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

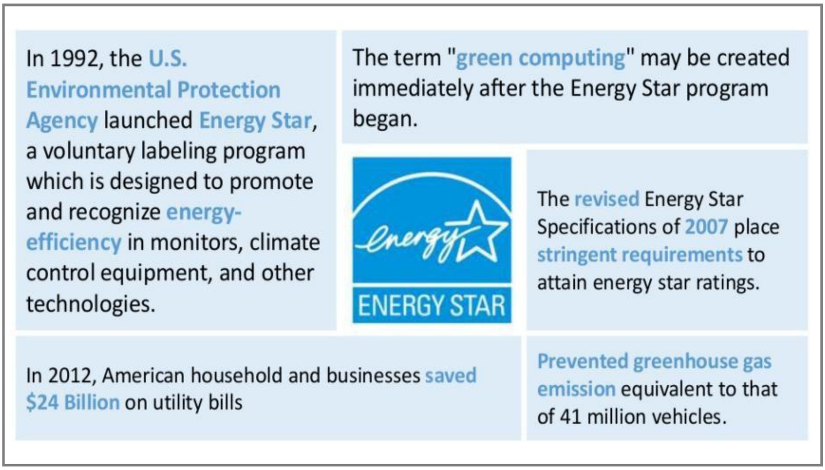


Figure 1.1 – History of Green IT

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 1/7th 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

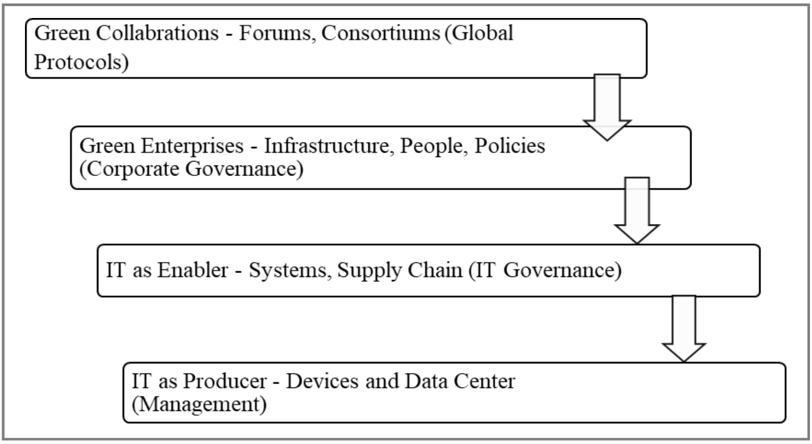


Figure 1.2 – Green Enterprises a vision beyond Green IT

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.

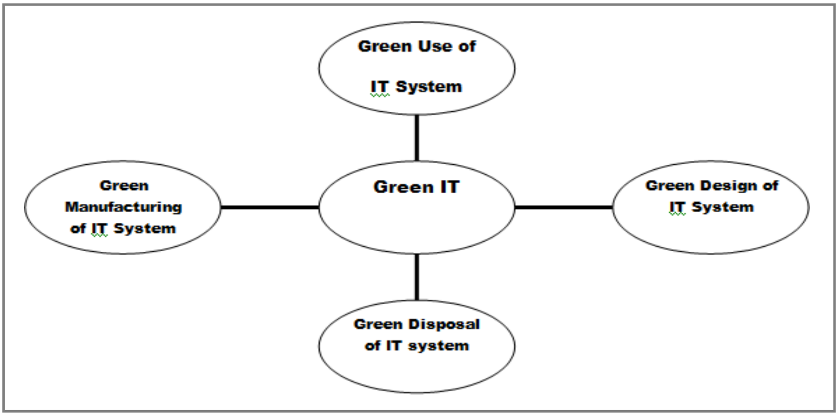


Figure 1.3 – Path way to Green IT

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

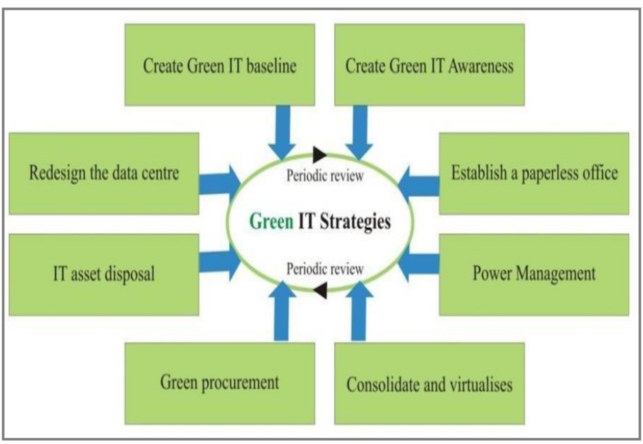


Figure 1.4 Green IT strategies to reduce the carbon emission in IT sectors

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.

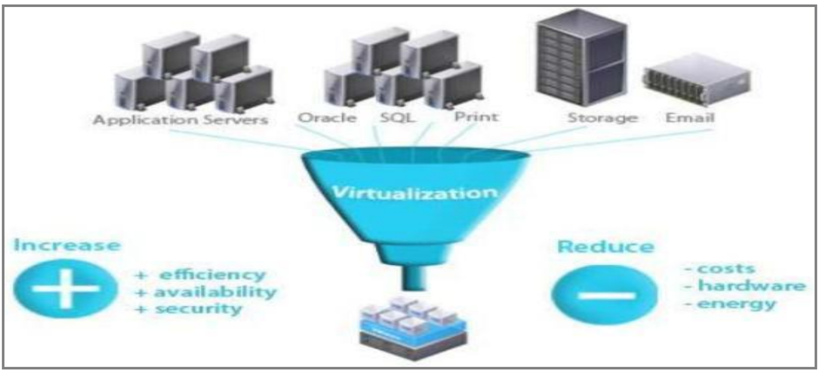


Figure 1.5 –Depicts Virtualization

- ❖ 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.

Unit-2

GREEN ASSETS AND MODELING

2.1 GREEN ASSETS

The green assets and infrastructure comprise substantial part of that long-term approach to managing the carbon performance of the organization. The three major phases or activities associated with the lifecycle of these assets is depicted: the way they are established or procured, the manner in which they are operated or run, and eventually the strategies for their disposal or demolishment. The assets made up of building, data centre, devices and vehicles. The three major activities relating to infrastructure assets has the following carbon repercussions:

Establish (Procure) - deals with the green credentials of the asset in terms of its design and development. For example, the original design of a car engine or a mobile phone that makeit carbon efficient.

Operate (Run) – deals with total carbon contribution of the organization by means of operation of assets.

Dispose(Demolish) – deals with the eventual phase of an asset and impacts the overall carbon footprint of an organization.

Figure 1: Green assets need to be organized in an efficient way throughout their lifecycle.

Types of Assets	Impact on Environment
Buildings and Facilities	Long-term impact as major environmental considerations should be during architecture and construction. Purpose of buildings, people movements, geographical locations (weather), and durability of the building impact their overall carbon contribution.
Data Centre	This is a special purpose building to house data servers. In addition to the standard building considerations, the ratio between power usage by the servers versus the rest of the power is a popular environmental consideration
Devices	Design, development, procurement, operation, and usage of devices is considered here.
Vehicles	Direct fuel emissions, pollution level of the type of fuel, design of the engines, and so on. Procurement, operations and disposal activities apply to vehicles used by the organization

Table 1: Types of Assets (Categories) and Their Impact on the Environment

2.1.1 Green Building

–Green‖ Buildings are high performance structures that also meet certain standards for reducing natural resource consumption.

–Green‖ or –Sustainable‖ buildings are characterized by:

- ❖ efficient management of energy and water resources
- ❖ management of material resources and waste
- ❖ restoration and protection of environmental quality
- ❖ enhancement and protection of health and indoor environmental quality
- ❖ reinforcement of natural systems
- ❖ analysis of the life cycle costs and benefits of materials and methods
- ❖ integration of the design decision-making process

❖ –Metrics‖ for such –green‖ benefits are articulated and certified by LEED, BuiltGreen or other organizations

- ❖ Green standards measure different environmental qualities of buildings
- ❖ Each has a different emphasis and purpose

Green Building standards include:

- **Leadership in Energy and Environmental Design (LEED)**
- **Green Globes**
- **Model Green Homebuilding Guidelines**
- **BuiltGreen**
- **Energy Star**
- **Living Building**

Why go –Green‖?

Green makes business sense

- Increased flexibility to allow for longer building and TI useful life and reuse of materials
- Improved building performance
- Increased revenue (higher rents/sales price, improved productivity, fewer/shorter vacancies)
- Lower cost (utilities, costs of conversion)
- reduce carbon consumption,
- energy independence,
- encourage community,
- preserve natural systems

Table 2: rating Building features to environmental factors

Building Features	*Environmental Relevance*	*Comments and Actions*
Location	Use of geographically specific natural resources such as cool weather, natural sunlight.	Locating a data center in Iceland can reduce the cooling costs, effort and corresponding carbon.
Architecture and design	To maximize the use of available natural resources for the building.	Windows facing sunlight; cross-ventilation; air and water cooling of data centers.
Construction	Use of material (concrete, carpets, terracotta) to compliment the location and design to ensure that the material reduces wastage and maximizes natural resources.	Use terracotta roof instead of concrete.
Livability (occupancy)	People friendliness of the building/ facility that has health as well as aesthetic benefits.	Optimizes the way in which people use the facilities. A naturally lit, cheerful building will need less power.
Visibility	Promoting the physical building as a place of attraction adds marketing value, as also improved asset value.	Ivy's climbing on the walls. Terrace gardens.

Green IT Hardware

The Hardware aspect of Green IT deals with the design and architecture of IT hardware and the manner in which it is acquired and operated.

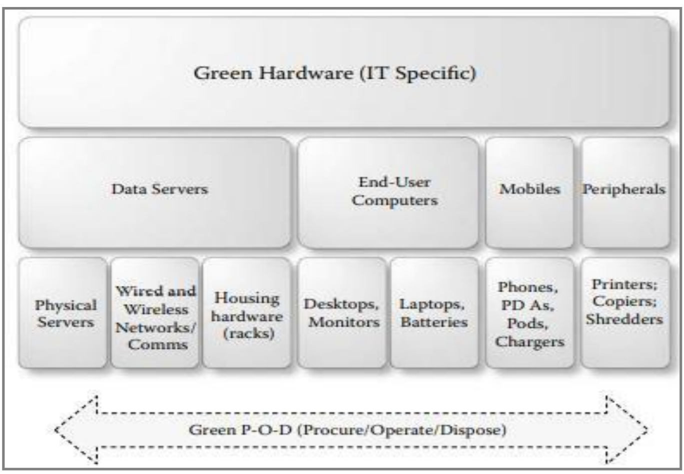


Figure 2: Range of Green IT hardware generating carbon

Following is a more detailed description of these IT hardware assets of an organization:

- **Data servers—** deals with the physical machines and the specific buildings in which they are housed. These servers also have both wired and wireless networks and corresponding communications equipment associated with them that are directly emitting carbon.

- **End-user computers—** laptops, desktops, their capacities, operational efficiencies, and their disposal (especially as the lifecycle of a computer is getting shorter by the day) need to be discussed from their P-O- D (Procurement – Operation – Disposal) viewpoint.

- **Mobile devices—** the mobile devices and associated hardware (e.g., extension leads), their batteries including the recharging mechanism and disposal of the batteries and the policies and actions when the devices become outdated (quickly).

- **Peripherals—** printers, photocopiers, shredders, and so on. These electronic gadgets are of immense interest in Green IT due to their large numbers, their potentially unnecessary overuse.

2.1.2 Green Data Centre

What is green Data Centre?

A green data centre is a repository for the storage, management and dissemination of data in which the mechanical, lighting, electrical and computer systems are designed for maximum energy efficiency and minimum environmental impact. These centres use more energy-efficient servers and most importantly the design technology to reduce energy demands for cooling and lighting.

Need for Data Centres:

1. Data centres are heavy consumer of energy, accounting for between 1.1% and 1.5% of the world‘s total energy usage in this decade. The Green data centres are energy efficient data centres that better utilize energy and increases performance.

2. Green Data centre reduces both operating costs and capital costs since they eliminate the need of additional power and cooling demands.

3. Green data centres reduces the technological impact on the environment and use of natural resources, thus helps environment to be sustainable.

4. They improve business by improving their corporate image and social image by meeting compliance and regulatory requirements.

5. They utilize resources such as office space, heat, light, electrical power etc, in an environmental friendly way.

Who are using Green data centres?

Steps to make a data centre Green.

- Turn off the dead servers and make few basic changes to existing data centres.
- Upgrade to energy-efficient servers.
- Switch to high-efficiency power supplies.
- Redesign cooling system
- Redesign air management
- Better environmental conditions are crucial for smooth running of data centre.

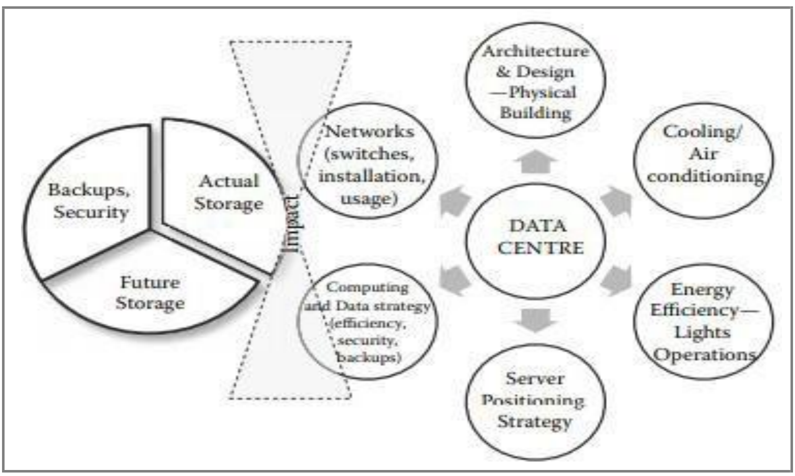


Figure 3 – Factors influencing Green data centre

Data Centre Building—Design, Layout, and Location

The challenges in handling data centres from carbon perspectives arises from the fact that the data centre buildings themselves are based on a ROI over 15–20 years.

Whereas the internal equipment, the data servers andother computing equipments themselves are usually Green Assets upgraded every 3 –5 years.

Therefore, the data centre building, together with thedata centre's non-ICT infrastructure, can quite easily consume more power than the equipment within it.

This is because of the architecture and design ofthe infrastructure and facilities that may not have kept up with the server technologies themselves.

Following are the specific design, layout, and location consideration for data centres.

- **Physical (geographical) location of the building.** This includes the weather patterns of the geographical region (such as warm or cold), proximity of the data centre building to water and air (for cooling) and the ease of access to the staff.

- **The building that houses the data centre**. This may be a dedicated stand-alone facility, or it may be purpose-built within a larger facility, or it may be retrofitted into existing premises. Whatever the case, there are a number of aspects of the built environment that will have an eff ect on power consumption, such as insulation.

- **The power supply**. Data centres usually have dedicated power supplies, and very often more than one. Ā ei r efficiency varies enormously. Data centres can also generate their own power, and backup power supplies are common for business continuity.

- **Cooling and lighting.** Modern ICT equipment typically demands significant a mounts of cooling, either air cooling or water cooling. There are many design and implementation issues that affect power consumption. Lighting is also a factor that maintains ambient temperature.

- **Server and storage virtualization**. This technology is meant to reduce power consumption as it reduces the overall number of devices; however, in practice the power consumption of data centres can rise as the virtualized servers may be more powerful and may use greater electricity.

- **Facilitation of new and emerging technologies**. The building of the data centre should be conducive to wireless communication, Cloud computing-related communication, and such best practices.

Data Centre ICT Equipment—Server Strategies

Servers are powerful computers that form a significant part of the IT assets of an organization. Increasingly these powerful servers provide the organization with the ability to access, provide, analyze, and store data, information, knowledge, and intelligence in myriad diff rent ways. As argued earlier, there is ever increasing demand for more powerful servers with increased storage and processing facilities. With more powerful processors and proliferating number of servers the power consumption continues to climb rapidly

Following are a list of green server strategy considerations that need to be expanded in detail in practice:

- Online, real-time list of server inventory that enables location and uses of the servers.
- Power consumption bill in real time—mapped to carbon generation that provides operational feedback to the entire organization.
- Bit to carbon ration as part of comprehensive—data strategy—that provides metrics on not only the used –bits‖ but also the carbon generated by the provisioned bits.
- Pue, DCiE—these popular metrics providingcomparative data over a length of time, as also across theindustry.
- Mirroring backup strategies that are balanced by the –acceptable risks‖ of the data centre director.
- Data capacity forecasting. Server capacities need to be estimated on a continuous basis as the business changes. The correlation between business change and growth,and corresponding data centre capacity, is ascertained based on statistical analysis, trend spotting, and estimating the impact of technological innovativeness.
- Carbon-cost visibility. Lack of visibility of server costs and particularly its mapping to individual or departmental use of space.
- Efficient decommissioning. Once the purpose of a server is consummated, there is a need for a formal yet quick way of decommissioning the server. Manual processes for decommissioning and lack of confidence of the data

centre director/manager can lead to servers lying around and consuming power for no apparent purpose.

- Incorporation right redundancy. Earlier discussion on bit-watt indicates the crucial need for optimum redundancy.
- Enhanced server distribution. Need to distribute, through proper assignment, the use of the data space across and between various departments/users. This would also enable server sharing between operational development and test environments.
- Incorporate server switching. Data servers should be capable of being switched from one type of usage to another (e.g., from test usage to production). This also enhance capacity sharing and peak load performance.
- Incorporate Cloud computing and server virtualization.

Data Servers Optimization

Optimization of servers deals primarily with the numbers, usage, and collaborations amongst the servers.

This data server optimization can be improved through better organization of the databases including their design, provisioning for redundancy, and improved capacity forecasting, following RDBMS (Relational Database Management Systems) standards such as data normalization and usage of proper data types within database as and when required.

It is worth noting that the cost associated with cooling of servers is much more than the initial cost of procurement and installation of the hardware.

Furthermore, power consumption of the servers themselves is rapidly increasing.

Therefore, the costs associated with the cooling of the servers are equally on the rise.

There is a discrepancy between the advanced technologies used in the servers, the supporting rack level infrastructure of the data centre, and the lagging air conditioning and building infrastructure of the data centre.

Data centres are also heavily occupied and are stretched for their cooling capacity as these buildings are catering for far more sophisticated servers than they originally are designed for.

More techniques that could be considered by an organization for server optimization are described as follows:

- Undertake intense and iterative capacity planning for the data centre. This will involve management, anticipation, and optimization of storage capacities of the data centre.
- Undertake in-depth optimization through identification of unused capacity of servers and storage disks within them.
- Implement full storage virtualization that will enable hosting of multiple data warehouses on the same server. This will include conversion of existing physical servers to –virtual servers‖—partition servers that can operate in parallel without any interference.
- Efficient server operations. For example, a server that is on but idle would consume half the power it needs when

being used fully. Therefore, instead of operating multiple servers, some of which may be idling, optimization and management of servers will enable running of servers as closer to their maximum capacities.

- Efficient management of air-conditioning and cooling equipment that require, at times, even more power to cool the servers than required to operate them.
- Decommissioning servers once their service level agreement has expired.
- Applying virtualization during architecture and design of the servers, corresponding operating systems, and even applications. Enabling virtual servers easily will enable efficient capacity management and reduced hardware maintenance costs.
- Making use of infrastructural and hardware economies of scale. This can be achieved by implementing Cloud computing and making use of services or software services from an already existing repository. This will significantly reduce the amount of resources being used in order to provide a software solution or a result.

What is Virtualization?

- Virtualization is one of the hardware reducing, cost saving and energy saving technology that is rapidly transforming the IT landscape and changes the way people compute.
- On a server or a desktop PC, it allows multiple operating system and multiple applications to run on a single computer.

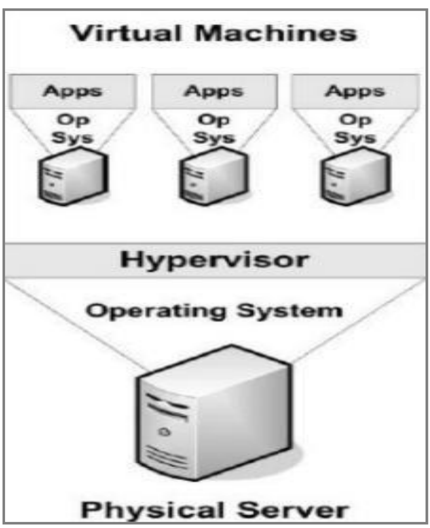
- The software that makes this possible is known as hypervisor.

Why green computing uses Virtualization?

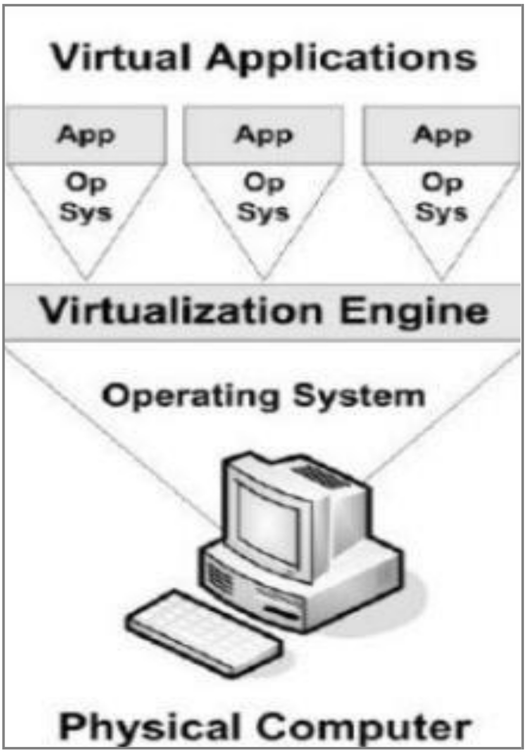
- **Decreased energy use–** reducing number of physical devices, the amount of energy required to operate the devices is decreased as well reduces the cooling system power requirement.
- **Reduction in toxic waste–** number of hardware devices are reduced so huge reduction in e-waste or toxic wastes.
- **Reduction in facility requirements–** decrease in number of system is directly proportional to reduced number of data centres.

Types of virtualization

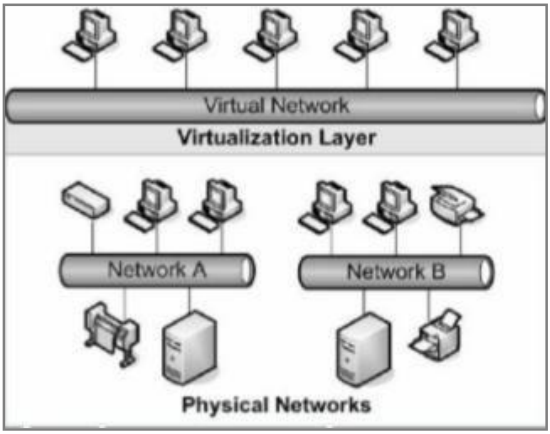
- **Server virtualization–** many servers run on single physical server. Helps decrease energy usage and provides more floor space.



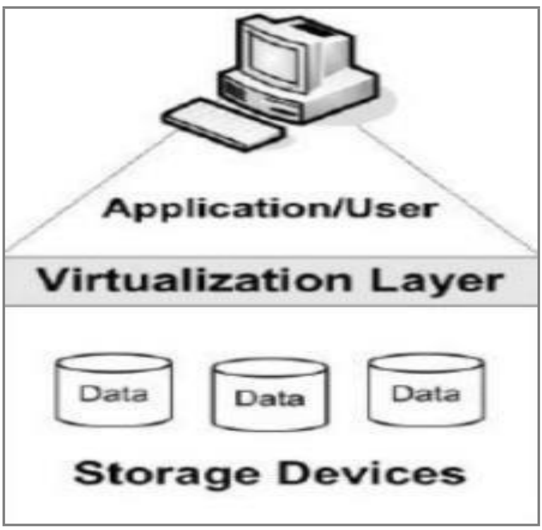
- **Application virtualization** – applications can be run independently of the underlying host operating system. Since no device drivers are installed can run application without administrative rights. Applications can be run from portable media, if not compatible can be executed on physical machine.



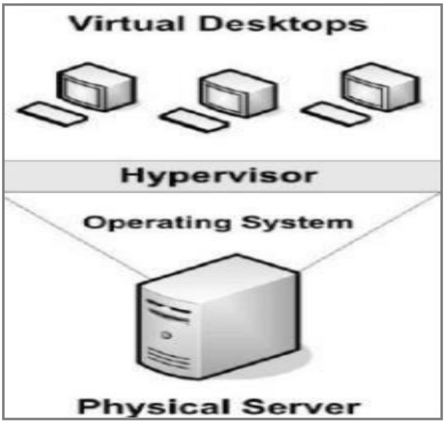
- **Network virtualization –** It allows us to combine all of the resources available on a network by splitting up the available bandwidth into independent channels. Consolidation of many physical networks into one virtual network. Partitioning of single physical network into many virtual networks is allowed.



* **Storage virtualization –** allows multiple storage devices to be combined as a one large storage device. Easier administration, monitoring of storage growth is possible.



* **Desktop virtualization –** allows virtual desktops to be centrally managed on a server and run by the end user on a thin client machine. Can access multiple monitors, USB devices, device recovery is simplified.



Green Assets – Devices

Sustainable steps by researcher

- Compaq EOS sustainable Desktop
  - Designed by Cody Stonerock, made of recycled aluminium & biodegradable resins by HP. Low cost PC with no screws or fasteners.
  - Monitor and other components are easily removed. Designed with fewer features with only basic computing power.

* Igglu modular PC concept
    * Looks like a book rack, updating is easy like replacing books in a shelf, since hard drives, PCI drivers, RAM etc. are placed like books in a book shelf.
    * Designed for maximum energy efficiency and resource usage.

* _Bento‘ Solar-powered concept computing system

- Batteries are powered by solar power, they come with integrated with solar panel and ITB hard drive.

- Sustainable Computer _Froot‘

- Bio degradable starch-based polymers constitute the _main frame‘ which are recyclable along with electrical components.
- High end-laser and projecting technology to beam a screen on the wall and keyboard.

- EVO PC concept

- This has two parts – First EVO client module which sits on the second part which is a docking unit for this module.
- Client has low processing power, low memory and low RAM.
- The client communicates with the server via broadband, thus server does the actual computation.
- The remote access comes with a cost, the client is recyclable and company provides a replacement.

Unit-3

GRID FRAMEWORK

3.1 Virtualization of IT systems

Virtualization is the latest in a long line of technical innovations designed to increase the level of system abstraction and enable IT users to harness ever-increasing levels of computer performance.

At its simplest level, virtualization allows you to have two or more computers, running two or more completely different environments, on one piece of hardware. For example, with virtualization, both Linux operating system and Microsoft Windows operating system can be used on one server.

In slightly more technical terms, virtualization essentially decouples users and applications from the specific hardware characteristics of the systems they use to perform computational tasks. This technology is likely to usher in an entirely new wave of hardware and software innovation. For example, and among other benefits, virtualization can simplify system upgrades (and in some cases may eliminate the need for such upgrades) by allowing users to capture the state of a virtual machine (VM), and then transporting that state in its entirety from an old to a new host system.

Virtualization is also designed to enable a generation of more energy-efficient computing. Processor, memory, and storage resources that today must be delivered in fixed amounts determined by real hardware system configurations will be delivered with finer granularity via dynamically tuned VMs.

What is a virtual machine (VM)?

In the simplest terms possible, a virtual machine (VM) is a virtual representation of a physical computer.

Virtualization allows an organization to create multiple virtual machines—each with their own operating system (OS) and applications—on a single physical machine.

A virtual machine can't interact directly with a physical computer.

Instead, it needs a lightweight software layer called a hypervisor to coordinate with the physical hardware upon which it runs.

What is a hypervisor?

The hypervisor is essential to virtualization—it's a thin software layer that allows multiple operating systems to run alongside each other and share the same physical computing resources.

These operating systems come as the aforementioned virtual machines (VMs)—virtual representations of a physical computer—and the hypervisor assigns each VM its own portion of the underlying computing power, memory, and storage.

This prevents the VMs from interfering with each other

The Benefits of Virtualization

Up to 80 percent greater utilization of every server.

Reductions in hardware requirements by a ratio of 10:1 or better.

Capital and operations expenses cut by half, with annual savings of more than $1,500 for each server virtualized.

Robust, affordable high availability.

How does Virtualization Help Green Computing?

Virtualization results in far more efficient use of resources, including energy.

Virtualization's purpose in a simple way is virtualize and make a single piece of hardware function as multiple parts.

Different user interfaces isolate different parts of the hardware, thereby making each one behave and function as an individual.

Installing virtual infrastructure allows several operating systems and applications to run on a lesser number of servers, helping to reduce the overall energy used for the data centre and for its cooling.

The energy saved per server would translate into approximately 7000 Kilo Watt hours per year, which is a tremendous potential for energy savings, Virtualization is the best to practice green computing, especially data centres.

3.1.1 Virtualisation can be classified into 3 categories, namely:-

Desktop Virtualisation

Server Virtualisation

Storage Virtualisation

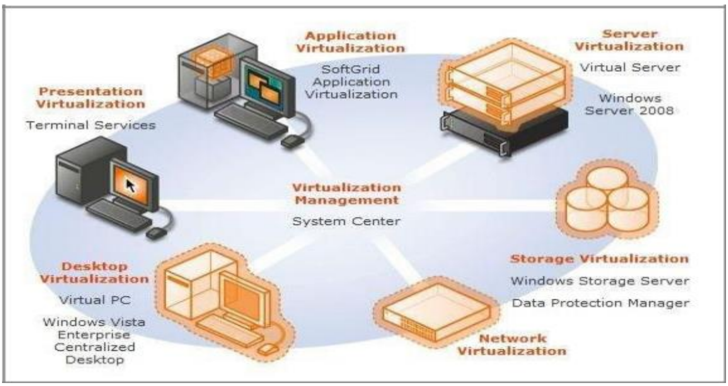


Figure 3.1 Virtualization Management

3.1.1.1 Desktop Virtualisation

Desktop virtualization, often called client virtualization, is a virtualization technology used to separate a computer desktop environment from the physical computer.

Desktop virtualization is considered a type of client-server computing model because the "virtualized" desktop is stored on a centralized, or remote, server and not the physical machine being virtualized.

Desktop virtualization "virtualizes desktop computers" and these virtual desktop environments are "served" to users on the network.

Another benefit of desktop virtualization is that is lets you remotely log in to access your desktop from any location.

Essential documents on Desktop Virtualisation

Managing the Desktop estate: the low risk route to desktop virtualisation

Ten Reasons to modernise the desktop

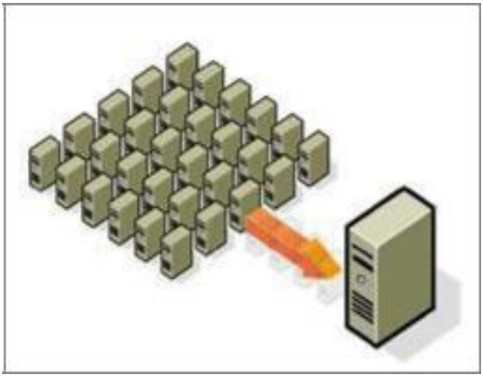
A Peer Survey: Desktop Virtualisation – Separating the Hype from Reality

The Next Generation Virtual Desktop Solution for Growing businesses

Best Practices for testing Desktop Virtualisation

Desktop Virtualisation: **A buyer's checklist**

3.1.1.2 Server Virtualisation



Server virtualization is the partitioning of a physical server into smaller virtual servers.

In server virtualization the resources of the server itself are hidden, or masked, from users, and software is used to divide the physical server into multiple virtual environments, called virtual or private servers.

One common usage of this technology is in Web servers. Virtual Web servers are a very popular way of providing low-cost web hosting services.

Instead of requiring a separate computer for each server, dozens of virtual servers can co-reside on the same computer.

Essential documents on Server Virtualisation

The Business Value Of Virtualization

The Future of Virtualization

Virtualizing Business-Critical Applications

Five Steps to Determine When to virtualise Your Servers

Benefitting from Server Virtualization - Beyond Initial Workload Consolidation

Getting the most out of virtualisation

User Survey Analysis: Next Steps for Server Virtualisation in the mid market.

3.1.1.3 Storage Virtualisation

Storage virtualization is the amalgamation of multiple network storage devices into what appears to be a single storage unit. Storage virtualization is often used in SAN (storage area network), a high-speed sub-network of shared storage devices.

The management of storage devices can be tedious and time-consuming. Storage virtualization helps the storage administrator perform the tasks of backup, archiving, and recovery more easily, and in less time, by disguising the actual complexity of the SAN.

Users can implement virtualization with software applications or by using hardware and software hybrid appliances.

The technology can be placed on different levels of a storage area network.

Essential documents on Storage Virtualisation

Learn about Storage virtualisation, its benefits and what it can mean for your business and storage infrastructure

Evaluating Storage Technologies For Virtual Server Environments

Storage Virtualisation- what to know and what to look for

Server and Storage Virtualization: A Complete Solution

3.6 GREEN DATA CENTRE

The demand for data centre capacity world wide has been on the rise. This has also lead to a steady increase in carbon emissions.

This is so because servers will not only handle greater volume but will also require greater processing.

Data centres house a suit of large computers and associated networks of the organization, forming the heart of most businesses.

Data servers can be seen as powerful computers that have the capacity to store as well as process vast amount of multiformatted data.

As Cloud computing makes rapid strides, data, in its myriad multimedia format will have to be stored and instantly made available upon request.

The business users need to store data endlessly and also comply with the legislations. The demand of storing and processing of data is unabating.

The businesses that particularly deal with contents have to improve their data centres through innovative strategies in data management.

The data management solutions need to be agile so as to cater to rapidly changing data needs.

Dynamic and agile data management implies ability to modify, update, backup, and mirror data even as the organizational needs of the data keep changing.

Innovation, together with disciplined operational management of the data centre is required. Costs and carbon emissions are also closely tied together in case of data centres.

3.6.1 Influencing factors of green data centres

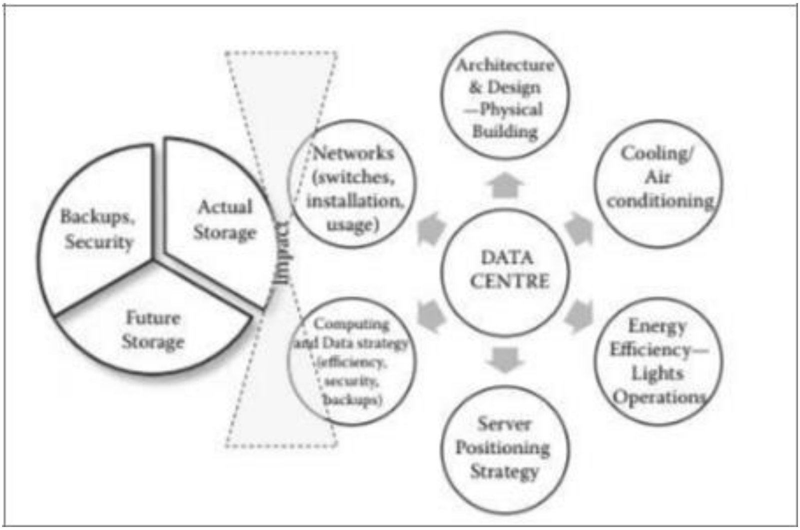


Fig 3.6: Influencing factors of Green data centre

Data centre design, layout, and location:

Physical building in which the data centre resides. This can be one building, or multiple buildings that house the machines but are themselves spread across geographical regions.

Architecture and design of the building, its geographical region and the material used in construction of the building are all valid considerations here.

The size and design of rooms in which servers are housed and also the location of the server rooms within the data centre can play a role in carbon reduction.

Cooling, air conditioning, power source and power consumption:

This includes the cooling strategies of the servers; and the air conditioning relating to the actual building.

This also includes use of green energy sources.

The impact of the physical location of the rooms to be cooled, that are housing the servers.

Power management:

This includes lights and operational aspect, number of people working, opening and closing of doors.

This would include procurement and installation of green products and use of green services.

Servers:

Their numbers, positioning and corresponding energy-efficient computing plays pivotal role.

Physical location of the racks, t heir positioning (hot isle/cold isle), architecture and the physical rooms in which they are placed are also important.

Design of each server—water cooled, air cooled, and other efficiencies are also to be considered.

Data strategy:

The main concerns here are including security and backup.

Virtualization within each server, and combined virtualization.

Organization of a cluster of servers—private cloud, Space storage and usage strategy.

Virtualization aims to pool resources together to deliver data centre services by pooling resources that may be otherwise underutilized.

Adopting virtualization strategies will foster the development of many virtualization architectures that will enhance the data centre energy efficiency.

Networks and communications equipment:

This made up of land-based as well as wireless communications such as switchgears, routers, and modems.

The numbers and capacities of these equipment in the data centre contribute to its carbon footprint.

3.6.2 Data Centre ICT Equipment—Server Strategies

They are housed within the green data centre and require specific strategies for positioning, cooling, and usage. Servers are powerful computers that form a significant part of the IT assets of an organization. Increasingly these powerful servers provide the organization with the ability to access, provide, analyze, and store data, information, knowledge, and intelligence in myriad different ways.

There is ever increasing demand for more powerful servers with increased storage and processing facilities. With more powerful processors and proliferating number of servers the power consumption continues to climb rapidly. Servers belong to the data centre manager who is responsible for providing a service to the rest of the organization rather than using it directly themselves.

The following are a list of green server strategy considerations:

Online, real-time list of server inventory that enables location and uses of the servers.

Power consumption bill in real time—mapped to carbon generation, that provides operational feedback to the entire organization.

Bit to carbon ration as part of comprehensive data **strategy that provides metrics on not only the used ―bits‖** but also the carbon generated by the provisioned bits.

Mirroring backup strategies that are balanced by the **―acceptable risks‖ of the data** centre director.

Data capacity forecasting: Server capacities need to be estimated on a continuous basis as the business changes. The correlation between business change and growth, and corresponding data centre capacity, is ascertained based on statistical analysis, trend spotting, and estimating the impact of technological innovativeness.

Carbon-cost visibility: Lack of visibility of server costs and particularly its mapping to individual or departmental use of space.

Efficient decommissioning: Once the purpose of a server is consummated, there is a need for a formal yet quick way of decommissioning the server.

Incorporation right redundancy

Enhanced server distribution: Need to distribute, through proper assignment, the use of the data space across and between various departments/users.

Incorporate server switching: Data servers should be capable of being switched from one type of usage to another.

Incorporate Cloud computing and server virtualization.

3.6.3 Data Strategy and the Carbon Emitting Bit

Data strategy encompasses the use, storage, mirroring, security, backups, clean ups, and architectures for data. It covers both external and internal approaches to data management. Data efficiency in relational database management systems includes use of techniques such as data normalization and incremental storage. Such practices enable creation of nonredundant and flexible data structures which tend to save data storage space when multiplied on a large scale. Using the correct data type would also affect the amount of data space that is being used in **every ―bit‖ of data. Every ―bit‖ adds to the carbon generation** from the data centre. Following are the impact of one extra bit in a data centre on the green performance of the organization:

Additional free s pace provisioning.

Speed and density.

Backup

Mirroring.

Quality and reliability.

Security.

Provisioning. Each bit requires provisioning for spare capacity, with corresponding need for spare room space, people and infrastructure.

[***1 bit + m b it (additional) leads to → 1.m bit × n w atts (direct energy need) → leads to nxp watts (support** energy-**infrastructure) influences → People (attitude)]***

In addition to the data server strategies discussed thus far, there is also a need to compliment those strategies with astute IT governances that ensure incremental improvements to the data centre performance. IT governance with additional focus on data centres help to manage the overall number of servers, their lifecycle and the underlying server virtualization strategies.

3.6.4 Data Servers Optimization

Optimization of servers deals primarily with the numbers, usage, and collaborations amongst the servers. This data server optimization can be improved through better organization of the databases including t heir design, provisioning for redundancy, and improved capacity forecasting.

Optimization also includes consolidation of various physical servers that would reduce their total numbers. Some of the techniques that could be considered by an organization for server optimization are:

Undertake intense and iterative capacity planning for the data centre.

Undertake in-depth optimization through identification of unused capacity of servers and storage disks within them.

Implement full storage virtualization that will enable hosting of multiple data warehouses on the same server.

Efficient server operations.

Efficient management of air-conditioning and cooling equipment that require, at times, even more power to cool the servers than required to operate them.

Decommissioning servers once their service level agreement has expired.

Applying virtualization during architecture and design of the servers, corresponding operating systems, and even applications.

Making use of infrastructural and hardware economies of scale.

Increasing B2B relation for a more common and efficient solution service

3.6.5 Data Servers Virtualization

Data server virtualization, as a key strategy, includes creation of many virtual servers from one physical server. Virtualization has been popular as an efficient hardware resource utilization; however, it also has significant impact on reducing carbon emissions. A rough virtualization, data centres can consolidate their physical server infrastructure as multiple virtual serversarehosted on lesser number of servers. This data centre specific program aims to improve energy monitoring, advanced 3-D power management and thermal modeling capabilities, better design techniques, cutting-edge virtualization technologies, enhanced power management systems, and new energy- efficient liquid cooling infrastructures. These initiatives can not only improve building use, data server use, but also reduce carbon emissions by almost 7,500 tons a year. Virtualization has to be supported by the operating system that would separate the underlying hardware from corresponding application software. Various types of virtualization are:

presentation virtualization- wherein users get a feel for owning the presentation of an application, whereas it is actually shared

application virtualization- enables multiple users to use the same application

desktop virtualization- applies the virtualization techniques of the servers at a local, desktop level

storage virtualization-applied to databases

network virtualization- relates to the communications and networking equipments of the data centre.

3.6.6 Physical Data Server Organization and Cooling

The physical arrangements of data servers, their organization, and the manner in which the floor space and racks are physically organized also impacts the overall carbon emission from that data centre

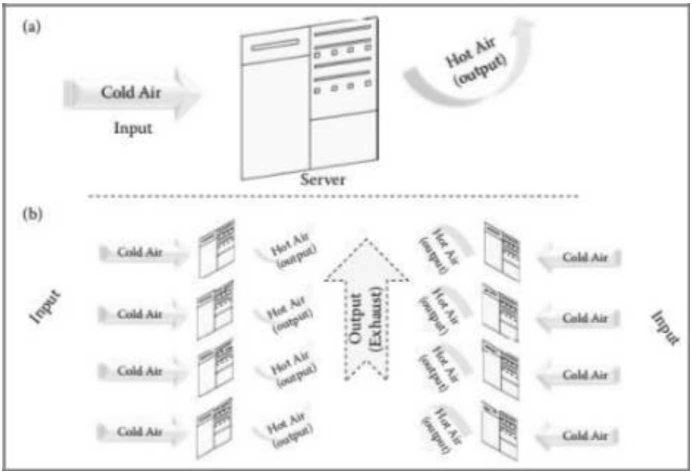


Fig 3. 7: Two ways of physical arrangement of servers

Data centres use a number of techniques to cool their servers.

Water cooling has been popular to handle the heat dissipation issues

Air cooling of servers using the concepts of hot-aisle and cold-aisle

They not only reduce the carbon footprint of the organization but, at the same time, improve its economic performance by reducing power consumption. Therefore, physical organization of the data servers, their operational effectiveness and cooling strategies all play a crucial role inthe overall reduction in carbon footprint.

Physical arrangements of servers require the following considerations:

Server optimization

Disk identification.

Implement a multitiered storage solution.

Specify low-power consumption, low voltage servers together with high-efficiency Power Supply Units

Equipment Reuse.

Re-engineer Layout.

3.6.7 Cloud Computing and Data Centres

Cloud computing provides lot of opportunities for organizations to consolidate their hardware and data space requirements. Cloud computing cuts the costs of services and also reduce carbon emissions. Saas can be used to to access key enterprise applications such as customer relationship management (CRM) and supply chain management (SCM) through the Internet. The opportunities to reduce carbon emissions increase with consolidation of both hardware and software applications. Furthermore, the payment models for SaaS-based applications is usually based on its usage. The typical data centre planning that makes provision for eventualities can be sidestepped for an overall planning by the cloud service provider.

3.6.8 Networking and Communications Infrastructure

The data centres hold the communication equipment and related assets. These communications infrastructure support the internal and external networks of an organization and play a significant role in its carbon footprint. Some of the communication devices that contribute to carbon emissions includes switches, routers, the LAN, WAN, and associated mobile transmission devices. Monitoring of networks, their interoperability, their uptimes and full-times, are also factors contributing to the carbon footprint. Reduction of communication traffic reduces server load, thus minimizing the memory and processing time of the server. Following are the categories of which demands attention in the context of carbon emissions:

Local Area Networks (LAN): Local networks of the organization that are made up of the physical connections amongst the machines and data centre. Usually they lack planning and architecture for LANs is a major factor in consuming substantial power and thereby adding to the cooling requirements.

Wide Area Networks (WAN): This enables communication amongst its desktop and laptop machines with and beyond its data centre. WAN comprises use of communication lines that make up the virtual private network (VPN) of the organization.

Mobile Networks: The mobile communications infrastructure stack is made up of TCP/IP at the base, followed by Well-integrated and optimized networks. They incorporate combination of centralized and decentralized approaches and plug-in sensors which can increasingly play a major role in reducing carbon effects.

Other techniques: Personal Area Networking (PAN), Metropolitan Area Networks (MAN), the IEEE 802.1x group of standards and Infrared, Bluetooth, RFID, WiMax, and Wireless VoIP also produce carbon.

Wireless L AN/WAN: While wireless communication may give the impression of reduced hardware and infrastructure it may still be inefficient and result in substantial carbon if not properly architected during installation and not monitored during operation.

WiMax: Mobile standard for point-to-point communication that is based on radio frequency standardized technology (IEEE 802.16) that tends to consume power, especially when it is on but not in use. WiMax, made up of transceivers to base antennas, need standards to ensure these networks are switched on-and-off depending on their usage pattern.

4. GREEN COMPLIANCE: PROTOCOLS, STANDARDS AND AUDITS

Successful Green enterprise transformation (GET) should result in a carbon-compliant organization. The organization should understand, measure, and Report its carbon performance according to the regulatory requirements of the carbon legislations in that region. Measuring, Reporting and validating the reports are crucial part for carbon compliance. Formal and informal audits of the carbon measures and reports are part of the governance for a responsible green organization. Meters and other recording devices, carbon-content databases, applications, and systems, used in producing the compliance reports and the accuracy of external green web services embedded in the applications should be formally audited. Carbon Emissions Management Software (CEMS) is developed for managing carbon performance of the organization. Various countries and regions interpret the need to reduce carbon differently. This variation is based on a number of factors such as the physical location, demographics, political will of the government, public opinion, economic and social development of the region, and the state of the industry.

4.7.1 Protocols and Standards

United Nations Framework Convention on Climate Change (UNFCCC, Rio)

The UN Framework Convention on Climate Change (UNFCCC) is an intergovernmental treaty developed to address the problem of climate change.

The Convention, which sets out an agreed framework for dealing with the issue, was negotiated from February 1991 to May 1992 and opened for signature at the June 1992 UN Conference on Environment and Development (UNCED) — also known as the Rio Earth Summit.

The UNFCCC entered into force on 21 March 1994, **ninety days after the 50th country's** ratification **had** been received. By December 2007, it had been ratified by 192 countries.

The UNFCCC sets out a framework for action aimed at stabilizing atmospheric concentrations of greenhouse **gases to avoid —dangerous anthropogenic interference‖** with the climate system.

Controlled gases include methane, nitrous oxide and, in particular, carbon dioxide.

Kyoto Protocol

In light of increasing scientific evidence about the risks of climate change, it soon became evident to policy makers that a further negotiated agreement might be necessary.

In December 1997, delegates at COP 3 in Kyoto, Japan, agreed to a Protocol to the UNFCCC that commits developed countries and countries in transition to a market economy to achieve quantified emission reduction targets.

These countries, known under the UNFCCC as Annex I parties, agreed to reduce their overall emissions of six greenhouse gases by an average of 5% below 1990 levels between 2008-2012 (the first commitment period), with specific targets varying from country to country.

The Protocol also established three flexible mechanisms to assist Annex I parties in meeting their national targets cost-effectively:

an emissions trading system; joint implementation (JI) of emission reduction projects between Annex I parties

Clean Development Mechanism (CDM), which allows for emission reduction projects to be implemented in non-Annex I parties (developing countries).

Following COP 3, parties began negotiating many of the rules and operational details governing how countries will implement and measure their emission reductions.

To date, the Kyoto Protocol has been ratified by 177 countries, including Annex I parties representing 63.7% of Annex I greenhouse gas emissions in 1990.

The Kyoto Protocol entered into force on 16 February 2005.

Green House Gas protocol

The Greenhouse Gas Protocol (GHGP) provides accounting and reporting standards, sector guidance, calculation tools, and trainings for business and government.

It establishes a comprehensive, global, standardized framework for measuring and managing emissions from private and public sector operations, value chains, products, cities, and policies.

The GHG Protocol also provides webinar, e-learning and in-person training and capacity-building support on its standards and tools.

In addition, GHG Protocol offers companies and **organizations the opportunity to apply for our ―Built on GHG Protocol‖ mark that recognizes sector guidance,** product rules, or tools that are in conformance with GHG Protocol Standards.

GHG classifies emissions into three separate Scopes (1, 2, and 3) from which a basis for calculating the **organization's overall carbon footprint can be** established (see OSCAR for details of calculations):

Scope 1 emissions—The direct emission of GHGs by the organization.

Scope 2 emissions—emissions form the indirect consumption of energy such as electricity.

Scope 3 emissions—emissions embedded in the supply chain of the organization—primarily belonging to the business partners.

Copenhagen protocol

The Copenhagen Climate Change Conference raised climate change policy to the highest political level. Close to 115 world leaders attended the high-level segment, making it one of the largest gatherings of world leaders ever outside

UN headquarters in New York. More than 40,000 people, representing governments, nongovernmental organizations, intergovernmental organizations, faith-based organizations, media and UN agencies applied for accreditation.

It significantly advanced the negotiations on the infrastructure needed for effective global climate change cooperation, including improvements to the Clean Development Mechanism of the Kyoto Protocol.

Significant progress was made in narrowing down options and clarifying choices needed to be made on key issues later on in the negotiations.

It produced the Copenhagen Accord, which expressed clear a political intent to constrain carbon and respond to climate change, in both the short and long term

The Copenhagen Accord contained several key elements on which there was strong convergence of the views of governments.

This included the long-term goal of limiting the maximum global average temperature increase to no more than 2 degrees Celsius above pre-industrial levels, subject to a review in 2015.

Developed countries' promises to fund actions to reduce greenhouse gas emissions and to adapt to the inevitable effects of climate change in developing countries..

Agreement on the measurement, reporting and verification of developing country actions, including a reference to "international consultation and analysis", which had yet to be defined.

4.7.2 The ISO 14000:2004 a Family of STANDARDS

The primary objective of the ISO 14000 series of standards is to promote effective environmental management systems in organizations. The standards seek to provide cost-effective tools that make use of best practices for organizing and applying information about environmental management. The ISO 14000 family was developed in response to a recognized industry need for standardization. With different organizational approaches to environmental management, comparisons of systems and collaboration had proved difficult

ISO 14001

ISO 14001 standards are part of a family of standards (ISO 14000) designed to promote and guide an environmental management approach. It is appropriate for any kind of organization (company, NGOs, union, etc) concerned about improving its system of production, management, and operations as a way to better control its environmental impacts.

ISO 140001 has 2 main objectives:

To give a standardized and proven framework that can help organizations to develop an effective environmental management strategy;

To work as an official recognition and prize for the **organizations' efforts to improve their environmental** strategies.

The application of ISO 14001 is not a legal obligation and like all standards set by ISO, adopting it is voluntary. Nevertheless, despite not being mandatory, it imposes a compliance commitment with the current environmental regulation and its future developments for those who follow it. The basic principle of ISO norms is the search for continuous improvement, in successive cycles, according to the four-step process of the Deming (PDCA) cycle:

Plan

Do

Study/Check

Act

Following the steps of the cycle PDCA mentioned above, the implementation of the ISO 14001 standards is carried out in three stages:

At first, there is the need to audit the current organizational practices regarding environmental management and their compliance or non-compliance with the regulations and objectives of the ISO 14001 standards.

This will allow organizations to identify and have a clear picture of their procedures, making it easier to re-think and transform them in order to achieve the necessary improvements required by the ISO 14001 standards.

This self-audit can be done internally before-hand, but **all the information about the organization's** environmental procedures and policies will have to be endorsed to the certification entity and confirmed by its consultants.

Once the inventory has been completed, a program of measures to be taken and actions to be developed (prerequisites needed for the certification) need to be established and implemented according to an appropriate schedule.

Finally, a rigorous evaluation of the new practices and their environmental impact will be carried out regularly

(an annual audit within every three years), where updates **or changes on the organizations' environmental** management systems may be requested.

ISO 14001 standards are above all a management tool.

As such, they do not impose certified organizations to achieve certain environmental objectives. Instead, ISO 14001 demands certificated organizations to have a system of procedures that must be respected in order to manage their environmental impacts.

An ISO 14001 certified organization is not necessarily an ecological one, what it means is that it has a system that allows it to improve on its environmental issues.

USA Energy Star

ENERGY STAR is a federal voluntary program run by the U.S. Environmental Protection Agency (EPA) to help people learn more about the many ways they can save money and help reduce environmental degradation through improved energy efficiency. Under the program the EPA identifies and promotes energy-efficient products and buildings, all with the overall goal of reducing energy consumption, improving energy security and reducing pollution.

One of the major sources of pollution is the formation of greenhouse gases. According to ENERGY STAR, two thirds of greenhouse gas (GHG) emissions in the U.S. come from energy use in homes, buildings and industry. Lowering the amount of greenhouse gases that go into the environment, then, has been a primary focus of the ENERGY STAR program and its ENERGY STAR rating system

A critical part of ENERGY STAR is its ENERGY STAR rating system, which focuses on three main areas: products, homes (new and existing) and commercial businesses. Getting an ENERGY STAR rating — which not every appliance has — means that a product meets certain federally mandated guidelines regarding energy efficiency. The guidelines vary depending on the product. The water requirements for a dishwasher to get an ENERGY STAR rating are different than for a washing machine. The EPA establishes its product specifications based on certain guiding principles:

Product categories must contribute significant energy savings nationwide.

Certified products must deliver the features and performance demanded by consumers, in addition to increased energy efficiency.

If the certified product costs more than a conventional, less-efficient counterpart, purchasers will recover their investment in increased energy efficiency through utility bill savings, within a reasonable period of time.

Energy efficiency can be achieved through broadly available, non-proprietary technologies offered by more than one manufacturer.

Product energy consumption and performance can be measured and verified with testing.

Labeling would effectively differentiate products and be visible for purchasers.

EPEAT—Electronic Product Environmental Assessment Tool

The Electronic Product Environmental Assessment Tool (EPEAT) is a global ecolabel for the IT sector. EPEAT helps purchasers, manufacturers, resellers, and others buy and sell environmentally preferable electronic products.

The EPEAT program provides independent verification of **manufacturers'** claims and the EPEAT online Registry lists sustainable products from a broader range of manufacturers than any comparable eco label.

National governments, including the United States, and thousands of private and public institutional purchasers around the world use EPEAT as part of their sustainable procurement decisions.

The Green Electronics Council (GEC) manages this flagship program, including ensuring the integrity of the EPEAT system.

EPEAT is one example of how GEC supports institutional purchasers around the world, fostering a market for sustainable IT products to achieve our mission of a world of only sustainable IT.

Purchasers can search for electronics based on product category, manufacturer, geography or EPEAT rating.

EPEAT-registered products can even be identified based on specific attributes valued by an organization (reduction of toxic materials, recyclability, use of recycled plastic, etc.).

Manufacturers register products in EPEAT based on the **devices'** ability to meet certain required and optional criteria that address the full product lifecycle, from design and production to energy use and recycling.

Bronze-rated products meet all of the required criteria in their category.

Silver-rated products meet all of the required criteria and at least 50% of the optional criteria, while Gold-rated products meet all of the required criteria and at least 75% of the optional criteria.

Manufacturers' claims of compliance are subject to ongoing verification by qualified conformity assurance bodies.

Products claims found non-conformant are announced publicly and removed from EPEAT to ensure Purchasers worldwide can use the system with confidence.

- Implementing EPEAT contract **language also gives purchasers a vehicle for requiring suppliers to document all EPEAT-registered products purchased through that contract during a given year.**

This data, if shared with the Green Electronics Council, qualifies the purchaser for annual recognition and can be used to calculate the **purchaser's** specific financial and environmental benefits.

EPEAT-registered products meet strict environmental criteria that address the full product lifecycle, from energy conservation and toxic materials to product longevity and end-of-life management. EPEAT-registered products offer a reduced environmental impact across their lifecycles.

Over their lifetime, the 1.34 billion EPEAT-registered electronics purchased globally since 2006 will deliver significant environmental benefits.

Compared to products not meeting EPEAT criteria, these electronics will result in the reduction of 184 million metric tons of greenhouse gasses, elimination of 830,311 metric tons of hazardous waste, and will reduce solid waste by the equivalen**t of 528,098 U.S. households'** annual waste.

EU RoHS—Restriction of Hazardous Substances Regulations

This restricts the use of six hazardous materials found in electrical and electronic products. All applicable products in the EU market since July 1, 2006 must pass RoHS compliance.

Directive 2011/65/EU was published in 2011 by the EU, which is known as RoHS-Recast or RoHS 2.

RoHS 2 includes a **CE-marking directive**, with RoHS compliance now being required for CE (Carbon Emission) marking of products. RoHS 2 also added Categories 8 and 9, and has additional compliance recordkeeping requirements.

Directive 2015/863 is known as RoHS 3.

Any business that sells applicable electrical or electronic products, equipment, sub-assemblies, cables, components, or spare parts directly to RoHS-directed countries, or sells to resellers, distributors or integrators that in turn sell products to these countries, is impacted if they utilize any of the restricted 10 substances.

With the rapid spread of digitization, the world's production of electrical and electronic devices is exploding.

Besides mobile devices, think about the coming wave of IoT, smart home assistants, robots, drones, 3D printers, and home medical devices to all corners of the planet are regulated by RoHS.

EU WEEE—Waste Electrical and Electronic Equipment Regulations

The objective of the Directive is to promote re-use, recycling and other forms of recovery of waste electrical and electronic equipment (WEEE) in order to reduce the quantity of such waste to be disposed and to improve the environmental performance of the economic operators involved in the treatment of WEEE.

The WEEE Directive sets criteria for the collection, treatment and recovery of waste electrical and electronic equipment.

Waste of electrical and electronic equipment (WEEE) such as computers, TV-sets, fridges and cell phones is one the fastest growing waste streams in the EU, with some 9 million tonnes generated in 2005, and expected to grow to more than 12 million tonnes by 2020.

WEEE is a complex mixture of materials and components that because of their hazardous content, and if not properly managed, can cause major environmental and health problems.

Moreover, the production of modern electronics requires the use of scarce and expensive resources (e.g. around 10% of total gold worldwide is used for their production).

To improve the environmental management of WEEE and to contribute to a circular economy and enhance resource efficiency the improvement of collection, treatment and recycling of electronics at the end of their life is essential.

To address these problems two pieces of legislation have been put in place:

The Directive on waste electrical and electronic equipment (WEEE Directive)

The Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive)

Green Grid—2007

The Green Grid is an affiliate membership level of the Information Technology Industry Council (ITI), a premier trade association that works to advance public policies for the tech sector.

ITI's Green Grid works to improve IT and data centre energy efficiency and eco-design around the world. It is an open industry consortium of information and communications technology (ICT) industry end-users, policymakers, technology providers, facility architects, and utility companies.

. The Green Grid works globally to create tools, provide technical expertise, and advocate for the optimization of energy and resource efficiency of Data Centre ecosystems which enables a low carbon economy.

The Green Grid was founded in 2007 with the collective viewpoint that energy efficiency in the data centre is one of the most significant issues facing technology providers and their customers.

This situation is not only due to exponential increases in power and cooling costs over the past few years, but also because customer demand for concentrated computing is outpacing the availability of clean reliable power in many places around the world.

The Green Grid is the first industry initiative chartered to take a holistic view of the ICT ecosystem, with a focus on addressing the pressing issues facing data centre users.

In 2019 TGG was acquired as an affiliate member of the Information Technology Industry Council (ITI), which is a premier trade association that works to advance public policies for the tech sector.

CSCI—Climate Savers Computing Initiative

The CSCI promotes the use of technologies such as power management features that both cut energy use when computers are not in use and improve power delivery efficiency.

Google and Intel founded CSGI in the U.S. as a nonprofit group of consumers, businesses and conservation groups aligned to reduce IT-related greenhouse gas emissions.

Consumer members of the initiative are asked to use energy efficient computers and enable power-management capabilities, such as sleep or hibernate mode.

Participating manufacturers agree to develop products that meet or surpass Energy Star standards, while systems buyers commit to use power management features and choose Energy Star products in their procurement.

NGOs agree to educating end users on power management tools and the perks of energy efficiency.

4.7.3 Green IT Audits

Green IT audits are formal, independent verification and validation of the carbon performance and carbon reporting of the organization.

With increasing legislative demands on carbon reporting, these Green IT audits play a vital role in establishing the Green claims of the organization.

Auditing of CEMS is a part of these audits. Every carbon reporting and carbon related transaction will be audited through an independent module of the CEMS itself—that is owned and controlled by the auditors.

Internal and external audits have slightly different roles to play in terms of carbon emissions reporting.

Internally, they provide the confidence to the decision maker on her investment in the Green project, and externally, they provide the legal backing required of any formal reporting of data. Such audits, as part of the overall audits of an organization, provide systematic assessment of the organizations structures and operations.

Externally they provide legitimacy to the reporting and the claims to greening made by the organization.

Green audit assess a company's environmental credentials and its claim for green products and services.

Audits can also determine whether the compan**y's supply** chain and/or product line can be accepted as truly environmentally sustainable.

Green audits are very closely associated with metrics and measurements. Green audits primarily validate that whatever is being reported in terms of carbon emissions is accurate and sufficient. Green audits can

also suggest areas for improvements in the **organization's compliance with standards as well as** legislations.

Green audits can cover the regularity accuracy, calculations, analysis, reporting, and storage of carbon emission data. Such validated data analysis can ascertain the Green IT readiness and maturity of an organization, that of its corresponding industry and even at a global.

This need of businesses to have reliable carbon data need to be supported by new metrics and measurements that are being invented rapidly and standardized across the industry.

Audits prove the validity of concrete carbon measures

that enable comparison ,justification, and optimization of **an organization's green credentials.**

Everything that can be measured within Green IT is not **necessarily a good ―indicator‖ of the greenness of the** organization. Furthermore, everything that needs to be measured is not necessarily easy to measure.

The challenges to these measures stem from the fact that currently many emissions get omitted, others get double calculated.

Green metrics

There are five areas of green metrics:

Measure: What is being measured? Is that measurement sufficient for reporting purposes?

Are there additional areas of carbon data that should be included in the measurements?

Monitor: What is the mechanism to collect the data? Where are the meters located?

Manage: Validate the feedback and management mechanisms of carbon data, information, and analysis. The carbon management, governance standards, processes, and controls are audited in this area.

Mitigate: Is the measurement and reporting of carbon data also being used to reduce the emissions?

What are the systems in place for carbon mitigation and how well they are operating? The audit in the area of mitigation will be mainly of interest to the internal stakeholders of the organization, but will have external effect.

Monetize: Audits of the monetizing aspects of carbon data will be of immense regulatory interests as the businesses move toward carbon economy. Ability to trade carbon requires accuracy and authenticity of systems that enable that trade.

Advantages in undertaking Green IT audits within organizations:

Validation of entire organizations asset register from a carbon emissions perspective.

Formalization of metrics and associated measurements

Validation, internally of cost-benefit calculations that demonstrate the ROI on green initiatives to corporate governance board and the shareholders on indexing of carbon measures with financial performance of the organization.

Cross-check on smart meters used for automatic reading and display of carbon data.

Stocks take of the skill set, experience, and necessary expertise within the organization to put together a Green IT measurement and optimization program.

Ratifying the agreement among the organizations stakeholders as to what should and should not be included within carbon emission calculations.

Validation of the calculation on electronic waste and its disposal.

Adequacy of policies and practices in addressing the complete and comprehensive carbon footprint of an organization.

Being part of the value proposition for business through its green initiatives both internally and externally.

Assist in objectifying (making explicit) the other tacit attitude and viewpoints of participating employees and management in measuring the green credentials of the organization.

Reducing the confusion and, perhaps, duplication of calculations that may occur in a collaborating group of partners.

Provision of relative benchmarks from audit to audit.

Validating the measuring of degree of sophistication or maturity.

4.7.4 Types of Green Audit

Green metrics and measurements used for green audits purpose need to be validated themselves. Measurement systems must be developed that can establish baselines and measure carbon storage and emissions changes on various scales, from individual machines to large processes of the business. The advanced ICT technologies and techniques such as SOA, web services, mobile technologies, semantic networks, Cloud computing, Information Management Systems can play an important role in the development of monitoring and measuring emission tools. Mitigation deals with reducing the carbon footprints of a business by identifying ways of operating more efficiently and thus reducing the costs and CO2 emissions. Monetizing is poised to take advantage of the opportunity to trade carbon credits in future. The following are the collection and use of carbon data needs to be audited during green audits:

Data collection mechanisms and corresponding gadgets/meters.

Data analysis undertaken by software systems

Carbon trends: Plotting of the carbon trends, their accuracy and reliability

Carbon compliance: Both internal and external auditing parties are involved in ensuring that the organization is complying with the limits set for emissions by the regulatory bodies.

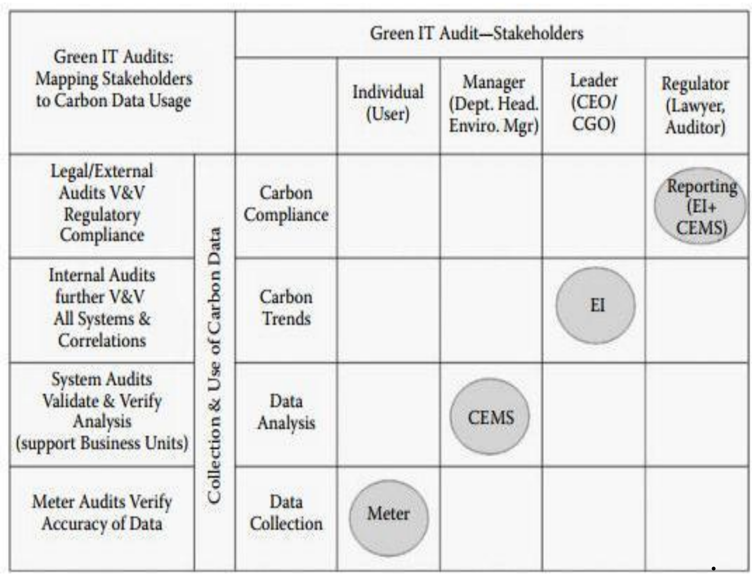


Fig 4.14: Various elements in Green audit

The stakeholders of green audit are as follows:

Individual users: provides input into the data collection mechanisms.

Departmental heads: involved in analysis provided by the software system (CEMS) dealing with carbon data. This analysis would show to a business unit or a department clearly the amount of carbon generated by its activities as well as potential carbon savings.

CEO/chief green officer (CGO): interested in all aspects of the Green IT audits, but particularly in the environmental intelligence aspect of the organization.

Regulators: external parties that want to determine the accuracy and validity of carbon data reporting as undertaken by the organization.

4.7.5 Green IT Audits—Approach, Maturity, and Comparison

An integrated model for Green IT audits includes steps required in the audit, the various dimensions of an organization that need to be audited, ascertaining the Green IT maturity of the organization and the various areas. within the organization that will be audited.

Undertaking Green IT Audits

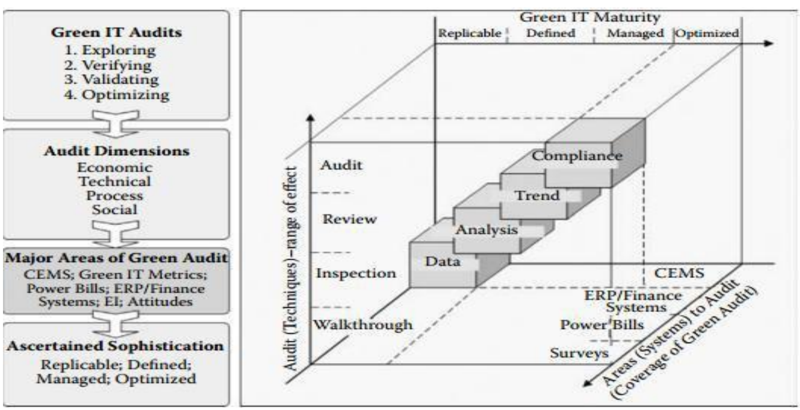


Fig 4.14 Integrated model for green IT systems

The core areas apply to the various systems, packages and surveys. The known quality techniques of walkthroughs, inspectors, reviews, and audits can be applied in undertaking audits. The following are the ways of conducting green audits:

Walkthroughs: Individually performed, to identify basic emissions data relating to an individual or a department. Walkthroughs can also be conducted of the CEMS algorithms that are used in calculating the emissions data.

Inspections: more rigorous than walkthroughs and are carried out by a person or party who is not the original producer of the artifact. Thus while the Green IT auditors will carry out the inspections, the staff responsible for smart meters and other gadgets used in collecting data, as well as those responsible for the processes for storing, reporting, and managing carbon data will provide the necessary information, and answer queries

Reviews: go beyond walkthroughs and inspections, and formally verify and validate a process. In the Green IT domain, reviews are conducted by both internal and

external auditors. Reviews would require preparation beforehand of the areas to be reviewed—such as systems, databases, equipment lifecycle, and wastage disposal processes. Reviews also encompass verification and validation of the accuracy and efficacy of the governance processes and methodologies, and also cover economic and social dimensions.

Audits: very formal, both internal and external to the organization. Green IT auditors will be invited or may enter the organization to conduct formal audits of the carbon data collection, analysis, and reporting. Audits cover all work areas and all four dimensions. Audits can make use of the aforementioned quality techniques of walkthroughs, inspections, and reviews. At the end of the auditing process, a formal report is prepared to present and discuss the outcomes. Whenever carbon benchmarks or limits are transgressed by the organization, they are pointed out by the auditors. Appropriate actions are also discussed and a plan to undertake them is highlighted during the audits.

4.7.6 Audit and Use of Carbon Emissions Management Software (CEMS)

A CEMS helps an organization manage its energy consumption by accurately recording, analyzing, and reporting on the carbon data. It is responsible for reduction and management of carbon emissions and help an organization meet its environmental goals.

Auditing a CEMS requires attention to the following:

Accuracy of the data captured by the system.

Security and ease of storage of carbon data.

Security and ease of retrieval

Validity of analysis and trend creation

Frequency and reliability reporting of emissions and related information

Ease and accuracy of updating environmental parameters that drive CEMS

Interfaces to the government regulatory portals using web services

Environmental compliance by vendors and other business partners

Use of CEMS in the audit function itself

Comparative Audits

Audits provide an organization with a feedback on its current performance as well as Green maturity. The results of audits will enable an organization to understand where it stands on the Green CMM. Audits can be conducted to ascertain the current state of an organization and plan for the future state. Reports on the results of a properly conducted Green IT audit will also enable an organization to understand its strong and weak areas, and thereby help it in its ongoing optimization effort by enabling selection of right projects within its transformation programs.

5. APPLYING GREEN IT STRATEGIES AND APPLICATIONS TO A HOSPITAL

5.3.1 ABC Hospital

ABCis a hypothetical large hospital in a metro city, providing public sector medical services. The services includes out patient department and various specialities. After the preliminary Green IT audit of the hospital, it has been revealed that the hospital had a significant carbon footprint. Significant reviews of patient management processes, management of Electronic Patient Records (EPR), laboratory equipment management, medical drugs and material management, and management of equipment and buildings were undertaken.CGO was appointed and suggested that optimization was possible in

all these areas of the hospital that will reduce its carbon footprint. The cost-**effectiveness and efficiency of the hospital's**

service processes is as important as its carbon efficiency. Further infrastructure of this data centre is now more than 10 years the initial investigation also highlighted that ABC has a significant investment in a data centre. Also, the building and to the attention on processes in terms of theunit 5ir carbonreduction,

old,and the server machines themselves are averaging 4 years in use.By Green enterprise transformation(GET), the hospital can influence many of its partnering organizations such as labs, pharmacies, and suppliers.

The Return On Investment (ROI) of the hospital's

attempt to transform to a Green hospital is meant to go beyond the carbon focus and into the overall business optimization arena. Thus, the hospital leadership is keen to make effective use of new fund allocations that have been indexed to carbon reduction.

Preliminary Green Investigation

The green audit was done by CGO. The CGO, with theIT auditors, departmental heads, and the CIO sought input into the current state of the hospital. The framework for this audit was based on the four dimensions of GET namely Economic, Technical, Process and Social. The findings were:

The hospital has to undertake action in terms of measuring, reporting, and reducing its carbon emissions.

The hospital has significant opportunity to influence its partnering organizations.

OPD (out-patient department) of the hospital is a large and complex department that operates out of its own separate building and infrastructure. This department has 220 stationary desktop machines, 100 mobile laptops and PDAs carried personally by the staff and numerous supporting IT devices like printers. This department alone accounts for 60 to65 kT (kilo Tonnes) of carbon emissions of the hospital

Additional desktops, printers, fax, laptops and PDA are present in other departments as well. These devices amount to 20 kT of emission sat this stage.

Printers are heavily used for writing of scripts, printing of patient records and reports and related documentation. On an average, the hospital prints 5,000 pages of normal paper and consumes corresponding ink and printer time.

Hospital has an attached pathological laboratory that conducts diagnostic blood and related tests. The lab equipment is aging.

The data stored in the hospital's servers that provides that information to staff on the results from the tests is also significant consumer of power and generates carbon emissions.

Pre and post surgical activities requires electronics equipment and IT support

The hospital has to need to product substantial amount of legal documentation.

The hospital collaborates with external pharmaceutical organizations, manufacturers and distributors of drugs and hospital equipment.

Staff rostering is not optimized, leaving the administrative staff to occasionally use physical notepads, whiteboards, and diaries to book availability of doctors.

Scheduling system for patient appointments, surgical procedures and human relation (HR)is also not optimized and requires a major upgrade. Scheduling patient consultations, scheduling work rosters for nurses and administrative staff is many times happening manually.

A comprehensive multimedia data warehouse project is underway.

With the availability of a multimedia database, there is opportunity for optional extensions to the project is to incorporate possibility of remote consulting by doctors through audio and video media using high-speed connectivity.

Security of access and privacy of patient's data (EPR) is of top priority and is not to be compromised under any circumstances.

Internal administrative systems

There are provisional inventories that are in excess.

5.3.2 Green Business Objectives

The green objectives provide the basis for the transformation plan.

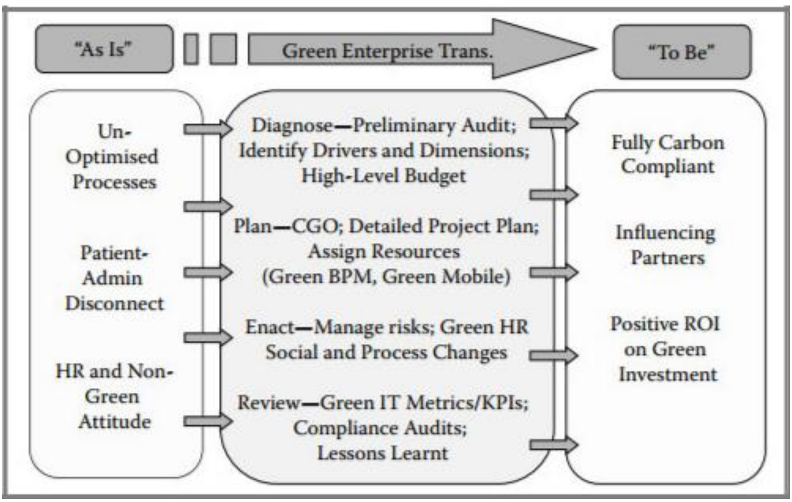


Fig 5.1: Green Transformation of ABC hospital

The four major phases of transformation—diagnose, plan, enact, and review—interspersed with metrics, are shown in this high-level transformation framework. Following are the important objectives of ABC in undertaking the GET:

Reduction in carbon emissions across all departments and processes of the organization

Compliance with carbon legislations and related carbon initiatives of the government

Be a leader in carbon management and, thereby, influence many business partners in reducing their emissions

Undertake electronic collaborations with partners, government regulatory bodies for monitoring and reporting

Undertake comprehensive Green BPM program that will enable result in modeling, optimization, and merger/elimination of processes

Aim for a comprehensive and holistic GET that is futuristic

Create positive green attitude across the entire staff through Green HR

5.3.3 SWOT analysis of ABC Hospital

SWOT analysis is helpful in understanding the approach that can be taken for the GET. A SWOT analysis makes it easier to understand how to capitalize on the inherent strengths of the hospital. The areas that will be directly affected by the transformation and bear risks will also become evident in such an analysis. SWOT analysis can help understand the scope and coverage of work during this transformation.

Strengths

Well-known public sector hospital.

Financially w ell supported by government.

Green IT budget.

Reputed teaching and research hospital

Weaknesses

Aging IT infrastructure.

Attitude not conducive to Green IT.

Carbon inefficient processes.

Opportunity

New Leadership (CEO, CIO)

Govt. Focus on Environment

Green Portals integrated with Regulatory

Portals

Uncertainty of Focus

Changing Legislations

Patient Privacy Risks exposure

Infrastructure/Change Management

Threats

Lack of collaboration with partners.

IT inexperience (new technologies).

Uncertainty of focus.

Changing legislations.

Patient privacy risks

Infrastructure/change management.

5.3. 4 Strategic Concerns of Management

The drivers of ERBS are shown in Fig 5.2.

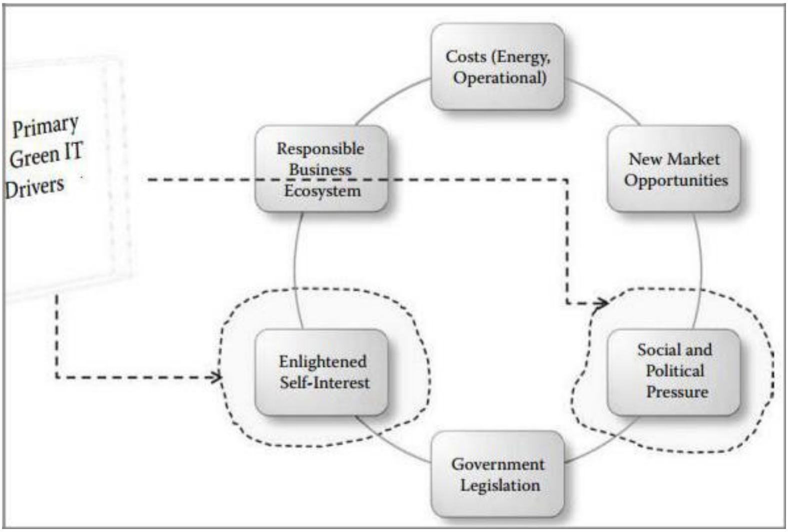


Fig 5.2: Green IT drivers

Sociopolitical pressure:

The hospital has a substantial standing in the community. There is significant social and political pressure on the hospital to demonstrate its environmental credentials. This pressure comes from the general community that views the hospital as a symbol of good service-based organization and cross-section of patients.

Enlightened self-interest:

The senior management of the hospital, the leaders/decision makers are keen to take up the challenge of changing their processes and internal social attitude to a positive, green attitude. While they are certainly buoyed by the availability of funds dedicated for this purpose, they are themselves realizing the need to undertake this green enterprise wide transformation to enable them to remain as a leader in the upcoming carbon economy.

5.3.4 Steps in Developing a Hospital's ERBS

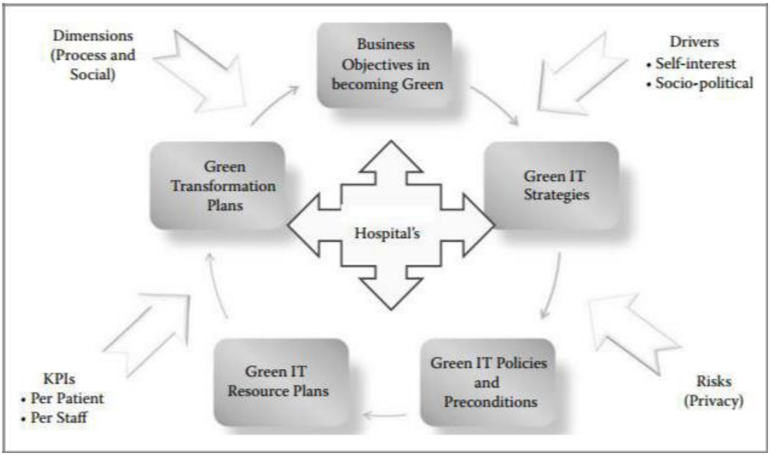


Fig 5.3: Development steps of ERBS

The business objectives of the hospital in becoming a green hospital were identified earlieron. These objectives and visions provide the initial direction for the hospital in its strategy formulation. The d rivers for the objectives are enlightened self-interest and sociopolitical pressure on the hospital.

Green IT strategies: These are the medium terms strategies that are driven by the CGO and that are based on the drivers and objectives of the organization. Strategies for Green IT also contain elements of risks or threats, as were identified during the SWOT.

Green IT policies and preconditions: These are the policies that are formed at the departmental level and are implemented by department heads.

Green IT resource plans: These include details of resources required in undertaking transformation.

Green transformation plans: These are the business transformation and change management plans that will focus on the dimensions and the work areas.

5.3.5 Green Transformational Elements

These elements are as follows:

The drivers and areas of influence.

The major dimension along with the GET will take place. This is the process dimension also supported by the social dimension for transformation.

The demographics of the organization can play a role in deciding on the type of transformation, its budgets, and its resources.

Maturity of its Green IT performance is very basic.

Some of the transformation measures:

User devices: Measuring, upgrading, and recycling monitors, PCs, laptops, and mobile phones; desktop virtualization; centralized green services

Data centre: Virtualization, optimization; self healing networks; network topology, database design, hardware and software components, security issues, and backup strategies. Redesign of data centre to include flexibility and agility to enable easy upgrades of future infrastructure

Systems and lifecycle: IT systems supporting hospital processes like booking, consultation, diagnosis, treatment, prescription, and education; Equipment procurement, installation and usage; integration of supply chain with local as well as overseas pharmacies and drug suppliers. Interaction with government and other regulatory bodies should also be enabled electronically.

Wastage: Electronic waste resulting from unused or broken devices; also, due consideration is given to areas of bio waste.

Attitude: Undertaking training and consulting programs for staff and promoting it amongst patients and business partners. Internet-based system to facilitate global management of the administration, rosters as well as the most HR functions. Change management for telework and telehealth.

5.3.6 Green Transformation Project

The overall GET project is to last between 12 and 18 months, with the full carbon value realized **over 3 to 5 year's** strategic time period. $ 1 million is the budget sanctioned by the corporate board and the CGO is authorized to undertake this transformation.

The process is divided into six quarters of 3 months each.

First quarter: The hospital transformation is primarily focused on investigation and diagnosis. This work includes identification of the key drivers for green transformation. The CGO will lead the strategic planning for the hospital, creating a 3 –5year actionable strategic **plan. Ā is plan will also include the return on investment** metricsfor the hospital.

Second quarter: This is the quarter where enactment of the plan created in the previous quarter takes place. The enactment of GET in this quarter deals withthe process dimension of transformation. Therefore, Green BPMcomes into play during this quarter. The process changes require extensive modeling, verification and validation, and tools support. Carboncontent of the key processes needs to be established beforehand.

Third quarter: This quarter of GET is dedicated to transformation ofthe social dimension. Therefore this quarter focuses on the attitude and behavior of individual staff . Social dimension also becomes important in a service organization as the output of the organization is the service to the customer (patient in this case). Thus while the employees are equipped here with training that enables them to tap into the environmental data, information and knowledge within the organization, the patients, and the society in general is updated with the changes occurring within the hospital. Metrics and measurements associated with the social dimensions come in to play.

Fourth quarter: This quarte**r is for the —Review‖ phase** of the transformation. There is heavy focus on measurements based on the earlier defined metrics: the Green KPI. The KPIs can also be fine tuned for ongoing and continuous improvement in the future. Review phase can include Green ITaud it to ascertain the maturity of the organization. Reduction in complexity of processes, improvement of quality of service and compliance with legislative requirements are included in the criteria for success.

Fifth quarter: If the Review phase indicates success in terms of GET, then the organization needs to immediately focus on providing the transformation support to its partners. These are the pharmaceuticals, laboratories, equipment suppliers and, various patient-related bodies such as medical insurance providers.

Sixth quarter: This is the quarter where feedback from the transformation will have a substantial effect on the next steps by the hospital. Formal external Green IT audits are conducted in this quarter and compliance with the regulatory requirements can be formalized. This quarter starts an ongoing journey for environmental program management for the hospital that will work closely with the Green HR function in ensuring Green IT specific roles are maintained, and individuals working in those roles are motivated and trained. Two important aspects to be noted here are

GET is closely tied with the profits

GET will lead to increase in the overall performance.

5.3.7 Social Dimension in Hospital GET

Changes to the social dimension of the hospital is particularly brought about during the third quarter of the transformation. These changes include the following:

Creation and delivery of training programs for staff at all levels

Review of attitude toward Green IT through quick surveys and feedback

Use of IT systems support to reduce the routine pressures on doctors beyond the needs oftheir own specialist or generalist skills

Implementation of metrics to provide real-time feedback to users on their daily carbon footprint.

Creation of telework program for support functions

Telehealth

Development of a Green HR function that includes training, reward, and growth structure, particularly for admin and support staff, in terms of Green IT.

5.3.8 Technology Changes in Hospital

Replacement of servers to the low-carbon emitting servers in the data centre.

Gradual replacement of devices to low-carbon devices.

Changes to the current backup, including off -site backups of data on the data servers.

Upgrade of IT systems to automate processes.

Upgrade to the EPR by implementing a strategy to move it on the Cloud. EPR can enhance medical record documentation and optimize the consulting process of the doctor with the patient.

Paper-less medical reports to reduce not only the paper wastage, but also time and effort in maintaining the manual records is saved.

Collaboration with partners

Green BPM for processes, including ordering and retrieving laboratory tests, prescription writing, consultation or referral notes, and billing.

CEMS will be involved in recording carbon data that corresponds to various clinical activities.

User devices changes includes end-user devices such as PCs in the consulting rooms, examination rooms, nursing workstations, and administrative hardware.

Communications and network equipment

Non-IT equipment and their lifecycle has to be subject to the Green Production, Operation and Development. These equipment, such as are used in operating theatres or X-rays or in the pathological tests may not come directly under IT domain, but are still significant contributors to carbon emissions.

Electronic wastage policies and procedures.

5.3.9 Applying Mobile Technologies in GET

A large number of hospital staff use mobiles to connect for both work and social networking. The following are the advantages from the perspective of carbon reduction:

- **Doctors:** Mobile technology can reduce carbon **throughout the physician's work and social processes. They can use handheld tools dedicated to a physician's** routine which can provide instantaneous data and information to the doctor. This improves health-care services to patients, eliminate geographical distances and reduce carbon content of the service. ABC hospital is providing dedicated health-care mobile tools and supporting technologies to all doctors that will enable them to serve the patients most efficiently, engage in conversations and conferences through their devices, and **have fast access to patients' data. The actions taken by** the physician are also documented through the device, enabling easy tracking of actions when a staff member hands over the care of a patient to another member.

  Nurses: The use of mobile technology is also helps the nursing staff to coordinate with the doctors andthe patients on a re gular basis. This helps in improving the consulting/advisory roles that nurses play and the record keeping activities.

  Patients: Use of mobile technology has given greater flexibility for thepatients without being physically go to the hospital for check up. The mobile technology has reduced patient movement, patient queuing and has provided location-independent advise to patients where they needed it most. Additional mobile gadgets that monitor patient data remotely, provides it to the hospital and also raises relevant alerts has optimized the processes and reduced their carbon contents.

Suppliers: Mobile technology improves receiving and ordering processes between hospital and its drug supplier. It also provides better management and storage system.

5.3.10 Important Lessons Learned in Implementing Green IT Strategies

Following are the lessons learned as a result of the GET initiative for the hospital.

Strategic reduction in carbon will require significant changes in the social, process, and also technical dimensions of the business.

Service organizations are particularly influenced by customer expectations. The patients and the society in general was more keen to see the hospital becomea green hospital, as compared with the internal staff and administrators.

Telework and telehealth are likely to play a significant role in not only improving the business processes of the hospital, but also its carbon emissions record.

Operational carbon reduction is more effective when processes are to be changed as compared with the changes to the procurement and disposal cycle.

Training and education play a significant role in carbon reduction in a hospital and similar service organizations. They bring about a change in attitude and approach to Green IT restructuring to Green HR is also a significant boost to the carbon reduction effort from asocial angle.

Changes to IT systems that support business and technical processes should be made with the backdrop of environmental intelligence. Simple carbon data mining will not provide strategic value of directions for a transforming organization.

Ongoing monitoring of risks associated with GET should be planned for enacted. These risks are not restricted to only the main dimension for transformation but can emerge from any of the four dimensions.