IMIT CUTTACK

MCA 2nd SEMESTER

MCA 205 (Environmental Studies and Green IT)

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MODULE-1

1.1 INTRODUCTION

The word 'Environment' is derived from the French word 'Environner' which means to encircle, around or surround. The biologist Jacob Van Uerkal (1864-1944) introduced the term 'environment' in Ecology. Ecology is the study of the interactions between an organism of some kind and its environment. As given by Environment Protection Act 1986, Environment is the sum total of land, water, air, interrelationships among themselves and also with the human beings and other living organisms. Environmental Science is the interdisciplinary field and requires the study of the interactions among the physical, chemical and biological components of the Environment with a focus on environmental pollution and degradation. It is the science of physical phenomena in the environment. It studies the sources, reactions, transport, effect and fate of a biological species in the air, water and soil and the effect of and from human activity upon these. Environmental Science deals with the study of processes in soil, water, air and organisms which lead to pollution or environmental damages and the scientific basis for the establishment of a standard which can be considered acceptably clean, safe and healthy for human beings and natural ecosystems.

The Environment is about the surrounding external conditions influencing development or growth of people, animal or plants; living or working conditions etc. Environment belongs to all living beings and is thus important for all. Hence, environment refers to the sum total of conditions surround in space and time. The scope of the term 'Environment' has been changing and widening by the passage of time. In the primitive age, the environment consisted of only physical aspects of the planet earth ie., land, water and air as biological communities. As of now, it includes social, economic and political conditions also.The answer for the question where surrounded is in nature that physical component of the planet earth, viz land, air, water etc., support and affect life in the biosphere..

DEFINITIONS OF ENVIRONMENT:

Some important definitions of environment are as under:

1. According to Boring, 'A person's environment consists of the sum total of the stimulation which he receives from his conception until his death.' Indicating that environment comprises various types of forces such as physical, intellectual, mental, economical, political, cultural, social, moral and emotional.

2. Douglas and Holland defined that 'The term environment is used to describe, in aggregate, all the external forces, influences and conditions, which affect the life, nature, behaviour and the growth, development and maturity of living organisms'.

1.3 SCOPE OF ENVIRONMENT:

The environment consists of four segments of the earth namely atmosphere, hydrosphere, lithosphere and biosphere:

1. Atmosphere: The Atmosphere forms a distinctive protective layer about 100 km thick around the earth. A blanket of gases called the atmosphere surrounds the earth and protects the surface of earth from the Sun's harmful, ultraviolet rays. It sustains life on the earth. It also regulates temperature, preventing the earth from becoming too hot or too cold. It saves it from the hostile environment of outer space. The atmosphere is composed of nitrogen and oxygen besides, argon, carbon dioxide and trace gases.

The atmosphere has a marked effect on the energy balance at the surface of the Earth. It absorbs most of the cosmic rays from outer space and a major portion of the electromagnetic radiation from the sun. It transmits only ultraviolet, visible, near infrared radiation (300 to 2500 nm) and radio waves. (0.14 to 40 m) while filtering out tissue-damaging ultra-violate waves below about 300 nm.

2. Hydrosphere: The Hydrosphere comprises all types of water resources oceans, seas, lakes, rivers, streams, reservoirs, polar icecaps, glaciers, and ground water. Oceans represent 97% of the earth's water and about 2% of the water resources is locked in the polar icecaps and glaciers. Only about 1% is available as fresh water as surface water in rivers, lakes, streams, and as ground water for human use.

3. Lithosphere: Lithosphere is the outer mantle of the solid earth. It consists of minerals occurring in the earth's crusts and the soil e.g. minerals, organic matter, air and water.

4. Biosphere: Biosphere indicates the realm of living organisms and their interactions with environment, viz atmosphere, hydrosphere and lithosphere.

The scope of environmental studies is very wide and it deals with many areas like i) Conservation of natural resources, ii) ecological aspects, iii) pollution of the surrounding natural resources, iv) controlling the pollution, v) social issues connected to it, and vi) impacts of human population on the environment.

Elements of Environment

Environment is constituted by the interacting systems of physical, biological and cultural elements inter-related in various ways, individually as well as collectively. These elements are:

(1) Physical elements

Physical elements are space, landforms, water bodies, climate, soils, rocks and minerals. They determine the variable character of the human habitat, its opportunities as well as limitations.

(2) Biological elements

Biological elements such as plants, animals, microorganisms and men constitute the biosphere.

(3) Cultural elements

Cultural elements such as economical, social and political elements are essentially man-made features, which make the cultural background.

ENVIRONMENT STUDIES: IMPORTANCE

The environment studies make us aware about the importance of protection and conservation of our mother earth and about the destruction due to the release of pollution into the environment. The increase in human and animal population, industries and other issues make the survival cumbersome. A great number of environment issues have grown in size and make the system more complex day by day, threatening the survival of mankind on earth. Environment studies have become significant for the following reasons:

1. Environment Issues are being of Global:

It has been well recognised that environment issues like global warming and ozone depletion, acid rain, marine pollution and biodiversity are not merely national issues but are global issues and hence require international efforts and cooperation to solve them.

2. Development and Environment:

Development leads to Urbanization, Industrial Growth, Telecommunication and Transportation Systems, Hi-tech Agriculture and Housing etc. However, it has become phased out in the developed world. The North intentionally moves their dirty factories to South to cleanse their own environment. When the West developed, it did so perhaps in ignorance of the environmental impact of its activities. Development of the rich countries of the world has undesirable effects on the environment of the entire world.

3. Explosive Increase in Pollution

World census reflects that one in every seven persons in this planet lives in India. Evidently with 16 per cent of the world's population and only 2.4 per cent of its land area, there is a heavy pressure on the natural resources including land. Agricultural experts have recognized soil health problems like deficiency of micronutrients and organic matter, soil salinity and damage of soil structure.

4. Need for an Alternative Solution

It is essential, specially for developing countries to find alternative paths to an alternative goal. We need a goal as under:

A true goal of development with an environmentally sound and sustainable development.

A goal common to all citizens of our planet earth.

A goal distant from the developing world in the manner it is from the over-consuming wasteful societies of the “developed” world.

It is utmost important for us to save the humanity from extinction because of our activities constricting the environment and depleting the biosphere, in the name of development.

5. Need for Wise Planning of Development

Our survival and sustenance depend on resources availability. Hence Resources withdraw, processing and use of the products have all to be synchronised with the ecological cycle. In

any plan of development our actions should be planned ecologically for the sustenance of the environment and development.

6. Misra (1991) recognized four basic principles of ecology, as under:

(i) Holism, (ii) Ecosystem, (iii) Succession and (iv) Conversation.

Holism has been considered as the real base of ecology. In hierarchical levels at which interacting units of ecology are discussed, are as under:

Misra (1991) has recognised four basic requirements of environmental management as under:

Impact of human activities on the environment,

Value system,

Plan and design for sustainable development,

Environment education.

Keeping in view of the goal of planning for environmentally sustainable development, India contributed to the United Nations Conference on Environment and Development (UNCED), also referred to as "Earth Summit" held at Rio de Janeiro, the Capital of Brazil, 3rd-14th June, 1992.

Components of Environment:

Environment mainly consists of atmosphere, hydrosphere, lithosphere and biosphere. But it can be roughly divided into two types such as (a) Micro environment and (b) Macro environment. It can also be divided into two other types such as (c) Physical and (d) biotic environment.

(a) Micro environment refers to the immediate local surrounding of the organism.

(b) Macro environment refers to all the physical and biotic conditions that surround the organism externally.

(c) Physical environment refers to all abiotic factors or conditions like temperature, light, rainfall, soil, minerals etc. It comprises of atmosphere, lithosphere and hydrosphere.

(d) Biotic environment includes all biotic factors or living forms like plants, animals, Micro-organisms.

Major components of the environment

The environment may broadly be considered to comprise the following five segments:
(1) Lithosphere, (2) Hydrosphere, (3) Atmosphere, (4) Biosphere, and (5) Anthrosphere.

Lithosphere

The Lithosphere, or solid Earth, is that part of the Earth upon which humans live and from which they extract most of their food, minerals, and fuels.

The most important part of the lithosphere for life on Earth is soil formed by the disintegrating weathering action of physical, geochemical, and biological processes on rocks. It is the medium upon which all plants grow, and virtually all terrestrial organisms depend upon it for their existence. Good soil – and a climate conducive to its productivity – is the most valuable asset a nation can have. The productivity of soil is strongly affected by environmental conditions and pollutants.

Hydrosphere

The hydrosphere contains Earth's water. It is a vitally important substance and occurs in all parts of the environment.

A fragile resource—water is perhaps the most fundamental of the resources we require. It is unquestionably the lifeblood of the Earth—no animal or plant life would exist without it. Water is essential part of all living systems and is the medium from which life evolved and in which life exists. Energy and matter are carried through various sphere of the environment by water.

Water covers about 70% of Earth's surface. So the total amount of water on our planet is immense—more than 1.4 billion km3. If the Earth had a perfectly smooth surface, an ocean about 3 km deep would cover everything.

Over 97% of Earth's water is in oceans and most of the remaining fresh water is in the form of ice.

- All water (100%): Oceans and saline lakes = 97.5%;
- Fresh water = 2.5%
  - Ice caps and glaciers = 1.97%;
  - Groundwater = 0.5%;
  - Other water (lakes, rivers, soil moisture, atmosphere, etc) = 0.03%.

Thus, not even 1% of the total world's water resources is available for exploitation by man for domestic, agricultural and industrial purposes. It is a critical, limited, renewable resource in many regions on Earth.

Atmosphere

The atmosphere is the thin layer of gases that envelopes earth is a great resource to all living things on the planet. It is composed of gas molecules held close to Earth's surface by a balance between gravitation and thermal movement of air molecules. It is the source of carbon dioxide for plant photosynthesis and of oxygen for respiration. It provides the nitrogen that nitrogen-fixing bacteria and ammonia-manufacturing industrial plants use to produce chemically-bound nitrogen. As a basic part of the hydrologic cycle, the atmosphere transports water from the oceans to land. The atmosphere serves a vital protective function, absorbing harmful ultraviolet (UV) radiation from the sun and stabilizing Earth's temperature.

The atmosphere is a dynamic system, changing continuously. Many complex chemical reactions take place in the atmosphere; changing from day to night and with chemical elements available.

Biosphere

Biosphere is the life zone of the earth, including the lower part of the atmosphere, the hydrosphere, soil, and the lithosphere to a depth of about 2 kilometers. The biosphere covers the entire realm of living organisms and their interactions with other segments of the environment, namely lithosphere, atmosphere, and hydrosphere.

The biosphere strongly influences, and is strongly influenced by the other parts of the environment. Ecosphere is the regions of the universe, especially on the earth, that are capable of supporting life; the biosphere.

Anthrosphere:-

The anthrosphere may be defined as that part of the environment made or modified by humans and used for their activities.

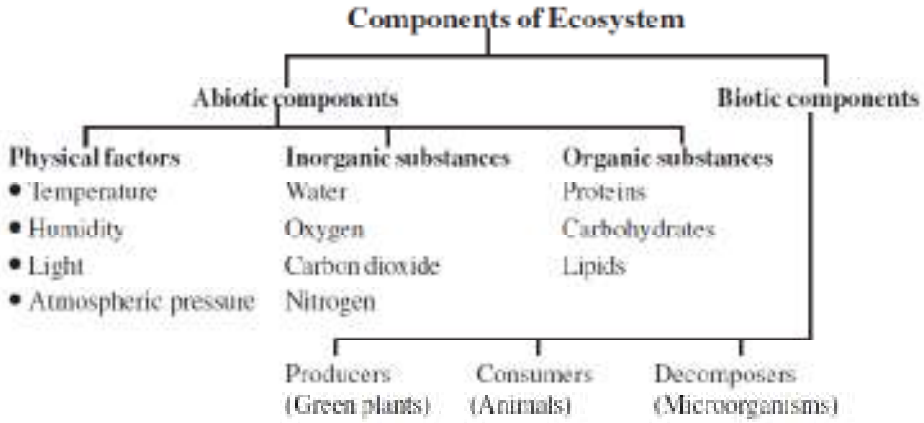
The anthrosphere consists of a number of different parts. These may be categorized by considering where humans live; how they move; how they make or provide the things or services they need or they want; how they produce food, fiber and wood; how they obtain, distribute, and use energy; how they communicate; how they extract and process nonrenewable minerals; how they collect, treat and dispose of wastes. It is obvious that the anthrosphere is very complex with an enormous potential to affect the environment.

ECOSYSTEM:-

You know that earth is perhaps the only planet in the solar system that supports life. The portion of the earth which sustains life is called biosphere. Biosphere is very huge and can not be studied as a single entity. It is divided into many distinct functional units called ecosystem. The term 'ecosystem' was coined by A.G. Tansley in 1935. An ecosystem is a functional unit of nature encompassing complex interaction between its biotic (living) and abiotic (non-living) components. For example- a pond is a good example of ecosystem.

Components of ecosystem: They are broadly grouped into:-

(a) Abiotic and (b) Biotic components



(a) Abiotic components (Nonliving): The abiotic component can be grouped into following three categories:-

(i) Physical factors: Sun light, temperature, rainfall, humidity and pressure. They sustain and limit the growth of organisms in an ecosystem.

(ii) Inorganic substances: Carbon dioxide, nitrogen, oxygen, phosphorus, sulphur, water,

rock, soil and other minerals.

(iii) Organic compounds: Carbohydrates, proteins, lipids and humic substances. They are the building blocks of living systems and therefore, make a link between the biotic and abiotic components.

(b) Biotic components (Living)

(i) Producers: The green plants manufacture food for the entire ecosystem through the process of photosynthesis. Green plants are called autotrophs, as they absorb water and nutrients from the soil, carbon dioxide from the air, and capture solar energy for this process.

(ii) Consumers: They are called heterotrophs and they consume food synthesized by the autotrophs. Based on food preferences they can be grouped into three broad categories. **Herbivores** (e.g. cow, deer and rabbit etc.) feed directly on plants, **carnivores** are animals which eat other animals (eg. lion, cat, dog etc.) and **omnivores** organisms feeding upon both plants and animals e.g. human, pigs and sparrow.

(iii) Decomposers: Also called **saprotrophs.** These are mostly bacteria and fungi that feed on dead decomposed and the dead organic matter of plants and animals by secreting enzymes outside their body on the decaying matter. They play a very important role in recycling of nutrients. They are also called **detrivores or detritus feeders.**

Types of ecosystems

Ecosystems are classified as follows:

(i) Natural ecosystems (ii) Man made ecosystems

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(a) Totally dependent on solar radiation e.g. forests, grasslands, oceans, lakes, rivers and deserts. They provide food, fuel, fodder and medicines.

(b) Ecosystems dependent on solar radiation and energy subsidies (alternative sources) such as wind, rain and tides. e.g tropical rain forests, tidal estuaries and coral reefs.

(ii) Man made ecosystems

(a) Dependent on solar energy-e.g. Agricultural fields and aquaculture ponds.

(b) Dependent on fossil fuel e.g. urban and industrial ecosystems.

ECOSYSTEM

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ecosystem. in nature several communities of organisms live together and interact with each other as well as with their physical environment as an ecological unit. We call it an **ecosystem**.

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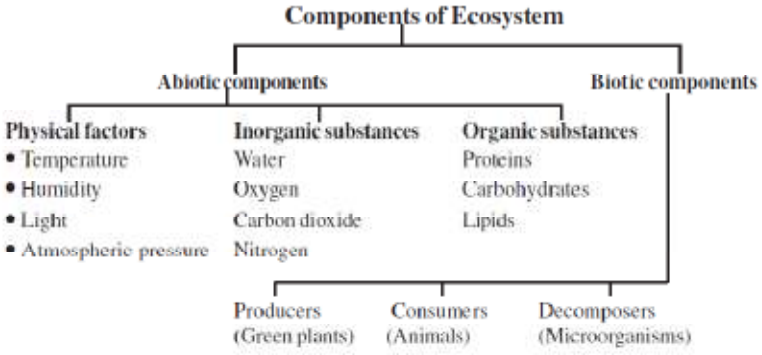

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Functions of ecosystem

Ecosystems are complex dynamic system. They perform certain functions. These are:-

(i) Energy flow through food chain

(ii) Nutrient cycling (biogeochemical cycles)

(iii) Ecological succession or ecosystem development

(iv) Homeostasis (or cybernetic) or feedback control mechanisms

Ponds, lakes, meadows, marshlands, grasslands, deserts and forests are examples of natural ecosystem. Many of you have seen an aquarium; a garden or a lawn etc. in your neighbourhood. These are man made ecosystem.

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Food Chain:-

Transfer of food energy from green plants (producers) through a series of organisms with repeated eating and being eaten is called a food chain. e.g.

Grasses □□Grasshopper □□Frog □□Snake □□Hawk/Eagle

Each step in the food chain is called **trophic level**. In the above example grasses are 1st, and eagle represents the 5th trophic level.

Following trophic levels can be identified in a food chain.

(1) **Autotrophs:** They are the producers of food for all other organisms of the ecosystem. They are largely green plants and convert inorganic material in the presence of solar

energy by the process of photosynthesis into the chemical energy (food). The total rate at which the radiant energy is stored by the process of photosynthesis in the green plants is called **Gross Primary Production** (GPP). This is also known as total photosynthesis or total assimilation. From the gross primary productivity a part is utilized by the plants for its own metabolism. The remaining amount is stored by the plant as **Net Primary Production** (NPP) which is available to consumers.

(2) **Herbivores:** The animals which eat the plants directly are called primary consumers or herbivores e.g. insects, birds, rodents and ruminants.

(3) **Carnivores:** They are secondary consumers if they feed on herbivores and tertiary consumers if they use carnivores as their food. e.g. frog, dog, cat and tiger.

(4) **Omnivores:** Animals that eat both plant and animals e.g. pig, bear and man

(5) **Decomposers:** They take care of the dead remains of organisms at each trophic level and help in recycling of the nutrients e.g. bacteria and fungi.

There are two types of food chains:

(i) **Grazing food chains:** which starts from the green plants that make food for herbivores and herbivores in turn for the carnivores.

(ii) **Detritus food chains:** start from the dead organic matter to the detrivore organisms which in turn make food for protozoan to carnivores etc.

In an ecosystem the two chains are interconnected and make y-shaped food chain. These two types of food chains are:-

(i) Producers □□Herbivores □□Carnivores

(ii) Producers □□Detritus Feeders □□Carnivores.

Carbon cycle

The source of all carbon is carbon dioxide present in the atmosphere. It is highly soluble in water; therefore, oceans also contain large quantities of dissolved carbon dioxide.

The global carbon cycle consists of following steps-

□□**Photosynthesis**

Green plants in the presence of sunlight utilize CO2 in the process of photosynthesis and convert the inorganic carbon into organic matter (food) and release oxygen. A part of the food made through photosynthesis is used by plants for their own metabolism and the rest is stored as their biomass which is available to various herbivores, heterotrophs, including human beings and microorganisms as food. Annually 4-9 x1013 kg of CO2 is fixed by green plants of the entire biosphere. Forests acts as reservoirs of CO2 as carbon fixed by the trees remain stored in them for long due to their long life cycles. A very large amount of

CO2 is released through forest fires.

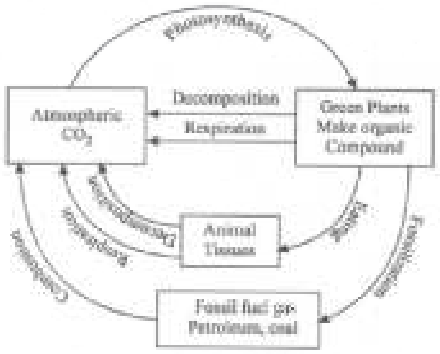

Fig. 5.6: Carbon cycle

Respiration

Respiration is carried out by all living organisms. It is a metabolic process where food is oxidized to liberate energy, CO2 and water. The energy released from respiration is used for carrying out life processes by living organism (plants, animals, decomposers etc.).

Thus CO2 is released into of the atmosphere through this process.

Decomposition

All the food assimilated by animals or synthesized by plant is not metabolized by them completely. A major part is retained by them as their own biomass which becomes available to decomposers on their death. The dead organic matter is decomposed by microorganisms and CO2 is released into the atmosphere by decomposers.

Combustion

Burning of biomass releases carbon dioxide into the atmosphere.

Impact of human activities

The global carbon cycle has been increasingly disturbed by human activities particularly since the beginning of industrial era. Large scale deforestation and ever growing consumption of fossil fuels by growing numbers of industries, power plants and automobiles are primarily responsible for increasing emission of carbon dioxide.

Carbon dioxide has been continuously increasing in the atmosphere due to human activities such as industrialization, urbanization and increasing use and number of automobiles. This is leading to increase concentration of CO2 in the atmosphere, which is a major cause of global warming.

Nitrogen cycle

Nitrogen is an essential component of protein and required by all living organisms including human beings.

Our atmosphere contains nearly 79% of nitrogen but it can not be used directly by the majority of living organisms. Broadly like corbondioxide, nitrogen also cycles from gaseous phase to solid phase then back to gaseous phase through the activity of a wide variety of organisms. Cycling of nitrogen is vitally important for all living organisms. There are five main processes which essential for nitrogen cycle are elaborated below.

(a) **Nitrogen fixation:** This process involves conversion of gaseous nitrogen into Ammonia, a form in which it can be used by plants. Atmospheric nitrogen can be fixed by the following three methods:-

(i) **Atmospheric fixation**: Lightening, combustion and volcanic activity help in the fixation of nitrogen.

(ii) **Industrial fixation**: At high temperature (400oC) and high pressure (200 atm.), molecular nitrogen is broken into atomic nitrogen which then combines with hydrogen to form ammonia.

(iii) **Bacterial fixation**: There are two types of bacteria-

(i) Symbiotic bacteria e.g. Rhizobium in the root nodules of leguminous plants.

(ii) Freeliving or symbiotic e.g. 1. *Nostoc* 2. *Azobacter* 3. Cyanobacteria can combine atmospheric or dissolved nitrogen with hydrogen to form ammonia.

(b) **Nitrification:** It is a process by which ammonia is converted into nitrates or nitrites by *Nitrosomonas* and *Nitrococcus* bacteria respectively. Another soil bacteria *Nitrobacter* can covert nitrate into nitrite.

(c) **Assimilation:** In this process nitrogen fixed by plants is converted into organic molecules such as proteins, DNA, RNA etc. These molecules make the plant and animal tissue.

(d) **Ammonification** : Living organisms produce nitrogenous waste products such as urea and uric acid. These waste products as well as dead remains of organisms are converted back into inorganic ammonia by the bacteria This process is called ammonification. Ammonifying bacteria help in this process.

(e) **De nitrification:** Conversion of nitrates back into gaseous nitrogen is called denitrification. Denitrifying bacteria live deep in soil near the water table as they like to live in oxygen free medium. Denitrification is reverse of nitrogen fixation.

Environmental pollution is one of the most serious problems facing humanity and other life forms on our planet today. Environmental pollution is defined as “the contamination of the physical and biological components of the earth/atmosphere system to such an extent that normal environmental processes are adversely affected.” Pollutants can be naturally

occurring substances or energies, but they are considered contaminants when in excess of natural levels. Any use of natural resources at a rate higher than nature's capacity to restore itself can result in pollution of air, water, and land.

AIR POLLUTION:- **Air Pollution is the release of pollutants such as gases, particles, biological molecules, etc. into the air that are harmful to human health and environment.**

What is Air Pollution?

Air pollution refers to any physical, chemical or biological change in the air. It is the contamination of air by harmful gases, dust and smoke which affects the plants, animals, and humans drastically.There is a certain percentage of gases present in the atmosphere. An increase or decrease in the composition of these gases is harmful to survival. This imbalance in the gaseous composition has resulted in an increase in earth's temperature which is known as global warming.

Types of Air Pollutants

There are two types of air pollutants:

Primary Pollutants

The pollutants that directly cause air pollution are known as primary pollutants. Sulphur-dioxide emitted from factories is a primary pollutant.

Secondary Pollutants

The pollutants formed by the intermingling and reaction of primary pollutants are known as secondary pollutants. Smog, formed by the intermingling of smoke and fog, is a secondary pollutant.

Causes of Air Pollution

Following are the important causes of air pollution:

Burning of Fossil Fuels

The combustion of fossil fuels emits a large amount of sulphur dioxide. Carbon monoxide released by incomplete combustion of fossil fuels also results in air pollution.

Automobiles

The gases emitted from vehicles such as jeeps, trucks, cars, buses, etc. pollute the environment. These are the major sources of greenhouse gases and also result in diseases among individuals.

Agricultural Activities

Ammonia is one of the most hazardous gases emitted during agricultural activities. The insecticides, pesticides and fertilizers emit harmful chemicals in the atmosphere and contaminate it.

Factories and Industries

Factories and industries are the main source of carbon monoxide, organic compounds, hydrocarbons, and chemicals. These are released into the air degrading its quality.

Mining Activities

In the mining process, the minerals below the earth are extracted using large equipments. The dust and chemicals released during the process not only pollute the air but also deteriorate the health of the workers and people living in the nearby areas.

Domestic Sources

The household cleaning products and paints contain toxic chemicals that are released in the air. The smell from the newly painted walls is the smell of the chemicals present in the paints. It not only pollutes the air but also affects breathing.

Effects of Air Pollution

The hazardous effects of air pollution on the environment include:

Diseases

Air pollution has resulted in several respiratory disorders and heart diseases among humans. The cases of lung cancer have increased in the last few decades. Children living near polluted areas are more prone to pneumonia and asthma. Many people die every year due to the direct or indirect effects of air pollution.

Global Warming

Due to the emission of greenhouse gases, there is an imbalance in the gaseous composition of the air. This has led to an increase in the temperature of the earth. This increase in earth's temperature is known as global warming. This has resulted in the melting of glaciers and an increase in sea levels. Many areas are submerged under water.

Acid Rain

The burning of fossil fuels releases harmful gases such as nitrogen oxides and sulphur oxides in the air. The water droplets combine with these pollutants, become acidic, and fall as acid rain which damages human, animal and plant life.

Ozone Layer Depletion

The release of chlorofluorocarbons, halons, and hydrochlorofluorocarbons in the atmosphere is the major cause of depletion of ozone layer. The depleting ozone layer does not prevent the

harmful ultraviolet rays coming from the sun and causes skin diseases and eye problems among individuals.

Effect on Animals

The air pollutants suspend on the water bodies and affect the aquatic life. Pollution also compels the animals to leave their habitat and shift to a new place. This renders them stray and has also led to the extinction of a large number of animals species.

Air Pollution Control

Following are the measures one should adopt to control air pollution:

Avoid Using Vehicles

People should avoid using vehicles for shorter distances. Rather they should prefer public modes of transport to travel from one place to another. This not only prevents pollution but also conserves energy.

Energy Conservation

A large number of fossil fuels are burnt to generate electricity. Therefore, do not forget to switch off the electrical appliances when not in use. Thus, you can save the environment at the individual level. Use of energy-efficient devices such CFLs also controls pollution to a greater level.

Use of Clean Energy Resources

The use of solar, wind and geothermal energies reduce air pollution at a larger level. Various countries including India have implemented the use of these resources as a step towards a cleaner environment.

Other air pollution control measures include:

By minimizing and reducing the use of fire and fire products.

Since industrial emissions are one of the major causes of air pollution, the pollutants can be controlled or treated at the source itself to reduce its effects. For example, if the reactions of a certain raw material yield a pollutant, then the raw materials can be substituted with other less polluting materials.

Fuel substitution is another way of controlling air pollution. In many parts of India, petrol and diesel are being replaced by CNG – Compressed Natural Gas fuelled vehicles. These are mostly adopted by vehicles that aren’t fully operating with ideal emission engines.

Although there are many practices in India which focus on repairing the quality of air, most of them are either forgotten or not being enforced properly. There are still a lot of vehicles on roads which haven’t been tested for vehicle emissions.

Another way of controlling air pollution caused by industries is to modify and maintain existing equipments so that the emission of pollutants is minimized.

Sometimes controlling pollutants at the source is not possible. In that case, we can have process control equipment to control the pollution.

A very effective way of controlling air pollution is by diluting the air pollutants.

The last and the best way of reducing the ill effects of air pollution is tree plantation. Plants and trees reduce a large number of pollutants in the air. Ideally, planting trees in areas of high pollution levels will be extremely effective.

WATER POLLUTIN:- Water pollution is characterised by the presence of excess physical, chemical or biological substances that change the qualities of the water and are capable of causing harm to living organisms. Water that tastes or smells bad or is cloudy can be said to have the symptoms of water pollution. However, some water pollutants cannot be seen or tasted, for example some chemicals, such as pesticides, and most of the micro-organisms that cause waterborne diseases. So, water pollution involves more than just the appearance of the water. Polluted water should not be used for drinking, washing, bathing or agriculture. If polluted water is used by humans, then it can adversely affect the body in different ways, depending on the type and concentration of pollutant.

Invariably the industrial and domestic wastes (sewage) are flushed into water bodies. The surface deposition of wastes also pollute the underground water through sepage. The pesticides

and insecticides, industrial wastes, radioactive chemicals find some way to water bodies and pollute the water. Treatment of waste water is complicated by the presence of wide varieties of

synthetic organic pollutants, many of which are not bio-degradable.

SOIL POLLUTION:- “

1. Soil pollution” refers to the presence of a chemical or substance out of place and/ or present at a **higher than normal concentration** that has adverse effects on any non-targeted organism.
2. Industrial accidents (such as the Chernobyl Nuclear Disaster Incident) can contaminate the soil with toxins or other substances. These can severely impact the ecosystem and human health. Even agrochemicals stored in bulk may pose a significant risk in the event of an accidentally spilt.
3. Acid rain has high levels of hydrogen ions, making it acidic. When this rain seeps into the soil, it can change adversely change the soil chemistry. This means the acid rain

may negatively affect plants and important microbes that live in the soil; thereby affecting the food chain.

4. Electronic wastes have many components inside them, some of which may be toxic to human life. When these components are disposed of, these toxins may leech into the soil and affect life.
5. Microplastics are extremely small pieces of plastic that are less than 5 mm in length. As we all know, plastics do not easily decompose – it may take between 10 to 500 years to decompose. Hence, microplastics can cause soil pollution.
6. Oil spills typically occur in a marine environment. However, it can also occur on land. Such a situation can affect soil chemistry and also disrupt plant and animals life.
7. Improper waste disposal methods can cause soil pollution. For instance, chemicals from various waste products could leech into the soil, contaminating it.

Thermal Pollution:

An increase in the optimum water temperature by industrial process (steel factories, electric power houses and atomic power plants) may be called as "Thermal Pollution." Many industries generate their own power and use water to cool their generator. This hot water is released into the system from where it was drawn, causing a warming trend of surface water. If the system is poorly flushed, a permanent increase in the temperature may result. However, if the water is released into the well flushed system, permanent increase in temperature does not occur.

What are the sources of Thermal Pollution?

1. Nuclear Power Plant

2. Coal-fired power Plant

3. Industrial Effluents

4. Domestic Sewage

5. Hydro-electric power

6. Thermal Power Plant

What are the harmful Effects of the Thermal Pollution?

The harmful effects of the thermal pollution are:

1. Reduction in dissolved Oxygen

The pollutant from various industrial plants are heated decreases the concentration of oxygen with an increase in the temperature of water.

2. Change in water properties

The decrease in density, viscosity and solubility of gases in water increases the setting speed of suspended particles which seriously affect the food supplies of aquatic organism.

3. Increase in toxicity

The concentrated pollutant causes the rise in the temperature of water which increases the toxicity of the poison present in water. The toxicity in water will increase the death rate in marine life.

4. Disruption of Biological activities

Temperature changes disrupt the entire marine ecosystem because changes in temperature causes change in physiology, metabolism and biological process like respiration rate, digestion, excretion and development of an aquatic organism.

5. Damage of biotic organism

Aquatic organisms like juvenile fish, plankton, fish, eggs, larva, algae and protozoa which pass through screens and condenser cooling system are extremely sensitive to abrupt temperature changes. They are habitual of warmer water may suddenly face increase or decrease in temperature of water bodies and thus die because of sudden changes in the temperature of water.

How can thermal pollution be prevented?

The following measures can be taken to prevent or control high temperature caused by thermal pollution:

1. Heated water from the industries can treated before discharging directly to the water bodies.

2. Heated water from the industries can be treated by the installation of cooling ponds and cooling towers.

3. Industrial treated water can be recycled for domestic use or industrial heating.

4. Through artificial lakes: In this lake Industries can discharge their used or heated water at one end and water for cooling purposes may be withdrawn from the other end. The heat is eventually dissipated through evaporation.

Hence, we can say any kind of pollution may directly or indirectly affect humans because the loss of biodiversity causes changes that affect all the aspects of the environment.

What is Nuclear Energy Pollution , its causes , effects and prevention

Radiation is a term given for waves caused by electromagnetism and high energy particles.

Radioactive substances have **High energy particles** which are tiny bits of matter that are made to move at high speeds releasing **nuclear radiation.** There are about 50 naturally occurring radioactive substances and More than 2000 man-made ones. There are three kinds of radioactive radiation – alpha particles, beta particles and gamma radiation.

Another kind of radiation we face each day is cosmic radiation. This is the radiation that reaches us from outer space but is filtered out to a large extent by the layers of atmosphere that surrounds our earth

Contamination of the atmosphere by radiation and radioactive particles is called nuclear pollution.

CAUSES OF NUCLEAR POLLUTION

Most activities that involve radioactive substances have potential to contaminate the environment .these include

- **Nuclear weapons testing-**

Beginning with the Second World War when Japan was subdued after the use of the nuclear bombs on the cities of Hiroshima and Nagasaki, countries have been in the race to develop their own nuclear arms, in the name of defence, but more to threaten rival nations. These were led by US, Russia, Britain, France and China. Nowadays N. Korea, Iran and many of the developing countries are equipped to build these weapons as well.

Testing the weapons involves explosions is the atmospheric layer called stratosphere. The exploded debris emitting radiation then falls back to the earth. Some of the radiation is absorbed by our atmosphere. But some of it reaches the earth falling on areas that are far away from the site where the weapon was released initially. This is called **Fallout**. When

these particles settle on the vegetation and are consumed by animals they enter into the food chain. When fallout settles over the sea, the ecosystem of the sea gets affected and again entering the food chain.

- **Nuclear Power Plants**

Intense Nuclear energy from radioactive fuel is used to heat water to steam. The steam is then used to turn the turbines that in turn work the generators to produce electricity. Small amounts of radiation are released during this process into the water which may then dispose off indiscriminately causing nuclear pollution.

- **Improper disposal of spent nuclear fuel.**

Spent nuclear fuel contains very active radioactive atoms that remain so sometimes almost for 600yrs or more. These must be disposed of in a very careful manner, with strict regulations in well designated spaces. But the fact is many governments tend to approve of dumping nuclear fuel as far from their country as possible. The favourite dumping ground of many countries was the Pacific Ocean. Greenpeace an organisation dedicated to preserving the environment and saving the earth from pollution has brought attention to this activity and opposes it with fervour.

Some plants store spent fuel in underground water pools as these release a high amount of heat and need to be cooled down. There is always the danger of seepage into the land nearby, contaminating ground water and surrounding lands.

On a smaller scale is the radioactive waste that is produced in diagnostic Imaging in Health sector.

- **Accident/Damage to Nuclear power plants**

This most famous of these was the Chernobyl Nuclear Disaster in Russia in 1986. The fallout of this accident was felt over three countries- Russia, Ukraine and Belarus. The area surrounding the reactor is still polluted and not suitable for inhabitation or farming.

The other more recent accident was the Fukushima Daichii nuclear disaster on March 11th, 2011. An earthquake followed by a tsunami caused the main reactors and supplementary generators severe damage. Inadequate preparation to deal with an incident of

this scale was also a factor that leads to hydrogen explosions and the seepage of radioactive material in the ground water.

Effects of Nuclear Pollution

The effect of nuclear pollution is seen on every organism in the environment from the bacteria to plants to human beings. Nothing is spared.

- The immediate and closest to the source, experience **Radiation Sickness**. In small doses of 75-200 rems. One experiences vomiting, fatigue and loss of appetite. At higher exposures of 300 rem and more changes in the blood cells and bleeding occurs. Above 600 rems there is loss of hair, loss of immunity usually resulting in death in a few days to weeks. Radiation causes changes in the cell and gene structure of rapidly multiplying cells of the body, such as bone marrow, skin, intestines, lymphoid tissue and embryo.
- Those exposed from a distance may not show any immediate symptom. But the tendency to develop various forms of **cancers** and have a **shortened life span** is seen. Radiation also causes **cell mutations** which can be transferred to the next generation.
- **Foetuses** are affected with birth defects and cancers. They may also have a shorter life span.
- Plants die and some show genetic changes and stunted growth. Animals are also affected and do not survive for too long.
- The radiation in the atmosphere will not dissipate quickly. Every water source will also be affected. In fact it may take years or centuries to reach a point where such a space may become habitable.
- An average person will be exposed to about 180 milli rem of radiation in a year from exposure to natural radiation, medical and dental X rays, Colour TVs, airport baggage X rays etc.

Prevention of Nuclear pollution

- Whilst undergoing procedures for X rays or radiation therapy, correct protection gear such as lead aprons must be worn. This includes pregnant women. Using lead sheathed walls in imaging facilities is also mandatory.
- As a lay person one must be aware of the dangers of nuclear pollution. If living in the vicinity of a nuclear plant or hearing of one being planned, one should use one’s right

to make sure the governing bodies are planning thoroughly on the building, implementing and disposal of the wastes. Make certain that the authorities are prepared in case of a disaster, to handle all the situations such as containing the contamination to arranging an evacuation.

- While working at a radiation facility or in nuclear plant workers are always monitored for the amount of radiation they have been exposed to.
- Radioactive wastes are actually recyclable to a good extent because usable fuel is still being created in the wasted material which can then be reprocessed.
- Governments are authorising research on developing better means for disposal of radioactive wastes. The most feasible method now appears to be deep underground storage of wastes.
- Power plants must ensure that the radioactive fuel and wastes are being transported and disposed of in safe containers which are long lasting and unbreakable.
- Governing agencies need to make sure that radioactive material does not fall into wrong hands that will, for a profit sell these to people who are in the business of war mongering.

Nuclear energy is a clean source of energy, inexpensive and extensive too. With a small amount of fuel a large amount of energy can be generated. Though there have been mishaps in the past and wrongful use of this energy, there is still great potential for it. Any well intentioned effort must be backed by good research, a well-designed plan and proper back up plans for any setbacks. The safety of the environment and the people must always come first.

"E-waste" is a popular, informal name for electronic products nearing the end of their "useful life. "E-wastes are considered dangerous, as certain components of some electronic products contain materials that are hazardous, depending on their condition and density. The hazardous content of these materials pose a threat to human health and environment. Discarded computers, televisions. VCRs. stereos, copiers, fax machines, electric lamps, cell phones, audio equipment and batteries if improperly disposed can leach lead and other substances into soil and groundwater. Many of these products can be reused, or recycled in an environmentally sound manner so that they are less harmful to the ecosystem.
For example, personal computers (PCs) contain certain components, which are highly toxic, such as chlorinated and brominated substances, toxic gases, toxic metals, biologically active materials, acids, plastics and plastic additives. The

hazardous content of these materials pose an environmental and health threat. Thus proper management is necessary while disposing or recycling e-wastes. **E-toxic components in computers could be summarized as circuit boards containing heavy metals like lead & cadmium; batteries containing cadmium; cathode ray tubes with lead oxide & barium; poly vinyl chloride (PVC) coated copper cables and plastic computer; casings that release highly toxic dioxins & furans when burnt to recover valuable metals; mercury switches; mercury in flat screens; poly chlorinated biphenyl's (PCB's) present in older capacitors; transformers; etc**. Basel, Action Network (BAN) estimates that the 500 million computers in the world contain 2.87 billion kgs of plastics, 716.7 million kgs of lead and 286,700 kgs of mercury. The average 14-inch monitor uses a tube that contains an estimated 2.5 to 4 kgs of lead. The lead can seep into the ground water from landfills there by contaminating it. If the tube is crushed and burned, it emits toxic fumes into the air.

EFFECTS ON ENVIRONMENT AND HEALTH THE HUMAN:
Computer wastes that are land filled produces contaminated leachates. which eventually pollute the groundwater. Acids and sludge obtained from melting computer chips, if disposed on the ground causes acidification of soil.

MANAGEMENT OF E-W ASTES :-It is estimated that 75% of electronic items are stored due to uncertainty of how to manage it. These electronic junks lie unattended in houses, offices, warehouses etc. and normally mixed with household wastes, which are finally disposed off at landfills. This necessitates implementable management measures.

In industries management of e-waste should begin at the point of generation. This can be done by waste minimization techniques and by sustainable product design. Waste minimization in industries involves adopting:

- inventory management,
- production-process modification,
- volume reduction,
- recovery and reuse.

Inventory management

Proper control over the materials used in the manufacturing process is an important way to reduce waste generation (Freeman, 1989). By reducing both the quantity of hazardous materials used in the process and the amount of excess raw materials in stock, the quantity of waste generated can be reduced. This can be done in two ways i.e. establishing material-purchase review and control procedures and inventory tracking system.

Developing review procedures for all material purchased is the first step in establishing an inventory management program. Procedures should require that all materials be approved prior to purchase. In the approval process all production materials are evaluated to examine if they contain hazardous constituents and whether alternative non-hazardous materials are available.

Another inventory management procedure for waste reduction is to ensure that only the needed quantity of a material is ordered. This will require the establishment of a strict inventory tracking system. Purchase procedures must be implemented which ensure that materials are ordered only on an as-needed basis and that only the amount needed for a specific period of time is ordered.

Production-process modification

Changes can be made in the production process, which will reduce waste generation. This reduction can be accomplished by changing the materials used to make the product or by the more efficient use of input materials in the production process or both. Potential waste minimization techniques can be broken down into three categories:

i) Improved operating and maintenance procedures,

ii) Material change and

iii)Process-equipment modification.

Improvements in the operation and maintenance of process equipment can result in significant waste reduction. This can be accomplished by reviewing current operational procedures or lack of procedures and examination of the production process for ways to improve its efficiency. Instituting standard operation procedures can optimise the use of raw materials in the production process and reduce the potential for materials to be lost through leaks and spills. A strict maintenance program, which stresses corrective maintenance, can

reduce waste generation caused by equipment failure. An employee-training program is a key element of any waste reduction program. Training should include correct operating and handling procedures, proper equipment use, recommended maintenance and inspection schedules, correct process control specifications and proper management of waste materials.

Hazardous materials used in either a product formulation or a production process may be replaced with a less hazardous or non-hazardous material. This is a very widely used technique and is applicable to most manufacturing processes. Implementation of this waste - reduction technique may require only some minor process adjustments or it may require extensive new process equipment. For example, a circuit board manufacturer can replace solvent-based product with water-based flux and simultaneously replace solventvapor degreaser with detergent parts washer.

Installing more efficient process equipment or modifying existing equipment to take advantage of better production techniques can significantly reduce waste generation. New or updated equipment can use process materials more efficiently producing less waste. Additionally such efficiency reduces the number of rejected or off-specification products, thereby reducing the amount of material which has to be reworked or disposed of. Modifying existing process equipment can be a very cost-effective method of reducing waste generation. In many cases the modification can just be relatively simple changes in the way the materials are handled within the process to ensure that they are not wasted. For example, in many electronic manufacturing operations, which involve coating a product, such as electroplating or painting, chemicals are used to strip off coating from rejected products so that they can be recoated. These chemicals, which can include acids, caustics, cyanides etc are often a hazardous waste and must be properly managed. By reducing the number of parts that have to be reworked, the quantity of waste can be significantly reduced.

Volume reduction

Volume reduction includes those techniques that remove the hazardous portion of a waste from a non-hazardous portion. These techniques are usually to reduce the volume, and thus the cost of disposing of a waste material. The techniques that can be used to reduce waste-stream volume can be divided into 2 general categories: source segregation and waste concentration. Segregation of wastes is in many cases a simple and economical technique for waste reduction. Wastes containing different types of metals can be treated separately so that

the metal value in the sludge can be recovered. Concentration of a waste stream may increase the likelihood that the material can be recycled or reused. Methods include gravity and vacuum filtration, ultra filtration, reverse osmosis, freeze vaporization etc.

For example, an electronic component manufacturer can use compaction equipments to reduce volume of waste cathode ray-tube.

Recovery and reuse

This technique could eliminate waste disposal costs, reduce raw material costs and provide income from a salable waste. Waste can be recovered on-site, or at an off-site recovery facility, or through inter industry exchange. A number of physical and chemical techniques are available to reclaim a waste material such as reverse osmosis, electrolysis, condensation, electrolytic recovery, filtration, centrifugation etc. For example, a printed-circuit board manufacturer can use electrolytic recovery to reclaim metals from copper and tin-lead plating bath.

However recycling of hazardous products has little environmental benefit if it simply moves the hazards into secondary products that eventually have to be disposed of. Unless the goal is to redesign the product to use nonhazardous materials, such recycling is a false solution.

Sustainable product design

Minimization of hazardous wastes should be at product design stage itself keeping in mind the following factors*

- ***Rethink the product design:*** Efforts should be made to design a product with fewer amounts of hazardous materials. For example, the efforts to reduce material use are reflected in some new computer designs that are flatter, lighter and more integrated. Other companies propose centralized networks similar to the telephone system.
- ***Use of renewable materials and energy:*** Bio-based plastics are plastics made with plant-based chemicals or plant-produced polymers rather than from petrochemicals. Bio-based toners, glues and inks are used more frequently. Solar computers also exist but they are currently very expensive.
- ***Use of non-renewable materials that are safer:*** Because many of the materials used are non-renewable, designers could ensure the product is built for re-use, repair and/or

upgradeability. Some computer manufacturers such as Dell and Gateway lease out their products thereby ensuring they get them back to further upgrade and lease out again.

MODUL-2

Green IT- Basic Green Concepts:-

Green IT (green information technology) is the practice of environmentally sustainable computing. Green IT aims to minimize the negative impact of IT operations on the environment by designing, manufacturing, operating and disposing of computers and computer-related products in an environmentally-friendly manner. The motives behind green IT practices include reducing the use of hazardous materials, maximizing energy efficiency during the product's lifetime and promoting the biodegradability of unused and outdated products.

What is Green IT?

There are many definitions for Green IT. Some of them listed below.

Green computing or Green IT is "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment. It includes the dimensions of environmental sustainability, the economics of energy efficiency, and the total cost of ownership, which includes the cost of disposal and recycling."

Another definition for Green IT says, it is the "optimal use of information and communication technology (ICT) for managing the environmental sustainability of enterprise operations and the supply chain, as well as that of its products, services, and resources, throughout their life cycles."(The Gartner report, "Green IT: The New Industry Shock Wave," by analyst Simon Mingay)

Why Green IT Matters

IT systems are not only a large source of emissions that need to be carefully managed, but they are also the most important part of an organisation's compliance. IT is the measuring tool and the data repository. ICT typically accounts for more than 20% of the energy used in an office building, with some offices registering up to 70% attributed to ICT. Although energy costs typically comprise less than 10% of an overall IT budget. A recent report states that this could rise to more than 50% over the next few years (Gartner Research). Green IT is about IT's contribution to reducing the whole organisation's carbon footprint, and to facilitating mandatory reporting on carbon emissions and the subsequent emissions trading system.

Green IT is part of a fundamental change in the economy and society (see Figure 1). It is a subset of the larger green (or sustainable) business trend, which reconciles sustainable business practices with profitable business operations. In the IT industry, both suppliers and buyers are coming to realize that they should incorporate green principles into the design, manufacturing, operation, and disposal of IT assets. The momentum for this change comes from a variety of sources which is listed below

1. Government mandates
2. Energy efficiency
3. Product and Company differentiation and
4. CSR (Corporate social responsibility (CSR) is a self-regulating business model that helps a company be socially accountable—to itself, its stakeholders, and the public. By practicing corporate social responsibility)

   Globally, the top three reasons listed for making greener IT choices include reducing energy-related expenses; doing "the right thing" for the environment; and bringing IT in-line with larger corporate initiatives.

   IBM has been singled out by leading technology media for its emphasis on energy-efficient technology and services internally and for clients. A Computerworld executive noted that "IBM…has taken a serious look at how they impact the environment and how they can address those challenges with good business sense, through their Project Big Green initiative and a company-wide focus on energy-efficient technology services."

IBM expects to double the computing capacity of its own data centres over the next three years, without increasing power consumption or its carbon footprint. Based on greenhouse gas production, the size of a carbon footprint is determined by the amount of carbon dioxide that comes from human activities. Compared to building new space to double the size of its own data centres, IBM expects to help save more than five billion kilowatt hours of energy per year.

As a result of these initiatives, IBM was named the "Top Green IT Company for 2008" by IDG's Computerworld. (Jon Brodkin, 2009)

IBM combined with Mainline developed a range of Products and Processes that combine Information Technology, energy efficiency and environmental responsibility, as well as address the following challenges in a company:

1. Continued rise of overall energy costs and demand

2. Cost of air conditioning to cool data centres and/or computer rooms
3. Concern over power surges and energy shortages affecting business
4. Government-imposed levies on carbon production and regulations on power consumption and waste
5. Increased drive toward centralized data centres
6. Too many servers that are partially used or not used to capacity
7. Need for an environmentally safe way to dispose of old software or hardware

Benefits of Green IT

Green IT solutions benefit the environment, as well as the bottom-line. By focusing on Green Computing, an IT organization can:

1. Lower overall energy expenses including general energy consumption, as well as power and cooling costs.
2. Optimize server capacities and performance.
3. Reduce data centre footprint, reclaiming valuable floor space through consolidation and/or virtualization.
4. Provide required, rapid and secure access to data.
5. Increase ease of systems and solutions management.
6. Recycle end-of-life equipment.
7. Recapture resiliency.(the capacity to recover quickly from difficulties, elasticity)
8. Free-up budget components

In short, Green Computing enables companies to meet business demands for cost-effective, energy-efficient, flexible, secure and stable solutions while being environmentally responsible (Jon Brodkin, 2009)

Five Steps to a Successful Green Computing Solution

Green Computing involves a range of services and technologies based on best practices for reducing energy usage. As noted above, IBM recommends a comprehensive five-step plan in developing energy-efficient, cost-effective, environmentally responsible information technology operations. Analyses of the five steps follow.

1. Diagnose – It is difficult to manage what cannot be measured, particularly when it comes to energy efficiency. It is important for a company to collect accurate, detailed information on its energy efficiency as a first step in pinpointing areas for potential improvement and to identify existing systems ready for retirement. Mainline and IBM provides Energy Efficiency Assessments, which are proven tools for diagnosing the energy demands of physical infrastructure and IT equipment.
2. Build – After identifying needs and solution requirements, and reviewing Energy Efficiency Assessments, the second step includes planning and designing the new solution including building or preparing facilities for replacements, migrations or upgrades. Implementing best practices, innovative technologies and solution expertise will result in improved operations while reducing costs.
3. Virtualize – Virtualization can produce the fastest and greatest impact on energy efficiency in an information technology centre. Consolidating an IT infrastructure can increase utilization and lower annual power costs. Reducing the number of servers and storage devices through virtualization strategies can create a leaner data centre without sacrificing performance. Less complexity, reduced cost, better utilization and improved management are all benefits of server, storage and desktop virtualization, and helps achieve Green Computing.
4. Manage – Data centre energy consumption is managed through provisioning and virtualization management software, providing important power alerts, as well as trending, capping and heat measurements. Such software can reduce power consumption by 80% annually.
5. Cool – Excessive heat threatens equipment performance and operating stability. Innovative IBM cooling solutions for inside and outside the data centre minimize hotspots and reduce energy consumption. IBM's patented Rear Door Heat exchanger "cooling doors" are now available across most IBM Systems offerings. While requiring no additional fans or electricity, they reduce server heat output in data centres up to 60% by utilizing chilled water to dissipate heat generated by computer systems.

INTRODUCTION:-

Green IT describes the study and use of computer resources in an efficient way. Green IT starts with manufacturers producing environmentally friendly products and encouraging IT departments to consider more friendly options like virtualization, power management and proper recycling habits.

The government has also recently proposed new compliance regulations that would work towards certifying data centers as green. Some criteria includes using low-emission building materials, recycling, using alternative energy technologies and other green technologies.

IT Ecosystem:-

It is focussed on environmentally sound business transformation, IT based sustainability innovation, sustainability-based IT innovations and enterprise-wide sustainability. For instance, in addition to being green itself, IT can help create a more sustainable environment by

• coordinating, reengineering and optimizing the supply chain, manufacturing activitiesmand organizational workflows to minimize their environmental impact;
• making business operations, buildings and other systems energy efficient;
• helping decision making by analysing, modelling and simulating environmental impacts;
• providing platforms for eco-management and emissions trading;
• auditing and reporting energy consumption and savings; and
• offering environmental knowledge management systems and decision support systems.

Holistic Approach to Greening IT

six complementary directions are

1. Green design. Design energy-efficient and environmentally sound components, computers, servers and cooling equipment.
2. Green manufacturing. Manufacture electronic components, computers and other associated subsystems with minimal or no impact on the environment.
3. Green use. Reduce the energy consumption of computers and other information systems, and use them in an environmentally sound manner.
4. Green disposal. Refurbish and reuse old computers, and properly recycle unwanted computers and other electronic equipment.
5. Green standards and metrics. These are required for promoting, comparing and benchmarking sustainability initiatives, products, services and practices.
6. Green IT strategies and policies. These effective and actionable strategies and policies add value and focus on both short- and long-term benefits. These are aligned with

business strategies and practices, and are key components of greening IT.

Green IT Standards and Eco-Labelling of IT

To promote and adopt standardization, a number of green IT standards and directives have emerged. Key among them are EPEAT (Electronic Product Environmental Assessment Tool), RoHS (Restriction of Hazardous Substances Directive), WEEE, Energy Star, LEED (Leadership in Energy and Environmental Design), the ISO14001 core set of standards for designing and implementing an effective environmental management system and the EN 16001 Energy Management System.

A **greenhouse gas** (sometimes abbreviated **GHG**) The primary greenhouse gases in Earth's atmosphere are water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Without greenhouse gases, the average temperature of Earth's surface would be about −18 °C (0 °F),

Making business case for Green IT:-

Each enterprise must develop comprehensive green IT strategy, which should be a component of, and aligned with, an enterprise-wide green strategy. It should then develop a green IT policy outlining aims, objectives, goals, plans of action and schedules. Large enterprises should also appoint an environmental sustainability officer to implement their green policy and to monitor their progress and achievements. To green their IT, enterprises can take any one or a combination of the following three approaches:

1. Tactical incremental approach. In this approach, an enterprise preserves the existing IT infrastructure and policies and incorporates simple measures to achieve moderate green goals such as reducing energy consumption. These measures include adopting policies and practices such as power management, switching off computers when not in use, using compact energy-efficient light bulbs and maintaining an optimal room temperature. These measures are generally easy to implement without much cost. However, enterprises should work towards these measures only as short-term, ad hoc solutions.

2. Strategic approach. In this approach, an enterprise conducts an audit of its IT infrastructure and its use from an environmental perspective, develops a comprehensive plan addressing broader aspects of greening its IT and implements distinctive new initiatives. For example, an enterprise may deploy new energy-efficient, environmentally friendly computing systems, or it may develop and implement new policies on procuring, operating and/or disposing of computing resources. WHILE the primary rationale is

still cost efficiency and a reduced carbon footprint, this approach also considers other factors such as branding, image creation and marketing.

3. Deep green approach. This approach expands upon the measures highlighted in the strategic approach, wherein an enterprise 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{** What Is a Carbon Credit?

A carbon credit is a permit that allows the company that holds it to emit a certain amount of carbon dioxide or other greenhouse gases. One credit permits the emission of a mass equal to one ton of carbon dioxide. The carbon credit is one half of a so-called "cap-and-trade" program. Companies that pollute are awarded credits that allow them to continue to pollute up to a certain limit. That limit is reduced periodically. Meanwhile, the company may sell any unneeded credits to another company that needs them.

Private companies are thus doubly incentivized to reduce greenhouse emissions. First, they will be fined if they exceed the cap. Second, they can make money by saving and reselling some of their emissions allowances.}

or using green power generated from solar or wind energy.

Policies for change:-

This impact, or time-based range, of green IT strategy's influence within and across an organization ranges from operational to strategic-exploratory.

Operational (immediate). Simple, immediate action taken by an organization with respect to green IT. For example, switching off the computer monitors when not in use or not printing on paper whenever possible are immediate actions, also called the low-hanging fruits. Whilst these are the most visible actions, they do not require what is considered a strategic approach. Simply inform users that they need to switch off computers when not in use, or implement an internal method to charge the users' cost centre for the use of paper. Feedback in terms of carbon usage per action, developing a consensus amongst a group of users and initial training is helpful in getting these operational green IT initiatives off the ground. Many early adopters of green IT have done precisely this.

• Tactical (within one year). At a tactical level, the organization needs about one year to build up its ability to reduce carbon emissions. Examples of these tactical actions include the replacement of the organization's existing computer monitors with green,

flat-screen monitors, or replacing mobile gadgets and networking equipment within a year. Similarly, recycling programmes can be put together by managers for their respective departments that will encourage staff to have processes for recycling paper and reducing printing.

• **Strategic-initial (within three years)**. The three-year timeframe for impact of green IT initiatives is based on strategic initiatives. These initiatives would include the senior leadership of the organization including a dedicated 'C-level' role (such as a chief sustainability
officer). These green IT strategies are formulated and approved by the board, have substantial budgetary backing and are based on a holistic approach to greening that included the organization's data centres, buildings, supply chains, disposal strategies and even sales and marketing. Implementing green policies, using software and applying metrics will provide tremendous value to a green enterprise transformation – and that value will itself be maximized by keeping a 3–5-year timeframe for implementing those strategies and plans.

• **Strategic (within five year**s). This green IT strategy is a further extension of the aforementioned three-year strategy but has greater depth and breadth of coverage. For example, in addition to reengineering efforts over the three-year period, this strategy would also bring about a complete attitude change in people at all levels, reorganize the business architecture and implement substantial governance mechanisms for the board. The physical infrastructure, such as buildings and data centres, will also undergo a major revamp in this period. Strategic use of carbon data involves not only collecting and reporting data, but also identifying risks and opportunities associated with the greening and also plotting trends and patterns in terms of internal carbon savings and external carbon credits and trading. Green IT strategies thus expand into the areas of capacity planning for the organization, resourcing and skills (human resource) strategies, technology acquisitions, risk management and governances. Furthermore, the organization
will be influenced by and, in turn, influence other partnering organizations through collaborative
efforts. Renewable energy sources are explored and consumed – with fully automated, systems-based measurement, reporting and monetizing.

• **Strategic-exploratory (within eight years).** A green IT strategy over an eight-year time period will have to continuously explore the possibilities of carbon reduction and strive to align them with the business, which would also be changing over that time

period. Therefore, such a long-term approach would require strategists to imagine the future in terms of technologies and business and incorporate it into the green IT strategy. Such explorations are important, especially for large and global organizations as well as government bodies, as they result in a think tank–based output that enables organizations to prepare for multiple, futuristic technologies. For example, such organizations will have the resources to create prototypes and measure the impacts of, say, nanotechnologies and biomimicry (technologies that mimic nature to get the best carbon results) on their carbon emissions. Coming close to a decade in future, one would expect the carbon economy to be a truly mainstream economy (with carbon trading on the stock exchange) requiring organizations to deal with carbon in all of their processes, people and technologies.

Balancing Carbon Foot Print:-

it might refer just to carbon dioxide output; in other cases it means greenhouse gas emissions. In other organizations, *carbon footprint* might mean that everything is tallied—sourcing materials, manufacturing, distribution, use, disposal, and so forth. following steps are taken to balance the carbon footprint in an organisation.

• **Measuring and reporting footprints:** The number of businesses that measure and report their carbon emissions (carbon footprint), as part of their annual or corporate social responsibility report, continues to increase. To be transparent, businesses must themselves know how much carbon emission equivalent they generate, how much energy they consume and other factors contributing to their environmental footprint. Businesses have begun to pay more attention to the environmental friendliness of their supply chain and business partners. Many big companies have taken steps to measure their carbon footprints and small businesses increasingly are beginning to adopt this practice. Governments in a number of countries are mandating large businesses to report and reduce their energy consumption and carbon footprint.

• **Demand for green transparency:** Consumers have begun to pay attention to the green credential of products or the services they buy and use. They want to know where products are sourced, what they are made of and what their carbon footprint is. Businesses are responding to this demand by giving them more information about the environmental aspects of their products or services.

Customer engagement: Savvy green businesses are not just widely publicizing their

own environmental good deeds and gaining green credits, but also engaging customers and other stakeholders in sourcing their ideas and opinions and more actively in their green initiatives. For example, eBay launched a Green Team programme (www.ebaygreenteam.com) to tap into the wisdom of crowds. The programme's mission is to 'inspire the world to buy, sell and think green every day'. Over 300 000 sellers – individuals who sell goods on eBay's platform – had signed up to share ideas and views aimed at making eBay a greener sales partner. Another example is the 'GE ecomagination Challenge' (http://challenge.ecomagination.com/ideas) which seeks ideas for development and adoption of the Smart Grid and 'powering your home'.

• **Green hardware and devices:** Manufacturers are also rolling out more green computers and green electronic devices and systems. For instance, several green IT products – PCs, notebook computers, monitors, printers and others – that meet the Electronic Product Environmental Assessment Tool (EPEAT) environmental labels of Gold, Silver and Bronze are now available. Even small companies and individuals are turning to recycling and learning how to dispose of equipment in eco-friendlier ways.

• **Telecommuting:** With the use of Voice Over Internet Protocol (VOIP) services, telecommuting is becoming more popular among businesses. Companies are able to offer their employees the option of telecommuting – an attractive option in an age of high fuel prices, traffic jams and long commutes.

• **Green data centres:** Data centres that host a variety of Web applications, popular e-commerce sites and social networks are becoming greener with significant improvement in energy efficiency and use of greener, cleaner power sources for their operation.

• **Green awareness and responsibility:** Among businesses and individuals, environmental awareness and responsibility are increasing. For instance, the use of power management features and products has increased and customers who are willing pay more for green IT products are growing.

Standards and Metrics:-

Metrics for green IT performance of an organization can be based internal ROI(RETURN ON INVESTMENT)goals and/or on legal reporting requirements. Whilst the ISO 14000 series of standards can provide an excellent starting point for the Key Performance Indicators (KPIs) for green IT, CEMS can be used to automate, measure and report on carbon emissions and the carbon footprint.

Following are some typical KPIs that must be embedded in an organization that is undertaking green strategies.

• **Economic outcome.** Reduce energy consumption by 10% of its current level per year for three years; increase green services (e.g. the addition of one detailed insurance service dedicated to green).

• **Technical.** Use virtualized data servers for all warehoused data; use smart meters to record, repost and control emissions.

• **Process.** Optimize supply chain management to reduce or reengineer individual processes.

• **People.** Train people for green IT at all levels. Telecommute once a week to reduce emissions.

The KPI groups described here can be further expanded in greater detail, and they will have their own nuances depending on the dimension to which they belong. For example, a KPI that is entirely focussed on carbon reduction irrespective of cost considerations

may not be acceptable to an organization's economic dimension. Alternatively, a technologically advanced energy-efficient cooler might use less energy and hence have lower operational cost, but the capital expenses towards such a cooler will be part of the economic dimension. Thus, KPIs should regularly tie business efficiency with carbon reduction efficiency. Savings in carbon related to an organization's various aspects, such as production, sales and marketing, research and development and administration, need to be related to savings in costs.

Emerging standards with IT practices

the perspective of emerging IT technologies and their green initiatives. We select **(a)** cloud computing, **(b)** mobile computing, **(c)** Internet of Things (IoT), **(d)** big data analytics, and **(d)** software-based networks as emerging IT technologies.

Multiple computing technologies have emerged over the last decade as enablers of scientific, industrial, and social businesses. To select the emerging IT technologies for a discussion on green computing, we set metrics on popularity, social integration, and future application in smart environments [6]. We chose cloud computing, mobile computing, IoT, big data analytics, and software-based networks as the emerging IT technologies based on the

aforementioned metrics. The integration and high correlation of these technologies create opportunities that assist various organizations in performing their duties efficiently.

Green cloud computing

Cloud computing has established itself as an enabling technology for multiple IT services. The increase in the number of cloud-based IT services and applications demands establishment of data centers that house thousands of web servers, storage, and network devices. Cloud data centers (CDC) provide a range of services from high-performance computing to large-scale data analytics to end users. The massive scale of cloud data centers that are setup at multiple geographical locations to facilitate distributed users means that they contribute 25% to the total IT electricity share [10]. Moreover, IT services are shifting from single server operations to rack-mounted blade servers. The rack-mounted server designs result in higher electronic densities, higher energy consumption, and heat dissipation [11]. As a result, both direct energy and indirect cooling energy demands rise in cloud data centers. The techniques to "green" cloud data center operations can be broadly classified into three categories: **(a)** resource management with virtualization, **(b)** sustainability with renewable energy and waste heat utilization, **(c)** and resource scheduling with state-of-the-art evolutionary algorithms [12].

Cloud data center resources are managed by a virtualization layer that resides over the physical resources. The virtualization layer abstracts the hardware layer interfaces to provide a higher level interface for users and applications. The virtualization layer helps in management and consolidation of cloud data center resources through multiple backup techniques, such as resource migration and snapshot [13]. The primary objective of virtualization in cloud data centers is to provide scalable and fault-tolerant operations. Increasingly, virtualization is being used for resource consolidation and energy efficiency. A virtual resource residing on a 40% utilized server can be migrated to another 40% utilized server while the former is operated in low-power idle mode [10]. The virtual machine (VM) migration is exploited in both inter and intra-data center configurations while providing energy efficient operations. However, the network cost resulting from the VM migration needs to be addressed for joint network and server resource optimization [14]. The intra-data center VM migration network cost is reduced by placing related and "talkative" VMs in optimal server proximity so that their communications are limited to a part of the network

[15]. Similarly, the inter-data center VM migration cost is reduced by data deduplication and compression techniques over long-haul networks [16].

The green computing initiative also embodies sustainability in operations. Cloud data centers operating on renewable energy resources lead to zero GHG emissions. Renewable energy from sources such as the sun and the wind can be generated from on-site installations or purchased from off-site corporations [4]. The main drawbacks of renewable energy based cloud data center operations are the associated cost and unpredictable supply of the renewable resource. It is estimated that with the advances in storage capacities, the cost/Watt of renewable energy will halve in the next decade [17]. Moreover, to address the unpredictability of renewable energy resources, techniques such as dynamic power-workload balancing and server power capping are exploited [1]. The integration of renewable energy resources to cloud data center power designs requires utilization of hybrid power supplies and Autonomic Transfer Switches (ATS). The ATS shift power between grid and renewable energy resources to match the dynamic data center workload with the power generation [18].

The re-use of resources is a major goal of the green computing paradigm. Modern modular data centers with blade servers of higher electronic densities are leading to increased cooling requirements. It is estimated that 40% of data center electricity is used in cooling the servers while keeping their temperatures in operational range [19]. The waste heat generated by data centers can be utilized or re-used in various waste heat recovery scenarios. Firstly, cloud data centers provide ample opportunity for waste heat re-use in the cooling process. The heat recovered from servers is captured in the vapor-absorption based cooling systems where reversible heat pumps transfer thermal energy to cooler space. Secondly, in cooler places, data centers can be co-located with residential buildings for district heating [20]. Thirdly, modular data center designs can be migrated to cooler areas to reduce the cooling requirements while directly utilizing ambient air in the cooling process [1]. The major concern with energy re-use in CDCs is the low quality of heat generated that is applicable to few heat recovery processes [11].

The basic objective of cloud data centers is to provide IT services at an optimal pay-as-you-go model. In most software-based green cloud computing solutions, the network, processor, storage devices, and user tasks are modeled as graph and tree-based structures. The resultant optimization model of the cloud services generally focuses on the task makespan and cost minimization while determining which task is allocated to which resource [21]. Recently,

with a shift in focus on the energy consumption, the energy costs have been included in the optimization models. However, the task makespan and energy minimization requirements often conflict. The task makespan minimization requires exploitation of multiple resources that leads to higher energy costs. The multi-objective modeling of the task allocation problem in cloud data centers with thousands of resources and applications leads to great complexity in solution finding [22]. Evolutionary algorithms are employed to swiftly find near-optimal solutions for the multi-objective energy efficient resource scheduling problems in cloud data centers [3]. Interested readers can refer to comprehensive surveys on the greening of cloud computing [1, 21]. Figure 1 illustrates the options for greening cloud computing systems.

Fig. 1

Green Cloud Computing Techniques

Full size image

Green mobile computing

Smartphones of recent generations are equipped with high storage capacity and the computational power to perform resource-intensive tasks. The preference of smartphone users has lessened the dependency on desktop servers to perform computing tasks. As a result, the resource requirements of the smartphone applications have also increased [23]. Emerging media-rich smartphone applications frequently trigger sensors, such as GPS, accelerometer, and wireless radios to provide context-aware services. As a result, the computation, communication, and energy cost of smartphones significantly increase. To handle the energy-performance trade-off, energy-efficient system designs are necessary to meet the requirements of modern smartphone devices. Moreover, the energy-efficient design of smartphone applications and system components. Energy estimation helps to identify the rogue applications within a smartphone [24].

Effective management of the hardware components of a smartphone device significantly improves the total energy budget. The architectural design of hardware modules within the smartphone is based on Complementary Metal–Oxide–Semiconductor (CMOS). The total power consumption of CMOS based circuits (e.g. CPU, static RAM, and GPU) consists of static and dynamic power. The static power of a circuit varies from device to device depending on the insulation capabilities of transistors and represents the power consumption

when the transistor is not in the switching state [25]. Dynamic power represents the power consumption when a device changes logic state from on to off or vice versa. Power gating embeds a high voltage threshold transistor between actual ground and circuit ground of a device to switch off the transistor during its sleep hours to reduce leakage power. For the CPU module, dynamic frequency scaling (DFS) enables dynamic adjustment of power consumption for greening the smartphones at the cost of throughput [26]. The tail power represents the state of a smartphone component that remains in high power state although it has already finished its required task. The tail power state of smartphone components such as Wi-Fi, 3G, GPS, and SD-CARD, depletes battery charge quickly. Software tools, such as E-prof, empower smartphones to measure/estimate the device energy consumption at the component level. However, software-based solutions significantly impact the device's energy consumption due to their profiling activities [27].

Software based green computing solutions such as mobile cloud computing based computational offloading, energy bug handling, and energy efficient application development significantly reduce the energy budget of the smartphone. Mobile cloud computing empowers smartphone devices to augment device lifetime by carefully offloading energy critical tasks to remote cloud servers. Computational offloading decisions consider total execution time, resource consumption, energy requirements, and privacy issues of an application before migrating a task to resource-rich cloud servers [28]. Energy bugs within a smartphone lead to abnormal power consumption behavior of mobile applications. Energy bugs are difficult to track, and mainly occur due to **(a)** faulty batteries, **(b)** damaged mobile battery chargers, **(c)** infected memory cards, and **(d)** damaged SIM cards. Alternatively, within an OS, changing OS configuration impacts the mobile battery power consumption rate. For instance, setting SetCPU function incorrectly for kernel overclocking results in high battery power consumption [29]. Similarly, infected mobile applications and frameworks also drain mobile application abnormally. For instance, a "no sleep" bug hinders a smartphone component from going into a sleep state that consequently depletes mobile battery charge. A mobile application, with no sleep bug, acquires a lock on a mobile component and does not release it for a long period of time. The ADEL framework reported energy bugs of Wi-Fi components by tracking the packet transmission rate within the mobile application using dynamic taint-tracking analysis. Handling energy bugs puts some extra burden on programmers to explicitly manipulate power control APIs for energy-efficient operations of mobile applications [24].

Smartphone energy estimation provides the basis for green computing within smartphones. It provides feedback to the application developers to consider energy as a metric in addition to maintainability, complexity, and understandability. Smartphone application energy estimation schemes are broadly classified into components power model and code analysis based estimation categories. Component power model based methods use State of Charge (SOC) estimation methods to forecast the energy consumption of an application [24, 30]. Alternatively, the code analysis based method considers base cost energy of instructions within the source code of an application to estimate energy consumption [31]. SOC estimation methods include coulomb counting and voltage based methods. Coulomb counting estimates SOC by communicating to the smartphone's built-in sensors to find the accumulative current drop rate over time. However, coulomb counting produces inaccurate estimation results due to internal factors such as battery aging, the temperature within the smartphone, and charging/discharging rate. Alternatively, voltage-based SOC estimation employs fuel gauge sensors. Fuel gauge sensors are inaccurate owing to low charge update rate. Base cost energy methods assign base cost to the operations within an instruction to estimate energy consumption of an application based on static code analysis. The estimation method helps either to improve the hardware components of smartphones or software for green computing [31]. Figure 2 highlights the hardware and software options for green mobile computing.

Green Mobile Computing. The figure depicts techniques for green mobile computing

Full size image

Inefficient code design within a smartphone application has a high impact on the total energy consumption. Within an application, resource optimal placement of classes and functions reduces the power consumption. For instance, minimizing the memory distance between two functions that frequently communicate reduces the energy consumption of target application [32]. Also, educating developers with energy efficient application development techniques including loop unrolling, branch optimization, dead store elimination, value numbering, code inlining, constant propagation, code motion, inter-procedural analysis, and instruction scheduling, greens smartphone operations [33]. Extensive studies on green mobile computing are listed for detailed analysis [24, 34].

Green internet of things

IoT is another emerging technology that facilitates data communication among multiple electronic devices without human and computer intervention. Green IoT is a set of procedures adopted by the IoT in the form of hardware or software efficiency techniques. Green IoT aims to achieve energy efficiency through the reduction of the greenhouse effect in the current services and applications. Moreover, to reduce the impact on the environment, Green IoT focuses on the issues of green productions, green redesign, and green recycling/disposal [35]. Table 1 highlights enabling technologies and greening strategies for IoT.

Table 1 IoT Enabling technologies and their greening strategies

Full size table

Real deployment of IoT is performed through the collaboration of enabling technologies, communication strategies, and protocols. This section mainly focuses on the most crucial communication strategies and technologies that lead towards green IoT.

Green Radio-Frequency IDentification (GRFID) Radio Frequency Identification (RFID) is one of the promising IoT enablers. A RFID system comprises of RFID tags and tags readers. RFID tags are in the form of microchips attached to the radio that works as a transceiver. Every RFID tag has a unique ID and can store context data regarding the entities to which they are attached. Generally, in the elementary process, the RFID tag reader triggers information flow through transmitting a query signal. Consequently, the responses come from the nearby RFID tags. Mostly, RFID system transmission ranges are not more than a few meters. Moreover, the transmission frequencies start at 124-135 kHz up to ultra-high at 860-960 MHz. Currently, RFID tags can be found in two types: active and passive tags. The active tag uses onboard power batteries to do its functions. The passive tags depend on harvesting energy from the signal of the readers following the principle of induction [36].

To obtain green RFID, two factors should be considered. Firstly, RFID tag sizes should be reduced since tags themselves are difficult to recycle. Consequently, the amount of non-degradable material should be reduced in tag manufacturing (e.g. printable RFID tags, paper-based RFID tags, and biodegradable RFID tags). Secondly, using communication algorithms and protocols that support energy efficiency can lead to Green IoT. Green communication protocols provide energy efficiency through dynamic adjustment of the level of transmission power, optimization of tag estimation, and avoiding of tag collision and overhearing [37].

Green Wireless Sensor Network (GWSN) A Wireless Sensor Network (WSN) comprise of numerous sensor nodes that have resource-constraints, such as limited computing capability, storage capacity, and power. Commonly, the sensor nodes are connected to a powerful base station called sink. Usually, sensor nodes are equipped with multiple on-board sensors to read the surroundings circumstances, such as humidity, temperature, acceleration, etc. Commercial WSN solutions are based on the IEEE 802.15.4 standard [38]. Techniques such as **(a)** sleep mode activation during sensor idle time, **(b)** wireless charging mechanisms that harvest environmental mechanisms, **(c)** radio optimization, and **(d)** energy efficient routing and data collection are utilized for GWSN [39].

WSN aggregate sensed data into a sink from cluster heads through event-detection and continuous monitoring. Cluster heads receive and send aggregated data continuously, which leads to faster energy depletion around the sink [40]. There are two strategies for optimizing energy usage in WSN, namely, periodic reporting instead of continuous monitoring and timestamp-less synchronization. In a periodic reporting strategy, time periods of data reporting are set by the sensor owner to avoid energy spikes that are raised in event-driven reporting. In timestamp-less synchronization, the broadcast control messages to sensors for synchronization are not put to practice. The participating sensor pairs performs REQUEST/RESPONSE until the achievement of synchronization process [41].

Green M2M communication(GM2MC) Machine-to-machine (M2M) communication is one of the popular paradigms in IoT. There are two communication domains in IoT: M2M and networks. In an M2M domain, multiple nodes are deployed to intelligently monitor and gather data. In the network domain, wireless/wired networks carry the gathered data to the desired base station (BS). The BS supports different M2M applications through the network. The challenge is that the massive nodes involved in M2M interactions consume a lot of energy. The techniques that can be utilized to improve energy-efficiency of M2M communications are: **(a)** intelligently adjusting the transmission power to the necessary level, **(b)** developing energy-efficient routing protocols, **(c)** scheduling the activity in the machine domain, and **(d)** using energy-harvesting techniques [42]. Zhu et al. [39] provide exhaustive reading on Green IoT technologies.

Green big data analytics

Big data introduces the era of data with new challenges such as petabyte scale structured and unstructured data sets which are growing at an exponential rate and have heterogeneous

formats. Fast data retrieval and accuracy of search from a pool of big data are the main challenges to maximize value for decision making in big data analytics [43]. Traditional data management systems lack the capability to handle big data storage and analytics requirements and thus NoSQL technology is contributing to provide suitable solutions for timely data retrieval and efficient data processing. The process of greening is crucial for big data as analytics on tremendous size of data sets requires high computing power, scalable and efficient storage space, high availability of main memory, and fast communication media on always-on local physical or enterprise cloud servers [44]. Consequently, green big data analytics requires efficiency in resource utilization, energy consumption, and infrastructure scalability.

Big data analytics procedures may contribute to preserving the usage of processing and storage resources, scalability of systems, and improved productivity. Big data analytics requirements such as high availability, reliability, and consistency are significant in the development of technological infrastructures. However, energy preserving and resource optimization are the green computing aspects of analytics which have not being reported in the literature frequently. Cloud computing is revealed as a big data analytics technology which offers resource outsourcing in order to avoid physical occupation and thus multiple users with varying analytics requirements can utilize remotely accessible resources. The advancement in cloud computing for big data analytics is expected to lead to low dependency on the usage of personal computers in the new era of computing. Along with resource preservation, cloud computing also offers lower energy consumption for executing high computational procedures on big data [45]. Cloud computing has great importance as being a highly available platform for big data analytics which allows minimization in resource utilization and energy consumption [46].

There is a visible advancement in today's technology towards green big data analytics. For instance, GreenPlum [47] and GreenHadoop [48] are proposed in big data analytics for green computing. GreenPlum is an open source data warehouse, licensed under Apache Inc., which offers fast analytics on petabyte-scale data with efficient query processing via parallel processing and optimization. Cost-based query optimization introduced by GreenPlum ensures high analytics on large volume data sets with usage efficiency. GreenHadoop, on the other hand, brings the idea of renewable energy sources in order to balance the supply and demand of energy sources associated with big data analytics. The GreenHadoop framework

uses a photovoltaic solar array and electrical grid energy resources. The GreenHadoop framework for green analytics achieves maximized energy consumption by estimating available solar energy and scheduling MapReduce jobs accordingly. GreenPlum provides support to both batch and interactive modes of processing. However, GreenHadoop achieves real-time energy estimates based on prior data center workload.

Figure 3 shows a green big data analytics process where storage and processing resources reside on clouds and can be requested on demand. Cloud computing technology provides the basis for green big data analytics as the optimum resource utilization with reduced energy consumption. Currently, major big data sources and consumers are social networks, healthcare, industries, commerce, and business enterprises. Data from these sources and consumers is extensively scalable and brings critical analytics requirements for timely decision making. This big data storage and processing load are efficiently handled by data centers and processors residing on the cloud which ensures green analytics. According to a study [49], it is estimated that cloud computing will be able to achieve 38% reduction in energy usage by 2020. The concept of recycling is stated in [50] which suggests that renewable energy technology will be a preferable choice of investment in finding energy resources by 2040. Renewable energy technology is emerging with reduced adaptation cost, efficient green housing, and increased renewability demands which aim to achieve reduced carbon discharge, lower and stable energy costs, and access to reliable energy sources. 64% of the IT industry are meeting their targets of energy saving by using renewable energy technology [51].

Fig. 3

Green Big Data Analytics. The figure depicts techniques for green big data analytics

Green big data analytics is significant in optimizing energy consumption and re-usability of available sources to meet extensive analytics requirements of big data. Green computing is analogous to green chemistry and allows usage minimization for enormous computing and storage resources required by big data. Green computing aligns the big data analytics technologies with the concept of sustainability i.e. reduction, reusability, and recycling. Researchers [51] suggest that the technology industry seems more concerned about analytics efficiency than environmental sustainability and computational complexity. However, implementation of green analytics on big data surely results in reduced memory usage and

computational cost. Interested readers can refer to an extensive future perspective on green big data analytics [52, 53].

Green networking

Networks are the basic component and enabler of the innovations that have occurred in human society in the past few decades. As more industries and business have integrated IT technologies and services, the networks have grown into complex structures connecting billions of devices worldwide. As a result, network devices consume a large amount of energy constituting approximately 10% of the aggregate IT energy consumption [54]. The basic techniques applied for energy efficient networks are: **(a)** energy efficient protocols for routing, medium access, hand-off and **(b)** Adaptive Link Rate (ALR) techniques that scale link rate and utilize sleep states for energy-proportional computing [55].

The software and virtualization techniques have led to current advancements in the energy efficiency of networking technologies. Software Defined Networks (SDN) separate the data and control plane of network routers with the help of a central controller. SDN do not have a direct impact on the energy consumption of a network. However, the pervasive programmable interface of SDN supports energy efficient network operations indirectly through resource consolidation [56]. A minimum energy efficient subset of network resources can be calculated through a resource optimization technique and implemented through SDN as demonstrated in [57]. Hence, server and network resource management techniques can be utilized in parallel with the virtualization and SDN enabling technologies. SDN can help implement green computing policies at the network level based on their programmable control plane. Similarly, security policies can be implemented with the help of SDN while eliminating the need for stand-alone security devices. Consequently, SDN-enabled network devices can also implement security functions, lowering the total operational costs and energy bill [58].

Network Function Virtualization (NFV) is another technological shift in telecommunication systems. NFV decouples network forwarding and routing functions from underlying physical systems through virtualization [59]. Network functions, such as a firewall, can be implemented in software (virtual network function) and implemented on any of the industry standard physical servers. Similarly, network devices can offer virtual computation services. As a result of virtualization, network and compute devices offer agile computing and forwarding functions reducing the capital and operational costs of all IT services, especially

cloud computing. The decoupling of network functions from physical devices results in flexible and dynamic resource scheduling, hence, energy efficiency [60]. Five out of six case studies show that the NFV based networks provide energy savings compared to baseline networks. Similarly, higher performance and energy efficiency were observed as compared to commodity servers while experimenting with a virtualized Deep Packet Inspection (DPI) application [59]. However, a balance between network function performance and energy efficiency achieved through virtualization has to be resolved.

Both SDN and NFV technologies are in early stages of deployment. Therefore, research on the development of green computing architectures based on SDN and NFV technologies has significant future prospects in terms of integration with other IT technologies. Interested readers can refer to [61] for a detailed survey on green networks.

Practices, research challenges, and issues

In this section, we debate the practices, research issues, and challenges to the green initiatives in emerging IT technologies in particular and computing in general.

Green computing practices emphasize the implementation of green technologies at industrial and organizational level. The cost of per unit energy will rise significantly owing to a considerable decrease in global energy resources. As a result, it has become necessary for both public and government sectors to propose and practice state-of-the-art strategies and plans for green computing [62]. State-of-the-art green computing practices consider implementation of energy friendly IT equipment, lightweight resource consumption protocols, and disposal of electronic waste [63]. Green computing practices emphasize turning off IT resources when not utilized for an extended period of time. Green computing practices also schedule IT resources in low system power and idle states. The standby execution mode is applied for saving power if the execution power state is lower than a threshold [64]. The management of aging IT resources is another important issue in green computing. Older hardware devices have increased power consumption and require resource replacements and disposals. Hence, the practice of recycling needs to be applied to aging IT resources. Similarly, practices limiting the utilization of paper prints should be applied at organizational level [4]. The research challenges to emerging IT technologies are listed in the paragraphs below.

Green cloud computing: Green cloud computing demands divergence from conventional computing techniques, hence, increased operational and infrastructural costs. For example, renewable energy has a higher cost than conventional grid energy. Similarly, waste heat utilization measures in data centers also demand costly thermal heat exchange materials. Incorporating green measures with cost-efficient business operations is a challenging task in cloud data centers. The efficiency of renewable energy generation and storage mediums needs to be rigorously increased in order to provide comparable business incentives. The cost of VM migrations for resource consolidation over long-haul networks is also a highly debated research issue [14, 65]. Moreover, government policies need to be devised that provide incentives to green cloud computing business providers and users.

Green mobile computing: Mobile application energy optimization demands precise estimation accuracy for efficient battery resource usage. Empowering application developers with a fine granular energy estimation tool to estimate the energy behavior of an application at earlier development stages augments device battery lifetime. Existing energy estimation tools such as power tutor, trepn profile, and Nokia energy profiler, run the application on the smartphone to record power states of power models for smartphone components to estimate energy consumption. However, because of low accuracy of fuel gauge sensors within smartphone batteries, the estimate accuracy is limited. Also, the energy estimation time and overhead is high. To challenge the aforementioned issues, there is a need to develop an estimation tool that should offer high estimation accuracy and limited estimation overhead. One possible solution to this problem is to estimate energy consumption based on operational cost (energy and execution time) of different functions within the software. However, due to the non-deterministic nature of smartphone applications, estimation accuracy is significantly affected. Moreover, software operational cost based estimation also requires accurate estimation of code storage location. The weighted probabilistic approach is a possible solution to resolve these issues [24].

Green big data: Estimation and calculation of energy consumption for big data analytics is challenging. High and rapid analytic demands of big data are only satisfied when an efficient estimation is available. Similarly, for Green Hadoop, it is challenging to estimate the energy and time requirements for a job based upon which scheduling decisions are made. Estimation is also significant in renewable energy technology and thus, requires extensive work from academia and industry. Continuously increasing big data volume requires scalable increment

in available analytic resources and cost. However, the concept of green computing suggests sustainability of energy and processing resources. Consequently, big data analytics technology with minimized impact on the environment is highly desirable [43].

Green IoT: To preserve Green IoT some challenges arise and need to be addressed such as Green IoT Architectures, Green Infrastructure, Green Spectrum Management, Green Communication and Green Security and Quality of Service (QoS) Provisioning [37]:

- Green IoT Architectures: IoT architecture is still under standardization. The committees of standardization are trying to enable communication between heterogeneous networks, containing various types of devices, across various applications. The challenge is that communication protocols and devices should also consider energy-efficiency while performing their duties as anticipated by end users.

- Green infrastructure: Providing energy-efficient infrastructure for IoT is considered an important issue towards greening. Green infrastructure can be achieved through a clean-slate redesign approach. Redeploying and adapting existing infrastructure is a complex task.

- Green Communication: Communication is one of the influential factors in greening IoTs. Energy efficient communication between IoT nodes faces several challenges, such as supporting energy-efficient communication protocols along with reliable connectivity.

- Green Security and QoS Provisioning: Implementation of reliable security and privacy algorithms puts the burden of computation on IoT devices, consequently it increases the energy consumption.

Computing architectures, circuits, protocols, and algorithms are advancing innovations on green challenges faced by IT. Similarly, the efficiencies of the energy systems have also shown reasonable growth over the last decade. The demand and popularity for computing systems, storage devices, and networks has also increased, hence, neutralizing the advances in green computing. While researchers recognize the importance of continued innovations in efficient and sustainable computing and energy systems, industrial practices lag behind in the adoption of green computing. Operational costs of computing systems can significantly

decrease on adoption of green computing practices benefiting both service consumers and managers. IT enabled businesses and industries need to comprehend the advantages of green computing in terms of customer value, operational cost sustainability, and environmental sustainability. The future of green computing lies in effective endorsement of green computing practices by IT industries and IT empowered businesses.

Conclusion

the Green Computing paradigm was presented with a focus on emerging IT technologies. Cloud computing, mobile computing, big data analytics, IoT, and software-based networks were identified as the emerging IT technologies driving the current popularity of the IT industry. The demand and social integration of IT technologies is increasing rapidly, hence, increasing the energy consumption. With a renewed focus on the global energy crisis, IT researchers and practitioners have proposed and implemented several algorithms and protocols for the green operation of the IT industry. These algorithms and protocols implement mechanisms such as idle sleep states, energy-aware decision making, and resource scheduling. However, minimizing the energy consumption of a system significantly affects its performance parameters. The energy optimization level for a device highly depends on the use case of the application. Aggressive energy minimization policies effect system durability due to frequent power off and on system routines.

An overall analysis of the state-of-the-art in green computing shows that the green algorithms and protocols are reaching a high level of maturity, and significant efficiencies are possible. In contrast, the study has demonstrated that, in the IT industry, governance is lagging significantly behind, and hence consideration of green practices is a high priority. In particular, green computing practices need to be implemented at the organizational level to complement and enforce the underlying optimization techniques and technologies proposed by researchers. The strength of green computing solutions lies in their diversity, with consideration of low-level processor, memory, and network components for system optimization alongside greedy and evolutionary heuristics. However, again, this must coincide with robust and intelligent strategies that consider the overall performance energy trade-offs in terms of multi-objective optimization. The paper highlights that further research is required to analyze the impact of energy optimization techniques on system performance parameters such as throughput, and response time. This analysis of system performance and energy will lead to more fine-tuned solutions for green computing that will be more

acceptable to IT industry governors who prioritize performance parameters rather than energy.

Assessing performance is the periodic process of evaluating energy use for all major facilities and functions in the organization and establishing a baseline for measuring future results of efficiency efforts.

Key aspects include:

Data Collection and Management

2.1 **Gather and track data** — Collect energy use information and document data over time.

Baselining and Benchmarking

2.2 **Establish baselines —** Determine the starting point from which to measure progress.

2.3 **Benchmark —** Compare the energy performance of your facilities to each other, peers and competitors, and over time to prioritize which facilities to focus on for improvements.

Analysis and Evaluation

2.4 **Analyze —** Understand your energy use patterns and trends.

2.5 **Technical assessments and audits —** Evaluate the operating performance of facility systems and equipment to determine improvement potential.

Assessing your energy performance helps you to:

- Categorize current energy use by fuel type, operating division, facility, product line, etc.
- Identify high performing facilities for recognition and replicable practices.
- Prioritize poor performing facilities for immediate improvement.
- Understand the contribution of energy expenditures to operating costs.
- Develop a historical perspective and context for future actions and decisions.
- Establish reference points for measuring and rewarding good performance.

Gather and Track Data

Evaluating energy performance requires good information on how, when, and where energy is being used. Collecting and tracking this information is necessary for establishing baselines and managing energy use.

Organizations of all sizes have established systems for gathering and tracking energy use data. For commercial buildings ENERGY STAR's **Portfolio Manager** tracks energy use over time. In the case of industrial plants, the ENERGY STAR industry specific **Energy Performance Indicator (EPI)** and **Energy Tracking Tool** can be used to track yearly energy use patterns. All or part of data collection and management can also be outsourced. Regardless of what method you use to gather and track data, consider the steps below.

Account for all energy sources — Inventory all energy purchased and generated on-site (electricity, gas, steam, waste fuels) in physical units (kWh, mMBtu, Mcf, lbs of steam, etc.) and on a cost basis.

• **Document all energy uses** — For the sources identified above, assemble energy bills, meter readings, and other use data.

o Energy data may reside in the accounting department, be held centrally or at each facility, or can be acquired by contacting the appropriate utilities or energy service providers.

o Gather at least two years of monthly data or a more frequent interval if available. Use the most recent data available.

Establish Tracking System

a. A system for tracking performance can range from a simple spreadsheet to detailed databases and IT systems. In developing an appropriate tracking system for your organization, consider the following:

□□**Scope** — The design of your tracking system will be shaped, in large part, by the level and scope of information that will be tracked and the frequency of data collection.

• **Maintenance** — Tracking systems must be easy to use, update, and maintain.

• **Reporting and communicating** — Use tracking systems to communicate energy performance to other parts of the organization and motivate change. Consider developing formats that express energy performance information in ways that are easily understandable across the organization

Benchmark

EPA (Environmental Protection Agency (**EPA**))has made this step easier by providing a national energy performance rating system, currently available for common commercial and institutional buildings and selected industrial plants. The rating system, found in **Portfolio Manager** for commercial buildings and through **Plant Energy Performance Indicators (EPIs),** allows you to compare your performance against similar facilities.

Conduct Technical Assessments & Audits:-

The main steps for conducting technical assessments and audits are:

• **Assemble expert team** — Expertise should cover all energy-using systems, processes, and equipment. Include facility engineers, system specialists, and other support. Outside support may be helpful and provide an objective perspective or specific expertise.

• **Plan and develop a strategy** — Identify and prioritize systems for evaluation, assign team members to tasks, and schedule completion dates for the activities. Use benchmarking results to identify poor-performing facilities whose equipment and systems should be targeted for evaluation.

• **Create final report** — Based on the audit results, produce a detailed summary of actual steps that can be taken to reduce energy use. The report should recommend actions from simple adjustments in operation to equipment replacement. Estimates of resource requirements for completing actions should be included.

Energy Audit: Types And Methodology

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management programme.

Energy Audit is defined as "the verification, mon- itoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption".

Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities. Such an audit programme will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies.

Thus Energy Audit can be classified into the following two types.

i) Preliminary Audit

ii) Detailed Audit

Preliminary Energy Audit Methodology

Preliminary energy audit is a relatively quick exercise to:

• Establish energy consumption in the organization

• Estimate the scope for saving
• Identify the most likely (and the easiest areas for attention
• Identify immediate (especially no-/low-cost) improvements/ savings
• Set a 'reference point'
• Identify areas for more detailed study/measurement
• Preliminary energy audit uses existing, or easily obtained data

Detailed Energy Audit Methodology

A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems.

This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost. In a comprehensive audit, one of the key elements is the energy balance. This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is then compared to utility bill charges.

Detailed energy auditing is carried out in three phases: Phase I, II and III.

Phase I - Pre Audit Phase

Phase II - Audit Phase

Phase III - Post Audit Phase

Phase I -Pre Audit Phase Activities

A structured methodology to carry out an energy audit is necessary for efficient working. An initial study of the site should always be carried out, as the planning of the procedures necessary for an audit is most important.

Initial Site Visit and Preparation Required for Detailed Auditing

An initial site visit may take one day and gives the Energy Auditor/Engineer an opportunity to meet the personnel concerned, to familiarize him with the site and to assess the procedures necessary to carry out the energy audit.

During the initial site visit the Energy Auditor/Engineer should carry out the following actions: -

• Discuss with the site's senior management the aims of the energy audit.
• Discuss economic guidelines associated with the recommendations of the audit.
• Analyse the major energy consumption data with the relevant personnel.
• Obtain site drawings where available - building layout, steam distribution, compressed air distribution, electricity distribution etc.

• Tour the site accompanied by engineering/production

The main aims of this visit are: -

• To finalise Energy Audit team

• To identify the main energy consuming areas/plant items to be surveyed during the audit.

• To identify any existing instrumentation/ additional metering required.

• To decide whether any meters will have to be installed prior to the audit eg. kWh, steam, oil or gas meters.

• To identify the instrumentation required for carrying out the audit.

• To plan with time frame

• To collect macro data on plant energy resources, major energy consuming centers

• To create awareness through meetings/ programme

Phase II- Detailed Energy Audit Activities

Depending on the nature and complexity of the site, a comprehensive audit can take from several weeks to several months to complete. Detailed studies to establish, and investigate, energy and material balances for specific plant departments or items of process equipment are carried

out. Whenever possible, checks of plant operations are carried out over extended periods of time, at nights and at weekends as well as during normal daytime working hours, to ensure that nothing is overlooked.

The audit report will include a description of energy inputs and product outputs by major department or by major processing function, and will evaluate the efficiency of each step of the manufacturing process. Means of improving these efficiencies will be listed, and at least a preliminary

assessment of the cost of the improvements will be made to indicate the expected payback on any capital investment needed. The audit report should conclude with specific recommendations for detailed engineering studies and feasibility analyses, which must then be performed to justify the implementation of those conservation measures that require investments.

The information to be collected during the detailed audit includes: -

1. Energy consumption by type of energy, by department, by major items of process equipment, by end-use

2. Material balance data (raw materials, intermediate and final products, recycled materials, use of scrap or waste products, production of by-products for re-use in other industries, etc.)

3. Energy cost and tariff data
4. Process and material flow diagrams
5. Generation and distribution of site services (eg. compressed air, steam).
6. Sources of energy supply (e.g. electricity from the grid or self-generation)
7. Potential for fuel substitution, process modifications, and the use of co-generation systems (combined heat and power generation).
8. Energy Management procedures and energy awareness training programs within the establishment. Existing baseline information and reports are useful to get consumption pattern, production cost
and productivity levels in terms of product per raw material inputs. The audit team should collect the following baseline data:

- Technology, processes used and equipment details
- Capacity utilisation
- Amount & type of input materials used
- Water consumption
- Fuel Consumption
- Electrical energy consumption
- Steam consumption
- Other inputs such as compressed air, cooling water etc
- Quantity & type of wastes generated
- Percentage rejection / reprocessing
- Efficiencies / yield

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on any capital investment needed. The audit report should conclude with specific recommendations for detailed engineering studies and feasibility analyses, which must then be performed to justify the implementation of those conservation measures that require investments.

Carbon reduction options:-

1. **Switch to renewable energy backed by REGO certificates**

   REGOs – or Renewable Energy Guarantees of Origin – assures that the origin of the energy supplied to you is 100% renewably sourced.

Using the GHG Protocol market-based calculation method to work out your carbon footprint.

2. **Reduce your emissions from air travel**

   Increasingly, companies are opting to travel less for business by using popular software programmes such as Zoom and Skype.

   Consider travelling by train domestically to reduce emissions from air travel.

   3 Reduce your emissions from road travel Choosing more fuel efficient or alternatively fuelled vehicles such as alternative fuel or electric vehicles.

4. **Increase the efficiency of your office lighting**

   Changing lighting across a building to more energy efficient options such as LED can make a big difference and is a quick win with long lasting effects. Where possible ensure that natural light is used when adequate, many offices are artificially lit unnecessarily. Natural light saves energy and has been found to improve sleep and avoid health risks associated with unnatural lighting such as an elevated stress response.

   Solar shading and transparent film can be used to help, by minimising glare and excessive heat. There is also an array of technology available, such as motion sensors which will automatically ensure lights are switched off if rooms are not in use. Dimmable lights are another method to ensure lights aren't at their brightest maximum when not required. This should also help reduce electricity costs.

5. **Reduce energy usage in your data centre and comms room**

   Set cooling systems to a higher temperature to save energy and increase cooling capacity

   Often data centres are set around 19°C resulting in unnecessary energy usage. Data centres can save 8% to 9% in energy costs for every 1°C increase in server inlet temperature. 23°C is the optimum temperature for many data centres to save energy without risking overheating.

   Set up hot and cool isles

   Typically, only 40% of the electricity consumed in a data centre is used by IT equipment. A staggering 60% is consumed by the server room infrastructure: air conditioning, lighting, UPS systems, etc. Reorganising your aisles into either hot or cold air containment systems could save you 20% to 40% in annual cooling system energy.

6. **Optimise your heating and cooling systems**

   Implement temperature controls, ensuring heating and air conditioning is timed correctly and according to outside air temperatures. This can minimise over heating or cooling. Ensuring that temperature is minimal during the night is important. Lots of energy can be wasted if

heating and cooling systems are competing, this can be avoided by installing a Building Management system.

7. **Reduce, reuse, recycle**

Thinking about sustainable procurement can act as an exercise to engage employees with thinking of ways they can reduce consumption of items such as water, paper, food and drink, laptops, phones and packaging. Manufacture and transport of all these items has an associated carbon footprint.

Purchasing recycled paper or refurbished phones and IT equipment is an easy way to reduce your businesses carbon footprint. Buying recycled paper instead of primary production reduces carbon emissions as stipulated by the GHG Protocol.

8 Print as minimally as possible

Many offices consume vast amounts of paper. Take action to cut down paper usage, especially by reducing printing, and digitising (e.g. online contract signings, avoiding printing emails, presentations and annotating on screen instead).

If printing is required, ensure double sided printing is set as a default. Having 'follow me' printing services across office printers can also help cut down any accidental or unnecessary printing as options can be altered at the time of printing.

MODULE-3

Greening the data center :-A green data center is built to have a minimal effect on the natural environment. The following are primary green data center features:

- Built from the ground up in an environment friendly facility
- Consume minimal power resources for operation and maintenance - both for the primary computing infrastructure and supporting electronic resources, such as cooling, backup and lighting
- Typically operate with green or renewable energy, such as solar, wind or hydel power
- Entire infrastructure is installed with the lowest power and carbon footprint
- Minimal e-waste with recyclable or reusable equipment.

Organizations can successfully build and implement green data center initiatives that maximize efficiency and return on investment by following these five steps:

1. Conduct a Baseline Energy Audit

Any green data center initiative should start with a baseline energy audit. The baseline audit provides both a real-time assessment of usage and efficiency and a benchmark for future assessments to guide long term planning.

Because data centers are comprised of a variety of diverse and interconnected systems, it's critical to drill down into individual systems to pinpoint where inefficiencies reside within the infrastructure. From there, the energy audit assesses the impact of these inefficiencies on total usage and outlines a tangible and trackable remediation plan.

2. Select Green-Friendly Materials and Environmental Attributes

Many factors support less energy usage and a smaller carbon footprint, including compact building, low emission materials, waste recycling, and alternative energy sources for power and cooling. Changes like upgrading air compressors, shutting down dormant servers, paper shredding, and transitioning to LED lighting can make a big impact over time.

Organizations further save by building data centers using locally sourced renewable resources to power servers and building in naturally cold locations to take advantage of

free cooling. With respect to energy efficiency specifically, it's estimated that these improvements collectively will save 620B kWh between 2010 and 2020.

3. Prioritize the Reduction of Data Center Power Usage

While location and materials selection significantly affect environmental impact, data center power use is the primary driver of variable cost. Gartner estimates that ongoing power costs are steadily rising at 10 percent per year due to a combination of an increase in cost per kilowatt-hour and growing demand attributable to high power density servers. Currently, the report states, power costs comprise 10 percent of data center's OpEx, and they are projected to increase to 15 percent within five years.

To reduce data center power use, it's critically important to lower the amount of energy required to power the IT equipment. In fact, 60 percent of payload power is consumed by servers. To decrease this power drain, data center managers should focus on consolidating and virtualizing workloads, eliminating powered servers that are dormant, and replacing old servers with newer models.

4. Optimize Data Center Cooling

While building data centers in naturally cold environments contributes significantly to more efficient data center cooling, data center facility managers can amplify this effect by installing outside air economizers that draw from the natural environment instead of a power source for cooling. Optimizing air conditioning through using an alternative cooling source and continuously adjusting the speed to match real-time requirements can make a significant impact on power use.

Additionally, isolation structures contain the data center equipment that generates the most heat, siphoning the heat to other parts of the building while funneling the excess out of the building.

5. Design Modular Data Centers

Prefabricated data center solutions accelerate the speed of business through delivering modular packages for data center facility managers. These pre-engineered solutions target specific parameters, including deployment speed, performance, reliability, and cost reduction.

The pre-fabricated approach both increases the predictability and minimizes the organizational disruption of the build process because the bulk of the construction occurs in the factory and not in the field. Additionally, modular datacenters like those in remodeled shipping containers provide organizations more flexibility for satisfying their computation demand while saving the resources and space required to build an entirely new data center. Once purchased, the vendor delivers pre-configured and tested modules to the customer typically within 12-16 weeks.

Building a green data center starts with pinpointing and addressing inefficiencies in the infrastructure. Smart choices around green-friendly materials and location attributes will also make a significant impact over time. Prioritizing the reduction of data center power usage will drive the bulk of the cost savings associated with green design, and modular prefabricated solutions have these efficiencies built in and can be installed with minimal disruption. By following these five steps, data center facility managers can make significant progress on both decreasing environmental impact and lowering power costs.

Managing Information Lifecycles

Information Lifecycle Management (ILM) is a set of concepts critical to formulating IT policies.

ILM enables organizations to build processes and implement best practices for creating, storing, archiving, and ultimately disposing of data that no longer has any value to the organization.

ILM enables an organization to match the storage costs of the information to the business value of the information, and to adjust the levels of storage costs as the value of information changes.

ILM is important to our green strategy because it helps us identify our actual storage needs. This model classifies data according to its value so we aren't using electricity to power storage devices for information that's not currently needed, and helps eliminate obsolete data so we can reuse storage and avoid or delay buying additional storage.

The ILM model identifies five stages in the lifecycle of data:

1- **Creation:** This phase pertains to generating documents in a word processor, filling a spreadsheet with data, or using a Customer Relationship Management (CRM) system to

input customer information. New information might also include scanned paper correspondence, drawings created on a computer-aided design (CAD) system, PowerPoint presentations, recorded video conferences, and so on.

2- **Distribution:** After some one generates a document, it usually needs to go somewhere beyond the computer it's created on. For example, an e-mail is distributed to desktop through a company network and a mail server, but we may also send a copy to a customer. The distribution stage encompasses delivery of data both within a company and externally.

3- **Use:** After the document, e-mail, presentation, or other type of data arrives at its intended destination, something happens to it. May be the presentation is delivered to an outside salesperson for a meeting tomorrow morning, or six people read the document and add their comments, and then some unfortunate, long suffering soul has to integrate all those contentious comments to create a final version in time for some deadline. Whatever the case, the data is used as part of a business activity.

4-**Maintenance:** The data is managed in this phase. For example, an e-mail may be kept in an e-mail inbox, which is one form of filing it. It may also be backed up, forwarded, or archived. What happens to data depends in part on its *currency* (how readily available it needs to be) and how valuable the data is considered to be by the organization. The notion of currency takes into account the fact that data can (and does) lose its value over time. From a cost-effective standpoint, data should be indexed and moved to less expensive storage or even offline as its value fades. If the IRS conducts an audit or a lawsuit requires data to be provided, that data again acquires currency and needs to be recovered.

5- **Disposition:** Faced with increasing regulatory pressure to keep certain kinds of data, some companies have responded by trying to "keep everything." Such a strategy
creates an indexing nightmare and the continual need to buy more storage capacity to respond to unbridled demand. Companies that analyze their data use and storage needs can better determine which data needs to be retained and for how long. Each organization needs to first decide what types of data it needs to keep, classify that data according to how readily available it needs to be, and move the data to appropriate
Types of storage. Different organizations have different requirements around what's important to them and for how long. Knowing what we need to keep, keeping only what we need to keep, and keeping it only as long as we need to keep it allows us to use the fewest resources .

Optimizing Storage

We can use a variety of technologies and methodologies to optimize our storage utilization. Together they can reduce the amount of storage we need, and thereby the energy we use to power and cool it.

Using storage tiers helps companies think in terms of storage efficiency. Moving data from one tier to the next uses progressively less energy and supports a green data strategy.
To grasp the idea of tiered storage, think of data descending a staircase along its lifecycle, with each tier reflecting how the data is currently being used (or not used) and how accessible it needs to be. The number of tiers varies, but most companies recognize five tiers.

Tier 1 — mission-critical data
This tier involves highly transactional data that needs to be accessed frequently. Examples of Tier 1 storage include Web servers that support the Web site our customers use and accounting databases. Tier 1 data is the most expensive to store, both in monetary and environmental costs. This data occupies space on spinning disk drives and may be duplicated on user machines, particularly laptops, as access may be needed when the network is not available. If we have the option, store this data at data centers that are powered by renewable sources.

Tier 2 — high value but not mission critical
In this tier, data needs to be accessed less frequently, so performance is less of an issue than it is with Tier 1 data. This storage is less expensive. Sample Tier 2 data may include documents stored on a collaboration server, or databases that are accessed infrequently. Data de-duplication can ensure that Tier 2 data is stored only once.

Tier 3 — transitional storage
Tier 3 data is valuable data that needs to be accessed infrequently. Examples may include an indexed e-mail or document repository. Tier 3 data is a candidate for *MAID (massive arrays of idle disk)* storage. Such systems save energy by keeping disk drives powered down until the data on them is needed.

Tier 4 — disaster recovery
This tier serves as a repository for applications and data that need to be available to restore continuity of operations in the event of a business interruption, such as a power outage. Disaster recovery systems can often be powered down or kept in standby. Periodic testing can be scheduled at a time when power is more available, keeping load off less efficient "peaking" generators.

Tier 5 — archive

Tier 5 is the repository of data that needs to be retained but doesn't need to be online. Here are some suggestions for being green with our archiving:

✓Archive off-site in a secure, protected location. Any data can be put into an archive, but it's most likely data that the company intends to keep for a long period of time.

✓Compress data, which allows two to three times as much information to be stored in the same amount of space.

✓Tape offers better cooling and power consumption than disk and has a longer life span lasting 10 to 20 years.

Conclusion:- Implementing a records management policy can help ensure that information we determine to have business value is retained according to corporate, government and industry guidelines. For example, organizations need policies to define rules about how long e-mail is retained.

Hosted Data Center Services

The company has a choice when it comes to building our information infrastructure: We can build a physical infrastructure that we staff and maintain, or we can outsource these services totally or partially. We can still categorize our data according to the tiered storage architecture. We can store our data for some or all tiers with an off-premises provider. Here are some reasons to consider using a hosted data center provider:

✓**Greener:** Dedicated data centers consolidate the operations of many organizations and gain economies of scale, reducing the amount of power and equipment that those organizations would gobble up individually.

✓**Cheaper:** Acquiring and maintaining data center equipment, and powering and cooling it is expensive. Hosted services provide a cheaper alternative to running all these systems in-house.

✓**Physical plant:** Locate data in buildings designed to support IT. Data centers need power and cooling. Some cities restrict the amount of power available for powering data centers, and data centers are being relocated to areas near cheaper, cleaner power and cooling. Some companies prefer to use the services of a provider that has expertise in archiving. Some use remote services to complement in-house IT staff.

the most effective ways to improve the power consumption and cooling requirements is by consolidating parts of the IT infrastructure. Reducing the number of physical servers will almost always result in power savings, and as system maintenance costs decrease, less staff is required to manage the physical infrastructure.

You can consolidate your servers in the following ways:

1- **Use a larger server.** A server with faster processors and increased memory capacity replaces several servers.

2- **Replace physical servers with virtual servers.** Each application runs in its own virtual "machine." The virtualization manager allocates resources to each running application so to maintain performance.

3 – **more Rack space and less floor space** As you consolidate servers you can reduce the number of racks needed. Increasing hard drive capacity has a similar effect on storage racks: more capacity in less space. Fewer racks mean reducing total floor space as well as reducing power consumption and cooling.

Servers generate the most heat and consume the most power in the data center. Servers are becoming greener because greater amounts of energy aren't always available, and system deployments grow beyond the capacity of current facilities to supply their power and cooling needs.

Some of IBM's solutions for Green Servers include the following:

1-IBM Systems Director is energy management technology that monitors and control energy usage for energy efficiency, performance, reliability, and availability. Systems use less power, generate less heat and use less energy to cool systems.

2-IBM's POWER6 architecture with Energy Scale provides power trending, power-saving, capping of maximum power and thermal measurement, allowing you to measure the energy of the system and direct policies
toward energy-efficiency.

3-IBM POWER6 processor-based servers deliver outstanding performance per watt as well as virtualization technologies. Live Partition Mobility allows you to move running partitions from one POWER6 server to another, conserving power by moving workloads off underutilized servers.

They can work together to optimize system utilization, improve application availability, balance critical workloads across multiple systems and respond to ever-changing business demands.

4- The IBM Rear Door Heat eXchanger removes heat generated from the back of computer systems before it enters the room. The Rear Door Heat eXchanger reduces up to 55 percent of the heat load coming from any IBM

enterprise rack. It requires no fans or electricity and its design allows systems to air-cool without opening or removing the door. It attaches to the back of the rack without taking extra space and prevents condensation.

Blade servers put each processor, memory, and hard drive on a single card called a blade. Blades plug into a *backplane*. Blade servers offer a real opportunity for green efficiency because the power and cooling is shared among all the blades plugged into the backplane. These common services include

✓**A single power supply:** A larger supply is generally more efficient, so the blade packaging uses less power for the same amount of computation.

✓**A shared cooling system:** The concentration of blades in one chassis allows the server designers to use fewer but larger and more efficient fans and to engineer the air flow for better effectiveness.

✓**A shared network interface:** In place of individual network interfaces, which frequently use considerable power, the blade server case provides a common network backplane with a port for each blade server.

Lower management cost When you consolidate your servers, deployment, management, and administration are simplified and improved. This, of course, also manifests itself in cost savings.

Conclusion:- Because of the concentration of blades within the blade server case, manufacturers often supply software to control the power usage of individual blades or the system as a whole. blade servers generally saves power and space. Designed to address thermal concerns without sacrificing performance, IBM Blade Center infrastructure uses energy-efficient components and a shared infrastructure architecture. Calibrated Vectored Cooling capabilities enable dual paths of air to each component, improving uptime and longevity while reducing wasteful air movement. The optimized airflow, the blade form-factor and power-efficient processors provide thermal management without more fans, allowing more servers.

the energy efficiency factor of a server.

1- Use virtualization to increase server utilization.

2-Update your organization's software because more efficient software can reduce server loads.

3-Use less efficient servers to provide peak capacity, and power them down when not needed.

4-Platform monitoring and reporting of energy usage across all IBM server platforms within the IT infrastructure

5- Measuring and reporting server energy consumption.

6- Understanding how energy is used within the data center so you can optimize servers and their workloads.

7-Active Energy Manager lends a hand in reducing energy consumption by automatically varying fan speeds based on ambient temperature, turning off unused processor cores and allowing you to set energy usage limits.

8- *Performance per watt* is a measure of a computer's energy efficiency. Applying a similar metric to a group of machines from different manufacturers, or a product line from one manufacturer, results in a ranking of energy efficiency.

9- *Power-capping* refers to the practice of limiting the amount of energy supplied to a server at various times during the server's operation. Power capping is generally implemented in a software management tool that uses policies set by IT to limit power consumption when the server in question isn't being heavily loaded.

the basic idea behind cooling the data centre.

Air conditioners are essentially steam engines operating in reverse. Rather than use a difference in temperature to create power, they use power to create a difference in temperature. The same second law of thermodynamics governs their efficiency as well, air conditioner

efficiencies can be greater than 100 percent. In other words, an air conditioner can move more energy in the form of heat than the electrical energy supplied to the unit. Moving cold air long distances is difficult. In most large building air conditioning systems, the evaporator extracts

heat from a flow of water instead of air. The chilled water is pumped to heat exchangers throughout the building, where it cools air in the building's ventilation system. To improve your power usage effectiveness (PUE) and Data Center infrastructure Efficiency (DCiE), consider these steps:

1. Assemble a team to review current approaches to
data center cooling and to evaluate alternatives.

2. Identify vendors with promising approaches.

3. Develop a proposal with cost saving estimates,
including benefits like reduced carbon.

4. Develop an implementation plan that allows changes to be made with minimal disruption.

5. Take baseline measurements that allow you to quantify benefits after the changes have been implemented.

Restyling your aisles:-

A more efficient arrangement is *cold aisle/hot aisle cooling,* where you arrange the racks holding your servers in alternating cold and hot aisles so that the intake side of the equipment always faces a cold aisle and the exhaust side faces a hot aisle. No cold air is allowed to enter the hot aisle.

The cold aisle/hot aisle approach is most suitable for data centers with enough racks to organize this way, but you can apply the principle to smaller centers by ducting the cold air to a location near the intake side of the equipment racks.

Maintaining the temperature In consultation with computer manufacturers, recently lowered its recommendations for data center air temperature and computer room humidity.

The new recommendations for maintaining IT equipment safely are as follows:

✓**Maximum temperature:** 80.6°F (27°C)

✓**Minimum temperature:** 64.4°F (18°C)

✓**Maximum relative humidity:** 60 percent

✓**Maximum dew point:** 59°F (15°C)

✓**Minimum dew point:** 41.9°F (5.5°C)

the precautionary measure taken for cooling the small data centre.

Here are some suggestions aimed at

smaller data centers:

✓Check your air conditioning system's manuals for required maintenance.

✓Change air conditioner filters and clean coils regularly.

✓Inspect refrigerant piping to ensure that insulation on the cold leg is intact.

✓Arrange the (computer room air conditioners)CRAC output so it's near server inputs.

✓Consider using outside air during the cooler times of year.

✓Use waste heat to heat the rest of the building.

✓Increase computer room air temperature per (American Society of Heating, Refrigerating, and Air- Conditioning Engineers)ASHRAE 2008 guidelines.

✓Shade outside air conditioning units from direct sunlight where feasible.

✓If fan motors require periodic lubrication, do this regularly.

✓Make sure tower servers aren't shoved up against a wall or other obstacle.

green storage. And the strategies for green storage at system level.

Green storage is the practice of using a variety of "clean energy" storage methods and products to cut down on a data center's carbon footprint, as well as cost.

With green storage, the goal goes beyond being environmentally friendly. Other benefits include lower costs, preserving energy and improving efficiency. There are a number of systems that can be used for green storage, and by analyzing your data center and specific needs,

Storage systems' energy consumption could be managed effectively at the system level taking into consideration media type, data characteristics, data access patterns and overall system operation. Common techniques for managing energy consumption at the system level include

1. RAID with power awareness,
2. power-aware data layout,
3. HSM,
4. storage virtualization
5. cloud storage.

RAID with power awareness:-

Energy-efficient redundant and inexpensive disk array (EERAID) is a RAID engine aimed at minimizing the energy consumption of RAID disks by adaptively scheduling requests to various disks that form the RAID group. Specifically, by controlling the mapping of logical requests to a RAID stripe, the disk idle period of a subset of disks is maximized facilitating the spin down of these disks. Power-aware redundant array of inexpensive disks (PARAID) dynamically varies the number of powered-on disks to satisfy this varying load. In addition, to tackle the problem of high penalties due to requests for data on spun down disks, PARAID maintains a skewed data layout. Specifically, free space on active and idle disks is used to store redundant copies of data that are present on spun down disks.

Hibernator is a disk array design for optimizing storage power consumption. It assumes the availability of multispeed disks and tries to dynamically create and maintain multiple layers

of disks, each at a different rotational speed. Based on performance, the number of disks in each layer and the speed of the disks themselves are adjusted.

power-aware data layout

A massive array of idle disks (MAID) system only spins active drives, cutting down on energy use and prolonging shelf-life. MAID uses a small subset of disks as dedicated cache disks and uses traditional methods to exploit temporal locality. The remaining disks are turned on on-demand.

Hierarchical Storage Management:-

In HSM, data are migrated between different storage tiers based on data access patterns. Different storage tiers have significant differences in one or more attributes – namely, price, performance, capacity, power and function. HSM monitors the access pattern of the data, predicts the future usage pattern of the data, stores the bulk of cold data on slower devices (e.g. tapes) and copies the data to faster devices (hard disks) when the data become hot. The faster devices act as the caches of slower devices. Moving data from hard disks to tapes, or from FC(**Fibre Channel**) disks to SATA(**Serial Advanced Technology Attachment**) disks and then to tapes, can not only reduce the storage costs but also reduce the power consumption of the storage system by storing rarely accessed data to low-power devices.

Storage Virtualization:- Storage virtualization is another strategy for reducing storage power consumption. With storage virtualization, access to storage can be consolidated into fewer number of physical storage devices, which reduces storage hardware costs as well as energy costs.

Storage virtualization is commonly used in data centre storage and for managing multiple network storage devices, especially in a storage area network (SAN). It creates a layer of abstraction or logical storage between the hosts and the physical storage devices, so that the management of storage systems becomes easier and more flexible by disguising storage systems' actual complexity and heterogeneous structure. Logical storage is created from the storage pools, which are the aggregation of physical storage devices. Virtualization also increases storage utilization by allowing multiple hosts to share a single storage device, and by data migration. The improved utilization results in a reduction of physical storage devices, and fewer devices usually mean less power consumption.

Cloud Storage:-

cloud storage refers to online storage generally offered by third

parties, instead of storing data to the local storage devices. Those third parties, or hosting parties, usually host multiple data servers (storages) which form the data centres. The user stores or accesses data to or from the data servers using the Internet through a Web-based interface and will pay the cloud storage provider for the storage capacity that he or she uses. In general, the fee charged by the service providers is much less than the costs of maintaining local storage for most individual users, small and medium-size companies and even enterprises.

IT and energy costs are reduced because the user does not need to buy and manage his or her own local physical storage devices, perform storage maintenance like replication and backup, prevent over-provisioning, worry about running out of storage space and so on. The provider can also use storage virtualization to consolidate the workloads from different users to a single storage device to improve storage efficiency and reduce the device's idle time.

Green Networking and its Objectives and Objectives of Green Network Protocols.

Green Networking

Some of the main strategies associated with green networking involve consolidating devices or otherwise optimizing a hardware setup. Software virtualization and efficient server use can contribute to this general goal. Green networking could also include such diverse ideas as remote work locations, energy use in buildings housing hardware, or other peripheral aspects of a network infrastructure.

Objectives of Green Networking:-

- Minimizing the carbon footprint of delivery networks;
- Improving operational sustainability in wireless networks;
- Minimizing the financial cost for operators to transmit;
- Allowing application QoS to be achieved within network resource constraints;
- Reducing load on the network and hence per transaction power consumption;
- Removing the digital divide between urban and rural areas;
- Contributing to industrial standards.

Objectives of Green Network Protocols

In empowering the network with energy awareness and efficiency ability, it is necessary to understand protocol overhead in terms of mandatory fields in packet headers and control packets currently used to manage transmissions. This leads to identification of ways in which protocols may be optimized such that their degree of reliability is maintained through

reducing the number of bits associated with each, the cost of which to transmit may be incurred during any transaction, and hence energy efficiency improved.

From the point of view of network protocols, the number of bits involved can be reduced by (i) minimizing the number of overhead packets per protocol, (ii) minimizing the number of mandatory bits per protocol, (iii)
minimizing retransmission attempts and (iv) maximizing the number of successful data packets sent.

Conclusions :- Green network protocols transmit fewer bits than standard default protocols developed with reliability as opposed to energy efficiency as core operational objectives. Green networking includes the selection of least-cost paths in terms of node number queuing delay, carbon and financial cost, maximization of node and link resources and use of optimized protocols.

Module-4

Virtualization and its Benefits.

Definition of Virtualization:

The **definition** of **Virtualization** is actually the creation of a **virtual** (rather than actual) version of something, like an operating **system (OS),** a **server,** a **storage device** or **network resources.** The use of **software, Operating system Virtualization,** is to allow a part of hardware to run several multiple **operating system images concurrently.** By using Virtualization we can save time energy and less **hardware** is required for the **multiple software.** These types of software such as **Microsoft** and **VMware** have lowered the costs at a **high scale.**

Benefits of Virtualization:

One of the major advantages of **virtualization** is the use of one **machine** to host so many systems that reduce the number of physical servers, **reduce hardware maintenance** costs and it also can enhance the space utilization efficiency in the data center due to the lower number of **physical servers.** Nowadays 50 to 60% of servers are now **virtualized.**
The **shakeout** process of your working servers and its permanent relocation lowers the cost of **administration** at a **high level.** The management of the **basic physical infrastructure** that are dependent upon the virtual servers bring us with lots of **advantages** such as saving time money, **physical space,** betterment of working productivity and improved disaster recovery solutions and **deliver high availability** throughout the **data center.**

The different types of virtualization are

1. Desktop Virtualization,
2. Application Virtualization,
3. Server Virtualization,
4. Storage Virtualization, and
5. Network Virtualization.

Desktop Virtualization

The virtualization of the desktop, which sometimes is referred to as Virtual Desktop Infrastructure (VDI), is where a desktop operating system (OS), such as Windows 7, will run

as a virtual machine on a physical server with other virtual desktops. The processing of multiple virtual desktops occurs on one or a few physical servers, typically at the centralized data center. The copy of the OS and applications that each end user utilizes will typically be cached in memory as one image on the physical server. In today's VDI marketplace, there are two dominate vendors, VMware Horizon View and Citrix Xen Desktop, are the leader in the desktop virtualization marketplace. End users can take advantage of virtualization by remotely accessing their own computer's resources and applications (their *desktop*), as well as applications, such as word processing, spreadsheet, e-mail, or calendar. Virtualization can even replace the traditional desktop computer with a smaller, less power device.

Application Virtualization

Application virtualization uses software to package an application into a "single executable and run anywhere" type of application. The software application is separated from the operating system and runs in what is referred to as a "sandbox." Virtualizing the application allows things like the registry and configuration changes to appear to run in the underlying operating system, although they really are running in the sandbox. There are two types of application virtualization: remote and streaming of the application.

A remote application will run on a server, and the client uses some type of remote display protocol to communicate back to the client machine. Since a large number of system administrators and users have experience running remotely, it can be fairly easy to set up remote displays for applications.

With a streaming application, you can run one copy of the application on the server, and then have many client desktops access and run the streaming application locally. By streaming the application, the upgrade process is easier, since you just set up another streaming application with the new version and have the end users point to the new version of the application. Some of the application virtualization products in the marketplace are Citrix XenApp, Novell ZENworks Application Virtualization, and VMware ThinApp,

Server Virtualization

Server virtualization allows for many virtual machines to run on one physical server. The virtual servers share the resources of the physical server, which leads to better utilization of the physical servers resources. The resources that the virtual machines share are CPU, memory, storage, and networking. All of these resources are provided to the virtual machines through the hypervisor of the physical server. The hypervisor is the operating system and

software that operate on the physical box. Each virtual machine runs independently of the other virtual machines on the same box. The virtual machines can have different operating systems and are isolated from each other. The server virtualization offers a way to consolidate applications that used to run on individual physical servers, and now with the hypervisor software runs on the same physical server represented by virtual machines. Server virtualization is what most people think of when they think of virtualization, due to VMware's vSphere, which has a large percentage of the marketplace. In addition, some of the other vendors are, Citrix XenServer, Microsoft's Hyper-V, and Red Hat's Enterprise Virtualization.

Storage Virtualization

Storage virtualization is the process of grouping physical storage using software to represent what appears to be a single storage device in a virtual format. Correlations can be made between storage virtualization and traditional virtual machines, since both take physical hardware and resources and abstract access to them. There is a difference between a traditional virtual machine and a virtual storage. The virtual machine is a set of files, while virtual storage typically runs in memory on the storage controller that is created using software.

A form of storage virtualization has been incorporated into storage features for many years. Features such as Snapshots and RAID take physical disks and present them in a virtual format. The storage array vendors have implemented storage virtualization within the operating system of their respective arrays. This type of storage virtualization is called internal storage virtualization. In addition, there is external storage virtualization that is implemented by Veritas and many other storage vendors.

Network Virtualization

Network virtualization is using software to perform network functionality by decoupling the virtual networks from the underlying network hardware. Once you start using network virtualization, the physical network is only used for packet forwarding, so all of the management is done using the virtual or software-based switches. When VMware' ESX server grew in popularity, it included a virtual switch that allowed enough network management and data transfer to happen inside of the ESX host. This paradigm shift caught the eye of Cisco, so when VMware was upgrading to vSphere 4.0, Cisco helped to write the code for VMware's new Distributed Switch. This helped Cisco learn how to work and design

network virtualization, and an internal movement was started to write all of the Cisco switches to be software-based administrative entities.

virtual infrastructure and its requirements

a virtual infrastructure is one in which servers, storage, and maybe even desktops use some form of virtual technology to provide services, is surprisingly easy. As with any IT strategy, building a virtual infrastructure requires

1-**A thorough understanding of the current infrastructure's architecture:** What applications run on which servers, end user usage patterns, and so on

2- **A formal plan to implement virtualization:** Including costs and benefits, a plan to test virtual servers before putting them in production, and making sure that staff is trained to implement and maintain the infrastructure.

3-Application requirements

To building a virtual infrastructure we have to know which applications run on which servers. We must understand every application's requirements for memory and disk usage. For example, database applications are highly transactional — they read and write records almost constantly. Applications like these require the fastest server and the fastest, most available storage for maximum performance.

4-Identifying under used servers

Servers that are only lightly used are another likely target for application consolidation. Some applications require that storage space be allocated in advance. These servers become good candidates for virtualization because the virtual machine's resources can be dynamically allocated to allow for increasing application requirements.

5-Building virtual machines:- Power VM virtualizes processor and I/O resources for client partitions enabling increased asset utilization, enhanced infrastructure flexibility and reduced costs.

Thin Client and its usages

A thin client is a computing device that's connected to a network. a thin client functions as a virtual desktop, using the computing power residing on networked servers. The thin client can't run applications or store data or documents on its own; it functions as an interface to

convey your keystrokes and connect to the applications, documents, data and storage on networked servers, where the actual work is done.

Most thin clients run Web browsers and/or remote desktop software, such as Microsoft Terminal Services or Citrix XenApp

With thin clients, you run the desktop environment on the server, and remotely display the desktop screens on the thin clients. You need to manage this on the server side with what's called a virtual desktop infrastructure (VDI) — software that creates the desktop images, stores them on servers and sends them over the network to the thin clients.

usage of thin client

Because they lack hard drives, CD-ROM drives, fans and other moving parts, thin clients are smaller, cheaper and simpler for manufacturers to build than traditional PCs or notebooks—and cheaper for you to buy.

Thin clients decrease client maintenance costs and hassles. With fewer moving parts, and very little software running on the device, fewer things can go wrong with a thin client, so they're easier to maintain and fix. If a thin client does fail, you can easily swap in a replacement without losing productivity because employees don't store any data on their client device.

Since everything is managed, stored and secured centrally, from the data center, thin clients eliminate the issues of installing, updating and patching applications, backing up files, or scanning for viruses on individual computers. Because employees see and have access only to what they need to do their job, thin clients are easier for non-technical people to use.

Centralized management also provides security benefits. You're not storing any data or information on the thin client, so you don't need to worry about exposing confidential data if a thin client gets lost or stolen.

Thin clients also use less energy than standard desktops and notebooks. Because they run cooler, they can help reduce air conditioning requirements as well.

Companies have traditionally turned to thin clients to give employees access to certain applications and functions, such as in a call center or retail setting via remote desktop

software. Thin clients are also a good fit for remote offices, where it can be difficult and time consuming to get PCs fixed.

Collaboration tool and types of Collaboration tool to make information technology green.

A **collaboration tool** helps people to collaborate. The purpose of a collaboration tool is to support a group of two or more individuals to accomplish a common goal or objective. They can also include software tools and applications such as collaborative software.

E-Mail

The invention of email as a collaboration tool changed the way we used to communicate in the workplace. It is the easiest method to make contact within an organization and is well established. Especially for organizing daily correspondence, email can reach various people with just one click.

Although email is still the most common used tool in communication collaboration it is not very efficient on a big scale and other forms of communication seem to take over. Besides its flexibility it is not very good for group conversations as they grow too fast. There is no way to be sure that a person has the latest version of a document that has been sent to them and it is impossible to always track via their email what tasks need to be done and by which deadline.

> Voicemail A **voicemail** system is a computer-based system that allows users and subscribers to exchange personal voice messages; to select and deliver voice information; and to process transactions relating to individuals, organizations, products, and services, using an ordinary phone. The term is also used more broadly to denote any system of conveying a stored telecommunications voice messages, including using an answering machine. Most cell phone services offer voicemail as a basic feature; many corporate private branch exchanges include versatile internal voice-messaging services.

Voicemail as a collaboration tool is more and more integrated in services such as **Google Voice**. As pointed out in an IBM future scenario the role of voicemail could be that of what email is for us today.

Instant messaging (IM) technology is a type of online chat that offers real-time text transmission over the Internet. A LAN messenger operates in a similar way over a local area

network. Short messages are typically transmitted between two parties, when each user chooses to complete a thought and select "send". Some IM applications can use push technology to provide real-time text, which transmits messages character by character, as they are composed. More advanced instant messaging can add file transfer, clickable hyperlinks, Voice over IP, or video chat.

VoIP (voice over IP)

Voice over Internet Protocol (VoIP), also called IP telephony, is a method and group of technologies for the delivery of voice communications and multimedia sessions over Internet Protocol (IP) networks, such as the Internet. The terms Internet telephony, broadband telephony, and broadband phone service specifically refer to the provisioning of communications services over the public Internet, rather than via the public switched telephone network (PSTN), also known as plain old telephone service (POTS).

Voice over IP as a collaboration tool has quickly gained popularity among companies and is part of their communication portfolio. the VoIP is moving towards the state to totally replace our telephones in our offices and also integrate in existing collaboration service environments.

Paperless Office **and the advantages of Paperless office.**

A paperless office is a concept in which usage of paper is greatly reduced or eliminated totally in a office environment.
This is achieved by converting document into digital form. a paperless office is not only environmentally friendly, but also helps in boosting the productivity and efficiency of an office while also saving money and making work processes easier and more convenient as digital documents can be easily shared between users.

Advantages of Paperless office:

- Documents can be found and retrieved with ease using paperless office. This can save a significant amount of time during the work day.
- The same document can be duplicated, faxed, manipulated or combined at the same time.
- The paperless office helps multiple users to access the same document at the same time with more ease and convenience.
- With respect to storage and space involved, the paperless office provides bigger and more efficient storage. Large amounts of documents can be stored in a single computer. Bulky file cabinets can be eliminated.
- A document can be retrieved without having to move physically from one location in the office to another.
- There are greater communication capabilities involved, particularly with employees working in different locations.

Benefits of Going Paperless.

Saves Time

Time spent filing, organizing, and searching for paper documents is time that could be spent on more productive tasks. Digitized documents are stored in a central repository, which is basically a well-organized digital filing cabinet where all of your documents live.

Using a digital document management system, you'll get to harness the same powerful search abilities that you're used to using on Google. This means employees can find files at the click of a button, much more quickly than the laborious, manual process of searching for a specific file in a buried folder. **Employees are able to use this extra time on revenue-generating projects.**

Saves Space

Paper takes up a lot of space – as do filing cabinets and space to store those filing cabinets. Books and bookshelves are bulky, too. What's worse, paper keeps piling up, oftentimes accumulating more quickly than it can be sorted and organized. This is particularly true of industries that have long mandatory retention periods for paperwork like the financial industry.

Digitizing files allows you to store all documents either on an on-premises server or in the cloud. Digital file folders in a repository require much less space than a physical records archive.

Saves Money

Going digital improves process efficiency, saving you money. Paperless offices can process a much larger volume of paper work compared to traditional offices in the same amount of time.

Further, digitization reduces money spent on paper, printers, ink, postage, office space for files and employee time to manage paperwork. The savings on employee time become especially valuable in regards to regulatory audits and repetitive, high-volume tasks like expense reimbursements.

Eases Transfer of Information

Document management software offers a simple process for saving documents. The software easily compiles digital documents using scanners, mobile capture using a camera on a phone or tablet or importing any file type (.docx, .pdf, image files). Many commonly used applications, like Microsoft Office and Adobe Acrobat, integrate with document management systems and have native plugins which allow you to file your document into your content management system with just one click.

Promotes the Environment

Manufacturing paper products produce greenhouse gases, causing deforestation and global warming. Recycling can offset some of the environmental impact, but not by much. Most paper eventually ends up in a landfill. Further, ink and toners contain volatile compounds and non-renewable substances which are damaging to the environment. It is much more sustainable to simply reduce paper use altogether by switching to a paperless office.

Boosts Security

Physical documents are hard to track – reams of paper can get lost, misfiled or destroyed without anyone noticing. It can also be difficult to monitor the access, printing and copying of sensitive files. Document management software has advanced security capabilities that can

tackle these challenges. System administrators can set-up granular access rights, which assign permissions at the document level (e.g. settings based on the type of document), user level (e.g. settings based on person's job function), or system level (e.g. overarching security for all data in the system).

powering gadgets to consume less energy.

The amount of energy consumed by different kinds of electronic devices varies widely, and ways to reduce their energy use vary widely too, and some of them are as follows-

Notebook Computers Strategies that help in reducing their power consumption include the following:

1. Reduce the brightness of the monitor to an appropriate level. A brighter screen consumes more energy.
2. When some background task is running on the computer and there is no need to use the monitor during this time, switch off the monitor instead of using screen savers as screen savers also consume some energy.
3. Most computer operating systems provide power-saving profiles which, when enabled, reduce the amount of energy consumed by the computer.

Mobile Devices:- These devices are small in size and are powered by a small rechargeable battery. These devices are produced in large numbers and are designed for operation with low power consumption.

chargers should be switched off or unplugged when they are not charging, or disconnected from mobile devices. Awareness needs to be created among users to switch off chargers when they are not needed.

The Advantages of LED Lights for the Environment.

Most of us are already aware of environmentally friendly processes such as recycling to minimise the amount of waste we produce and reduce our carbon footprint. this is LED lighting, which provides many environmental advantages.

Energy Efficient

LED lights are up to 80% more efficient than traditional lighting such as fluorescent and incandescent lights. 95% of the energy in LEDs is converted into light and only 5% is wasted as heat. This is compared to fluorescent lights which convert 95% of energy to heat and only 5% into light! LED lights also draw much less power than traditional lighting; a typical 84

watt fluorescent can be replaced by a 36 watt LED to give the same level of light. Less energy use reduces the demand from power plants and decreases greenhouse gas emissions.

No Toxic Elements

LED lights contain no toxic elements. Most offices currently use fluorescent strip lights which contain noxious chemicals such as mercury. This will contaminate the environment when disposed of in landfill waste. Disposal has to be arranged through a registered waste carrier so switching to LED avoids the cost and time implications required for compliant disposal – and helps to protect the environment from further toxic waste.

Less Lights Needed

LEDs have a better quality of light distribution and focus light in one direction as opposed to other types of lighting which waste energy by emitting light in all directions, often illuminating areas where light isn't required (such as the ceiling). This means that less LED lights are needed to achieve the same level of brightness given off by fluorescents and incandescent lights. Fewer lights will reduce energy consumption and will therefore be a benefit to the environment.

Life span

A longer life span means lower carbon emissions. LED Lights last up to six times longer than other types of lights, reducing the requirement for frequent replacements. This results in using fewer lights and hence fewer resources are needed for manufacturing processes, packaging materials and transportation.

Renewable energies and its types And their use in organisations.

Renewable energies are sources of clean, inexhaustible and increasingly competitive energy. They differ from fossil fuels principally in their diversity, abundance and potential for use anywhere on the planet, but above all in that they produce neither greenhouse gases – which cause climate change – nor polluting emissions. Their costs are also falling and at a sustainable rate, whereas the general cost trend for fossil fuels is in the opposite direction in spite of their present volatility.

Growth in clean energies is unstoppable, as reflected in statistics produced in 2015 by the International Energy Agency (IEA)

TYPES OF RENEWABLE ENERGY

Renewable energies include:

Wind energy: the energy obtained from the wind

Solar energy: the energy obtained from the sun. The main technologies here are solar photovoltaic (using the light from the sun) and solar thermal (using the sun's heat)

Hydraulic or hydroelectric energy: energy obtained from rivers and other freshwater currents

Biomass and biogas: energy extracted from organic material

Geothermal energy: heat energy from inside the Earth

Tidal energy: energy obtained from the tides

Wave energy: energy obtained from ocean waves

Bioethanol: organic fuel suitable for vehicles and obtained from fermentation of vegetation

Biodiesel: organic fuel for vehicles, among other applications, obtained from vegetable oils

Solar Panels

Solar panels can be used to collect solar energy and turn it into electricity, and more and more they are used in homes. In fact, you may already have a garden lantern that is powered by a solar panel. When used as a major power source, solar panels are often quite large and may be mounted on the roof of a home. The solar energy collected is converted to electricity and can be used and stored, as with purchased electricity. Solar panels can also be used to charge batteries and perform smaller electric tasks as well.

Wind

A windmill is typically attached to a generator that is powered by its rotation: When the wind blows, its force turns the windmill. Wind energy was first used not to produce electricity, but to perform repetitive mechanical tasks, such as pump water from wells or to grind grain. Today, windmills can be used for a variety of situations, including when a small amount of power is needed.

recycling and reusing process of IT equipments.

Give preference to manufacturers that have a take-back program for their equipment.

Buy equipment made from materials that are easier to recycle.

Label machines that are covered by a take-back program so when the time comes to dispose of it.

Look for equipment you can upgrade without replacing the entire mechanical assembly.

Consider leasing equipment. When you don't want it any more it goes back to the leasing company.

The best form of recycling is reuse. IT equipment typically has a three-to-five-year working life. Keeping equipment in service for even a year longer reduces — by as much as 33 percent — the environmental cost of manufacturing, transporting, and disposing of new hardware.

Older servers can be kept as standby units for use during periods of high demand.

Older desktop equipment can be handed down to users who don't need fast machines.

Desktop virtualization can greatly extend the service life of older computers as can the installation of Linux, which performs quite well on older PCs.
Offering equipment donations to a non profit group — school, library, job-training program, or other charity — that can use your old computers provides another way to extend their life.

the safe disposal policy adopted by the organisation.

Policy Statement

This information technology (IT) asset disposal policy is concerned with managing the secure disposal of equipment owned by the organisation but no longer required.
IT equipment such as computers, tablet computers, mobile phones and digital storage devices are vital and valuable assets to any modern organisation. IT equipment, for example, is used in most modern administrative processes which involve creating or handling information, some of which may be confidential and sensitive to individuals or to the organisation.

The disposal of such equipment, due to its need for replacement or upgrade, or merely because it has become obsolete, surplus or redundant, is an issue because:

IT equipment may contain data or information that must be protected

the equipment represents an asset value

the equipment may be reused or recycled

the equipment must be disposed of safely according to the law and in an environmentally sustainable way.

This organisation aims to ensure that all of its IT equipment is managed effectively, including its disposal. The organisation understands that responsible IT asset management and disposal is essential for compliance with the Data Protection Act 2018.

Procedures

In organisation:

this policy relates to technological equipment that can record or hold data, including:

PCs

laptops

tablets

mobile phones

multi-functional devices — printers/scanners

servers

fax machines

USB memory sticks and external hard drives

managers should identify all such devices and ensure that these are recorded in an asset register

all IT equipment which has been purchased by the organisation must be recorded on the register and have an asset tag assigned to it; where practical, the asset tag will be physically visible on the equipment stipulating that it is the property of the organisation; asset numbers should be recorded in the asset register

the asset register should be used to record not only purchase and value information, but also the form used and date of disposal

all IT equipment that is identified for disposal should be accompanied by an Equipment Disposal Verification Form and an entry included in the asset register

any IT equipment that has the potential to store sensitive data and which is no longer needed or has reached its "end of life" must have its data securely deleted/wiped and sensitive data deemed unreadable and unrecoverable before:
redistribution or reuse within the organisation decommissioning and disposal all such equipment should be processed by a registered and approved contractor to securely remove any personal data when agreeing a contract with a professional equipment disposal service, the management of the home should obtain clear evidence of sufficient data security arrangements, including a written statement regarding confidentiality, destruction methods, and indemnity should the contractor fail to adequately destroy information; companies should comply with the ISO 27001:2013 IT Asset Disposal Standard
IT and data equipment should not leave the organisation's premises unless a chain of custody is established relating to the data contained within the device; this means establishing who is responsible for deleting the personal data contained on them
deleting visible files, emptying files from the "Recycle Bin" of a computer or reformatting a drive are not considered a sufficiently secure method of wiping equipment, as data recovery software could be used by a new owner to "undelete" files or "unformat" a drive
in the event that IT assets containing sensitive information are no longer needed by the care service and cannot be securely wiped, the equipment may need to be physically destroyed
in all cases, the Equipment Disposal Verification Form should be completed and signed and kept with the asset register redundant IT equipment should not be donated to charities/schools, etc managers should ensure that any equipment that is leased has a data destruction clause written into the contract. Under such an arrangement, the supplier will ensure that data is wiped when it is returned.

Responsibilities

Staff and managers in the organisation are responsible for compliance with this policy. They are responsible for all IT equipment being appropriately data cleansed before disposal, and then for the appropriate destruction or disposal of equipment in compliance with waste regulations.
All managers and staff have responsibilities under the Data Protection Act 2018 to have appropriate security in place to prevent personal data held from being accidently or deliberately compromised. This is relevant in the IT asset destruction and recycling processes.