S3 - Sustainable Engineering

Module 1

SUSTAINABILITY- INTRODUCTION

The concept of sustainability become so important nowadays, because of the irreparable damage caused to the environment by industrial civilization & consumerism, which originated about 3 centuries ago. They were based on the following wrong assumptions:

- The earth belongs to humans only
- Ignore the fact that humans are part of the Earth's biosphere
- Earth's stock of resources are infinite
- The environment can bear any amount of damage that is caused by human activity.

The advantages & disadvantages of industrial civilization & consumerism are listed below:-

Advantages

1. Flourished the economy
2. Improved the living quality of the society

Disadvantages

1. Caused irreparable damage to the environment
2. Pose a threat to the life support systems of the earth.
3. E.g.1.The hole in the ozone layer surrounding our planet as a shield against the dangerous ultraviolet radiation from the sun
4. E.g.2. Increased carbon dioxide content and greenhouse gases in the atmosphere that causes global warming

Several warnings concerning the instability of Earth's life support systems have been raised in recent times. In 1992, some of the world's senior scientists from 70 countries, signed and sent an urgent warning "The environment is suffering critical stress..." to the government leaders of all nations as part of the United Nations Conference on Environment and Development (the "Earth Summit") held in Rio de Janeiro, Brazil. This marked the beginning of the concept of sustainability.

Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permits fulfilling the requirements of present and future generations. Sustainability is important to make sure that we have and will continue to have, the water, materials, and resources to protect

human health and our environment.

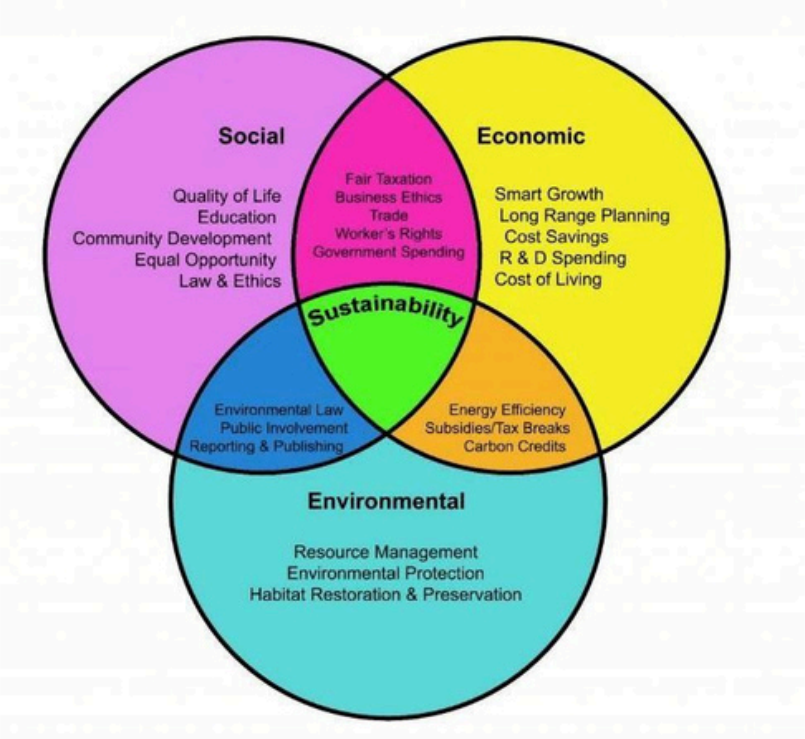
SUSTAINABILITY- DEFINITION

Sustainability is the ability to achieve continuing economic prosperity while protecting the natural systems of the planet and providing a high quality of life for its people.

SUSTAINABILITY- NEED & CONCEPT

Sustainability has three components, which are inter-related, as shown in Fig.1:

1. Environment
2. Society
3. Economy



The environmentgives resources, raw materials to the Economy for production activities. The economy creates products and sells them to society for use. Production by Economy Consumption by Society leads to the following environmental impacts.

1. Exhaustion of Resources – Water, Petroleum, Forests **2. Loss of Biodiversity** - Extinction of Animal/Plant Species due to Water, Soil, Air Pollution **3. Deforestation** - conversion of forestland to farms, urban use, etc.

4. Ozone Depletion - reduction of the amount of ozone in the stratosphere due to the emission of chlorofluorocarbons (CFCs). CFC/s emitted from the industries, rises to the Stratosphere. Sunlight breaks CFCs to release Chlorine. Chlorine reacts with Ozone and destroys it.

5. Acid Deposition – results in acid rain, acid fog, and acid mist.

6. Desertification - a type of land degradation in which a land region becomes dry, typically

losing its water bodies, vegetation, and wildlife.

7. Eutrophication - a form of water pollution that occurs when excessive fertilizers run into lakes

and rivers. This encourages the overgrowth of algae and other aquatic plants.

8. Global Warming - a gradual increase in the average temperature of the Earth's atmosphere and

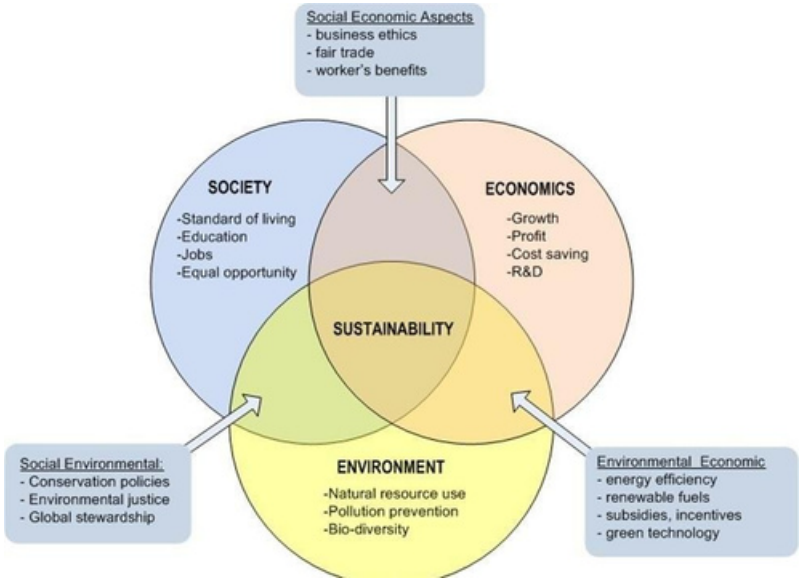
its oceans, caused by increasing concentrations of greenhouse gases – Carbon oxides,

Nitrous oxides, sulfur oxides, Fluorocarbons

The environmental impact, caused by the economy on production and society on consumption, leads to the following damages to human life.

1. Freshwater scarcity
2. Climate change
3. Exposure to toxins in food, air, water, and soil
4. Emerging diseases
5. Food insecurity resulting in poverty
6. Energy scarcity due to depletion of non-renewable resources
7. Ecosystem damage and habitat loss due to pollutant discharges
8. Sea level rise

The need for sustainability is to reduce these damages and create livable planet earth for future generations. For this, United Nations presented the following key sustainability concepts:- Intergenerational equity – Expects the present generation to hand over a safe, healthy, and resourceful environment to the future generation. Intra-generational equity – Emphasize the technological development should support the economic growth of the poorer section, so as to reduce the gap between nations. Sustainability means balancing the environment, society, and economy.



SOCIAL- ENVIRONMENTAL AND ECONOMIC SUSTAINABILITY CONCEPTS

The concept of sustainability is based on the basis that people and their communities are made up of social, economic, and environmental systems that are in constant interaction and that must be kept in harmony.

SOCIAL SUSTAINABILITY

There are six principles of sustainability that can help a community ensure that its social, economic, and environmental systems are well integrated and will endure. A community or society that wants to pursue sustainability will try to:

1. Maintain residents' quality of life.

Quality of life has many components: income, education, health care, housing, employment, legal rights. Each locality must define and plan for the quality of life it wants and believes it can achieve, for now, and for future generations.

2. Enhance local economic vitality.

A viable local economy is essential to sustainability. This includes job opportunities, a sufficient tax base and revenue to support the government and the provision of infrastructure and services, and a suitable business climate.

3. Promote social and intergenerational equity.

A sustainable community's resources and opportunities are available to everyone, regardless of ethnicity, age, gender, cultural background, religion, or other characteristics. Further, a sustainable community does not deplete its resources and destroy natural systems.

4. Maintain the quality of the environment.

A sustainable community tries to find ways to co-exist with the natural environment and ecosystem. It avoids unnecessary degradation of the air, oceans, freshwater, and other natural systems.

5. Incorporate disaster resilience and mitigation into its decisions and actions.

A community is resilient in the face of inevitable natural disasters like tornadoes, hurricanes, earthquakes, floods, and drought if it takes steps to ensure that such events cause as little damage as possible.

6. Use a consensus-building, participatory process when making decisions.

Participatory processes are vital to community sustainability... It encourages the identification of concerns and issues, promotes the wide generation of ideas for dealing with those concerns, and helps those involved find a way to reach an agreement about solutions.

ENVIRONMENTAL SUSTAINABILITY

Environmental sustainability requires:

1. Maintenance of biodiversity (genes, species, and ecosystems)
2. Protection of natural capital (air, water, soils, etc)
3. Maintenance of the energy and material cycles of the planet
4. Health and resilience of all life support systems.

This can be achieved by:

1. Reduce dependence upon finite, virgin resources like Fossil fuels, minerals, and metals
2. Nature must not be subjected to increased concentrations of substances produced by society. This requires that consideration be given to the biodegradability of substances and the length of time it takes the earth to reabsorb them.
3. The physical basis for the productivity and biodiversity of nature must be not systematically degraded. This requires that we protect diverse and special habitats.
4. There must be efficient use and fair distribution of resources to enable humans to meet their needs. This requires a reduction in consumerism, especially among wealthy nations.

ECONOMIC SUSTAINABILITY

Economic sustainability ensures that the industry or business is making a profit without creating much damage to the environment/ecology. Economic growth is expressed in terms of Gross Domestic Product (GDP). This is the total amount of products produced within a nation, within one year. Economic growth has to be sustainable if it improves the quality of human life. Thus population factors must be included to ensure fair resource consumption.

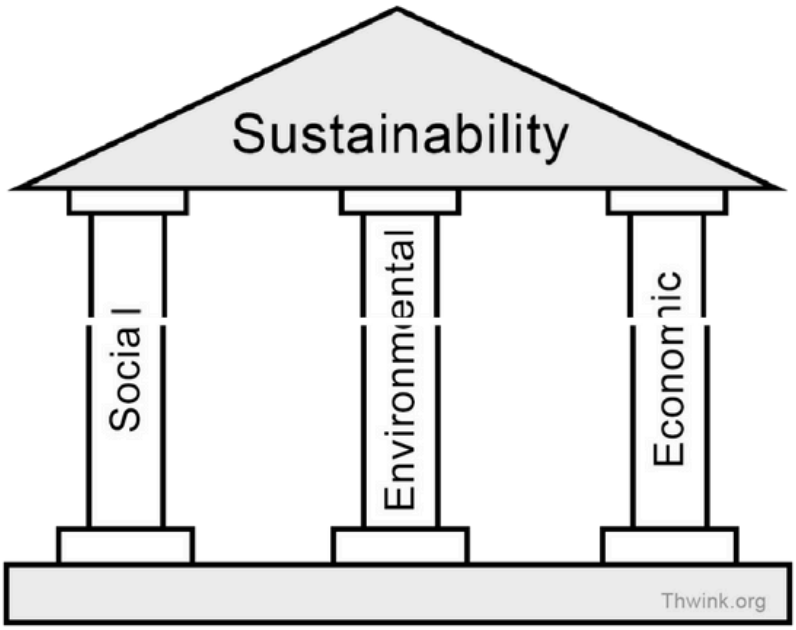
ECONOMIC-SOCIAL AND ENVIRONMENTAL MATRIX

Quality of Life Concerns	Economic Issue		Social Issue		Environmental Issue	
	Unsustainable	Sustainable	Unsustainable	Sustainable	Unsustainable	Sustainable
Water	High cost of drinking water	Drinking water availability at low cost	Access to drinking water denied to weaker section	Adequate water supply to all sections	High-level of pollution in lakes and rivers	Conservation of existing fresh water bodies
Food	High cost of food and use of fertilizers and pesticides in farming	Good food available at low cost	Access to good food denied to weaker section	Adequate access to good food to all sections	Overuse of fertilizers and pesticides pollute the environment. Deforestation - conversion of forestland to farms	Food is of nutritious quality and related diseases are lowered.
Energy	High cost and intermittent power supply	Electricity available at low cost	Overuse of energy by the rich society and inadequate energy distribution	Adequate energy available to all sections	Use of fossil fuels and pollution	Use of renewable resources.(solar, wind, biomass)

SUSTAINABLE DEVELOPMENT

The concept of sustainable development has received much recognition after the Stockholm declaration in the year 1972. Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (Definition proposed by the Brundtland Commission in 1987 in their report “Our Common Future”).

The three pillars of sustainable development are environment, society, and economy



Sustainable development should have the following features:-

1. Satisfying human needs
2. Favouring a good quality of life through decent standards of living
3. Sharing resources between rich and poor
4. Acting with concern for future generations
5. Looking at the 'cradle-to-grave' impact when consuming
6. Minimizing resource use, waste, and pollution

MEASURES OF SUSTAINABLE DEVELOPMENT

The following are the measures of sustainability development:-

(i) Technology:

Using appropriate technology is one that is locally adaptable, eco-friendly, cost-effective, resource-e몫cient, and culturally suitable. Nature is often taken as a model, using the natural conditions of that region as its components. This concept is known as "design with nature".

(ii) Reduce, Reuse, and Recycle Approach:

The 3-R approach advocating minimization of resource use, using them again, and recycling the materials. It reduces pressure on our resources as well as reduces waste generation and pollution.

(iii) Promoting Environmental Education and Awareness:

Making environmental education the center of all learning processes will greatly help in changing the thinking pattern and attitude of people towards our earth and the environment.

(iv) Resource Utilization as Per Carrying Capacity:

Any system can sustain a limited number of organisms on a long-term basis which is known as its carrying capacity. If the carrying capacity of a system is crossed (say, by overexploitation of a resource), environmental degradation starts.

(v) Improving Quality of Life Including Social, Cultural and Economic Dimensions:

Development should not focus just on one section of already afluent people. Rather it should include sharing of benefits between the rich and the poor. The tribal, ethnic people and their cultural heritage should also be conserved.

NEXUS BETWEEN TECHNOLOGY AND SUSTAINABLE DEVELOPMENT

Technology is the offspring of science. Technological innovation can be seen as a 'double-edged sword, with respect to sustainable development.

1. Technology improves the quality of life, eliminate diseases, and increase life expectancy

2. On the other hand, technology creates irreparable environmental damage due to resource

   extraction and pollution of air, water, soil.

As technology advances, environmental degradation accelerates exponentially. Also, the benefits of technological innovations are mostly enjoyed by the developed countries. Technology remains a dream for underdeveloped countries which still face poverty, inadequate sanitation facilities, etc. Hence it is essential to integrate technology, society into sustainability.
Technology can support sustainability by

1. Conserving natural capital (renewable and nonrenewable resources)
2. Reducing waste and pollution
3. Raising efficiency standards
4. Finding substitutes for toxic/hazardous materials

Pollution prevention and cleaner production technologies are more cost-effective than the end of pipe waste treatment technology. Some of the technological applications towards sustainable development in various sectors are given below.

1. SUSTAINABLE AGRICULTURAL TECHNOLOGY

Sustainable agriculture integrates three main goals-environmental health, economic profitability, and social and economic equity. Some of the common ways towards sustainable agriculture are:

a) Integrated Pest Management (IPM)
b) Rotational Grazing
c) Soil conservation
d) Water quality/wetlands
e) Cover crops
f) Crop/ landscape diversity
g) Nutrient management
h) Agro-forestry

2. SUSTAINABLE ENERGY

Sustainable energy is the energy that, in its production or consumption, has minimal negative impacts on human health and the healthy functioning of vital ecological systems, including the global environment. This can be achieved by using the following:

a. Renewable energy sources

- Solar
- Biomass (It is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the timber industry, agricultural crops, raw material from the forest, major parts of household waste, and wood.)
- Wind
- Tide
- geothermal Heat

b. Energy-efficient systems - upgrading the efficiency of the existing equipment, reduction of energy loss, saving of fuel, and optimization of its operating conditions and service life provide an ecologically safe strategy.

MILLENNIUM DEVELOPMENT GOALS (MDGs)

The United Nations Millennium Development Goals are eight goals that all 191 UN member states have agreed to try to achieve by the year 2015. The United Nations Millennium Declaration, signed in September 2000 commits world leaders to combat poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women. The MDGs are derived from this Declaration, and all have specific targets and indicators.

The Eight Millennium Development Goals are :

4.1. To eradicate extreme poverty and hunger;
4.2. To achieve universal primary education;
4.3. To promote gender equality and empower women;
4.4. To reduce child mortality;
4.5. To improve maternal health;
4.6. To combat HIV/AIDS, malaria, and other diseases;
4.7. To ensure environmental sustainability; and
4.8. To develop a global partnership for the development

The MDGs are interdependent; all the MDG influence health, and health influences all the MDGs. For example, better health enables children to learn and adults to earn. Gender equality is essential to the achievement of better health. Reducing poverty, hunger and environmental degradation positively influences, but also depends on, better health.

SUSTAINABLE DEVELOPMENT GOALS (SDGs)

Recently, the international community decided to adopt a new set of development goals focusing on improving the sustainability of nation-states. The need for a new set of targets was developed

at the Rio +20 Conference, held in Rio de Janeiro, in June 2012. The Sustainable Development Goals (SDGs) build on the achievements of the Millennium Development Goals. As mentioned, in a press release, by Wu Hongbo, the UN Under-Secretary-General for Economic and Social Affairs.

Sustainable development goals that build on the successes of the Millennium Development Goals, and that apply to all countries, can provide a tremendous boost to efforts to implement sustainable development and help us address issues ranging from reducing poverty and creating jobs to the pressing issues of meeting economic, social and environmental aspirations of all people.

The 17 sustainable development goals (SDGs) to transform our world:

GOAL 1: No Poverty
GOAL 2: Zero Hunger
GOAL 3: Good Health and Well-being
GOAL 4: Quality Education
GOAL 5: Gender Equality
GOAL 6: Clean Water and Sanitation
GOAL 7: Affordable and Clean Energy
GOAL 8: Decent Work and Economic Growth
GOAL 9: Industry, Innovation, and Infrastructure
GOAL 10: Reduced Inequality
GOAL 11: Sustainable Cities and Communities
GOAL 12: Responsible Consumption and Production
GOAL 13: Climate Action
GOAL 14: Life Below Water
GOAL 15: Life on Land
GOAL 16: Peace and Justice Strong Institutions
GOAL 17: Partnerships to Achieve the Goal

CLEAN DEVELOPMENT MECHANISM (CDM)

The Clean Development Mechanism is regarded as one of the most important internationally implemented market-based mechanisms to reduce carbon emissions. Created under the Kyoto Protocol, the CDM was designed to help developed nations meet domestic greenhouse gas (GHG) reduction commitments by investing in low-cost emission reduction projects in developing countries.

The Clean Development Mechanism (CDM), established under the Kyoto Protocol, is the primary international offset program in existence today. It generates offset through investments in GHG reduction and avoidance projects in developing countries. These offset credits, called Certified

Emission
Reduction credits (CERs), represent a reduction in one metric ton of carbon dioxide (CO_2) emitted to the atmosphere. Developed countries can use CERs to more cost-effectively achieve their

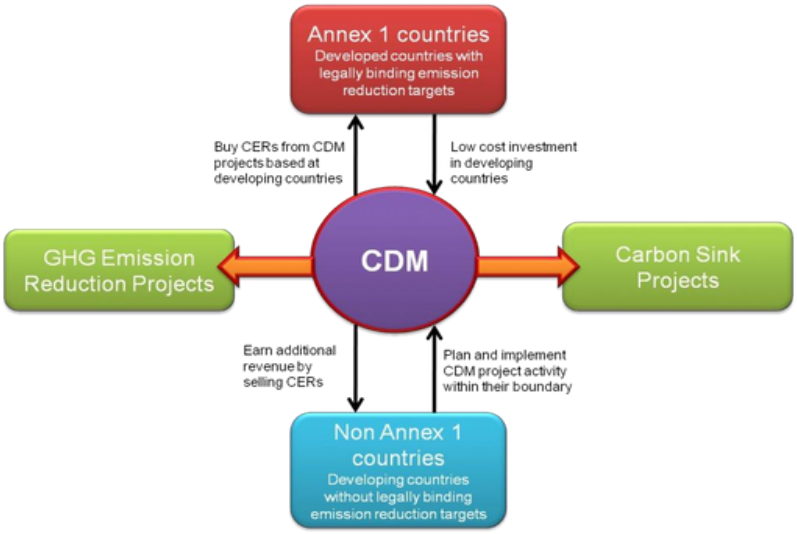
Kyoto
Protocol GHG emission reduction targets.

The stated purpose of the Clean Development Mechanism is to help developing countries achieve sustainable development, and assist industrialized countries in complying with their emission reduction commitments.

PURPOSE OF CLEAN DEVELOPMENT MECHANISM

Private companies fund projects in developing countries that reduce greenhouse gas emissions. They must also meet sustainable development criteria and the “additionality” requirement, which means the emission reductions made, must be “additional” to what would have been possible without CDM funding. Upon verification, the CDM awards these projects certified emission reductions (CERs), each equivalent to one ton of carbon dioxide. CERs are then sold to developed countries, which use them to meet a part of their reduction commitments under the Kyoto Protocol. CERs are also called “offset credits” because they “offset” the developed countries’ emissions with reductions in developing countries.

CDM allows countries to continue emitting greenhouse gases, so long as they pay for reductions
made elsewhere. The justification for this is based on the premise that it would be far more expensive to implement emission reduction in industrialized countries than in developing countries. It would help developing countries to gain sustainable development benefits from the
entry of “clean” and more energy-efficient technologies.



SUSTAINABLE ENGINEERING

Module 2

Air Pollution

Air pollution is the presence of substances in the atmosphere that are harmful to the health of humans and other living beings or cause damage to the climate or to materials. There are different types of air pollutants, such as gases, particulates, and biological molecules.

Types of Pollutants

In order to understand the causes of Air pollution, several divisions can be made. Primarily air pollutants can be caused by primary sources or secondary sources. The pollutants that are a direct result of the process can be called primary pollutants. A classic example of a primary pollutant would be the sulfur dioxide Emission from factories Secondary pollutants are the ones that are caused by the intermingling and reactions of primary pollutants. Smog created by the interactions of several primary pollutants is known to be a secondary pollutant.

Causes of Air pollution

Burning of Fossil Fuels: Sulfur dioxide emitted from the combustion of fossil fuels like coal, petroleum and other factory combustibles is one of the major causes of air pollution. Pollution emitting from vehicles including trucks, jeeps, cars, trains, airplanes cause an immense amount of pollution. We rely on them to fulfill our daily basic needs of transportation. But their overuse is killing our environment as dangerous gases are polluting the environment. Carbon Monoxide caused by improper or incomplete combustion and generally emitted from vehicles is another major pollutant along with Nitrogen Oxides, which is produced from both natural and man-made processes.

Agricultural activities: Ammonia is a very common by-product of agriculture-related activities and is one of the most hazardous gases in the atmosphere. The use of insecticides, pesticides, and fertilizers in agricultural activities has grown quite a lot. They emit harmful chemicals into the air and can also cause water pollution.

Exhaust from factories and industries: Manufacturing industries release a large amount of carbon monoxide, hydrocarbons, organic compounds, and chemicals into the air thereby depleting the quality of air. Manufacturing industries can be found at every corner of the earth and there is no area that has not been affected by it.
Petroleum refineries also release hydrocarbons and various other chemicals that pollute the air and also cause land pollution.

Mining operations: Mining is a process wherein minerals below the earth are extracted using large equipment. During the process dust and chemicals are released in the air causing massive air pollution. This is one of the reasons which is responsible for the deteriorating health conditions of workers and nearby residents.

Indoor air pollution: Household cleaning products, painting supplies emit toxic chemicals in the air and cause air pollution. Suspended particulate matter popular by its acronym SPM, is another cause of pollution. Referring to the particles afloat in the air, SPM is usually caused by dust, combustion etc.

Effects of Air pollution

Respiratory and heart problems: The effects of Air pollution are alarming. They are known to create several respiratory and heart conditions along with Cancer, among other threats to the body. Several million are known to have died due to direct or indirect effects of Air pollution. Children in areas exposed to air pollutants are said to commonly suffer from pneumonia and asthma.

Global warming: Another direct effect is the immediate alterations that the world is witnessing due to Global warming. With increased temperatures worldwide, increase in sea levels and melting of ice
from colder regions and icebergs, displacement and loss of habitat have already signaled an impending
disaster if actions for preservation and normalization aren't undertaken soon.

Acid Rain: Harmful gases like nitrogen oxides and sulfur oxides are released into the atmosphere during the burning of fossil fuels. When it rains, the water droplets combine with these air pollutants,
become acidic, and then fall on the ground in the form of acid rain. Acid rain can cause great damage
to humans, animals, and crops.

Effect on Wildlife: Just like humans, animals also face some devastating effects of air pollution. Toxic
chemicals present in the air can force wildlife species to move to new places and change their habitat.
The toxic pollutants deposit over the surface of the water and can also affect aquatic organisms.

Depletion of the Ozone layer: Ozone exists in the earth's stratosphere and is responsible for protecting humans from harmful ultraviolet (UV) rays. Earth's ozone layer is depleting due to the presence of
chlorofluorocarbons, hydrochlorofluorocarbons in the atmosphere. A thin ozone layer allows the passage of harmful UV rays onto the earth and can cause skin and eye-related problems. UV rays also have the capability to affect crops

Methods to reduce Air Pollution

Use the public mode of transportation: Encourage people to use more and more public modes of
transportation to reduce pollution. Also, try to make use of carpooling. If you and your colleagues come
from the same locality and have the same timings you can use the same vehicle at a time to save energy and money.

Conserve energy: Switch off fans and lights when you are going out. A large number of fossil fuels

are
burnt to produce electricity. We can save the environment from degradation by reducing the number of
fossil fuels to be burned.

Understand the concept of Reduce, Reuse, and Recycle: Do not throw away items that are of no use.
In fact, reuse them for some other purpose or recycle them to produce new products. Emphasis on clean energy resources: clean energy technologies like solar, wind, and geothermal are utilized effectively these days. Governments of various countries have been providing grants to consumers who are interested in installing solar panels for their homes. This will go a long way to curb air pollution.

Use energy-efficient devices: CFL lights consume less electricity than their counterparts. They live longer, consume less electricity, lower electricity bills and also help you to reduce pollution by consuming less energy.

Monitor Air quality in industry periodically to identify irregularities in pollutants level in the air and keep pollutant level within limits.

Water Pollution

Water pollution is the contamination of water bodies (e.g., lakes, rivers, oceans, aquifers, and groundwater). This form of environmental degradation occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds.

SourcesofWaterPollution

There are various classifications of water pollution. The two chief sources of water pollution can be seen as Point and Non-Point. Point refers to the pollutants that belong to a single source. An example of this would be emissions from factories into the water. Non-Point on the other hand means pollutants emitted from multiple sources. Contaminated water after rains that has travelled through several regions may also be considered as a Nonpoint source of pollution.

CausesofWaterPollution

Industrial waste: Industries produce a huge amount of waste that contains toxic chemicals and pollutants which can cause air pollution and damage to us and our environment. They contain pollutants
such as lead, mercury, sulfur, nitrates, and many other harmful chemicals. Many industries do not have
a proper waste management system and drain the waste in the fresh water which goes into rivers, canals, and later into the sea. The toxic chemicals have the capability to change the color of water, increase the number of minerals, also known as Eutrophication, change the temperature of the water, and pose a serious hazard to water organisms.

Sewage and wastewater: The sewage and wastewater that is produced by each household are chemically treated and released into the sea with fresh water. The sewage water carries harmful

bacteria
and chemicals that can cause serious health problems. Pathogens are known as common water pollutants. Microorganisms in water are known to be causes of some very deadly diseases and become
the breeding grounds for other creatures that act as carriers. These carriers inflict these diseases via various forms of contact onto an individual. Eg:- Malaria.

Mining activities: Mining is the process of crushing rock and extracting coal and other minerals from underground. These elements when extracted in the raw form contain harmful chemicals and can
increase the number of toxic elements when mixed up with water which may result in health problems.
Mining activities emit many metal waste and sulfides from the rocks and get mixed with water.

Marine dumping: The garbage produce by each household in the form of paper, aluminum, rubber,
glass, plastic, food, etc are sometimes deposited into water bodies.. These items take 2 weeks to 200
years to decompose. When such items enter the sea, they not only cause water pollution but also harm
aquatic organisms.

Accidental Oil leakage: Oil spill pose a huge concern as a large amount of oil enters the sea and does not dissolve with water; thereby opens problem for local marine wildlife such as fish, birds, and sea otters. For e.g.: a ship carrying a large quantity of oil may spill oil if met with an accident and can cause varying damage to species in the ocean depending on the quantity of oil spill, size of the ocean, the toxicity of pollutant.

Burning of fossil fuels: Fossil fuels like coal and oil when burnt produce a substantial amount of ash in
the atmosphere. The particles which contain toxic chemicals when mixed with water vapor result in acid rain.

Chemical fertilizers and pesticides: Chemical fertilizers and pesticides are used by farmers to protect
crops from insects and bacterias. They are useful for the plant's growth. However, when these chemicals
are mixed up with water produce harmful for plants and animals. Also, when it rains, the chemicals
mix up with rainwater and slow down into rivers and canals which pose serious damages for aquatic animals.

Leakage from sewer lines: A small leakage from the sewer lines can contaminate the

underground
water and make it unfit for people to drink. Also, when not repaired on time, the leaking water can come onto the surface and become a breeding ground for insects and mosquitoes.

Radioactive waste: Nuclear energy is produced using nuclear fission or fusion. The element that is used in the production of nuclear energy is Uranium which is a highly toxic chemical. The nuclear waste that is produced by radioactive material needs to be disposed of to prevent any nuclear accident. Nuclear waste can have serious environmental hazards if not disposed of properly. Few major accidents have already taken place in Russia and Japan.

Urban development: As the population has grown, so has the demand for housing, food, and cloth. As more cities and towns are developed, they have resulted in increased use of fertilizers to produce more food, soil erosion due to deforestation, increase in construction activities, inadequate sewer collection and treatment, landfills as more garbage is produced, increase in chemicals from industries to produce more materials.

Leakage from the landfills: Landfills are nothing but a huge pile of garbage that produces an awful smell and can be seen across the city. When it rains, the landfills may leak and the leaking landfills can pollute the underground water with a large variety of contaminants.

Animal waste: The waste produce by animals has washed away into the rivers when it rains. It gets mixed up with other harmful chemicals and causes various water-borne diseases like cholera, diarrhea, jaundice, dysentery, and typhoid.

Underground storage leakage: Transportation of coal and other petroleum products through underground pipes is well known. Accidentals leakage may happen anytime and may cause damage to
the environment and result in soil erosion.

Methods to reduce water pollution

Sewage treatments: The household water should be treated properly so that they become environmentally safe. Adequate care should be taken to ensure that an effective sewage treatment process is in place and that contaminated water does not get mixed with the environment. in order to prevent water pollution, human and animal excreta should be prevented from mixing with its sources. Construction of pit toilets and proper sewage treatments can offer some solution to this problem.

Prevent river water to get polluted: The flowing water of the river cannot be cleaned easily by natural
process. Since a large number of external substances are discharged into the water, the river water
becomes polluted. This may cause diseases to the people using river water. Thus, every effort should be
made to prevent the river water to get contaminated. People should not be allowed to throw wastes into
the river water.

Treatment of wastes before discharge: Factories are expected to treat their effluent wastes prior to discharge. Toxic material must be treated chemically and converted into harmless materials. If possible, factories should try to recycle the treated water. Strict adherence to water laws: Laws and legislation relating to pollution should be strictly followed by all.

Treatment of drainage water: In cities, a huge amount of water is put into drains every day. The water that flows through the city drainage system should be properly treated. Harmful pollutants must be removed before they are introduced into reservoirs.

Treatment plants: Big cities and towns usually have effluent treatment plants. These plants filter out undissolved materials. Chemical treatment is also given to separate out unwanted dissolved chemicals.
The treated water is either allowed to go into the water reservoirs or refused in houses.
Occasionally, the treated water is used for farming if the fields to be irrigated lie in the vicinity of the water treatment plants.

Routine cleaning: Ponds, lakes, and wells meant for human use should be routinely cleaned and treated, so that it remains fit for human use. It is an essential step that should not be avoided. A system of regular testing of pond and lake water can be introduced to ensure the safety of the water.

Self-hygiene: Self-hygiene must be maintained and drinking water must not be polluted. Drinking water should be kept undercover in a clean place. One should not put his hands into the drinking water containers. Also, the practice of cleaning the drinking water reservoirs on a regular basis needs to be strictly followed. The water meant for drinking should be purified prior to use. In the absence of a good water purifier, it is recommended to drink boiled water.

Sanitation: The sanitation system must be improved. The benefits of cleanliness on human health need to be understood. Human contact with hazardous materials should be prevented.

Public Awareness: Common public should be aware of the effect of water pollution. Voluntary organizations should go door-to-door to educate people about environmental problems. They should perform street plays for creating awareness about the environment. They should run environmental

education centers. Students can impart health education to enable people to prevent water pollution

Zero Waste Concept

Zero Waste Concept is a philosophy that encourages the redesign of resource life cycles so that all products are reused and no wastes will be produced. The process recommended is similar to the way that resources are reused in nature.

Zero Waste concept requires:-

- Designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials,
- conserving and recovering all resources,
- investment in community waste reduction and recovery systems
- Public participation in recycling.
- Eliminate all discharges to land, water, or air that are a threat to planetary, human, animal, or plant health.
- Adopting 3R concepts (reduce, reuse, recycle)
- Acquiring waste to energy technologies.

Zero waste is more of a goal or ideal rather than a hard target. Zero Waste provides guiding principles for continually working towards eliminating wastes. Zero waste promotes not only reuse and recycling but, more importantly, promotes prevention and product designs that consider the entire product life cycle.

Benefits proposed include:

- Saving money---Since waste is a sign of inefficiency, the reduction of waste can reduce costs.
- Faster Progress-- A zero waste strategy improves upon production processes and improving environmental prevention strategies which can lead to taking larger, more innovative steps.
- Supports sustainability---A zero waste strategy supports all three of the generally accepted goals of sustainability - economic well-being, environmental protection, and social well-being.
- Improved material flows-- A zero waste strategy would use far fewer new raw materials and send no waste materials to landfills. Any material waste would either return as reusable or recycled materials or would be suitable for use as compost.

3R Concept of waste management

Reduce, Reuse and Recycle (R3) are the three essential components of environmentally- responsible consumer behavior.

Reduce

- Lower the consumption of products through hiring, sharing, borrowing
- Reduce the number of components in product design
- Minimize wastes.

Here's how the 3R might apply to computers:

- The concept behind the first R, reduce, is that you should limit the number of purchases that you make in the first place. So, for example, you might limit your household to a single computer.
- The concept behind the second R, reuse, is that you should reuse items as much as possible before replacing them. For example, it generally makes more environmental sense to update your computer rather than get rid of it and buy a new one. However, if you do replace your computer, you should ensure that it, or its components, are reused. Many charitable organizations welcome donations of second-hand computers.
- The concept behind the third R, recycle, is that you should ensure that items or their components are put to
- some new purpose or create something new as much as possible. If your computer is not 묻t for reuse, you
- can donate it to one of several organizations, which will refurbish it or recycle its electronic components to
- manufacture new electronic devices.

Advantages of 3R

- Protects the environment and natural resources.
- Reduces energy consumption
- Reduces pollution, global warming, etc
- Reduces waste generation
- Creates jobs at recycling sites.

Waste Management Hierarchy:

The waste management hierarchy is a nationally and internationally accepted guide for prioritizing waste management practices.

Green House Effect

The greenhouse effect is a natural phenomenon that refers to the rise in temperature of the earth due to the presence of certain greenhouse gases (water vapor, carbon dioxide, methane, nitrous oxide, etc.) in the atmosphere. These gases are transparent to the incoming ultraviolet solar radiations but trap the outgoing infrared radiations, reflected back from the earth's surface. If these gases were not present, the annual average temperature of the earth would be much lower -18 0 C) than they are now (15 0 C). But the excess amount of greenhouse gases will create problems. An excess amount of greenhouse gases will create excess hot conditions all over the earth.

GlobalWarming

Global Warming is the increase of Earth's average surface temperature due to the presence of the excess amount of greenhouse gases, such as carbon dioxide, methane, etc which trap heat that would otherwise escape from Earth. Greenhouse gases include carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons.

> *Releasing 1 kg of methane is equivalent to releasing 25 kgs of CO 2*
> *Releasing 1 kg of nitrous oxide is equivalent to releasing 298 kgs of CO 2*

Global Warming is caused by:

- Burning of fossil fuels

- Refrigerants and air conditioners release CFC
- Deforestation – carbon dioxide intake is reduced when forests are cut
- down. Methane emission occurs due to anaerobic decomposition at huge
- landfills. Methane emission from livestock (animal farm)

Global Warming Impacts

1. Rising Seas--- inundation of freshwater marshlands (the everglades), low-lying cities, and islands with seawater.
2. Changes in rainfall patterns --- droughts and fires in some areas, flooding in other areas.
3. Increased likelihood of extreme events--- such as flooding, hurricanes, etc.
4. Melting of the ice caps --- loss of habitat near the poles. Polar bears are now thought to be greatly endangered by the shortening of their feeding season due to dwindling ice packs.
5. Melting glaciers - significant melting of old glaciers is already observed.
6. Widespread vanishing of animal populations --- following widespread habitat loss.
7. Spread of disease --- migration of diseases such as malaria to new, now warmer, regions.
8. Bleaching of Coral Reefs due to warming seas and acidification due to carbonic acid formation --- One-third of coral reefs now appear to have been severely damaged by warming seas.

Measures to control global warming

1. Promote renewable energy usage (solar energy, wind energy, etc)
2. Depend more on public transport system to reduce the use of fossil fuels.
3. Afforestation and reforestation
4. Adopt the 3R concept whenever possible.
5. Reduce energy consumption at the home, office, etc
6.

Climate Change

Climate change refers to a change in average weather conditions, that exists for an extended period of time. Many frequent changes in climate had occurred on our earth. A number of natural factors like continental drift, earth's tilt, ocean currents, etc were responsible for such climatic changes. Recently, many anthropogenic (originating in human activity) causes have led to alarming variations in climatic patterns all over the world.

These include:-

- Increase in the usage of fossil fuels: Fossil fuels (coal, oil, and natural gas) are used as energy sources all over the world. The burning of fossil fuels produces CO 2, which spreads into the atmosphere leading to global warming and an increase in temperature.
- Deforestation: When trees are cut down on a large scale, the amount of atmospheric CO 2 increases, leading to global warming and an increase in temperature.
- Population growth, urbanization, and the industrial revolution: More and more needs of the people have to be satisfied for which cities were developed and industries were set up on a large scale. All these have led to an increase in the number of greenhouse gases resulting in global climatic changes.

Effects of climatic change

- Increase in global surface temperature: climatic changes lead to an increase in temperature levels all over the world and thereby disturbing the balance of the whole ecosystem.
- Changes in climate can put pressure on the whole natural system, leading to ecological imbalance.
- Melting of glaciers: It leads to a rise in sea levels
- Ocean acidification: oceans absorb CO 2 into the atmosphere, making them more acidic.
- Availability of freshwater decreases.
- Changes in rainfall patterns (high and low rainfall) may occur.
- Occurrence of drought, heatwaves, and flood.
- Breeding patterns, migration patterns, and the entire life cycle of plants and animals are disturbed due to climatic change.
- Climatic change will increase the distribution of mosquitoes, bugs, etc leading to diseases like malaria, dengue fever, etc

Control measures

- Promote renewable energy usage(solar energy, wind energy etc)
- Depend more on public transport system to reduce the use of fossil fuels.
- Afforestation and reforestation
- Adopt the 3R concept whenever possible.
- Reduce energy consumption at the home, office, etc

Ozone Layer Depletion

Ozone layer is a deep layer in earth's atmosphere that contains ozone which is a naturally occurring molecule containing three oxygen atoms. These ozone molecules form a gaseous layer in the Earth's upper atmosphere called stratosphere. This lower region of stratosphere containing relatively higher concentration of ozone is called Ozonosphere. The ozonosphere is found 15-35 km (9 to 22 miles) above the surface of the earth. The ozone layer forms a thick layer in stratosphere, encircling the earth, which has large amount of ozone in it. It protects our planet from the harmful UV radiations. The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson. The ozone layer has the capability to absorb almost 97-99% of the harmful ultraviolet radiations that sun emits and which can produce long term devastating effects on human beings as well as plants and animals.

Ultraviolet radiation can destroy organic matter. For humans, excessive exposure to ultraviolet radiation leads to higher risks of cancer (especially skin cancer) and cataracts. It is calculated that every 1 percent decrease in the ozone layer results in a 2-5 percent increase in the occurrence of skin cancer. Other ill-effects of the reduction of the protective ozone layer include – increase in the incidence of cataracts, sunburns, and suppression of the immune system.

Human activities had resulted in a considerable reduction in the ozone layer of the atmosphere. Ozone depletion occurs when the destruction of the stratospheric ozone is more than the production of the molecule. Scientists have observed a reduction in stratospheric ozone since the early 1970s. It was found to be more prominent in Polar Regions.

Man-made causes for ozone layer depletion:

The main reason for the depletion of ozone is determined as excessive release of chlorine and bromine from man-made compounds such as chlorofluorocarbons (CFCs). CFCs (chlorofluorocarbons), halons, CH_3CCl_3 (Methyl chloroform), CCl_4 (Carbon tetrachloride), HCFCs (hydro-chlorofluorocarbons), hydro Bromo fluorocarbons, and methyl bromide are found to have a direct impact on the depletion of the ozone layer. These are categorized as ozone-depleting substances (ODS). Chlorofluorocarbons are released into the atmosphere from:

- Cleaning Agents
- Air conditioning
- Coolants in refrigerators
- Aerosol spray cans etc.

The problem with the Ozone-Depleting Substances (ODS) is that they are not washed back in the form of rain on the earth and in fact remain in the atmosphere for quite a long time. With so much stability, they are transported into the stratosphere. The emission of ODS accounts for roughly 90% of the total depletion of the ozone layer in the stratosphere. These gases are carried to the stratosphere layer of the atmosphere where ultraviolet radiations from the sun break them to release chlorine (from CFCs) and bromine (from methyl bromide and halons). The chlorine and bromine free radicals react with ozone molecules and destroy their molecular structure, thus depleting the ozone layer.

- Halogen molecules in CFC 's ($CFCl_3$) is converted into an active free radical by photochemical decomposition:

$$CFCl_3 + h\nu \rightarrow CFCl_2 + Cl$$

- This chlorine reacts with ozone, and as a result chlorine monoxide and oxygen are formed:

$$Cl + O_3 \rightarrow ClO + O_2$$

- Chlorine Monoxide reacts with nascent oxygen (formed by the decomposition of ozone) to form chlorine again.

$$O_3 + h\nu \; O_2 + O \rightarrow O + ClO \; O_2 + Cl$$

-Chlorine again reacts with ozone and this cycle continues. One chlorine atom can break more than 1, 00,000 molecules of ozone. Bromine atom is believed to be 40 times more destructive than chlorine molecules. The implementation of the Montreal Protocol in the year 1987 has helped to reduce the presence of ODS in the atmosphere. Montreal Protocol is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.

Carbon credit

A carbon credit (often called a carbon offset) is a financial instrument or permit representing the right to emit one tonne of CO 2 (carbon dioxide) or CO2 e (carbon dioxide equivalent gases) into the atmosphere. It represents the amount of GHG s removed or reduced from the atmosphere from an emission reduction project. This carbon credit can be used by governments, industries, or private individuals to offset the damaging carbon emissions that they are generating. Thus carbon credits are used as a permit to emit a certain amount of CO 2 into the atmosphere. So, in a nutshell, carbon credit (often called carbon offset) is a credit for greenhouse emissions reduced or removed from the atmosphere from an emission reduction project, which can be used, by governments, industry, or private individuals to compensate for the emissions they are generating. One carbon credit corresponds to one tonne of CO 2.

Carbon credits are acquired through: -

- Project-based transactions--- credits are acquired as a result of successful implementation of carbon reduction projects. For eg:- If a private organization has successfully implemented an afforestation project and if it is found to have reduced carbon dioxide from the atmosphere, then that private company can acquire carbon credits equivalent to their reduction levels.

- Allowance based transactions ---Regulatory authority issues allowances or permits to industries. If one carbon credit is issued to an industry, it means that they can emit one tonne of carbon dioxide or equivalent.

Carbon trading:

It refers to buying and selling of carbon credits that have been either distributed by a regulatory authority or generated by GHG emissions reduction projects. In cap & trade mechanism, a regulatory authority limits (cap) the amount of GHG to be released over a period of time. If organizations have a shortfall or surplus in GHG allowances, they can engage in trade with each other.

Carbon credits are typically measured in tonnes of CO 2 -equivalents (or CO 2 e) and are bought and sold through a number of international brokers, online retailers, and trading platforms. Businesses that find it hard to comply with the carbon emissions, purchase carbon credits to offset their emissions by making finance readily available to renewable energy projects, forest protection, and reforestation projects around the world. These renewable energy and energy efficiency projects replace fossil fuel and industrial processes.

This all helps businesses in mitigating their emissions and compliance with global standards. Offsetting one tonne of carbon means there will be one less tonne of carbon dioxide in the atmosphere than there would otherwise have been. For e.g.: when solar energy companies sell carbon offsets, this helps them as these projects become more viable. The buyers of the credits benefit as they can use these credits to overcome their greenhouse gas emissions. Many types of activities can generate carbon offsets. Projects which acquire carbon credits include wind, solar, geothermal, biomass projects which replace fossil fuel-powered plants, low-cost household device projects that can eliminate the need for extra energy, methane capture from landfill gas and agriculture, different afforestation projects, forest protection from illegal logging, destruction of

heat-trapping greenhouse gases from the atmosphere and many more.

Carbon Tax

A carbon dioxide tax is a tax on businesses and industries that produce carbon dioxide through their operations.

The tax is designed to reduce the output of greenhouse gases and carbon dioxide. The tax is imposed with the goal of environmental protection.

Carbon footprint

It is a measure of the total amount of carbon dioxide emissions that are directly and indirectly caused by an activity, individual, organization, etc.

In other words: When you drive a car, the engine burns fuel which creates a certain amount of CO 2, depending on its fuel consumption and the driving distance. When you heat your house with oil, gas, or coal, then you also generate CO 2. Even if you use electricity, the generation of the
electrical power may also have emitted a certain amount of CO 2 (thermal power plants). When you buy food and goods, the production of the food and goods also emitted some quantities of CO 2. Your carbon footprint is the sum of all emissions of CO 2 (carbon dioxide), which were induced by your activities in a given time frame.

Each of us contributes to the greenhouse gas emissions either by the way we travel, the food we eat, the amount of electricity we consume, and many more. Every individual, organization, business unit, etc should focus to reduce their carbon footprints.

- *(i) Primary footprint—direct emission of carbon dioxide as in the case of burning of fossil fuels*

(ii) Secondary footprint --- idirect emission s assciate d with the manufacture of a

> *product*
>

Main Contributors to Carbon Footprint

- **Population** – more people lead to more carbon emission
- **Energy** – Here, carbon footprint emissions are collective, coming from a variety of sources, namely industrial processes, transport, and electricity and fuel emissions.
- **Industrialization** – Since the industrial revolution began during the middle of the twentieth century, CO2 has continued to rise unchecked and at alarming rates.
- **Agriculture** – Most agricultural processes within developed and developing nations are still being carried out commercially with the result that mass production of livestock has led to large levels of methane gas being released into the atmosphere.
- **Human action (and inaction)** – Ultimately, the way humankind has become accustomed to doing things every day, keeping pace with the need to do things more quickly and with more convenience, has contributed towards the exponential increase in carbon footprints on an annual basis.

Ways to Reduce Your Carbon Footprint

- **Energy efficiency at home** – All appliances that are not being used must be switched off immediately. And all electrical outlets not in use must also be switched off. Hot-water geysers should be switched off for the entire day and only turned on when needed. These are simple, yet practical lifestyle habits that are easy to adopt.
- **Buy renewable energy** – It is quite possible to power your own home with environmentally- sustainable alternatives of energy production without compromising your lifestyle and waiting for national grids to be connected via green energy supply sources. For instance, technology is now available for you to install your own solar power panels.
- **Recycle and re-use** – Vegetable produce can be converted into compost (or manure) for gardens, even vegetable gardens. Instead of buying more food containers, plastic containers sourced from the supermarket can be refashioned as ideal kitchen utensils. Also, where plastic waste is no longer required, seek out recycling depots rather than relying on your supplied garbage disposal units.
- **Plant a Tree** – One of the best ways to give it back to the environment is to plant trees. Plants absorb CO 2 and release oxygen that is then used by humans and animals. According to the Urban Forestry Network, a single young tree absorbs 13 pounds of carbon dioxide each year.
- **Buy local** – Adding to the above remark, buying local, organic produce effectively counters mass-produced agricultural outcomes. There is a dramatic reduction in the amount of plastic being used to package products and fuel usage during long road transits is also reduced.

Legal Provisions for Environmental Protection

Some of the important legislations for environmental protection are as follows:

- The National Green Tribunal Act, 2010
- The Air (Prevention and Control of Pollution) Act, 1981
- The Water (Prevention and Control of Pollution) Act, 1974
- The Environment Protection Act, 1986
- The Hazardous Waste Management Regulations, etc.

The National Green Tribunal Act, 2010

The National Green Tribunal Act, 2010 (No. 19 of 2010) (NGT Act) has been enacted with the objectives to provide for the establishment of a National Green Tribunal (NGT) for the effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to the environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto.

The Air (Prevention and Control of Pollution) Act, 1981

The Air (Prevention and Control of Pollution) Act, 1981 (the "Air Act") is an act to provide for the prevention, control, and abatement of air pollution and for the establishment of Boards at the Central and State levels with a view to carrying out the aforesaid purposes.

The Water (Prevention and Control of Pollution) Act, 1974

The Water Prevention and Control of Pollution Act, 1974 (the "Water Act") has been enacted to provide for the prevention and control of water pollution and to maintain or restore the wholesomeness of water in the country. It further provides for the establishment of Boards for the prevention and control of water pollution with a view to carrying out the aforesaid purposes. The Water Act prohibits the discharge of pollutants into water bodies beyond a given standard, and lays down penalties for non-compliance.

The Environment Protection Act, 1986

The Environment Protection Act, 1986 (the "Environment Act") provides for the protection and improvement of the environment. The Environment Protection Act establishes the framework for studying, planning, and implementing long-term requirements of environmental safety and laying down a system of speedy and adequate response to situations threatening the environment. It is an umbrella legislation designed to provide a framework for the coordination of central and state authorities established under the Water Act, 1974, and the Air Act. T

Hazardous Wastes Management Regulations

Hazardous waste means any waste which, by reason of any of its physical, chemical, reactive, toxic, flammable, explosive, or corrosive characteristics causes danger or is likely to cause danger to health or environment, whether alone or when in contact with other wastes or substances.

Some of the rules dealing with hazardous waste management are discussed below:

- *Hazardous Wastes (Management, Handling and Transboundary) Rules, 2008, brought out a guide for manufacture, storage and import of hazardous chemicals and for management of hazardous wastes.*
- *Biomedical Waste (Management and Handling) Rules, 1998, were formulated along parallel lines, for proper disposal, segregation, transport, etc, of infectious wastes.*

SUSTAINABLE ENGINEERING

Module 3

Environmental management standards

ISO14001:2015framework andbenefits,Scope andgoalofLife CycleAnalysis (LCA), Circular economy, Bio-mimicking, Environment Impact Assessment (EIA), Industrial ecology, and industrial symbiosis.

Environmental Management System ("EMS")

An Environmental Management System ("EMS") is a tool that is continuously growing in importance for
companies. An Environmental Management System (EMS) is a framework that helps an organization achieve its
environmental goals through consistent review, evaluation, and improvement of its environmental performance.
EMS – "Tool that enables an organization to control impact of its activities, products or services on the natural environment."

Advantages:

• Serves as a tool to provide a systematic way of managing an organization's environmental affairs.
• Focuses on continual improvement of the system.
• Restrict and regulate overexploitation of natural resources.
• Set targets to reduce the use of energy and water and waste going to landfills.
• Set environment-friendly purchasing procedures.

The three primary processes of a management system include:

1. Core processes, their outputs, and the identification of significant environmental aspects and impacts
2. Key supporting processes, such as those for maintaining awareness of legal requirements, ensuring
competency of employees, providing infrastructure, communicating EMS information, and monitoring and
evaluating environmental performance
3. Management system supporting processes, such as document control, record control, and internal auditing

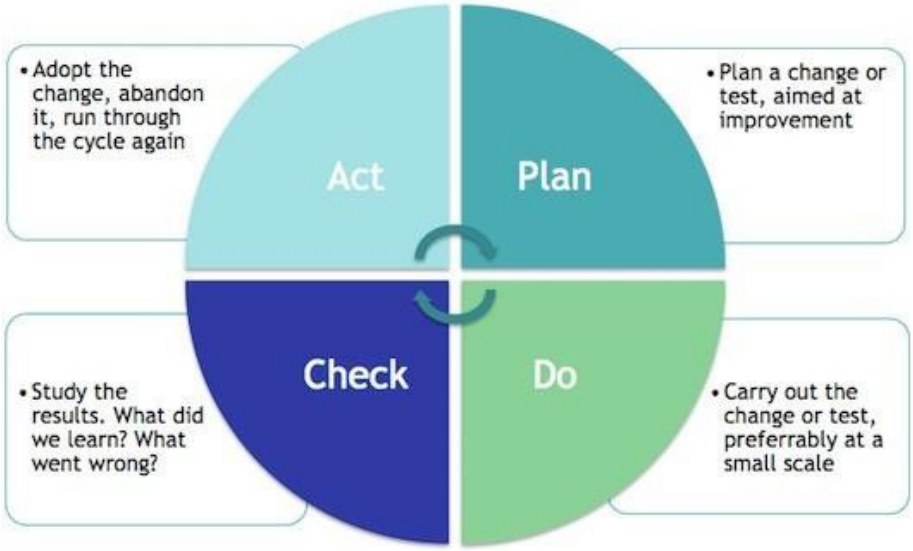
Basic Elements of an EMS include the following:

- Reviewing the organization's environmental goals;
- Analyzing its environmental impacts and legal requirements;
- Setting environmental objectives and targets to reduce environmental impacts and comply with legal requirements;
- Establishing programs to meet these objectives and targets;
- Monitoring and measuring progress in achieving the objectives;

- Ensuring employees' environmental awareness and competence; and,
- Reviewing the progress of the EMS and making improvements.

Basis EMS framework

An EMS follows a Plan-Do-Check-Act Cycle or PDCA.



1. Develop an environmental policy
2. Planning your EMS
3. Implementing it in your organization
4. Monitor the system
5. Take action

Environmental Management Standards

EMS cannot be implemented in a random manner.
Requires regular and robust verification to ensure its operation effectively. A set of standards are required

ISO 14000 series

ISO 14000 is a series of standards developed by the International Organization for Standardization (ISO) to help organizations to reduce their impact on the environment. The core of the ISO 14000 family of standards is ISO 14001:2015, but there are related standards to help you implement, evaluate, and improve your ISO 14001 Environmental Management System. Organizations do not become certified in the ISO 14000 series, they ONLY register to ISO 14001:2015. The other documents will help an organization implement an EMS, audit properly, etc.

The standard requires your organization to:

- Determine your organization’s impact on the environment and relevant regulations to the operations of the business.
- Create a plan to control your processes to minimize the environmental impact.

- Monitor the effectiveness of the system at meeting objectives as well as legal and other.
- Continually analyze the results and improve your systems.

An EMS that meets the requirements of ISO 14001:2015 is a management tool enabling an organization of any size or type to:

- Identify and control the environmental impact of its activities, products, or services
- Continually improve its environmental performance
- Implement a systematic approach to setting environmental objectives, achieving these objectives, and demonstrating that they have been achieved
- Ensure legal compliance (aided by ISO 14001 registration/certification

BENEFITS OF ISO 14001

Using ISO 14001:2015 has many benefits for organizations with environmental management systems.
Organizations and companies find that using the standard helps them:

- Improve resource efficiency
- Reduce waste
- Drive down costs
- Provide assurance that environmental impact is being
- measured Gain a competitive advantage in supply chain design
- Increase new business opportunities
- Meet legal obligations
- Increase stakeholder and customer
- trust Improve overall environmental impact
- Manage environmental obligations with consistency

Environmental Benefits: The main reason to implement ISO 14001:2015 is to reduce your environmental impact. .ISO 14001 certificate serves as a driver and reminder that it is everyone's job to protect the environment by preventing pollution and continually improving the air we breathe, the water we drink, and the earth we inhabit

Legislative and Regulatory Benefits: Meeting ISO 14001:2015 requirements also ensures that you meet any legislative or regulatory requirements. This will reduce your organization's potential to pay liability fees, while also improving your organization's efficiency.
\
Customer Satisfaction: Customer Satisfaction is a key reason for organizations to become certified to ISO 14001. There has been a huge push in the two decades by consumers for companies to adopt better environmental management systems. Implementing ISO 14001 can lead to improved public perceptions, and give organizations a competitive advantage to operate in the international marketplace

ISO 14001 FRAMEWORK

1. Context of the organization

This clause sets out the requirements for an organization to take a high-level overview of the business, considering the key internal and external factors which impact it, and how it should respond in the form of a defined management system.

i) Understanding the organization and its context:

This clause requires the organization to consider a wide range of potential factors which can impact the management system, in terms of its structure, scope, implementation, and operation. The areas for consideration quoted in the Annex A guidance of the standard are wide-ranging, including;

a) environmental conditions related to climate, air quality, water quality, land use, existing contamination, natural resource availability and biodiversity, that can either affect the organization's purpose or be affected by its environmental aspects;

b) the external cultural, social, political, legal, regulatory, financial, technological, economic, natural, and competitive circumstances, whether international, national, regional, or local;
c) the internal characteristics or conditions of the organization, such as its activities, products and services, strategic direction, culture, and capabilities (i.e. people, knowledge, processes, systems

ii) Understanding the needs and expectations of interested parties

The organization requires to determine the need and expectations of "interested parties", both internal and external. Previous versions of the draft standard also contained the term "stakeholder", which many
organizations will be more familiar with – the terms are synonymous and there is no need to consider them to be any different. Interested parties could include;

- Employees
- Contractors n Clients/Customers,

- Neighbors, Suppliers, regulators, Shareholders
- Non-Governmental Organizations (NGOs)
- Parent organizations

iii) Determining the scope of the environmental management system

This should encourage a clearer and more logical approach to scope, driven by external and internal requirements - it should not be used to exclude activities, processes or locations which have significant environmental aspects and impacts and should not be used to avoid areas with clear compliance obligations.

2. Leadership

This clause includes a good proportion of content that will be familiar from ISO 14001:2004 but also introduces some significant changes on overall leadership and commitment and the expectations for top manage

> .
> *i) Leadership and commitment*
>
> *This clause encompasses a range of key activities which top management need in order to "demonstrate*
> *leadership and commitment with respect to the management system".*
>
> *ii)Environmental policy*
>
> *The Environmental Policy is an important document because it acts as the driver for the organization. It provides the direction and formally establishes goals and commitment. Top management should ensure that the policy is appropriate, compatible with the strategic direction, and not a bland statement that could apply to any business. It should provide clear direction to allow meaningful objectives to be set that align with fitment to engage more fully with the critical aspects of the quality management system.*
>
> *iii)Organizational roles, responsibilities, and authorities*
>
> *For a system to function effectively, those involved need to be fully aware of what their role is. Top management must ensure that key responsibilities and authorities are clearly defined and that everybody involved understands their roles. Defining roles is a function of planning, ensuring awareness can then be achieved through communication and training.*
>
> .

3.Planning

This clause is an excellent addition to ISO 14001:2015, introducing the concept of risk (and opportunity)
i) Actions to address risks and opportunities
ii) Environmental objectives and planning to achieve them: This clause requires the organization to establish environmental objectives and plans, ensuring that these are clear, measurable, monitored, communicated, updated, and resourced.

4.Support:

An effective environmental management system cannot be maintained or improved without adequate resources.
As a function of planning, such resources should be determined and provided.

- Resources
- Competence
- Awareness
- Communication
- Documented Information

5.Operation

This clause basically represents the operational control and emergency planning parts of the current
standard – the ‘engine house’ of production and control

i) Operational planning and control the overall purpose of operational planning and control is to ensure that processes are in place to meet the environmental management system requirements and to implement actions

ii) Emergency Preparedness and Response This clause is clear in requiring the organization to establish, implement and maintain processes needed to handle potential emergency situations

6. Performance evaluation

i) Monitoring, measurement, analysis, and evaluation This sub-clause encompasses two key areas: n Monitoring, measurement, analysis, and evaluation of environmental performance and the effectiveness of the system; n Evaluation of compliance with all legal and other obligations.

ii) Internal audit Internal audits have always been a key element of ISO 14001 in helping to assess the effectiveness of the environmental management system. An audit program needs to be established to ensure that all processes are audited at the required frequency, the focus being on those most critical to the business. To ensure that internal audits are consistent and thorough, a clear objective and scope should be defined for each audit.

iii) Management reviews The main aim of management review is to ensure the continuing suitability, adequacy, and effectiveness of the quality management system.

7. Improvement

i) General This states that the organization shall determine opportunities for improvement and implement necessary actions to achieve intended outcomes.

ii) Nonconformity and corrective action the main aim of the corrective action process is to eliminate the causes of actual problems so as to avoid the recurrence of those problems. It is a reactive process; in that it is triggered after an undesired event (e.g., a pollution event). In essence, the process uses the principles of root cause analysis. A basic approach to problem- solving is “cause” and “effect”, and it is the cause that needs to be eliminated.

iii) Continual improvement This sub-clause of ISO 14001:2015 effectively summarizes the key aim of an environmental management system: to continually improve the suitability, adequacy and effectiveness of the environmental management system to enhance environmentally performance

LIFE CYCLE ANALYSIS(LCA)

• Life Cycle Assessment/Cradle-to-grave analysis. • Process to assess the environmental impacts associated with all the stages of a product, process, or activity from cradle to grave by identifying the materials used and waste generated. Life Cycle Assessment (LCA) identifies, quantifies, and evaluates the environmental impacts (inputs and outputs) of a product, service, or activity, from cradle to grave. That is, the environmental impacts of all phases of the product's life are assessed, from the time materials are extracted through manufacture, transportation, storage, use, recovery, reuse, and disposal. LCA can be a very involved and lengthy process. However, the basic steps in LCA

are: Generally, LCA has four stages or components:

1. Goal and scope
2. Inventory
3. Impact assessment
4. Improvement assessment

1. Goal and scope of an LCA

What are we looking at? The point at which all decisions are made about what to include in the study, why it's being carried out, the "functional unit" that is being focused on, the different systems that need to be investigated, as well as the boundaries – it's often not practical (or possible) to measure every single input and output and in the cases where there is good reason to think they are small or where they are deemed to be beyond the scope of what you are interested in, they are left out. Every LCA has boundaries.

This is also the point where you ask what data do you need, what are your data quality requirements, what methods will you use to assess impact, to interpret, and how you will report it. Another task at this point involves "screening", which is the preliminary execution of the LCA and any adjustmentin the plan.

2. Inventory

Every LCA has an inventory. This is the data that you are collecting. The inventory includes things like emissions, energy requirements and material flows for each process involved. These are the flows into and out of the system you are studying. The data of these are adjusted depending on the functional unit you're looking at. This is known as a Life Cycle Inventory (LCI)
This can be extremely complex because it can involve dozens of separate processes, as well ashundreds of tracked substances. This is where most of the complexity of an LCA is involved

3. Impact Assessment

The Life Cycle Impact Assessment (LCIA) is where the impacts on the environment are calculated. The categories of impacts are chosen and the impacts on them based on the flow of emissions, energy and material from the inventory, are assessed. There are lots of different types of impacts (depletion of abiotic resources, global warming, ozone layer depletion, acidification, etc.) so this stage accounts for allthe different impactsthat have been chosen.

4. Improvement Assessment

Finally, the results are analyzed in the context of the goal and scope of the study set out at the beginning.
What have we learned about the system from this LCA? This is where recommendations are typically included.

What does an LCA actually look at? (LCA PROCESS)
At the life cycle inventory stage is where you're breaking product system and getting data on all the elements.
The materials and energy that go into these five processes:

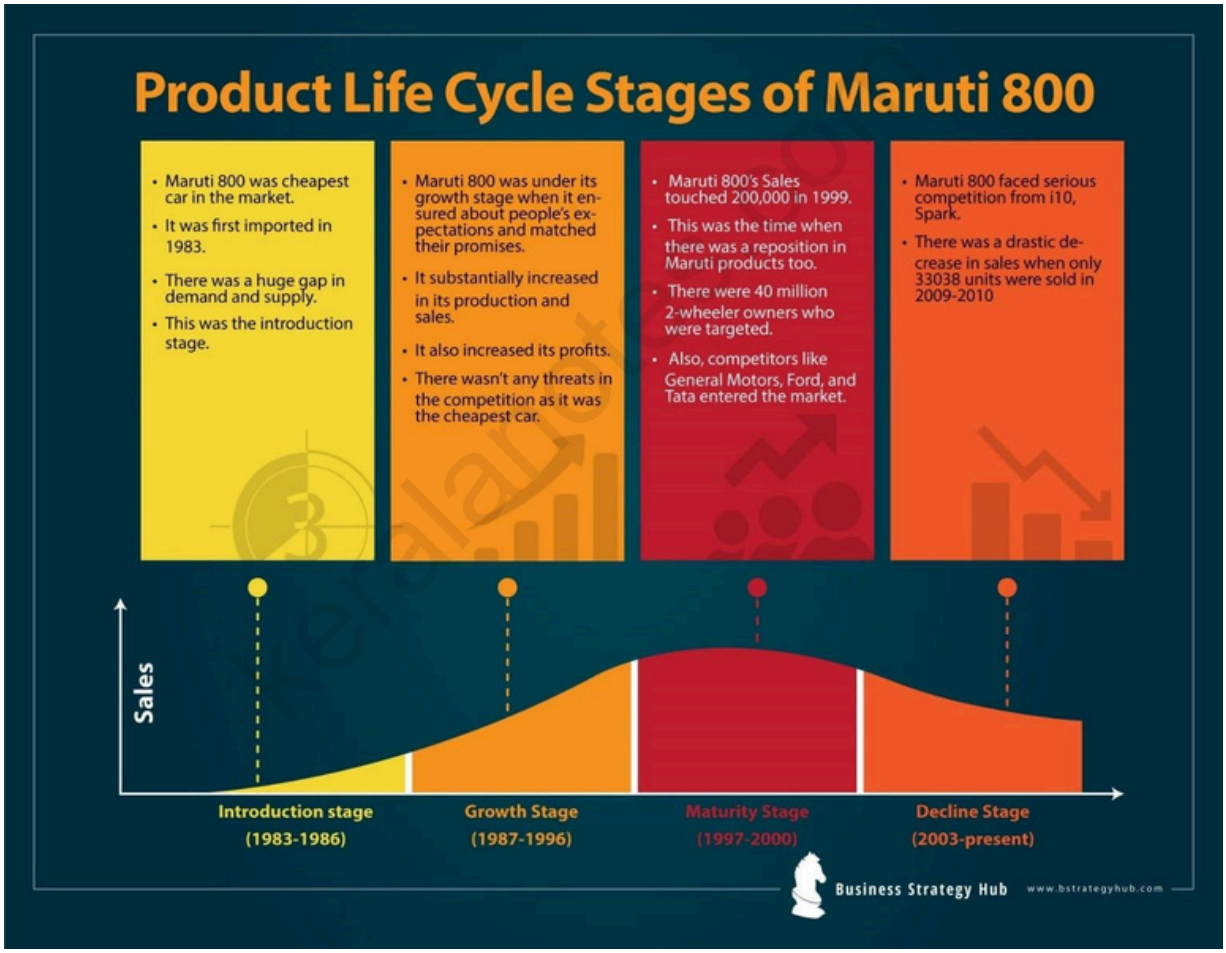
- Raw material extraction

- Manufacture
- Distribution and transport
- Use and maintenance
- Disposal and recycling

These are then looked into their impacts in terms of:

- Global warming potential
- Air, water and soil pollution
- Ecotoxicity
- Resource depletion

When you put it like that, it seems quite straightforward. But when you get into it, it becomes a lot less black and white. Drawing the boundaries of these boxes, which bits to include and which to leave out, often ends up in lots of careful decisions as to what's relevant.



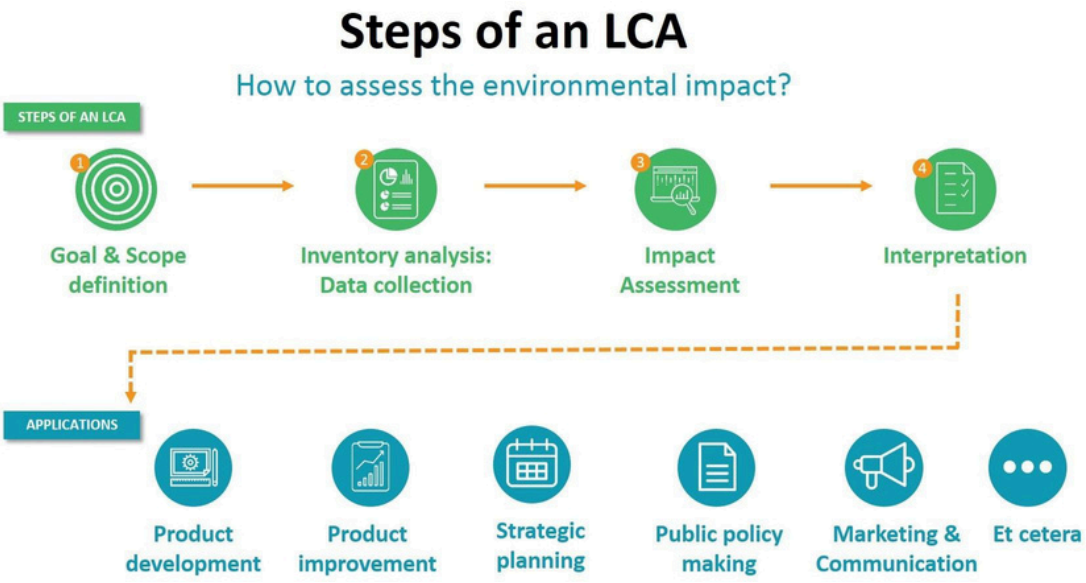
Limitations of LCAs

As with every scientific method, there are always some limitations that we should be aware of. In the case of LCAs, they do not detract from the depth of understanding that is available only through the comprehensive LCA route. These limitations include:

- Studies relate to normal operations, rather than where incidents occur, which must be

understood through separate risk assessments

- The quality of the available data: obviously this is what determines the validity of the whole LCA
- Reliability of the environmental scores is dependent on the skill of the LCA practitioners employed
- Investment decisions are delayed as a consequence of how long LCAs take

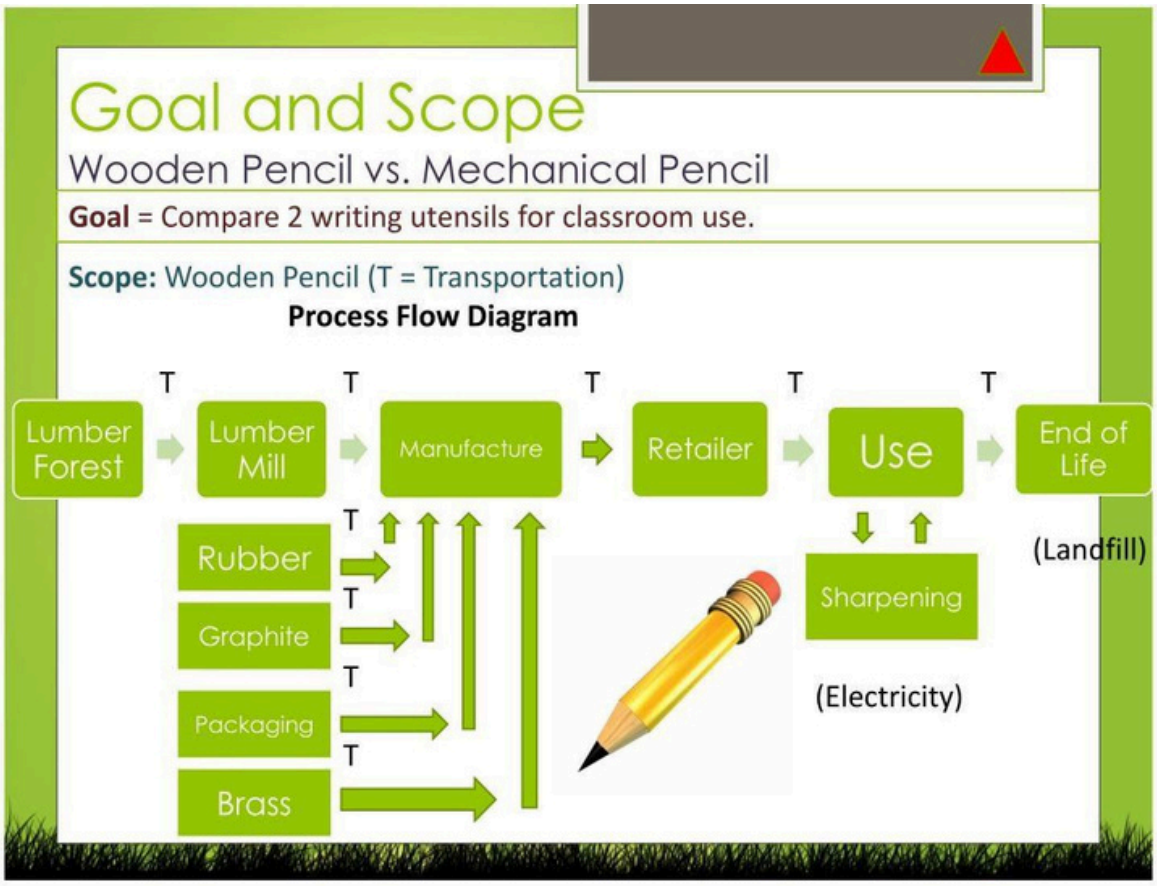


Life Cycle Analysis

• Wood cased pencils

- 4 time more raw material consumption
- Similar energy consumption –
- 5 to 6 times more CO emissions

- Twice the non-renewable resource materials
- 40% more water consumption
- More non-renewable energy used
- 90% more organic pollutants emitted
- Greater waste water effluents
- More net process solid waste Significantly
- more hazardous waste



A Better Solution

•Extend the life of plastic pencils even more – Larger eraser – More graphite included in barrel –

Higher quality – Discourage misplacement

• Reduce wastes – Minimize packaging

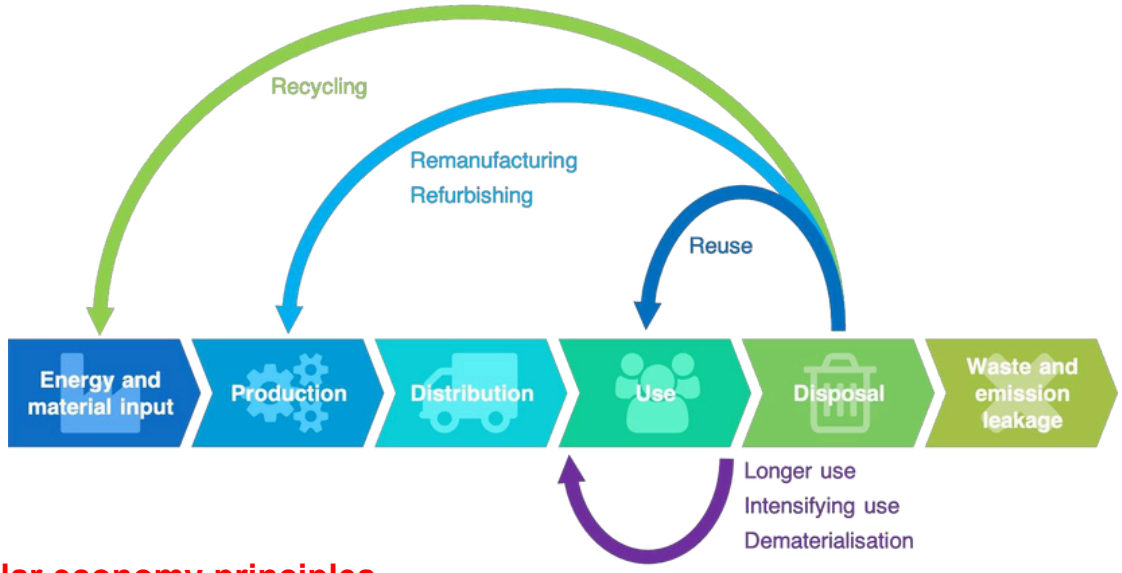
A circular economy is an economic system of closed loops in which raw materials, components and products lose their value as little as possible, renewable energy sources are used and systems thinking is at the core The circular economy refers to an economic model whose objective is to produce goods and services in a sustainable way, by limiting the consumption and waste of resources (raw materials, water, energy) as well as the production of waste.

It is based on three principles:

- Design out waste and pollution

- Keep products and materials in
- use Regenerate naturalsystems

It is breaking with the model of the linear economy, based on a take-make-consume-throw away pattern, by proposing to transform waste into recycled raw material for product design or other uses.
The circular economy model fits directly into the more general framework of sustainable development. It is part of a global strategy that also uses, among other things, the principles of the green economy, industrial ecology, eco-design or the economy of functionality.



Circular economy principles

The circular economy encompasses a very large number of sectors of activity and can be broken down into 7 complementary patterns of production and consumption which, when combined, make sense and reinforce each other:

1.Sustainable procurement: development and implementation of a responsible purchasing policy 2. Eco-design: process of reducing the environmental impacts of a product or service throughout its life cycle
3. Industrial and territorial ecology: search for eco-industrial synergies at the scale of a business area - the waste
of one company can become the resources of another one
4. Economics of functionality: collaborative economy that favors use over possession and thus tends to sell
services related to products rather than the products themselves
5. Responsible consumption: rational consumption and choice of products according to social and ecological criteria
6. Extending the duration of use: through repair, reuse and repurpose
7. Recycling: treatment and recovery of the materials contained in
collected waste

Circular economy Benefits

ENVIRONMENTAL

The first advantage of a circular economy is the protection of the environment, reducing waste and the emissions of greenhouse gases, systematizing recycling, and ending planned obsolescence. The circular economy
also allows to decrease the dependence on importation of resources (raw materials, water, energy).

ECONOMIC

Another huge benefit of the circular economy is that it stimulates innovation and boost economic growth, and could in the long run enhance the competitiveness of national companies

SOCIAL

In addition, the circular economy creates jobs and enables people to save money, cutting unemployment and poverty as well as reducing the social impacts of pollution and climate change.

BIO-MIMICRY

Bio mimicry is an innovative methodology to observe, inspire and value nature to learn from it and find and derive solutions from natural models to solve human problems.

– bios, meaning “life” + mimesis, meaning “to imitate” Biomimicry = to imitate life

BI-O-MIM-IC-RY

Biomimicry as having three components with

> .
> *Nature as model: Biomimicry is a new science that studies Nature’s models and then imitates or takes*
> *inspiration from these designs and processes to solve human problems.*
> *Nature as measure: Biomimicry uses an ecological standard to judge the sustainability of our innovations.*
> *After billions of years of evolution, nature has learned what works and what lasts...*
>
> *Nature as mentor: Biomimicry is a new way of viewing and valuing Nature. It introduces an era based on what we can extract from natural world , but what we can learn from it. Nature is all around as.*
> .

Biomimicry Principles

Nature

1: Runs on sunlight
2: Uses only the energy it needs
3: Fits form to function
4: Recycles everything
5: Rewards co-operation
6: Banks on diversity
7: Demands local expertise
8: Curbs excesses within
9: Taps the power of limits

BIOMIMICRY EXAMPLES

Kingfisher-Inspired Bullet Train

The fastest train in the world at speeds of up to 200 miles per hour, Japan's Shinkansen Bullet Train was a marvel of modern technology. But there was one major problem after its initial debut: noise. Each time the train emerged from the tunnel; it caused a change in air pressure that caused thunder-like sounds that were a nuisance from a quarter of a mile away. The train's chief engineer, a bird-watcher, had an idea: taking inspiration from the shape of a bird's beak to make it more aerodynamic. The resulting design was based on the narrow profile of a kingfisher's beak, resulting in a quieter train that also consumes 15% less electricityand goes 10% faster than before

Shape of leaves of a wind mill inspired from fins of whales

Whales have been swimming around the ocean for a long time, and evolution has crafted them into a super- efficient form of life. They are able to dive hundreds of feet below the surface and stay there for hours. They sustain their massive size by feeding on animals smaller than the eye can see, and they power their movement with über-efficient fins and a tail.

In 2004, scientists at Duke University, West Chester University and the U.S. Naval Academy discovered that the bumps at the front edge of a whale fin greatly increase its efficiency, reducing drag by 32 percent and increasing lift by 8 percent. Companies are applying the idea to wind turbine blades, cooling fans, airplane wings and propellers.

Termite dens

Termite dens look otherworldly, but they are surprisingly comfortable places to live. While the temperature outside swings wildly throughout the day from lows in the 30s to highs over 100, the inside of a termite den holds steady at a comfortable (to a termite) 87 degrees.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

WHAT IS EIA?

It is defined as an activity designed to identify and predict the impact of legislative proposals, policies, programs, projects and operational procedures on the bio- geophysical environment and on the health and well-being of human beings and to interpret and communicate information about the impact. **EIA** is intended to identify the impacts (both beneficial and adverse) of proposed public

and private development activities. Often, the focus is dominantly environmental (biophysical).

EIA is mainly used at the level of specific developments and projects such as dams, industrial plants,
transport infrastructure (eg airport runways and roads), farm enterprises, and natural resource exploitation
(e.g., sand extraction).

EIA focuses on problems, conflicts or natural resource constraints that could affect the viability

of a project. It also examines implications of a project that might harm people, their homeland or their livelihoods, or other nearby developments.

After predicting the problems, an EIA identifies measures to minimize the problems and outlines ways to

- improve the project's suitability for its proposed
- environment. Main goals of EIA:
- Resource conservation
- Waste minimization
- Recovery of byproducts
- Energy conservation through efficient equipment's etc...

Environmental impact statement (EIS):

The environmental impact statement (EIS) provides documentation of the information and estimates derived from the various steps in the EIA process. The information contained in an EIS provides the decision-makers/regulators with valuable information that could ultimately contribute to either the abandonment or substantial modification of a proposed development action.

A typical EIS contains the following three parts:

Part 1 – Methods and key issues: This part deals with the statement of methods used

and a summary of key issues.

Part 2 – Background to the proposed development: This part deals with preliminary studies (i.e., need, planning, alternatives, site selection, etc.), site description/baseline conditions, description of proposed development and construction activities and programmes.

Part 3 – Environmental impact assessments on topic areas: This part deals with land use, landscape and visual quality, geology, topography and soils, hydrology and water quality, air quality and climate, terrestrial and aquatic ecology, noise, transport, socio-economic
, interrelationships between effects.

Need for EIA

Economic, social and environmental change is inherent to development. Whilst development aims to bring about positive change it can lead to conflicts. In the past, the promotion of economic growth as the motor for increased well-being was the main development thrust with little sensitivity to adverse social or environmental impacts. The need to avoid adverse impacts and to ensure long term benefits led to the concept of sustainability. This has become accepted as an essential feature of development if the aim of increased well-being and greater equity in fulfilling basic needs is to be met for this and future generations.

In order to predict environmental impacts of any development activity and to provide an opportunity to mitigate against negative impacts and enhance positive impacts, the environmental impact assessment (EIA) procedure was developed in the 1970s. An EIA may be defined as:

> *A formal process to predict the environmental consequences of human development activities and to plan appropriate measures to eliminate or reduce adverse effects and to augment positive effects. EIA thus has three main functions:*
>
> *to predict problems,*
> *to find ways to avoid them, and to*
> *enhance positive effects.*

The third function is of particular importance.

The EIA provides a unique opportunity to demonstrate ways in which the environment may be improved as part of the development process. The EIA also predicts the conflicts and constraints between the proposed project, programs or sectoral plan and its environment. It provides an opportunity for mitigation measures to be incorporated to minimize problems. It enables monitoring programs to be established to assess future impacts and provide data on which managers can take informed decisions to avoid environmental damage.

EIA is a management tool for planners and decision makers and complements other project studies on engineering and economics. Environmental assessment is now accepted as an essential part of development planning and management. It should become as familiar and important as economic analysis in project evaluation.

The aim of any EIA should be to facilitate sustainable development. Beneficial environmental effects are maximized while adverse effects are ameliorated or avoided to the greatest extent possible. EIA will help select and design projects, programs or plans with long term viability and therefore improve cost effectiveness.

It is important that an EIA is not just considered as part of the approval process. Volumes of reports produced for such a purpose, which are neither read nor acted upon, will devalue the process. A key output of the EIA should be an action plan to be followed during implementation and after implementation during the monitoring phase. To enable the action plan to be effective the EIA may also recommend changes to laws and institutional structures.

EIA Process and Procedures

Steps in EIA process

EIA involves the steps mentioned below. However, EIA process is cyclical with interaction between the various steps.

Screening: The project plan is screened for scale of investment, location and type of development and if the project needs statutory clearance.
Scoping: The project's potential impacts, zone of impacts, mitigation possibilities and need for monitoring.
Collection of baseline data: Baseline data is the environmental status of study area.
Impact prediction: Positive and negative, reversible and irreversible and temporary and permanent impacts need to be predicted which presupposes a good understanding of the project by
the assessment agency.
Mitigation measures and EIA report: The EIA report should include the actions and steps for preventing, minimizing or by passing the impacts or else the level of compensation for probable environmental damage or loss.
Public hearing: On completion of the EIA report, public and environmental groups living close to project site may be informed and consulted.
Decision making: Impact Assessment Authority along with the experts consult the project-in- charge along with consultant to take the final decision, keeping in mind EIA and EMP (Environment Management Plan).
Monitoring and implementation of environmental management plan: The various phases of implementation of the project are monitored.
Assessment of Alternatives, Delineation of Mitigation Measures and Environmental Impact
Assessment Report: For every project, possible alternatives should be identified, and environmental attributes compared. Alternatives should cover both project location and process technologies.
Once alternatives have been reviewed, a mitigation plan should be drawn up for the selected option
and is supplemented with an Environmental Management Plan (EMP) to guide the proponent towards environmental improvements.
Risk assessment: Inventory analysis and hazard probability and index also form part of EIA procedures.

Steps in Preparation of EIA report

1. Collection of baseline data from primary and secondary sources;
2. Prediction of impacts based on past experience and mathematical modelling;
3. Evolution of impacts versus evaluation of net cost benefit;
4. Preparation of environmental management plans to reduce the impacts to the minimum;

5. Quantitative estimation of financial cost of monitoring plan and the mitigation measures.

Benefits of EIA

- EIA links environment with development for environmentally safe and sustainable development.
- EIA provides a cost-effective method to eliminate or minimize the adverse impact of developmental projects.
- EIA enables the decision makers to analyze the effect of developmental activities on the environment well before the developmental project is implemented.
- EIA encourages the adaptation of mitigation strategies in the developmental plan.
- EIA makes sure that the developmental plan is environmentally sound and within limits of the capacity of assimilation and regeneration of the ecosystem.

INDUSTRIAL ECOLOGY (IE)

Industrial ecology (IE) is the study of material and energy flows through industrial systems. The global industrial economy can be modelled as a network of industrial processes that extract resources from the Earth and transform those resources into commodities which can be bought and sold to meet the needs of humanity. Industrial ecology seeks to quantify the material flows and document the industrial processes that make modern society function. Industrial ecologists are often concerned with the impacts that industrial activities have on the environment, with use of the planet's supply of natural resources, and with problems of waste disposal.

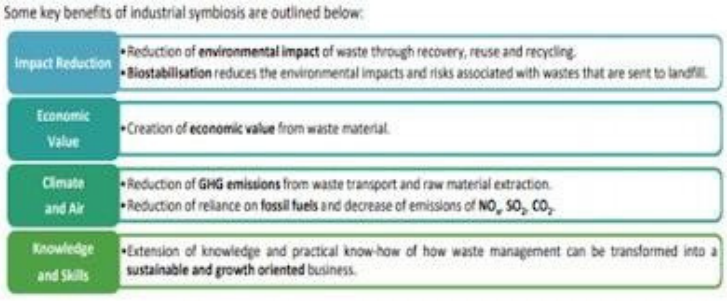
Industrial ecology is a young but growing multidisciplinary field of research which combines aspects of engineering, economics, sociology, toxicology and the natural sciences. Industrial ecology is concerned with the shifting of industrial process from linear (open loop) systems, in which resource and capital investments move through the system to become waste, to a closed loop system where wastes can become inputs for new processes.

Much of the research focuses on the following areas

- material and energy flow studies ("industrial metabolism")
- dematerialization and decarbonization technological change and
- the environment life-cycle planning, design and assessment
- design for the environment ("eco-design") extended producer
- responsibility ("product stewardship") eco-industrial parks
- ("industrial symbiosis") product-oriented environmental policy
- eco-efficiency
-
-

INDUSTRIAL SYMBIOSIS

- Industrial symbiosis a subset of industrial ecology. It describes how a network of diverse organizations can foster eco-innovation and long-term culture change, create and share mutually profitable transactions—and improve business and technical processes.
- Industrial symbiosis is the process by which wastes or byproducts of an industry or industrial process become the raw materials for another.
- Application of this concept allows materials to be used in a more sustainable way and contributes to the creation of a circular economy. The transition to such an economy is the goal of the European Commission's Circular Economy Action Plan as it will result in the increase of Europe's economic competitiveness, sustainability, resource efficiency and resource security.
- Industrial symbiosis creates an interconnected network which strives to mimic the functioning of ecological systems, within which energy and materials cycle continually with no waste products produced. This process serves to reduce the environmental footprint of the industries involved. Virgin raw materials are required to a lesser degree, and the need for landfill waste disposal is reduced. It also allows value to be created from materials that would otherwise be discarded and so the materials remain economically valuable for longer than in traditional industrial systems.
- It also contributes to the reduction of greenhouse gas (GHG) emissions. Industrial symbiosis creates an interconnected network which strives to mimic the functioning of ecological systems, within which energy and materials cycle continually with no waste products produced. This process serves to reduce the environmental footprint of the industries involved. Virgin raw materials are required to a lesser degree, and the need for landfill waste disposal is reduced. It also allows value to be created from materials that would otherwise be discarded and so the materials remain economically valuable for longer than in traditional industrial systems. Examples of industrial symbiosis are wide ranging and include the use of waste heat from one industry to warm greenhouses for foo d production, the recovery of car tire shavings for use in construction materials, and the use of sludge from fish farms as agricultural fertilizer. Industrial symbiosis has been applied for waste management and valorization in Lahti, Finland, and Pécs, Hungary. Kujala Waste Centre, Lahti, Finland



Module IV

ENERGY SOURCES

CONVENTIONAL & NON-CONVENTIONAL

SOURCES SOLAR ENERGY
WIND POWER
HYDROPOWER
BIOFUEL
GEOTHERMAL
ENERGY DERIVED FROM OCEANS

ENERGY SOURCES

Renewable & Non-Renewable Resources
Conventional & Non-Conventional Sources

+ Renewable Resources

- Solar energy
- Wind
- Geothermal
- Wood
- Hydropower
- Biomass

+Non-Renewable Resources

- Coal
- Petroleum (Crude oil)
- Natural gas
- Nuclear (Uranium)

Conventional Resources

- Coal
- Petroleum (Crude oil)
- Natural gas
- Firewood / Fuelwood

Non-Conventional Resources

- Solar wind, Hydropower,
- tidal power Biomass,
- biofuel geothermal
-
-

SOLAR ENERGY TECHNOLOGIES

- Thermal conversion

- Solar water heater
- Solar space heating of
- buildings
- Solar air conditioning
- Solar refrigeration
- Solar drying
- Solar cooking
- Solar electricity – thermal

- photo-conversion

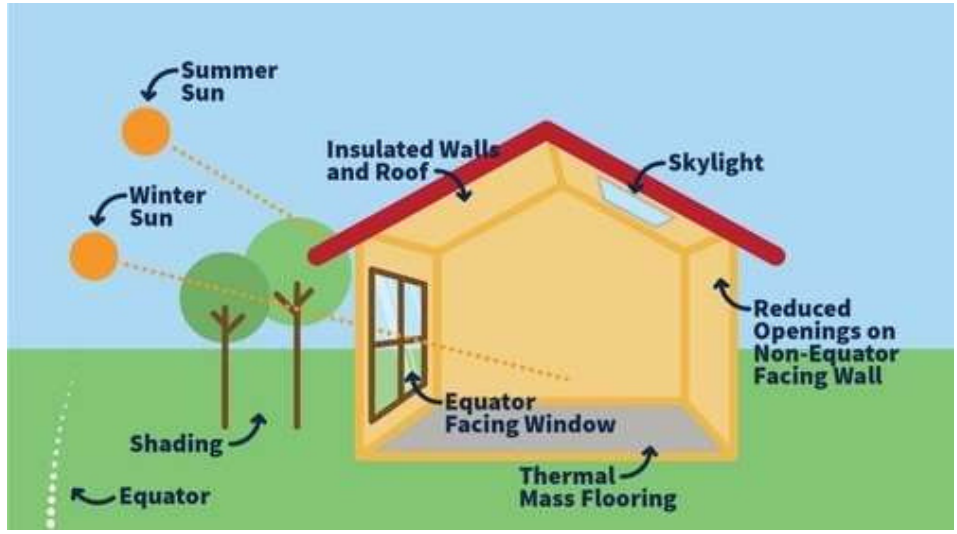
- Solar greenhouses
- Solar furnaces
- Solar desalination
- Salt production
- Solar electricity -
- photovoltaic

SOLAR WATER HEATING

Glass panels on roof collect & absorb heat - heat water

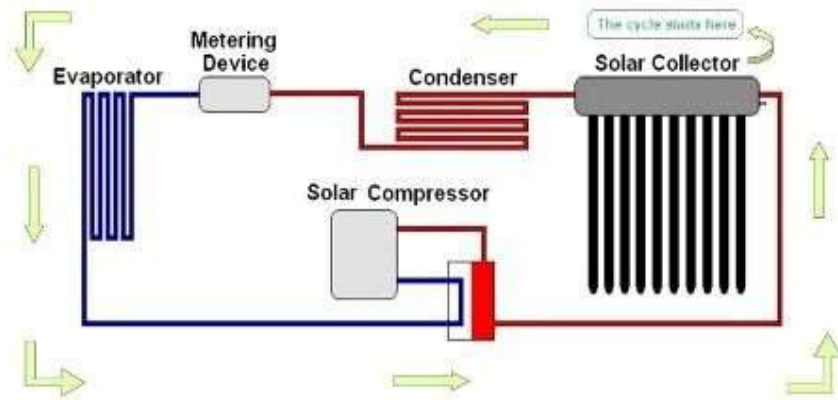
SOLAR SPACE HEATING OF BUILDINGS

Provided architectural design of the building with large south-facing windows

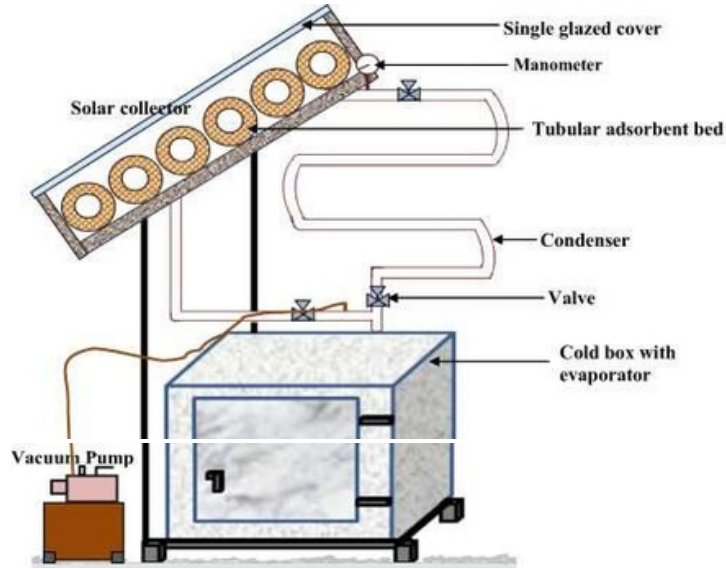


SOLAR AIR CONDITIONING

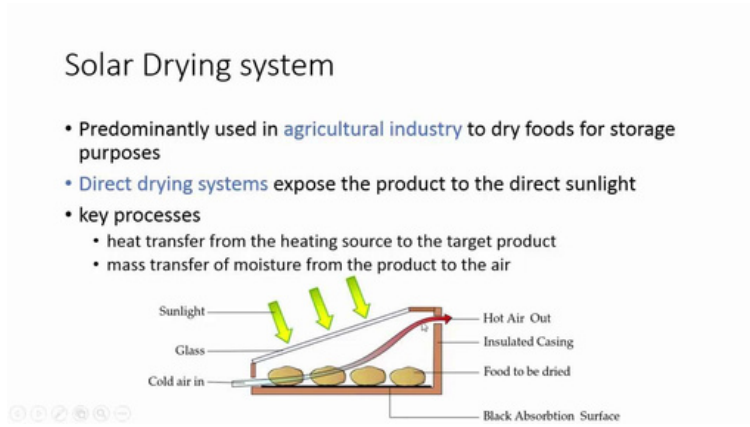
- Solar-powered AC system for buildings
- uses a solar panel (not electricity) to superheat the pressurized refrigerant



SOLAR REFRIGERATION



SOLAR DRYING



- The traditional method of utilizing direct solar energy
- Agricultural products – crops, fruits, vegetables, fish, hay, etc. all are sun driedS implest
- and cheapest way to dry

SOLAR COOKING

- It is well insulated shallow rectangular/square metal box with a flat glass cover - blackened inside (to increase the temperature)
- heat absorbed by the more blackened surface is used for cooking

SOLAR GREENHOUSE

The greenhouse is a closed structure covered with a transparent material(glass/plastic)
Utilize solar energy for the growth of plants

SOLAR FURNACES

- Use huge array of mirrors to concentrate the sun's energy into a small area & produce very high temperature
- Can produce around 35000C
- Can be used to melt refractory

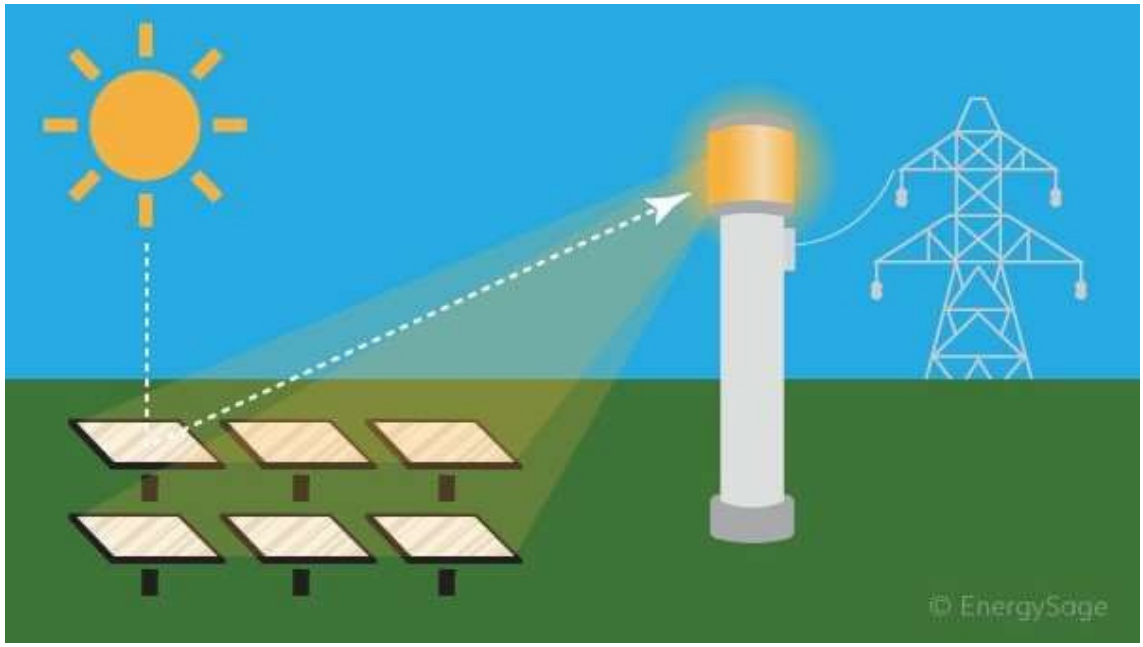
SALT PRODUCTION

Traditional method to obtain salt

SOLAR DESALINATION

- Solar radiation passed through glass cover and is absorbed and converted into heat, which evaporates the water in the saline water
- The produced vapor is condensed to form purified water & collected from the underside of flat sloping roof

SOLAR ELECTRICITY - THERMAL



Solarenergyisusedtoheatafluid&runstheturbine- generates electricity

SOLAR ELECTRICITY - PHOTOVOLTAIC

Made of semiconducting materials – that converts sunlight directly into electricity

Case: Cochin International airport Ltd

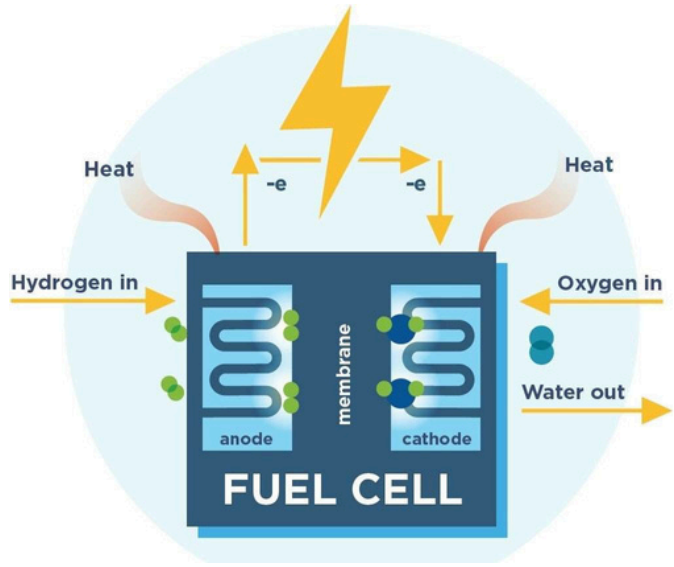
- World's first airport - that completely operates on solar power. --- 18 August 2015th
- Comprise - 46,150 solar panels laid across 45 acres near cargo complex.
- 12 MWp solar power plant – producing 50,000 to 60,000 units of electricity per day
- This is a grid connected system without battery storage and a power banking module

- with the Kerala State electricity board (KSEB) has been worked out-
  wherein, CIAL gives as much power it produces (in day time) to (the grid of) KSEB and'
- buy ' back the power from them when needed (especially in night).
  Reduce carbon emissions equal to 1.75 lakh MT for the next 25 years. This is equal to planting 30 lakh trees.

FUEL CELLS

Adevice thatgenerates electricity by a chemical reaction every fuel cell has

1. 2 electrodes Onepositive-anode&otheronenegative-cathodeanelectrolyte
2. An electrolyte Whichcarrieselectricallychargedparticlesfromoneelectrode to another
3. A catalyst Which speeds the reaction at the electrodes



- hydrogen is the basic fuel, but fuel cells also require oxygen
- fuel cells generate electricity with very little pollution
- Only byproduct - water

WIND ENERGY

Windmills–are erected at high altitudes & its blades are attached to the turbines

As the blades rotate, the kinetic energy of the wind can be used to run the turbines, which run the generator and generates electricity.

Turbines generally require a wind speed of 20km/hr. Coastal areas, at top of rounded hills, open plains, gaps in mountains

places where the wind is strong and reliable

HYDRO-ELECTRIC POWER

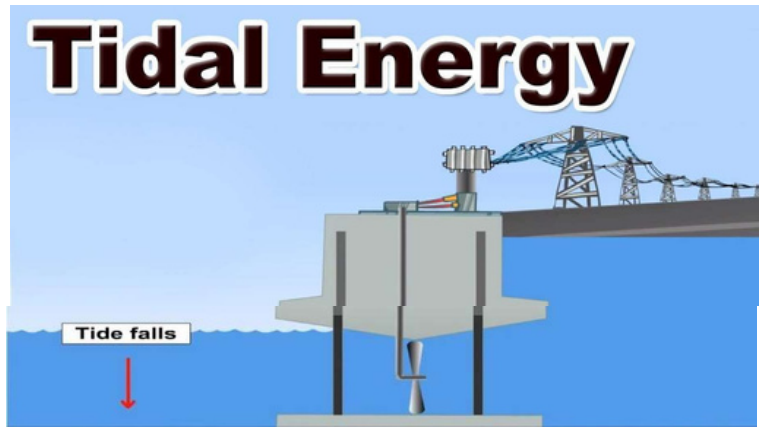
Dam

- Gravitational potential energy is stored in the water above the dam
- As water flows from higher elevation to lower elevation through penstock and it attains kinetic energy
- It arrives at the turbines at high pressure and turns it and thus drives the generators and generates electricity
- Classified based on station capacity

1. Micro hydropower: < 100 kW
2. Mini hydropower: 101 – 2000 kW
3. Small hydropower: 2001 – 25000 kW

ENERGY DERIVEDFROM OCEAN

ENERGY DERIVED FROM TIDES



ADVANTAGES OF TIDAL POWER

1. Once we've built it, tidal power is free
2. Not produce greenhouse gases or other waste
3. It produces electricity reliably

CATEGORIES OF TIDAL POWER

1. Tidal stream systems
2. Barrages
3. Tidal lagoons

ENERGY DERIVED FROM WAVES

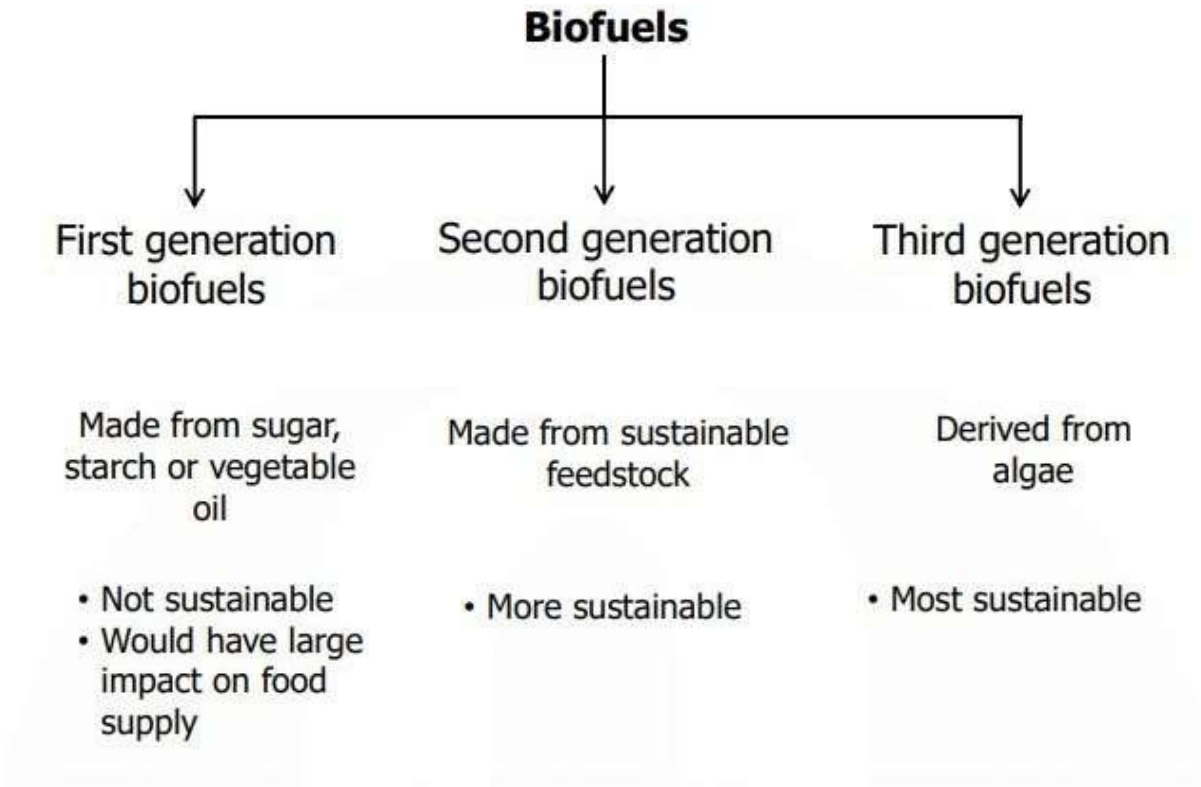
- Ocean waves are caused by the wind as it blows across the sea.
- But it's not easy to trap this energy and convert it into electricity in large amounts. Thus, wave power stations are rare
- At a wave power station – the incoming waves cause the water in the chamber to rise and fall, which

DISADVANTAGES OF WAVE POWER

- Depends on waves - sometimes wave energy will be more and sometimes almost nil
- Needs a suitable site where waves are consistently strong
- Some designs are noisy

BIOFUELS

- Biofuels are fuels derived from biomass.
- Biomass is any organic material that has stored sunlight in the form of chemical energy Plants use chlorophyll to convert the solar energy to stored energy in the plants by a process called photosynthesis.
- As a fuel, biomass may include wood, wood waste, straw, manure, sugarcane, and many other by-products from a variety of agricultural processes. They can be burnt to produce energy.



Biofuels that can be derived from biomass: Examples

1. Bio alcohols
2. Biodiesel
3. Bio ethers
4. Biogas
5. Green diesel (Green diesel is produced through a refining process, rather than through a chemical reaction.)

Geothermal energy

- It is the energy obtained by tapping the heat of the earth itself, usually from kilometers deep into the earth's crust.
- Geothermal energy can be tapped in two ways.

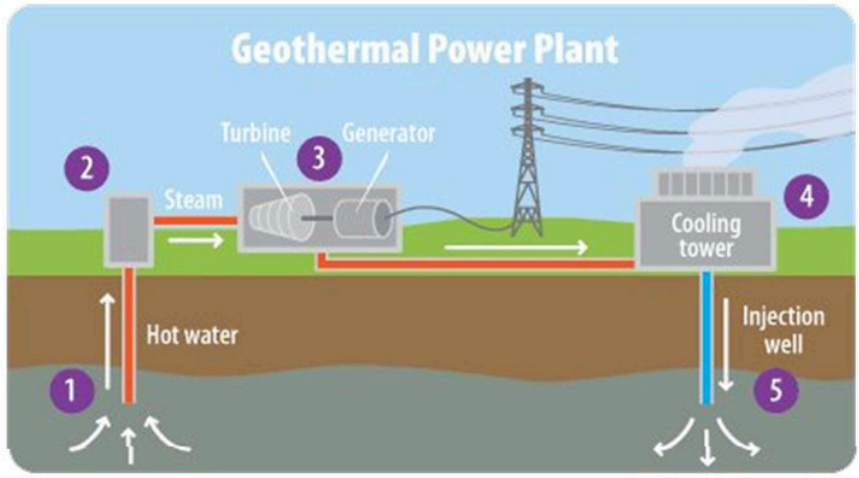
1. Geothermal power plants.

2. Geothermal heat pumps

1. Geothermal power plants

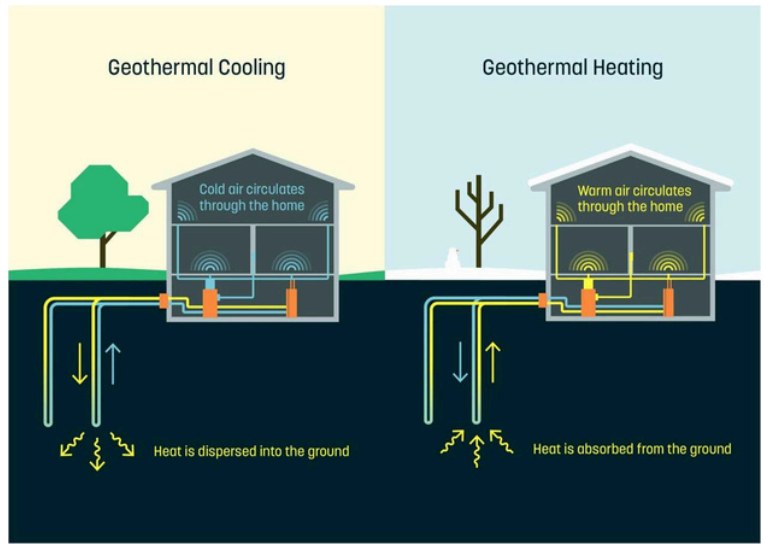
- Geothermal power plants use heat from deep inside the earth to generate steam to make electricity.
- Wells are driven deep into the earth.
- There will be a set of pumping well and injection well.

Geothermal power plants: Working



- Hot water is pumped from deep underground through a well under high pressure.
- When the water reaches the surface, the pressure is dropped, which causes the water to turn into steam.
- The steam spins a turbine, which is connected to a generator that produces
- electricity The steam cools off in a cooling tower and condenses back to the water.
- The cooled water is pumped back into the Earth to begin the process again

Geothermal Heat Pumps



- Geothermal power pumps tap heat from shallow reservoirs close to the earth's surface.
- These systems transfer heat by pumping water or a refrigerant through pipes just below the earth's surface.
- During the winter season, the pumped water or refrigerant from the building absorbs

warmth from beneath the earth and brings heat to the building.

- In summer, some heat pumps can run in reverse and bring coolness to the building.

Geothermal Heat Pumps: Working

Water or a refrigerant move through a loop of pipes. ‰ When the weather is cold, the water or refrigerant heats up as it travels through part o of the loop buried underground.

Once it gets back above ground, the warmed water or refrigerant transfers heat into the building. ‰ The water or refrigerant cools down after its heat is transferred. It is pumped back underground where it heats up once more, starting the process again. ‰

On a hot day, the system can run in reverse. The water or refrigerant cools the building and then is pumped underground where extra heat is transferred to the ground around the pipes.

Geothermal Heat Pumps: Advantages

- Inexhaustible and renewable energy
- source. Non-polluting and eco-friendly source
- An excellent supplement to other renewable
- sources. Not affected by seasonal changes.

Disadvantages

- Not available on many occasions.
- The overall efficiency of power production is low.