Unit-2

GREEN ASSETS AND MODELING

2.1 GREEN ASSETS

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

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

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

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

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

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

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

2.1.1 Green Building

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

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

- efficient management of energy and water resources
- management of material resources and waste
- restoration and protection of environmental quality
- enhancement and protection of health and indoor environmental quality
- reinforcement of natural systems
- analysis of the life cycle costs and benefits of materials and methods
- integration of the design decision-making process
- –Metrics‖ for such –green‖ benefits are articulated and certified by LEED, BuiltGreen or other organizations
- Green standards measure different environmental qualities of buildings
- Each has a different emphasis and purpose

Green Building standards include:

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

Why go –Green?

Green makes business sense

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

Table 2: rating Building features to environmental factors

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

Green IT Hardware

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

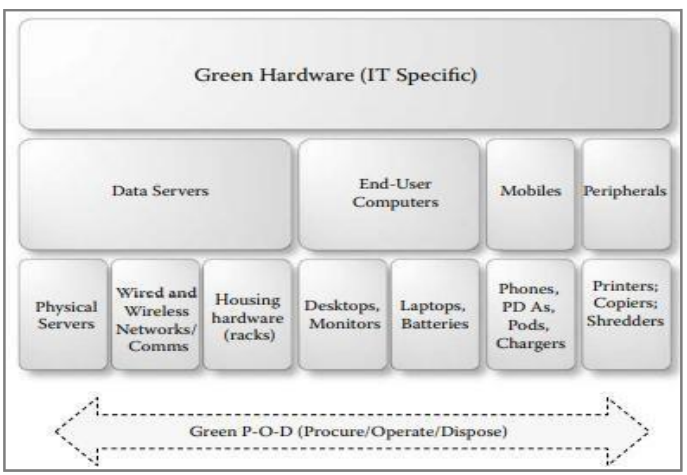


Figure 2: Range of Green IT hardware generating carbon

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

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

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

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

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

2.1.2 Green Data Centre

What is green Data Centre?

A green data centre is a repository for the storage, management and dissemination of data in which the mechanical, lighting, electrical and computer systems are designed for maximum energy efficiency and minimum environmental

impact. These centres use more energy-efficient servers and most importantly the design technology to reduce energy demands for cooling and lighting.

Need for Data Centres:

1. Data centres are heavy consumer of energy, accounting for between 1.1% and 1.5% of the world's total energy usage in this decade. The Green data centres are energy efficient data centres that better utilize energy and increases performance.
2. Green Data centre reduces both operating costs and capital costs since they eliminate the need of additional power and cooling demands.
3. Green data centres reduces the technological impact on the environment and use of natural resources, thus helps environment to be sustainable.
4. They improve business by improving their corporate image and social image by meeting compliance and regulatory requirements.
5. They utilize resources such as office space, heat, light, electrical power etc, in an environmental friendly way.

Who are using Green data centres?

Steps to make a data centre Green.

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

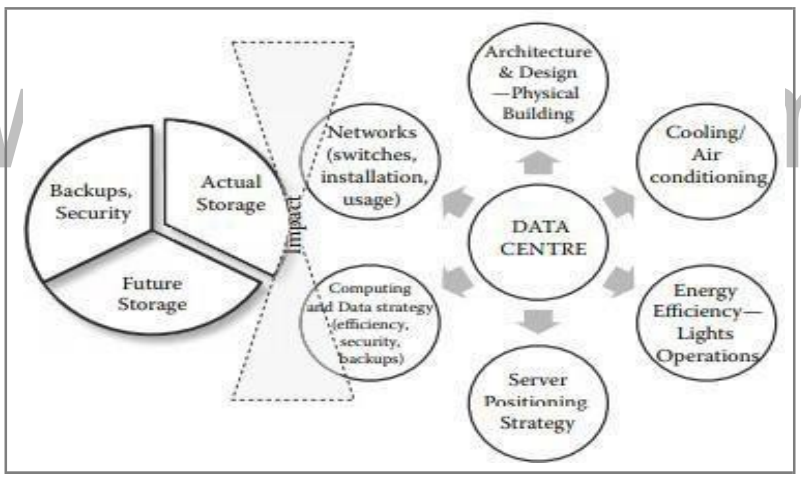


Figure 3 – Factors influencing Green data centre

Data Centre Building—Design, Layout, and Location

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

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

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

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

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

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

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

- **The 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 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 kilowatt 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.

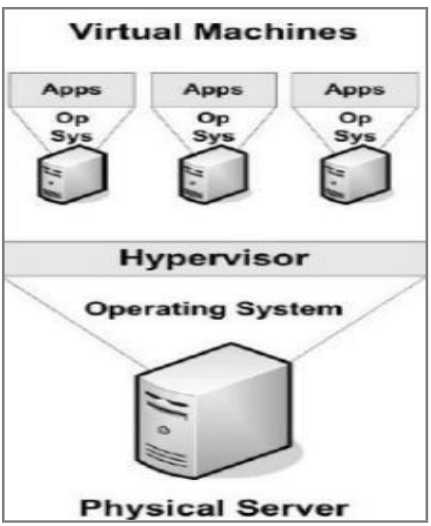
- The software that makes this possible is known as hypervisor.

Why green computing uses Virtualization?

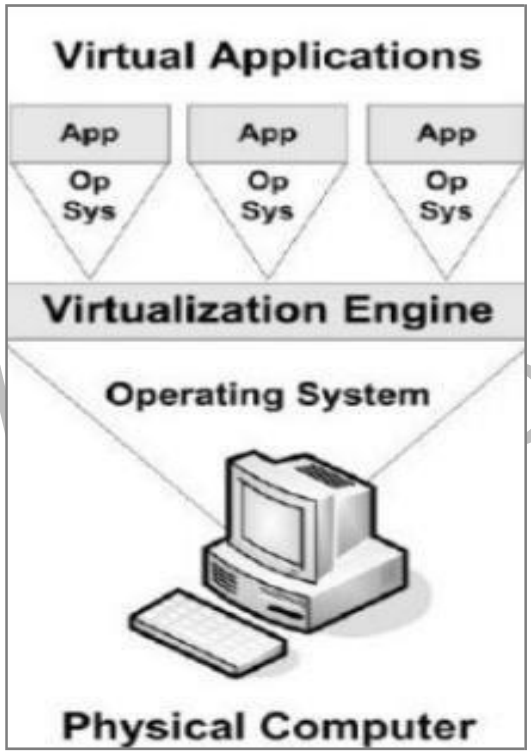
- **Decreased energy use–** reducing number of physical devices, the amount of energy required to operate the devices is decreased as well reduces the cooling system power requirement.
- **Reduction in toxic waste–** number of hardware devices are reduced so huge reduction in e-waste or toxic wastes.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

Types of virtualization

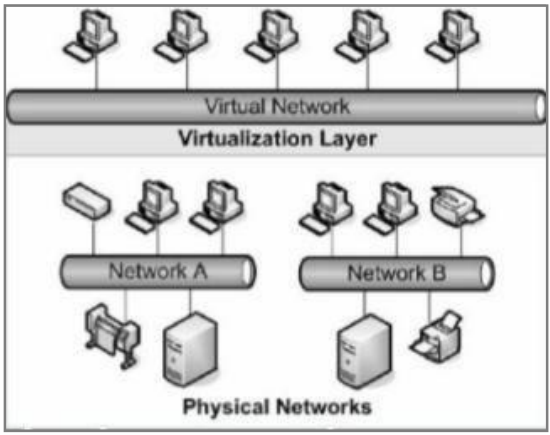
- **Server virtualization–** many servers run on single physical server. Helps decrease energy usage and provides more floor space.



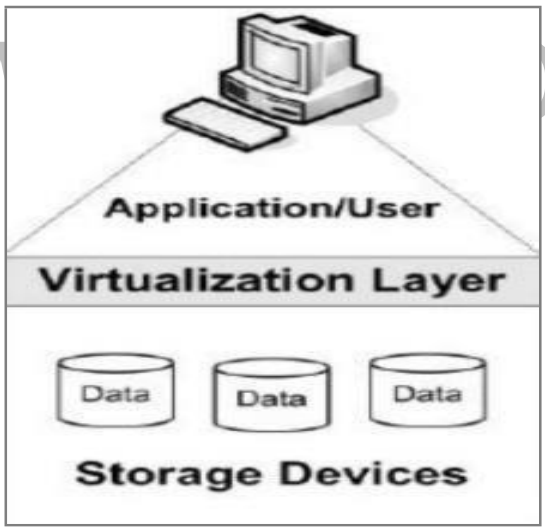
- **Application virtualization** – applications can be run independently of the underlying host operating system. Since no device drivers are installed can run application without administrative rights. Applications can be run from portable media, if not compatible can be executed on physical machine.



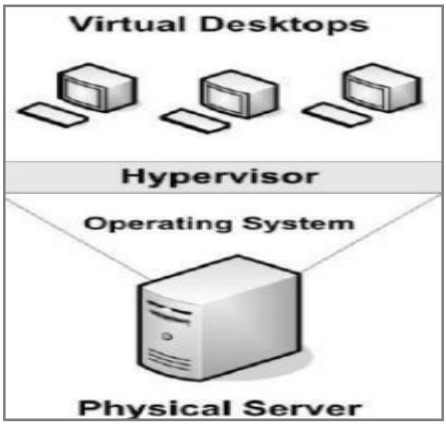
- **Network virtualization** – It allows us to combine all of the resources available on a network by splitting up the available bandwidth into independent channels. Consolidation of many physical networks into one virtual network. Partitioning of single physical network into many virtual networks is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

Table 3: Basic Process Characteristics and Corresponding Green Connotation

Process Characteristic	Description	Green Business Connotations
Necessary	Challenges - theneed 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 supportinghardware, 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.

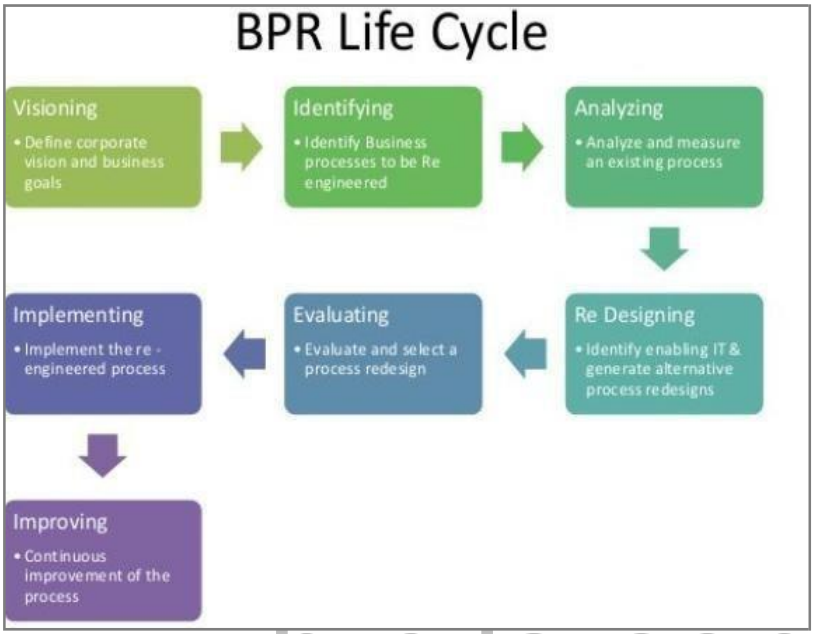


Figure 4: Life cycle of BPM

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 movesfrom 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.

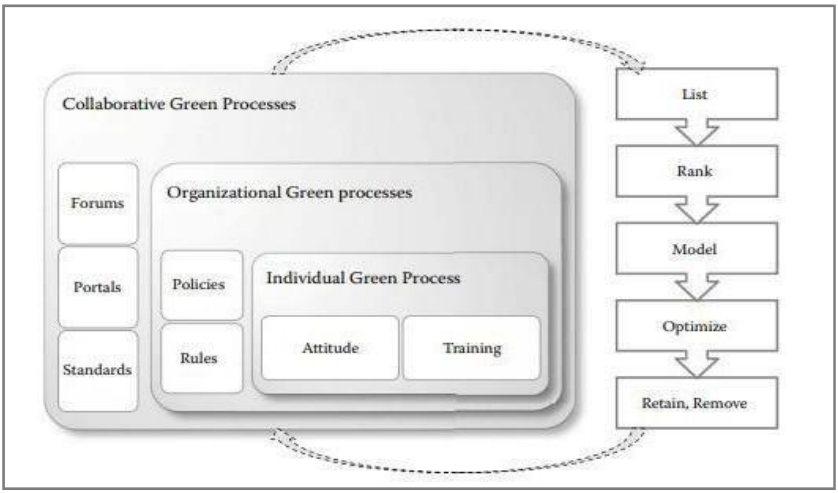


Figure 5: Individual, organizational, and collaborative green processes and their reengineering

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 intelligentsystems
- 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

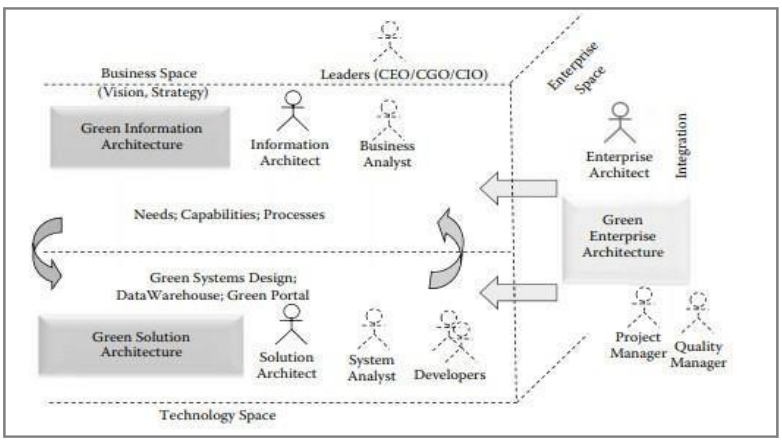


Figure 6: views of a Green enterprise architecture

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 andservices.
- 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

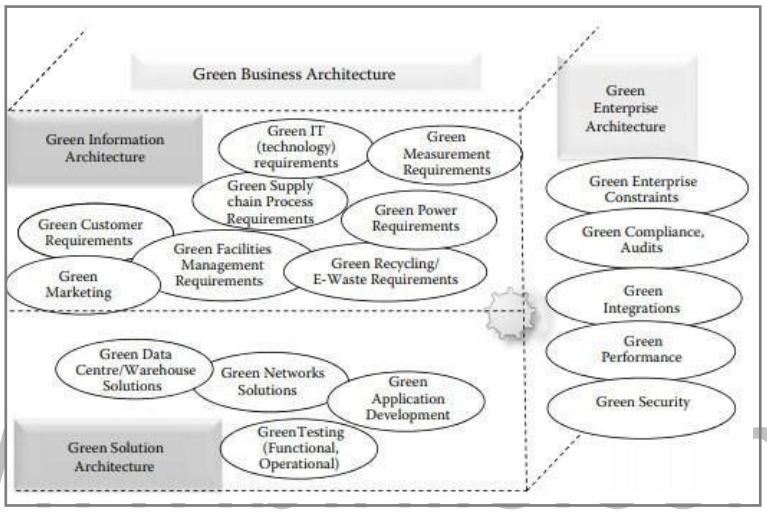


Figure 7: Categories of requirements of various GEA

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.

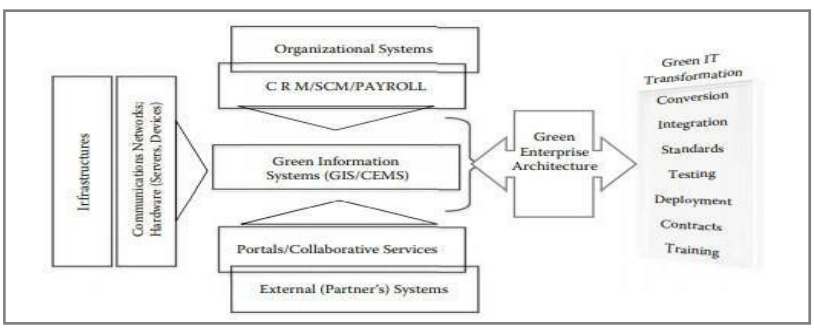


Figure 8: Green enterprise architecture impact

- **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 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.

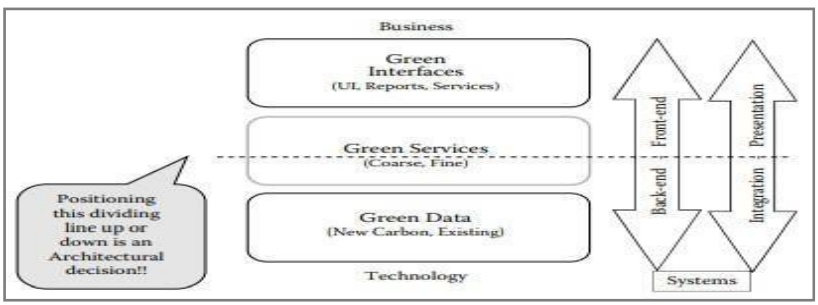


Figure 9: Fundamentals of GSA

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

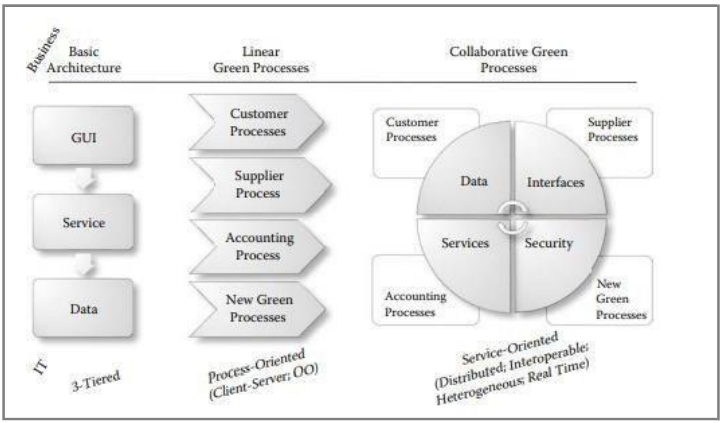


Figure 10: Evolution of Green System Architecture

- A GEA has evolved from a basic base 3-tiered architecture, to a collaborative green processarchitectures.
- 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, collaborativegreen 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.

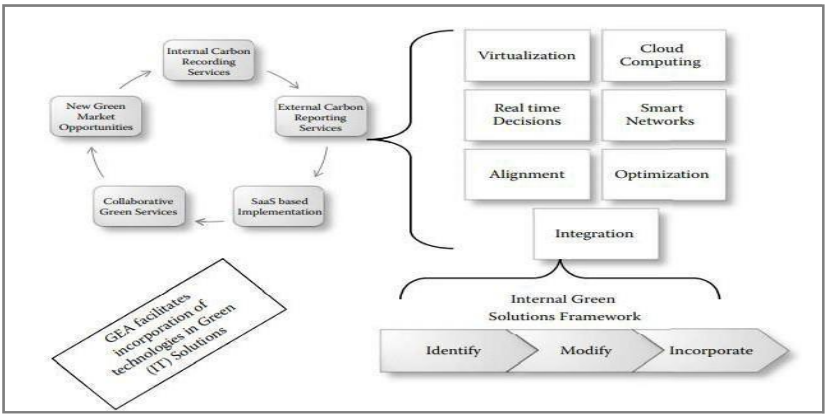


Figure 11: Various aspects of a Green solutions architecture

2.6 Green Information Systems: Design and DevelopmentModels.

What is GIS?

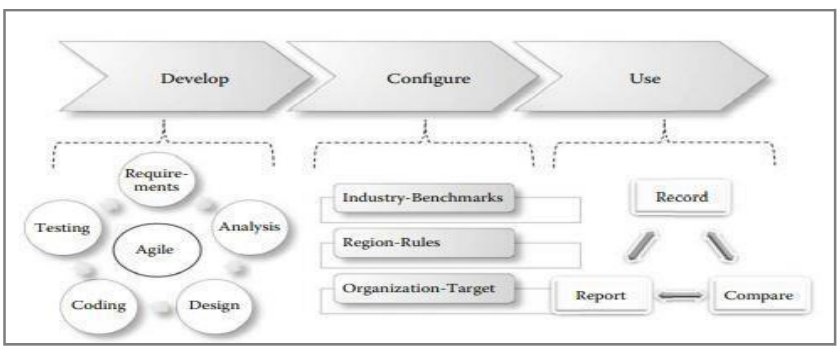
A GIS (or a CEMS (Carbon Emission Management Software) **or EIS**(Environmental Intelligence System)**)** is a software system that provides support to the business to implement its environment responsible business strategies (ERBS), it has processes and applications that help analyze that data, identify 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 categoriesthat 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.

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 materialtransfer 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 distributioncentres 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.

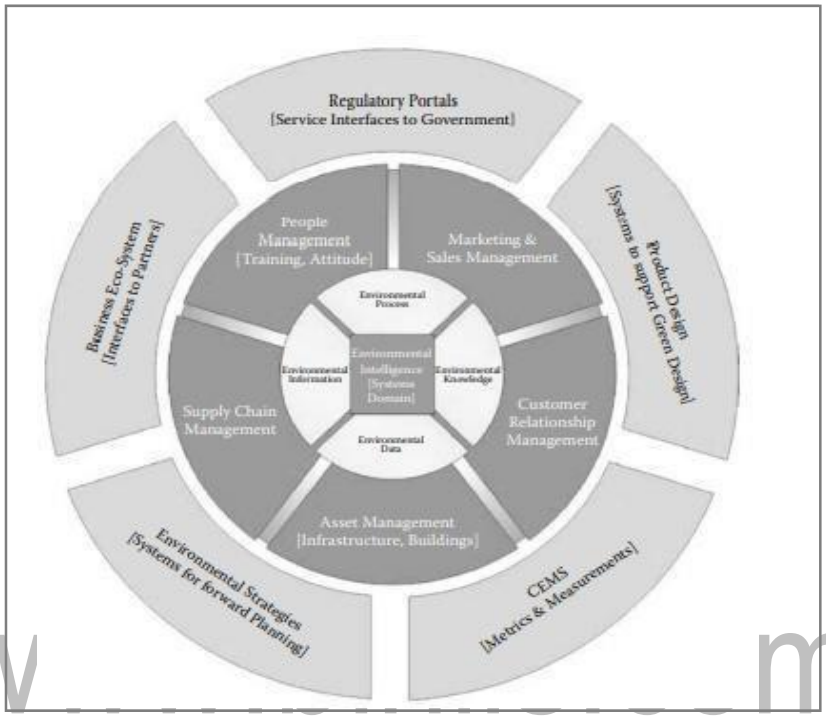


Figure 12: Environmental Intelligence

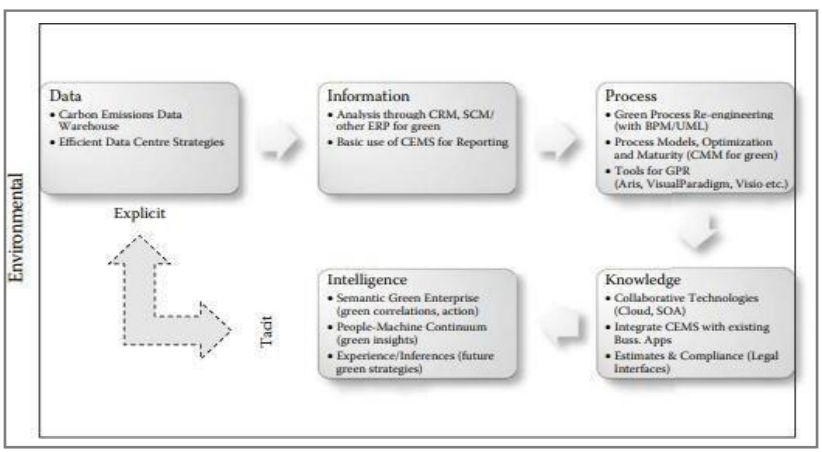


Figure 13: Environmental Intelligence - complexities