Green Computing

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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 as one 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, ―Green Data 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

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

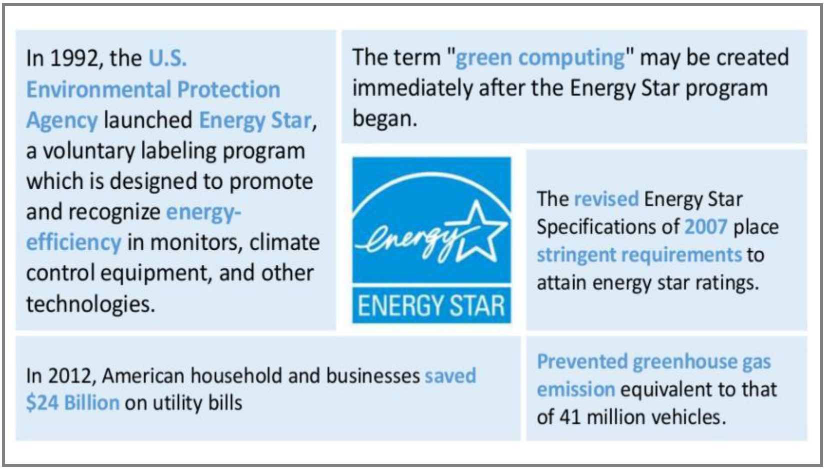


Figure 1.1 – History of Green IT

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

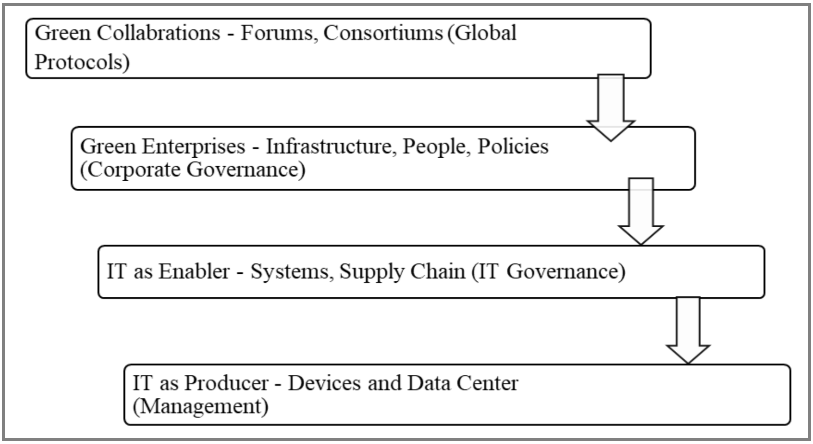


Figure 1.2 – Green Enterprises a vision beyond Green IT

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.

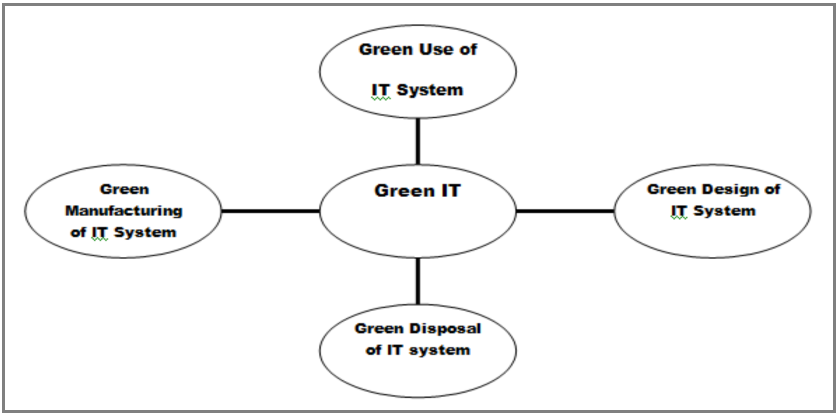


Figure 1.3 – Path way to Green IT

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 recognize this 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

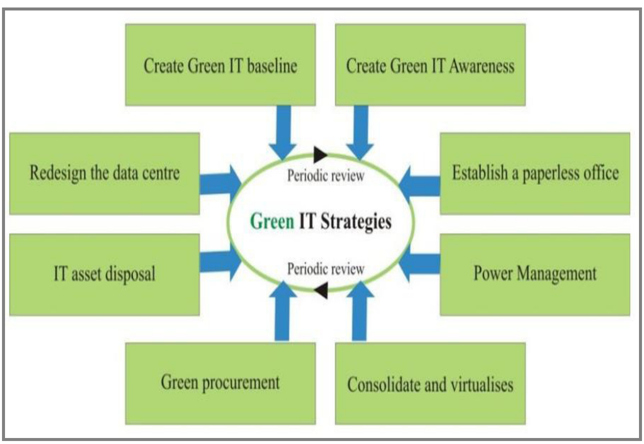


Figure 1.4 Green IT strategies to reduce the carbon emission in IT sectors

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 that a green product or service can provide to the consumers.
- Consumers evaluate offerings based on these benefits and 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 few examples.
- 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.

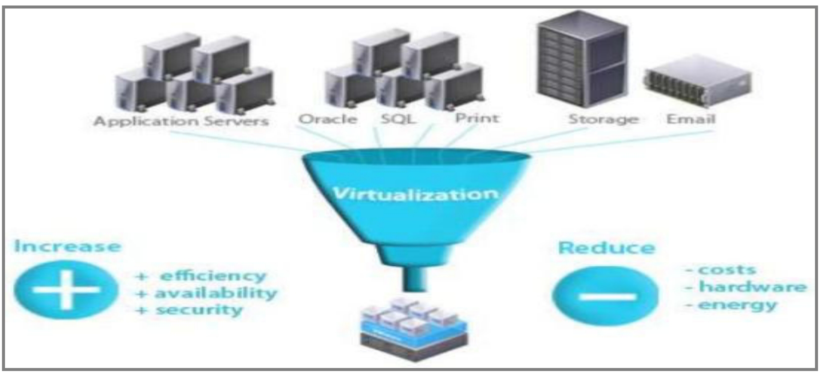


Figure 1.5 –Depicts Virtualization

- ❖ 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 for sharing software when display required, Use motherboard 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.

Sun Ray Thin Client – Consumes to a maximum of 8 watts because most of the heavy computation is performed by a server suitable for call centres, education and healthcare sectors.

1. 2 Carbon Footprint

What is Carbon Footprint?

- ❖ The total amount of Greenhouse Gases produced to directly and indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO_2).
- ❖ Sum of all emission of carbon dioxide for a given time frame is referred as Carbon footprint.
- ❖ Carbon foot print is also referred as total set of Green House Gas emission caused by an organization, event, product or person.
- ❖ It is an extension of "Ecological Footprints".
- ❖ The carbon footprint is a very powerful tool to understand the impact of personal behaviour on global warming. Since Carbon dioxide is called greenhouse gas causing global warming.

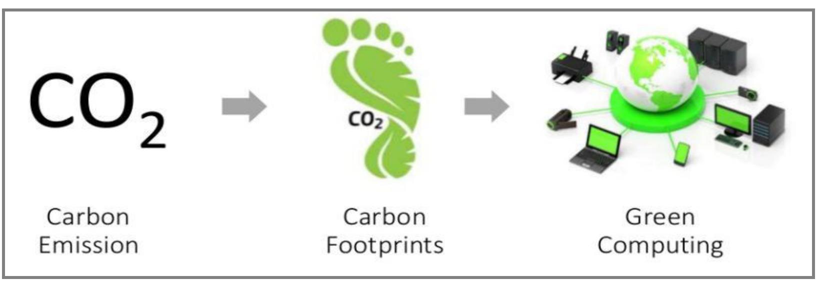


Figure 1.6 – Relation between carbon emission and green computing

- ❖ Every time a computer is powered it draws electricity from the power source which is powered by coal, oil or natural gas which releases carbon dioxide.

Energy	Leaving Computers on when not in use
Printing	Unnecessary printing of emails, agendas, drafts etc.
Pollution	Manufacturing techniques, packing etc
Toxicity	Chemical Usage like mercury, lead and cadmium

Table 1 – shows different forms of natural resources wasted

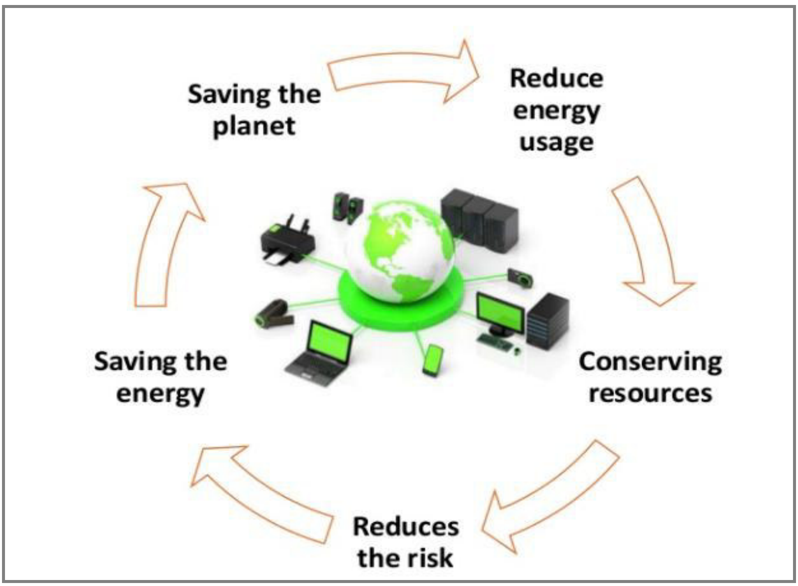


Figure 1.7 –Depicts the relationship between conversing energy and health of planet

- ❖ Energy Consumption

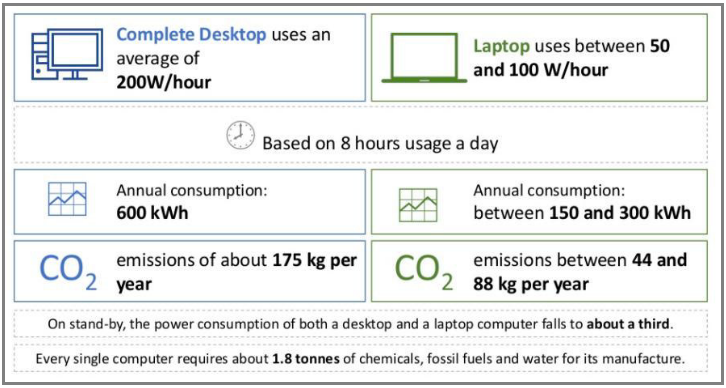


Figure 1.8 – Energy consumption comaprison between desktop and laptop

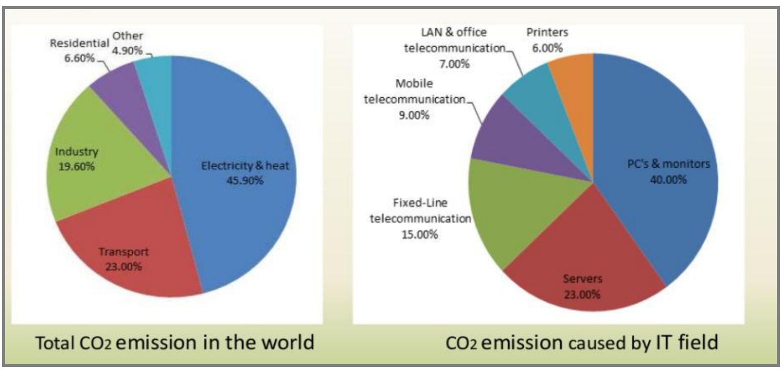


Figure 1.9 – CO_2 emission – world and IT field

Green Manufacturing

Bamboo is becoming increasingly popular in manufacturing casings for computers and peripherals.

Reusable plastic is used in place of non – recyclable plastic.

Flame retardant compounds that are eco-friendly and non-toxic materials are widely used to support implementation of Green IT.

Process of monitoring reduction in the quality of raw material and hazardous materials used in manufacturing consumables.

Segregation of hazardous and non-hazardous materials from disposed components will improve the environment to great extent.

Figure 1.10 – Bamboo Products

Figure 1.11 – Bamboo based computer components

1.3 Scoop on Power

In the past decade, a lot of research has been carried out aiming at providing better battery life to the mobile devices like PDAs, mobile phones and Laptops. However with the advent of data centres, Greening of Computing also deals with energy efficient designs for servers and to lower costs and carbon emissions produced by Data centres. A recent survey shows that quite a lot of power used in office buildings and colleges are spent on Computing. The scope of optimizing the usage of power are as follows:

- Input and Output devices – Black CRT utilizes less power than White CRT

Brightness	White CRT	Grey CRT	Black CRT
100	85	74	63
50	84	67.5	60.5
0	77.7	65	60.0

Table 2 – Comparison of Brightness in various CRT models

Power Consumption Parameter	CRT Monitor	LCD Monitor
Avg. consumption	76 W	20 W
Screen color sensitivity	Extremely sensitive. Consumes lot more power (43% more) when displaying white on screen.	Completely insensitive. Consumes same power for all colors on screen.
Brightness setting sensitivity	Moderately sensitive. Consumes more power at higher brightness.	Sensitive. Consumes higher power for higher brightness
Contrast setting sensitivity	Less sensitive. (Almost insensitive when brightness setting is low.)	Completely insensitive. Consumes same power for all contrast
Consumption when turned off from computer power settings	2W	0 W

Table 3 – Comparison between CRT and LCD monitor

- Storage Units
- Processors
- Operating Systems

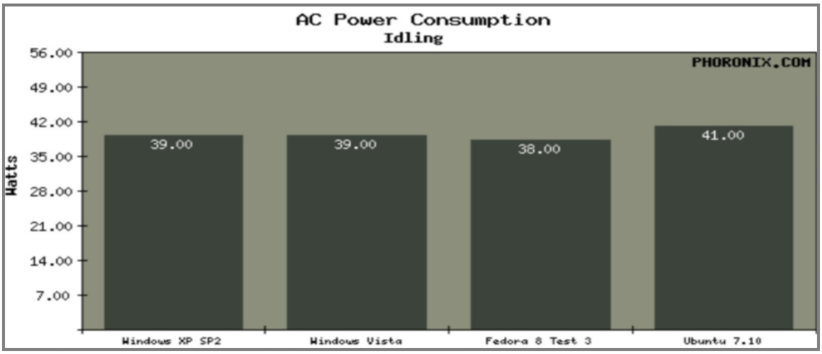


Figure 1.12 – Power Consumption of various Operatiing Systems

- Frequency of operation in any Computing Devices.

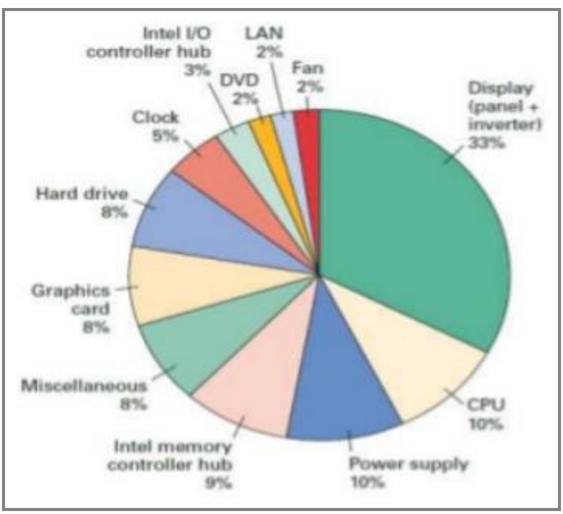


Figure 1.13- Power consumption in an average Laptop

Data Centres

- A Data Centre is a facility housing a large number of servers and data storage.
- In reality the electricity bill for a data centre is close to 6 million a month with about 20 percent of the power spent on cooling the data centres.
- The average amount of money spent on buying the servers amortized over a period of three years is almost equal to the cost of powering the servers.
- This shows that it is necessary to effectively utilize the electricity used by the Data centres.

Power Usage Effectiveness

- Power Usage Effectiveness = Total Facility Power/IT Equipment Power
- The PUE is a ratio of the input power to the actual amount of power required by the servers at a Data Centre.
- If the amount of power required to cool the system is 100 percent , then the PUE grows to 2 which is undesirable.

Low PUE Design

Better Power Infrastructure

- If there are multiple data centres in different locations then one way of making using of power infrastructure is to shift the load to the data centre that has a low-price period.

- The power generally undergoes a conversion from AC-DC a number of times before it reaches the server, by reducing the number of conversion the conversion loss can be avoided.
- Multi-phase power (use of a 3 phase AC) can help provide efficient power usage.

Better air conditioning

- Cold air is allowed to pass through the servers.
- On passing through the servers the cold air turns hot and this is cooled and then reused.
- Balancing load across the data centre helps eliminating hot spots Another means of cooling is to use the outside air to cool the machines.
- Iceland being a cold country and being a good source of Geo-thermal energy hosts a few data centres.
- Microsoft conducted an experiment by placing the servers outside and using the outside air to cool the systems. The servers worked fine even with temperatures in the late 90s.
- However they faced issues with filtering the outside air which contained leaves and other dust particles.

Better server and IT equipment

- It is observed that the servers consume 65% of the power.
- A server is not to be energy proportional if the power usage scales linearly with the workload intensity.

- However in practice, servers are not energy proportional and consume close to half the power even when they are in the idle state. This is attributed to various components like Disk , RAM, motherboard and network card which consume power even in the idle state.

- In practice it is observed that the servers are around 10-30% utilized all the time.

- The amount of work done by the server for each joule of energy used is defined as the efficiency. The servers are not efficient either. This is due to the unused CPU features like the large caches, complex architecture.

- If the CPU is not the bottleneck for the application then the use of a CPU with limited features can solve the problem and also make the server more efficient.

- The server is most efficient when its utilization is 100%. The efficiency of a server is also linked with the software flexibility.

- By using Virtualization, the CPU/memory usage can be controlled.

- Migrating virtual machines to a subset of the physical machines and switching the other machines off also helps in efficient usage.

Common Approaches

- One common approach is to make the Ensembles energy proportional.

- This is achieved by distributing the workload and with the decrease in utilization the components are turned off and the word-load is migrated to active components.
- If there is an increase in the utilization the components are turned on and the load is migrated to the newly active components.
- However, this method does have problems. Moving the workload might take a long time and turning on/off of the components takes a long time.
- It also does not work if the workload intensity changes faster than the data transfer and if the workload is not distributed.
- Some of the other IT components like the switches and the routers are much inefficient when compared to the servers. They are at 100% Utilization all the time.
- Turning off RAM memory banks is rarely done. Mechanical disks are not energy proportional. Flash disk use no energy but they are expensive

Renewables

- The Main reasons behind using renewables is due to the Bad press for using many fossil fuels, electricity costs and also to reduce carbon emissions.
- However with renewables the word-load and the available power are now changing and there is a need to match supply and demand since storage of power brings in additional overhead.

Information technology can be used to make the building more green using sensors, smart software, smart appliances and smart meters

Smart Buildings

- In order to make the building smart, there is a need to monitor the energy usage.
- The user must be able to control electricity usage by automatically turning devices on and off.
- Green Computing comes up with means to satisfy these needs cheaply and reliably.
- The Building Management Systems are existing systems that monitor the energy usage but lacks load balancing methods.

Monitoring Energy Usage

- Energy usage can be monitored at multiple levels of the wiring right from the electricity incoming level to the outgoing level. But this is not same with data transfer, which a tedious process is done using wireless networking techniques like Zigbee and Wifi.
- The most Challenging task to place sensors at every load since it's expensive, it may not look good and it's unreliable due to the bandwidth constraints.
- Some Alternatives include collecting high bandwidth data at the source, disaggregating data into multiple chucks or loads by using well placed sensors.

Controlling Energy Usage

- ❖ Programming load control switches are needed to control the energy usage.
- ❖ Generally the control involves switching a device on/off. The switching mechanism may be external or internal.
- ❖ An example of a Wi-Fi enabled washer and dryer has been provided. The control is provided by means of a mobile application.

Environment Monitoring

- ❖ It has similar issues as energy monitoring which monitoring weather, thermostats, and doors as well tracking motion.
- ❖ Energy usage can be implemented using recommendations via smart phones, enabling remote but manual control, automated scheduling policies.
- ❖ The main aim of the computing for greening is to optimize for lower costs, lower energy usage, lower peaks and aligning consumption with renewable generation.

1.4 Green IT Strategies: Driver's, Dimensions and Goals

Green IT Strategies

- ❖ Each enterprises must develop a holistic, comprehensive green IT strategy and policies that outline aims, objectives, goals, plan of action and schedules.

❖ A Large enterprise must appoint an environmental sustainability officer to implement their green policy and to monitor the progress and achievements.

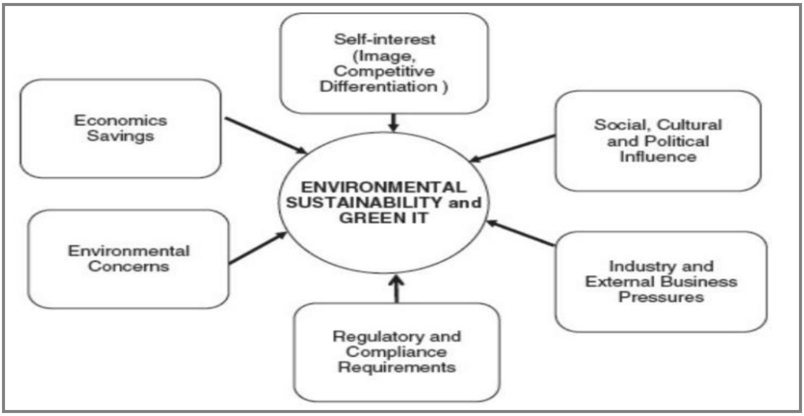


Figure 1.14 – Various factors responsible for Environemental Sustainability

❖ Every enterprise must have a tactical incremental approach with green goal such as reducing energy consumption.

❖ It must also have measures adopting policies and practices namely power management, switching off computers when not in use.

❖ Enterprises must conduct audit of its IT infrastructure and its use from an environmental perspective.

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

1.5 Green IT - Four Dimensions

Green IT practice translates the green IT strategies, plans, and policies in the day-to-day workings of the organization by using its transformational and operational capabilities. Green IT in practice is based on four distinct yet interrelated dimensions of business: economy (why), technology (what), process (how), and people (who).

1. Economy (Why)

The economic dimension deals with the financial justification for green enterprise transformation. The key practice in this dimension revolves around metrics that enable justification of the investment in green IT initiatives. Following are some of the economic factors appearing in green IT practice:

- **Green ROI metrics justify the business decision to invest in carbon reduction.**

  These are measures that reflect the business value emanating from the costs, effort, and risks in undertaking a green enterprise program. For example, the replacement costs of electronic devices is matched against the power and costs saved over the lifetime of those devices.

- **Metrics that demonstrate the net present value (NPV) of the carbon initiative over a three- to five-year period.**

  In this period, the carbon economy can be expected to be in full swing, and the carbon reduction investments made today will affect the worth of organizations on the stock exchange then (around 2013-15).

- **Incorporation of intangible and/or otherwise non-carbon measures, such as organizational image, subtle marketing, and motivated HR, in the overall justification for green IT.**

  For example, the image of an organization as perceived by its customers (or employees) can be measured through a survey and, then, the same image measured again after the green transformation has taken place. The difference in the two views of the organization by its customers can be made to count toward the economic benefits resulting from green initiatives.

- **The comparison of carbon performance across multiple organizations and industry sectors, especially when businesses are geographically dispersed.**

  This comparison facilitates understanding of the economic advantage of green initiatives among competing organizations.

- **The formulation of KPIs (key performance indicators) that provide financial benchmarks indexed to carbon benchmarks.**

  For example, a KPI can be “reduction in scope 2 carbon emissions by 10% per year over the next three years” and can be extended and mapped to “reduction in cost of production by three to five percent per year for the next three years.” KPIs not only measure progress in carbon efficiency but also provide an indication of what needs to change.

- **Carbon trading based on the recording and reporting of emissions.**

  This trade in carbon in a carbon economy on carbon stock exchanges will make use of CEMS, enabling it to mature into systems-based automated trades monitored and enforced by law.

2. Technology (What)

The practice of green IT in the technology dimension deals with reduction of emissions from IT equipment, such as monitors, computers, data servers, and network equipments. Examples of the technological dimension of green IT practice include:

- **Sophistication in managing desktops, laptops, and other individual computing devices when not in use.** This includes switching them off when not in use, using a blank screen saver, centralized power management, and use of smart operating systems.

- **Use of smart metering devices** that measure and relay emissions in real time and provide feedback and correction to the equipment.

- **Printer use in an efficient way** through default draft printing, default page cap per user, double-sided printing, distance printing (i.e., not have a printer by the side of the desktop), and recycling of ink cartridges.

- **Virtualization and optimization of data servers and desktop machines.**

- **Use of low-carbon-emitting green monitors and computers instead of the aging and high-power-consuming computers.**

- **Implementing basic to advanced carbon emissions management software**[2] for collection and dissemination of standardized carbon data.

- **Preferential use of renewal sources of energy such as solar, wind, and nuclear.** This would be based on increased ease in selecting the source of energy and greater transparency in viewing the effect of the choices through sophistication in carbon reporting systems.

- **Environmental intelligence (EI) comprises technologies like data warehouses, analytical tools, and reporting tools.** This EI will combine existing business intelligence systems and organizational processes with the tacit green knowledge people carry.

3. Process (How)

The process dimension of green IT practice deals with the use of IT systems in improving business processes (e.g., supply chains) and use of standards (e.g., ISO14001). The process dimension in the practice of green IT is affected as follows:

- Business optimization processes such as lean or Six Sigma would be also responsible for carbon reduction.

- Modeling and implementation of new green processes.

- Embedding green organizational policies within the systems that support business processes.

* Collaborative green business processes
* Processes associated with reuse and recycling of equipment that balance the longevity of the equipment and its ongoing power consumption.
* Collaborative business processes, based on Web services that enable support and sharing of carbon reduction across multiple organizations.

4. People (Who)

The people dimension of green IT practice deals with the soft, sociological aspects of changes to the organization. Following are some of the areas associated with people that undergo change in a green IT initiative:

* **Changing customer preferences** with respect to favoring green products and services needs to be considered and incorporated in product and service design, development, and production.
* **Basic training and creation of awareness of environmental sustainability and green IT** among various groups of people, including employees, customer groups, and suppliers.
* **Use of social media networks** that generate public opinion, provide carbon-related information, publicize green standards, as well as facilitate "crowd-sourcing" (e.g., a member of the crowd reporting a wastage such as street lights on during the day, an oil spill in the neighborhood, or unethical dumping of batteries or mobile phones).

- **Developing trust and ensuring security associated with carbon data.** This applies to both internal and external parties interested in the carbon performance of the organization.

1.6 Green IT Goals

The **goal of green computing** is to attain economic viability and improve the way computing devices are used. Green computing practices include the development of environmentally sustainable production practices, energy efficient computers and improved disposal and recycling procedures. There are other goals of green information technology, most notably at the design and manufacturing stages.

In all cases, four main aims are:

- to cut down to as little as possible the amount of energy used.
- to minimize the inclusion of harmful materials.
- to use as many biodegradable materials as possible.
- to extend as far as possible the life of the equipment.

1.7 Environmentally responsible business policies practices and metrics

- Sustainable business practices are characterized by environmentally-friendly practices initiated by a company for the purposes of becoming a more sustainable organization.
- These companies aim to reduce their environmental footprint through initiatives that cut down on waste, poor

environmental stewardship and unethical environmental practices that offer a reduced level of sustainability within company practices.

- ❖ Sustainable business practices differ among industries and are often specific to the company type and the product or service it produces.

The **definition of sustainability** is:

"The quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance."

1.8 Sustainable Business Practices

1. Be Intentional About Sustainability

- ❖ Sustainability needs to be incorporated into corporate strategies and reflected in **organizational business goals**.
- ❖ This means making this a priority in every aspect of organizational operations.
- ❖ As with any other business initiative, you need to make a plan of action and assign accountability. Hold people accountable and measure the results

2. Partner with Employees

- ❖ Invest the time in **training employees** on the importance of sustaining the environment and share what the organization is doing to help conserve resources.
- ❖ Solicit additional ideas from employees for resource conservation.

- ❖ Get an idea about what employees are experiencing and can offer ideas to reduce waste and improve their work environment.

3. Water and Electric Conservation

- ❖ Conserving water is something where everyone participate in by reducing the opportunities for wasting this valuable resource.
- ❖ For example, converting to energy-efficient faucets, toilets, and lighting can be a great way to save water, energy, and budget dollars.

4. Supply Chains

Statistics show that **customers prefer working with sustainable companies** that are environmentally friendly. Maintain a list of sustainable friendly vendors and make it a priority to only use organizations that embrace sustainable business practices. **Negotiate contracts** with this expectation made clear.

5. Develop a Recycling Program

Develop an in-house program for recyclable products like:

- ➢ fluorescent light-bulbs
- ➢ electronics
- ➢ computers and monitors
- ➢ paper products
- ➢ supplies

Use of waste management vendor to help create a process for this.

6. Chemical Management

Chemical impact on environment is been plundered in recent times. Strive to use green cleaning products and non-chemical products for pest control and weed management. Use chemical vendors to help train employees on the proper use and disposal of chemicals.

7. Purchase Only Energy Efficient Products

Use of energy-efficient electronic products and use environmentally friendly settings on office equipment. Choose computer, electronic, and IT acquisition products that are **EPEAT** registered to ensure the highest levels of efficiency.

8. Develop Sustainability Work Policies

Develop sustainability **policies and procedures** to reinforce the efforts. Things like, power down equipment at the end of the day and enable energy savings settings on all computers and desktops, are examples of policies that can support the cause. The challenge to sustain the environment can be overwhelming, but if each of the organizations, large or small, does its part, everyone can contribute to conserving this great planet that is home for all living things.

1.9 Metrics used for measuring power consumption in data centres.

a) (TDE) Thermal Design Power

It is the measurement of maximum amount of power required by cooling of computer system to dissipate. It is the maximum amount of power which a computer chip can take when running a real application.

b) (PUE) Power Usage Effectiveness

It is used for comparison of energy used by computing application and infrastructure Equipment and the energy wasted in overhead. The PUE can be described as the ratio of overall electricity consumed by the facility of a data centre to the overall electricity consumed by IT equipment's (network peripherals, servers, storage, routers, etc.). Value of PUE depends on the location of datacentres and construction done for that Datacentre. Thus it is different for all datacentres.

$$PUE = \frac{\text{Total Facility Energy}}{\text{IT equipment energy}}$$

c) (DCiE) Data centre Infrastructure Efficiency

It is the reciprocal of PUE. PUE and DCiE are most commonly used metrics that were designed for the comparison of efficiency of datacentres.IT Equipment Power can be described as the power that data centre has taken for the management of IT equipment's, processing of IT equipment's and storing the data in disk drives or routing the data within the datacentre. Total Facility Power is IT equipment power plus power needed by uninterrupted power supply (UPS), generators (needed to provide power in case of power failure),Batteries, cooling system components such as chillers, CRACs, DX air handler pumps, units, and cooling towers.

$$DCiE = \frac{1}{\text{PUE}}$$

d) (CPE) Compute Power Efficiency

It is a measure of the computing efficiency of a datacentre. As each watt consumed by server or cluster did not draw fruitful work all the time, some facility consumed power even in idle state and some consumed power for computing. Although 100% of facility capacity will never be used, but the need for maximum output from the electrical power which datacentre has taken. CPE is defined as

$$CPE = \frac{\text{IT equipment utilization}}{\text{PUE}}$$

e) (GEC) Green Energy Coefficient

It is a measure of green energy (energy that comes from renewable sources) that is used by the facility of a datacentre. For evaluating the environment friendly nature of a data centre this metric is used. It is selected as a PUE metric by green grid organization in November 2012. Energy consumed is measured in kWh. It is defined as

$$GEC = \frac{\text{Green Energy Consumed}}{\text{Total Energy Consumed}}$$

f) (ERF) Energy Reuse Factor

It is a measure of reusable energy (energy that is reused outside of datacentre) that is used by datacentre. For making cloud, environment friendly data centre should use renewable energy such as electricity generated by wind power, hydro power etc. ERF is selected as PUE metric by green grid organization in November 2012. It is defined as

$$ERF = \frac{\text{Reused energy used}}{\text{Total Energy Consumed}}$$

g) (CUE) Carbon Usage Effectiveness

It is a measure of carbon dioxide emission in environment by the data centre. It is selected as a PUE metric by green grid organization in November 2012. Where ECO2: Total carbon dioxide emission from total energy absorbed by the facility of a data EIT: Total energy consumed by IT equipment's. ECO2 includes all greenhouse gases (GHGs) such as CO2 and methane (CH4) that are emitted in atmosphere. This value is taken for whole year analysis.

$$CUE = \frac{\mathrm{E}_{CO2}}{\mathrm{E}_{IT}}$$

h) (WUE) Water Usage Effectiveness

It is a measure of required water by a data centre annually. Water is needed - a) For cooling the facility of a data centre. b) For humiliation. c) For apparatus associated power generating d) For production of energy.

$$WUE = \frac{\text{Water Used Annually}}{\mathrm{E}_{IT}}$$

Advantages of Green Computing

- Green computing can save energy
- Green computing can save money in the long run

* More sophisticated recycling processes
* Waste reduction
* Reduction of the resource depletion problem
* Less pollution
* Less greenhouse gas emissions
* More efficient hardware use
* Sustainable IT practice
* Increases pressure to go green in the IT industry
* Reduction of health risks for customers
* Better working conditions
* Teleworking may improve flexibility
* Green computing may strengthen the brand of companies
* Positive impact on our flora and fauna

Disadvantages of Green IT

* Significant upfront costs
* Plenty of knowledge may be required
* Green IT may conflict with profit maximization goals
* May slow down computer networks
* Technological change may make older IT-systems obsolete

- Acceptance inside companies may be rather low
- Lacking awareness of the general public
- Green IT may be vulnerable to safety issues
- May not be manageable for small businesses
- Reliance Maintenance may be difficult
- Many technologies aren’t actually that green

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 make it 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.

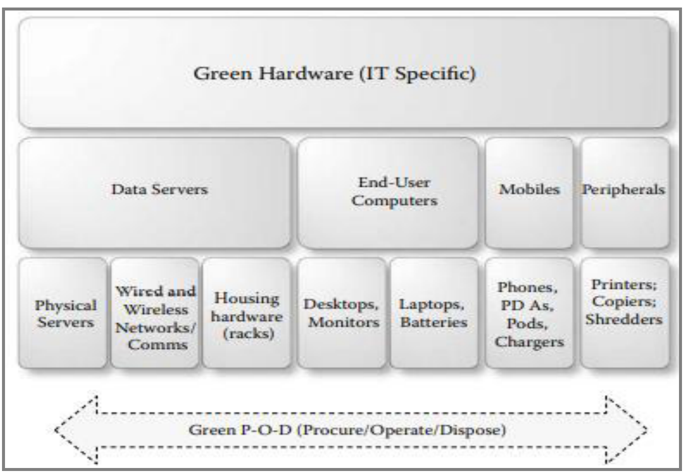


Figure 2: Range of Green IT hardware generating carbon

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.

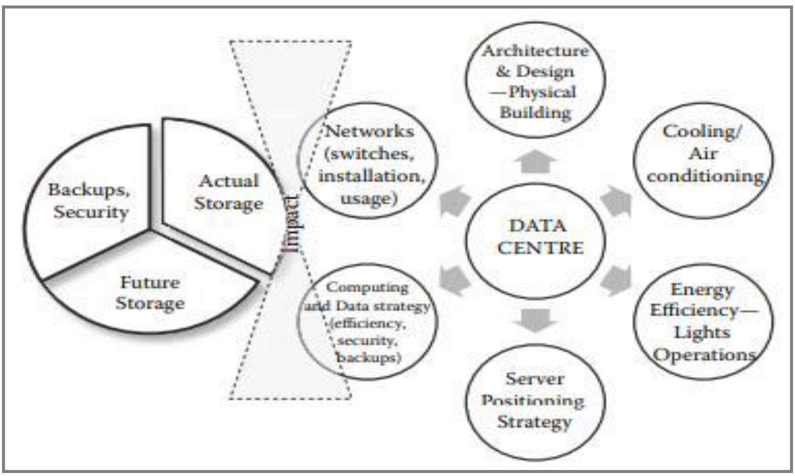


Figure 3 – Factors influencing Green data centre

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 and other computing equipments themselves are usually Green Assets upgraded every 3 –5 years.

Therefore, the data centre building, together with the data 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 providing comparative data over a length of time, as also across the industry.
- 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.

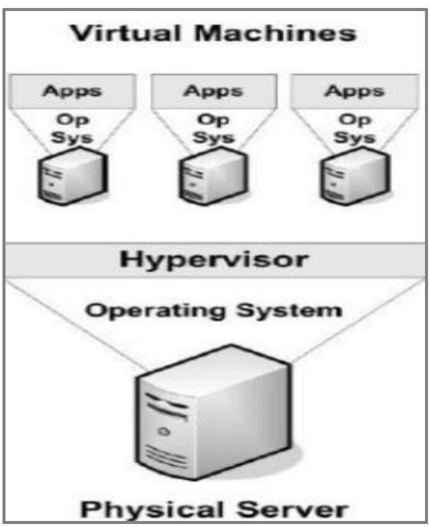
- The software that makes this possible is known as hypervisor.

Why green computing uses Virtualization?

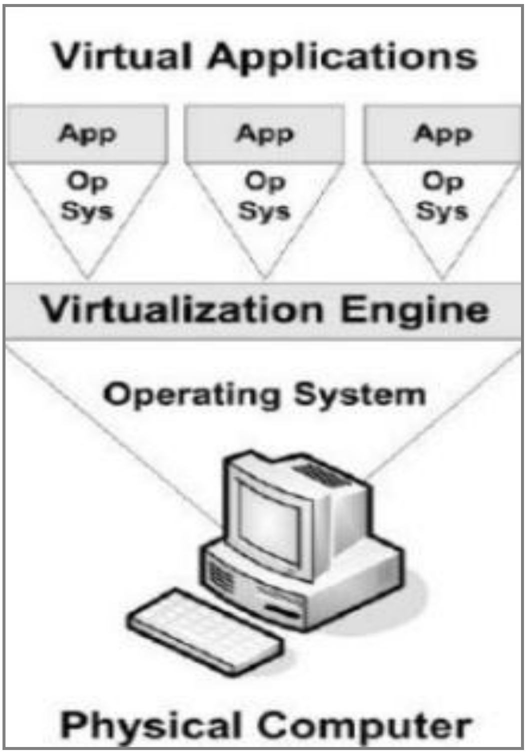
- **Decreased energy use**– reducing number of physical devices, the amount of energy required to operate the devices is decreased as well reduces the cooling system power requirement.
- **Reduction in toxic waste**– number of hardware devices are reduced so huge reduction in e-waste or toxic wastes.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

Types of virtualization

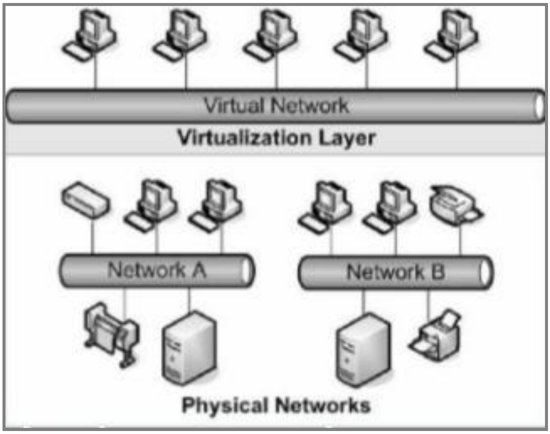
- **Server virtualization**– many servers run on single physical server. Helps decrease energy usage and provides more floor space.



* **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.

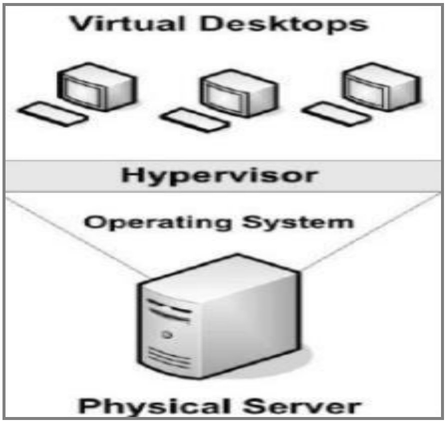


* **Network virtualization** – It allows us to combine all of the resources available on a network by splitting up the available bandwidth into independent channels. Consolidation of many physical networks into one virtual network. Partitioning of single physical network into many virtual networks is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

2.2 Green Business Process Management: Modelling, Optimization, and Collaboration

Green business process management

- Green business process management (Green BPM) deals with the overall management of all internal and external processes of an organization from a green perspective.
- BPM is a well-established industry practice encompassing process modeling, reengineering, and optimization of processes, and the measuring, merging, and elimination of business processes.
- Green business processes are environmentally conscious business processes that are necessary, efficient, effective, agile, and measureable in the context of an organization.
- In the green process optimization exercise, processes are challenged for their necessity in the first place, others are optimized for efficiency, some others are made more

effective and agile, and all are measured in order to ascertain their carbon contribution.

- The exploration of processes in this manner leads to many opportunities to improve and optimize them during a green enterprise transformation.

Table 3: Basic Process Characteristics and Corresponding Green Connotation

Process Characteristic	Description	Green Business Connotations
Necessary	Challenges - the need for the process in the first place.	Eliminating an unnecessary process eliminate its carbon contribution.
Efficient	Models the process to study its various activities/tasks.	Aims to reduce the carbon generation within the process by optimizing and/or eliminating the activities/tasks within the process
Effective	Ensures that the process is actually achieving the goals it is meant to achieve.	Substantial wasteful carbon is generated by a process that is not effective—as it does not achieve business goals.
Agile	Deals with the	An agile process will

	ability of the process to change itself in response to external and internal changes affecting the organization.	change easily and effortlessly in response to changing external situation
Measurable	Enables monitoring, control, and ascertaining the success of its optimization.	In addition to the standard process measures, such as cost, time, and quality, now the "carbon content" of a process is measured.

- BPM approach in an organization and can be considered as a set of management and technology disciplines focused primarily on workflow and process automation that drives the implementation of optimized and sustainable business processes.

- Optimization of processes covers many aspects of the performance.

- Processes can be optimized to ensure efficient utilization of resources.

- Processes can be reengineered to creatively eliminate the use of some redundant or duplicate resources.

- Reengineering has been described as the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance such as cost, quality, service, and speed.

Green Reengineering

- Green BPM includes reengineering of business processes to optimize their emissions.
- Reengineering of processes to green processes will incorporate re-evaluation of processes and also an understanding and modeling of their supporting hardware, software, and people in order to cut down the carbon generated through them.

Seven Reengineering Principles

1. Organize around outcomes, not tasks.
2. Identify all the processes in an organization and prioritize them in order of redesign urgency.
3. Integrate information processing work into the real work that produces the information.
4. Treat geographically dispersed resources as though they were centralized.
5. Link parallel activities in the workflow instead of just integrating their results.
6. Put the decision point where the work is performed, and build control into the process.
7. Capture information once and at the source.

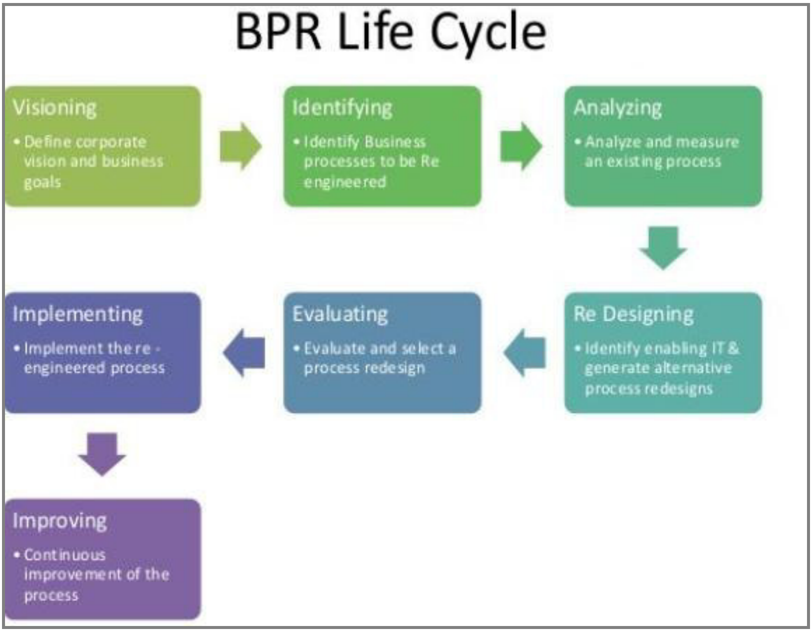


Figure 4: Life cycle of BPM

Green Processes: Individual, Organizational, and Collaborative

- Reengineering of business process to reduce their carbon contents has to happen at three levels: individual, organizational, and collaborative.
- These levels tend to be increasingly strategic, taking longer time and greater effort as the business moves from individual processes through to departmental- and organizational-level processes.
- Collaborative processes cut across multiple organizations and systems—making them even more challenging to be reengineered in the context of carbon reduction.

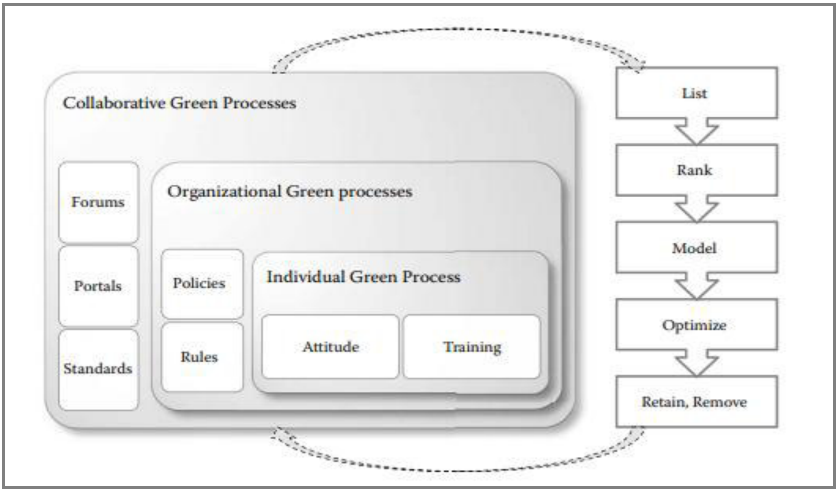


Figure 5: Individual, organizational, and collaborative green processes and their reengineering

Table 4:Green Process Categories and Their Carbon Impact

Green Process Categories	*Key Factors That Influence Carbon*	*Comments*
Individual	Attitude, Training	Personalized processes are influenced by attitude and training. Motivation of the individual may be based on personal value system, personal reward, and growth.
Organizational	Policies, Rules, KPIs	Dynamic creation and management of business rules that optimize processes. Metrics are crucial to demonstrate the ROI on investment for green enterprise.
Collaborative	Portals, Forums, Standards	Collaborative processes transcending organizational boundaries. Portals containing green knowledge, regulations across regions.

Green Business Analysis

- In green business processes, the role of business analysis activity, including the gathering of business requirements, understanding and modeling processes, process analysis and optimization, and testing prior to deployment are to be considered.

- A Green BA can play a dual role: First, modeling requirements for a Green IT project and, second, modeling existing processes for their optimization from a green perspective. BAs can ensure alignment of a Green IT technical solution (e.g., CEMS) with environmentally responsible business strategies.

- The Green BA involvement in a project promotes an understanding that even if certain business requirements are important to a stakeholder, they may not be still necessarily desirable in a solution if they are not aligned with the need to generate least carbon.

Green Requirements Modeling

- One of the major responsibilities of a Green BA is to undertake modeling of requirements for a green process or system.

- This requirements modeling can be considered as a sub discipline of systems engineering that is concerned with the behavior, quality attributes, and also technical constraints.

- Requirements modeling is widely recognized as both a challenging aspect of software development, as well as a crucial one, because it lays the foundation for all the subsequent project work.

- Green requirements modeling can be divided in two major parts— ***functional and nonfunctional (or operational).***

Functional requirements

- Are software requirements, describe the behavior that the software will have and the information the solution will manage.
- Functional requirements are associated with the required behaviors and operations of a system, defining its capabilities in terms of actions and responses.
- Functional requirements are frequently captured in the form of use cases.
- Green IT frequently impacts functional requirements as a consequence of new procedures or business rules emerging from corporate environmental policies and industry standards.

Non - Functional requirements

- There are requirements, however, that go beyond system behavior. These requirements describe the properties, attributes of the solution and are referred to as **nonfunctional requirements.**
- Examples of such requirements include availability, performance, usability, portability, robustness, etc., and they provide the design constraints for the project (e.g., technology or regulatory limitation).
- Green IT policies typically add nonfunctional requirements to software projects, imposing new demands in terms of quality attributes that become necessary or desirable, and also establishing new constraints.

Green IT Governance

- ❖ Green process management matures as proper business governance which align with performance governance, project governance, change governance, and IT governance and control is applied to it.
- ❖ An ideal way to do this is to incorporate green aspects within the existing governance structure within the organization.
- ❖ This can take shape of modifying the business process architecture, balance score card, and business policies for governance.

2.3 Green Enterprise Architecture

A Green Enterprise Architecture (GEA) considers the multiple existing systems and packages used by an organization in running its business. A GEA also provides basis for defining, assessing, measuring, analyzing, reporting, and monitoring the green IT systems and processes. Furthermore, a GEA results in the development of common terminologies that bring clarity, understanding, and consistency to the green enterprise initiative.

Following are the activities resulting from a green enterprise architecture for green information systems in an organization:

- ❖ Integration of the new CEMS (Carbon Emission Management Software) with existing organizational systems (typically ERP packages, CRM) using SOA-Web Services interfaces
- ❖ Modification of existing data structures to accommodate new carbon data elements and related contents

- Data conversion to enable use of that data in calculating carbon emissions
- Populating parts of data and systems with external carbon data (such as regulatory requirements/standards /benchmarks)
- Evolution of carbon data through to information, knowledge and environmental intelligence
- Evolution of existing decision support and knowledge management systems to environmentally intelligent systems
- Creation of a suite of green services using service oriented architecture (SOA) and Web Services (WS)
- Application of mobile technologies to provide location-independence and personalization to the green information portals that facilitate collaboration.
- Quality assurance and testing of Green IT systems

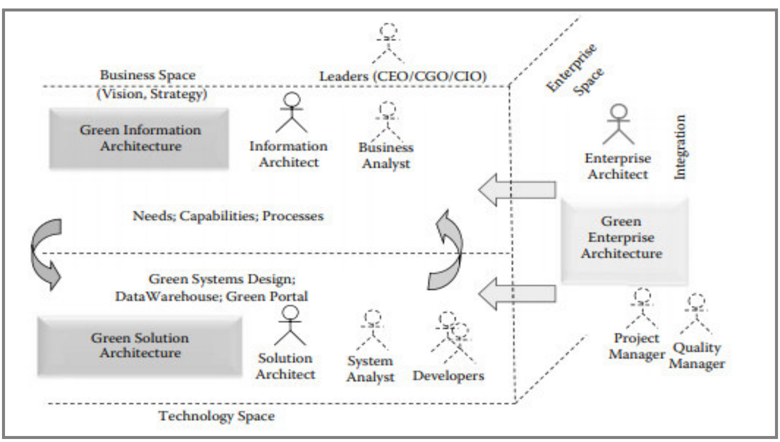


Figure 6: views of a Green enterprise architecture

Green Information Architecture

The GIA provides the basis for using enterprise applications, processes, and contents. The semantics for the master data including the green data are defined and the operational and analytical information is modeled in this architectural space. The requirements that influence the information architecture come from the business, information, and enterprise domains. This information architecture provides the context for facilitating integration across various applications. The information architecture also outlines the processes for capturing and modeling requirements. The information architecture also contains a repository of overall applications and their interrelationships. A good understanding of this interrelationship can help eliminate redundancy and eventually also contribute to the reduction of resources.

- Green customer requirements that are based on the demands of the customer for green products and services.
- Green marketing requirements that promote the organizations green products and services.
- Green supply chain process requirements that interface with the suppliers systems.
- Green technical requirements that are specifying the technologies that are needed to handle the Green IT initiative.
- Green facilities management requirements that describe the building and facilities infrastructure and the approach for measuring and reducing their carbon.

- Green metrics and measurement requirements that specify the elements to measure and report.
- Green recycling and e-waste management requirements that deal with the one-off disposal of assets

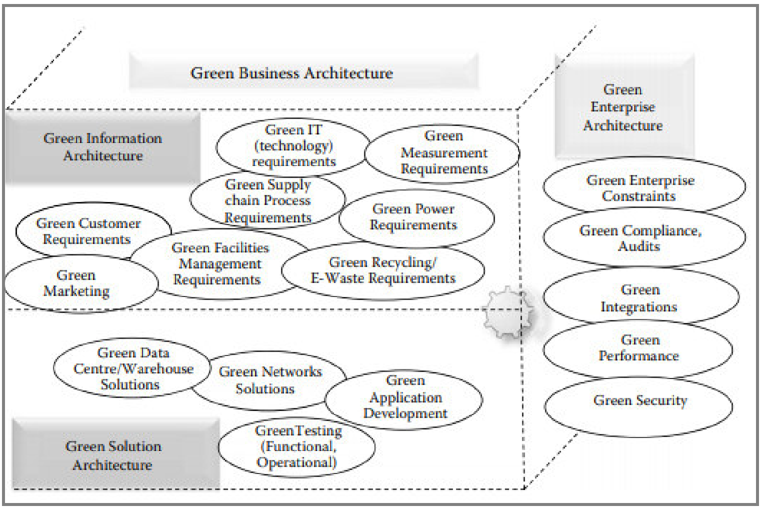


Figure 7: Categories of requirements of various GEA

A good GEA is a mechanism to incorporate the changes associated with Green IT transformation on the right in Figure 8 into the systems and processes on the left.

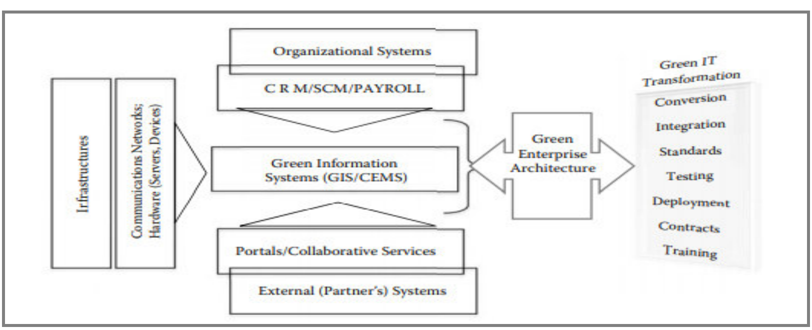


Figure 8: Green enterprise architecture impact

- **Organizational Systems -** These are the core systems that are primarily internal to the organization.
- **External Systems -** These are not just systems external to the organization, but also external interfaces of the organizational systems.
- **Infrastructure -** These are the communication Networks and Servers.

Green Solutions Architecture

- **Data:** changes here deal with creation of new carbon data and modification of existing enterprise data.
- **Services:** These include the functions, applications, and their use in analyzing green data. Services plot trends, estimate emissions, enable reporting, and create opportunities for collaboration.
- **Interfaces:** These are primarily the display mechanism of the services and applications. Figure 9 shows three interfaces as graphic user interfaces (GUI), the reporting and related physical interfaces, and the web service interfaces. They form the front-end of the GSA and enable personalization of services.

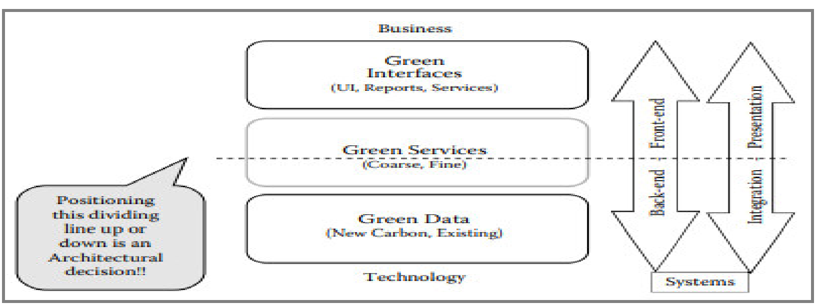


Figure 9: Fundamentals of GSA

Evolution of Green System Architecture (Basic through Linear to Collaborative)

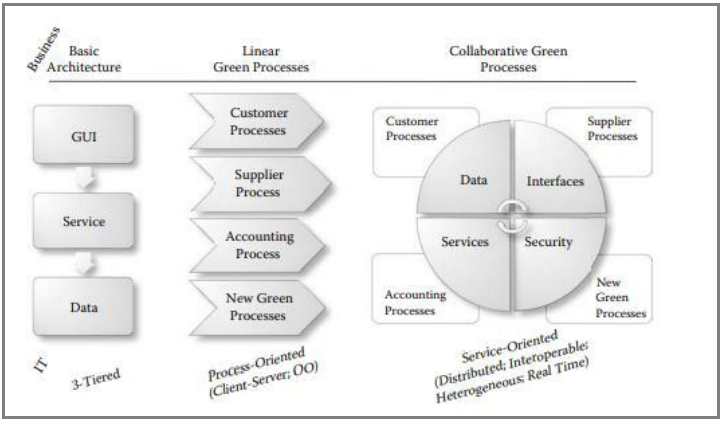


Figure 10: Evolution of Green System Architecture

- A GEA has evolved from a basic base 3-tiered architecture, to a collaborative green process architectures.
- The data, services, interfaces, and security apply to existing and new green processes in a collaborative manner.
- Figure 9 shows a basic architecture which has evolved as shown in figure 10 (collaborative green process) that makes use of concepts of SOA (service oriented architecture) and WS (web services).
- The linear green processes would be the typical business processes such as customer, supplier, and accounting.
- Linear processes also include totally new green processes within the organization such as counting carbon PPM.

- The collaborative processes on the right will include the data, services, interfaces, and security that encompass all the aforementioned processes that are now interconnected through WS.
- These collaborative processes are both internal and external to the organization.

Aspects of Green Solutions Architecture

- The Green IT solutions deal with internal carbon recording, reporting of carbon externally, implementation of SaaS-based solutions, collaborative green services and also technology-based opportunities for new green services.
- In order to deal with the aforementioned impact, the solution space of the enterprise uses many technologies.
- GEA facilitates incorporation of technologies in the Green IT solutions by providing the right interfaces and models.
- Figure shows these technologies as virtualization, Cloud computing, real-time decision making, smart network management, self-healing, alignment, integration, and optimization.
- The solutions space has its own internal Green IT framework that encourages the solutions architects and the systems analysts to continuously identify new and emerging technologies, model them to examine their repercussions, and eventually incorporate in the overall architecture of the organization.

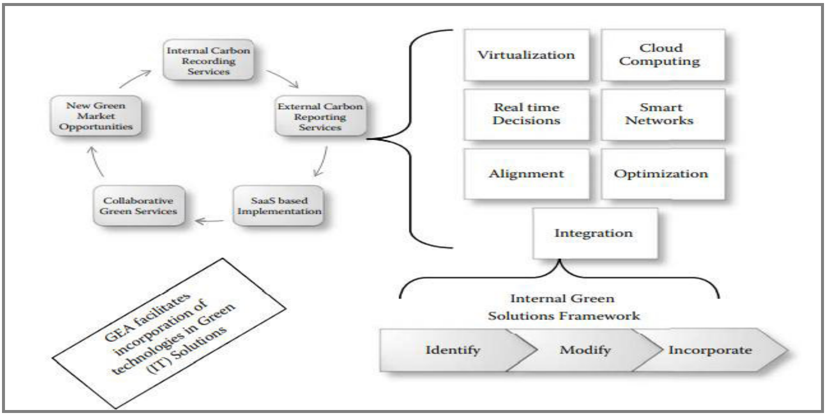


Figure 11: Various aspects of a Green solutions architecture

2.4 Green Supply Chain Management

Green supply chain systems, especially with mobile technologies incorporated in them, are a major component of GEA. They reduce inventories, costs, and carbon. However they require contract negotiations. SCM (Supply chain management) have evolved rapidly to automate and optimize the lifecycle of material procurement. Similarly, SCM are also integral to procurement and use of equipments and corresponding infrastructure. Integration with supply chains has also been studied resulting in integrated SCM (ISCM) and its extended to incorporate environmental considerations within them resulting in Green integrated supply chain management (GISCM) that brings together various stakeholders in the supply chain within and outside the organization.

These characteristics of a good ISCM are converted to handle the environmental issues related to the supply chain. Following are the advantages of GISCM (Green Integrated SCM):

- ❖ Reduction in unwanted inventory.
- ❖ Improved usage of infrastructure/equipment through sharing of resources
- ❖ Reduction in carbon overhead relating to material transfer and storage.
- ❖ Optimize the number of people in handling material.
- ❖ Eliminate business processes that do not add direct value to the most optimum movement of goods, thereby reducing carbon.
- ❖ Real-time integration and improved logistics of distribution centres reduces carbon.
- ❖ Planning the demand and supply, management of infrastructure planning, and planning the production includes environmental consciousness and metrics.
- ❖ Sourcing of materials, services, maintenance of catalogs, collaborative supply management of electronic payments are integrated and measured to ensure reduction in carbon.
- ❖ Integration in supply chain enables optimum product lifecycle management, demand planning, production management, and event management.
- ❖ Improved and effective handling of returns from customers.
- ❖ Mobile supply chain management (MSCM) can bring together, dynamically, factors such as number, location,

and size of warehouses; corresponding distribution centres and facilities; and relationships with distributors and customers.

- MSCM bring together technology infrastructure, demand planning, forecasting, sourcing, production, logistics, scheduling, inventory, and transportation that are also supported by mobile devices.
- MSCM can also use radio frequency identification devices (RFIDs) to improve material handling in distribution logistics.
- At individual customer levels, shipping, receiving, and store deliveries are also improved through mobility resulting in optimized business processes and reduced carbon emissions.

2.5 The Environmental Intelligence Domain

BI (Business Intelligence) can be considered as a technology that enables users to not only access historical and current data but to also create new correlations. These new correlations between data items produce insights that are used in business—to optimize processes, enhance customer experience, and reduce inventories. BI systems typically include online analysis, reporting, data mining, provision of consolidated dash boards, and enabling business performance management.

EI (Environmental Intelligence) combines tools, architecture, databases, data warehouses, business performance methodologies, and quality initiatives in order to produce environmentally responsible decisions and action. EI is further enhanced by the availability and application of mobility that enhances decision support system (DSS), executive information system (EIS), and knowledge management system (KMS).

This evolving EI complexity is understood as follows:

(a) ***Data***: Identification of carbon data related to equipments (gadgets) across the company that generates greenhouse gases; Provisioning the step-by-step collection and collation of thecarbon-related data within the organization.

(b) ***Information:*** Analysis and processing of the data in order to provide information to all parties concerned regarding the carbon-position of the organization.

(c) ***Process:*** Optimizing procedures and controls within the organization using the concepts of business process modeling (BPM) to ensure efficiency; developing an understanding of process maturity in the context of green processes.

(d) ***Knowledge:*** Incorporation of external climate change data such as those provided by governmental bodies or other third-parties, into the internal systems of the company by using WS and Cloud computing fundamentals.

(e) I***ntelligence***: This is the semantic green enterprise, where the systems embrace people machine continuum.

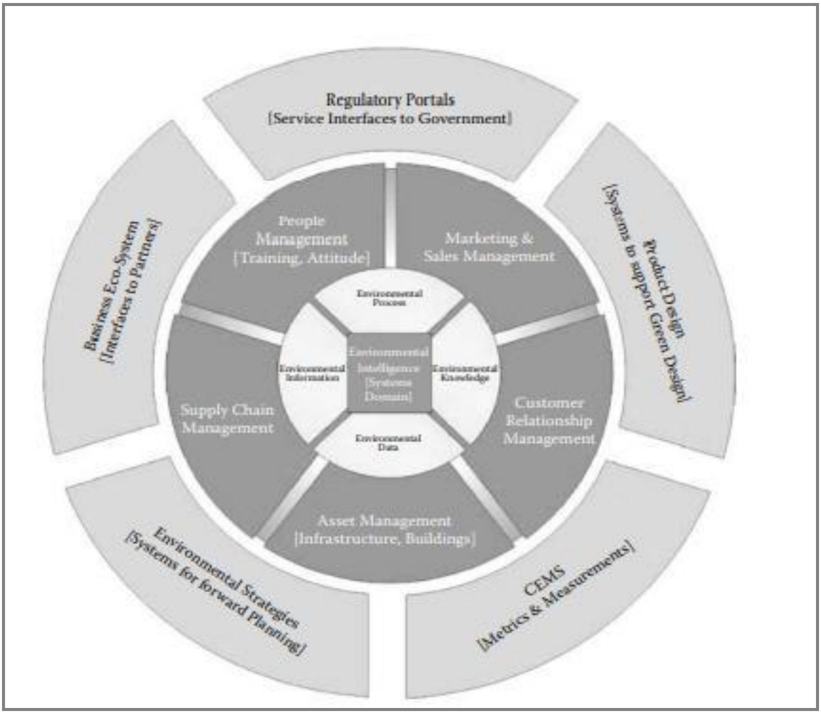


Figure 12: Environmental Intelligence

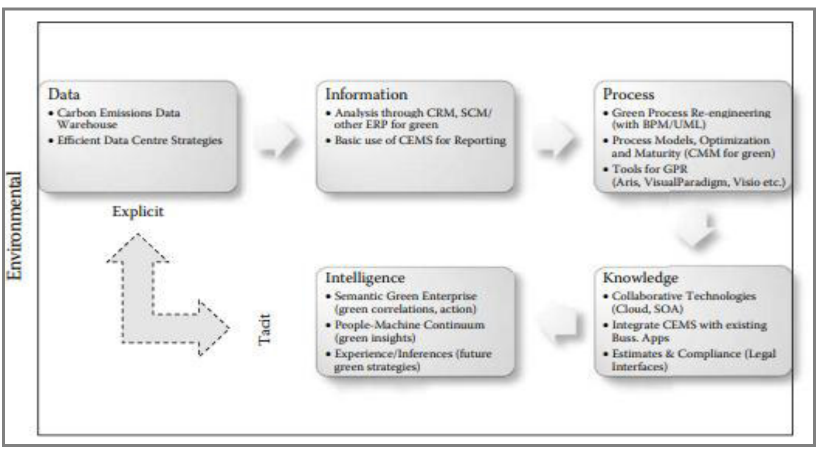


Figure 13: Environmental Intelligence - complexities

2.6 Green Information Systems: Design and Development Models.

What is GIS?

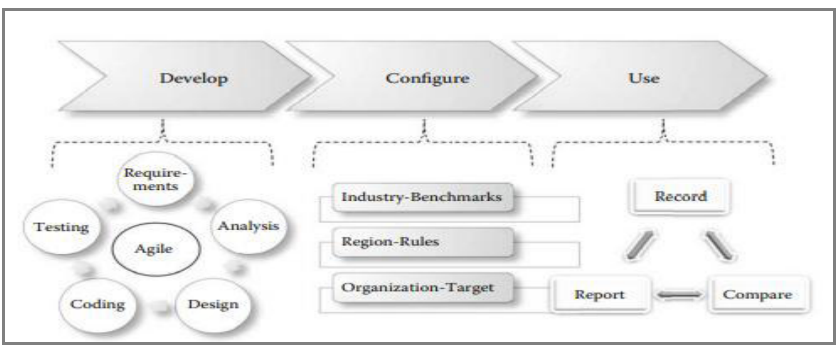
A GIS (or a CEMS (Carbon Emission Management Software) **or EIS**(Environmental Intelligence System)) is a software system that provides support to the business to implement its environment responsible business strategies (ERBS), it has processes and applications that help analyze that data, identify the trends, and, eventually, it has interfaces that present, report, and interact (and collaborate) with other external sources of carbon services and data.

Phases in a GIS Development and Deployment

Develop — GIS needs to be developed by following agile practices and considering the important phases of a SDLC starting from requirements, analysis, design, and code to testing.

Configure — configuring GIS according to benchmarks and rules of organization. This would be an activity specific to each organization within each industry sector.

Use — Use of GIS will lead to ongoing recording of carbon data creation of reports as well as comparisons.



The features of a GIS that play a significant role in enhancing this ability of business to coordinate its environmentally responsible approaches can be listed as follows:

Collecting environment-related data in real time.

Enhancing the decision-making capabilities of senior management by collating and computing up-to-date information from varied external sources (e.g., government regulatory bodies and weather information) and feeding that into GIS.

GIS substantiates the green effort of the organization through the metrics, thereby providing positive feedback and impact on the employees' job satisfaction.

GIS can continuously identify and upgrade business processes and business practices in manufacturing, sales, and field support operations in order to make them environmentally responsible.

GIS provides feedback to customers and other external users of the business

Aligning office and home activities through GIS can be a tremendous boost to the organizational effort in improving its green credentials.

GIS extends the tools and techniques of business management and applies them to the environmental aspect of business.

GIS enables collaboration amongst businesses for the purpose of achieving environmental responsibilities.

Modeling and Architecting GIS—Requirements, Design, Implementation, and Testing

GIS Requirements

A typical GIS would involve two subsystems:

- Green organizational portal (GOP)
- Regulatory standards portal (RSP)

Green Organizational Portal

The GOP is made up of organizational data on its "green" performance. These data are updated by the organizational representatives on an ongoing basis.

These data record the organization's pollutant performance such as

(a) heat generated by the desktop machines, data centres and network equipments within the organization,

(b) carbon emissions in the petrol/diesel consumed by the organization, and

(c) hazardous materials produced by the organization's activities such as lead in batteries and mobile phones.

Regulatory Standards Portal

RSP is a large portal that will be maintained by the government agency responsible for emission control within a country or region. The RSP will have to have detailed and continuously updated information on the pollutant categories that are producing the carbon emissions.

GIS—Technical Requirements

In addition to functional requirements, GIS also has operational technical requirements.

They are listed as follows:

GIS should be able to run in a wide variety of platforms such as Windows, Unix, Linux, and so on.

GIS should be able to operate on a variety of hardware including PC, laptop, and mobile devices.

The data should be stored in a server located in a secure environment. However, network connectivity with the applications should be on a 24×7 basis.

GIS will be deployed as SaaS via internet.

GIS user access should be based on a secured identification and password.

Users will have levels of authorization and access which will be administered by system administrators.

The GIS should have a sophisticated firewall that would block unwanted connections from outside the organizational boundary.

GIS should incorporate encryption. Public key encryption is a preferred mode although secret key encryption can be considered for the sake of speed.

A virtual private network (VPN) would be e stablished to ensure private communication between collaborating organizations using the same GIS.

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

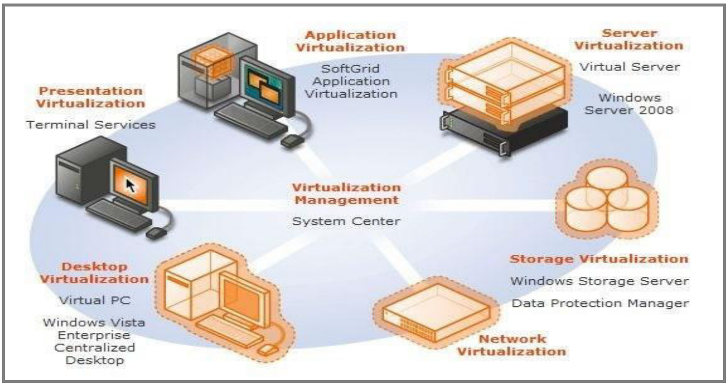


Figure 3.1 Virtualization Management

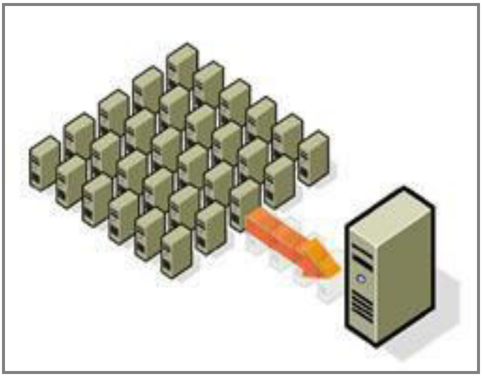
3.1.1.1 Desktop Virtualisation

- 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

3.2 Role of Electric Utilities

IT equipment has become the third largest source of power demand in the commercial sector, accounting for more than 10% of an organization's energy use.

In fact, IT and related communications technologies now account for more than 2% of all global CO_2 emissions.

To improving the energy efficiency and environmental friendliness of your IT Department can be a real challenge.

The easiest way to reduce energy costs is to implement an easy and cost-effective PC power management solution.

The Challenge of Power Management

- ❖ A typical PC consumes between 400 kWh (kilowatt hours) and 600 kWh of electricity each year, depending on the brand, how it is equipped (e.g. LCD or CRT monitor), and how hard the CPU is working.
- ❖ The average cost of a kilowatt hour of electricity in the United States averaged $.0898, and ranged from $.0533 to $.2536.
- ❖ Assuming all computers in a 10,000 machine environment are left turned on all of the time these rates would result in an annual cost for electricity of somewhere between $1,867,632 and $13,329,216.
- ❖ If you consider that 50% of all PC's are left on both overnight and on weekends (70% of the total hours each week), it's reasonable to expect that actively implementing effective power management policies across the organization can result in savings of up to 35% (i.e. 50% of 70%) on your PC-related electrical bill.
- ❖ Given the heat generated by a PC, reducing the number of hours that each PC is turned on each day will reduce the cost of electricity for air conditioning in warmer months.

3.2.1 Role of Telecommuting, Teleconferencing and Teleporting

Teleworking technologies are variously implemented for green computing initiatives and many advantages include lower greenhouse gas emissions related to travel, greater worker satisfaction and, as a result of lower overhead office costs, increased profit margins. Teleconferencing and telepresence technologies are often implemented in green computing initiatives.

The ways in which telecommuting is eco-friendly.

- ❖ It reduces carbon emissions. Whether it's by planes, trains or automobiles, traveling in to work has a negative impact on the environment. Cutting the commute, thus prevents an excessive amount of carbon emissions to go into the air.
- ❖ It reduces electricity. When people work in an office, almost everything is powered by electricity. From lights to computers and printers—even the coffee machine—everything consumes large quantities of electricity.
- ❖ Working at home allow reduce electricity consumption to what it really takes to make home office run.
- ❖ It reduces paper printing.
- ❖ It makes you take better care of your equipment. Think about how often you actually shut down your computer at work.
- ❖ In addition to flexible schedule and saving time and money, telecommuting also greatly helps the environment.

Why Telecommuting is a Green Way to Work

Studies have shown that remote workforces contribute to sustainable, environmentally-friendly workplaces by reducing congestion, lowering fuel consumption, minimizing construction, lessening pollution emissions, reducing the strain on transportation systems, and improving air quality.

Example: Dell and Xerox have experienced this first-hand.

The average U.S. commuter produces an estimated 380 lbs. of CO2 each year during rush hour, but switching to full-time telecommuting reduces each person's work-related carbon footprint by 98 percent.

According to Global Workplace Analytics, if workers in the U.S. who held telework-compatible jobs (50 percent) and wanted to (79 percent) worked from home just two days a week, the U.S. as a whole would:

- **Gas Use:** Save nearly 52 million gallons of gas—the greenhouse gas equivalent of taking approximately 88,000 vehicles off the road per year.
- **Oil:** Save over 2.6 million barrels of oil, valued at over $264 million.
- **Roads:** Reduce wear and tear on highways by over 1 billion miles a year.

The advantages are many-

- Increased worker satisfaction,
- Reduction of greenhouse gas emissions related to travel, and
- Increased profit margins as a result of lower overhead costs for office space, heat, lighting, etc.

Implementation

- Blackle
- Fit-PC: a tiny PC that draws only 5w
- Zonbu Computer
- The Asus Eee PC and other ultra portables

Blackle

- Blackle is a search-engine site powered by Google Search.
- Blackle came into being based on the concept that when a computer screen is white, presenting an empty word page or the Google home page, your computer consumes 74W.When the screen is black it consumes only 59W.
- Based on this theory if everyone switched from Google to Blackle, mother earth would save 750MW each year.

Fit-PC:

- A tiny PC that draws only 5w
- Fit-PC is the size of a paperback and absolutely silent, yet fit enough to run Windows XP or Linux.
- Fit-PC is designed to fit where a standard PC is too bulky, noisy and power hungry.
- Fit-PC draws only 5 Watts, consuming in a day less power than a traditional PC consumes in 1 hour.

Zonbu Computer

- The Zonbu is a new, very energy efficient PC.
- The Zonbu consumes just one third of the power of a typical light bulb.
- The device runs the Linux operating system using a 1.2 gigahertz processor and 512 meg of RAM. It also contains no moving parts, and does even contain a fan.

The Asus Eee PC and other ultra portables

- The "ultra-portable" class of personal computers is characterized by a small size, fairly low power CPU, compact screen, low cost and innovations such as using flash memory for storage rather than hard drives with spinning plotters.
- These factors combine to enable them to run more efficiently and use less power than a standard form factor laptop. The Asus Eee PC is one example of anultraportable.

3.2.2 Limitations

- Green Computing could be quite costly.
- Some computers that are green may be considerably underpowered.
- Rapid technology change.

3.3 Materials Recycling

3.3.1 E-Waste Definition

- E-Waste for short - or Waste Electrical and Electronic Equipment - is the term used to describe old, end-of-life or discarded appliances using electricity.
- It includes computers, consumer electronics, fridges etc which have been disposed of by their original users.
- "e-waste" is used as a generic term embracing all types of waste containing electrically powered components.
- e-Waste contains both valuable materials as well as hazardous materials which require special handling and recycling methods.
- Examples: Computers, LCD / CRT screens, cooling appliances, mobile phones, etc., contain precious metals, flame retarded plastics, CFC foams and many other substances.

3.3.2 Categories of e-waste

- Large Household Appliances
  - Washing machines, Dryers, Refrigerators, Airconditioners, etc.
- Small Household Appliances
  - Vacuum cleaners, Coffee Machines, Irons, Toasters, etc.
- Office, Information & Communication Equipment
  - PCs, Laptops, Mobiles, Telephones, Fax Machines, Copiers, Printers etc.

- Entertainment & Consumer Electronics
  - Televisions, VCR/DVD/CD players, Hi-Fi sets, Radios, etc
- Lighting Equipment
  - Fluorescent tubes, sodium lamps etc. (Except: Bulbs, Halogen Bulbs)
- Electric and Electronic Tools
  - Drills, Electric saws, Sewing Machines, Lawn Mowers etc.
- Toys, Leisure, Sports and Recreational Equipment
  - Electric train sets, coin slot machines, treadmills etc.
- Medical Instruments and Equipment
- Surveillance and Control Equipment
- Automatic Issuing Machines

Figure 3.2 E-waste types

3.4 Recycling Technologies

e-Waste management practices comprise of various means of final disposal of end-of-life equipment which have different impacts on human health and the environment. It can be distinguished between state-of-the-art recycling technologies, which comply with high environmental and occupational health standards and hazardous technologies that bear a great risk for both health and the environment and are often applied in countries, where no strict standards exist.

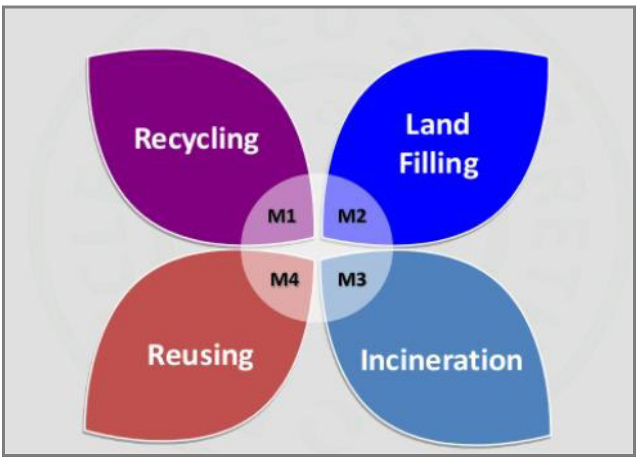


Figure 3.3 e-waste disposal

3.4.1 Hazardous Technologies

❖ **Incineration:**

Incineration is the process of destroying waste through burning. Because of the variety of substances found in e-waste, incineration is associated with a major risk of generating and dispersing contaminants and toxic substances.

❖ Open Burning:

Since open fires burn at relatively low temperatures, they release many more pollutants than in a controlled incineration process at an MSWI-plant. Inhalation of open fire emissions can trigger asthma attacks, respiratory infections, and cause other problems such as coughing, wheezing, chest pain, and eye irritation. Often open fires burn with a lack of oxygen, forming carbon monoxide, which poisons the blood when inhaled.

❖ Land filling:

Land filling is one of the most widely used methods of waste disposal. However, it is common knowledge that all landfills leak. The leach ate often contains heavy metals and other toxic substances which can contaminate ground and water resources.

3.4.2 State-of-the-art Recycling Technologies

The state-of-the-art recycling of e-waste comprises three steps

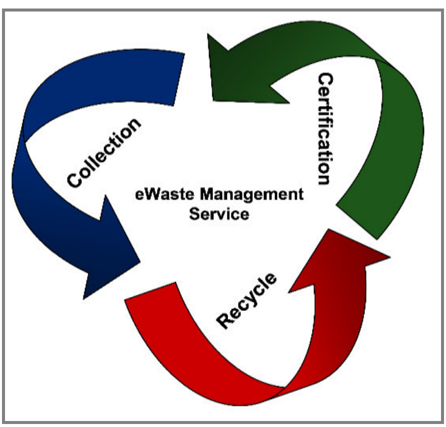


Figure 3.4 e-waste management services

❖ Detoxication

The first step in the recycling process is the removal of critical components from the e-waste in order to avoid dilution of and / or contamination with toxic substances during the downstream processes. Critical components include, e.g., lead glass from CRT screens, CFC gases from refrigerators, light bulbs and batteries.

❖ Shredding

Mechanical processing is the next step in e-waste treatment, normally an industrial large scale operation to obtain concentrates of recyclable materials in a dedicated fraction and also to further separate hazardous materials.

❖ Refining

The third step of e-waste recycling is refining. Refining of resources in e-waste is possible and the technical solutions exist to get back raw with minimal environmental impact. Most of the fractions need to be refined or conditioned in order to be sold as secondary raw materials or to be disposed of in a final disposal site, respectively. During the refining process, to three flows of materials is paid attention: Metals, plastics and glass.

3.4.3 E-waste Management – Six Steps

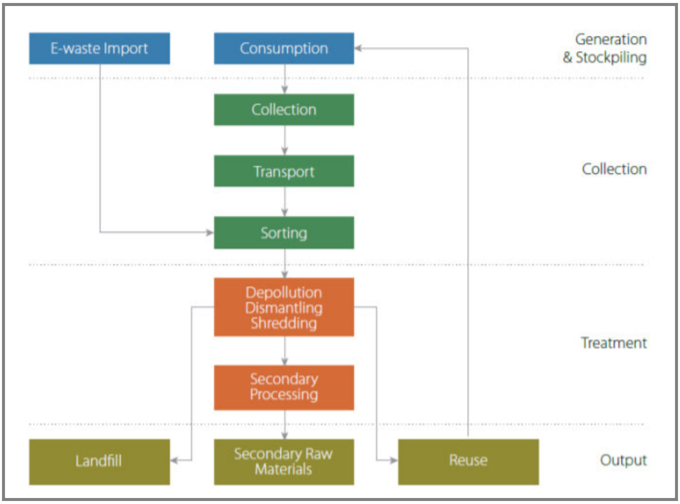


Figure 3.5 six steps to e-waste management

3.4.4 Benefits of recycling

Recycling raw materials from end-of-life electronics is the most effective solution to the growing e-waste problem. Most electronic devices contain a variety of materials, including metals that can be recovered for future uses. By dismantling and providing reuse possibilities, intact natural resources are conserved and air and water pollution caused by hazardous disposal is avoided. Additionally, recycling reduces the amount of greenhouse gas emissions caused by the manufacturing of new products.

3.5 BEST WAYS FOR GREEN PC

The hardware aspect of Green IT deals with the architecture and design of IT hardware, the manner in which it is procured and operated. The operational energy consumption is a major issue for computer manufacturers. The impact a good, energy optimum design can have on the overall energy consumed by a piece of hardware over its entire life has to be studied with utmost care. A purpose-built computer chip, or an efficient laptop battery design has potentially greater impact in reducing carbon emissions over its lifetime than its operation would have.

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 have both wired and wireless networks and other corresponding communications equipment associated with them that are directly emitting carbon.
- End-user computers: laptops, desktops, their capacities, operational efficiencies, and their disposal need to be discussed from t heir P-O-D viewpoint. While the efficient design and manufacturing of these end-user devices remains the perceiver of the hardware manufacturers, the efficient operation and disposal is with the user organization.
- Mobile devices: the mobile devices and associated hardware, their batteries including the recharging mechanism and disposal of the batteries and the policies and actions when the devices become outdated. The mobile devices P-O-D is heavily affected by the user's attitude. Thus, a sociocultural issue is an important contributor to the carbon behavior of these devices.

- Peripherals: printers, photocopiers, shredders, and so on. These electronic gadgets are of immense interest in Green IT due to their large numbers and overuse. These devices has more operational waste and the carbon associated with the eventual disposal of these fast moving items.

The carbon emissions from each of these Green IT hardware group mentioned above is affected by its procurement, operations, and disposal (Green P-O-D) phases in its lifecycle. Procurement focuses on well-designed, low-carbon emitting data servers or monitors, buying it from a green supplier and using the most efficient means of packaging and transporting the equipment. Operation is the ongoing use of hardware in an efficient and effective manner. Attitude of the end-user, affected usually by visible metrics, plays a significant part here. Disposal of IT equipment requires utmost care. The Green P-O-D phases are practiced based on the policies of the organization.

3.5.1 Best practices for Green PC

The following are some of the tips to accomplish green PC:

- **Buy energy efficient hardware:**
  - New offerings from major hardware vendors include notebooks, workstations, and servers that meet the EPA's Energy Star guidelines for lower power consumption.
  - Multicore processors increase processing output without substantially increasing energy usage.
  - Also look for high efficiency (80%) power supplies, variable speed temperature controlled fans, small form factor hard drives, and low voltage processors

- **Use power management technology and best practices:**
  - Modern operating systems running on Advanced Configuration and Power Interface (ACPI)-enabled systems incorporate power-saving features that allows to configure monitors and hard disks to power down after a specified period of inactivity.
  - Systems can be set to hibernate when not in use, thus powering down the CPU and RAM as well.
  - Hardware vendors have their own power management software, which they load on their systems or offer as options.
  - There are also many third-party power management products that can provide further flexibility and control over computers' energy consumption.
- **Use virtualization technology to consolidate servers:**
  - The number of physical servers can be reduced, and thus the energy consumption, by using virtualization technology to run multiple virtual machines on a single physical server.
  - Because many servers are severely underutilized the savings can be dramatic.
- **Consolidate storage with SAN/NAS solutions:**
  - Just as server consolidation saves energy, so does consolidation of storage using storage area networks and network attached storage solutions.

- The Storage Networking Industry Association (SNIA) proposes such practices as powering down selected drives, using slower drives where possible, and not overbuilding power/cooling equipment based on peak power requirements shown in label ratings.

❖ **Optimize data centre design:**

- Data centres are huge consumers of energy, and cooling all the equipment is a big issue.
- Data centre design that incorporates hot aisle and cold aisle layout, coupled cooling, and liquid cooling can tremendously reduce the energy needed to run the data centre.
- Another way to "green" the data centre is to use low-powered blade servers and more energy-efficient uninterruptible power supplies, which can use 70 percent less power than a legacy UPS.
- Optimum data centre design for saving energy should also take into account the big picture, by considering the use of alternative energy technologies and catalytic converters on backup generators, and from the ground up, by minimizing the footprints of the buildings themselves.
- Energy-monitoring systems provide the information you need to measure efficiency.

❖ **Use thin clients to reduce GPU power usage**

- Another way to reduce the amount of energy consumed by computers is to deploy thin clients.

- Because most of the processing is done on the server, the thin clients use very little energy.
- A typical thin client uses less power while up and running applications than an Energy Star compliant PC uses in sleep mode.
- Thin clients are also ecologically friendly because they generate less e-waste.
- There's no hard drive, less memory, and fewer components to be dealt with at the end of their lifecycles.

❖ **Use more efficient displays**

- Replace the old CRT monitors with LCD displays. This can save up to 70 percent in energy costs.
- Not all LCD monitors are created equal when it comes to power consumption.
- High efficiency LCDs are available from several vendors.

❖ **Recycle systems and supplies**

- To reduce the load on already overtaxed landfills and to avoid sending hazardous materials to those landfills, old systems and supplies can be reused, repurposed, and/or recycled.
- This hand-me-down method allows two workers to get better systems than they had, while requiring the purchase of only one new machine.
- Old electronics devices can also be reused by those outside the company.

- Much electronic waste can be recycled, the parts used to make new items. Things like old printer cartridges, old cell phones, and paper can all be recycled.

❖ **Reduce paper consumption**

- Another way to save money while reducing your company's impact on the environment is to reduce your consumption of paper.
- This can be done by switching from a paper-based to an electronic workflow: creating, editing, viewing, and delivering documents in digital rather than printed form.
- Send documents as e-mail attachments rather than faxing.
- When printing is unavoidable, you can still reduce waste and save money by setting your printers to use duplex (double-sided) printing.

❖ **Encourage telecommuting**

- The ultimate way to have a greener office to have less office.
- By encouraging as many workers as possible to telecommute, you can reduce the amount of office space that needs to be heated and cooled, the number of computers required on site, and the number of miles driven by employees to get to and from work.
- Telecommuting reduces costs for both employers and employees and can also reduce the spread of contagious diseases.

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

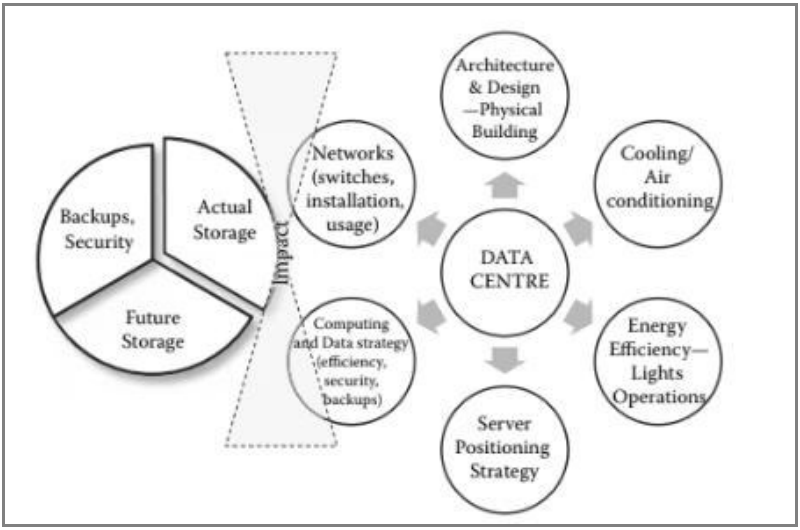


Fig 3.6: Influencing factors of Green data centre

❖ **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

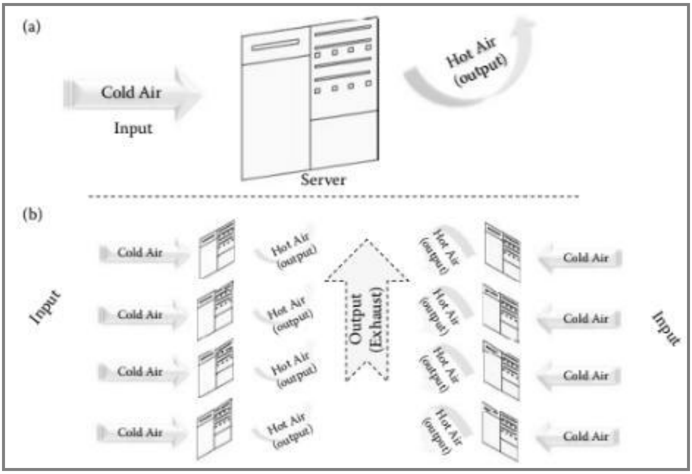


Fig 3. 7: Two ways of physical arrangement of servers

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.

3.7 GREEN GRID FRAMEWORK

The Green Grid is a nonprofit consortium whose mission is to become the global authority on resource efficiency in information technology and data centres. According to The Green Grid website, the organization provides a forum for IT directors, facilities managers and C-level executives to come together and discuss different options for improving resource efficiency. Findings and recommendations from these forums are published on a regular basis. Metrics created and endorsed by The Green Grid include:

- Electronic Disposal Efficiency (EDE) - the percentage of decommissioned information technology electronics and electrical equipment that is disposed of through known responsible entities.

- Power Usage Effectiveness (PUE) - the ratio of total facilities energy to IT equipment energy.
- Data Centre Infrastructure Efficiency (DCIE) - the ratio of IT equipment power to total facility power.
- Carbon Usage Effectiveness (CUE) - the product of the amount of carbon dioxide emitted per kilowatt hour (CEF) and the data centre's annual PUE.
- Water Usage Effectiveness (WUE) - the ratio of the annual site water usage in liters to the IT equipment energy usage in kilowatt hours (Kwh).
- Data Centre Productivity (DCP) - the quantity of useful information processing completed relative to the amount of some resource consumed in producing the work.

Deliverables of Green Grid:

Data Collection

- **Data Centre Standards and Metrics Inventory** – this study will document existing standards and metrics for energy efficiency, identify coverage gaps and make recommendations for future development.
- **The Green Grid Metrics: Describing Data Centre Power Efficiency** – this study will be an update to The Green Grid's existing study on data centre efficiency metrics and will look at workload classification through a data centre segmentation model.

- **Operationalizing Energy-Efficiency Data Collection** – this study will identify the requirements for collecting and aggregating data centre power consumption data.
- **Data Assessment**
- **Data Centre Efficiency Baseline Market Study** – this study on the current state of the industry will allow The Green Grid to identify key factors driving companies to take action on data centre power consumption and the challenges in doing so. Collecting and analyzing this data will help to provide companies with a baseline to compare their own initiatives, goals and performance.
- **Operational Best Practices** – these studies will focus on right-sizing the data centre and will outline best practices in the adoption of virtualization and consolidation technologies.
- **Database for Data Centre Performance** – The Green Grid will begin development work on a database focused on data centre characteristics and performance schema.
- **Technology Proposals**
- **Initial Technology Roadmap** – this roadmap provides an initial assessment of existing and emerging technologies affecting data centre efficiency and performance, taking into consideration both return on investment and risk to the end user.
- **Power Distribution Options for the Data CentreStudy** – this study will look at the qualitative advantages and

disadvantages of data centre power distribution configurations.

- **Cooling Options Study** – this study will focus on the qualitative advantages and disadvantages of data centre cooling architectures.

4

GREEN COMPLIANCE

4.1 GREEN COMPLIANCE

Environmental Compliance or green compliance are the actions performed during or after operations to obey the requirements of all Environmental Laws or contractual commitments related to reclamation of the Properties or other compliance with Environmental Laws.

- In a broad sense, green compliance involves conforming to various state, federal and local environmental laws and regulations.
- This a broad range of regulations, laws and standards created to manage the environment.
- The legislation affects everyone from householders to multi-national companies.
- The scope of green compliance includes wide range of areas such as carbon emissions, carbon management,

water quality, site permits, waste handling and storage, etc.

❖ The set of laws, regulations and standards vary from country to country.

❖ The purpose of this type of legislation is to make sure businesses that manufacture, import and sell products are responsible for their end of life environmental impact.

❖ Some of the goals of green compliance includes:

  ✷ Tracking of programs and schedules to ensure that steps requires to comply with the agreement is done.

  ✷ Processing, validating and evaluating data for compliance with reporting or creating alerts

  ✷ Generating compliance reports for internal purpose and for government agencies.

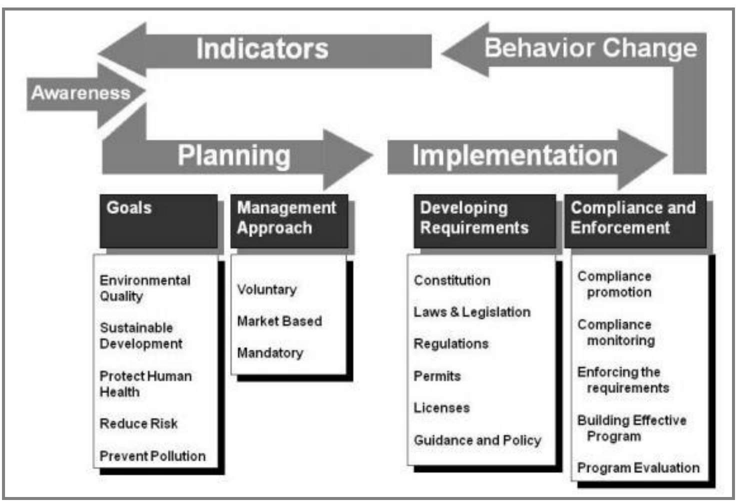


Fig 4.1: Green Compliance management lifecycle

The green compliance management lifecycle involves the following steps:

- **Defining the goals**
  - The first phase starts with awareness or acceptance that there is an environmental problem and there exists adequate support to address the problem.
  - Then the program supporters must begin strategic planning and goal setting.
  - These primary goals will focus on reducing environmental risk, preventing pollution, reducing harmful emissions or clearing past contamination.
- **Selecting a Management Approach**
  - The focus shifts to selecting the appropriate management approach or hybridization of existing approaches, to achieve program goals.
- **Developing Requirements**
  - The chosen approach may require the support from specific laws or regulations.
  - Laws and regulations, will include some specific requirements that define specific practices and procedures to directly or indirectly reduce or prevent harmful environmental effects.
- **Evaluation, Compliance and Enforcements**
  - Evaluating the impact of the implemented program through the use of compliance and enforcement

indicators is very crucial to measure the success of the management strategy.

- Evaluation leads to greater awareness of how the program is addressing the targeted environmental problem.
- The evaluation process results in development of compliance and enforcement indicators.

4.2 SOCIO- CULTUTAL ASPECTS OF GREEN IT

The socio-cultural aspect of any technology should adhere to the following aspects:

- maintaining decent work
- establishment of health care, safety and good working conditions
- commitment to improving environmental quality
- promoting environmental education
- promoting sustainable development in the construction industry
- the participation of government social projects
- encouraging "socially inclusive" motions
- producing maintenance manuals for buildings and systems users

The revolution in Green IT should comply with certain regulations, laws and standards apart from adhering to the socio cultural and political status of the region. Any organization that shifts its focus towards Green IT must adopt green working style and the employees must develop a green attitude.

- ❖ The social implications of Green IT is purely subjective. The degree of commitment by the employees and stakeholders directly influence the green transformation of the organization.
- ❖ Effectiveness of green transformation changes depend on the leadership changes. Significant amount of subjectivity in the decisions and practice of Green IT by the leadership.
- ❖ Green transformation of an entire society involves green ethics, morals, value systems, and attitude across multiple layers of people.
- ❖ This makes environmental changes for the society even more complicated than organizational and governmental changes.
- ❖ Initial efforts for green transformation by business units faces the social challenge of resistance to change. There is a great variation in the way in which the resistance to green transformation appears in various industry sectors.
- ❖ Government is also involved in the resisting activities
- ❖ Training and awareness associated with the Green IT issues can play a key role in handling the subjective nature of green transformation.
- ❖ The social values change and green consciousness gets inbuilt in the new generation of individuals.

- But this sociocultural transformation takes time to achieve and needs to be accommodated with the economic reforms and innovative market-driven setup.
- Discussions on the social aspects of green IT should include individuals, governments and industrialists as the environmental responsibility affects the structure and operation of the organizations and the society in which it exists.
- The outcome of this discussion results in Corporate Social Responsibility.

Corporate social responsibility (CSR) is a self-regulating business model that helps a company be socially accountable to itself, its stakeholders, and the public.

4.2.1 Organizational knowledge

- Any organization can discharge its CSR by incorporating Green IT in both subjective and explicit domains of the organization by delving the knowledge.
- The organizations needs to be environmentally and socially responsible.
- It requires regular and unified systems for knowledge management to implement Green IT.
- This is because an organization has to learn how to develop the necessary capacities and capabilities in discharging its CSR.

- Knowledge management brings about behavioral change within the organizations relating to sustainability.
- As the enterprise evolves to a green enterprise, there are changes associated with attitude, leadership and management styles, interpretation of technology, and the business environment.
- These subjective change require the organization to implement green knowledge management.

The process of systematically and actively managing and leveraging the stores of carbon-related knowledge in the organization is termed as Green knowledge management.

- The green knowledge management systems involve synchronization of the tacit and explicit bodies of knowledge carried by its stakeholders.
- This knowledge synchronization aspect of Green IT becomes more challenging in global, multinational organizations, whose business units and subsidiaries are often spread across geographical regions, exhibiting their quite distinct cultural attitudes and characteristics.
- Stakeholders in such global organizations need to particularly consider cross-cultural interactions in their green initiatives.

4.2.2 Issues with Green stakeholders

- Inoder to handle cross-cultural issues in long-scale green transformation is increasing the opportunities for physical (face-to-face) communications among the diverse stakeholders.

- ❖ Information flow between various groups of employees in different regions supported by the organizational change management is required for successful transition to a green organization.
- ❖ The issues relating to collaborative groups of people and organizations include their individual preferences, corporate policies, government regulations, social norms and practices, and ethical codes of conduct, different age groups, their preferences as customers, employees, and regulations, and their sociocultural background.

4.2.3 Role based Green IT

- ❖ Green IT initiatives and their subjective interpretations are based on various roles.
- ❖ When it comes to organizational stakeholders, these roles within an organization require detailed study.
- ❖ Green IT initiatives thus continue to have a wide-ranging subjective impact on the individuals and roles they play at work.
- ❖ It affects the way people are organized and operate within organizations.
- ❖ The roles and their subjective impact is given below:
  - ✷ **Decision maker:** Major interest in the ROI. But also involves in Legal, compliance requirements, however, change the balance of their ROI metrics,

Green IT strategy formulation and policies, Participation in consortiums.

- **Project manager/quality assurance manager**: Interested in the implementation of the green program, the steps to be taken for that implementation, and the successful review at the end of the project. Aims to complete the project with minimum time and budget.
- **Environmental regulator:** Creation of regulatory benchmarks. Compliance metrics, their measurements, reporting of that carbon data. Interested in issues arising out of noncompliance. Participation in standard creation.
- **Advisor (management consultant):** Analyses of the organization business processes in order to introduce green environment. How to reduce risks in implementing Green IT. Lean process. Participation in standards compliance.
- **IT consultant (including Green IT):** Model processes, optimize, smart networks, green enterprise architecture (ISO standards).
- **Engineer (manufacturing/ production):** Optimize production, improve design.
- **Technical manager:** Focus on technologies for carbon reduction.
- **Researcher:** Undertaking Green IT investigation, pure and applied research.

- Formation of attitude toward carbon emissions and its impact on the workplace provides a significant challenge to the transformation of the society to a carbon-conscious
society.

- The physical commuting (the normal, standard way of working) is replaced by land-based or wired means of communications and, eventually, totally location-independent mobile communications.

- These varied communication mechanisms have direct bearing on the carbon contents of the processes followed by these employees.

- Change in the business models by using collaborative technologies that foster resource sharing has also impacted the reduction of carbon content. These collaborative tools also enables sharing of tasks resulting in quicker completion time and less carbon.

- The underlying technologies and systems relating to environmental intelligence have also been used to reorganize processes that have a social impact.

4.2.4 Green practices

- The three areas of changes to working lifestyles that are involved in a green enterprise transformation are video conferencing, telecommuting and usage of mobile devices.

- These changes has greatly reduced the carbon footprints of the organization.

- Videoconferencing is technology that is used to better communicate with a group that may be geographically dispersed.

- Care should be taken, however, to balance the carbon savings due to the use of videoconferencing (such as fuel costs associated with vehicles or airplanes) versus the carbon generated as a result of videoconferencing itself.

- Another important user practice in the context of Green IT is reengineering of business processes of an organization based on virtual team.

- The changes resulting from formation and operation of virtual teams require corresponding changes to the processes that describe the way in which business is carried out is business reengineering.

- These virtual teams will be collaborating globally across the time z ones, with colleagues from diverse areas of business at various levels all drawn together to deliver outcomes.

4.2.5 Attitude and degree of Subjectivity in Green IT

- Subjectivity of Green IT can be viewed from a sociocultural perspective or in e role-based perspective.

- The green enterprise transformational work in the social dimension is based on bringing together the viewpoints of roles within and also outside the organization.

- The Environmental *Decision-Making* is justified as: “Given the critical state of the world’s environment, it is crucial to employ all of the beneficial knowledge, technology and tools that scientists, engineers and other professionals can offer."

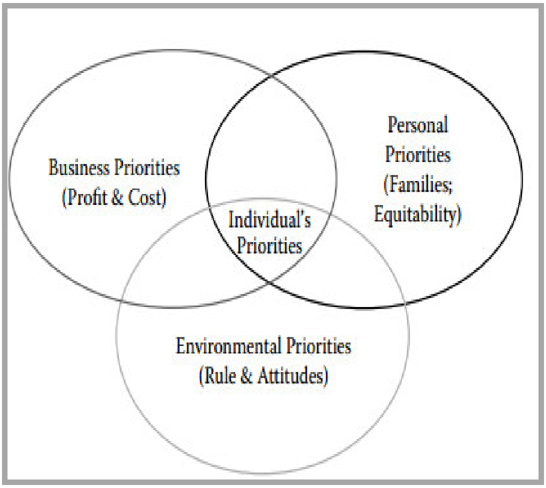


Fig 4.2: Subjectivity in Green IT

- From Fig 4.2, it is evident that the business priorities, the environmental priorities, and the personal priorities of individuals are disjoint.
- The area of intersection of these three priorities needs to be studied under the social aspect of Green IT.
- The organizational (HR) policies and practices then have to work on expanding that intersection of the three priorities.
- The domain of sustainability is highly complex and highly dependent on the context. The application and practice of sustainability requires knowledge that is specific to the context.

- The context is the situation and role played by the person. The knowledge acquired by that person confines to be local.
- Hence HR department must take utmost efforts to impart global view to the individuals in the organization.
- Imparting this knowledge makes the individuals change their attitude and behavior on carbon emission related to them.
- The data and information related to carbon emission is likely to be interpreted in accordance with the personal needs, existing attitudes, and interests of individuals.
- It is common that whenever approached with a new system, processes, and corresponding changes in the approach to work, users tend to be extremely sensitive.

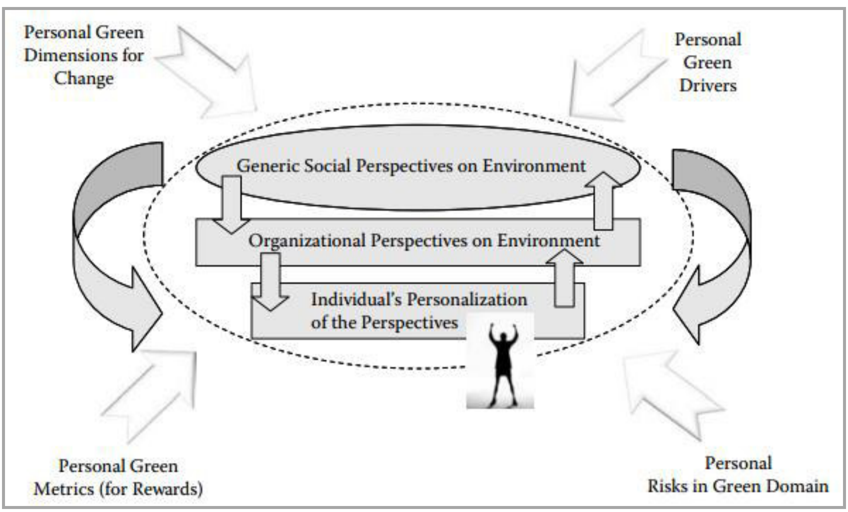


Fig 4.3: Personalization of the green context by end-users leads to change in attitude

- The success or failure of the entire green enterprise transformation program, from a social perspective, rests on the perceived ease, perceive usefulness, and perceived relevance of the initiative.
- Technology adoption, is the adoption of the Green IT systems to help, support, measure, and report on the activities and tasks of individual users.
- The effect of the green system on the career, future growth, and rewarding structure are issues of concern for the individual users.
- Starting right from the "personal" aspects of the drivers that drive this Green IT transformation and the dimensions or channels along which the transformation actually takes place, this personalization remains at the centre of the attitude of the users and their personal "buy-in."
- The tiers of influence namely social, organizational and personalized play great role in the green enterprise transformation
- The management, ICT, and other professionals within the organizations needs to collaborate in using the emerging technologies as a means to effect changes in their environmental behavior. Employee and customer participation is also very crucial for the success of Green IT.
- The strategies for acquisition and management of information as well as for proper implementation include all the employees in order to influence their practices,

secure their participation, and thus ensure success of the overall campaign-Green IT.

4.2.6 Green IT Ethics and Code of Conduct

- IT is a newer profession when compared with other professions like teaching, medicine etc.
- Green IT needs a code of conduct. Extending the current IT professional codes of conduct, and adding green-specific requirements to them, produces a list of code that individuals and organizations can strive to follow.
- Having an ethical base enables Green IT to have a common view, a common set of behavior and understanding that is shaped by the experiences of practitioners, sharing of case studies, and relating of work experiences.
- Green IT ethics are meant to provide guidelines through which an interpretation of what is commonly believed to be right or wrong can be made.
- The Green IT code of ethics also needs to delve into the seven areas of Information Criteria, that is, effectiveness, efficiency, confidentiality, integrity, availability, compliance, and reliability.
- The discussions in the context of Green IT should be communicated honestly with authenticity.
- Ethics and code of conduct for Green IT can control displeasing activities and bring in clarity and positive focus.

- This increases reliability and trust in green data, information, and knowledge dissemination.
- From the ethical point of view, Green IT needs to ensure that the transformation of the organization to a green organization contributes to society and human well-being.
- Thus the code of conduct provides the organization with guidelines and direction to remain compliant to the guidelines.
- Green transformation process must ensure ongoing compliance while evaluation of IT systems, analysis of possible risks, with their impacts.

Advantages of Green IT code of Conduct:

The following are the advantages of establishing code of conduct in Green IT:

- Agree to a fundamental obligation of business to reduce carbon emissions in all the activities.
- Conform to total honesty in recording, analyzing, and reporting of carbon data.
- Ensure that the effort to reduce carbon is undertaken in a socially responsible way and with no harm to people involved in the reduction attempt.
- Ensure ongoing effort at all levels of IT ranging from architecture, design, development, testing, deployment, and maintenance to reduce their carbon footprint.

- Ensure ongoing effort to reduce carbon in procurement, operation, and disposal.
- Promote confidentiality and integrity within the organization and the IT profession.
- Maintain security and confidentiality of carbon data and information.
- Make the carbon data available publically.
- Avoid green washing or incorrect promotion of the organization's carbon reduction effort.
- Contribute toward development of Green IT standards worldwide and their application in practice.
- Ensure participation in industry and research surveys including workshops to increase the overall body of knowledge.
- Attempt to use all emerging technologies to reduce existing carbon emissions and prevent increase in carbon emissions due to future business activities.
- Endeavour to maintain validity of carbon data by subjecting itself to regular reviews and audits.
- Maintain the security and privacy of carbon data.
- Honor contracts, responsibilities, protocols, and agreements associated with Green IT and carbon trading.
- Promote public understanding of the issues related to carbon emissions particularly in the context of the industry sector in which the individual/organization operates.

- Prioritize all business activities based on their ability to reduce carbon emissions.
- Adhere to these ethics and endeavour to create values that are based on the new green order of things.
- Ensure high level of competency in all carbon-related activities of the organization such as measurement and reporting of carbon data.
- Honestly represent "skills, knowledge, service and product" relating to carbon.
- Endeavour to interact with other disciplines within the organization to reduce the overall carbon footprint.

4.2.7 Privacy and Security issues in Green IT

- The transformation of an organization to green enterprise needs to address the privacy and confidentiality related issues of the information that is generated in the process.
- The sensitive nature of the carbon data requires careful control, secured storage, and proper reporting.
- It is the sole responsibility of the management to secure this data as the firm undergoes green transformation and later, as the data gets stored in the organizational systems.
- A trade off has to be maintained between data security and access of green information.
- The carbon data that is stored may include the emissions data pertaining to an individual, a department, or an organization in varied timespans.

- ❖ The organization has to compare their carbon footprint level with the benchmark set by the government in regular time intervals.
- ❖ Preserving the confidentiality of these data is a challenging task in large organizations.
- ❖ Elements of enterprise data architecture, principles of backup and security of data, and risks associated with maintenance of data needs to be applied to carbon data as well.
- ❖ Provisioning smart metering for automatic recording and analysis demands stricter security measures to protect data.

4.2.8 Communications in Green Transformation Projects

- ❖ Effective organizational communication, from a green viewpoint, focuses on creating and understanding of the technologies and processes that are explicit and the green attitude that are implicit.
- ❖ The subjectivity of attitude toward Green IT requires communication at multiple levels and various forms.
- ❖ The purpose, content, channel, frequency, entities involved, feedback, and interactivity are all part of the Green IT communication.
- ❖ Communication is required between internal departments of organizations to relate corporate philosophies, encourage teamwork, and develop strong relationships within and outside of an organization.

- ❖ The internal communication of the organizations includes instruction in the development and maintenance of transformed green process.
- ❖ Effective organizational communication, from a green viewpoint, focuses on creating an understanding of the technologies and process that are explicit and the green attitude that are implicit.
- ❖ The two major communication in the organization occurs:
  - ✸ Within the organization—between managers and employees.
  - ✸ Outside of the organization—with the customers, partners, and regulators
- ❖ The communications can occur in standard documents, emails, verbal phone, and so on.

4.2.9 Channels of communication in Green IT projects

Communication can be through various channels in a Green IT transformation program. The important parts of a green transformation project need to be explained in the most clear and understandable way. Green IT terminology can be a challenge in this communication and needs to be articulated correctly. The frequency of communication needs to be high earlier in the project. Standard meeting protocols like taking the minutes and circulating them to apply in particular to Green IT projects. Following are the categories of communication channels:

- **Personal:** face-to-face communication
- **Collaborative:** group-based electronic communication mechanism
- **Mobile:** phones and SMSs that enable context-based communications.
- **Asynchronous:** electronic communication that can be uploaded on the organization's site and then accessed by employees and users at their own convenience.
- **Physical:** paper form of communication
- **Group:** electronic as well as physical communication facilities (webinars, seminars, workshops).

4.2.10 Green HR and Changing Organizational Structures

Organization's social changes due to Green IT transformation initiative include changes to the skill set of individuals supporting the organizational systems and processes. This requires support from the green HR function of the organization in terms of understanding, positions, training, and rewarding the staff for their Green IT effort. It is favorable to equip the organization with greater automated, location-independent, and personalized capabilities of IT. The same occurs in business process reengineering initiatives. Changing skill sets of highly skilled workers demands advanced problem solving, superior communication skills, and the ability to leverage on Green I T is within the domain of HR.

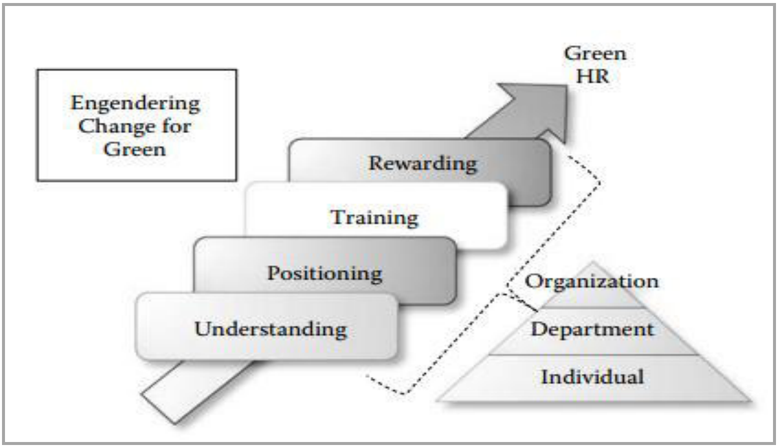


Fig 4.4: Genesis of Green IT in an organization

The following are pipeline of activities in bring the Green IT transformation in the organization:

- ❖ A HR has to engender change from the social perspectives.
- ❖ This change is initially focused at an individual level with the organization. The departmental change deals with procedures and practices. The organizational change involves restructuring the hierarchy, creation of new green-specific role, and spelling out the reward structure for meeting green goals.
- ❖ The HR department need to be organized.
- ❖ The adoption of the changes in working lifestyle will also occur in different ways and with differing pace in the new green enterprise. The various types of individuals and their varying speeds of adoption should be carefully planned for, and factored in, in the green HR initiatives of the organization.

- ❖ The three parameters that motivate the employees towards any transformation are:
    - ✷ Work with the support of technologies
    - ✷ Personalization of working style
    - ✷ Rewards and incentives
- ❖ The subjective or tacit aspects of Green IT systems are an important consideration in the social dimension of Green IT transformation
- ❖ Bridging of the gap between this tacit knowledge and the corresponding explicit knowledge stored in the green knowledge-base of the organization is vital in the social dimension.
- ❖ Green IT systems should offer spaces of interaction, permitting people to ask questions, to discuss themes, to define priorities, in ways of fostering the creation of knowledge, and doing a better use of the available knowledge.
- ❖ Institutionalized support for the available use of social media communication in Green IT transformations is vital. These social media networks also enable participation from employees, customers and public.

4.2.11 Decision Makers in Green IT: Roles and Skill Sets

Green HR considerations has led to creation of new job profile namely green collar worker. Green HR has to define and position green-collar workers correctly.

Green-collar workers are the ones that are associated directly or indirectly with an organization's endeavor to become a green organization.

A Green IT project will create new roles, as well as transform the known roles in IT and in the business. The business analysts, project managers, architects, and quality assurance managers may also be classified as green-collar workers. The following are the three main green collar categories:

- ❖ Roles that are newly created within the organization and that are specific to the green initiatives.
- ❖ Roles that exist within the organization but are modified to befit the green organizational initiatives.
- ❖ External roles that deal with the specification of carbon levels, and audits of its compliance.

4.2.12 Skill set Framework for Information Age (SFIA) and Green HR

The possibility of applying an industry-wide standard to the green collar roles should be considered by Green HR. The skills framework for information age (SFIA) provides an excellent framework for positioning Green IT roles within the organization. The mapping is given in Fig 4.5. SFIA is increasingly becoming popular because it enables identification of suitable levels of competencies within the IT industry. SFIA can be used to create formal description, registration, certification, and training of Green IT roles. Green HR will be most interested in the description and the training aspect of these new roles. Existing roles can also be redefined and/or mapped to the SFIA skill set. Together with the CMM scale for green maturity, and Green IT code of conduct, SFIA can be used in helping in the maturing of Green IT as a profession.

Scaling of Skillset

The SFIA skill levels can be mapped into three categories for carrying out Green activities:

❖ **Level 1 to 4: Managers and Team Leads**

The functions carried out at this level are Operational reporting and Training on reporting of green metrics within business operations

❖ **Level 4 to 6: Senior Management**

Functions to be accomplished are Operational risk management and Training on environmental risk and carbon risk within risk management

❖ **Level 6 to 7: Strategists and leaders**

They are responsible for Risk Anticipation Plan for carbon risks, legislative changes and global carbon trading.

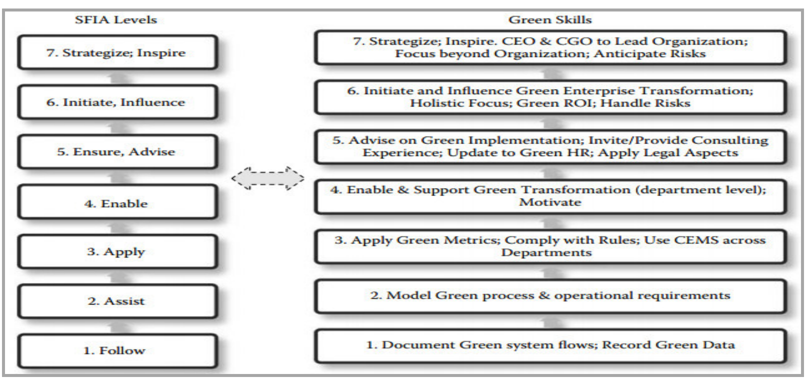


Fig 4.5: Mapping of SIFA roles with Green IT

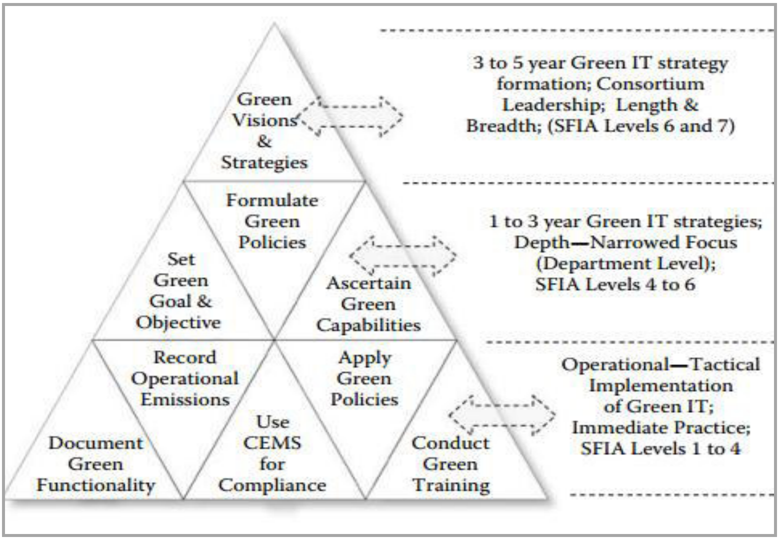


Fig 4.6: Levels of SIFA and green collar roles

4.2.13 Green Virtual Communities

- A virtual community formed through social networks allow people to interact irrespective of geographical and political boundaries.
- Green virtual communities can be social groups that addresses green issues.
- As people spend more time in these communities, they travel less, thus reducing carbon foot prints.
- They also play a major role in formulating consensus and opinion on green initiatives and enable diffusion of knowledge on environmental sustainability.
- The knowledge created through these communities can be embedded in knowledge management systems of the organization.

- ❖ Green enterprise transformation also implies a level of generalization that can be applied in the context of green environment
- ❖ Socialization and virtual communities help creation of subjective green knowledge which can then be codified into explicit green knowledge.
- ❖ Social networks can also participate in collaborative effort from a group of organizations rather than a single organization in creating and maintaining data centres.

4.3 GREEN ENTERPRISE TRANSFORMATION ROAD MAP

Green Enterprise Transformation (GET) is a program undertaken by an organization to change its structure and dynamics that would change its carbon footprint for the better. This transformation brings about the changes to the structure and dynamics of an organization. This may hinder normal operations and also its relationship with its customers and suppliers. Detailed analysis should be done to provide definitions for activities and tasks, deliverables and roles that can be used to achieve the goals of that transformation along with metrics and measurements. Such transformation is further augmented by a competent suite of metrics and

The GET has four phases:

- ✷ Diagnosis
- ✷ Planning
- ✷ Enactment
- ✷ review based on metrics

GET framework forms a matrix of the four phases and the four dimensions along which these phases get applied. The organization is viewed in a detailed GET through its various internal verticals such as its business portfolio, its networks and other IT infrastructure and, its people, and their attitudes. The enterprises should adopt a framework called **Green point method** that is an IT-specific Green framework encompassing equipment lifecycle, the end-user devices, the data centres, and servers within, and IT as enabler across the organization. There are two types of frameworks:

- **Green ICT framework** and its various elements that help understand and model the Enterprise.
- **GET process framework** that is used for undertaking the transformation process.

There are three elements that brings transformation namely cost, carbon, and customer priorities.

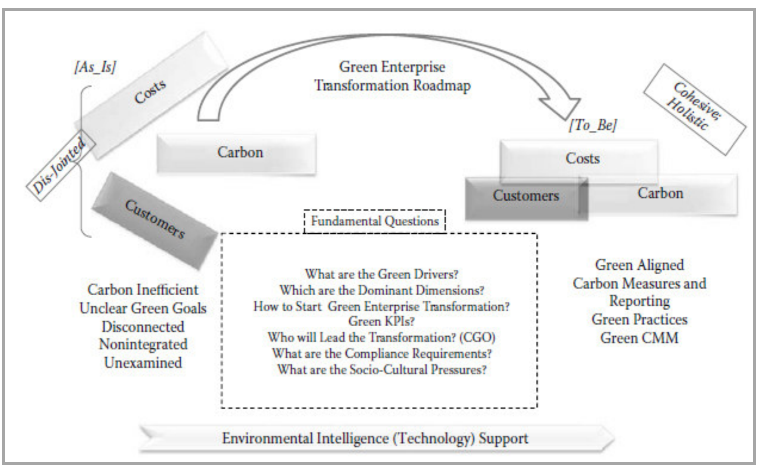


Fig 4.7: Process of Green Enterprise Transformation

The GET process must be able to identify the business goals, the current structure and maturity of the business and steps to be undertaken to become anew, cohesive, agile, efficient, and collaborative green business. A GET is planned and executed along the following four dimensions of an organization facilitate its transformation from where it is to its future green state:

- Economic
- Technical
- Process
- Social

A business can be modelled and understood in various ways and through multiple dimensions as a part of its transformation. The modelling should consider he associated risks and its advantages. The prominent factors that have to be considered are people, process and technologies.

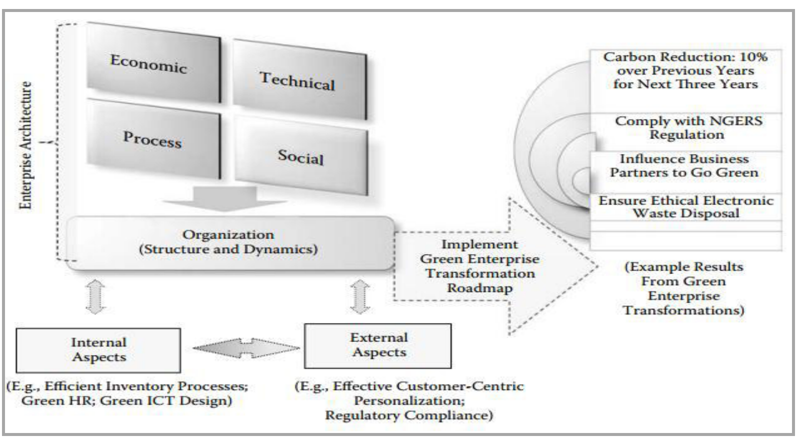


Fig 4.8: Four dimensions to achieve GET

These dimensions are foundations for achieving GET. It is also essential to include the current and future business trend as a part of the model. All the effects caused by GET will be placed under internal (eg: inventory) or external aspects (eg: CRM). Key Performance Indicators (KPI) will be the metric to measure this transformation process. This transformation process framework investigates scopes and incorporates these dimensions within its transformation phases.

i) Impact of Economic Dimension on GET

- The major economic changes in Green transformation in terms of financial steps is changes in budget, product portfolio and Return On Interest (ROI) estimation.
- This transforms the perception of business, investment strategies, customer relationships and partnering ventures.
- This brings about great change in the business model.

ii) Impact of Technical Dimension on GET

- Great changes are needed to transform technologies right from hardware, software, databases, ICT based security protocols, networks and its infrastructure based on the carbon emission ratings.
- A best way is to adopt virtualization technologies which can greatly reduce the carbon footprints.
- The real metric for assessing the technical impact is the reliability and ease of use of the new technology.
- These green technologies should be validated, passes the quality assurance with proper testing.

- Also these products must be agile, so that they can adopt to changing business circumstances.

iii) Impact of Process Dimension on GET

- This deal with how the business conducts its transactions including both internal and external processes of the organization.
- GET changes the manner in which the business interaction happens with its customers, customers and various collaborations.
- The success of GET in this dimension can be measured by reduction in carbon emission without compromising the quality and value.

iv) Impact of Social Dimension on GET

- The social dimension of GET deals with the sociocultural changes that occur in the GET business transformation.
- The transformation must focus on the interest in the people aspect of transformation including clients, employees and business users.
- Changes to work culture by adopting telecommuting, telemarketing can greatly impact the people and bring about socio economic change.
- Senior managers and leaders of the organization have a substantial effect in changing the attitude of individuals within the business.

- These organizational changes can take time to be implemented. Proper training, motivation and aspirations will positively contribute to the success of GET.
- A balance between the performance and functionality needs to be maintained during transformation.
- Effects of advertisements, value systems of the customers, ethical business practices, and adherence to the industry's code of conduct are also part of the social dimension.

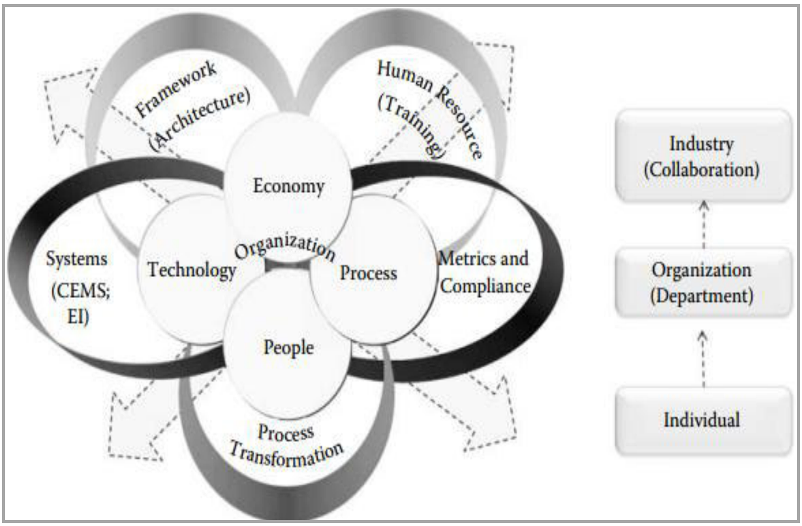


Fig 4.9: Overall framework of GET dimensions

4.3.1 Transforming the Individual, Organizational, Collaborative Processes

Transforming the individual, organizational and collaborative process are three main aspects of the GET. In addition to this, the supporting metrics, and the actual operation of the organization also undergoes change. The GET transformation requires a diagnostic approach to identifying and documenting the current state of the organization, followed by the vision of the organization. This will affect all the projects, technologies, processes, and demands redefinition of roles. Also, identifying the current and future state, outlining the path to complete the gap and executing the GET requires a combination of internal and external skill sets. Inviting a full-on consulting group for this exercise can include costs, and risks associated with the potential lack of knowledge of the core operations of the organization. Using only internal resources has the risks of not knowing the external legislations, consortium-based actions, and available technologies and resources for GETs. The green metrics for the transformation is given in fig 4.10.

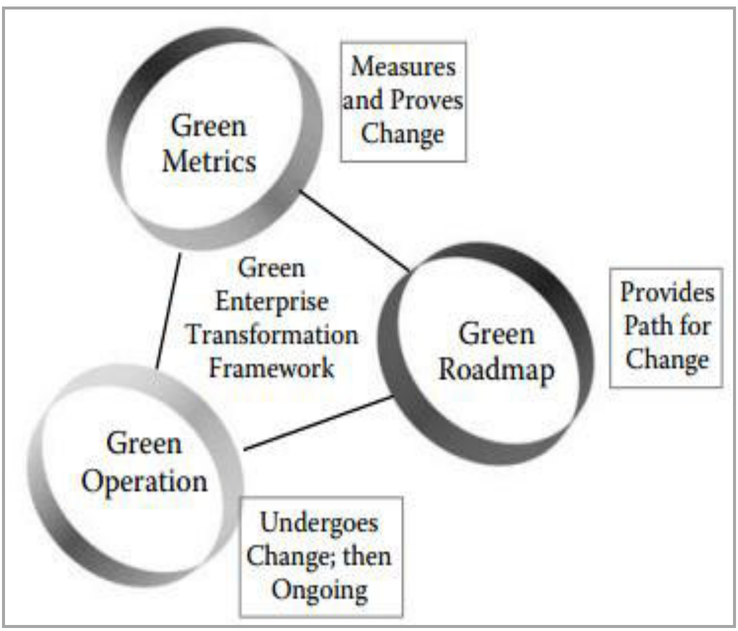


Fig 4.10: Green metrics and supporting roadmap

4.3.2 A Green ICT Framework

Green ICT is the application of technologies and practices that materially reduce resource consumption and harmful emissions in Information and Communications Technology (ICT)life cycles. It involves practice of using computers and telecommunications in a way which maximizes positive environmental benefit and minimizes negative impact.

The GET mainly focus on the state of the organization than the transformation process. The framework given in Fig 4.11 includes major areas of an enterprise from the Green IT perspective. It is actually a is made up of a matrix of four vertical "pillars" and five horizontal "rows.. The pillars depict the areas within an organization that will undergo change: equipment lifecycle, end-user computing, enterprise, and data centre and ICT as a low carbon enabler across the organization. The horizontal rows includes attitude, policy, practice, technology, and metrics.

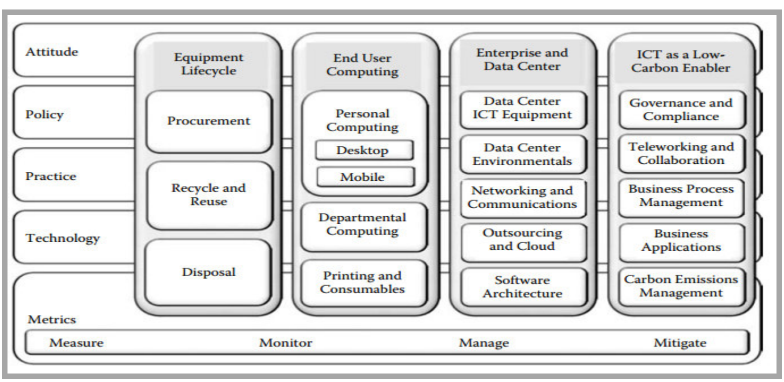


Fig 4.11: Green ICT framework

4.3.3 Equipment Lifecycle

Equipment lifecycle deals with the procurement, recycling and reuse, and eventual disposal of all equipment within the organization.

All equipment in the organization undergo this cycle where in they are procured (POD): Procurement, Operations and Disposal. At disposal of the equipments includes issues relating recycling or reuse. The entire equipment lifecycle is of immense interest in Green ICT as the process of carbon reduction can be initiated right from the procurement phase and continue through its operation and eventual disposal. Supply Chain Management (SCM) and procurement management systems are involved in supporting the optimization of the equipment lifecycle.

4.3.3 Procurement

Procurement makes great impact on sustainability. Focusing the design and procurement of ICT equipment makes a substantial impact on its Total Carbon Cost of Ownership (TCCO). Two major aspects are concentrated:

- the nature of the equipment itself
- the nature of the suppliers of that equipment.

Energy Star and the Electronic Product Environmental Assessment Tool (EPEAT) should be used before purchase of any equipment. Supplier's environmental values in the design and manufacture of equipment and how to measures them, its compliance with relevant environmental laws and codes of practice, and whether the supplier reclaims and recycles old equipment from customers must also be studied. Energy efficiency, emissions over lifecycle emissions, and the level of waste associated with an equipment are important purchasing factors.

Requests For Proposals (RFPs) and tender documents evaluate suppliers on their environmental credentials and their own green policies and practices.

4.3.4 Recycle and Reuse

Equipments must be periodically replaced. Some equipment have regular refresh cycles, some wait till they have to, and some utilize some sort of continuous update process. This is a natural aspect of the ICT function. Areas of the organization that need newer hardware may be able to share their old equipment to other parts of the organization with less critical processes. Any equipment that complies with the base hardware standards, and that can support the software, is potentially redeployable. Redeployment may also be based on changes to organizational structures, especially when roles are not being refilled.

4.3.5 Disposal of ICT Systems

After extending the useful life of equipment and eventually selling or reusing it, there will can be a situation where it will need to be physically disposed. Environmentally sound disposal practices are vital aspect of Green ICT. The importance of electronic waste disposal has led to the growth of an entire industry around the disposal of ICT and other electronic equipment, often based on the extraction of precious metals from printed circuit boards and other components. The industry has to be regulated, and there have been legislations, making the environmentally friendly disposal of e-waste mandatory. The manufacturers of computer monitors, printers, photocopiers, laptops, and mobile phones must know what has gone into these products and also understand the repercussion so its disposal in the air, water, and soil.

4.3.6 End-User Computing

End-user carbon efficiencies is very important. End-user computing has the greatest effect on the wider green attitudes and behavior of the organization's workforce. End-user computing deals with IT Efficiencies that the end-user has most control over. There are three main areas where Green ICT can be implemented: personal, departmental computing, and printing. The range of technologies where Green IT is deployed:

- ❖ **Desktop computing:** Important practices include turning PCs off and various PC power management techniques, and important technologies include thin client computing.
- ❖ **Mobile computing:** May have similar power management issues to desktop computers. An array of mobile devices, such as notebook computers, smart phones, and PDAs, may not in themselves use a large amount of power, but there are still a number of Green ICT considerations that need to be taken into account with their usage.
- ❖ **Departmental computing:** This computing that is localized to a department and not under direct control of the IT department of the organization.

- **Printing and consumables:** Consume significant energy particularly due to their large numbers and inbuilt inefficiencies.

4.3.7 Enterprise and Data Centre

Enterprise and data centre represent those aspects of an organization that are controlled directly by the IT department. The organizations which are large enough to have a data centre must implement the effective management of the equipment within it and its environmental can be one of the most important aspects of Green IT:

- Data centre ICT equipment
- Data centre environmental
- Networking communications
- Outsourcing and Cloud
- Software architecture

4.3.8 Data Centre ICT Equipment

The two most important types of ICT equipment in the data centre include servers and storage devices. Servers are usually the biggest consumers of power, and that power consumption continues to rise as more powerful processors are used inside them, and as the number of servers proliferates. Average power consumption of a rack of servers has increased five-fold over the last 10 years when cooling requirements are taken into account. Storage usage is also increasing exponentially—and as prices drop storage devices are often used very inefficiently. Server and storage virtualization has become one of the key technologies in data centres in recent years. It is often touted as a technology for reducing power consumption, because it reduces the overall number of devices, but in practice most data centre's power consumption continues to rise because the devices are becoming more powerful and use more electricity. The infrastructure of data centre is made up of the following three main aspects:

- **Power supply:** Data centres usually have dedicated power supplies, and very often more than one. Their 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 amounts of cooling, either air cooling or water cooling. there are many design and implementation issues that affect power consumption. Lighting is also a factor.

- **Building that houses the data centre:** It 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 effect on power consumption, such as insulation.

4.3.9 Networking and Communications

The area where Green ICT can be implemented in networking:

- **Local area networking:** Many organization's LANs and data centre networks consist largely of collection of cables that consume large amounts of power and which add to cooling requirements. More efficient cabling design means lower power consumption.

- **Wide area networking:** Many organizations use leased data lines or VPNs over the Internet. While they do not have direct control over these networks, their inefficient usage adds to overall power consumption and increases the overall carbon footprint.

- **Wireless communication:** Wireless will never wholly replace cabling, but it is becoming more widely used and it does have a major role to play. But wireless communications can be very inefficient, especially when transmitters and receivers are left on when they are not being used.

4.3.10 Outsourcing and Cloud Computing

Outsourcing has been one of the big issues in ICT since the industry began. The main issues here are cost and capability. The outsourcing vendor has economics of scale and availability of skills. Many facilities management companies are now highlighting their green credentials and building energy-efficient data centres that they say will enable users to lower their overall carbon footprint. The key issue is the measurement. It is impossible to tell if outsourcing is a good deal or not financially if you don't know the real cost of what is being outsourced.

4.3.11 Software Architecture

Computer systems consist of software running on hardware. Software is the system, and hardware is simply an enabling technology. Most discussion about Green ICT refers to hardware, but software is also a factor. Software architecture often determines the hardware architecture, which in turn may have a significant effect on the amount or type of hardware used—with all the consequences of the energy consumption of those systems. A software that preinstalled on new devices, come bundled with other downloads, or are injected into your system through malicious sites are bloat wares. Systems can be developed from scratch, adapted or borrowed from other software, or purchased off -the-shelf. Each approach has consequences for energy consumption.

4.3.12 IT for Enterprise

A vital aspect of Green IT is its use in reducing the carbon footprint as the whole organization. It is generally agreed that IT emissions are mainly through the usage of electricity which in turn comes from carbon emitting power stations. The real potential benefits of Green IT are in using IT as an enabling technology to help the organization, and the wider community, reduce its carbon emissions.

4.3.13 Governance and Compliance

Publicity about climate change and related issues has greatly raised the profile of sustainability, and virtually all organizations are attempting to boost their green credentials. In some cases they do it because they are forced to. Many organisation sincerely wants to do the right thing. Corporate governance is the processes by which organizations ensure that they are properly managed, not only in terms of meeting their regulatory obligations, but to ensure that they do the right things by all their stakeholders. This also includes management, shareholders, and staff , and is extended to include business partners and others in the organizations extended supply chain. This extension is based on a growing awareness that, when it comes to the environment, everybody is a stakeholder, and that good corporate governance also includes good environmental management. Green ICT is in many ways a management and governance issue.

4.3.14 Teleworking and Collaboration

Teleworking is a range of technologies and practices that have to do with working at a distance or working remotely. The carbon reduction benefits of teleworking are mostly associated with reduction in personal travel obviating the need to drive a car or catch a plane reduces the carbon footprint of that activity by the amount of fuel generated by that travel. Teleworking also opens up opportunity to collaborate more than in the physical world. Collaboration tools and techniques enhance the capability of a group of people to work together. There are a great many ways to do this, but all of them entail being able to share documents, processes, and information. Ā is showing makes the business processes more efficient and reduces the need for physical contact.

4.3.15 Business Process Management (BPM)

Business process management is the process of improving the ways an organization or an individual does things thus making them more efficient, with fewer steps or greater effect. Green BPM identifies five phases relating to a process: design, modeling, execution, monitoring, and optimization. A Green BPM refers to the managing and improving of all business processes from their carbon perspective. Environmental intelligence has a major role to play in Green BPM.

4.3.16 Business Applications

ICT-based business applications include financial management systems (FMS), enterprise resource planning (ERP), supply chain management (SCM), and customer relationship management(CRM). Many organizations also run customized applications that are specific to their industry that would provide them with competitive advantage.ICT is very important in each of these applications, which essentially support BPM. Green BPM seeks greater efficiencies in every phase of every process. Even small improvements can have a significant effect on carbon reduction, because of the scale of the operation and because of flow-on effects further up the supply chain. Green ICT has a very important role in improving the efficiency of many industrial and commercial processes specific to individual industries, paving the path for their leanness.

4.3.17 Carbon Emissions Management

Carbon emissions management is an emerging discipline that focuses on the management and ultimately the mitigation of an organization's carbon emissions. This includes the use of ICT systems specifically designed to reduce the carbon footprint, rather than doing so as a by product of greater efficiency. A key ICT application is CEMS, which provide a compliant and consistent format for presenting greenhouse gas emission data to executive management and regulators. As the carbon emissions regulatory framework continues to evolve, CEMS is becoming an increasingly popular tool to manage the carbon emissions lifecycle.

4.3.18 Attitude

Though attitude is intangible trait, it is a major part of the subjectivity in the social dimension of GreenIT. Much of the success of GETs depend on the attitude of the people within the organization. It is also very subjective. Attitude can be understood as a desire and a commitment to change by the individual that is based on honest belief in the ensuing results. Having a positive attitude toward Green IT is at the heart of the transformation as it is depend on individuals. And, as is often the case in business, those attitudes are most effective if they come from the top. Management buy-in is an essential part of any Green IT program.

4.3.19 Policy

Policies help set the direction for the organization and provided basis for action. Communication of policies is also vital and needs to take the HRs in confidence. Examples of policies affecting the entire organization include the organization shall only provide goods and services from certified, green vendors; users will be encouraged to not take separate, individual backups of their databases.

4.3.20 Practice

Practices are the things that are carried out in the organization. Practices implement policies. They are the techniques, the behavior that is expressed by the individuals and organizations. An interesting aside to practice is that they, like processes, involve alteration of habits and change of mindsets (attitude) rather than procurement of new equipment. This is involves training. Examples of practices include switching off computers when not in use; implementing virtualization of all services; replacing existing high carbon emitting equipments with new, green ones; and ethically disposing of electronic waste.

4.3.21 Technology

Technology is the hardware, databases, and network and systems aspect of Green IT. Green IT techniques of using thin clients, ritualizing data servers, and using duplex printers are all examples of technology-based changes in the organization that lead it toward Green IT. Procurement of new, low carbon emitting equipment is an investment that needs to be considered in the long term in the context of the TCCO metrics. The costs associated directly with a new equipment also needs to consider the waste inherent in disposing of the old equipment—especially if that equipment is still operational. An ideal way to approach equipment replacement is to balance out the change and incorporate the practice of Green IT as part of the normal equipment replacement cycle.

4.3.22 Metrics

Green IT metrics deal with measurement of carbon emissions of the organization in its state. Metrics also determine the future state has been achieved or not. Choosing the right tools to measure, monitor, and potentially mitigate power consumption and carbon emissions, both inside and outside the IT department, is critical in the GET. Good set of green measures ensure that Green IT projects receive maximum business commitment and are proven to be successful over time. Only with adequate measurement can progress be proved. Hence, metrics need to be supported by smart metering.

4.4 GREEN TRANSFORMATION PROCESS

Project from various dimensions in the business, infrastructure and systems area make up the transforming program. The four major phases of transformation are diagnose, plan, enact, and review. These phases are iterative. The number of iterations required for a successful transformation to be decided by the Chief Green Officer (CGO) together with the person responsible for GET. The objectives of the green transformation framework:

- To identify the current status of the organization and enlist the goals of GET. These goals will be identified, updated, and finalized through the diagnosis work.
- To add justification for the project using ROI calculations within a business case.
- To provide target metrics
- To organize the actual GET program.
- To provide the basis for the pathway/road map or project plan for transformation
- To review whether the KPIs have been achieved or not
- To promote the success along the individual, departmental, and organizational level.

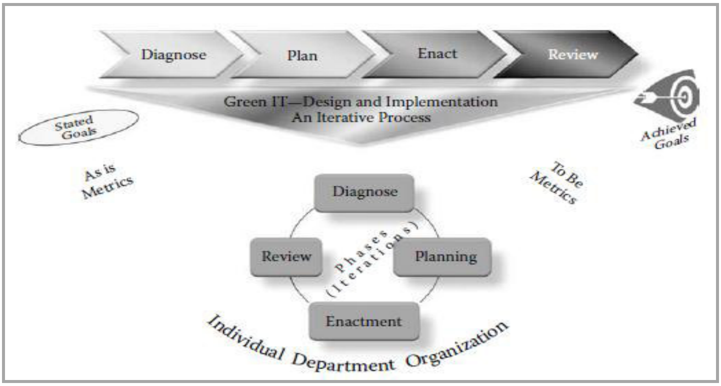


Fig 4.12: Green Transformation framework

The proposed framework is based on the transformation activities such as detailed planning, project accounting, risk management, and ongoing measurements. These phases are a logical approach to transforming any business.

4.5 Organizational Focus Areas for GET

The focus areas provide the structure of the business that will undergo change and to which the GET process and their emphasis can be applied.

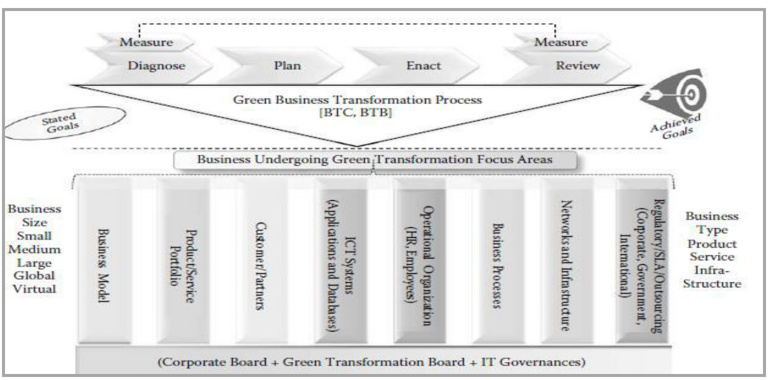


Fig 4.13: Focus areas for GET

- **Business Model:** which deals with the way a business is organized. GET influences and, usually, changes the business model to reflect the green priorities of the organization. Smaller organizations have a simple, subjective business model that can change easily.

- **Product and Service Portfolio:** provides an overall summary of the offerings of the business. GET results in the organization having new green products and, also, dropping of carbon-intensive products and corresponding services. Infrastructure-intensive organization may have buildings and facilities instead of products or services.

- **Customers and Partner:** describes the external parties interacting with the business.

- **ICT Systems, Applications, and Databases**: includes the technological changes in the software systems and technologies of the business.

- **Operational, Organizational:** handles the internal parties such as employees and management, and their reporting hierarchies, within the business.

- **Business Processes:** model and describe the way in which all activities of the business are sequenced and carried out.

- **Networks and Infrastructure:** focus on the underlying communications technologies used by the business.

- **Regulatory**: deals with legal, accounting, and financial aspects of the business.

Configuring a GET Road Map

- Major considerations in GET:
- Type and size of organization
- Nomination of roles and responsibilities
- Formation of the Green enterprise transformation board (GETB)
- Diagnose
- Plan: Formation of work areas; Outlining the GET deliverables, their format and their timings
- Enact: Format, timing and frequency of reporting
- Review
- Measure

GET Program: Roles and Deliverables

Chief Executive Officer (CEO) nominates the board, comprising experts, leaders, and personnel from marketing, technology/infrastructure, finance/legal, CRM, communications, and HR/union. The CEO, together with the members of the GTB, selects the Green Transformation Champion (GTC). A GTB is drawn from within the organization with occasional representation from outside such as a consulting organization specializing in GET. This works together with the various other governance boards that run the organization. These various governance setups participate in, and are affected by, the GET. The functions namely diagnose, plan, enact, review, and measurement phases of transformation are directed by the GETB.

Setting Up a Business Transformation Office (BTO)

The physical activity of setting up the BTO can be undertaken either before the commencement of the project or at the state of the diagnosis phase. BTO houses the transformation board which provides the administrative support to the project. The chief responsibility of BTO is taking care of the operational matters related to the project, coordination amongst various work areas, documenting the contractual requirements of the project and promoting the project within and outside the organization.

Forming Transformation Work Areas

Formation of the work areas for GET is based on the current state of the organization. The size and type of the organization affects the formation of these work areas. The current technical and process maturity of the organization also influences the work areas. In some cases, one work area may be more important than other. Formation of transformation work areas includes nomination of a work area leader who has expertise in that particular area of the business or technologies.

Green IT Project Roles

The goal of Green IT project include the business partners, business architect, technical architect, Green IT champion, end-user representative, IT managers, IT governance, business manager, data centre director, Green IT auditors, and corporate governance. A GTC takes leadership responsibility for the project.

Role of Green Enterprise Transformation Champion (GTC)

The responsibility of GTC will includes:

- Formalizing the leadership and constitution of the GETB
- Identifying the current Green maturity state of the organization based on Green metrics
- Benchmarking best practice goals for the organization that describe its "to be" state
- Manage budgets
- Organizing the creation of project management plan for GE T.
- Creation of an approach to risk management for GET that is based on priorities of the organization, its lead dimension, and so on
- Stakeholder management including expectation management of the board, related external parties, and the society
- Report progress on the GET to the corporate board
- Monitor KPI
- Coordination and management of GET resources, as well as the organizational resources undergoing transformation. Ā is will be done in conjunction with Green HR
- Coordinate implementation of changes through change management processes across the various focus areas of the business
- Balance the "driving dimension" of GET with other dimensions

- Track progress and of the GET project
- Astute use of the tools, technologies, and processes of GET.

Business Architect and Variations

GTC will appoint business architect to investigate and handle business model work area. The Business architect is aware of the underpinning technologies that can serve the business but is not a technical expert. A business architect takes a long-term view of the organization (3–5 years and above) when she participates in the GET project. A business architect would create business architectural map that will provide the overall view of the business model and associated work areas. This business architectural map can be a part of the overall enterprise architecture that is also used by the architect in creating operational strategies for the business after transformation. The map ensures that the technologies are aligned with business plans and the changes are tracked and monitored.

Technical Architect and Variations

GTC also appoints a technical architect. For smaller sized organizations undergoing small transformation, this role may be played by the GTC. The technical architect is responsible for the following:

- Creation of a technical architecture map to understand where the organization currently is.
- Collection and use of a toolbox of various tools that are used in technical implementations during GET.

- Creation of a comprehensive repository of software applications currently used by the organization—with a view to changing and integrating them.
- Dividing and categorizing these repositories of applications into different business/application domains that will enable ease of modification with carbon data.
- Ensuring that the applications that support specific decision making are part of the overall EI suite, and are available to decision makers.
- Creation of a new technical architecture that would reflect the goals of the business transformation itself.
- Ongoing alignment of technologies with business plans during and after GET.
- Coordinating the development of a Green IT portal.
- Tracking and monitoring technical changes resulting from applications notification and upgrades and integration.
- Managing quality initiatives during GET
- Develop an understanding of the future trends in technology that the organization will have to deal with after the GET.
- Produce a suitable technical strategy including a technical roadmap for transformation.

Business Partners

As the business interests of collaborating partners coincide, there is added impetus to provide wide array of support to the partners. This support can take shape in the form of knowledge and experience sharing, providing relevant tool support and help with understanding dynamic customer preferences as the business transforms.

- Participate
- Collaborate
- Interface
- Integrate

Green IT Auditors

Auditors carry out checks and balances throughout and after the transformation. Auditors measure and audit to ensure that the transformation has created value for the business as stated by its goals. These audits can use the reporting features of CEMS, if implemented and that the transformation has not adversely affected any of the reporting and regulatory requirements of the business. Furthermore, auditors are involved in the review process, ensuring that the calculations leading up to the ROI are accurate and reflect the reality resulting from transformation.

End-Users

End-users are the employees, managers, and customers of the organization who are affected by the

GET. The roles are:

- Represents user groups
- May be more than one

- Highlights device usage
- Highlights attitude for roles
- Helps in Green HR
- Understands CEMS and smart meters

IT Managers

IT management deals with the operational and management aspect of IT within the organization. They are responsible for the IT systems, their operations on the corresponding hardware and approaches to using IT for overall carbon reduction.

Business Managers

Business managers assume the responsibility at department level to measure, report, and reduce emissions. They are more interested in the economic and process dimension of the GET than in technology and social dimensions. The economic dimension directly affects their performance and the process dimension is the one on which they have immediate control. This business managers can directly assist in the modeling of business processes, their investigations, and optimizations.

IT Governance

This is an activity for which more than one roles within the organization can assume responsibility. IT governance deals with overseeing the IT management and providing strategic and policy input in the process of greening an organization.

Corporate Governance

Some of these processes have a need to be upgraded or fine tuned to reflect the green requirements of the business:

Lean—will move toward Lean-Green, as was alluded to in the process.

Six Sigma—will not only focus on quality but also the efficiencies in carbon reduction

TQM—Total Quality Management—will incorporate metrics for carbon reduction in addition to defect reduction

KPIs—the Key Performance Indicators are not only to enable corporate governance but also green governance

SIFA (Skills Framework for Information Age), AIBA (Australian Institute of Business Analysis) and PMBOK (Project Management Book of Knowledge) are examples of processes and frameworks that will all be modified to reflect the green awareness and green goals of the organization.

4.6 GREEN IT TRANSFORMATION DELIVERABLES

The following are the IT deliverables:

- Green IT Business Case: documents the ROI, the budgets, and overall justification for the project
- Enterprise Emission Measures: documents the existing carbon e missions across the organization
- Green Enterprise Emission Measures: resulting at the end of the GET

- Enterprise Architecture Document: that documents the enterprise architecture, using an existing or modified framework
- SLA
- Various docs relating to suppliers; outsourcing partners; legal

4.6.1 Phases in GET

There are four phases in GET:

- Diagnosis phase
- Planning phase
- Enacting phase
- Review phase

The deliverable in each phase is discussed here.

GET: Diagnosis Phase

- Accurate diagnosis provides a good understanding of the current state of the organization by investigating into the various work areas of the business from the point of view of transformation.
- An understanding of the structure and dynamics of the organization, as well as its ability to achieve goals, manage risks and ascertain the leading dimension of transformation is developed here.
- The state of an organization, with respect to its carbon emissions is based on the current emissions at this early stage.

- ❖ The demographics of the organization, its motivator, goals, size, and type would all affect its current state, as ascertained during this diagnostic activity.

- ❖ Diagnosis also includes a review or stock take of existing assets across all work areas.

- ❖ Diagnosis indicates the state of maturity of the organization.

- ❖ Once the transformation is complete along all dimensions and through all the work areas, the organization can be said to be in a matured green state.

- ❖ In this state the Business Transformation Office (BTO) is now fully set up and organized. The Business Transformation Board (BTB) is functioning and reporting to the corporate base. The Business Transformation Champion (BTC) is also busy managing stakeholder expectations. The diagnosis phase also ascertains and progresses the lead dimension of the organization for GET.

The diagnosis activities are carried out at these levels in any organization:

i) Equipment lifecycle carbon efficiency

ii) End user computing's carbon efficiency

iii) Data centre carbon efficiency

iv) IT as low carbon enabler

All of these levels possess unique challenges and deliverables in the GET.

Equipment lifecycle carbon efficiency

Activities	Challenges
✸ Lifecycle evaluation ✸ ascertains current Green maturity. ✸ updates the business case on the Green IT project. ✸ Reviews the existing procurement and disposal attitude ✸ Identify operational carbon emissions (CE). ✸ updates P&L carbon emissions. ✸ evaluates the business case risks ✸ reviews policies with business partners ✸ Reviews recycling policies and practices are revised. ✸ A certain the greenness of equipment using energy stars ✸ Optimization of operations is ascertained. ✸ Revise Waste disposal policies and practices	✸ Uncertain data on Current Carbon Emissions across Lifecycle/ Procurement ✸ Impact on SLAs a major challenge ✸ Minimal Industry experience in Changes to Software for Carbon Emissions

End user computing's carbon efficiency

Activities	Challenges
✷ Green IT champion creates and updates the business case on the Green IT project. ✷ end-user provides input into a survey to help ascertain the attitude toward Green IT. ✷ Measurements of carbon emissions are undertaken per device ✷ IT governance board is involved in permitting the creation of a device inventory; measurement of overall carbon emissions. ✷ The corporate governance evaluates the overall end-user policies on Green IT. ✷ Corporate governance also evaluates business case for Green IT as presented by the Green IT champion	✷ Patterns of usage based on End-User roles ✷ Existing Device Inventory may include irrelevant materials ✷ Existing Current Green technologies include software for "computers off" etc.

Data centre carbon efficiency

Activities	Challenges
✸ updates the business case on the Green IT project. ✸ takes an inventory of I T equipment from the point of view of calculating the current CE. ✸ Measurements of CE are undertaken per server(or similar unit of hardware measure). ✸ IT governance board (or similar governing body) reviews the existing SLAs ✸ Corporate governance (board or similar governing body) evaluates the overall end-user policies on Green IT. ✸ Corporate governance also evaluates the cost of running the data centre, and the costs associated with the Green initiatives related to the organization ✸ list of current virtualization or server consolidation techniques in use is made. ✸ physical environment and the facilities is recorded.	✸ Patterns of Carbon Emissions can be daily, monthly, yearly. ✸ Data/Information Ownership is a major challenge of Virtualization

IT as low carbon enabler

Activities	Challenges
✸ Evaluates existing organizational Green practices ✸ Ascertains the overall enterprise green maturity. ✸ Updates the business case on the Green IT project. ✸ Updates the divisional use of IT and models the current business processes. ✸ Examines software and hardware inventories. Evaluates the existing enterprise Green IT policies and ascertains or confirms the greening dimension. ✸ Telecommuting/teleconfer encing. ✸ Collaboration tools and SaaS. ✸ Supply chain.	✸ Overall organization presents a bigger challenge than I T ✸ Green IT champion has to convince business management, corporate governance

GET: Planning and Scoping Phase

- The strategic thinking and innovative capability of the organization are translated into actionable activities and their sequences in setting up the Green transformation project.
- Creative ways of bring about the change, including maximum use of internal and external resources, are explored in this phase.
- It is important to note that this road map remains a live document which means later, during enactment phase, this same road map is also
  - (a) modified depending on the nuances of the project
  - (b) refined through the feedback gleaned during transformation.
- The road map includes the Green transformation plan, the Green pilot project (which can be embedded within the transformation plan for small projects), the overall work area plan, the plan for the lead work area and the quality plan (which will include verification and validation of the changes).
- The deliverables resulting from the road map are the plans themselves as also the project task list, the performance and ROI measures, the ranking of risks and the plans to audit the results of the transformation.
- The roles involve in transformation planning include the GTC, the project manager, the quality manager, work area lead, business manager, and the IT auditors.

- ❖ The planning and scoping phase of GET explores the output of the previous diagnosis phase to identify and formalize the planning of the transformation project.
- ❖ Once the significant aspects of the business are identified, planning outlines the tasks to be performed for transforming each work area.
- ❖ While the risks are managed in practice during enactment, the planning phase identifies and ranks these risks, and also incorporates the effect of changes on the organization.
- ❖ Balancing between costs and benefits, technology and business; and balancing risks with outcome.
- ❖ Each organization has to separately identify and document its green success criteria in this planning phase and formulate the right metrics and measurements that would be used to ascertain its success.
- ❖ Work areas are organized, leaders for those work areas are nominated, and interrelationships between work areas are highlighted in planning phase.
- ❖ Planning for the Green IT project starts with the Green IT champion—who finalizes the leading area of the organization that will undergo transformation.
- ❖ The leading area will start becoming obvious through the diagnosis, but it is important to decide formally whether the end-user efficiencies should lead the way, or whether it should be the equipment lifecycle and procurement, or the data centre.

Enterprise Lifecycle Plan

Roles and activities	Deliverables: Input and Output	Challenges
Green IT Champion: Works with the business management, to plan the changes to product/ equipment lifecycle and procurement that will make the organization greener **Business Management:** Plans, along with the Green IT champion, to procure, use, and dispose equipment in a carbon-sensitive way. **IT Governance:** Oversees the planning process for hardware and software upgrades throughout the business lifecycle. **Corporate Governance**:	**Input** Green IT Business Case: Includes justification for the new equipment, their TCCO, and replacement costs. **Output** **Green IT Transformation Plan:** Includes plans for green recycling, updates on the Energy Star and other ratings, green procurement strategies, optimized operations, and waste disposal. **Procurement and Disposal Plan:** Specifically focused on procurement of	✸ procurement, disposal lifecycle is an integral part of overall business ✸ Changes to SLAs with external arties/ business partners require upfront planning.

Participates in the planning process on how the policies for corporate purchases and disposals will change.	equipment and their decommissioning. **SLA With Business Partners/External Parties:** will change the current lifecycle and moves toward a green lifecycle.	

Planning for End-User Efficiencies

Roles and activities	Deliverables: Input and Output	Challenges
Green IT Champion: Involved in leading and coordinating the planning activities; reporting to the board **End-User Representative:** Planning for the training as well as planning and	**Input** **Green IT Business Case:** Contains justification for the project. **Industry Standards:** Such as EPEAT are incorporated in the plan to ensure green procurement	✸ Estimations on Green IT costs and savings vital for corporate support ✸ Plan for training in attitude change: based on roles.

budgeting for the time and eff ort required to change to green practices. **IT Management:** Plans for the upgrades to the software and the hardware that will be required for the green eff ort.	and usage **Output GreenIT Transformation Plan:** Updated with step-by-step instructions on how to carry out the transformation enactment later. **GreenIT Enterprise Standards:** These are the new, expected, green standards within the organization for expected carbon emissions per end-user device, per day/month/year, and so on	

Enterprise IT Data Centre Efficiencies

Roles and activities	Deliverables: Input and Output	Challenges
Green IT Champion: Works to upgrade the Green IT transformation plan with the data centre details **Data Centre Director:** Plans, a long with the Green IT champion, to u pgrade the building, power supply, and air-conditioning/cooling upgrades. Server virtualization, which is a vital part of green initiative, is also a part of this planning process **IT Management:** Continues to participate in the planning process, including plans for changing to the current	**Input** **Green IT Business Case:** Provides justification for the investment in data centre upgrades; costs associated with server virtualization and optimization are listed. **Industry Standards:** Relating particularly to DCiE/ PUE metrics. **Output** GreenIT Transformation Plan: GreenIT Enterprise Standards:	✸ Plan for virtualizatio n must include data/ information ownership, backup plans ✸ Green data is a new suite of data within the organization

data centre practices **Corporate Governance:** Participates in the planning process		

Planning for IT as a Low-Carbon Enabler for the Enterprise

Roles and activities	Deliverables: Input and Output	Challenges
Green IT Champion: Works with the business management, IT governance and, most importantly, corporate governance to plan out strategies for transformation to a green enterprise. **Business Management:** Plans, along with the Green IT champion, to promote green activities across	**Input** Green IT Business Case **Output** **Green IT Transformation Plan:** Gets updated here with plan for the entire organization. **Task Plan:** Step-by-step tasks to be carried out in implementing the Green IT project plan.	✸ **Challenges** Return on investment is the major question that corporate governance asks, and planning in this dimensions must help enable answering that question. ✸ Organization-wide risks need to be estimated and prioritized

the business unit which, in turn, would result in a green organization. **IT Governance:** Oversees the planning process for technology upgrade across the organization. **Corporate Governance:** Participates in the planning process on how the corporate policies need to change together with possible changes to the business model and the organization structure.		

GET: Enactment Phase

❖ Enactment is the execution of the business transformation plan created in the previous phase.

- This primarily includes risk management, monitoring of progress, measurements and reporting.
- Following are issues to be considered during a GET enactment phase:
  - Identification of risks during execution of the transformation plan, their priorities, and how to ameliorate them.
  - Interrelationship amongst work areas, their dependencies and management of the lead work area as first priority.
  - Measurement of the GET outputs. Use of metrics created during diagnosis and formalized during planning are used here to ensure common measures for comparison with the help of CEMS.
  - Reporting to stakeholders and managing their expectations.
- While a GET project can be driven through any of the work areas, ideally the lead area is dictated by the lead dimension of transformation.
- Green information systems play a major role in measuring and reporting change related to the environment.
- Each individual employee's carbon generation can be measured, collated, and reported with the help of information systems.

- ❖ Feeding this information back to the employee through smart metering can bring about immediate change in behavior.
- ❖ The information coming out of the Green ICT systems that bring about positive change includes reports of daily, monthly, and yearly GHG generation and using that data to impact practices in enactment.
- ❖ Green ICT information systems need to produce numbers that not only focus on the environmental performance of the organization but also its overall efficiency and effectiveness.
- ❖ Metrics allow the transformation to provide visibility to success by understanding green strategy.
- ❖ The transformation plan may be utilized to help determine how best to measure progress and introduce accountability into the Green ICT initiatives, both at the enterprise and solution levels.
- ❖ IT governance representatives (board) may be also put in charge of supporting measurement and reporting, as well as of identifying when a realignment of internal measures or systems is needed to ensure that the expected results are seen, evaluated, and realized.

Technology-Driven Enactment

The ICT-driven enactment of the GET involves ICT systems, applications, and databases at the centre. There are many in-house systems that are affected by the transformation. The factors that affect these management levels include the standards, need for integration, the approach to testing and quality assurance, the contractual requirements and the deployment of the new ICT systems, applications, and databases. The adaptation of the organization to the new technology permeates all aspects of the organization.

Customer Relationships Management (CRM)

The CRM systems are updated during GET with the goal of combining green value to the customers. This value includes reliable and good quality service, personalized attention to customer need and support. A good CRM ensures that the customer is provided a single unified view of the business and not the possible internal fragments of the business.

Supply Change Management (SCM)

These applications undergo change to enable users, primarily employees of the organization, to perform many common warehouse, inventory, and shop floor related tasks. A technology-led transformation will monitor and control materials, their delivery and order status. Reduced movement of goods, holding of inventory and accurate production estimates are achieved by the Green SCM. Integration and migration are important technical consideration in these ICT systems, as substantial carbon data gets added to these systems.

Human Resource and Payroll Systems

HR systems provide opportunities for Green HR to be implemented. The HR systems are upgraded to offer greater support to individuals and departments in terms of training, rewards, and career. GET also changes the job roles, responsibilities, management, organizational structures, and hierarchies.

Business Partner's Systems

GET projects aim to improve the interactions of the business with its partner businesses. WS based technologies change the way the business sources services. Information and knowledge management within is changed to make it robust, accurate, reliable, and accessible.

Integration

A major challenge of ICT-driven GET is the handling of integration issues. While integration is always a challenge in even routine upgrades of systems, during GET this issue becomes particularly challenging as all the work areas of the business are likely to change. Integration of ICT systems has to also consider corresponding effect on people, their organizational structures, their device usage.

Business Process–Driven Enactment

Business process, partners, customers, operations, ICT systems and regulatory areas are the foundation of business transformation. Broadcasting and informative business processes are easy to transform as they have less security requirement but they are of less value to users. **Transactive processes**, the next a level of complexity, are mostly commercial in nature. **Operative processes** help in providing and ensuring efficiencies in different departments such as inventory, HR, and finance. **Collaborative processes** are most complex and require interfaces between business processes of external and internal business parties. The GET project should incrementally incorporate these levels of complexities of business processes. The integration of various systems, affects the internal, as well as external business processes. These business processes and supporting systems in the current state of the organization are studied carefully to effectuate the necessary changes in those processes and systems that would result in a unified view to the users. Process modeling tools and techniques can be very helpful in this regard. Training is a crucial aspect of deploying new and reengineered business processes Training of employees needs to handle the transformational complexities. Similarly, training in-house needs to be complimented by potential training for business partners and customers involved in large and complex transactions.

4.7 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 equivalent 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 company'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.

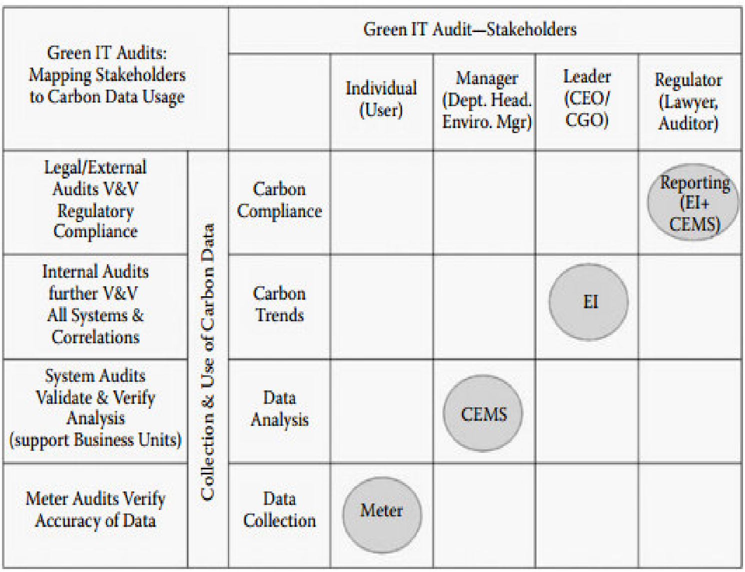


Fig 4.14: Various elements in Green audit

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

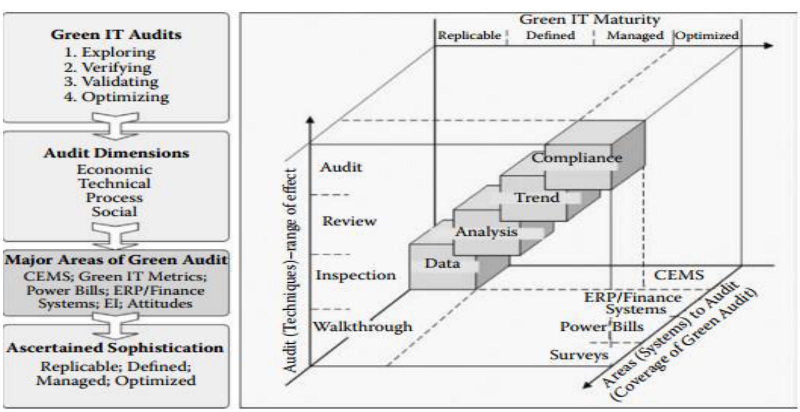


Fig 4.14 Integrated model for green IT systems

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.

4.8 EMERGENT CARBON ISSUES: TECHNOLOGIES AND FUTURE

Development of new environmental standards, potentials for new global understanding in terms of protocols, development, and integration of new CEMS adds value to the carbon reduction mission. The business models have also undergone changes that contributes to carbon reduction. The emergent technologies, innovative processes, innovative business models, demanding customer preferences, synergetic standards, and new, positive social attitudes will foster the development of Green IT.

4.8.1 Future Carbon Landscape

- ❖ The factor influencing Green IT are scientific breakthroughs, innovative approaches, updated standards and legislations, social attitude towards carbon emissions.
- ❖ The directions of growth in Green IT focus towards: Technology, Economy, Process and Social factors.
- ❖ Use of knowledge management tools can foster the creation of more insights and knowledge in Green IT domain.
- ❖ Carbon trading will bring in application of mathematical formulae like Black scholes and Binomials, graphs and tables to price and facilitate trading in the software applications. These applications need to allow for further changes to environmental standards, legislations, and processes.
- ❖ Users also have a varying level of knowledge and appreciation of Green ICT and their interests and priorities also vary. Hence Green ICT applications will have to remain continuously adaptable and agile.
- ❖ The future of Green ICT is in innovation that makes use of social media networks ,puts together groups of people and organizations in consortiums, enhances general opinion on the issues, and activates the Green HR function within the organization.

- ❖ Social networks relating to Green IT and environmental responsibilities can be formed at local, regional, and global level.
- ❖ At each level, these groups have different interpretation and priorities in terms of the environment. Innovation in social approaches will capitalize on these different interpretations and priorities and bring them together on a common platform.
- ❖ This can be achieved by organizations and governments getting actively involved in the social media network phenomena rather that merely observing it or making attempts to control it.
- ❖ The innovation requires due consideration to the mind maps of the individuals operating with carbon reduction responsibilities within the organization, the tools and technologies used by them, and the way these individuals are trained, retained, and promoted.

4.8.2 Green ICT and Technology Trends

Environmental intelligence (EI) includes the correlation and insights into carbon data and information and innovative application of technologies. The technologies that have an impact on Green IT are Cloud computing, software as a service, nanotechnologies, quantum/ternary computing, ecodesign and biomimicry. Similarly, alignment of these technologies with business will be promoted through creation and upgrading of ISO standards, corporate governance standards and fresh look at Green IT strategies and policies.

Cloud Computing

- The underlying premise of Cloud computing has been the consolidation of hardware and software services that are made available through the uninterrupted internet connectivity.
- Lot of advantages can be listed in terms of carbon emission reduction through consolidation of resources.
- The sharing of infrastructure and applications, pooling of reusable data, and flexibility in terms of IT planning resulting from the Cloud has many possibilities that are yet to be explored.
- The opportunities to reduce the overall carbon footprint through dynamic collaboration are on the rise by creation of public and private Clouds.
- Dynamic collaboration on the Cloud enhances the opportunities to use the business principle of Cloud computing: "pay as you go" in terms of using computing services.
- The future of Cloud computing will also be affected immensely by the availability of commonly accepted standards as well as excellence is metrics and measurements.
- Currently, carbon emission calculations in the Cloud are treated external to the organization, resulting in a reduction of the carbon footprint of the user organization.

- A much more precise calculation that balances the consolidation of computing devices with the power expended by the communication networks in communicating with those centralized computing devices is required.

- Cloud-based services will be offered by a conglomeration of large computing vendors with specialist skills, including those in server management, location and infrastructure, metrics and measurements, standards, and, of course, ability to comply with the legal and reporting requirements.

- Following are the areas of Cloud computing that have the potential for reducing the overall carbon emissions across the industry:

  i) Infrastructure

  ii) Applications development

  iii) Application execution

  iv) Reusable Data service

SaaS

Software as a service (SaaS) provides an ideal way to deploy software applications. SaaS provides access to the application that is executing on a remote server, by anyone, as and when needed.

- SaaS is the execution of application from a centralized server through the connectivity accorded by the Internet.

- SaaS model offers a combination of shared services model, improved power consumption, cooling efficiency, and equipment density. Thus SaaS is closely associated with Cloud computing, and adheres to the principle of pay as you go, mentioned earlier.
- While the Cloud offers opportunities to consolidate infrastructure and hardware, and enables expansion without the usual overheads, SaaS creates opportunities to execute applications that are not installed, and configured on the local servers of the organizations.
- Application vendors themselves may no longer be offering their applications as packages but, rather, as services.
- The challenge with SaaS-based deployment is related to data, its integration and its security. SaaS applications are easier to maintain and upgrade as they are installed and configured in centralized place.
- With increasing acceptance of SaaS-based deployment of software there will be a significant reduction in the "clutter" of hardware and software components.

Nanotechnologies

Nanotechnology deals with computing at a microscopic level.

- These technologies have the potential to impact Green IT in terms of both its hardware and its software.
- Nanotechnologies provide means to create, measure, and manipulate electronic data and communications at atomic size.

- ❖ The reduction in size requires considerable research effort—design, development, and production.

- ❖ The power to these minuscule devices requires innovation in battery power technologies. However, the amount of power required by these devices is also small due to t heir smaller size.

- ❖ Reduction is device size, potential elimination of movement (e.g., spinning of disks) within the devices, and ease of handling can all reduce overall carbon emissions resulting from these devices.

Quantum/Trinary Computing

Trinary (or ternary) computing has significant possibilities not only for computing itself but also for improving on the carbon footprint of IT. Trinary computing works at the very fundamental of computing by adding to the binary bit options of “0” and “1,” another option of “-1.”

New Renewable Energies

- ❖ Wind, solar, tidal, nuclear, and biomass are some of the renewable energy resources. Exploring new energy sources that would not deplete with use is a field on ongoing research.

- ❖ Advent of the renewable sources of energy will change the carbon emissions calculations as the emissions resulting from these energies are expected to be much less than those generated by coal and gas.

ISO—New and Upgraded Standards

- The ISO 14001 standard, specifies the requirements of an environmental management system in the context of a specific product or an organization. However, this standard does not contain requirements for that would handle environmental practices associated with collaborative organizations—especially if these organizations are collaborating dynamically.

- Either the ISO 14000 series of standards need to be upgraded to include dynamically collaborating businesses or a new set of standards are required to cover the environmental practices of such collaborations.

- The environmental governance standards that deal with embedding environmental management within corporate governance structures are also required.

- Standards that can dictate, from an environmental perspective, the use of aforementioned emerging technologies, are also required.

Security and Legal

- The current legal frameworks governing carbon emissions come out of the ratification of agreements at various international summits on the environment.

- However, a carbon emission in the context of IT is a global phenomena—especially as Cloud, SaaS, and outsourcing continue to dominate the ITservices sector.

- ❖ While the real user of a service could be sitting in one geographical region, the emissions resulting from his or her work will be attributed to a totally different geographical region.
- ❖ The laws that govern these emissions, and the standards and protocols that surround the measurements of these emissions, need to be developed and agreed upon.
- ❖ The dichotomy between the developing and developed nations in terms of carbon emissions is also a key in the development of laws and regulations that can apply globally.
- ❖ Integral to such a legal framework are the issues associated with security of carbon data. This is particularly so when the data is generated and owned by one organization, whereas it is stored, maintained, and backed up by a totally different vendor of such services.
- ❖ Security of carbon data requires procedures, norms, practices, standards and legal framework.

Ecodesign

- ❖ This is based on the environmental design in very early stage of architecture and design of product lifecycle.
- ❖ While environmental consideration is a product, lifecycle themselves are not a new thing, in depth consideration of the Green P-O-D is involved in this process.
- ❖ Thus eco-design can cover design, raw materials, production, packaging, and distribution.

Biomimicry

Biomimicry, as an emergent trend, requires substantial study, experimentation and usage in all areas of an organization's products and services. Biomimicry can be considered as a combination of science and art that aims to learn from and emulate nature, which is usually sustainable. Nature uses only the energy it needs to carry out a function, ensures that the functionality matches the form, recycles and relies on diversity. Lot of opportunities can be explored by Green IT in the area of data centre infrastructure, design, operations and communication systems. Going by nature, which relies and makes good use of local expertise, the Cloud architecture may become a distributed architecture that takes advantage through decentralizing some aspects of the otherwise centralized architecture.

4.8.3 Green ICT—Business and Economic Trends

- Collaborations, based on internet connectivity offer many business opportunities.
- New collaborative business models that are also dynamic can lead to many different ways in which Green IT is understood and implemented by these collaborations.
- Collaborations enable relationships between a network of organizations enabling them to buy and sell their products and services electronically, thereby making them cheaper to sell or buy as well as enabling the businesses to reach a wide range of market.
- Business collaborations offer opportunity for reusability of data, processes, and systems that in itself is advantageous in reducing carbon footprint.

- ❖ This can also foster information and knowledge gained in implementing Green IT strategies.
- ❖ Green IT should become a self-sustaining commodity that can be traded for its own sake, or increase the share value of a firm.
- ❖ Product based businesses need significant use of the Cloud for calculating raw materials and inventories, relating them to supply chains and also distributing the finished products.
- ❖ Service-based industries have negligible raw materials, inventories are only associated with the equipment and the reis no distribution network.
- ❖ Cloud-based business models, wherein these businesses are using Cloud computing, require the service level agreements to be drafted differently.
- ❖ The services and support required from the cloud as service based business has time critical components.
- ❖ Numerous aspects of such a business model come into play including requirements for uptime, redundancies in data and systems, staff support, education and training, and even marketing and advertising.
- ❖ From a business viewpoint, the future of Green ICT can also be linked closely with good corporate citizenship and ensuing promotion and marketing.
- ❖ Business models reflect changes to the internal organization of business. deliver results. The internal

business model includes addressing internal communication, integrating processes, and enabling sharing of information amongst team members.

4.8.4 Dichotomy of Developing Economies

- ❖ The dichotomy exists between rapid economic development and corresponding carbon control in the developing economies.
- ❖ This issue was the main point of contention between these two groups of economies and was based on the need to consider total carbon emissions over a substantial period of time.
- ❖ If emissions are considered only over last couple of years or even a decade, then the developing nations produce substantial emissions—as the economic development is more or less related to increases in carbon emissions.
- ❖ The developed economies, in the past, generated significant carbon during their own growth periods.
- ❖ New and emergent approaches to sustainability in practice need to incorporate the global factors.
- ❖ Governments, companies, and individuals need to build on them further by bringing in elements of geographical regions as well as time periods in measuring and restricting emissions.
- ❖ Thus new economic models in the way resources are shared over regions and time is required.

- ❖ The disparity of consumption and corresponding carbon emission between the developed and developing countries needs to be bridged.

4.8.5 Collaborative Environmental Intelligence

The various areas of collaborations include those between various stakeholders and parties: between organizations, between individuals and organizations and between government and organizations. Thus, collaborative EI goes beyond the insights required and used by a single organization and into the realms of multiple, dynamic collaborative entities. Collaborative intelligence is a technical platform where multiple organizations are collaboratively sharing their business intelligence for the w in-win outcome without compromising their own market position and differentiation. Developing and formalizing the collaborative EI capabilities will provide collaborating organizations with market differentiators in the environmental space
The following are topics of interest in collaborative EI:

- Collaborative carbon data for trend plotting
- Collaborative data warehouses
- Collaborative EI using Cloud computing
- Collaborative EI with mobile technologies.
- Collaborative EI and Green Blogs
- Collaborative EI and Web 2.0/Web 3.0.
- Collaborative EI and GRID computing

5

CASE STUDIES

Telecom Sector

5.1 ENVIRONMENTALLY RESPONSIBLE BUSINESS STRATEGIES (ERBS)

ERBS is a **business** approach that incorporates environmental factors in it. The major elements of ERBS are:

- the business architecture
- Green policies
- processes that create waste and emissions
- enablement of efficient use of resources
- metrics for monitoring the greening of the organization
- Implementation of environmental strategies.

Environmental sustainability is induced by planning and implementing appropriate strategies and functions like green processes, product developments, energy conservations etc. It is necessary to ensure that all the business aspects such as product life cycle management, operations, Information and technology are effective enough to preserve the environment. The overall strategies of the company to improve business efficiency must include complete environmental obligations and energy consumption guidelines. Companies must introduce innovative methods to improve Information and technology operations to enhance the performance, without increasing the energy consumption. Also, by minimizing waste, preventing pollution and eliminating health and safety risks, the company saves on operating cost.

5.1.1 Stakeholders of ERBS

The ERBS is a goal that can be achieved be involving the employees at high, mid and low levels. The management must commit itself to foster environmental sustainability. Some of the stake holders involved in implementing ERBS are:

- Decision maker
- Green consultant
- Engineers
- Quality Assurance manager
- Technical manager
- Researchers & developers
- Environment regulators
- IT consultant

5.1.2 Formulating Environment Sensitive Business and Strategic Plan

The organizations must implement green practices at every levels. It is the responsibility of the top level management to formulate the business and strategic plans to foster green environment. Some of the important sectors to be attended are:

❖ **Understanding current business scenario**

The following points are the matter of concerns regarding understanding the overall business trends:

- Has a higher power consumption than other similar organizations
- Assumes responsibility for its carbon footprints
- Measures its carbon emissions accurately
- Has a person responsible for environmental matters
- Is aware of the importance of Green metrics
- Uses devices and/or software to measure carbon emissions

❖ **Understanding your business policies with respect to environment:**

This deals with the mapping the business objectives with the environmental goals. Some of them are:

- Policies for purchase of Green equipment and related services
- Policies related to safe disposal of hazardous waste, material, or equipment
- Policies for adopting and implementing recycling of equipment

- Policies for optimizing energy consumption in all business processes
- Policies for use of renewable energy (e.g., solar, nuclear)
- Policies to influence attitudes of staff toward carbon emissions

❖ **Influencing factors of the organization to adopt Green policies**

The following are the factors that plays prominent role in adopting green policies:

- Government rules and regulation in implementing environmental measures
- Customer's demand or pressure for Green policies and Green products
- Pressure from society (physical/electronic groups) to adopt Green policies
- Self-initiated implementation of environmental policies
- Energy consumption in your organization
- Carbon footprint in your organization
- Operational costs in your organization

❖ **Environmental goals of the organization to adopt Green policies**

- Reduction of energy consumption in your organization
- Reduction of carbon footprint in your organization

  - ✷ Reduction of the operational costs in your organization
  - ✷ Improvement of the reputation of your organization
  - ✷ Meet government regulations and legislation
  - ✷ Meet the sustainability goals of your organization
  - ✷ Increase revenue and profitability due to Green initiatives

- ❖ Some of the Green ICT practices:
  - ✷ Videoconferencing
  - ✷ Telecommuting/Teleworking
  - ✷ Fleet and field force management
  - ✷ Web and use of collaboration tools such as e-mails
  - ✷ Mobile phones/PDAs

5.1.3 Technical Strategy and Planning

The organizations practices regarding energy saving data centres and equipment are deals under technical strategy and planning. Some of them are:

- ❖ Energy saving choice when purchasing new ICT hardware
- ❖ Reducing energy used by data centres (ICT)
- ❖ Uses open source system software (ICT) and applications
- ❖ Machine/Server Virtualization (ICT)

- ❖ Counts and monitors ICT devices for emissions
- ❖ Replaces conventional devices with environment friendly devices
- ❖ Reduce the use of paper and related materials (e.g., ink or toner)
- ❖ Reduce use of hazardous materials that can damage the environment
- ❖ Reduce number of high power consuming equipment
- ❖ Use of alternative energy source such as wind, solar
- ❖ Monitor emissions and evaluate on a regular basis
- ❖ Provide training to employees to implement and enhance Green practices
- ❖ Separately monitor the electricity consumed by the data centre
- ❖ Encourage product innovation and environmentally conscious design
- ❖ Life cycle assessment of energy consuming equipment
- ❖ Maintain equipment and instruments in good condition to reduce wear

It is very important to measure the carbon emissions. The tools that aid in that area are:

Dashboard displays attached to the devices to display emissions

- ✸ Mobile gadgets attached to devices for measuring emissions

- Surveys of employees and other stakeholders
- Inventory of the organization to identify unused goods
- Interviews of employees and stakeholders to ascertain carbon emissions

5.1.4 Procurement and Supply Management

The green practices must be followed in procurement of raw materials, processing them and their storage organization etc.

❖ Supply management procurement

- Adheres to environmental criteria for approved suppliers
- Requires or encourage suppliers to undertake environment certification
- Builds environmental criteria into supplier contract conditions
- Incorporates environmental conscious staff on sourcing team
- Keeps record of supplier environmental questionnaires
- Records and evaluate supplier environmental audits and assessment
- Modify the current ERP system to meet environmental challenges
- Buy a new ERP software package that will meet environmental needs
- Seek external help for training and implementation of Green ERP

Apart from greening the supply chain management, periodical audits must be done to check whether the environmental goal are met.

❖ Compliance audits

- Well-documented model for carbon emissions that can be audited
- Regular updates and modification of environmental parameters
- Standard approach to accessing government rules and regulations
- Provides feedback to the government on carbon emission
- Periodically checks environmental documents of the vendor

5.1.5. Strategic Measures for Reducing Emissions

The mission for reducing emissions is very essential to reduce the harmful impact. **Some of the measures are:**

- Use of ICT in minimizing the organization's environmental footprints
- Government regulations that require organizations to limit carbon emissions
- Implementing monitoring methods for carbon footprints in an organization
- Use of alternate source of energy such as solar/wind energy

- Costs involved in implementing Green initiatives
- Formation of an executive body for overall responsibility for environment
- Documented targets for carbon footprint reduction
- Investment funds dedicated to incorporate Green policies
- Training plans and budgets to help employees understand Green issues
- Seek external help for upgrades to a Greener business system
- Modify the current business processes to incorporate environmental needs
- Create power management policies to reduce energy consumption
- Methodology to undertake suitable and defensive power consumption
- Use of power management software

One of the option in reducing the impact of carbon emissions is deploying cloud computing technologies. Software as a Service (SaaS) can be used. Also other devices that can be used to foster green ICT

- Use of SaaS in reducing carbon emissions
- Use of process reengineering to reduce waste
- Use of Cloud computing to implement environmental policies

- ✷ Use of new ICT initiatives as part of a strategy to reduce power consumption
- ✷ Use of devices that provide real time statistical data
- ✷ Use of devices that configured and managed from central services in an organization
- ✷ Use of devices that configured in any designated boundary in the organization

5.2 CASE STUDY SCENARIOS FOR TRIAL RUNS

New Bank Carbon Scenario

New Bank is a hypothetical bank with head office in a large city on the Eastern coast of Australia. The bank has strong customer base and about 24,000 employees. The bank is equipped with good Enterprise Resource Planning (ERP) software. This bank is perceived as a model bank by the Australian government. The bank is aware of the upcoming legislations regarding carbon emissions. The top management of the bank has incorporated Green IT as an integral part of business. The leaders believe that:

(a) undertaking a transformation of the bank to a Green bank

(b) putting in place environmental strategies that align closely with the bank's business strategy.

New bank plans to grow through acquisition. A well-known home loans vendor is in the process of being acquired.

- ❖ There are approximately 650 branches across Australasian region.

- ❖ The acquisitions are not evaluated for their carbon footprint at all.
- ❖ The bank is already above the 150 kiloTonne carbon emission threshold, and is going to berequired to report its carbon data to the government in the next few months.
- ❖ Bank has recently appointed a chief green officer (CGO)
- ❖ The bank maintains a fleet of approximately 300 cars—50 of which are diesel engine cars.
- ❖ 10% of the banks car fleet is usually "hired" through a large car rental company (Hybris).
- ❖ Fifteen percent of the employees need to travel by air to manage the bank's business across allcities in Australia, New Zealand, the Asian region, and globally. This averages out to approximately 5000 km per year per employee depending on the global economic climate, bank's business and need for management.

Following Is the Result of the Initial Green ITAudit Undertaken by the Bank.

Desktop Machines

- ❖ Numbers: 2 0,000
- ❖ Value (current $): $1,200,000
- ❖ Status: Most conventional PCs are between 2 and 3 years old
- ❖ Emissions data (as a rough estimate based on spreadsheet): 1,777,500 watts per hour

- ❖ Conventional = 12,000 × 110 w = 1,320,000 w
- ❖ Laptops = 7,500 × 60 w = 450,000 w
- ❖ Thin clients = 500 × 15 w = 7500 w

Mobile Devices

- ❖ Numbers: 2 6,000
- ❖ Value (current $): $250,000
- ❖ Status: 2.5 years
- ❖ Emissions data (estimate): 10 w per day × 26,000 = 260,000 watts per day

Printers and Peripherals

- ❖ Numbers (total across the organization): 1000
- ❖ Value (current $): 500,000
- ❖ Status (how old/new, etc.): average age 4 years
- ❖ Emissions data: could not be estimated during the Green IT audit

Data Centre IT and Communication Equipment

- ❖ Numbers (total across the organization): 12 + 4 = 16
- ❖ Value (current $): N/A
- ❖ Status (how old/new, etc.): 2-year old equipment
- ❖ Emissions data (if available—or estimate): 16 × 0.5 kW ph × 24 = 192 kw per day

Network Devices; Routers

10 devices, 50 routers and 20 switches

Challenge: Apply Green IT strategies to New Bank to transition it to a green bank—with statedgoals of 10% carbon reduction over every previous year for 3 years.

Bluewaters Travel Agency Carbon Scenario

Bluewaters is a small to medium travel agency operating out of New York. The company has an excellent, elite client base. The company is well-controlled and well-managed single-owner enterprise with approximately 25 employees. At any one time, the company has about eight computers running, together with associated paraphernalia. In addition, there are copiers, faxes, and shredders in the main office. Some employees do occasional telework, especially when they don't have to face a client.

OpenAir Airline Carbon Scenario

OpenAir is a medium, regional airline operating out of the Asian region. The airline has been vulnerable to oil costs during most of its operation. However, with improved opportunities to fly to further destinations than the local region comes the challenge of controlling, reporting, and reducing the carbon footprint. Following are the notes based on an initial investigation commissioned by the corporate board of OpenAir, in the context of carbon emissions: Economic viability of OpenAir is no longer independent of its carbon footprint. Passengers are expecting a m uch greater role from OpenAir in terms of carbon reduction than merely offering carbon off sets to passengers, e specially a s it expands be yond the Asian region.

While electronic ticketing and check in has been introduced with some success, the board sees a need for mobile ticketing and check in. IT as well as carbon costs for introduction of mobile technologies has not been carefully estimated. Need for sophisticated IT systems on the rise, especially in supporting the growth in passenger travels, especially in the business market. Ā e airline has also been launching new products that are based around premium economy seats, luggage-free, or slow-luggage flights, choices of food and beverage on long flights, and so on. The IT support for these processes required substantial changes to the data centre hardware, operating systems, and the applications themselves. There are still, however, many nonstandard IT systems that are not integrated with each other. Fuel efficiency metrics are not tied to carbon metrics. Scheduling of flights, variations to those schedules, and rostering of staff (pilots, stewards) is not optimized. Besides, there is practically no telework culture within the organization. There is some understanding within the organization about carbon emissions from airline fuel, but hardly any acknowledgment and understanding of internal IT emissions.

OpenAir has about 2000 desktop computers, 300 laptops provided by the organization to the employees, and unaccounted mobile devices. Ā ere is a single data centre catering to all the IT systems requirements, with a non-real time off site backup that is a major risks to the airline's business.

5.3 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 to the attention on processes in terms of their carbonreduction, the initial investigation also highlighted that ABC has a significant investment in a data centre. Also, the building and infrastructure of this data centre is now more than 10 years 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.

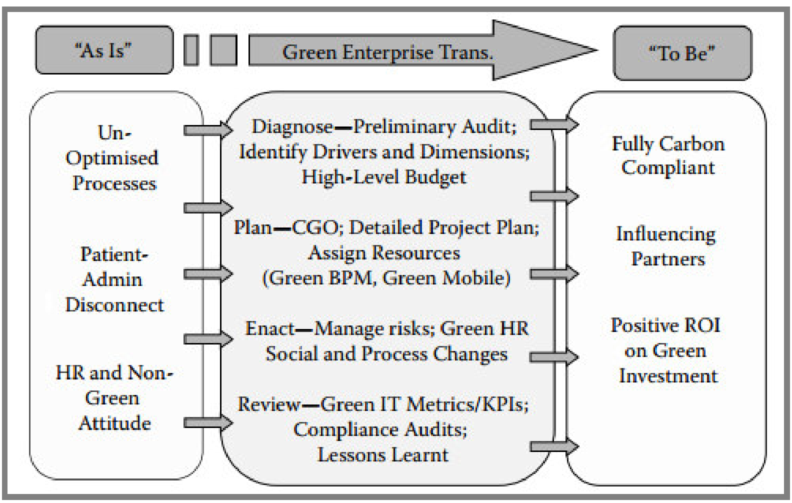


Fig 5.1: Green Transformation of ABC hospital

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.

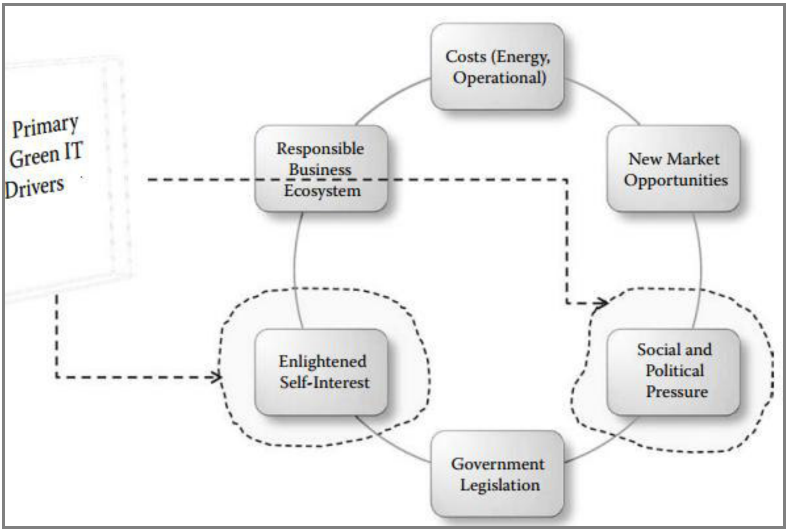


Fig 5.2: Green IT drivers

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

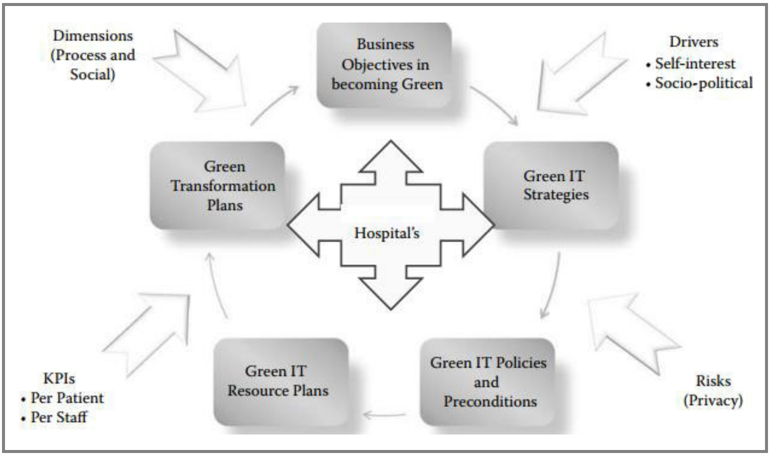


Fig 5.3: Development steps of ERBS

- ❖ 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 quarter 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

  i) GET is closely tied with the profits

  ii) 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.

5.4 APPLYING GREEN IT STRATEGIES TO THE PACKAGING INDUSTRY

B4Pack is a hypothetical organization in the business of manufacturing packages and containers. This is medium sized industry, that has established itself over the last decade as a reliable, honest organization. B4Pack has around 10,000 workers and corporate board led by young CEO. 4Pack is keen to move forward in the area of Green IT. The carbon emissions from its production lines are on the rise, and also the electronic and other wastages. The wastages, are not just restricted to the organization but are occurring at an alarmingly high rate with the end-users of the contents of the packages. The local regulatory authorities are also showing interest in B4Pack's carbon footprint. The products of B4Pack include variety of packages that are made up of materials such as cardboard, foam, plastic, choir, and rubber. These packages or containers are sold to other manufacturers who use them to wrap, store, and distribute their own products, including food medical drugs, equipment, and electronic goods. The containers produced by B4Pack, therefore, need to range from boxes, tubes, and bubble-wraps through to tin cans and jars. Manufacturing of the packages requires materials to be sourced, planning of the production process, inventory of produced packages, and a customer management system.

A recent internal audit revealed that the organization has around 350 desktop machines, close to 100 laptops, and two large data servers in a small, backend data centre. Most PCs have been inuse for 5 or more years, have cathode ray tube (CRT) monitors, and are used by accountants, production shift managers, and administrators. Connectivity for most machines is provided through internal LANs and WANs and externally using a combination of virtual private network and the Internet. The hardware of the organization is used to run variety of applications including B4Pack's assets and inventory management, customer service, financial management, procurement, and HR/Payroll. Data corresponding to these applications is stored in the underlying data warehouse of B4Pack on the two servers. A significant part of the production and inventory data is collected from the shop floor automatically and updated in the data warehouse.

Following are the current observations of the CEO together:

- Raw materials for packaging are available in abundance. There is excessive availability of raw materials particularly from the regions where B4Pack is located.

- ❖ Workers are dedicated to the company. However, most workers have had very basic education, and in some cases no education at all. While expert in particular production process, these workers had no current interest in Green IT or carbon reduction.
- ❖ Wide customer base from both developed and developing region with the business from the developing regions on the rise.
- ❖ Network of transporters who partner with B4Pack to bring in raw materials as well as deliver blank, ready-to-go container packages, typically to the corporate customers.
- ❖ Continuously changing needs of customers—as their products are changing too.
- ❖ Other departments of B4 Pack, that are under the direct influence of these changing requirements are sales, financial, customer service and legal department.

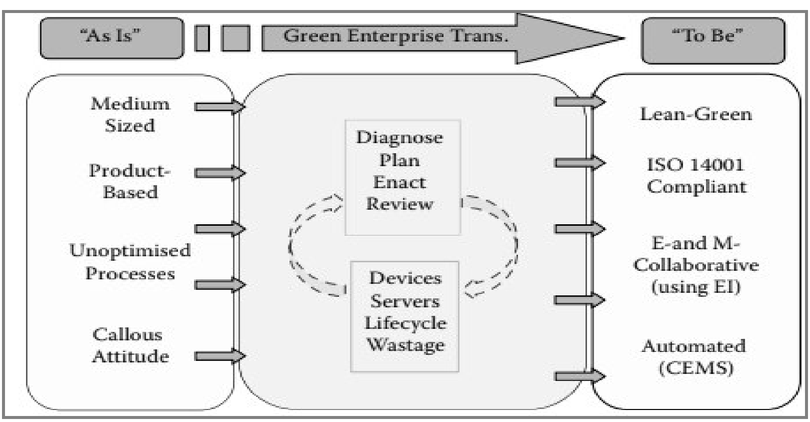


Fig 5. 4: GET for B4Pack

5.4.1 B4Pack's Green IT Strategies

- Focus on use and capitalization of technologies with the creation of a Green IT portal. Use of the portal itself for reporting on carbon compliance by the organization.
- Launching of a GET program that is going to enable compliance with ISO 14001 standard.
- Understand the g rowing environmental awareness of all its customers
- Extend the current process optimization initiative to make it a formal Lean process implementation that will also be measured and reporting for corresponding greenness.
- Form a consortium of likeminded businesses in the region and provide leadership through initial experience of GET.
- Influence and be influenced by customers and suppliers in terms of carbon compliance.

5.4.2 SWOT of B4Pack in Green Context

Strengths

- Visionary leadership through the new CEO and corresponding CGO
- Growing business with sufficient funds enabling easier green IT initiative
- Material-savvy region, with more than a decade of experience in packing/container production

- Strong distribution network—particularly overseas customers

Weakness

- Aging infrastructure—especially technical assets such as computers
- Workforce only experienced in package production—not necessarily IT literate
- Non-serious attitude of most workers toward carbon footprint
- Noticeable wastages in packaging products and IT

Opportunities

- Leadership in packaging materials and designs
- Potential to leap-frog in terms of computing technologies by directly using the latest, low carbon emitting machines and servers
- Acceptance of ideas by partners—customers and suppliers—thereby creating leadership in the Green IT/carbon compliance space

Threats

- Attitude of majority of staff
- Differences in compliance requirements of the developing region versus the developed regions where customers are located
- Inexperience in undertaking GET in the region

5.4.3 Diagnosis in B4Pack

- The CEO of B4Pack realizes that the reduction in costs and optimization of processes will be an ideal driver for the Green IT initiative of the organization. Carbon reduction for its own sake may not provide sufficient motivation for the organization. A good sustainable approach for B4Pack will include optimization of processes, consolidation of its information technology hardware and software and thereby reduce its costs and carbon together. Cost reduction is an excellent driver for Green IT in B4Pack.

- Regional environmental legislation requires B4Pack to monitor and report its overall carbonemissions. These are the operational emissions from the package production process, supporting IT systems and infrastructure and the distribution transport network.

- B4Pack has many partner organizations both locally in the geographical region of the developing country where it operates and overseas, where its customer base is growing rapidly. The visionary leadership of B4Pack is keen to capitalize on these myriad associations with its collaborating organizations and influence them in terms of their carbon footprint.

5.4.4 Planning for GET

The sections that get affected by GET are the customers and business partners, the IT systems and the Regulatory areas:

- **Customers and partners**: Changes to these relationships will be based on changes to the way improving the customer information systems to get ongoing sales from customers.

- **IT systems and applications:** Upgrade of CAD/CAM computers to high powered computers that are networked in a way to reduce the interactions required through the various systems and applications.
- A new Carbon Emission Management Software (CEMS) together with an optimized manufacturing system that would support new and existing business.
- Changes to Service Level Agreements (SLAs) with partners as the organization transitions as also changes to governance structures with greater focus on environment.
- External and internal business processes supporting the manufacturing as well as sales/ distribution of the packaging products will be optimized.
- Operational organization and green HR resulting from changes to the people structure as a result of green initiative.

5.4.5 Economic Dimension in B4Pack

- The economic dimension involves reduction in cost and increase in profit.
- This is done by creating value for customers through reduced carbon footprint in the packaging product.
- The availability of funds to undertake the transformation is a strength of the organization.

- It also includes responsibility on part of the CGO to ensure there is return on this investment in the next 2–3 years.
- Direct and positive involvement and interest from the CEO is extremely helpful as the organization moves along this economic dimension.
- As a result of green transformation, the CGO anticipates growth and expansion of the packaging product business.

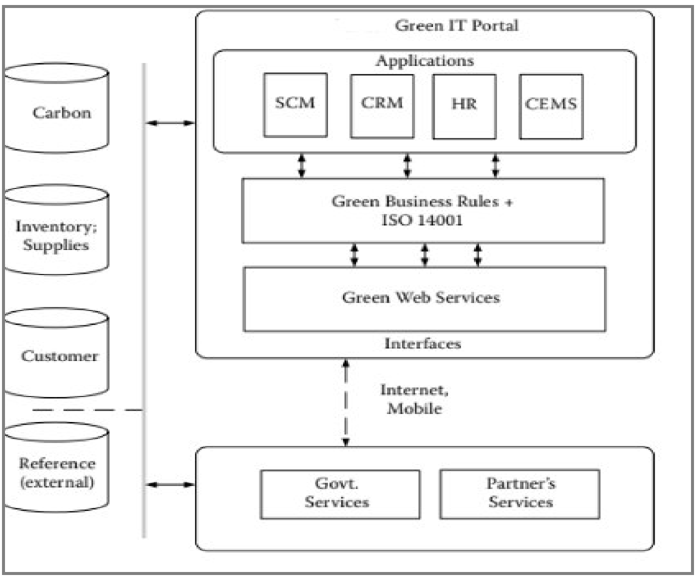


Fig 5. 5: B4Pack Portal

5.4.7 Technical Dimension in B4Pack

A simple CRM package is used for managing technical dimension. Current carbon related data, that was use din the initial investigation is maintained in Microsoft Excel spreadsheet. There is no access to this and such information that resides on the company's servers to most of the employees. B4Pack investigated and has decided to procure a CEMS from Microsoft business solutions and form a Environmental Sustainability Dashboard. This product will be integrated withB4Pack's existing ERP applications to enable tracking of energy consumption and carbon emissions. This is a measure to decrease the carbon emissions with cost savings. The CEMS will create opportunity for the staff at all levels to understand, in real time, the carbon emissions of B4Pack. Also, the dashboard provides information to all users on their desktop and laptop machines within the organization's firewalls. A Green SOA will ensure that the new CEMS is properly integrated with the existing applications. The collaborative business partners will be able to tap into the organization's systems and receive as well as provide feedback.

5.4.8 Process Dimension in B4Pack

This deals with creation of process models that reflect both existing and new green processes. The modeling of the processes can be undertaken using the use cases and activity graphs various roles within and outside of B4Pack. The process dimension of GET has to consider collaborative customers, who will be interacting with B4Pack electronically. The services provided to these corporate customers can be enhanced and optimized to not only add value through accuracy and timeliness but also reduce the overall carbon associated with the collaborative processes.

5.4.9 Social Dimension in B4Pack

The social dimension of the GET is involved with the changing of the attitude of its staff and, also, the changing Green

HR function. B4Pack has to move toward creation of a social networking site. Awareness of the carbon issues and the way they will impact the future of not only the organization, but the country and the global business can bring about a change in attitude. Green HR brings about changes to the organizational structure. This change starts with the appointment of the CGO and the subsequent formation of the green transition project team.

In addition to the CGO, there is an external consultant with expertise in GET, two department level managers fully dedicated to environmental management and 6 supervisors to support them. All of them are involved in diagnosis, planning, enactment, and review phases. Green IT auditor is an additional support role which is also involved in creation, validation, and use Green IT metrics and measurement. Staff will be trained to use the CEMS. Smart meters will be fitted to most equipment involved in the production line to calculate directly the emissions from those production lines.

The social dimension of GET also takes responsibility for management of the changes to the designations and responsibilities of line managers, legal implications a rising from the changes, possibilities of telework, and related privacy issues.

5.4.10 Enactment of GET for B4Pack

The following are the specific highlights of the enactment:

- CEMS—Implement and integrate with the existing systems.
- Comply and maintain ISO 14001

- Model and optimize green processes
- Setup customer/partner portal collaborations through electronic web services
- Upgrade to green data centre
- Emissions reporting through web services to government portal
- Undertake Green IT audits (internal and external)

5.4.11 Review of GET for B4Pack

The review phase deals with verifying and validating the stated outcomes of GET for B4Pack.Green IT audits that have already started during enactment. The formalized findings are reported.

Furthermore, the outcomes need to be measured and studied not only for the new business, but also for the new environment in which the business is now operating. B4Pack's Green IT outcomes are slightly different to the stated goals. This was expected as the business itself was changing and growing during the period of GET. Evaluation of the outcomes include reviewing in accuracy of CEMS, the way in which it collects and reports data and undertaking sample tests to run through the CEMS. Furthermore, green process models are subjected to walkthroughs and inspections to ascertain their accuracy and value in GET. Potential changes to organizational structures and business models are internally audited to ensure they do not adversely affect the business.

These measurements are incorporated in the feedback by the Green Transformation Cham-pion (GTC) to the boards responsible for the green transformation as also to the business stake-holders. Thus, the review process not only ascertains the achievements of the GET but also opensupdoors for further improvements with partners. The Service Level Agreements (SLA) has to be revisited and necessary modifications has to be made.

5.4.12 Lessons Learned in GET for B4Pack

- B4Pack as a product organization with supporting IT systems had to focus on the end-user and its processes.
- GET is a comprehensive business transformation process that includes people, processes, technologies, and return on investment (ROI) calculations.
- Attitude change for people working on production lines is not achieved only through training. A manual process such as one using whiteboards on the shop floor was as valuable as the implementation of CEMS.
- Data centre upgrade required coordination with the production processes that are heavily dependent on the production applications.
- It is difficult to measure the overall carbon reduction by optimizing the design of a package, since the carbon footprint of a package is made up of its usage and eventual disposal.
- Compliance with ISO 14001 is easy to implement in a production shop, but maintaining that compliance proved to be more challenging.

5.5 APPLYING GREEN IT STRATEGIES AND APPLICATIONS TO THE TELECOM SECTOR

TellUs is a hypothetical, large telecom company operating in the African region. This responsible for the core telecom infrastructure in the region, in addition to offering some land-based and mobile services. Main focus of TellUs's business has been the creation of the telecom platform that provides the backbone for communications infrastructure in that geographical region. The customers range from corporate people to households. Although owned by the government, TellUs's board is able to control its own directions and also has its own responsibility. The corporate board of TellUs comprises its business leadership(CxO level), representatives from the trade unions belonging to the large workforce and government representatives.

The core business of TellUs (i.e., creation of high-end communications infrastructure) involves technology innovation and adaptations that result in large-scale construction and implementation of physical and wireless communications networks. TellUs is owned by the government under financial as well as legal agreements. However, with the operational independence of the organization, and the receipt of a government directive on climate change, TellUs is now considering extending, embellishing, and putting into practice its environmental plans. Increasing awareness of the environment in the region implies that these corporate customers, including contents and service providers, have started demanding carbon reduction particularly in the networks that are used by them to provide their own contents and services.

An important aspect of this formal approach to the green telcom initiativeis to ensure it is not carried out by reducing business volume and service. The green enterprise transition directive from TellUs's CEO includes the need to synergize between the carbon and cost efficiencies. This synergy between environmental and business benefits is expected to be achieved by optimizing the business processes of TellUs with the help of information technologies and systems.

An important motivating factor in TellUs's board decision to control and reduce its carbon footprint is that it is a government owned organization that needs to showcase the government's carbon reduction commitment. TellUs has the opportunity to impact many comparatively smaller organizations that have to use its platform and infrastructure services.

Such an impact opens up possibilities of reduced work travel across the metropolitan cities where TellUs's platform is heavily used and, eventually, large-scale attitude, and behavioral change.

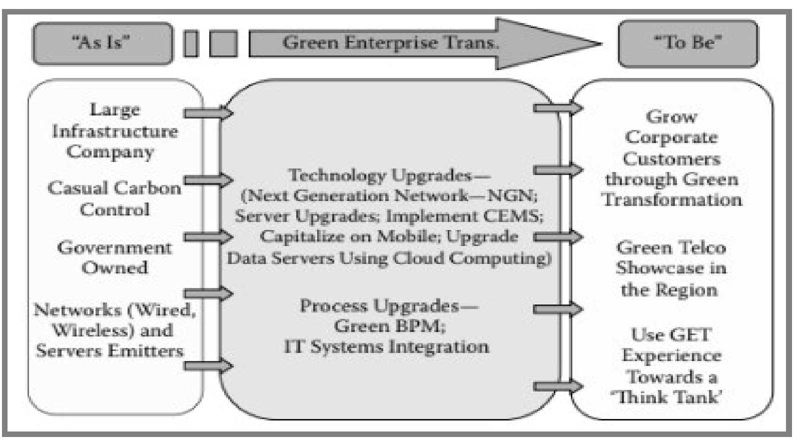


Fig 5. 6: GET forTellUs

The highlights of business and technology advantages of the GET approach of TellUs:

- ❖ Growth in business with corporate customers, due to carbon reduction and corresponding boost in the image of TellUs.
- ❖ Upgrades of hardware, software, and networks, but now closely aligned with environmental performance.
- ❖ Ability to comply with policies, legislative, and regulatory frameworks that are put together by the government as well as telecom's summit bodies and industrial consortiums.

  Ability to handle carbon taxes, particularly as a government organization. These carbon taxes are envisaged to be applicable directly to large, infrastructure organizations such as TellUs.

- ❖ Preplanning on how to deal with corporate customers in terms of financial models that will enable sharing of carbon taxes between them and TellUs.
- ❖ Ability to ensure there are no carbon penalties and fines.
- ❖ Capitalizing on incentives. Properly and accurately measured carbon emissions and their subsequent reduction may also create opportunities for government incentives in terms of financial rewards as well as support for growth.
- ❖ Make good use of mobile technologies and services which, while requiring additional power to operate, also create opportunities to significantly reduce carbon.

- ❖ Ability to enhance network efficiency and effectiveness of the communications equipment.
- ❖ Create and promote policies to help the corporate customers with their own Green IT strategies, such as recycling of handsets.
- ❖ Ability to dynamically create and manage policies through sophisticated CEMS.

5.5.1 Strategic Approach to Green ICT

The infrastructure of TellUs have substantially large numbers of data servers, communication switches, and related networking equipment, large physical buildings across multiple regions. TellUs has service-oriented interfaces with the IT systems of the energy vendors. The setup is different from hospital or manufacturer of packaging industry. The end-user is not directly visible. The major carbon emissions come from the power consumed by the overall infrastructure including communications network and data servers rather than individual user devices. Device level power management systems as well as training the users canbring about reduction in carbon emissions. Power-smart add-ons to manage the operating systems of these devices will also enable improved measurement and control of carbon through these large number of end-user devices.

The carbon produced by the organization is primarily through its infrastructure platform and related services. These are large-scale communications services across the region consumed by corporate customers and content providers. The strategies for carbon measurement, reporting and control need to focus directly on these large-scale infrastructures like communications towers, telecom switches, wired and wireless relaying equipment, associated routers, data servers and the many IT supporting hardware. Specialized software will also be equipped with these infrastructures. These systems enable the business to operate but, at the same time, generate carbon that contributes to the overall carbon footprint of the organization. Siloed data in these applications, which requires continuous interaction amongst these data bases, is a source of major, wasteful carbon.

With an infrastructure organization likeTellUs, the strategies for Green IT are brought forward in time as compared with the generic suggested timelines. Thus, the strategies that are created, in a generic Green IT approach for 3 years,are hurried forward and brought to bear results within an year. The long-term 5-yearstrategies are brought closer in time to around 3 years.

From a technology viewpoint, the focus should be on the data centre and IT systems right at the outset. The longer-term strategy of Green IT for the organization, in a 3-year period, will be re-architecture and design of the communications infrastructure. While this communications infrastructure is of immense value in the GET for TellUs, the actual transformation of the network is likely to take 3–5 years. This network redesign will closely involve both business and technology expertise as it will require an investment that goes beyond that only for a GreenIT project. The GET of an infrastructure company such as TellUs will include substantial influence on all its customers and partners. Changes will include implementation of TCCO metrics even to servers and New Generation Network (NGN) across its operating life. Green collaborative architecture of its systems through a web services based portal with underlying data warehouse. These long-term Green IT strategies also incorporate dedicated use of renewable energy sources.

5.5.2 SWOT Analysis of TellUs

Strengths

- ❖ Government owned and supported organization that is aware of the upcoming legislations in the carbon context.
- ❖ Excellent channel relations including corporate partners and government representatives.
- ❖ Influential, monopolistic organization with no competition in infrastructure.
- ❖ Ample opportunity for steady revenue that frees the organization to focus on its Green IT eff ort.

Weaknesses

- ❖ Inflexible infrastructure as is expected in a large telecom in a developing region
- ❖ LargeIT systems that are based on past, legacy databases and applications.
- ❖ Bureaucratic decision-making process, that is invariably a part of a government owned body; but such decision making creates challenges in terms of timings and follow up actions as the organization transitions.
- ❖ Physically dispersed infrastructure, with buildings, communications towers, and supporting data servers, all

physically spread across the geographical region, making coordination extremely challenging.

Opportunities

- ❖ Combining business with green transformation will lead to show casing of the Green IT strategy created by the CGO that does not discount one goal over the other.
- ❖ Business shift to mobile platform resulting in reducing needs for physical wired connectivity and corresponding reduction in the required infrastructure.
- ❖ Growing content and service providers who will need the increasing sophistication of theNGN platform.

Threats

- ❖ Resistance to change.
- ❖ Long time for visible results of the GET
- ❖ Total inexperience in GET in the region as this would be the first large project of its kind that will bring together the knowledge and expertise of Green It with that of telecommunications. External, overseas consulting help will be required to ameliorate this risk.

5.5.3 Motivators and Dimensions

Developing and influencing a responsible business ecosystem, together with reduction in cost of operations is emerging as a major motivator for TellUs to undertake GET. Other motivators includes government legislation and social pressure. This telecom company by upgrading its technological platforms, will not only grow its corporate customer base but also influence all its partners in its business ecosystem to be carbon compliant.

The technical nature of the challenge, particularly the communications networks, also indicates that the Green enterprise transformation will be best achieved by immediate focus on technologies. These technologies include the IT systems and hardware, as well as the communications networks. The company's corporate board has sanctioned the formation of the GET board. The current CTO (chief technology officer) has been appointed as the CGO for the transformation. Knowledge of the inner working is very crucial for technological upgrades. The CGO, together with select members of the Greenenteprise transformation board, has extracted the existing, information Green IT strategy and has created a full programme to undertake transformation.

The diagnose, plan, enact, and review are the four phases also established in business transformation. These transformation phases are interspersed with metrics that help in stating the goals (KPIs) as also measuring whether the stated goals have been achieved or not.

5.5.4 Diagnosing of the TellUs

- ❖ The current carbon footprint and its carbon readiness is being conducted by the Green Enterprise Transformation Board.
- ❖ This activity is authorized by the corporate board after in-depth discussions with the trade unions representing the large workforce of the organization.

- This diagnosis phase examined the data centre, the communications networks, the equipment lifecycle processes and the supporting H R function.

- TellUs's as-is business processes were not modeled or optimized. Due to lack of formality associated with modeling and documentation of business processes there was substantial wastage and resultant carbon emissions.

- The current investigations are into the assets such as networks infrastructure, information systems, and data bases also indicated a close nexus between the unoptimized business processes and these technology hardware and software.

- Formal diagnosis phases also revealed that the transformation of the telecommunication networks and information systems to achieve green maturity has to be closely aligned to business model to ensure that it is not achieved at the cost of business growth.

- Green IT strategy for TellUs includes transformation of communications networks, IT hardware, I T systems, and business processes.

- The organizational culture has to also undergo change, which will be brought about through training and education.

- TellUs will undertake transformation in Strategy, Infrastructure and Product (SIP) processes as the seare the most technology-intense processes.

❖ These changes in these processes will also change other processes and affect the internal staff as well as people from the corporate customer groups.

❖ Starting with the strategic aspect of the lifecycle, the GET will then undertake changes and alignment to infrastructure lifecycle management and eventually product lifecycle management processes.

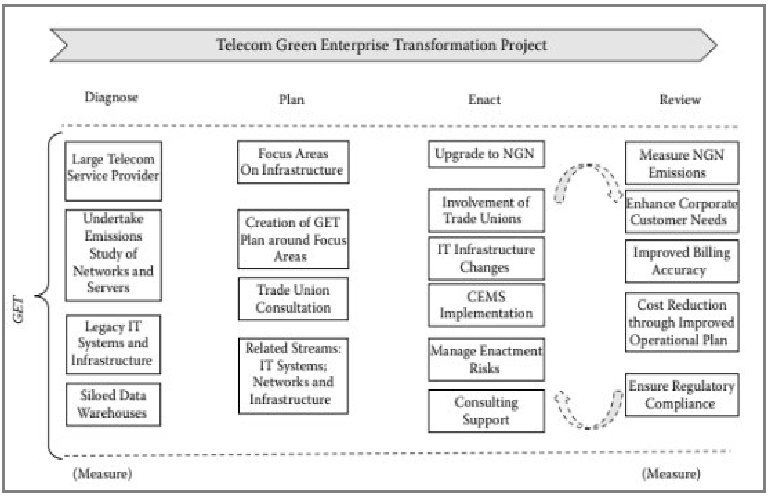


Fig 5.7 GET for TellUs

❖ Green IT metrics and measurements apply to all of these enhance telecommunication operations map (eTOM) based processes.

❖ The transformation of IT systems and resources provides opportunities to measure the KPIs of the TellUs processes supported by the IT systems.

❖ Optimization of the process also ensures cost- and time-effective delivery of services.

- ❖ Training and education will lead to carbon consciousness throughout the organization.
- ❖ This implies clear understanding among the staff.
- ❖ Changes to the IT systems and applications include review of the database, setting up of integration interfaces through SOA and accurate reporting in terms of both carbon and non carbon data.

5.5.5 Planning for GET

- ❖ eTOM provides an excellent and comprehensive reference model for the telecom sector.

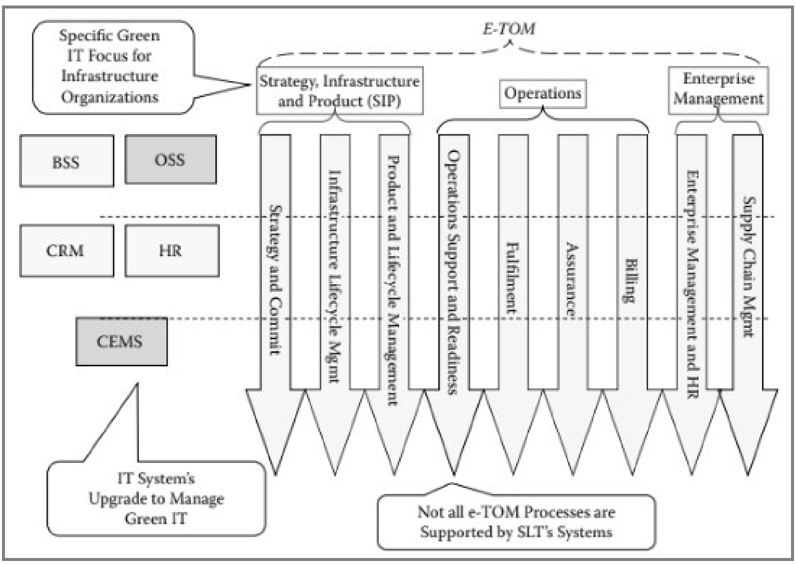


Fig 5.8: eTOM model for TellUs GET

- ❖ The strategy and commit, infrastructure lifecycle management, and product lifecycle management are the major areas of focus.

- The processes that support and align with these major areas are the marketing and off er management, service development and management, resourced envelopment and management, and supply chain development and management.
- These processes derived directly from eTOM are supported by the various IT systems and applications of TellUs.
- The proximity of technology-based changes with the process dimension.
- In large, infrastructure-based GET, such as in TellUs, all four dimensions are involved.
- Thus though one dimension, such as the technology dimension, takes lead, other dimensions immediately follow and support the transformation.
- The modernization effort is aimed to not only reduce carbon but also optimize processes for its corporate customers, including content providers.
- Planning for green process reengineering will involve grouping the processes based on the "operations" group. The process groups formed during planning phase will continue during enactment and review.

5.5.6 Enterprise Data Centre Transformation Plan

- TellUs has two large data centres in two major cities in the region.

- Both data centres operate on a24 × 7 basis as it needs to support the corporate customers, service and content providers, as well asinternal HR.
- Together, there are 12 high-end servers, with four additional servers as backup servers for emergency.
- The data centre does not currently have a space allocation strategy and the data and application requirements are growing at the rate of 1Gig per day.
- The data centre director has made some attempt to measure PUE (power usage effectiveness) and the results are a PUE of 2.4.
- There are a few local servers within the organization.
- Implementation of CEMS will include incorporation of the aforementioned KPIs that bring together carbon and measurement of IT system's performance.
- The reduction in data usage, duplication, and storage will also reflect corresponding carbon reduction.
- Processes associated with content and service providers will enable them to use the upgraded communication platform in new and innovative ways.
- The Green ITstrategies of TellUs will align the transformation to the NGN with the business strategies of the content and service providers.
- Increase in contents and demand for greater network coverage—especially on the 3G networks implies need for high-capacity networks. NGN, providing some

capacity, needs to be balanced with the carbon footprint of NGN.

- ❖ TellUs's cost consideration in GET project includes costs of network upgrades, costs associated with formation of the project, and cost of procuring and implementing CEMS.
- ❖ Data servers in the current setup at TellUs have been left running irrespective of usage.
- ❖ Manual control is also used to reduce their emissions when they were not in use.
- ❖ Post-GET server management will have to be automated through power management software.
- ❖ TellUs is in a position to influence handset manufacturers as well, as a part of its influence on its business ecosystem, to put together plans for take back of mobile devices.
- ❖ Mobile devices need to be recycled, ensuring regulatory policies that make the manufacturers responsible for taking back devices that would be e-waste.

5.5.7 Enacting GET for TellUs

- ❖ The suggested timeline that considers two major iterations for enactment and review.
- ❖ The first enactments and review focus on initial changes to the network.
- ❖ Changes to the enterprise architecture based oneTOM and the procurement and implementation of eco

Governance as the CEMS is also happening during this enactment.

- ❖ IT systems and applications need to be mapped to the reengineered business processes—occurring in the second part of enactment.
- ❖ Changes to the IT applications will impact the collaborative business processes of partners such as the content and service providers.

5.5.8 Data Centre Changes in GET

The actions in data centres arebased on the planning for GET discussed in earlier section:

- ❖ Implement integrated blade servers that will consume less power.
- ❖ All new servers that are procured will be low carbon emitting blade servers that will have inbuilt virtualization capacity.
- ❖ TellUs will actively seek renewable energy sources such as solar and gas, which can be combined with the current coal-based power generation.
- ❖ Integration of connectivity among the servers within and across the cities, outsourcing of some of the hardware maintenance aspects of the data centre to ensure highly optimized services.
- ❖ Implement natural cooling for data centre.
- ❖ Optimization of signals creating opportunities to reduce demands on the servers, which in turn would reduce

power consumption for the servers and corresponding air conditioning

- ❖ Implement eco-friendly air conditioning for the servers.

5.5.9 Next-Generation Networks in GET

Complete the implementation of NGN within TellUs's entire communications network. This implementation is expected to take between 3 and 4 years to complete in the region where TellUs operates. This change to NGN will result in strategic reduction in carbon due to improved network efficient, intelligent routing methods, and consolidation of switching centres. This reduction in power consumption is envisaged to be effective even if there is increase in network traffic as expected over the coming years. The Green IT metrics used in the return on investment (ROI) calculations needs to consider not only the replacement costs of the network and equipment, but also the drop in emissions per user over increased number of users.

5.5.10 Equipment Lifecycle

The entire lifecycle of TellUs is subjected to Green POD. The activities relating to material and equipment lifecycle that will undergo change include carbon reduction consideration in current POD practices within the organization. The new servers will be procured based on their power consumption ratings as well as their total carbon cost of ownership. The disposal of IT hardware is through a series of ranked options including giving it to employees, then charity, and fi nally for safe disposal.

The business infrastructure of TellUs, such as its buildings and car fleet will be accounted for in the updated financial systems where Scope 1 emissions can be calculated and updated. Enacting changes to t he procurement-operation-disposal process will be based on following considerations:

- All procurement to be based on EPEAT/energy star based ratings
- Highly optimized processes that would support procurement of IT hardware as well as communications equipment
- Incorporation of carbon calculations and Green credentials to support procurement of the NGN.
- Renegotiation of SLA with hardware and network equipment suppliers
- Optimized operation of network, servers, and associated IT hardware
- Apportioning operational carbon over the life of the equipment to arrive at TCCO
- Ethical disposal of existing legacy network hardware

5.5.11 Attitude and Training

The following measures are essential to provide necessary training to the employees and bring a change in the attitude of the employees:

- Creation and de livery of brief 2 -hour seminars on the relevance of Green ICT.
- Detailed training to IT managers, network managers and data centre managers

- External training to Green enterprise transformation board on the transformation process.

5.5.12 Review and Measure

- There are two specific reviews after each iteration of enactment.
- A significant learning that has happened is the need to understand the politics and underlying motivation of individuals participating in the transformation project.
- The age-old management understanding of the risks associated with change hold utterly true in this transformation.
- Quality assurance and testing activities were also required to be formally carried out on the new and integrated IT systems and content management.