JAWAHARLAL COLLEGE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, Affiliated to APJ Abdul Kalam Technological University, Kerala)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(NBA Accredited)

COURSE MATERIAL

MCN 201 Sustainable Engineering

VISION OF THE INSTITUTION

Emerge as a centre of excellence for professional education to produce high quality engineers and entrepreneurs for the development of the region and the Nation

MISSION OF THE INSTITUTION

- To become an ultimate destination for acquiring latest and advanced knowledge in the multidisciplinary domains.
- To provide high quality education in engineering and technology through innovative teaching-learning practices, research and consultancy, embedded with professional ethics.
- To promote intellectual curiosity and thirst for acquiring knowledge through outcome based education.
- To have partnership with industry and reputed institutions to enhance the employability skills of the students and pedagogical pursuits.
- To leverage technologies to solve the real life societal problems through community services.

ABOUT THE DEPARTMENT

- Established in: 2008
- Courses offered: B.Tech in Computer Science and Engineering
- Affiliated to the A P J Abdul Kalam Technological University.

DEPARTMENT VISION

To produce competent professionals with research and innovative skills, by providing them with the most conducive environment for quality academic and research oriented undergraduate education along with moral values committed to build a vibrant nation.

DEPARTMENT MISSION

- Provide a learning environment to develop creativity and problem solving skills in a professional manner.
- Expose to latest technologies and tools used in the field of computer science.
- Provide a platform to explore the industries to understand the work culture and expectation of an organization.
- Enhance Industry Institute Interaction program to develop the entrepreneurship skills.
- Develop research interest among students which will impart a better life for the society and the nation.

PROGRAMME EDUCATIONAL OBJECTIVES

Graduates will be able to

- Provide high-quality knowledge in computer science and engineering required for a computer professional to identify and solve problems in various application domains.
- Persist with the ability in innovative ideas in computer support systems and transmit the knowledge and skills for research and advanced learning.
- Manifest the motivational capabilities, and turn on a social and economic commitment to community services.

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 clearinstructions.

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 leaderin 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.

CODE		CATEGORY	L	T	P	CREDIT
MCN201	SUSTAINABLE ENGINEERING		2	0	0	NIL

Preamble: Objective of this course is to inculcate in students an awareness of environmental issues and the global initiatives towards attaining sustainability. The student should realize the potential of technology in bringing in sustainable practices.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

S.NO	DESCRIPTION
C206.1	Understand the relevance and the concept of sustainability and the global initiatives in this direction
C206.2	Explain the different types of environmental pollution problems and their sustainable solutions
C206.3	Discuss the environmental regulations and standards
C206.4	Outline the concepts related to conventional and non-conventional energy
C206.5	Demonstrate the broad perspective of sustainable practices by utilizing engineering knowledge and principles
C206.6	Discuss the sustainale transportation and its applications

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1						2	3					2
CO 2						2	3					2
CO 3						2	3					2
CO 4						2	3					2
CO 5						2	3					2
CO6						2	3					2

Assessment Pattern

Mark distribution

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	40
Understand	20	20	40
Apply	10	10	20
Analyse			
Evaluate			
Create			

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand the relevance and the concept of sustainability and the global initiatives in this direction

1. Explain with an example a technology that has contributed positively to sustainable development.
2. Write a note on Millennium Development Goals.

Course Outcome 2 (CO2): Explain the different types of environmental pollution problems and their sustainable solutions

1. Explain the 3R concept in solid waste management?
2. Write a note on any one environmental pollution problem and suggest a sustainable solution.
3. In the absence of green house effect the surface temperature of earth would not have been suitable for survival of life on earth. Comment on this statement.

Course Outcome 3(CO3): Discuss the environmental regulations and standards

1. Illustrate Life Cycle Analysis with an example of your choice.
2. "Nature is the most successful designer and the most brilliant engineer that has ever evolved". Discuss.

Course Outcome 4 (CO4): Outline the concepts related to conventional and non-conventional energy

1. Suggest a sustainable system to generate hot water in a residential building in tropical climate.
2. Enumerate the impacts of biomass energy on the environment.

Course Outcome 5 (CO5): Demonstrate the broad perspective of sustainable practices by utilizing engineering knowledge and principles

1. Suggest suitable measures to make the conveyance facilities used by your institution sustainable.

Model Question paper

Part A

(Answer all questions. Each question carries 3 marks each)

1. Define sustainable development.
2. Write a short note on Millennium Development Goals.
3. Describe carbon credit.
4. Give an account of climate change and its effect on environment.
5. Describe biomimicry? Give two examples.
6. Explain the basic concept of Life Cycle Assessment.
7. Name three renewable energy sources.

8. Mention some of the disadvantages of wind energy.

9. Enlist some of the features of sustainable habitat.

10. Explain green engineering.

Part B

(Answer one question from each module. Each question carries 14 marks)

11. Discuss the evolution of the concept of sustainability. Comment on its relevance in the modern world.

OR

12. Explain Clean Development Mechanism.

13. Explain the common sources of water pollution and its harmful effects.

OR

14. Give an account of solid waste management in cities.

15. Explain the different steps involved in the conduct of Environmental Impact Assessment.

OR

16. Suggest some methods to create public awareness on environmental issues.

17. Comment on the statement, "Almost all energy that man uses comes from the Sun".

OR

18. Write notes on:

    a. Land degradation due to water logging.

    b. Over exploitation of water.

19. Discuss the elements related to sustainable urbanisation.

OR

20. Discuss any three methods by which you can increase energy efficiency in buildings.

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.

Reference Books

1. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
2. Bradley. A.S; Adebayo,A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
3. Environment Impact Assessment Guidelines, Notification of Government of India, 2006
4. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998
5. ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System
6. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.
7. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Language Book Society (ELBS).
8. Purohit, S. S., Green Technology - An approach for sustainable environment, Agrobios Publication

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Sustainability	
1.1	Introduction, concept, evolution of the concept	1
1.2	Social, environmental and economic sustainability concepts	1
1.3	Sustainable development, Nexus between Technology and Sustainable development	1
1.4	Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs)	1
1.5	Clean Development Mechanism (CDM)	1
2	Environmental Pollution	
2.1	Air Pollution and its effects	1
2.2	Water pollution and its sources	1
2.3	Zero waste concept and 3 R concepts in solid waste management	1
2.4	Greenhouse effect, Global warming, Climate change, Ozone layer depletion	1
2.5	Carbon credits, carbon trading and carbon foot print.	1
2.6	Legal provisions for environmental protection.	1
3	Environmental management standards	
3.1	Environmental management standards	1
3.2	ISO 14001:2015 frame work and benefits	1
3.3	Scope and Goal of Life Cycle Analysis (LCA)	1
3.4	Circular economy, Bio-mimicking	1
3.5	Environment Impact Assessment (EIA)	1
3.6	Industrial Ecology, Industrial Symbiosis	1
4	Resources and its utilisation	
4.1	Basic concepts of Conventional and non-conventional energy	1
4.2	General idea about solar energy, Fuel cells	1
4.3	Wind energy, Small hydro plants, bio-fuels	1
4.4	Energy derived from oceans and Geothermal energy	1
5	Sustainability Practices	
5.1	Basic concept of sustainable habitat	1
5.2	Methods for increasing energy efficiency of buildings	1
5.3	Green Engineering	1
5.4	Sustainable Urbanisation, Sustainable cities, Sustainable transport	1

MODULE 1- SUSTAINABILITY

Syllabus Covered:

- Sustainability- Introduction
- Sustainability- Definition
- Sustainability- Need & Concept
- Social Sustainability Concept
- Environmental Sustainability Concept
- Economic Sustainability Concept
- Sustainable Development
- Nexus Between Technology And Sustainable Development
- Millennium Development Goals (MDGs)
- Sustainable Development Goals (SDGs)
- Clean Development Mechanism (CDM)

1. SUSTAINABILITY- INTRODUCTION

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

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

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

Advantages

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

Disadvantages

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

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

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

2. SUSTAINABILITY- DEFINITION

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

3. SUSTAINABILITY- NEED & CONCEPT

Sustainability has three components, which are inter-related, as shown

1. Environment
2. Society
3. Economy

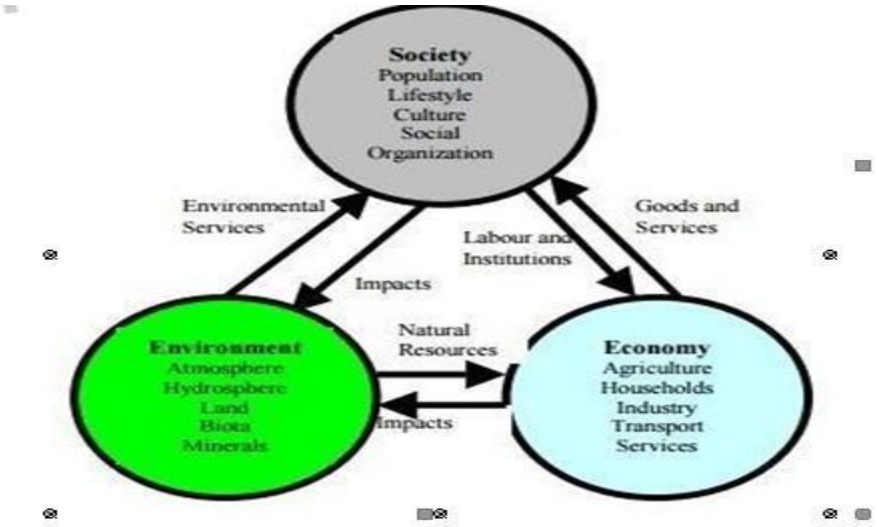


Fig.1. Environment-Economy-Society Inter-relation

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:- **Inter-generational 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, as shown in Fig 2.

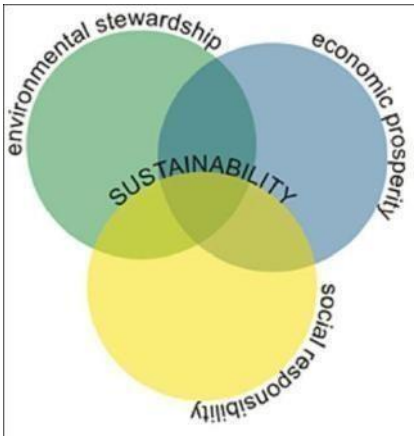


Fig 2: Sustainability

4. SOCIAL- ENVIRONMENTAL AND ECONOMIC SUSTAINABILITY CONCEPTS

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

SOCIAL SUSTAINABILITY

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

1. Maintain residents' quality of life.

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

2. Enhance local economic vitality.

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

3. Promote social and intergenerational equity.

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

4. Maintain the quality of the environment.

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

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

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

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

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

ENVIRONMENTAL SUSTAINABILITY

Environmental sustainability requires:

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

This can be achieved by:

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

ECONOMIC SUSTAINABILITY

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

	Developed Country	Developing Country
Resource Consumption	Not Sustainable	Sustainable
Population	Sustainable	Not Sustainable

ECONOMIC-SOCIAL AND ENVIRONMENTAL MATRIX

5. 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").

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

The three pillars of sustainable development are environment, society and economy as shown in Fig.3.

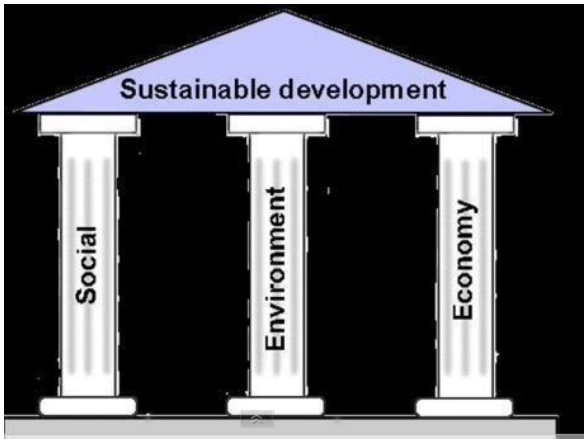


Fig. 3. Pillars of Sustainable Development

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

WHAT IS TO BE SUSTAINED?	WHAT IS TO BE DEVELOPED?
Nature – Earth, Biodiversity, Ecosystems	People – Child survival, Life expectancy, Education, Equity, Equal opportunity
Life support – Resources, Environment	Economy – Wealth, Production, Consumption
Community – Cultures, Places	Society – Institutions, Social capital, States, Regions

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.

6. 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

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

1. SUSTAINABLE AGRICULTURAL TECHNOLOGY

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

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

2. SUSTAINABLE ENERGY

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

a. Renewable energy sources
    i. Solar
    ii. Biomass (It is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the timber industry, agricultural crops, raw material from the forest, major parts of household waste and wood.)
    iii. Wind
    iv. Tide
    v. Geothermal Heat
b. Energy efficient systems - upgrading the efficiency of the existing equipment, reduction of energy loss, saving of fuel, and optimization of its operating conditions and service life provide an ecologically safe strategy.

7. MILLENIUM DEVELOPMENT GOALS (MDGs)

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

The Eight Millennium Development Goals are:

1. to eradicate extreme poverty and hunger;
2. to achieve universal primary education;

3. to promote gender equality and empower women;
4. to reduce child mortality;
5. to improve maternal health;
6. to combat HIV/AIDS, malaria, and other diseases;
7. to ensure environmental sustainability; and
8. to develop a global partnership for development.

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

8. SUSTAINABLE DEVELOPMENT GOALS (SDGs)

Recently, the international community decided to adopt a new set of development goals focusing on improving the sustainability of nation-states. The need for a new set of targets was developed at the Rio +20 Conference, held in Rio de Janeiro, in June 2012. The Sustainable Development Goals (SDGs) build on the achievements of the Millennium Development Goals. As mentioned, in a press release, by Wu Hongbo, the UN Under-Secretary-General for Economic and Social Affairs.

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

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

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

9. 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 cost-effectively achieve their Kyoto Protocol GHG emission reduction targets.

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

PURPOSE OF CLEAN DEVELOPMENT MECHANISM

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

CDM allows countries to continue emitting 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.

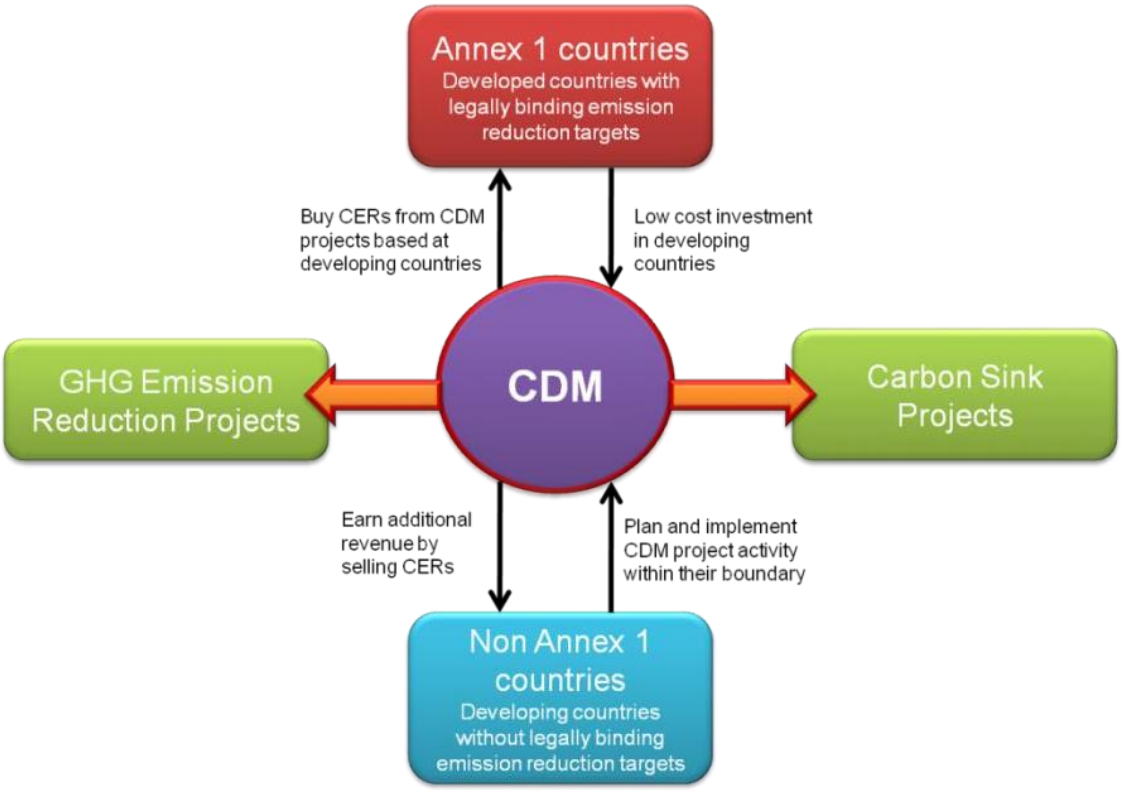


Fig: Clean Development Mechanism

MODULE – 2

Topics :- Air Pollution, Effects of Air Pollution; Water pollution- sources, Sustainable wastewater treatment, Solid waste - sources, impacts of solid waste, Zero waste concept, 3 R concept. Global environmental issues- Resource degradation, Climate change, Global warming, Ozone layer depletion, Regional and Local Environmental Issues. Carbon credits and carbon trading, carbon foot print.

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 to fulfill our daily basic needs of transportation. But, there overuse is killing our environment as dangerous gases are polluting the environment. Carbon Monoxide caused by improper or incomplete combustion and generally emitted from vehicles is another major pollutant along with Nitrogen Oxides, that is produced from both natural and man-made processes.
- **Agricultural activities:** Ammonia is a very common by product from agriculture related activities and is 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 large 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.
- **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 irregularities 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 a common 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 carriers inflict 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 acid rain.
- **Chemical fertilizers and pesticides:** Chemical fertilizers and pesticides are used by farmers to protect crops from insects and bacterias. They are useful for the 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 and mosquitoes.
- **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 effluent wastes prior to discharge. Toxic material must be treated chemically and converted into harmless materials. If possible, factories should try to recycle the treated water.
- **Strict adherence to water laws:** Laws and legislation relating to pollution should be strictly followed by all.
- **Treatment of drainage water:** 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.
- **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.
- ✓ 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.
- ✓ **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 and toxicity of waste and materials,
- conserving and recovering all resources,

- investment in community waste reduction and recovery systems
- Public participation in recycling.
- Eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health.
- Adopting 3R concepts (reduce, reuse, recycle)
- Acquiring waste to energy technologies.

Zero waste is more of a goal or ideal rather than a hard target. Zero Waste provides guiding principles for continually working towards eliminating wastes. Zero waste promotes not only reuse and recycling, but, more importantly, 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.

educe

- Lower the consumption of products through hiring,sharing,borrowingetc
- Reduce number of components inproduct 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.

Advantages of 3R

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

Waste Management Hierarchy: The waste managem
nationally and internationally accepted guide for prior
management practices

MCN 201: SUSTAINABLE ENGINEERING

MODULE III

SYLLABUS

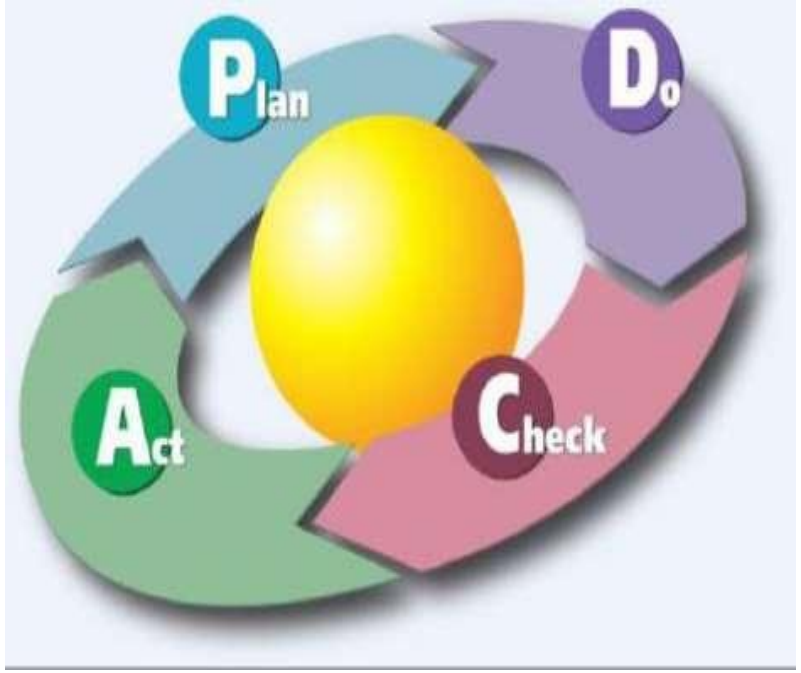
- Environmental management standards: ISO 14001:2015 frame work and benefits
- Scope and goal of Life Cycle Analysis (LCA),
- Circular economy, Bio-mimicking
- Environment Impact Assessment (EIA)
- Industrial ecology and industrial symbiosis.

Environmental Management System ("EMS")

- EMS – "Tool that enables an organization to control impact of its activities, products or services on the natural environment."
- The three primary processes of a management system include:
  - Core processes
  - Key supporting processes,
  - Management system supporting processes

Basis EMS framework

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



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

- ISO 14000 is a series of standards developed by International Organization for Standardization (ISO) to help organizations to reduce their impact on the environment

The standard requires your organization to:

- Determine your organization's impact on the environment and relevant regulations to the operations of the business.
- Create a plan to control your processes to minimize the environmental impact.
- Monitor the effectiveness of the system at meeting objectives as well as legal and other.
- Continually analyze the results and improve your systems.

ISO 14001:2015

- ISO 14001:2015 is the international standard that states requirements for an effective environmental management system, otherwise referred to as EMS.ISO standards provide a framework for organizations to follow

BENEFITS OF ISO 14001

- Using ISO 14001:2015 has many benefits for organizations with environmental management systems. Organizations and companies find that using the standard helps them:
- • Improve resource efficiency
- • Reduce waste
- • Drive down costs
- • Provide assurance that environmental impact is being measured
- • Gain competitive advantage in supply chain design
- • Increase new business opportunities
- • Meet legal obligations
- • Increase stakeholder and customer trust
- • Improve overall environmental impact
- • Manage environmental obligations with consistency

Contd….

- Environmental Benefits
- Legislative and Regulatory Benefits
- Customer Satisfaction

ISO 14001 FRAME WORK

1. Context of the organization

i)Understanding the organization and its context

a) environmental conditions

b) External and internal issues

i) Understanding the needs and expectations of interested parties

Interested parties could include;

- Employees ,Contractors n Clients/Customers ,Suppliers etc

iii) Determining the scope of the environmental management system

2. Leadership

i)Leadership and commitment

- encompasses a range of key activities which top management need in order to “demonstrate leadership and commitment with respect to the management system”.

ii)Environmental policy: Frame work for setting environmental objectives

iii)_Organizational roles, responsibilities and authorities

- Top management must ensure that key responsibilities and authorities are clearly defined and that everybody involved understands their roles

3. Planning

i) Actions to address risks and opportunities

ii) Environmental objectives and planning to achieve them :

- The organization requires to establish environmental objectives and plans, ensuring that these are clear, measurable, monitored, communicated, updated and resourced.

4. Support

i. Resources
ii. Competence
iii. Awareness
iv. Communication
v. Documented Information

5. Operation

i)Operational planning and control

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

ii) Emergency Preparedness and Response

The organisation requires to establish, implement and maintain processes needed to handle potential emergency situations

6. Performance Evaluation

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

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

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

7. Improvement

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

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

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

LIFE CYCLE ANALYSIS(LCA)

- Life Cycle Assessment/Cradle-to-grave analysis.
- Process to assess the environmental impacts associated with all the stages of a product, process or activity from cradle to grave by identifying the materials used and waste generated

STAGES IN LCA

LCA has four stages or components:

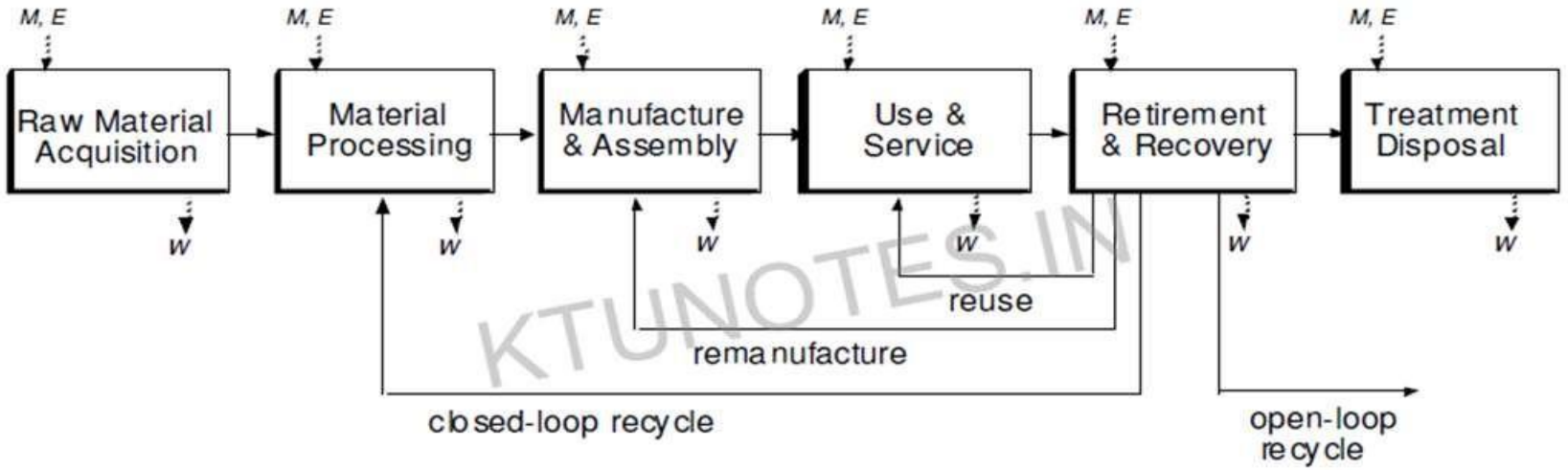
- 1. Goal and scope
- 2. Inventory
- 3. Impact assessment
- 4. Improvement assessment

FIVE PROCESS IN LCA

The materials and energy that go into these five processes:

- Raw material extraction
- Manufacture
- Distribution and transport
- Use and maintenance
- Disposal and recycling

Product Life Cycle



M, E = Material and Energy inputs to process and distribution

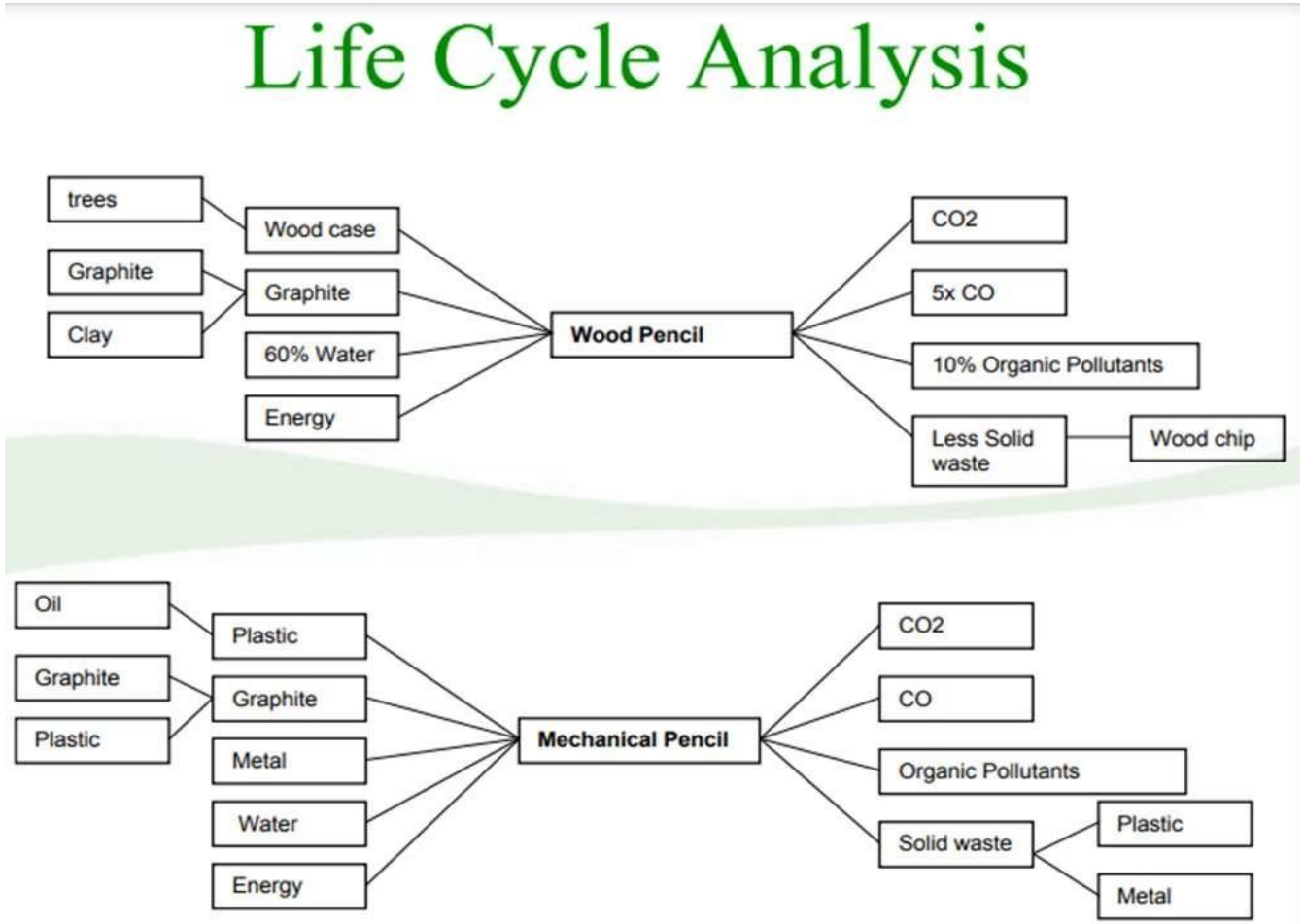
W = Waste (gas, liquid, or solid) output from product, process, or distribution

Material flow of product component

LIMITATIONS OF LCA

- Studies relate to normal operations, rather than where incidents occur, which must be understood through separate risk assessments
- The quality of the available data: obviously this is what determines the validity of the whole LCA
- Reliability of the environmental scores is dependent on the skill of the LCA practitioners employed
- Investment decisions are delayed as a consequence of how long LCAs take

EXAMPLE
WOODEN PENCIL VS MECHANICAL PENCIL



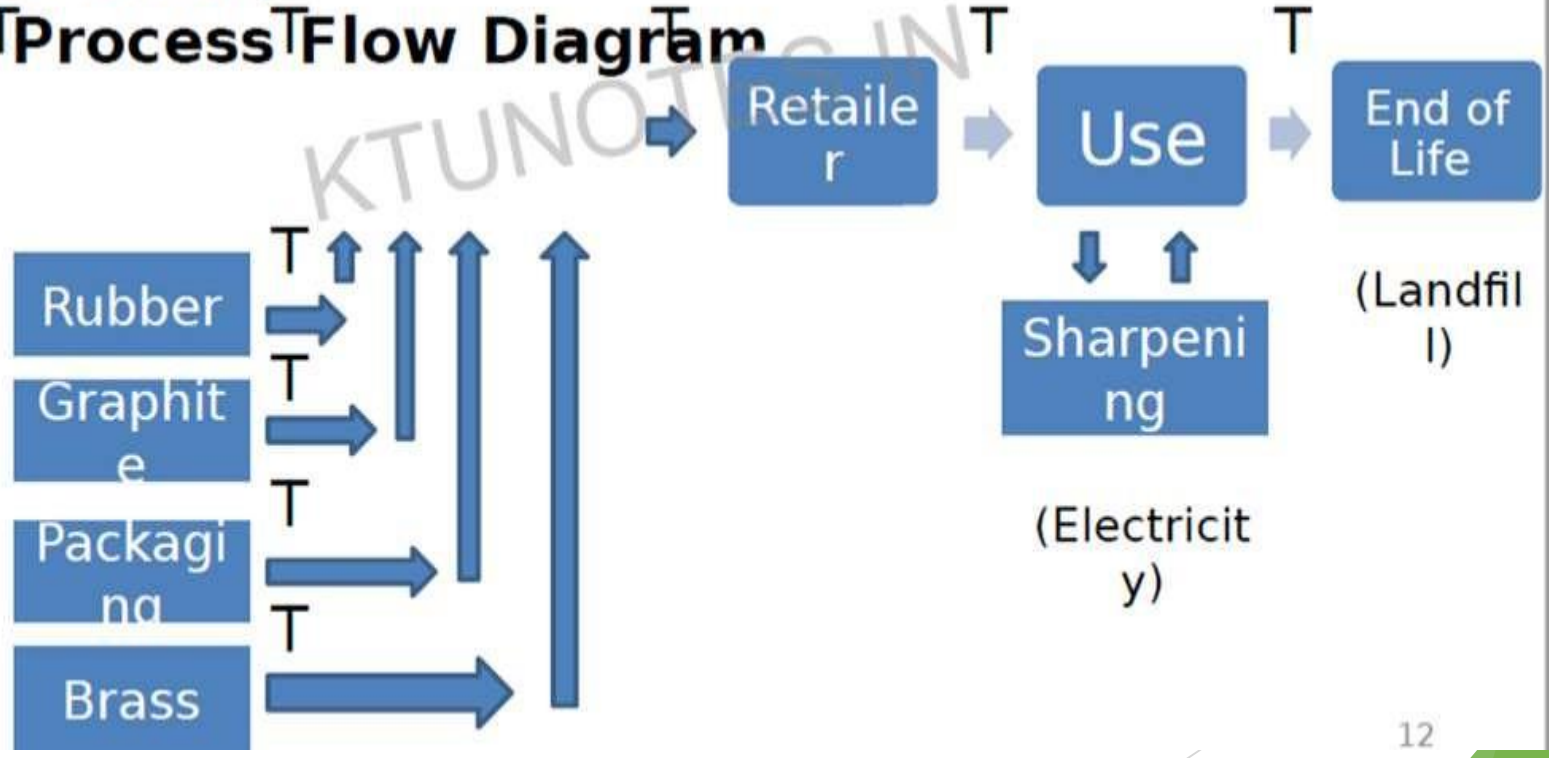
Goal and Scope

Wooden Pencil vs. Mechanical Pencil

Goal = Compare 2 writing utensils for classroom use.

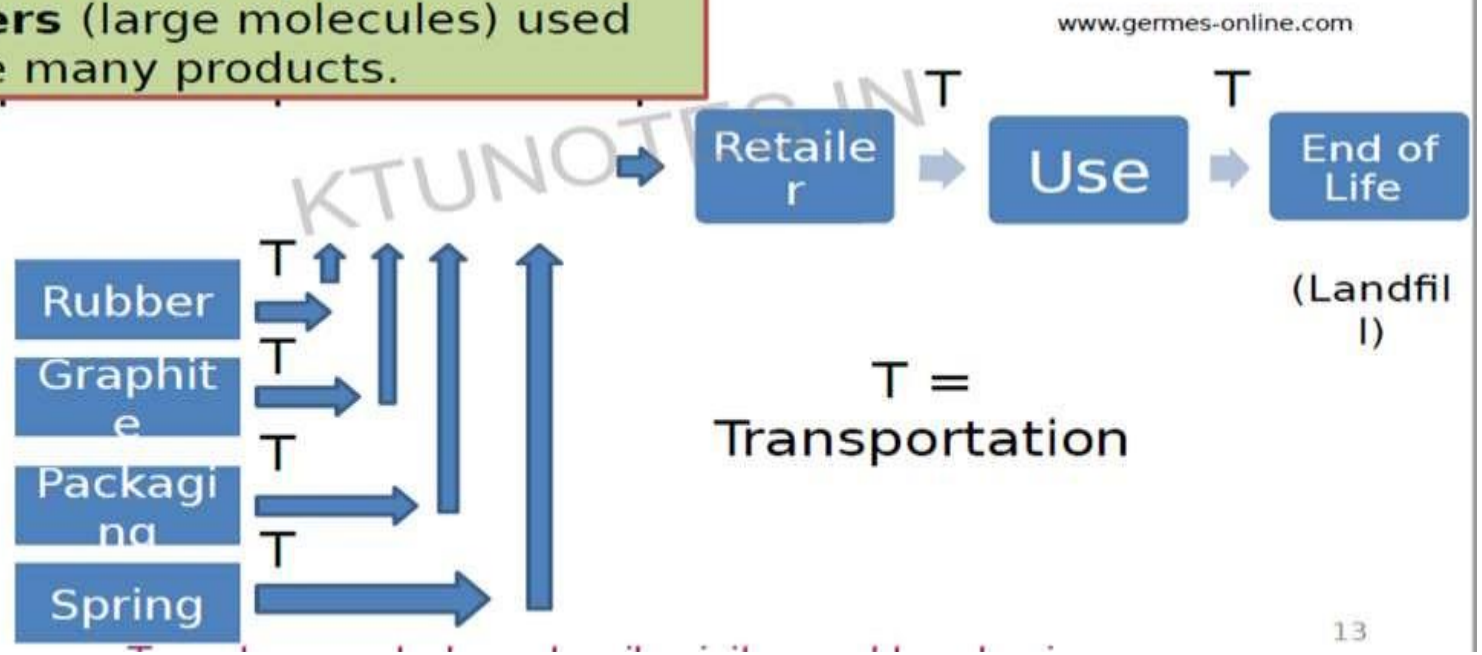
Scope: Wooden Pencil (T = Transportation)

Process Flow Diagram



Scope: Mechanical Pencil

PE = Polyethylene
PP = Polypropylene
Both materials are **plastic polymers** (large molecules) used to make many products.



Life Cycle Analysis

- Wood cased pencils
  - 4 time more raw material consumption
  - Similar energy consumption –
  - 5 to 6 times more CO emissions
- Plastic pencils
  - Twice the non-renewable resource materials
  - 40% more water consumption
  - More non-renewable energy used
  - 90% more organic pollutants emitted
  - Greater waste water effluents
  - More net process solid waste
  - Significantly more hazardous waste

A Better Solution

- • Extend the life of plastic pencils even more – Larger eraser – More graphite included in barrel – Higher quality – Discourage misplacement
- Reduce wastes – Minimize packaging

Circular economy

- A circular economy is an economic system of closed loops in which raw materials, components and products lose their value as little as possible, renewable energy sources are used and systems thinking is at the core
- It is based on three principles:
  - Design out waste and pollution
  - Keep products and materials in use
  - Regenerate natural systems


LINEAR ECONOMY
RESOURCE EXTRACTION
PRODUCTION
DISTRIBUTION
CONSUMPTION
WASTE
CIRCULAR ECONOMY
RECYCLING SECTOR
PRODUCTION
DISTRIBUTION
CONSUMPTION
RE-USE/REPAIR/RECYCLE

Circular economy principles

1..Sustainable procurement: development and implementation of a responsible purchasing policy

2. Ecodesign: process of reducing the environmental impacts of a product or service throughout its life cycle

3. Industrial and territorial ecology: search for eco-industrial synergies at the scale of a business area - the waste of one company can become the resources of another one

4. Economics of functionality: collaborative economy that favors use over possession and thus tends to sell services related to products rather than the products themselves

5. Responsible consumption: rational consumption and choice of products according to social and ecological criteria

6. Extending the duration of use: through repair, reuse and repurpose

7. Recycling: treatment and recovery of the materials contained in collected waste

Circular economy Benefits

- **Environmental**
  - The first advantage of a circular economy is the protection of the environment, reducing waste and the emissions of greenhouse gases, systematizing recycling,
- **Economic**
- Another huge benefit of the circular economy is that it stimulates innovation and boost economic growth, and could in the long run enhance the competitiveness of national companies

- **SOCIAL**

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

BIO-MIMICRY

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

  – **bios, meaning "life" + mimesis, meaning "to imitate**"

  Biomimicry = to imitate life

Componemts of Bio MIMICRY

Biomimicry as having three components with ¬

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

Biomimicry Principles

Nature…..

1: Runs on sunlight

2: Uses only the energy it needs

3: Fits form to function

4: Recycles everything

5: Rewards co-operation

6: Banks on diversity

7: Demands local expertise

8: Curbs excesses within

9: Taps the power of limits

BIOMIMICRY EXAMPLES

1.Kingfisher-Inspired Bullet Train

2.Termite den = Office building.

3.Birds = Jets

4.Whale = Turbine

ENVIRONMENTAL IMPACT ASEESSMENT (EIA)

- It is defined as an activity designed to identify and predict the impact of legislative proposals, policies, programmes, projects and operational procedures on the bio- geophysical environment and on the health and well being of human beings and to interpret and communicate information about the impact
- It also examines implications of a project that might harm people, their homeland or their livelihoods, or other nearby developments.
- After predicting the problems, a EIA identifies measures to minimize the problems and outlines ways to improve the project's suitability for its proposed environment

Main goals of EIA:

- ▫ Resource conservation
- ▫ Waste minimization
- ▫ Recovery of byproducts
- ▫ Energy conservation through efficient equipments etc

Environmental impact statement (EIS):

- The environmental impact statement (EIS) provides documentation of the information and estimates derived from the various steps in the EIA process.
- The information contained in an EIS provides the decision-makers/regulators with valuable information that could ultimately contribute to either the abandonment or substantial modification of a proposed development action.
- A typical EIS contains the following three parts:
  - Part 1 – Methods and key issues: This part deals with the statement of methods used and a summary of key issues.
  - Part 2 – Background to the proposed development: This part deals with preliminary studies (i.e., need, planning, alternatives, site selection, etc.), site description/baseline conditions, description of proposed development and construction activities and programmes.
  - Part 3 – Environmental impact assessments on topic areas: This part deals with land use, landscape and visual quality, geology, topography and soils, hydrology and water quality, air quality and climate, terrestrial and aquatic ecology, noise, transport, socio-economic ,interrelationships between effects.

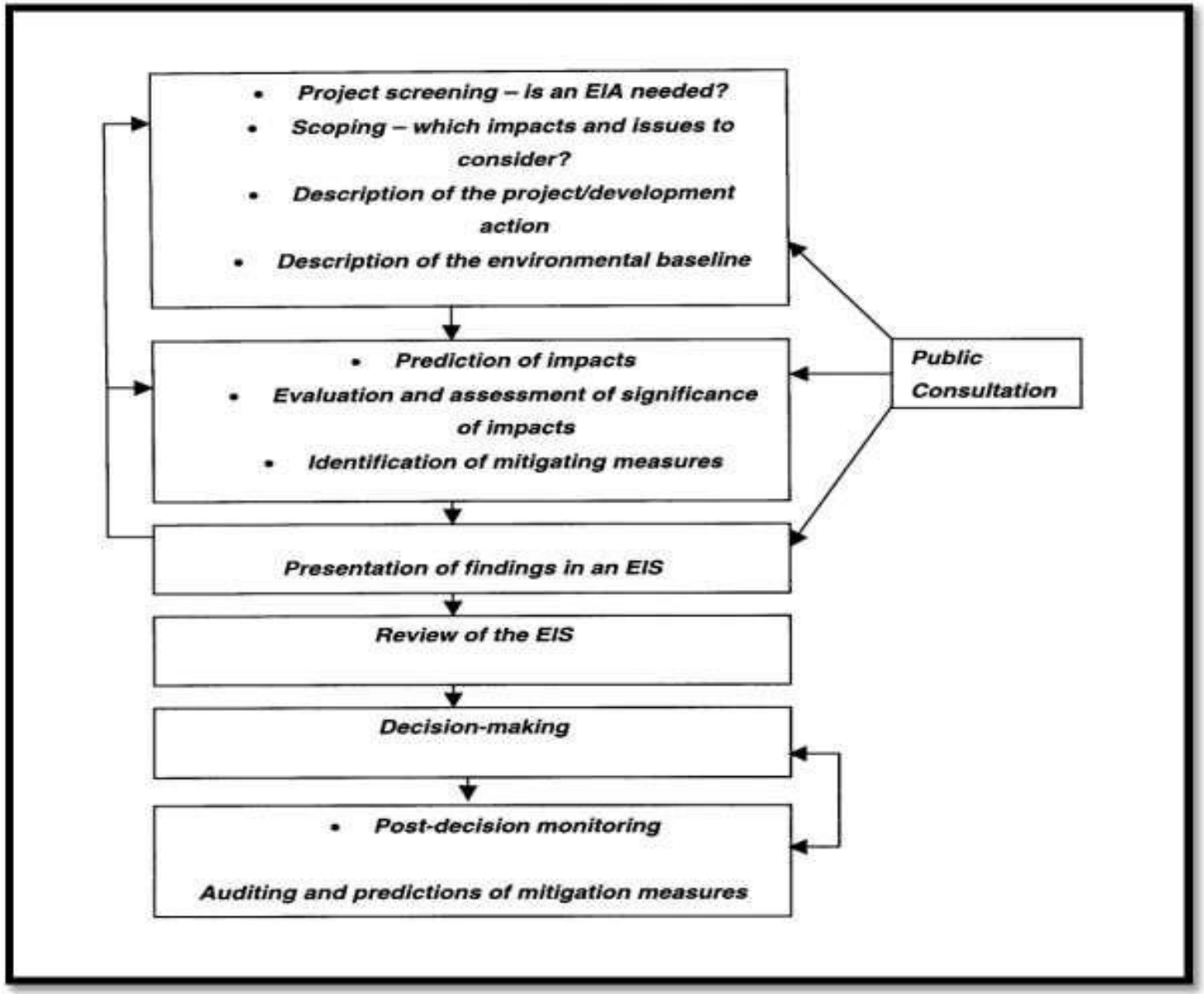
Steps in EIA process

- **Screening:** The project plan is screened for scale of investment, location and type of development and if the project needs statutory clearance.
- **Scoping:** The project's potential impacts, zone of impacts, mitigation possibilities and need for monitoring.
- **Collection of baseline data:** Baseline data is the environmental status of study area.
- **Impact prediction:** Positive and negative, reversible and irreversible and temporary and permanent impacts need to be predicted which presupposes a good understanding of the project by the assessment agency.
- **Mitigation measures and EIA report:** The EIA report should include the actions and steps for preventing, minimizing or by passing the impacts or else the level of compensation for probable environmental damage or loss.

contd….

- **Public hearing:** On completion of the EIA report, public and environmental groups living close to project site may be informed and consulted.
- **Decision making:** Impact Assessment Authority along with the experts consult the project-in-charge along with consultant to take the final decision, keeping in mind EIA and EMP (Environment Management Plan).
- **Monitoring and implementation of environmental management plan:** The various phases of implementation of the project are monitored.
- **Assessment of Alternatives, Delineation of Mitigation Measures and Environmental Impact Assessment Report:** For every project, possible alternatives should be identified, and environmental attributes compared. Alternatives should cover both project location and process technologies.
- Once alternatives have been reviewed, a mitigation plan should be drawn up for the selected option and is supplemented with an Environmental Management Plan (EMP) to guide the proponent towards environmental improvements.
- **Risk assessment:** Inventory analysis and hazard probability and index also form part of EIA procedures.

STEPS IN EIA PROCESS



Benefits of EIA

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

INDUSTRIAL ECOLOGY (IE)

- **Industrial ecology** (**IE**) is the study of material and energy flows through industrial systems. The global industrial economy can be modelled as a network of industrial processes that extract resources from the Earth and transform those resources into commodities which can be bought and sold to meet the needs of humanity.
- Industrial ecology is concerned with the shifting of industrial process from linear (open loop) systems, in which resource and capital investments move through the system to become waste, to a closed loop system where wastes can become inputs for new processes.

Clip slide

- IE is a dynamic system-based framework that enables management of human activity on a sustainable basis by:
  - Minimizing energy and materials usage
  - Ensuring acceptable quality of life for people
  - Minimizing the ecological impact of human activity to levels natural system can sustain
  - Maintaining the economic viability of systems for industry

Economic Benefits of IE

Hidden Resource Productivity Gains

- **Within Firm**: eliminating waste

Making plant more efficient

- **Within Value Chain**: reducing costs

Synergies between production and distribution

- **Beyond Production Chain**: closed loop

  Eco-Industrial Parks and inter-firm relations

INDUSTRIAL SYMBIOSIS

- **Industrial symbiosis** a subset of industrial ecology. It describes how a network of diverse organizations can foster eco-innovation and long-term culture change, create and share mutually profitable transactions—and improve business and technical processes.
- Industrial symbiosis is the process by which wastes or byproducts of an industry or industrial process become the raw materials for another.

Key Benefits

Some key benefits of industrial symbiosis are outlined below:

Impact Reduction	• Reduction of **environmental impact** of waste through recovery, reuse and recycling. • **Biostabilisation** reduces the environmental impacts and risks associated with wastes that are sent to landfill.
Economic Value	• Creation of **economic value** from waste material.
Climate and Air	• Reduction of **GHG emissions** from waste transport and raw material extraction. • Reduction of reliance on **fossil fuels** and decrease of emissions of **NO_x, SO_2, CO_2**.
Knowledge and Skills	• Extension of knowledge and practical know-how of how waste management can be transformed into a **sustainable and growth oriented** business.

THANK YOU

Module 4

ENERGY SOURCES

- CONVENTIONAL & NON CONVENTIONAL SOURCES
- SOLAR ENERGY
- WIND POWER
- HYDROPOWER
- BIOFUEL
- GEOTHERMAL
- ENERGY DERIVED FROMOCEANS

ENERGY SOURCES

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

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

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

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

- Non Conventional Resources
  - Solar , wind,
  - Hydropower, tidal power
  - Biomass, biofuel
  - geothermal

SOLAR ENERGY

SOLAR ENERGY TECHNOLOGIES

- Thermal conversion

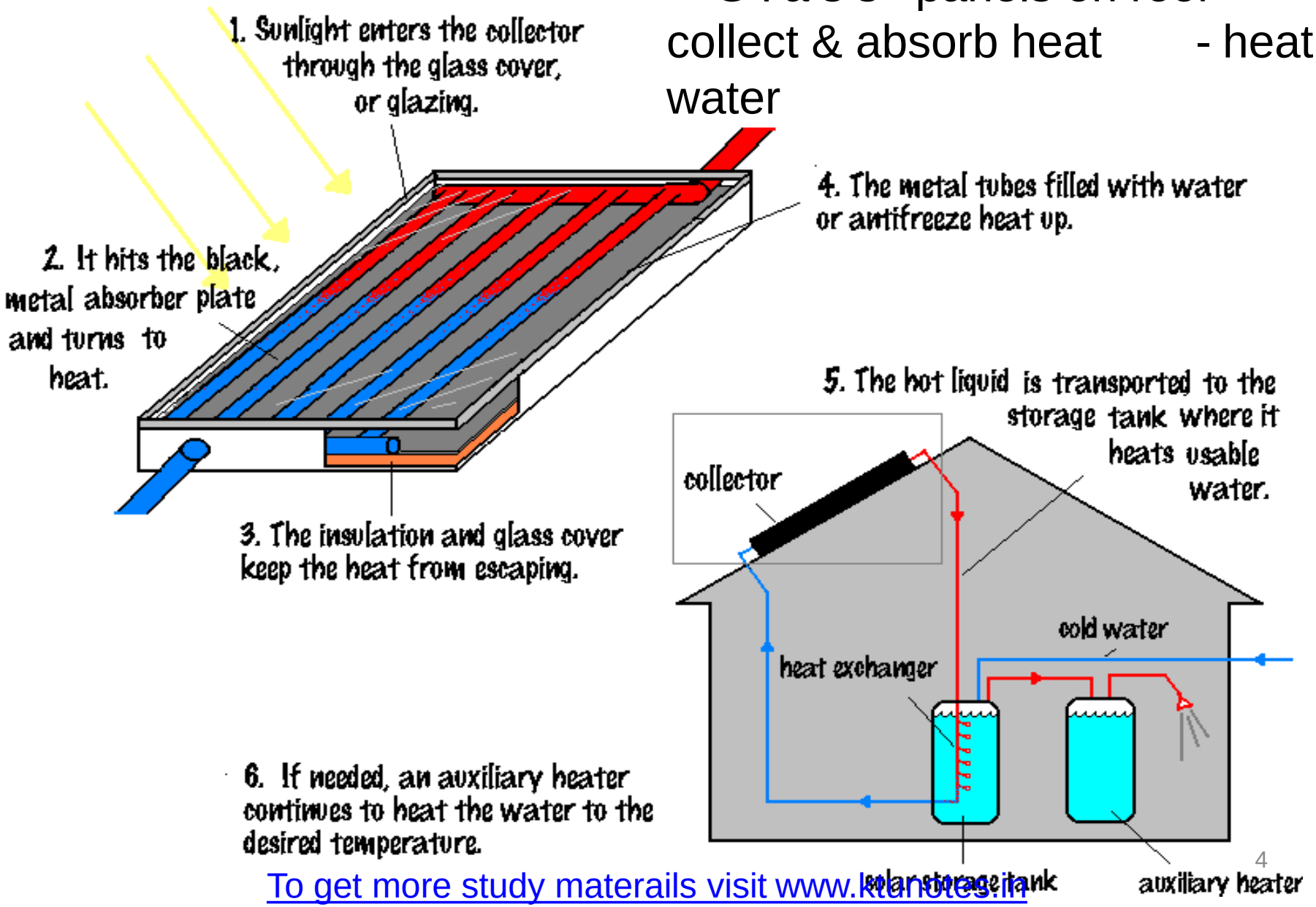
- Solar water heater
- Solar space heating of buildings
- Solar air conditioning
- Solar refrigeration
- Solar drying
- Solar cooking
- Solar electricity – thermal

- photo-conversion

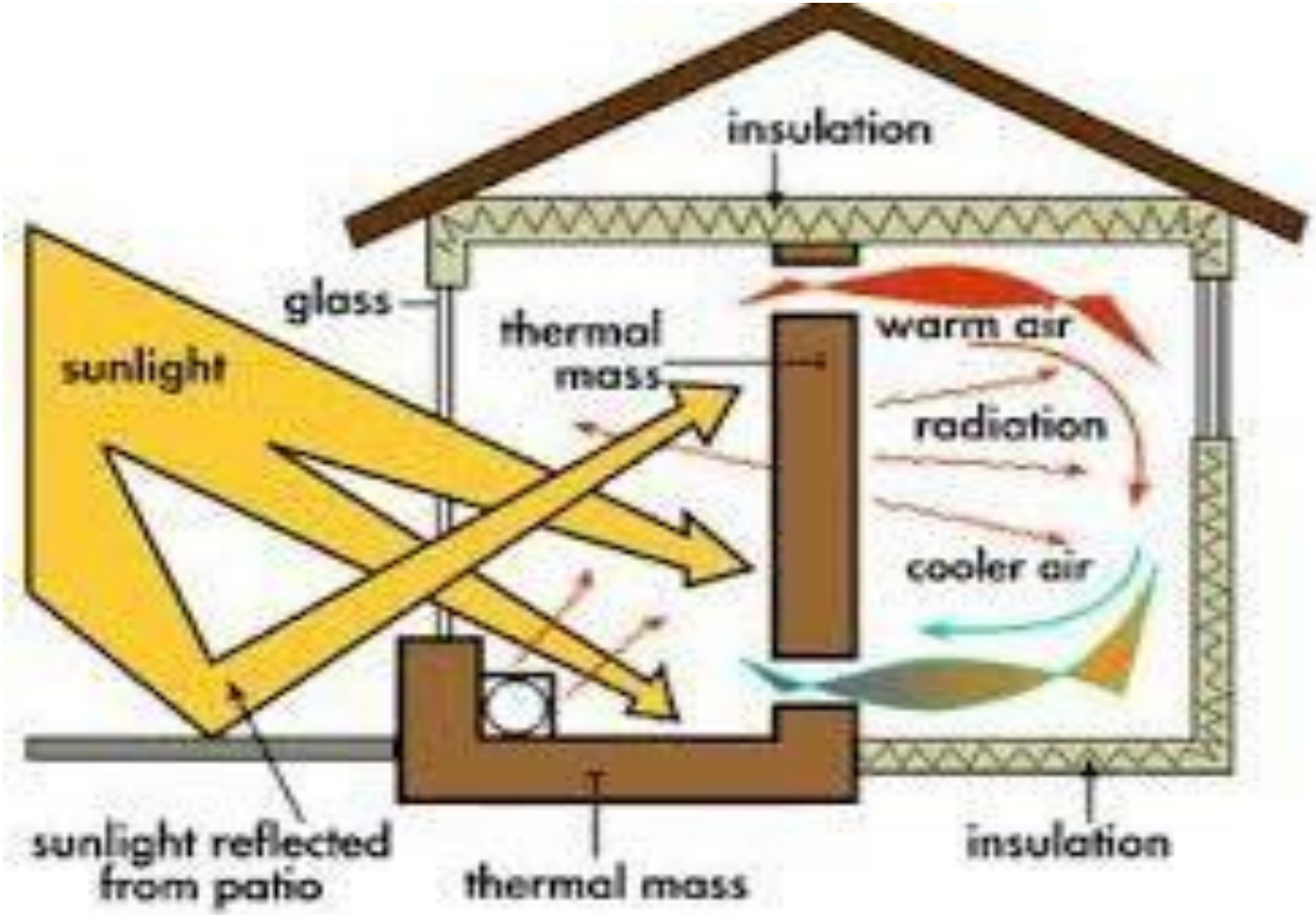
- Solar green houses
- Solar furnaces
- Solar desalination
- Salt production
- Solar electricity - photovoltaic

1. SOLAR WATER HEATING

- Glass panels on roof collect & absorb heat - heat water



2. SOLAR SPACE HEATING OF BUILDINGS

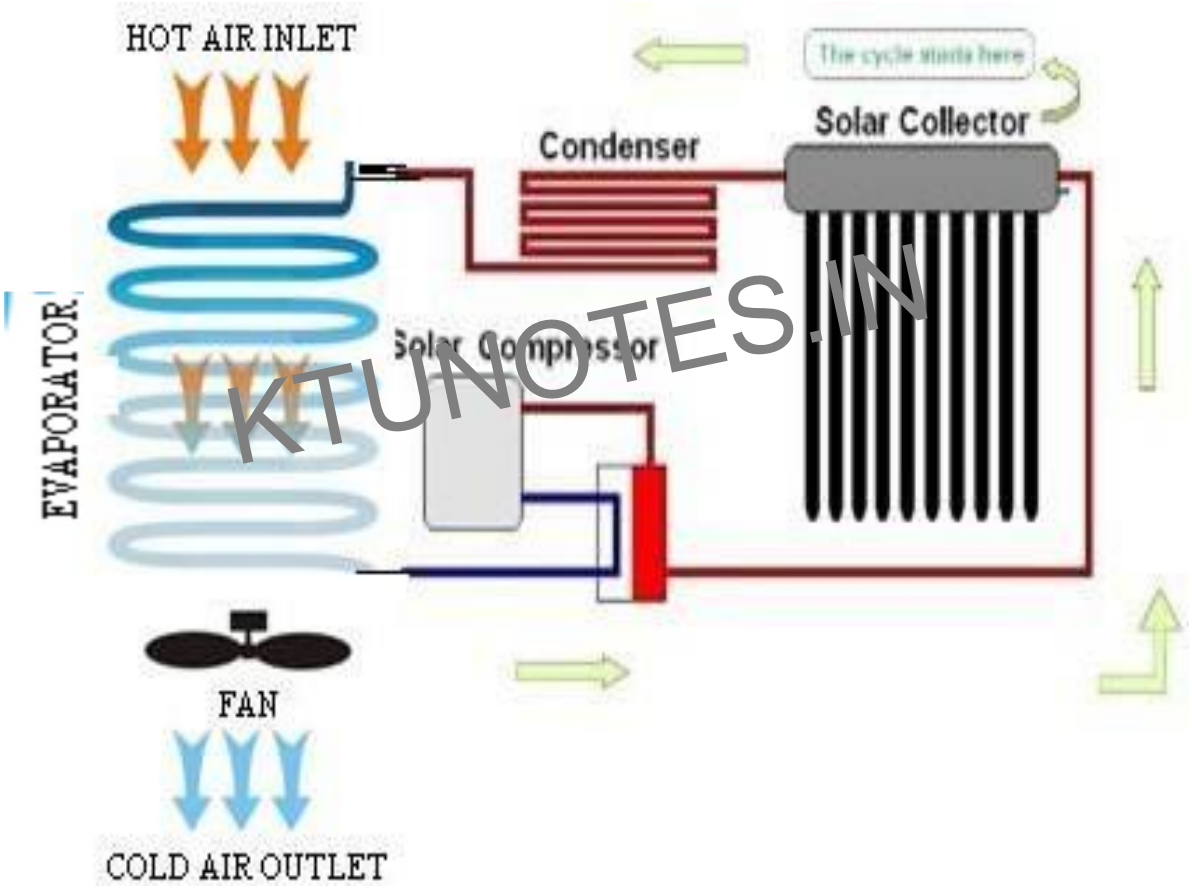


- Provided
  - architectural design of the building
  - large south facing windows

3. SOLAR AIR CONDITIONING

- Solar powered AC system for buildings

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

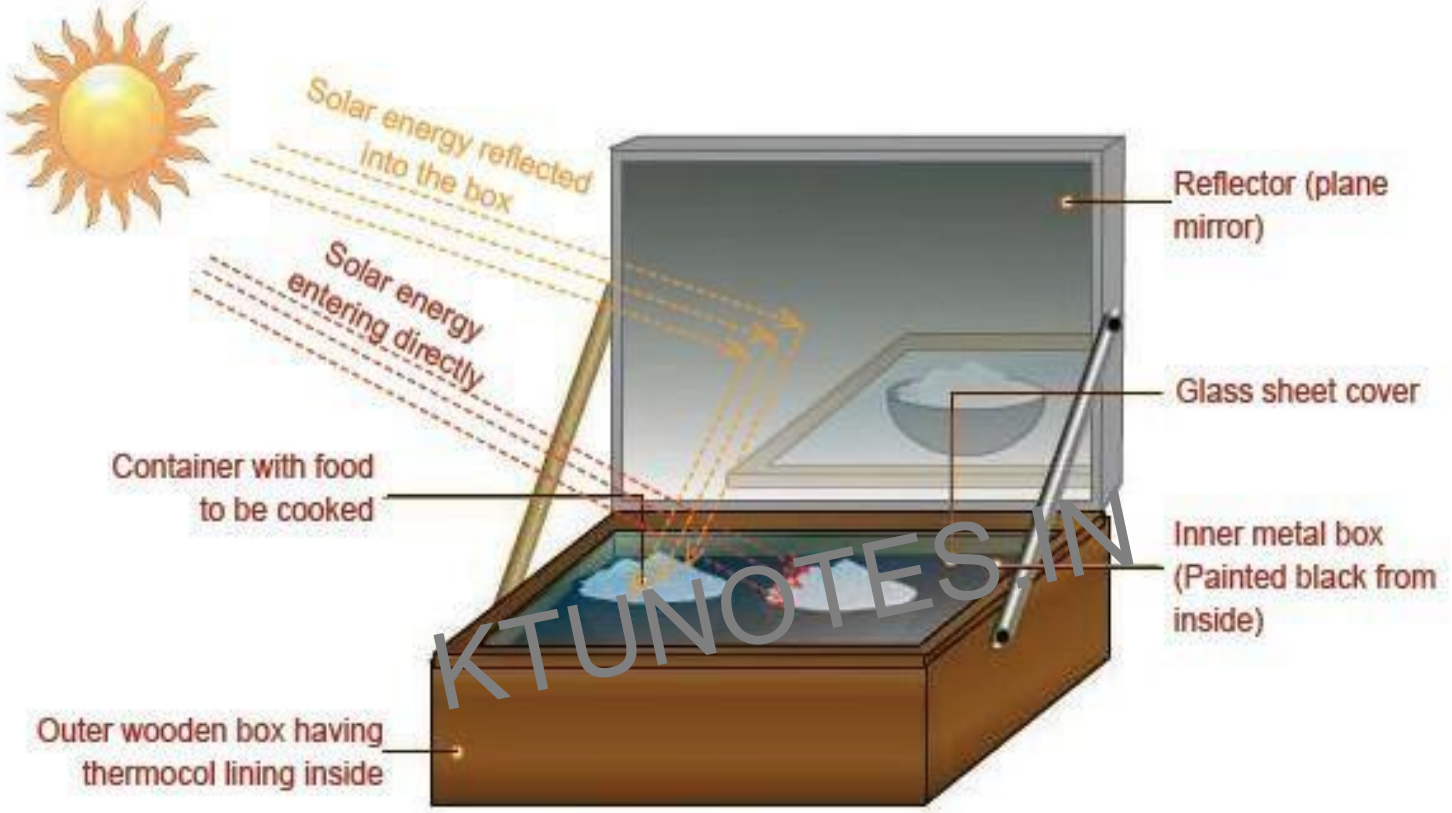


4. SOLAR REFRIGERATION

5. SOLAR DRYING

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

6. SOLAR COOKING

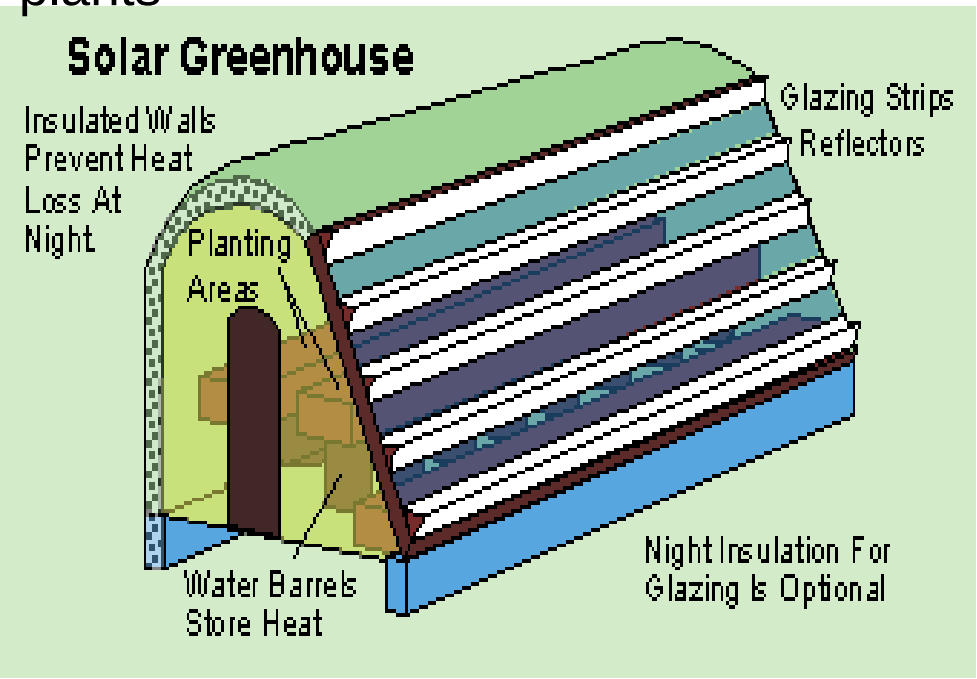


- It is well insulated shallow rectangular/square metal box with a flat glass cover
  - blackened inside (to increase the temperature)

- heat absorbed by blackened surface is used for cooking

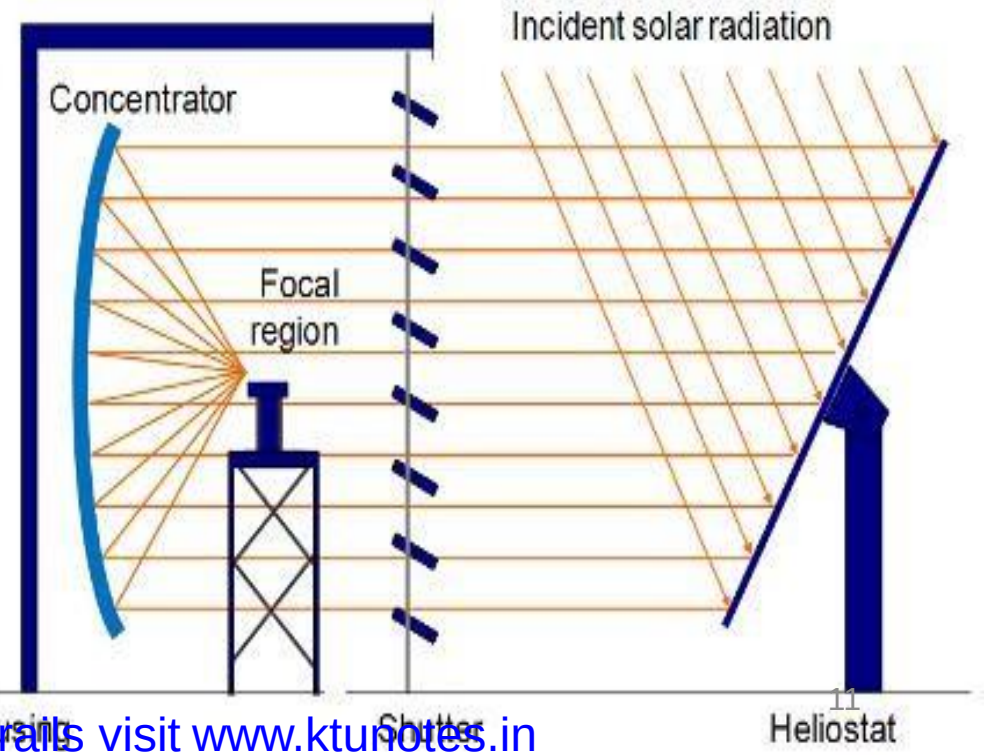
7. SOLAR GREENHOUS

- Greenhouse is a closed studure 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 tapped inside & increases inside temperature

8. SOLAR FURNACES

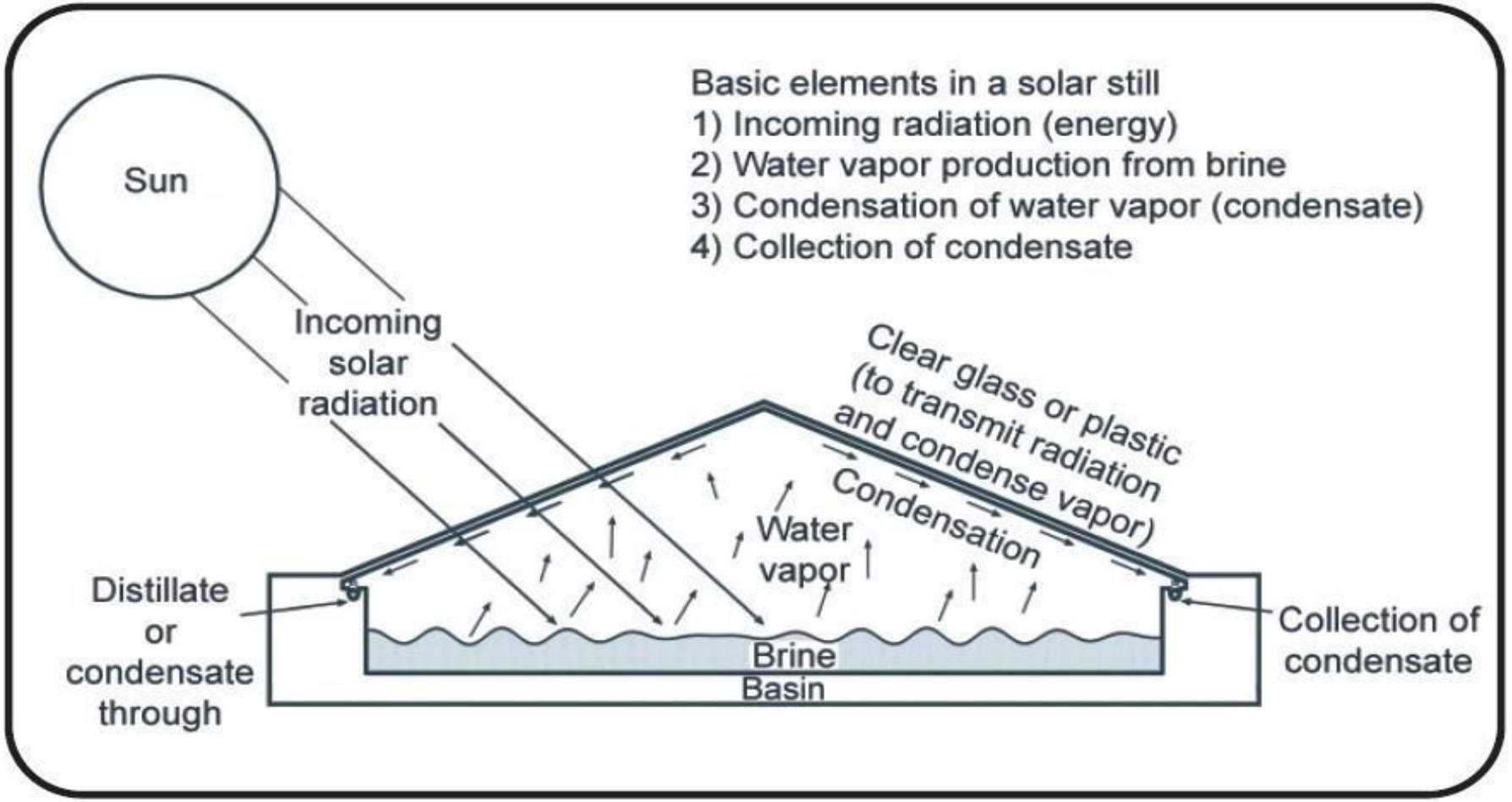


- Use huge array of mirrors to concentrate the sun's energy into a small area & produce very high temperature
- Can produce around 3500^0C
- Can be used to melt refractory materials

9. SALT PRODUCTION

- Traditional method to obtain salt

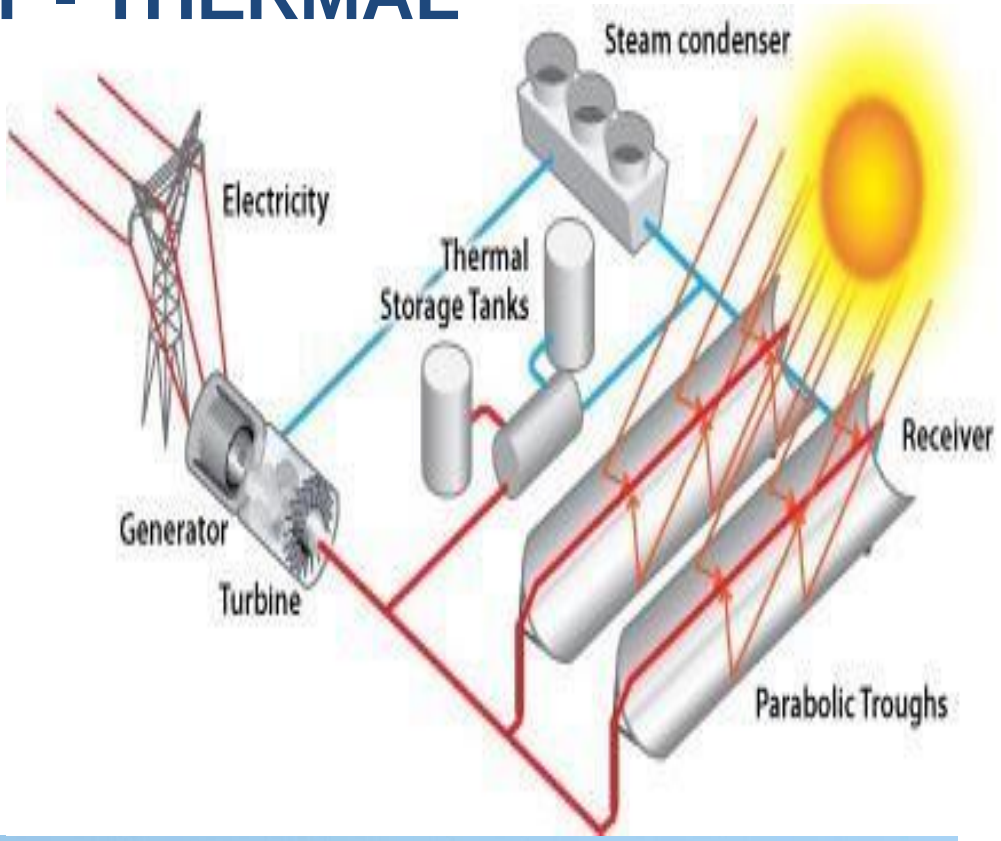
10. SOLAR DESALINATION



- Solar radiation passed through glass cover and is absorbed and converted into heat , which evaporates the water in the saline water

- The produced vapour is condensed to form purified water & collected from the under side of slopping roof

11. SOLAR ELECTRICITY - THERMAL



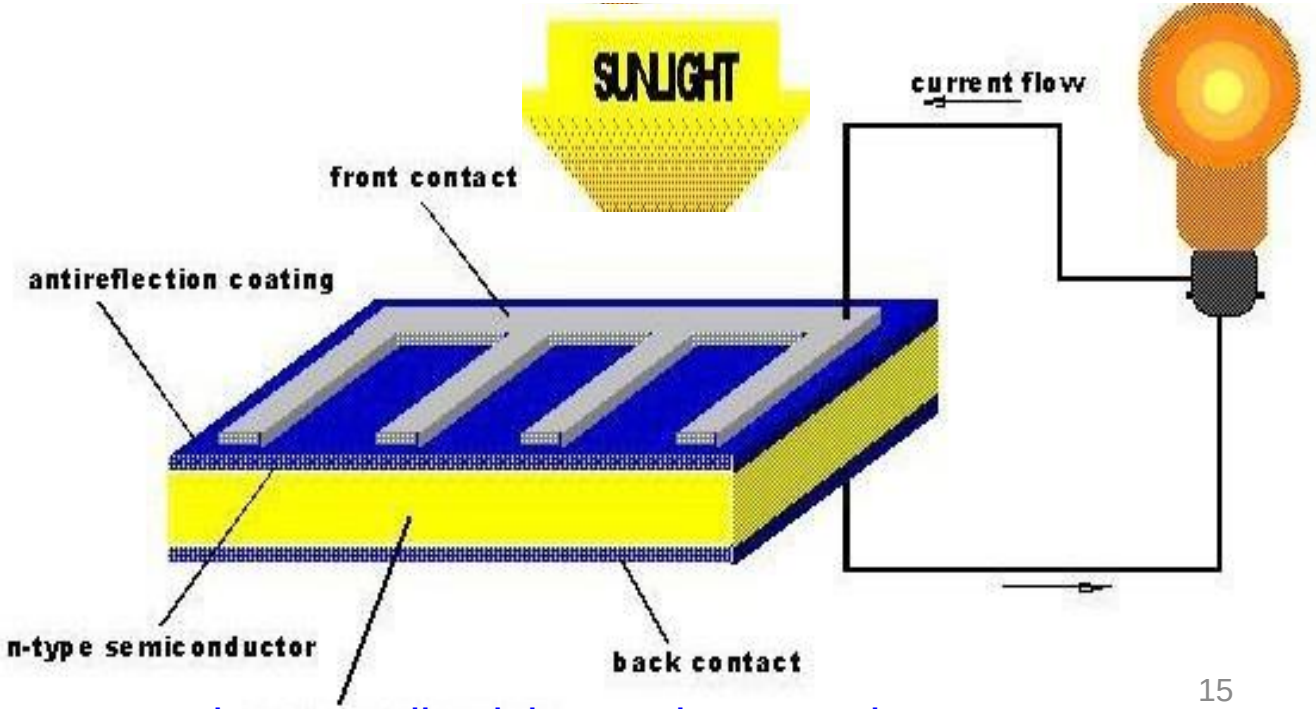
- Solar energy is used to heat a fluid

  & runs the turbine- generates electricity

12. SOLAR ELECTRICITY - PHOTOVOLTAIC

- **SOLAR CELLS**
- Made of semiconducting materials – that converts sunlight directly into electricity

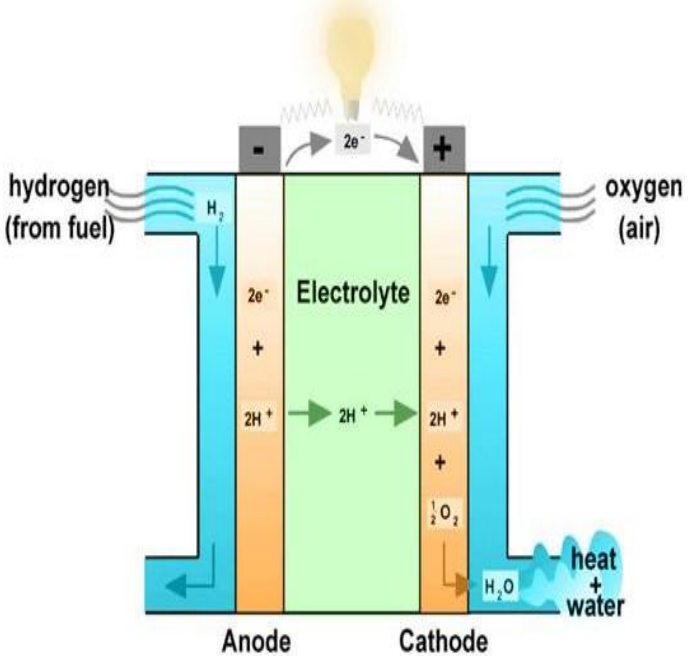
- **Photovoltaic roof tiles** (used for covering roof) are special tiles which trap sunlight and transform to electricity Solar Photo – Voltaic Ce



Cochin International airport Ltd

- World's first that completely operates on solar power. --- 18th August 2015
- Comprise - 46,150 solar panels laid across 45 acres near cargo complex.
- 12 MWp solar power plant – producing 50,000 to 60,000 units of electricity per day
- This is a grid connected system without battery storage and a power banking module with the Kerala State electricity board (KSEB) has been worked out-
  - wherein, CIAL gives as much power it produces (in day time) to (the grid of) KSEB and ' buy ' back the power from them when needed (especially in night).
- reduce carbon emissions equal to 1.75 lakh MT for the next 25 years. This is equal to planting 30 lakh trees.

FUEL CELLS



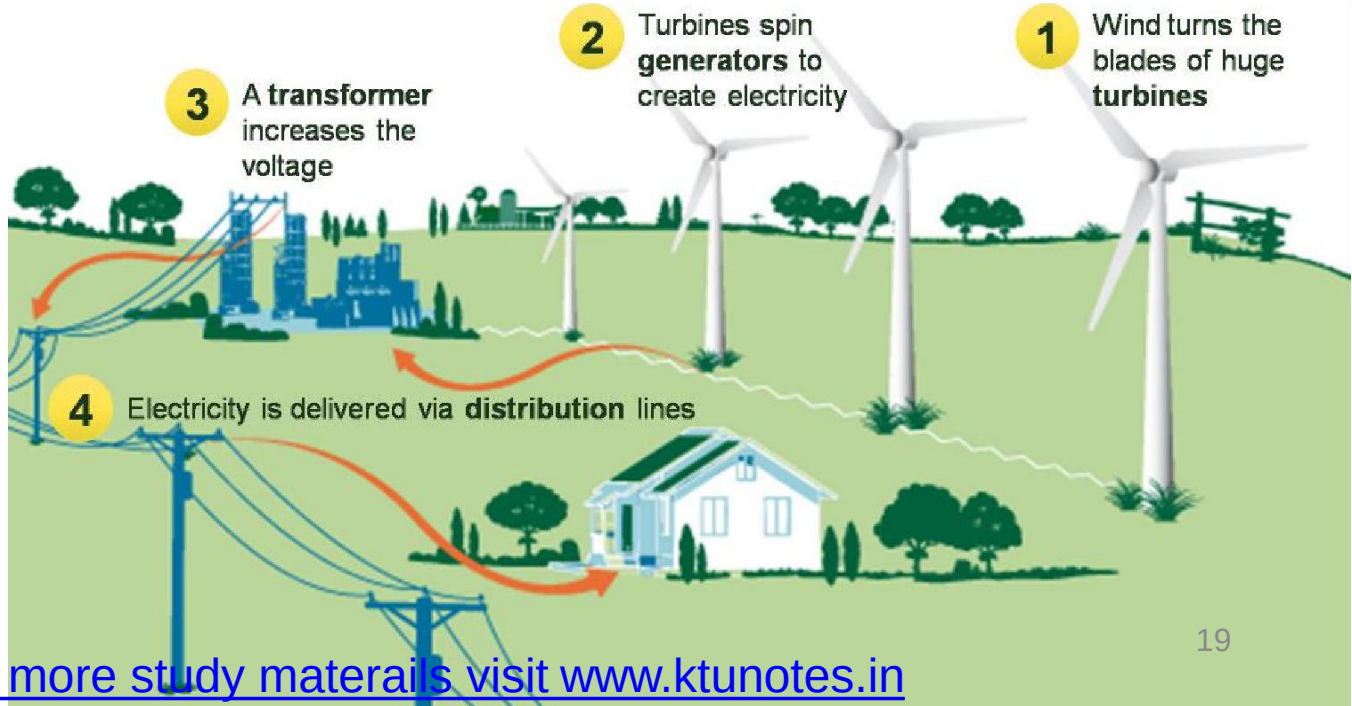
- device that generates electricity by a chemical reaction
- every fuel cell has
  - 2 electrodes
    - One positive -anode & other one negative-cathode
  - an electrolyte
    - Which carries electrically charged particles from one electrode to another
  - a catalyst
    - Which speeds the reaction at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

- Windmills –are erected at high altitudes & its blades are attached to the turbines
  - As the blades rotates, the kinetic energy of the wind can be used to run the turbines, which runs the generator and it generates electricity.
- Turbines generally requires a wind speed of 20km/hr
- Best places for wind farms
  - Coastal areas, at top of rounded hills, open plains, gaps in mountains
  - Places where wind is strong & reliable

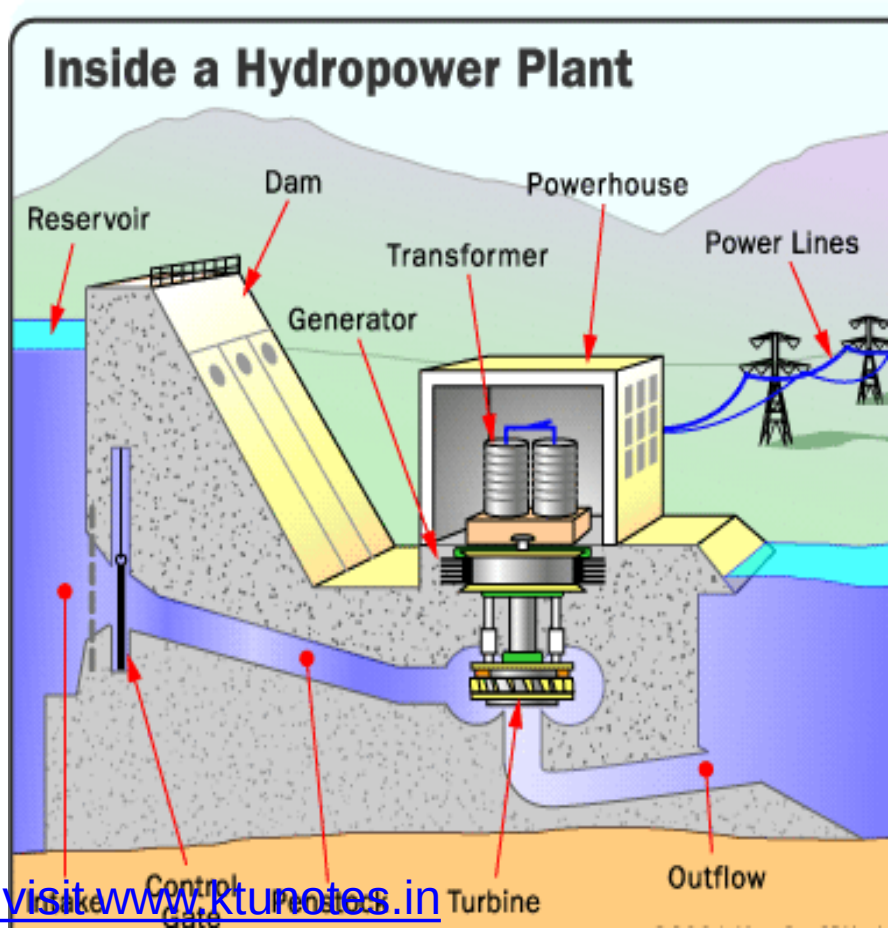


HYDRO-ELECTRIC POWER

- Dam
  - Gravitational potential energy is stored in the water above the dam

- As water flows from higher elevation to lower elevation through penstock and it attains kinetic energy

- It arrives at the turbines at high pressure and turns it and thus drives the generators and generates electricity



TYPES OF HYDRO-ELECTRIC POWER

- Classified based on station capacity
  - Micro hydropower : < 100 kW
  - Mini hydropower : 101 – 2000 kW
  - Small hydropower : 2001 – 25000 kW

ENERGY DERIVED FROM OCEANS

- Ocean energy captured by
  - Tidal energy
  - Wave energy

NERGY DERIVED FROM TIDES

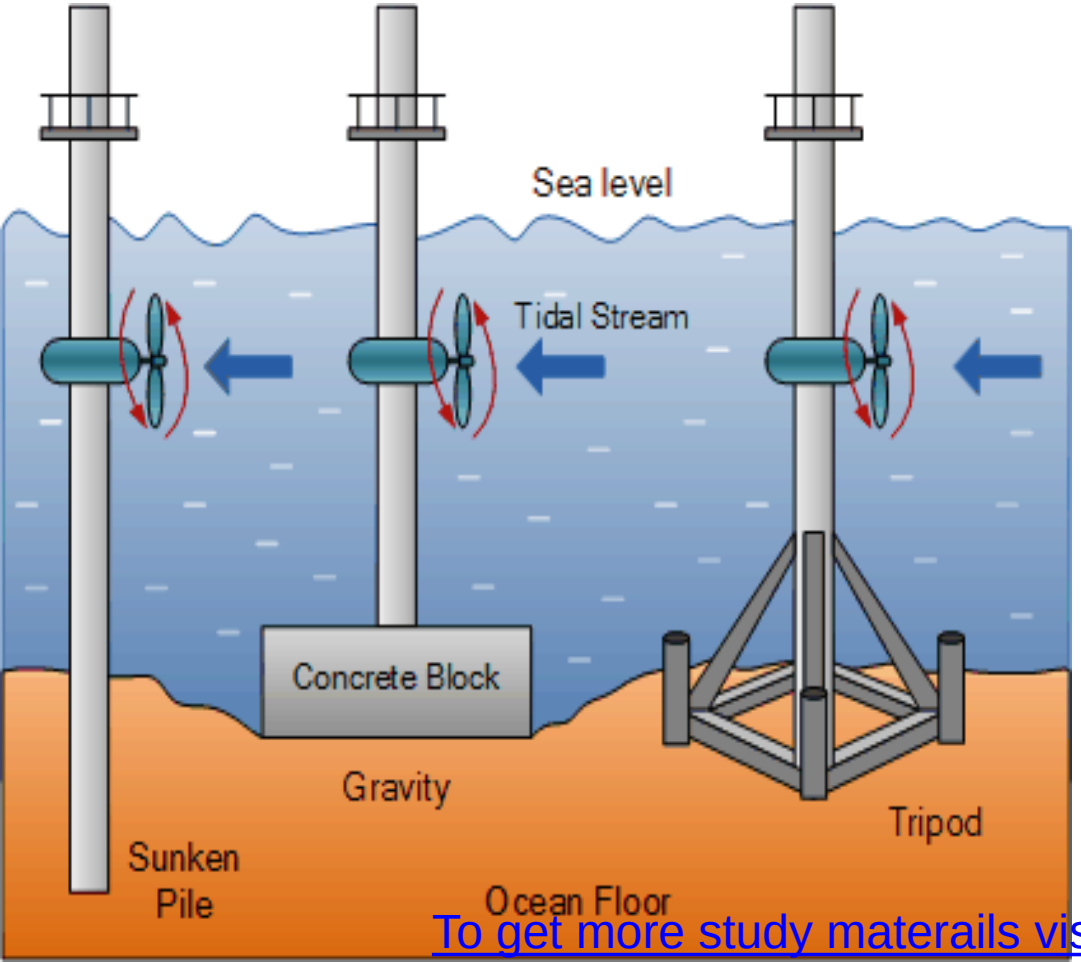
- Tidal energy is generated by the relative motion of earth, sun & moon, due to gravitational force

ADVANTAGES OF TIDAL POWER

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

CATEGORIES OF TIDAL POWER

- Tidal stream systems
- Barrages
- Tidal lagoons



1.Tidal stream systems

- Use kinetic energy of moving water to power turbines

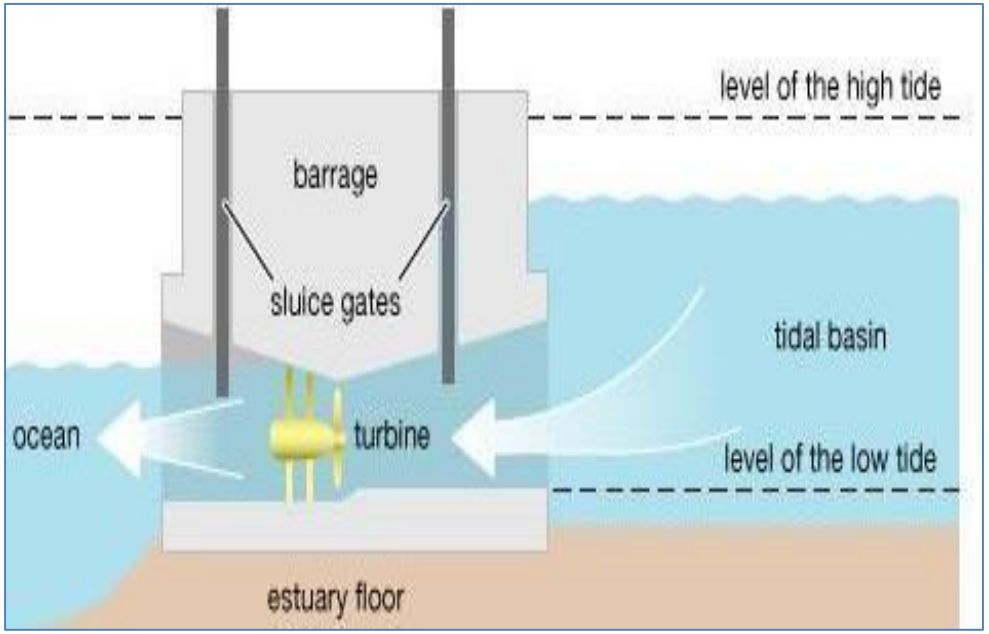
(similar to wind mill)

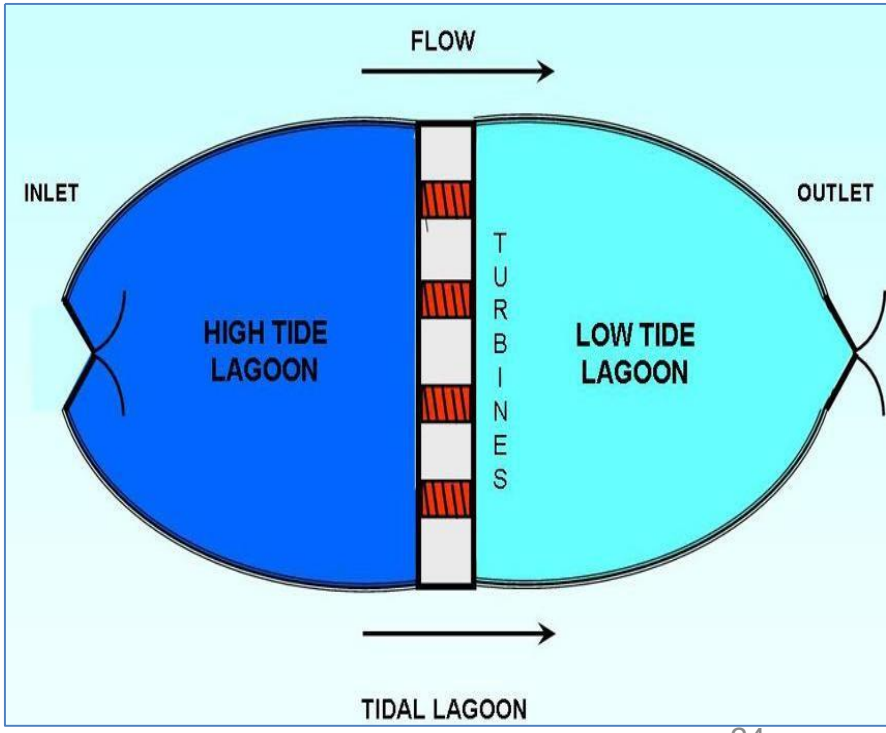
2. Barrages

- Use potential energy in the height difference between high & low tide
- They are dams across full width of a tidal estuary

3. Tidal lagoons

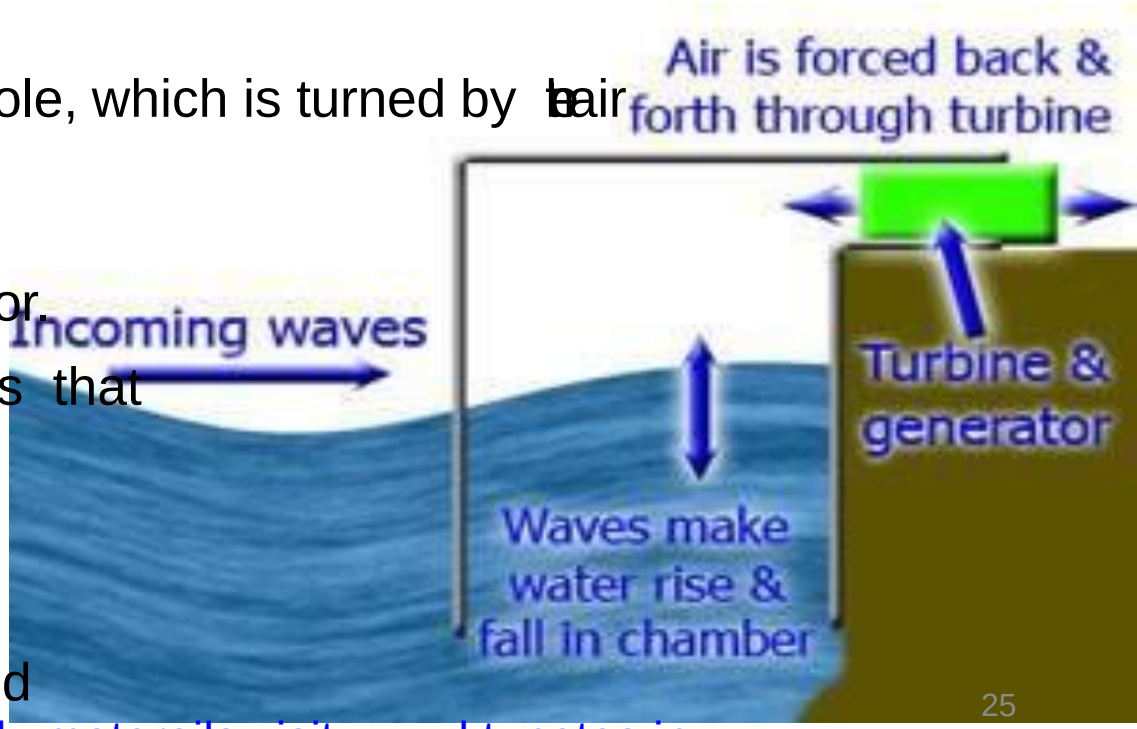
- Similar to barrages
- Not fully across an estuary
- Low impact & low cost





2. ENERGY DERIVED FROM WAVES

- Ocean waves are caused by the wind as it blows across the sea.
  - But it's not easy to trap this energy and convert it into electricity in large amounts. Thus, wave power stations are rare
- At a wave power station –
  - the incoming waves cause the water in the chamber to rise and fall, which means that air is forced in and out of the hole in the top of the chamber.
- We place a turbine in this hole, which is turned by the air rushing in and out.
- The turbine turns a generator.
- A problem with this design is that the rushing air can be very noisy, unless a silencer is fitted



ADVANTAGES OF WAVE POWER

- Energy generated is free – no fuel needed, no waste produced
- Not expensive to operate and maintain

DISADVANTAGES OF WAVE POWER

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

BIOFUELS

- Biofuels are the fuels derived from **biomass** (organic material derived from living, or recently living organisms)
  - which is burned to release its stored chemical energy

- Biofuels
  - First generation biofuels
  - Second generation biofuels
  - Third generation biofuels

- **First-generation biofuels** or **conventional biofuels**
  - Constitute majority of biofuels currently in use
  - made from sugar, starch, or vegetable oil.
    - They are not sustainable/ green
    - if used in large quantity would have a large impact on the food supply

Second generation biofuels or **advanced biofuels**

- they are ‘greener’, as they are made from sustainable materials
- fuels that manufactured from various types of biomass.
  - I e . from lignocellulosic biomass or crops, agricultural residues or waste
  - b u t harder to extract the required fuel.
  - A series of physical and chemical treatments might be required

    to convert biomass to liquid fuels suitable for transportation.
- M o s t second generation fuels are under development and not

widely available for use.

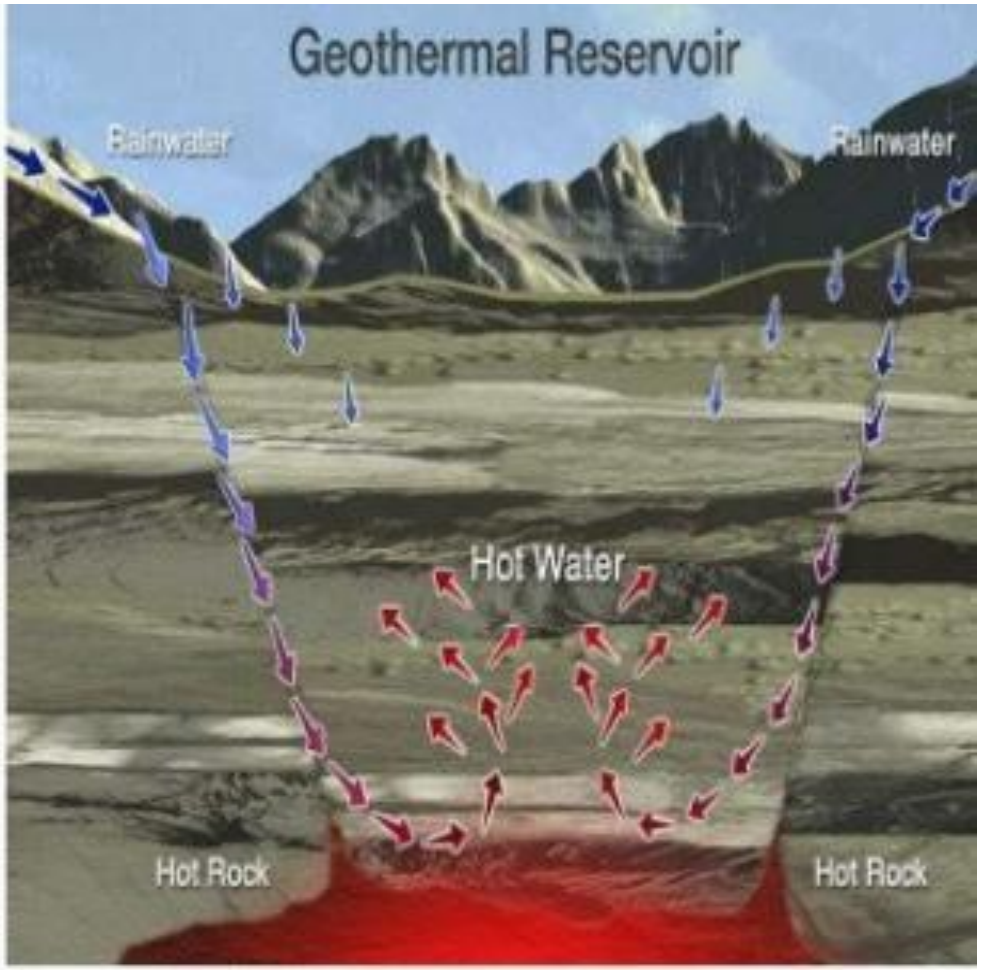
Third generation biofuel

- It has only recently developed
- it refers to biofuel derived from,algae

- **List of biofuels - derived from biomass**
  1. Bio alcohols
  2. Biodiesel & green diesel
  3. Bioethers
  4. Biogas
  5. Aviation biofuel
  6. Solid biofuels
  7. Advanced biofuels

GEOTHERMAL ENERGY

- Geothermal energy is the heat from the Earth
- heat comes from radioactive decay of core of the earth
- this power can be extracted for use



The rising hot water & steam is trapped in permeable & porous rocks to form a geothermal reservoir.

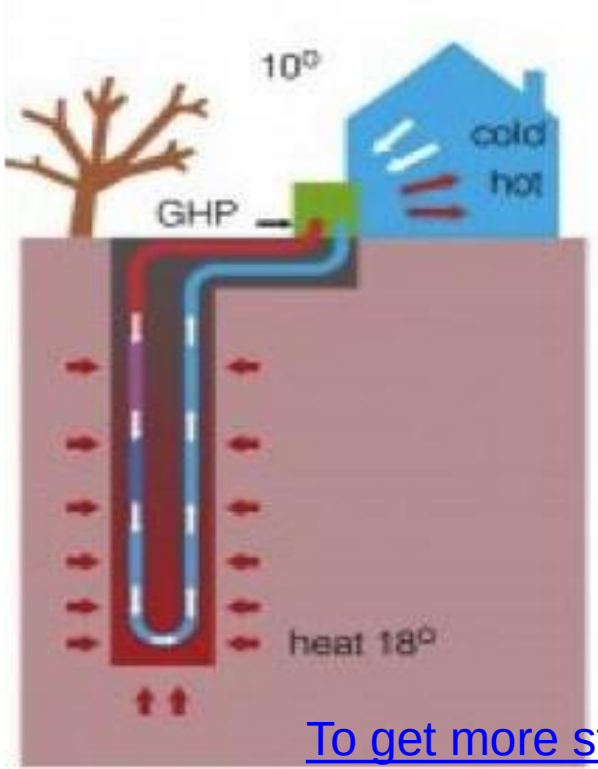
Reservoirs can be discovered by

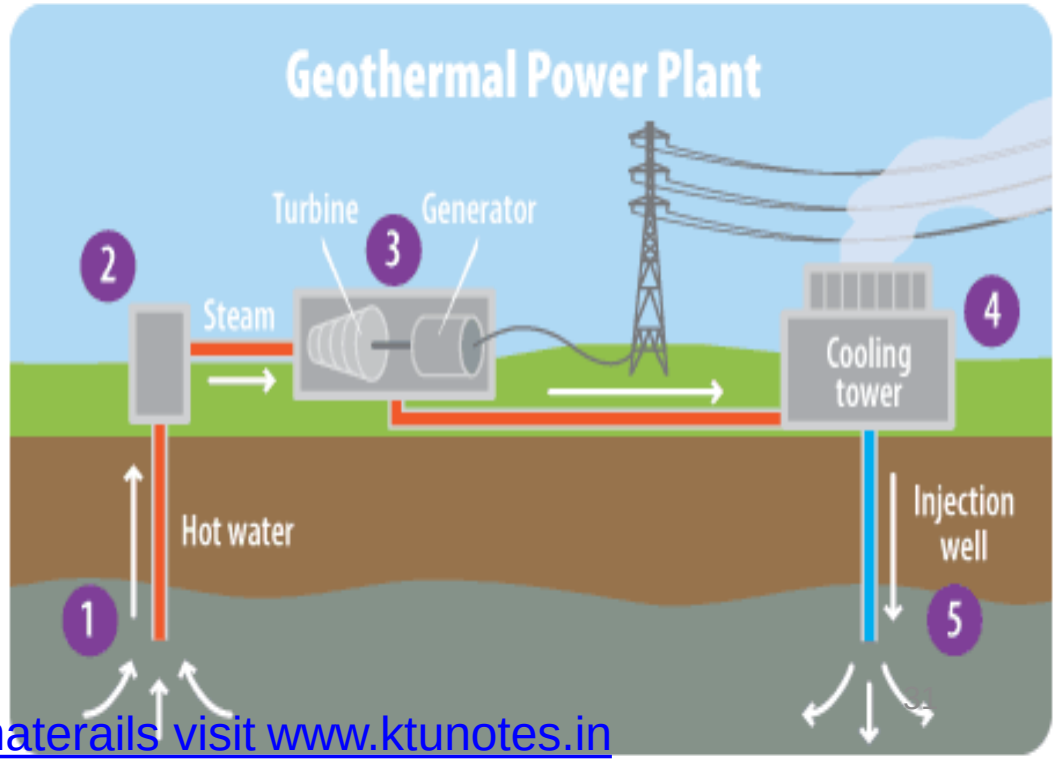
- testing the soil
- analyzing underground temperature

Extraction & uses

- The heat energy can be brought to earth surface by following ways..
  - → directly from hot springs/ geysers
  - → geothermal heat pump

- It can be used in two ways
  - geothermal heating
  - Geothermal electricity



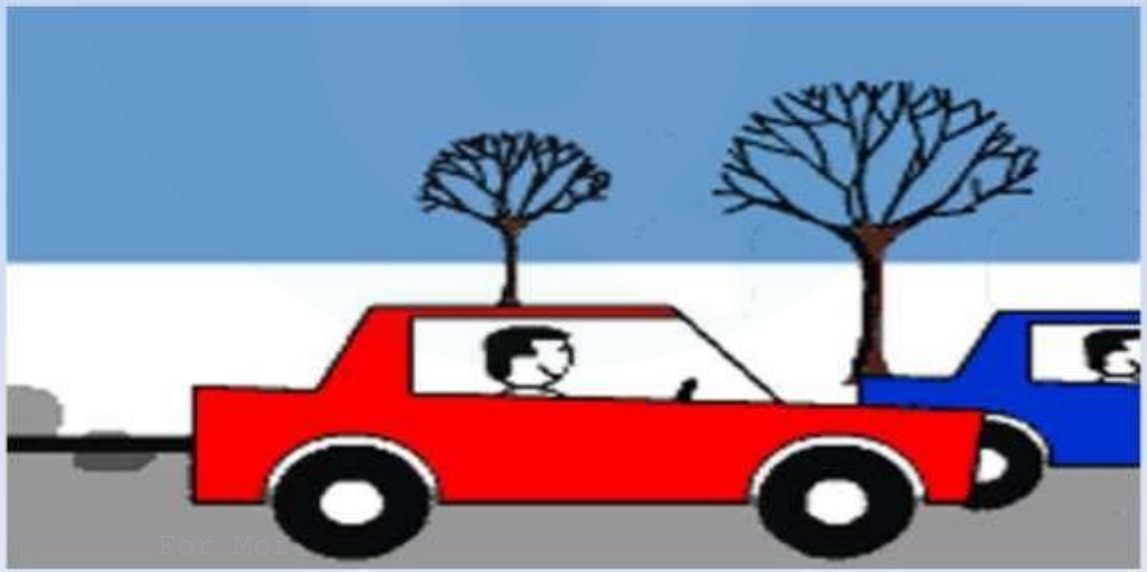


THANK YOU…

SUSTAINABLE TRANSPORTATION

Why is This Issue Important?

1. Regular transportation causes air pollution
2. There are limited fossil fuels
3. Wasted resources on a micro scale



Air Pollution

- #1 pollutant in oil driven vehicles is **CO_2** , or **carbon dioxide** .

Air Pollution & Your Health

- Between 350,000 and 500,000 Chinese die prematurely each year because of the country's disastrous air pollution

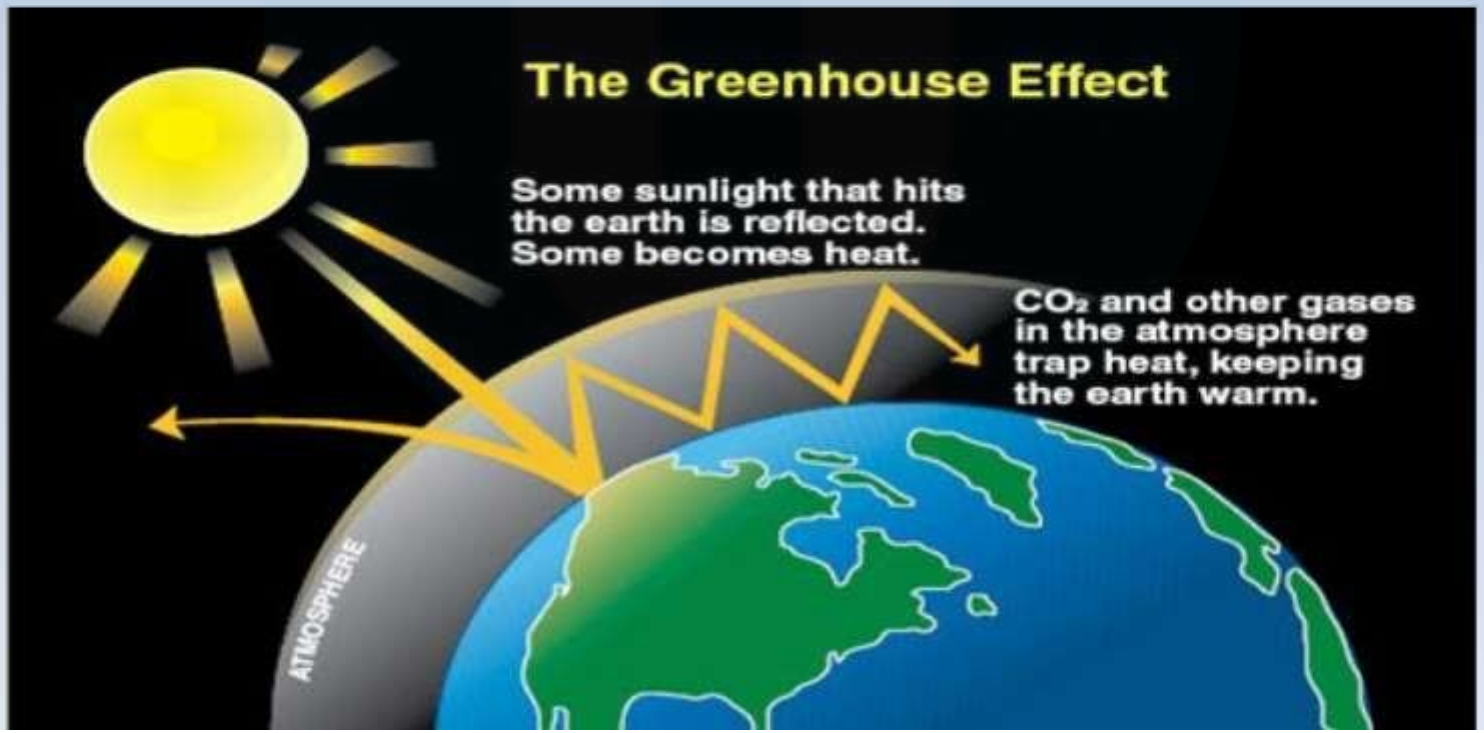
Beijing, China

Air Pollution & Transportation

- This pollution comes partially from a vehicle's **exhaust**, which outputs large amounts of CO_2 .

Air Pollution & The Environment

- A **greenhouse gas** is any gaseous compound in the atmosphere that is capable of absorbing infrared radiation, thereby trapping and holding heat in the atmosphere. Increasing the heat in the atmosphere ultimately leads to global warming.
- In 2012, U.S. greenhouse gas emissions totaled 6,526 million metric tons of carbon dioxide equivalents, which equaled 82% of all human caused greenhouse gasses.



What is Sustainable Transportation?

- **Sustainable transportation** is human transportation that does not rely on fossil fuels or other finite resources, does not harm the environment, and still allows mankind to travel the world as quickly and safely as they do today.

Potential Solutions

- Many solutions are being implemented *today* across the globe in order to overcome these challenges.
- While these solutions are a slow start, they are a step in the right direction to achieve full sustainability in our transportation systems.