimizing energy Consumption
- ✸ Purchasing green energy
- ✸ Reducing the paper and other consumables used
- ✸ Minimizing equipment disposal requirements
- ✸ Reducing travel requirements for employees/customers

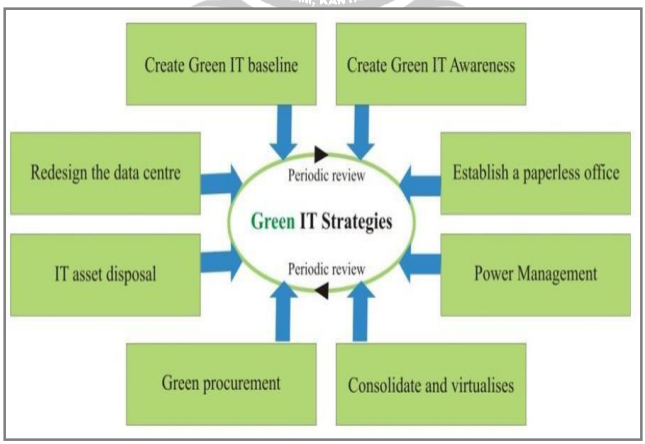

Figure 1.4 Green IT strategies to reduce the carbon emission in IT sectors

Green Value

- Green value is the overall value consumer's gain by using green products and services.
- Green value is the sum of the financial, environmental, social, information and functional benefits thata green product or service can provide to the consumers.
- Consumers evaluate offerings based on these benefitsand form positive or negative attitudes.
- Cost savings is one of the major reasons why green IT has taken off among large organizations.
- Spending reductions on equipment, energy, and even tax breaks and other financial incentives make green computing that much more practical and attractive for companies to adopt.
- Regulations established to address climate change have forced businesses to change their ways and become environmentally friendly.
- As a result, new economic opportunities exist.Companies can enter the market and grow revenue and job growth by supplying or servicing energy efficient equipment, or developing green technology, just as a fewexamples.
- In addition, it's no surprise that green IT is just good PR for companies. Customers and stakeholders care about the environment and the effects of global warming, so companies that are demonstrating good initiative in this area are showing they are responsive and taking action.

Green IT: An Opportunity

- The opportunities presented by Green IT are to reduce carbon emissions, for example in the transportation area.
- The use of smart automation and driving, real-time traffic alerts, and the Green IT-enabled logistics systems,helps to decrease total mileage and the amount of fuel essential to transport people and goods.
- Online maps available in mobile with real-time traffic data enables to optimize routing decisions, reduce fuel consumption, and lower emissions.
- The adoption of telecommuting and video conferencing eliminates transportation requirements.
- All of these subsidise to discounts in energy use and, reductions in GHG (Green House Gas) emissions while offering convenience and other benefits.
- A universal and neutral valuation reveals that even if one feels burdened with 'go green' initiatives and demands, it is better to adopt them in the interest of several opportunities and benefits it offers to the businesses, the society and to the planet.
- Smart companies are adopting an environmental strategy to innovate, create value and build a competitive advantage.
- Greening of – and by – IT will soon be necessities – not options.
- Green initiatives are becoming a key agenda for many enterprises, and enterprises need to develop and

implement the green IT strategy that is aligned with their business strategy and goals.

Roadblocks to adopting green IT

- Resistance to change, apathy, and competing priorities are universal problems. However, they can be overcome through education and leadership.
- The data needed to make informed decisions around green IT initiatives is often fragmented and must be collected and analyzed from a holistic point of view.
- Manual data collection makes it difficult to piece together a complete picture of a business's carbon footprint.
- Lack of robust metrics and measurements across all dimensions of an organizations.
- Lack of availabilities of substantial support in usage of Green IT.
- Uncertainty in terms of the scopes of the emissions to be included in the calculations.
- Technologies like virtualizations, thin clients and cloud computing are implemented in organizations, but not for improving its environmental performances.
- Non recognition of inefficient businesses processes and lack of corresponding business process management.
- Disposal of Electronic wastes.
- Equipment Life Cycle management – Cradle of Grave.

Practical Applications of Green IT

- Product Longevity – reuse part of the disposed devices.
- Algorithmic Efficiency – Reduces computer resources for computing function
- Resource Allocation - by reducing routing traffic and moving data to centralized location for easy access latter from anywhere.
- Virtualization – virtual machine are powerful system, which reduces power consumption.

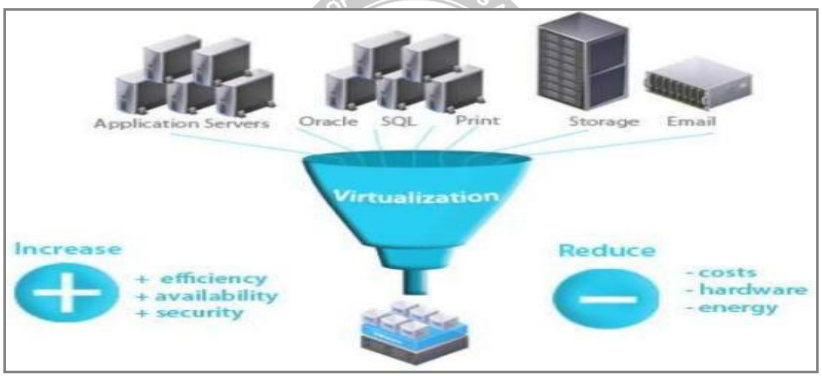

Figure 1.5 –Depicts Virtualization

- Terminal Servers – end users make all computation in central servers thus cutting down cost through computation
- Power Management – by using advanced power management techniques like ACPI allows operating system to directly control the power saving aspects of underlying hardware.

- Power supply – by purchasing and using products with energy star certificate.
- Data Centre – by improving inefficient cooling systems in data centres.
- Video Card – Use of shared terminal or desktop forsharing software when display required, Usemotherboard video output for reducing power consumption and by reusing older video card that uses less power.

Recent and Future Implementation of Green Computing

Recyclable paper laptop - One of the most environment friendly computers are Recyclable Paper Laptop. These laptop is manufactured using paper pulp or recycled materials packed in layers.

IMEC Laptop – These are powered by solar energy.

Life book Leaf multipurpose laptop – These gadgets uses OLED touch screen which could be folded like a laptop, whose exterior are carved out of polycarbonate a sensitive and shatterproof.

LOOP and EVO PC concept – These are devices that uses less carbon foot print.

Zonbu Computer – Consumes 1/3rd of power of light bulb with Linux OS.

Fit – PC draws only 5 watts which is typically less than the traditional PC consumes.