NEHRU COLLEGE OF ENGINEERING AND RESEARCH CENTRE
(NAAC 'A' Accredited)
(Approved by AICTE, Affiliated to APJ Abdul Kalam Technological University, Kerala)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

COURSE MATERIALS

MCN 201 SUSTAINABLE ENGINEERING

VISION OF THE INSTITUTION

To mould true citizens who are millennium leaders and catalysts of change through excellence in education.

MISSION OF THE INSTITUTION

NCERC is committed to transform itself into a center of excellence in Learning and Research in Engineering and Frontier Technology and to impart quality education to mould technically competent citizens with moral integrity, social commitment and ethical values.

We intend to facilitate our students to assimilate the latest technological know-how and to imbibe discipline, culture and spiritually, and to mould them in to technological giants, dedicated research scientists and intellectual leaders of the country who can spread the beams of light and happiness among the poor and the underprivileged.

ABOUT DEPARTMENT

- Established in: 2002
- Course offered : B.Tech in Computer Science and Engineering

  M.Tech in Computer Science and Engineering

  M.Tech in Cyber Security
- Approved by AICTE New Delhi and Accredited by NAAC
- Affiliated to the University of A P J Abdul Kalam Technological University.

DEPARTMENT VISION

Producing Highly Competent, Innovative and Ethical Computer Science and Engineering Professionals to facilitate continuous technological advancement.

DEPARTMENT MISSION

1. To Impart Quality Education by creative Teaching Learning Process
2. To Promote cutting-edge Research and Development Process to solve real world problems with emerging technologies.
3. To Inculcate Entrepreneurship Skills among Students.
4. To cultivate Moral and Ethical Values in their Profession.

PROGRAMME EDUCATIONAL OBJECTIVES

PEO 1: Graduates will be able to Work and Contribute in the domains of Computer Science and Engineering through lifelong learning.

PEO 2: Graduates will be able to Analyze, design and development of novel Software Packages, Web Services, System Tools and Components as per needs and specifications.

PEO 3: Graduates will be able to demonstrate their ability to adapt to a rapidly changing environment by learning and applying new technologies.

PEO 4: Graduates will be able to adopt ethical attitudes, exhibit effective communication skills, Team work and leadership qualities.

PROGRAM OUTCOMES (POS)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics,

natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1: Ability to Formulate and Simulate Innovative Ideas to provide software solutions for Real-time Problems and to investigate for its future scope.

PSO2: Ability to learn and apply various methodologies for facilitating development of high quality System Software Tools and Efficient Web Design Models with a focus on performance optimization.

PSO3: Ability to inculcate the Knowledge for developing Codes and integrating hardware/software products in the domains of Big Data Analytics, Web Applications and Mobile Apps to create innovative career path and for the socially relevant issues.

SUBJECT CODE: C206		
COURSE OUTCOMES		
C206.1	K2	**Understand** the concepts of sustainability and associated global initiatives and protocols.
C206.2	K4	**Analyze** different types of environmental pollution problems and provide appropriate solutions
C206.3	K2	**Understand** various environmental regulations and standards.
C206.4	K1	**Outline** the concepts of conventional and non-conventional energy
C206.5	K5	**Demonstrate** various sustainable practices using engineering knowledge and technology

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C206.1	-	-	-	-	-	2	3	-	-	-	-	2
C206.2	-	-	-	-	-	3	3	-	-	-	-	2
C206.3	-	-	-	-	-	2	3	-	-	-	-	2
C206.4	-	-	-	-	-	3	3	-	-	-	-	3
C206.5	-	-	-	-	-	3	3	2	-	-	-	3
C206	-	-	-	-	3	2.6	3	2	-	-	-	2.4

CO'S	PSO1	PSO2	PSO3
C206.1	-	-	-
C206.2	3	-	-
C206.3	-	-	-
C206.4	-	-	-
C206.5	3	-	-
C206	3	-	-

Syllabus

Sustainability- need and concept, technology and sustainable development-Natural resources and their pollution, Carbon credits, Zero waste concept. Life Cycle Analysis, Environmental Impact Assessment studies, Sustainable habitat, Green buildings, green materials, Energy, Conventional and renewable sources, Sustainable urbanization, Industrial Ecology.

Module 1

Sustainability: Introduction, concept, evolution of the concept; Social, environmental and economic sustainability concepts; Sustainable development, Nexus between Technology and Sustainable development; Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs), Clean Development Mechanism (CDM).

Module 2

Environmental Pollution: Air Pollution and its effects, Water pollution and its sources, Zero waste concept and 3 R concepts in solid waste management; Greenhouse effect, Global warming, Climate change, Ozone layer depletion, Carbon credits, carbon trading and carbon foot print, legal provisions for environmental protection.

Module 3

Environmental management standards: ISO 14001:2015 frame work and benefits, Scope and goal of Life Cycle Analysis (LCA), Circular economy, Bio-mimicking, Environment Impact Assessment (EIA), Industrial ecology and industrial symbiosis.

Module 4

Resources and its utilisation: Basic concepts of Conventional and non-conventional energy, General idea about solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans and Geothermal energy.

Module 5

Sustainability practices: Basic concept of sustainable habitat, Methods for increasing energy efficiency in buildings, Green Engineering, Sustainable Urbanisation, Sustainable cities, Sustainable transport

QUESTION BANK

Q:NO:	QUESTIONS	CO	KL	PAGE NO:
	MODULE I			
1	Define sustainable development	CO1	K1	9
2	Write a short note on Millennium Development Goals	CO1	K3	13
3	Define Sustainability.	CO1	K1	9
4	Write a short note on the need of sustainability	CO1	K3	10
5	Explain sustainability with respect to social, economical, environmental concept.	CO1	K2	11
6	Explain the link between Sustainable Development and Technology	CO1	K2	12
7	Explain the purpose of Clean Development Mechanism.	CO1	K2	13
8	List out sustainable development goals.	CO1	K3	12
9	What are the eight goals of millennium development?	CO1	K2	12
10	Compare sustainable development goals andmillennium development goals.	CO1	K3	12
	MODULE II			
1	Explain air pollution and its effect**.**	CO2	K2	16
2	What are the source of water pollution?	CO2	K1	17
3	Briefly explain zero waste concept.	CO2	K2	27
4	How to apply 3R concept for waste management.	CO2	K2	28
5	What are the methods to reduce air pollution?	CO2	K1	18
6	What are the methods to reduce water pollution?	CO2	K1	22
7	What are the after effect of air pollution?	CO2	K1	17
8	Write a short note on global warming and ozone layer depletion.	CO2	K2	30
9	Discuss in detail about carbon credits and carbon trading.	CO2	K3	35
10	Compare carbon credits and carbon footprint .	CO2	K3	38
	MODULE III			

1	Explain environmental management standards in detail.	CO3	K2	40
2	Discuss in detail about life cycle analysis.	CO3	K3	41
3	List out the goals of LCA.	CO3	K2	43
4	Discuss the scope of LCA in detail.	CO3	K3	43
5	Define bio-mimicking. Give two example for bio-mimicking.	CO3	K1	45
6	Explain environment impact assessment (EIA).	CO3	K2	46
	MODULE IV			
1	What are the basic concepts of conventional and non - conventional energy resources?	CO4	K2	50
2	Compare conventional and non - conventional energy resources.	CO4	K3	50
3	Compare renewable and non- renewable energy resources.	CO4	K3	50
4	With a neat sketch explain the working of small hydro power plant.	CO4	K3	61
5	Give general idea about solar energy.	CO4	K2	51
6	Explain Energy derived from oceans.	CO4	K2	66
7	Explain the working of a fuel cell with fig.	CO4	K2	59
	MODULE V			
1	What are the basic concepts sustainable habitat?	CO5	K1	71
2	What are Methods for increasing energy efficiency in buildings.	CO5	K2	71
3	Write a short note on green building.	CO5	K3	71
4	Explain sustainable cities in detail.	CO5	K2	75
5	Write a short note on sustainable transport.	CO5	K3	76

APPENDIX 1

CONTENT BEYOND THE SYLLABUS

MODULE 1
SUSTAINABILITY

INTRODUCTION TO SUSTAINABILITY

- Sustainability means meeting our own needs without compromising the ability of future generations to meet their own needs. In addition to natural resources, we also need social and economic resources. Sustainability is not just environmentalism. Embedded in most definitions of sustainability we also find concerns for social equity and economic development.

- While the concept of sustainability is a relatively new idea, the movement as a whole has roots in social justice, conservationism, internationalism and other past movements with rich histories. By the end of the twentieth centuries, many of these ideas had come together in the call for _sustainable development.‘

- development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

- Sustainability is a holistic approach that considers ecological, social and economic dimensions, recognizing that all must be considered together to find lasting prosperity.

SUSTAINABILITY- NEED & CONCEPT

Sustainability has three components, which are inter-related

1. Environment
2. Society
3. Economy

Environment gives resources, raw materials to the Economy for production activities. Economy creates products and sells it to society for use. Production by Economy and Consumption by Society lead 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 - type of land degradation in which a land region becomes dry, typically losing its water bodies, vegetation and wildlife.
7. Eutrophication - form of water pollution occurs when excessive fertilizers run into lakes and rivers. This encourages the overgrowth of algae and other aquatic plants.

8. Global Warming - 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, sulphur oxides, Fluorocarbons

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

1. Fresh water scarcity
2. Climate change
3. Exposure to toxics 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 of sustainability is to reduce these damages and create a livable planet earth for the 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 economic growth of the poorer section, so as to reduce the gap between nations. Sustainability means balancing environment, society and economy.

Three pillars of sustainability

Environmental Sustainability

Ecological integrity is maintained, all of earth‘s environmental systems are kept in balance while natural resources within them are consumed by humans at a rate where they are able to replenish themselves. ***Environmental sustainability*** is the rates of renewable resource harvest, pollution creation, and non-renewable resource depletion that can be continued indefinitely. If they cannot be continued indefinitely then they are not sustainable

Environmental sustainability is defined as responsible interaction with the environment to avoid depletion or degradation of natural resources and allow for long-term environmental quality. The practice of environmental sustainability helps to ensure that the needs of today's population are met without jeopardizing the ability of future generations to meet their needs.

When we look at the natural environment, we see that it has a rather remarkable ability to rejuvenate itself and sustain its viability. For example, when a tree falls, it decomposes, adding nutrients to the soil. These nutrients help sustain suitable conditions so future saplings can grow.

When nature is left alone, it has a tremendous ability to care for itself. However, when man enters the picture and uses many of the natural resources provided by the environment, things change. Human actions can deplete natural resources, and without the application of environmental sustainability methods, long-term viability can be compromised.

Environmental Aspects

υ Prudent exploitation of natural resources so that it can be used for a longer period.

υ For non renewable find substitutes

υ For renewable, give time to replenish

υ Minimize the impact on the environment during waste disposal.

Economic Sustainability

Human communities across the globe are able to maintain their independence and have access to the resources that they require, financial and other, to meet their needs. Economic systems are intact and activities are available to everyone, such as secure sources of livelihood.

Economic Aspects

υ The expenditure and revenue generation

υ Steady and sufficient food availability in an economic way

υ Economic use of raw materials

υ Economic production patterns

υ Steady rate of productivity

Social Sustainability

Universal human rights and basic necessities are attainable by all people, who have access to enough resources in order to keep their families and communities healthy and secure. Healthy communities have just leaders who ensure personal, labour and cultural rights are respected and all people are protected from discrimination.

Social sustainability occurs when the formal and informal processes; systems; structures; and relationships actively support the capacity of current and future generations to create healthy and livable communities. Socially sustainable communities are equitable, diverse, connected and democratic and provide a good quality of life

Social sustainability is a process for creating sustainable successful places that promote wellbeing, by understanding what people need from the places they live and work. Social sustainability combines design of the physical realm with design of the social world – infrastructure to support social and cultural life, social amenities, systems for citizen engagement, and space for people and places to evolve.

The ability of a community to develop processes and structures which not only meet the needs of its current members but also support the ability of future generations to maintain a healthy community.

Social Aspects of sustainability

1) Lessening of poverty
2) Health and education status of the community
3) Adequate job opportunities
4) Protection of rights
5) Equitable access to resources
6) Elimination of gender inequality

SUSTAINABLE DEVELOPMENT

The concept of sustainable development has received much recognition after the Stockholm declaration in the year 1972. Sustainable development is the development which 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‖)

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 which is locally adaptable, eco-friendly, cost effective, resource efficient 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 centre of all learning process 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 over exploitation 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 affluent 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 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, the environmental degradation accelerates exponentially. Also the benefits of technological innovations are mostly enjoyed by the developed countries. The technology remains as 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

Sustainable development goals

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

Millennium Development Goals

The 8 Millennium Development Goals

- Eradicate extreme poverty and hunger.
- Achieve **universal primary education**.
- Promote gender equality and empower women.
- Reduce child mortality.
- Improve maternal health.
- **Combat HIV/AIDS**, malaria, and other diseases.
- Ensure **environmental sustainability**.
- Develop a global partnership for development.

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 (CO2) emitted to the atmosphere. Developed countries can use CERs to more costeffectively 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 green house 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.

MODULE 2

Pollution is the introduction of contaminants into the natural environment that cause adverse change. Pollution can take the form of chemical substances or energy, such as noise, heat, or light. Pollutants, the components of pollution, can be either foreign substances/energies or naturally occurring contaminants. Pollution is often classed as point source or nonpoint source pollution. In 2015, pollution killed 9 million people worldwide.

Major forms of pollution include air pollution, light pollution, litter, noise pollution, plastic pollution, soil contamination, radioactive contamination, thermal pollution, visual pollution, and water pollution.

The major forms of pollution are listed below along with the particular contaminant relevant to each of them:

- Air pollution: the release of chemicals and particulates into the atmosphere. Common gaseous pollutants include carbon monoxide, sulfur

dioxide, chlorofluorocarbons (CFCs) and nitrogen oxides produced by industry and motor vehicles. Photochemical ozone and smog are created as nitrogen oxidesand hydrocarbons react to sunlight. Particulate matter, or fine dust is characterized bytheir micrometre size PM_{10} to $PM_{2.5}$.

- Electromagnetic pollution: the overabundance of electromagnetic radiation in their non-ionizing form, like radio waves, etc, that people are constantly exposed at, especially in large cities. It's still unknown whether or not those types of radiation have any effects on human health, though.
- Light pollution: includes light trespass, over-illumination and astronomical interference.
- Littering: the criminal throwing of inappropriate man-made objects, unremoved, onto public and private properties.
- Noise pollution: which encompasses roadway noise, aircraft noise, industrial noise as well as high-intensity sonar.
- Plastic pollution: involves the accumulation of plastic products and microplastics in the environment that adversely affects wildlife, wildlife habitat, or humans.
- Soil contamination occurs when chemicals are released by spill or underground leakage. Among the most significant soil contaminants are hydrocarbons, heavy metals, MTBE, herbicides, pesticides and chlorinated hydrocarbons.
- Radioactive contamination, resulting from 20th century activities in atomic physics, such as nuclear power generation and nuclear weapons research, manufacture and deployment. (See alpha emitters and actinides in the environment.)
- Thermal pollution, is a temperature change in natural water bodies caused by human influence, such as use of water as coolant in a power plant.
- Visual pollution, which can refer to the presence of overhead power lines, motorway billboards, scarred landforms (as from strip mining), open storage of trash, municipal solid waste or space debris.
- Water pollution, by the discharge of wastewater from commercial and industrial waste (intentionally or through spills) into surface waters; discharges of untreated domestic sewage, and chemical contaminants, such as chlorine, from treated sewage;

release of waste and contaminants into surface runoff flowing to surface waters (including urban runoff and agricultural runoff, which may contain chemical fertilizers and pesticides; also including human feces from open defecation – still a major problem in many developing countries); groundwater pollution from waste disposal and leaching into the ground, including from pit latrines and septic tanks; eutrophication and littering

Air Pollution

Air pollution is the introduction of particulates, biological molecules, or other harmful materials into Earth's atmosphere, causing diseases, allergies, death to humans, damage to other living organisms such as animals and food crops, or the natural or built environment.

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 emitted from factories

Secondary pollutants are the ones that are caused by the inter mingling and reactions of primary pollutants. Smog created by the interactions of several primary pollutants is known to be as 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 the major cause of air pollution. Pollution emitting from vehicles including trucks, jeeps, cars, trains, airplanes cause immense amount of pollution. We rely on them tofulfill our daily basic needs of transportation. But, there overuse is killing our environment as dangerousgases are polluting the environment. Carbon Monoxide

caused by improper or incomplete combustionand generally emitted from vehicles is another major pollutant along with Nitrogen Oxides, that is produced from both natural and man-made processes.

 Agricultural activities: Ammonia is a very common by product from agriculture related activities andis one of the most hazardous gases in the atmosphere. 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 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 larg equipments. During the process dust and chemicals are released in the air causing massive air pollution. This is one of the reason 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 millions 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 combines with these air pollutants, becomes acidic and then falls on the ground in the form of acid rain. Acid rain can cause great damage to human, 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 place and change their habitat.The toxic pollutants deposit over the surface of the water and can also affect aquatic organisms.

 Depletion of Ozone layer: Ozone exists in 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, hydro chlorofluorocarbons in the atmosphere. Thin ozone layer allows the passage of harmful UV rays onto earth and can cause skin and eye related problems. UV rays also have the capability to affect crops.

Methods to reduce Air Pollution

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

 Conserve energy: Switch off fans and lights when you are going out. Large amount of fossil fuels are burnt to produce electricity. We can save the environment from degradation by reducing the amount 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 home. This will go a long way to curb air pollution.

 Use energy efficient devices: CFL lights consume less electricity as against 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 irregularit ies in pollutants level in 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.

Sources of Water Pollution

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 traveled through several regions may also be considered as a Non point source of pollution.

Causes of Water Pollution

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

 Sewage and waste water: The sewage and waste water that is produced by each household is chemically treated and released in to sea with fresh water. The sewage water carries harmful bacteria and chemicals that can cause serious health problems. Pathogens are known as acommon water pollutant. Microorganisms in water are known to be causes of some very deadly diseases and become the breeding grounds for other creatures that act like carriers. These carriersinflict these diseases via various forms of contact onto an individual. Eg:- Malaria.

 Mining activities: Mining is the process of crushing the rock and extracting coal and other minerals from underground. These elements when extracted in the raw form contains harmful chemicals and can increase the amount of toxic elements when mixed up with water which may result in health problems.

Mining activities emit several metal waste and sulphides 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 large amount of oil enters into the sea and does not dissolve with water; there by opens problem for local marine wildlife such as fish, birds and sea otters. For e.g.: a ship carrying 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 ocean, toxicity of pollutant.

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

 Chemical fertilizers and pesticides: Chemical fertilizers and pesticides are used by farmers to protect crops from insects and bacterias. They are useful for the plants growth. However, when these chemicals are mixed up with water produce harmful for plants and animals. Also, when it rains, the chemicals mixes up with rainwater and flow 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 the people to drink. Also, when not repaired on time, the leaking water can come on to the surface and become a breeding ground for insects andmosquitoes.

 Radioactive waste: Nuclear energy is produced using nuclear fission or fusion. The element that is used in 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 off to prevent any nuclear accident. Nuclear waste can have serious environmental hazards if not disposed off properly. Few major accidents have already taken place in Russia and Japan.

 Urban development: As 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 huge pile of garbage that produces 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 large variety of contaminants.

 Animal waste: The waste produce produce by animals is 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 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 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 toilet 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 its efflu ent 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 sho uld be strictly followed by all.

 Treatment of drainage water: It 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 good water purifier, it is recommended to drink boiled water.

 Sanitation: 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 about the effect of water pollution. Voluntary organization should go door-to-door to educate the 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

Solid waste Management

Solid waste is the unwanted or useless solid materials generated from human activities in residential, industrial or commercial areas. Solid waste management is a term that is used to refer to the process of collecting and treating solid wastes. It also offers solutions for recycling items that do not belong to garbage or trash. As long as people have been living in settlements and residential areas, garbage or solid waste has been an issue. Solid waste management should be embraced by each and every household including the business owners across the world. Various Sources of Solid Waste

 Residential: Residences and homes where people live are some of the major sources of solid waste. Garbage from these places include food wastes, plastics, paper, glass, leather, cardboard, metals, yard wastes, ashes and special wastes like bulky household items like electronics, tires, batteries, old mattresses and used oil.

 Industrial: Industries are known to be one of the biggest contributors of solid waste. They include light and heavy manufacturing industries, construction sites, fabrication plants, canning plants, power and chemical plants. These industries produce solid waste in form of housekeeping wastes, food wastes, packaging wastes, ashes, construction and demolition materials, special wastes, medical wastes as well as other hazardous wastes.

 Commercial: Commercial facilities and buildings are yet another source of solid waste today. Commercial buildings and facilities in this case refer to hotels, markets, restaurants, go downs, stores and office buildings. Some of the solid wastes generated from these places include plastics, food wastes, metals, paper, glass, wood, cardboard materials, special wastes and other hazardous wastes.

 Institutional: The institutional centers like schools, colleges, prisons, military barracks and other government centers also produce solid waste. Some of the common solid wastes obtained from these places include glass, rubber waste, plastics, food wastes, wood, paper, metals, cardboard materials, electronics as well as various hazardous wastes.

 Construction and Demolition Areas: Construction sites and demolition sites also contribute to the solid waste problem. Construction sites include new construction sites for buildings and

roads, road repair sites, building renovation sites and building demolition sites. Some of the solid wastes produced in these places include steel materials, concrete, wood, plastics, rubber, copper wires, dirt and glass.

 Municipal services: The urban centers also contribute immensely to the solid waste crisis in most countries today. Some of the solid waste brought about by the municipal services include, street cleaning, wastes from parks and beaches, wastewater treatment plants, landscaping wastes and wastes from recreational areas including sludge.

 Treatment Plants and Sites: Heavy and light manufacturing plants also produce solid waste. They include refineries, power plants, processing plants, mineral extraction plants and chemicals plants. Among the wastes produced by these plants include, industrial process wastes, unwanted specification products, plastics, metal parts just to mention but a few.

 Agriculture: Crop farms, orchards, dairies, vineyards and feedlots are also sources of solid wastes. Among the wastes they produce include agricultural wastes, spoiled food, pesticide containers and other hazardous materials.

 Biomedical: This refers to hospitals and biomedical equipment and chemical manufacturing firms. In hospitals there are different types of solid wastes produced. Some of these solid wastes include syringes, bandages, used gloves, drugs, paper, plastics, food wastes and chemicals. All these require proper disposal or else they will cause a huge problem to the environment and the people in these facilities.

Effects of Poor Solid Waste Management

 Due to improper waste disposal systems particularly by municipal waste management teams, wastes heap up and become a problem. People clean their homes and places of work and litter their surroundings which affects the environment and the community.

 Dumping of waste materials forces biodegradable materials to rot and decompose under improper, unhygienic and uncontrolled conditions. After a few days of decomposition, a foul

smell is produced and it becomes a breeding ground for different types of disease causing insects as well as infectious organisms. On top of that, it also spoils the aesthetic value of the area.

 Solid wastes from industries are a source of toxic metals, hazardous wastes, and chemicals. When released to the environment, the solid wastes can cause biological and physicochemical problems to the environment and may affect or alter the productivity of the soils in that particular area.

 Toxic materials and chemicals may seep into the soil and pollute the ground water. During the process of collecting solid waste, the hazardous wastes usually mix with ordinary garbage and other flammable wastes making the disposal process even harder and risky.

 When hazardous wastes like pesticides, batteries containing lead, mercury or zinc, cleaning solvents, radioactive materials, e-waste and plastics are mixed up with paper and other scraps are burned they produce dioxins and gasses. These toxic gases have a potential of causing various diseases including cancer.

Methods of Solid Waste Management

 Sanitary Landfill: This is the most popular solid waste disposal method used today. Garbage is basically spread out in thin layers, compressed and covered with soil or plastic foam. Modern landfills are designed in such a way that the bottom of the landfill is covered with an impervious liner which is usually made of several layers of thick plastic and sand. This liner protects the ground water from being contaminated because of leaching or percolation. When the landfill is full, it is covered with layers of sand, clay, top soil and gravel to prevent seepage of water.

 Incineration: This method involves burning of solid wastes at high temperatures until the wastes are turned into ashes. Incinerators are made in such a way that they do not give off extreme amounts of heat when burning solid wastes. This method of solid waste management can be done by individuals, municipalities and even institutions. The good thing about this method is the fact that it reduces the volume of waste up to 20 or 30% of the original volume.

 Recovery and Recycling: Recycling or recovery of resources is the process of taking useful but discarded items for next use. Traditionally, these items are processed and cleaned before they are recycled. The process aims at reducing energy loss, consumption of new material and reduction of landfills.

 Composting: Due to lack of adequate space for landfills, biodegradable yard waste is allowed to decompose in a medium designed for the purpose. Only biodegradable waste materials are used in composting. Good quality environmentally friendly manure is formed from the compost and can be used for agricultural purposes.

 Pyrolysis: This is method of solid waste management whereby solid wastes are chemically decomposed by heat without presence of oxygen. This usually occurs under pressure and at temperatures of up to 430 degrees Celsius. The solid wastes are changed into gases, solid residue and small quantities of liquid.

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 one 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 andtoxicity 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, it 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 take 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 etc

 Reduce number of components in product design

 Minimise 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 fit 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 environment and natural resources.

 Reduces energy consumption

 Reduces pollution, global warming etc

 Reduces waste generation

 Creates jobs at recycling sites.

Green House Effect

Greenhouse effect is a natural phenomenon which refers to the rise in temperature of the earth due to the presence of certain greenhouse gases (watervapour, 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(150 C).But the excess amount of greenhouse gases will create problems . Excess amount of greenhouse gases will create excess hot conditions all over the earth.

Global Warming

Global Warming is the increase of Earth's average surface temperature due to the presence of 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, sulphur hexafluoride, hydro fluorocarbons and perfluorocarbons.

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 live stock (animal farm)

Global Warming Impacts

1. Rising Seas--- inundation of fresh water 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

- 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 3R concept whenever possible.
- Reduce energy consumption at home, office etc

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 naturalfactors 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 an 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. Burning of fossil fuels produce CO2 ,which spreads into the atmosphere leading to global warming and increase in the temperature.

 Deforestation: When trees are cut down on a large scale, the amount of atmospheric CO2 increases, leading to global warming and increase in the temperature.

 Population growth, urbanization and 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 amount of greenhouse gases resulting in global climatic changes.

Effects of climatic change

 Increase in global surface temperature: climatic changes lead to increase in temperature levels all over the world and thereby disturbing the balance of whole eco-system.

 Changes in climate can put pressure on the whole natural system, leading to ecological imbalance.

 Melting of glaciers : It leads to rise in sea levels

 Ocean acidification: oceans absorb CO2 into the atmosphere, making them more acidic.

 Availability of fresh water decreases.

 Changes in rainfall pattern (high and low rainfall) may occur.

 Occurrence of drought, heat waves and flood.

 Breeding pattern, migration pattern 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 3R concept whenever possible.

 Reduce energy consumption at home, office

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 the 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 1percent decrease in ozone layer results in a 2-5 percent increase in the occurrence of skin cancer. Other ill-effects of the reduction of protective ozone layer include – increase in the incidence of cataracts, sunburns and suppression of the immune system. Human activities had resulted in considerable reduction in the ozone layer of the atmosphere. Ozone depletion occurs when destruction of the stratospheric ozone is more than the production of the molecule. The scientists have observed reduction in stratospheric ozone since 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, CH3CCl3 (Methyl chloroform), CCl4 (Carbon tetrachloride), HCFCs (hydro-chlorofluorocarbons), hydrobromofluorocarbons and methyl bromide are found to have 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
- Coolants in refrigerators
- Air conditioning
- 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 remains in the atmosphere for quite a long time. With so much stability, they are transported into the stratosphere. The emission of ODS account for roughly 90% of total depletion of ozone layer in stratosphere. These gases are carried to the stratosphere layer of atmosphere where ultraviolet radiations from the sun break them to release chlorine (from CFCs) and bromine (from methyl bromide and halons). The chlorine and brominefree radicals react with ozone molecule and destroy their molecular structure, thus depleting the ozone layer.

- Halogen molecules in CFC_s ($CFCl_3$) are converted into an active free radical by photochemical decomposition:

$CFCl_3 + hv \rightarrow CFCl_2 + Cl$

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

$Cl + O_3 \rightarrow ClO + O_2$

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

$O_3 + h\nu \rightarrow O_2 + O$

$O + ClO \rightarrow O_2 + Cl$

- 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 Montreal Protocol in the year 1987 has helpedto 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 CO_2 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, industry or private individuals to offset damaging carbon emissions that they are generating. Thus carbon credits are used as a permit to emit 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

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 engagein trade with each other.

	Company A	Company B
Alloted :	10 carbon credits	12 Carbon credits
Used :	8 carbon credits	14 carbon credits
	2 carbon credits not used	2 carbon credits overused

Here company A can sell 2 carbon credits to company B for financial benefit. Thus a carbon market is created.

How Does Carbon Credits Work?

Carbon credits are typically measured in tonnes of CO2-equivalents (or CO2e) and are bought and sold through 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 comply with the 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 carbonoffsets. 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 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 is 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 CO2, depending on its fuel consumption andthe driving distance. When you heat your house with oil, gas or coal, then you also generate CO2. Even if you use electricity, the generation of the electrical power may also have emitted a certain amount of CO2 (thermal power plants). When you buy food and goods, the production of the food and goods also emitted some quantities of CO2.Your carbon footprint is the sum of all emissions of CO2 (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.

Carbon footprint

Primary footprint—direct emission of carbon dioxide as in the case of burning of fossil fuels

Secondary footprint --- indirect emissions associated with 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 which 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 way to give it back to the environment is to plant trees. Plants absorb CO2 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.

MODULE 3

ENVIRONMENTAL MANAGEMENT SYSTEMS (EMS)

• Population explosion, rapid industrial growth –depletion of natural resources- unsustainable.

• Environmental management came as a response to the increasing seriousness of the human impact on our environment.

• Impacts – controlled – applying a systematic approach.
• 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 landfill.
• Set environment friendly purchasing procedures.

Basis EMS framework PDCA Cycle

• Plan-Do-Check-Act

Plan : Planning, identifying environmental aspects and establishing goals in accordance with the organizations environmental policy

Do : Implement the planned processes which includes
training and operational controls

Check : Checking (monitoring) and corrective actions Act Reviewing, includes progress reviews and actions to make needed changes which continually improve performance of the environmental management system

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

• Series of internationally recognized standards for structuring the EMS of an organization and managing the environmental performance of the system to induce environmental improvement and cost savings.

• Managed by the International Organization for Standardization (ISO)

Elements of ISO 14000 EMS

• Formulate and design policy and objectives in this regard.

• Formulate a plan to implement the policy and objectives.

• Develop the capabilities and support system to achieve the implementation of policy objectives.

• Monitor and evaluate the environmental performance.

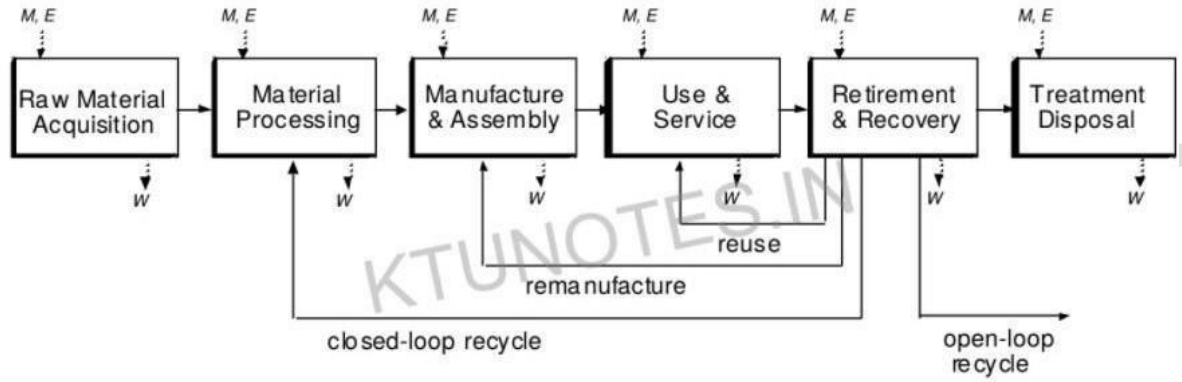
• Review the EMS for continued improvement.

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.

Product Life Cycle



M, E = Material and Energy inputs to process and distribution
W = Waste (gas, liquid, or solid) output from product, process, or distribution

Material flow of product component

Life-cycle assessment or **LCA** (also known as **life-cycle analysis**) is a methodology for assessing environmental impacts associated with all the stages of the life-cycle of a commercial product, process, or service. For instance, in the case of a manufactured product, environmental impacts are assessed from raw material extraction and processing (cradle), through the product's manufacture, distribution and use, to the recycling or final disposal of the materials composing it (grave)

An LCA study involves a thorough inventory of the energy and materials that are required across the industry value chain of the product, process or service, and calculates the corresponding emissions to the environment.[2] LCA thus assesses cumulative potential environmental impacts. The aim is to document and improve the overall environmental profile of the product.

Widely recognized procedures for conducting LCAs are included in the 14000 series of environmental management standards of the International Organisation for Standardisation (ISO), in particular, in ISO 14040 and ISO 14044. ISO 14040 provides the 'principles and framework' of the Standard, while ISO 14044 provides an outline of the

'requirements and guidelines'. Generally, ISO 14040 was written for a managerial audience and ISO 14044 for practitioners. As part of the introductory section of ISO 14040, LCA has been defined as the following:

LCA studies the environmental aspects and potential impacts throughout a product's life cycle (i.e. cradle-to-grave) from raw materials acquisition through production, use and disposal. The general categories of environmental impacts needing consideration include resource use, human health, and ecological consequences.

Goal and Scope

Life Cycle Inventory (LCI) analysis involves creating an inventory of flows from and to nature (ecosphere) for a product system. It is the process of quantifying raw material and energy requirements, atmospheric emissions, land emissions, water emissions, resource uses, and other releases over the life cycle of a product or process. In other words, it is the aggregation of all elementary flows related to each unit process within a product system.

To develop the inventory, it is often recommended to start with a flow model of the technical system using data on inputs and outputs of the product system. The flow model is typically illustrated with a flow diagram that includes the activities that are going to be assessed in the relevant supply chain and gives a clear picture of the technical system boundaries. Generally, the more detailed and complex the flow diagram, the more accurate the study and results. The input and output data needed for the construction of the model is collected for all activities within the system boundary, including from the supply chain (referred to as inputs from the technosphere).

According to ISO 14044, an LCI should be documented using the following steps:

1. Preparation of data collection based on goal and scope
2. Data Collection
3. Data Validation (even if using another work's data)
4. Data Allocation (if needed)
5. Relating Data to the Unit Process
6. Relating Data to the Functional Unit
7. Data Aggregation

As referenced in the ISO 14044 standard, the data must be related to the functional unit, as well as the goal and scope. However, since the LCA stages are iterative in nature, the data collection phase my cause the goal or scope to change. Conversely, a change in the goal or scope during thecourse of the study may cause additional collection of data or removal or previously collected data in the LCI.

The output of an LCI is a compiled inventory of elementary flows from all of the processes in the studied product system(s). The data is typically detailed in charts and requires a structured approach due to its complex nature.

When collecting the data for each process within the system boundary, the ISO LCA standard requires the study to measure or estimate the data in order to quantitatively represent each process in the product system. Ideally, when collecting data, a practitioner should aim to collect data from primary sources (e.g. measuring inputs and outputs of a process on-site or other physical means). Questionnaire are frequently used to collect data on-site and can even be issued to the respective manufacturer or company to complete. Items on the questionnaire to be recorded may include:

1. Product for Data Collection
2. Data Collector and Date
3. Period of Data Collection
4. Detailed Explanation of the Process
5. Inputs (raw materials, ancillary materials, energy, transportation)
6. Outputs (emissions to air, water, and land)
7. Quantity and Quality of each input and output

Often times, the collection of primary data may be difficult and deemed proprietary or confidential by the owner. An alternative to primary data is secondary data, which is data that comes from LCA databases, literature sources, and other past studies. With secondary sources, it is often you find data that is similar to a process but not exact (e.g. data from a different country, slightly different process, similar but different machine, etc.). As such, it is important to explicitly document the differences in such data. However, secondary data is not always inferior to primary data. For example, referencing another work's data in which the author used very

accurate primary data. Along with primary data, secondary data should document the source, reliability, and temporal, geographical, and technological representativeness.

When identifying the inputs and outputs to document for each unit process within the product system of an LCI, a practitioner may come across the instance where a process has multiple input streams or generate multiple output streams. In such case, the practitioner should allocate the flows based on the "Allocation Procedure" outlined in the previous "Goal and Scope" section of this article.

One area where data access is likely to be difficult is flows from the technosphere. The technosphere is more simply defined as the human-made world. Considered by geologists as secondary resources, these resources are in theory 100% recyclable; however, in a practical sense, the primary goal is salvage. For an LCI, these technosphere products (supply chain products) are those that have been produced by human and unfortunately those completing a questionnaire about a process which uses a human-made product as a means to an end will be unable to specify how much of a given input they use. Typically, they will not have access to data concerning inputs and outputs for previous production processes of the product. The entity undertaking the LCA must then turn to secondary sources if it does not already have that data from its own previous studies. National databases or data sets that come with LCA-practitioner tools, or that can be readily accessed, are the usual sources for that information. Care must then be taken to ensure that the secondary data source properly reflects regional or national conditions.

LCI methods include "process-based LCAs", economic input–output LCA (EIOLCA), and hybrid approaches. Process-based LCA is a bottom-up LCI approach the constructs an LCI using knowledge about industrial processes within the life-cycle of a product, and the physical flows connecting them. EIOLCA is a top-down approach to LCI and uses information on elementary flows associated with one unit of economic activity across different sectors. This information is typically pulled from government agency national statistics tracking trade and services between sectors. Hybrid LCA is a combination of process-based LCA and EIOLCA.

Environmental Impact Assessment

Environmental Impact Assessment (EIA) is a process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse.
UNEP defines Environmental Impact Assessment (EIA) as a tool used to identify the environmental, social and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers. By using EIA both environmental and economic benefits can be achieved, such as reduced cost and time of project implementation and design, avoided treatment/clean-up costs and impacts of laws and regulations.
Although legislation and practice vary around the world, the fundamental components of an EIA would necessarily involve the following stages:

a. **Screening** to determine which projects or developments require a full or partial impact assessment study;
b. **Scoping** to identify which potential impacts are relevant to assess (based on legislative requirements, international conventions, expert knowledge and public involvement), to identify alternative solutions that avoid, mitigate or compensate adverse impacts on biodiversity (including the option of not proceeding with the development, finding alternative designs or sites which avoid the impacts, incorporating safeguards in the design of the project, or providing compensation for adverse impacts), and finally to derive terms of reference for the impact assessment;
c. **Assessment and evaluation of impacts and development of alternatives** , to predict and identify the likely environmental impacts of a proposed project or development, including the detailed elaboration of alternatives;
d. **Reporting the Environmental Impact Statement (EIS) or EIA report**, includingan environmental management plan (EMP), and a non-technical summary for the general audience.
e. **Review of the Environmental Impact Statement (EIS)**, based on the terms of reference (scoping) and public (including authority) participation.
f. **Decision-making** on whether to approve the project or not, and under what conditions; and
g. **Monitoring, compliance, enforcement and environmental auditing** . Monitor whether the predicted impacts and proposed mitigation measures occur as defined inthe EMP. Verify the compliance of proponent with the EMP, to ensure that unpredicted impacts or failed mitigation measures are identified and addressed in a timely fashion.

Objectives:

• Predict environmental impacts of projects.

• Find ways and means to reduce adverse impacts.

• Refine/shape the proposed project to suit the local

environment.

• Present the predictions and options before the decision

maker

• Under Environmental Protection Act 1986,- EIA notification

(1994)- environmental clearance mandatory.

• EIA notification – 3 schedules:

• Schedule I- list of projects requiring environmental clearance

from the Central Government.

• Schedule II – Application Form

• Schedule III – Composition of Expert Committee for giving Environmental clearance

Various disciplines: Air Pollution, Risk Analysis, NGO‘s, etc (15regular members)

Ministry of Environment and Forest (MoEF) amended

• Schedule IV – Procedure for public hearing Representatives of SPCB, State Govt., District Collector, local bodies, 3 senior citizens of the area

Biomimicry

• From

– bios, meaning ‒life‖ + mimesis, meaning ‒to imitate‖

• Biomimicry = to imitate life

Biomimicry Definition

• Viewing nature as role model/teacher– nature has already solved many of the technological and sustainability problems that we face today - learning from nature, not about nature

• Imitate nature‘s processes, not products

Airplane

Imitated not the bird (product)
but the air flow around the wings (process)

Biomimicry Principle

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

Kingfishers

MODULE 4
ENERGY SOURCES

Renewable Resources

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

Non Renewable Resources

- Coal
- Petroleum (Crude oil)
- Natural gas
- Nuclear (Uranium)
- Renewable & Non Renewable Resources
- Conventional & Non Conventional Sources

Conventional Resources

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

Non Conventional Resources

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

SOLAR ENERGY
SOLAR ENERGY TECHNOLOGIES

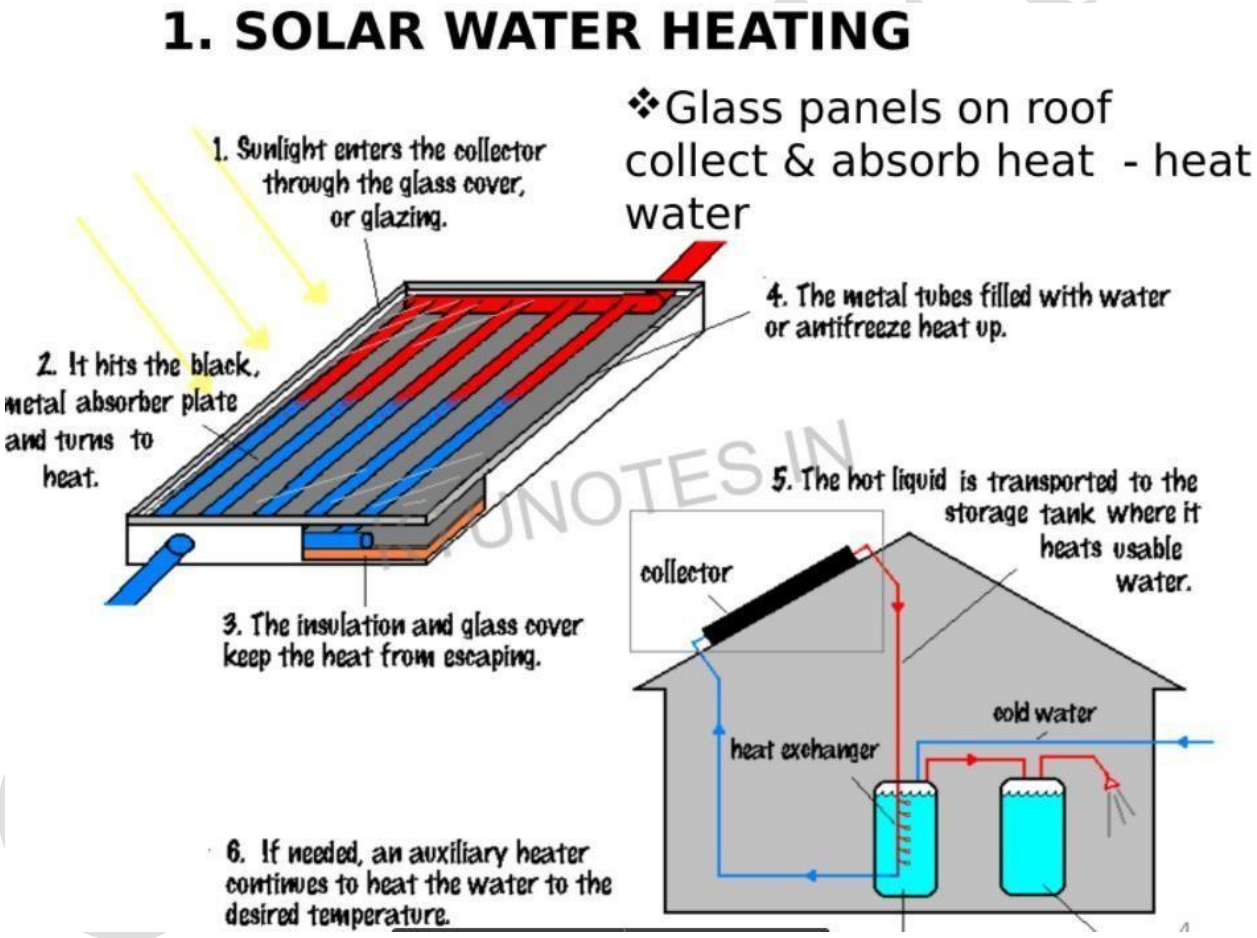
- Thermal conversion

- Solar water heater
- Solar space heating of buildings
- Solar air conditioning

- **Solar refrigeration**
- **Solar drying**
- **Solar cooking**
- **Solar electricity – thermal**

- photo-conversion

- **Solar green houses**
- **Solar furnaces**
- **Solar desalination**
- **Salt production**
- **Solar electricity -photovoltaic**



2. SOLAR SPACE HEATING OF BUILDINGS

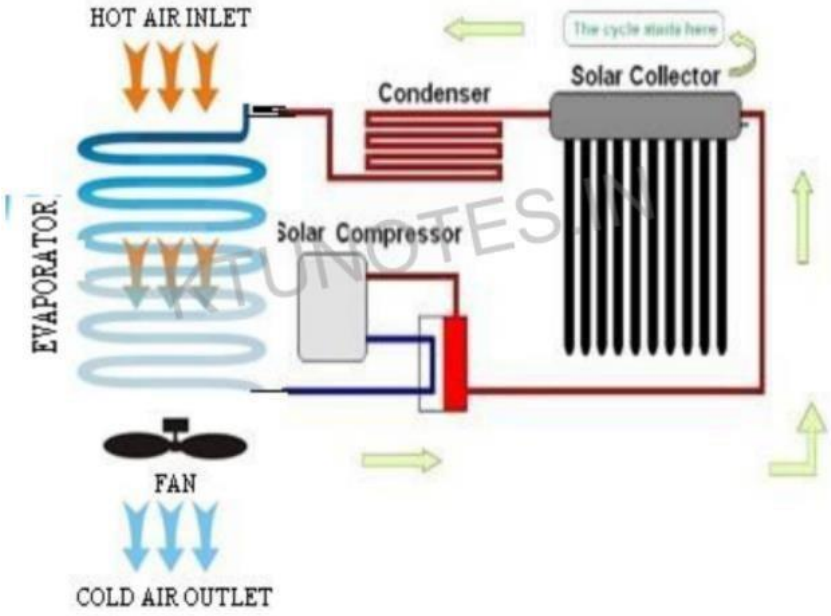
- Provided
  - architectural design of the building
  - large south facing windows

5

3. SOLAR AIR CONDITIONING

❖Solar powered AC system for buildings

❖uses a solar panel (not electricity) to super heat the pressurized refrigerant



4. SOLAR REFRIGERATION

5. SOLAR DRYING

- Traditional method of utilizing direct solar energy
- Agricultural products – crops, fruits, vegetables, fish, hay, etc all are sun dried
- Simplest and cheapest way to dry

6. SOLAR COOKING

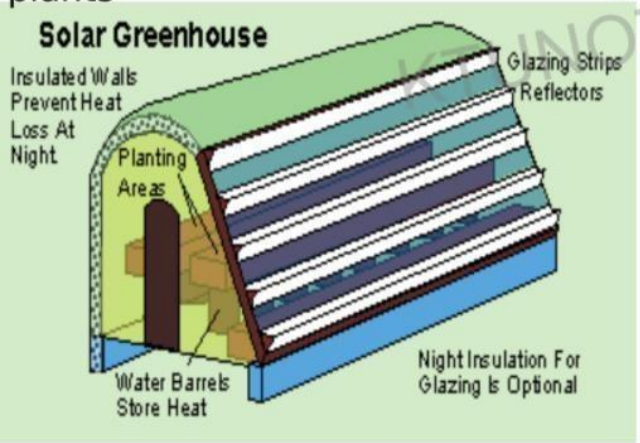
❖**It is well insulated shallow rectangular/square metal box with a flat glass cover**
- blackened inside (to increase the temperature)

❖**heat absorbed by blackened surface is used for cooking**

7. SOLAR GREENHOUS

❖Greenhouse is a closed structure covered with transparent material(glass/plastic)

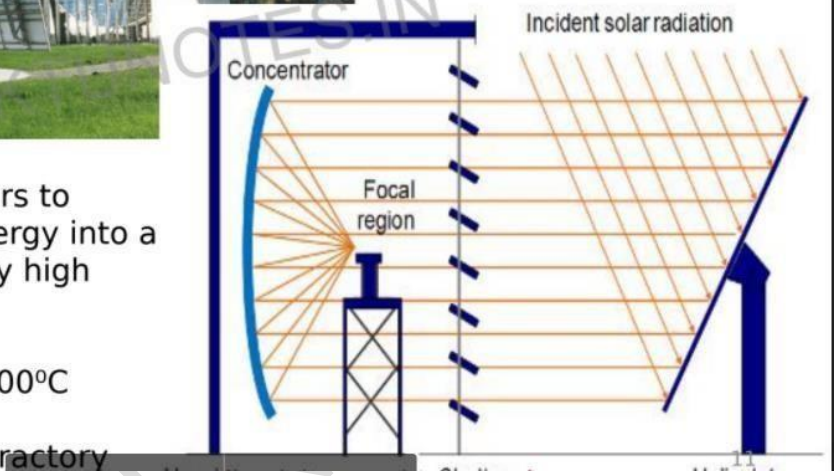
❖Utilize solar energy for growth of plants



❖Incoming short wave radiation pass through greenhouse; but long wave thermal radiations emitted by objects inside cannot escape through glazed surface

❖Thus radiations get trapped inside & increases inside temperature

8. SOLAR FURNACES



- Use huge array of mirrors to concentrate the sun's energy into a small area & produce very high temperature
- Can produce around 3500^{o}C
- Can be used to melt refractory

9. SALT PRODUCTION

❖Traditional method to obtain salt

12

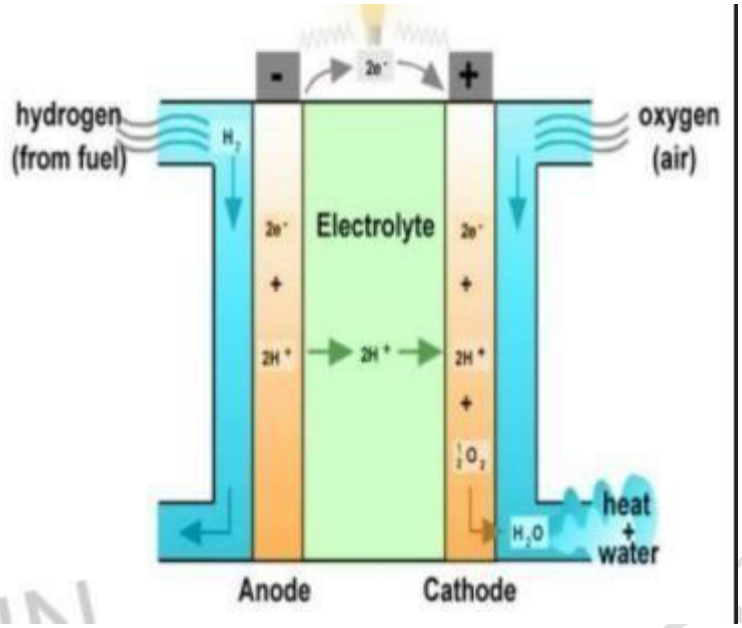
FUEL CELL

- device that generates electricity by a chemical reaction
- every fuel cell has
- 2 electrodes
- One positive -anode & other one negative-cathode
- an electrolyte
- Which carries electrically charged particles from one electrode to another
- a catalyst
- Which speeds the reaction at the electrodes

- hydrogen is the basic fuel, but fuel cells also requires oxygen

- fuel cells generate electricity with very little pollution

- Only byproduct – water



WIND ENERGY

Wind power or **wind energy** is the use of wind to provide mechanical power through wind turbines to turn electric generators for electrical power. Wind power is a popular sustainable, renewable source of power that has a much smaller impact on the environment compared to burning fossil fuels.

Wind farms consist of many individual wind turbines, which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants. Onshore wind farms have a greater visual impact on the landscape than other power stations, as they need to be spread over more land and need to be built away from dense population. Offshore wind is steadier and stronger than on landand offshore farms have less visual impact, but construction and maintenance costs are significantly higher. Small onshore wind farms can feed some energy into the grid or provide power to isolated off-grid locations.

The wind is an intermittent energy source, which cannot be dispatched on demand. Locally, it gives variable power, which is consistent from year to year but varies greatly over shorter time scales. Therefore, it must be used together with other power sources to give a reliable supply. Power-management techniques such as having dispatchable power sources (often gas-fired

power plant or hydroelectric power), excess capacity, geographically distributed turbines, exporting and importing power to neighboring areas, energy storage, reducing demand when wind production is low, are used to overcome these problems. As the proportion of wind powerin a region increases the grid may need to be upgraded. Weather forecasting permits the electric- power network to be readied for the predictable variations in production that occur.

WIND FARM

A wind farm is a group of wind turbines in the same location used for the production of electric power. A large wind farm may consist of several hundred individual wind turbines distributed over an extended area. Wind turbines use around 0.3 hectares of land per MW, but the land between the turbines may be used for agricultural or other purposes. For example, Gansu Wind Farm, the largest wind farm in the world, has several thousand turbines. A wind farm may alsobe located offshore.

Almost all large wind turbines have the same design — a horizontal axis wind turbine having an upwind rotor with 3 blades, attached to a nacelle on top of a tall tubular tower.

In a wind farm, individual turbines are interconnected with a medium voltage (often 34.5 kV) power collection system and communications network. In general, a distance of 7D (7 times the rotor diameter of the wind turbine) is set between each turbine in a fully developed wind farm.[40] At a substation, this medium-voltage electric current is increased in voltage witha transformer for connection to the high voltage electric power transmission system

HYDRO POWER PLANTS

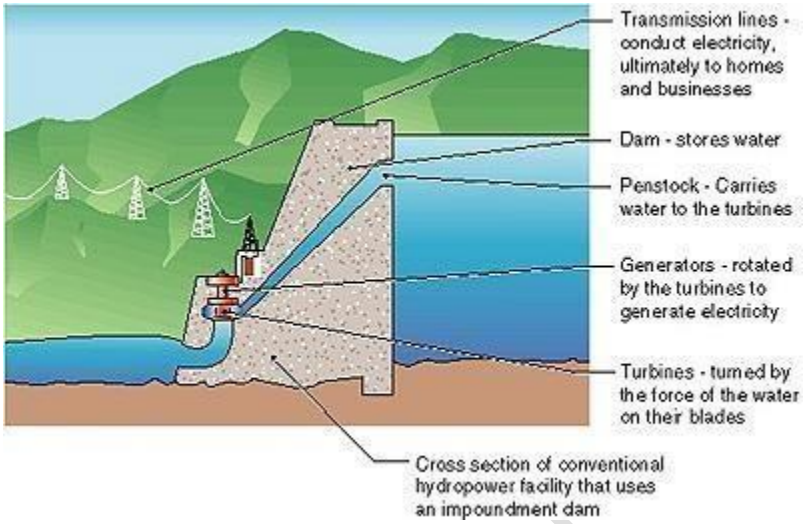
There are three types of hydropower facilities: impoundment, diversion, and pumped storage. Some hydropower plants use dams and some do not. The images below show both types of hydropower plants.

Many dams were built for other purposes and hydropower was added later. In the United States, there are about 80,000 dams of which only 2,400 produce power. The other dams are for recreation, stock/farm ponds, flood control, water supply, and irrigation.

Hydropower plants range in size from small systems for a home or village to large projects producing electricity for utilities. The sizes of hydropower plants are described below.

IMPOUNDMENT

The most common type of hydroelectric power plant is an impoundment facility. An impoundment facility, typically a large hydropower system, uses a dam to store river water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water may be released either to meet changing electricity needs or to maintain a constant reservoir level.



DIVERSION

A diversion, sometimes called run-of-river, facility channels a portion of a river through a canal or penstock. It may not require the use of a dam.

PUMPED STORAGE

Another type of hydropower called pumped storage works like a battery, storing the electricity generated by other power sources like solar, wind, and nuclear for later use. It stores energy by pumping water uphill to a reservoir at higher elevation from a second reservoir at a lower elevation. When the demand for electricity is low, a pumped storage facility stores energy by pumping water from a lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir and turns a turbine, generating electricity.

SIZES OF HYDROELECTRIC POWER PLANTS

Facilities range in size from large power plants that supply many consumers with electricity to small and micro plants that individuals operate for their own energy needs or to sell power to utilities.

Large Hydropower

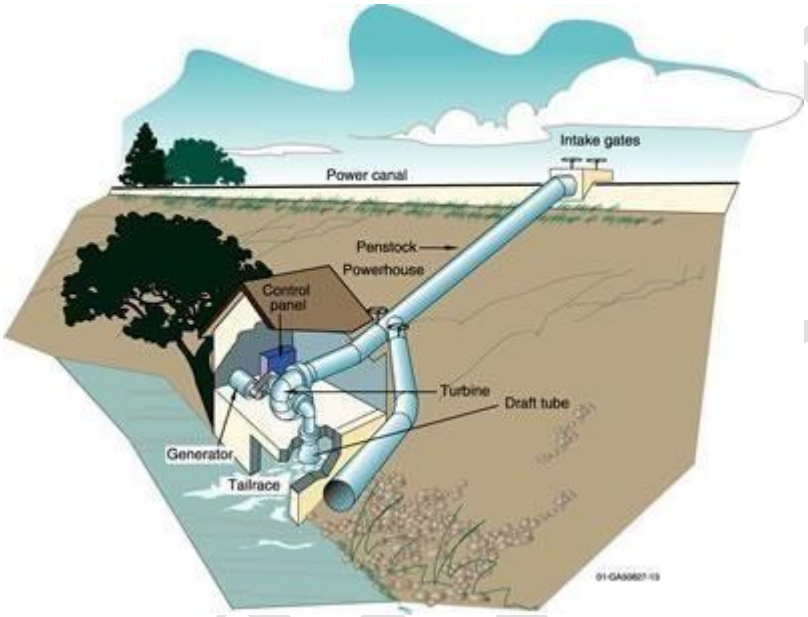
Although definitions vary, DOE defines large hydropower as facilities that have a capacity of more than 30 megawatts (MW).

Small Hydropower

Although definitions vary, DOE defines small hydropower as projects that generate 10 MW or less of power.

Micro Hydropower

A micro hydropower plant has a capacity of up to 100 kilowatts. A small or micro-hydroelectric power system can produce enough electricity for a home, farm, ranch, or village.



BIO-FUELS

A **biofuel** is a fuel that is produced through contemporary processes from biomass, rather than a fuel produced by the very slow geological processes involved in the formation of fossil fuels, such as oil. Since biomass technically can be used as a fuel directly (e.g. wood logs), some people use the terms biomass and biofuel interchangeably. More often than not, however, the word biomass simply denotes the biological raw material the fuel is made of, or some form of thermally/chemically altered *solid* end product, like torrefied pellets or briquettes.

The word biofuel is usually reserved for liquid or gaseous fuels, used for transportation. The U.S. Energy Information Administration (EIA) follows this naming practice. Drop-in biofuels are

functionally equivalent to petroleum fuels and fully compatible with the existing petroleum infrastructure.[2] They require no engine modification of the vehicle.

Biofuels can be produced from plants (i.e. energy crops), or from agricultural, commercial, domestic, and/or industrial wastes (if the waste has a biological origin).[4] Renewable biofuels generally involve contemporary carbon fixation, such as those that occurin plants or microalgae through the process of photosynthesis. If the biomass used in theproduction of biofuel can regrow quickly, the fuel is generally considered to be a formof renewable energy. The greenhouse gas mitigation potential of biofuel varies considerably, from emission levels comparable to fossil fuels in some scenarios to negative emissions in others.

The two most common types of biofuel are bioethanol and biodiesel.

- Bioethanol is an alcohol made by fermentation, mostly from carbohydrates produced in sugar or starch crops such as corn, sugarcane, or sweet sorghum. Cellulosicbiomass, derived from non-food sources, such as trees and grasses, is also being developed as a feedstock for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form (E100), but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is widely used in the United States and in Brazil.
- Biodiesel is produced from oils or fats using transesterification and is the most common biofuel in Europe. It can be used as a fuel for vehicles in its pure form (B100), but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles.

In 2019, worldwide biofuel production reached 161 billion liters (43 billion gallons US), up 6% from 2018, and biofuels provided 3% of the world's fuels for road transport. The International Energy Agency want biofuels to meet more than a quarter of world demand for transportation fuels by 2050, in order to reduce dependency on petroleum. However, the production and consumption of biofuels are not on track to meet the IEA's sustainable development scenario. From 2020 to 2030 global biofuel output has to increase by 10% each year to reach IEA's goal. Only 3% growth annually is expected the next 5 years.

First-generation biofuels

First-generation biofuels are fuels made from food crops grown on arable land. The crop's sugar, starch, or oil content is converted into biodiesel or ethanol, using transesterification, or yeast fermentation.

Second-generation biofuels

Second-generation biofuels are fuels made from lignocellulosic or woody biomass, or agricultural residues/waste. The feedstock used to make the fuels either grow on arable land but are byproducts of the main crop, or they are grown on marginal land. Second-generation feedstocks include straw, bagasse, perennial grasses, jatropha, waste vegetable oil, municipal solid waste and so forth.

Third-generation biofuels

Algae can be produced in ponds or tanks on land, and out at sea. Algal fuels have highyields, can be grown with minimal impact on fresh water resources, can be produced using salinewater and wastewater, have a high ignition point, and are biodegradable and relatively harmless to the environment if spilled. Production requires large amounts of energy and fertilizer, the produced fuel degrades faster than other biofuels, and it does not flow well in cold temperatures. By 2017, due to economic considerations, most efforts to produce fuel from algae have been abandoned or changed to other applications.

Fourth-generation biofuels

This class of biofuels includes electrofuels and solar fuels. Electrofuels are made by storing electrical energy in the chemical bonds of liquids and gases. The primary targets are butanol, biodiesel, and hydrogen, but include other alcohols and carbon-containing gases such as methane and butane. A solar fuel is a synthetic chemical fuel produced from solar energy. Light is converted to chemical energy, typically by reducing protons to hydrogen, or carbon dioxide to organic compounds.

ENERGY FROM OCEAN

Marine energy or **marine power** (also sometimes referred to as **ocean energy**, **ocean power**, or **marine and hydrokinetic energy**) refers to the energy carried by ocean waves, tides, salinity,and ocean temperature differences. The movement of water in the world's oceans creates a vast store of kinetic energy, or energy in motion. Some of this energy can be harnessed to generate electricity to power homes, transport and industries.

The term marine energy encompasses both wave power i.e. power from surface waves, and tidal power i.e. obtained from the kinetic energy of large bodies of moving water. Offshore wind power is not a form of marine energy, as wind power is derived from the wind, even if the wind turbines are placed over water.

The oceans have a tremendous amount of energy and are close to many if not most concentrated populations. Ocean energy has the potential of providing a substantial amount of new renewable energy around the world.

Forms of ocean energy

Renewable

The oceans represent a vast and largely untapped source of energy in the form of surface waves, fluid flow, salinity gradients, and thermal.

Marine and Hydrokinetic (MHK) or marine energy development in U.S. and international waters includes projects using the following devices:

- Wave power converters in open coastal areas with significant waves;
- Tidal turbines placed in coastal and estuarine areas;
- In-stream turbines in fast-moving rivers;
- Ocean current turbines in areas of strong marine currents;
- Ocean thermal energy converters in deep tropical waters.

Marine current power

Strong ocean currents are generated from a combination of temperature, wind, salinity, bathymetry, and the rotation of the Earth. The Sun acts as the primary driving force,

causing winds and temperature differences. Because there are only small fluctuations in current speed and stream location with no changes in direction, ocean currents may be suitable locations for deploying energy extraction devices such as turbines.

Ocean currents are instrumental in determining the climate in many regions around the world. While little is known about the effects of removing ocean current energy, the impacts of removing current energy on the farfield environment may be a significant environmental concern. The typical turbine issues with blade strike, entanglement of marine organisms, and acoustic effects still exists; however, these may be magnified due to the presence of more diversepopulations of marine organisms using ocean currents for migration purposes. Locations can be further offshore and therefore require longer power cables that could affect the marine environment with electromagnetic output.[5]

Osmotic power

At the mouth of rivers where fresh water mixes with salt water, energy associated with the salinity gradient can be harnessed using pressure-retarded reverse osmosis process and associated conversion technologies. Another system is based on using freshwater upwelling through a turbine immersed in seawater, and one involving electrochemical reactions is also in development.

Significant research took place from 1975 to 1985 and gave various results regarding the economy of PRO and RED plants. It is important to note that small-scale investigations into salinity power production take place in other countries like Japan, Israel, and the United States.In Europe the research is concentrated in Norway and the Netherlands, in both places small pilotsare tested. Salinity gradient energy is the energy available from the difference in salt concentration between freshwater with saltwater. This energy source is not easy to understand, as it is not directly occurring in nature in the form of heat, waterfalls, wind, waves, or radiation.

Ocean thermal energy

Water typically varies in temperature from the surface warmed by direct sunlight to greater depths where sunlight cannot penetrate. This differential is greatest in tropical waters, making

this technology most applicable in water locations. A fluid is often vaporized to drive a turbine that may generate electricity or produce desalinized water. Systems may be either open-cycle, closed-cycle, or hybrid.

Tidal power

The energy from moving masses of water – a popular form of hydroelectric power generation. Tidal power generation comprises three main forms, namely: tidal stream power, tidal barrage power, and dynamic tidal power.

Wave power

Solar energy from the Sun creates temperature differentials that result in wind. The interaction between wind and the surface of water creates waves, which are larger when there is a greater distance for them to build up. Wave energy potential is greatest between 30° and 60° latitude in both hemispheres on the west coast because of the global direction of wind. When evaluating wave energy as a technology type, it is important to distinguish between the four most common approaches: point absorber buoys, surface attenuators, oscillating water columns, and overtopping devices.

The wave energy sector is reaching a significant milestone in the development of the industry, with positive steps towards commercial viability being taken. The more advanced device developers are now progressing beyond single unit demonstration devices and are proceeding to array development and multi-megawatt projects.[9] The backing of major utility companies is now manifesting itself through partnerships within the development process, unlocking further investment and, in some cases, international co-operation.

At a simplified level, wave energy technology can be located near-shore and offshore. Wave energy converters can also be designed for operation in specific water depth conditions: deep water, intermediate water or shallow water. The fundamental device design will be dependent on the location of the device and the intended resource characteristics.

Non-renewable

Petroleum and natural gas beneath the ocean floor are also sometimes considered a form of ocean energy. An ocean engineer directs all phases of discovering, extracting, and delivering

offshore petroleum (via oil tankers and pipelines,) a complex and demanding task. Also centrally important is the development of new methods to protect marine wildlife and coastal regions against the undesirable side effects of offshore oil extraction.

MODULE 5
SUSTAINABLE HABITAT

A ***sustainable*** **habitat** is an ecosystem that produces food and shelter for people and other organisms, without resource depletion and in such a way that no external waste is produced. Thus the habitat can continue into future tie without external infusions of resource. Such a sustainable habitat may evolve naturally or be produced under the influence of man.A sustainable habitat that is created and designed by human intelligence will mimic nature, if it is to be successful. Everything within it is connected to a complex array of organisms, physical resources and functions. Organisms from many different biomes can be brought together to fulfill various *ecological niches.*

GREEN BUILDINGS

OBJECTIVES

- Energy Efficiency
- Preserving natural ecosystem
- Reduced air and water pollution
- Reduced water consumption
- Minimum waste generation

MATERIAL SELECTION

- Resource efficiency
- Use of locally available materials
- Reuse of salvaged materials
- Use of recycled products
- Use of long lasting materials
- Indoor air quality

- Products which emits low VOC
- Products which resist moisture

- Energy efficiency

- Eco friendly refrigerants
- Natural lighting
- Renewable technologies

- Water conservation
- Ground water recharge
- Minimum water consumption
- Affordable
- Affordable material cost

GREEN BUILDING CERTIFICATION

- Series of criteria to measure the overall greenery of individual buildings
- To differentiate environmental or socially preferable products from their conventional alternatives
- Green building rating system include
- GRIHA (Green Rating For Integrated Habitat Assessment)
- LEED (Leadership in Energy and Environment Design)

DIAMOND TOWER , SAUDI ARABIA

 Efficient usage of water(d

SOHRAJI GODREJ BUSINESS CENTRE

1

RAJIV GANDHI INTERNATIONAL AIRPORT

GREEN BUILDINGS PROJECT IN INDIA

- Suzlon Energy Limited-Pune
- Biodiversity Conservation India-Bangalore
- Olympia Technology Park-Chennai
- ITC Green Centre-Gurgaon
- The Druk White Lotus School-Ladakh
- Doon School-Dehradun
- Raintree Hotels-Chennai
- Nokia-Gurgaon
- Rajiv Gandhi International Airport-Hyderabad
- Hiranandini-BG House, Powai
- ABN Amro Bank, Chennai
- Palais Royale at Worli, Mumbai
- Punjab Forest Complex,Mohali

SUSTAINABLE CITIES

A city which meets their inhabitant's development needs without imposing unsustainable demands on local or global natural resources and systems

EXAMPLES OF SUSTAINABLE STRATEGIES

SUSTAINABLE STRATEGIES	CITY	EXAMPLE
ADEQUATE HOUSING	SAO PAULO BRAZIL	Upgrading of slums: government gives legal land tenure and provide subsidies to support quality self-built housing
CLEAN RENEWABLE ENERGY	COPENHAGEN DENMARK	Windmills built offshore
ENERGY CONSERVATION	PARIS FRANCE	•Timer on lights in hallways/stairs in apartment buildings •Eiffel tower only lit for a few hours at night •Free bike sharing system (Vélib)
TRAFFIC MANAGEMENT	SINGAPORE	•Electronic Road Pricing (ERP) to charge car usage rather than can ownership •Fast and rational public transportation system •Learn more: www.youtube.com/watch?v=6HofttbuWhA&feature=related
SMOG REDUCTION	MEXICO CITY MEXICO	•Alternate circulation for cars ("Hoy no circula" program) •Strict regulations on car emissions •Single-fare extensive metro system with long/frequent trains •Learn more: www.youtube.com/watch?v=oiJSibk1ok0
URBAN HEAT ISLAND REDUCTION	CHICAGO ILLINOIS	•Development of parks •Rooftop gardens on some buildings •Carpool + bike lanes
SOIL PROTECTION + FUEL EMISSION REDUCTION	SAN FRANCISCO	•Urban farms (Hayes Valley)

SUSTAINABLE TRANSPORT

- Any means of transport with low impact on environment
- Improving walking and cycling environment
- Hybrid vehicles with better fuel efficiency
- Promoting public transport system

CONTENT BEYOND SYLLABUS

Exergy analysis

Exergy analysis is a practical approach to evaluate the merit of energy conversion or distribution processes and systems. With the aid of an energy analysis, the performance of an energy conversion system cannot be evaluated efficiently and precisely. But, an exergy analysis complements and enhances an energy analysis. Exergy analysis involves the application of exergy concepts, balances, and efficiencies to evaluate and improve energy and other systems. Many scientists suggest that processes or sytems can be well evaluated and improved using exergy analysis in addition to or in place of energy analysis. Application of exergy analysis has given us more beneficial opportunities through a big part of a wide range of processes and systems particularly for the evaluation of energy systems and technologies as well as an environmental impact in all existing thermal and nuclear power plants. Conventional energy technologies, especially for power generation plants, have made numerous energy and exergy analyses and have produced beneficial results. Also, the use of energy and exergy analyses for advanced nuclear energy technologies can be expected to provide meaningful insights into performance that can assist in achieving optimal design concepts. Finally, explaining the analysis of thermal and nuclear power plant systems deals with exergetic approach.

The benefits of exergy analysis are numerous compared to energy analysis. Some of the more significant ones follow below:

- Exergy efficiencies are always the measures of the approach to true ideality and provide more meaningful information when assessing the performance of energy systems. Also, exergy losses clearly identify the locations, causes, and sources of deviations from ideality in a system.
- Exergy methods can help evaluate the thermodynamic values of the product energy forms in complex systems with multiple products (e.g., cogeneration and trigeneration plants).
- Exergy-based methods can be used to improve economical and environmental assessments.
- Exergy can improve understanding of terms like energy conservation and energy crisis.
- Exergy methods can help in optimization activities.

METRICS FOR SUSTAINABILITY

Five environmental metrics worth tracking

For companies focused on ESG (Environmental, Social, Governance) efforts, metrics matter. Metrics ensure companies can measure progress and track relevant goals while demonstrating effectiveness and impact. Environmental sustainability metrics are some of the most important.

There are four main types of sustainability: human, social, economic, and environmental. Each industry and organization will have different metrics that are material to their business, but some metrics commonly tracked by leading companies are:

Financial metrics such as cost/benefit analysis, internal rate of return (IRR), and return on investment (ROI) are examples of financial metrics that are essential to most organizations.
Environmental metrics typically include reduction of electricity usage, change in fuel consumption for company vehicles, carbon emissions reductions, gallons of water saved, and increased waste diversion.
Social metrics focus on employees and occupants, health & wellbeing, diversity & inclusion, supply chain management, and more.
Governance metrics are often determined by the existence of policies on a wide range of issues such as company values and business resilience plans.
While all ESG metrics and sustainability efforts are important, much of the world is focused heavily on environmental sustainability metrics and reporting as organizations take steps to reduce waste and use energy efficiently. Climate change poses significant financial risks and opportunities for the global economy as Earth's rising temperature is increasing natural disasters, disrupting ecosystems and human health, and causing unanticipated business losses while threatening assets and infrastructure.

To adequately prepare for climate-related risks, financial markets and businesses alike need comprehensive, reliable information to analyze the effect of regulations on industry costs, the implications of a low-carbon economy, and the impact of new technologies. Not only are these efforts good for the environment, tracking sustainability metrics benefit businesses in multiple ways.

What are the benefits of sustainability efforts?

The positive benefits that come from focusing on and tracking sustainability efforts can come in different forms, such as:

Increased investor demand. Mainstream advisors and investors are increasingly looking for ESG funds. In fact, according to Morgan Stanley, U.S. sustainable equity funds outperformed their traditional peer funds by a median total return of 4.3 percentage points in 2020.
Increased brand value. Nielsen deemed 2018 the year of the "sustainable shopper," and predicted the sustainability market will reach $150 billion by 2021. Almost half of U.S. shoppers say they change their consumption habits to benefit the environment.
Increased employee engagement. Believe it or not, a 2019 Fast Company article reported nearly 40% of millennials have chosen a job because of company sustainability and more than 10% of workers said they'd be willing to go as far as to take a $5,000-$10,000 pay cut.
Organizations that want to be seen as leaders in corporate environmental sustainability should consider five key environment sustainability metrics.

Five sustainability metrics to monitor

The 2020 State of Green Business GreenBiz report provides insights on five key environmental sustainability

metrics companies should consider for tracking and reporting purposes.

Climate risk is a hugely critical issue for environmental sustainability

Metric #1 - Climate risk

Climate risk was reported as a newly emerging environmental metric as companies account for the changing environment and the physical risks of climate change. The GreenBiz report data shows 86% companies now publish a sustainability report and a large majority of these companies are acknowledging their exposure to climate-related risks. Of these, 82% reported regulatory transition risks and 79% described physical risks from climate change in their reports that could negatively impact productivity and success.

As the world's response to climate change remains uncertain, forward-looking scenario-based assessments of transitional and physical climate risk, such as those recommended by the Task Force on Climate-related Financial Disclosures (TCFD), can help companies develop risk mitigation strategies across corporate asset locations, supply chains, and product life cycles.

Metric #2 - Carbon emissions

The Paris Agreement is a landmark international accord that was adopted by nearly every nation in 2015 to address climate change and its negative impacts. The agreement aims to substantially reduce global greenhouse gas emissions in an effort to limit the global temperature increase to 2° Celsius above pre-industrial levels by 2050.

The emission of carbon dioxide (CO2) and other pollution that results from the burning of fossil fuels used to generate electric power, provide power for transportation (cars, trucks, and air travel), and heat homes and buildings is the major factor contributing to climate change. Efforts to improve energy efficiency, migrate to renewable energy, and shift from coal to methane provide solutions to reducing harmful greenhouse gas emissions.

Companies are beginning to take efforts to reduce emissions, such as migrating from coal to natural gas, which is 85% more efficient in producing electric power. As companies make these migrations and reduce emissions, metrics and reporting will be the only reliable factor that tells the story of change and ensures companies can reach their target goals.

Metric #3 - Energy consumption

Energy use the largest factor impacting environmental sustainability and is a direct contributor to greenhouse gas emissions and other compounds that are detrimental to the environment. Therefore, every company's energy consumption matters and so do the metrics used to track this energy consumption. Companies are beginning to implement alternate, renewable sources of energy into their operations such as solar energy and wind power.

Companies are also utilizing different methods such as ESG platforms and IoT (Internet of Things) sensors to accurately measure and track energy consumption, a dynamic process that provides an analytical framework to monitor, measure, and catalog data.

Metric #4 - Water usage

Water is a critical and primary metric because of its prevalent, daily usage within most companies and facilities. The U.S. Energy Information Administration (EIA) estimated that the 46,000 large commercial

buildings (200,000+ square feet) in the U.S. used about 359 billion gallons of water (980 million gallons per day) in 2012.

Beyond water usage, the loss of water from leaking pipes or water distribution lines must be considered, along with water pollution, which was added as a new metric in the GreenBiz report. Water pollution is measured by the "total natural capital cost of the environmental impacts from heavy-metal and pesticide pollution or from excess fertilizer use causing algal blooms."

Unfortunately, the report also stated company water use has averaged a 9% yearly increase since 2015, both for U.S. companies and globally, and water pollution costs have nearly doubled since 2014. Utilizing goal-oriented metrics to monitor water quality, consumption, and leakage will play a crucial role in conserving water as well as protecting the health and safety of people and the environment.

Metric #5 - Waste & pollution

Waste management is a broad category, including food waste, agricultural and animal waste, medical waste, radioactive waste, hazardous waste, industrial non-hazardous waste, construction and demolition debris, extraction and mining waste, oil and gas production waste, fossil fuel combustion waste, and more.