SUSTAINABLE ENGINEERING

Module 1

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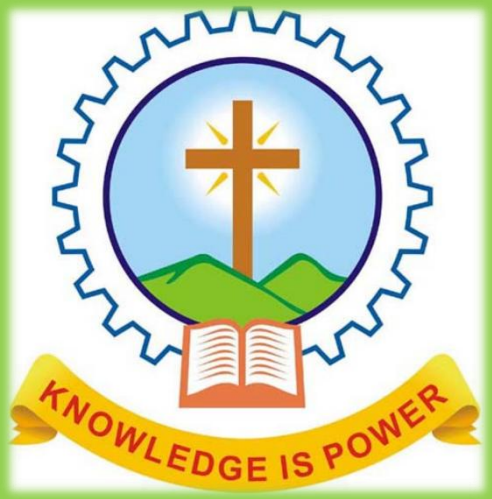

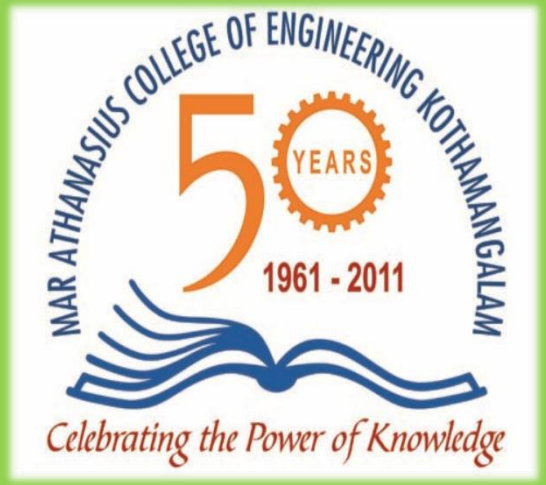

Sustainable Development

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ENGINEERING

The branch of science and technology concerned with the Planning, design, construction, and use of engines, machines, and structures. Engineers applying the theory of physics, chemistry and mathematics to solve problems.

DEVELOPMENT

Development is a process that creates growth, progress, positive change.

SUSTAINABILITY

Able to be maintain at a certain rate or level

The definition of "sustainability" is the study of how natural systems function, remain diverse and produce everything it needs for the ecology to remain in balance.

Sustainability takes into account how we might live in harmony with the natural world around us, protecting it from damage and destruction.

SUSTAINABLE DEVELOPMENT

Development that is conducted without depletion of natural resources.

What is Sustainable Development?

"Meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Earth provides enough to satisfy every man's needs, but not every man's greed.

— Mahatma Gandhi —

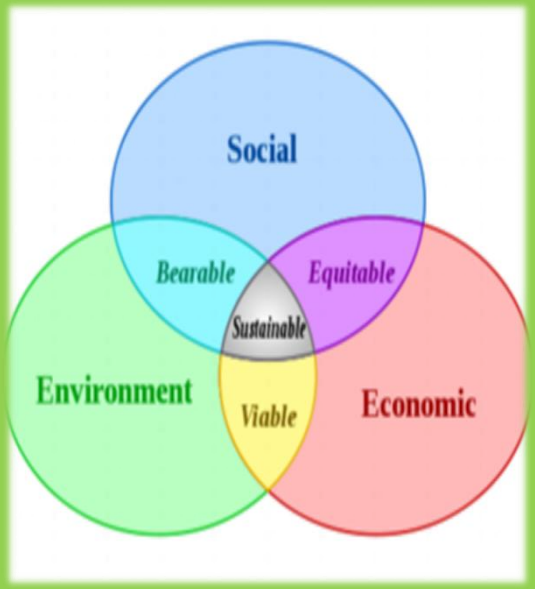
CHALLENGES FOR SUSTAINABILITY:

- Growth in the scale of human enterprise (population size, per-capita consumption, and effects of technologies to produce goods for consumption) and
- A mismatch between short-term needs and long-term societal well-being.
- Runoff of pesticides, fertilizers, and animal wastes,
- Pollution of land, water, and air resources affects biological productive land etc.
- Introduction of non-native species
- Overharvesting fishes - will wipe out certain species.
- Destruction of wetlands
- Erosion of soils
- Deforestation – will affect the excistence of certain species.
- Urban sprawl

CHALLENGES FOR SUSTAINABILITY

- Climate Change - due to Green house gases ,carbon dioxide, methane, nitrous oxide, carbon monoxide, chloro fluro carbon, Hydro fluro carbon etc...
- Ozone Depletion
- Exhaustion of Natural Resources – Non renewable resources (fossil fuels,Fresh water, minerals (copper) etc..
- Sea level rise
- Desertification
- Erosion
- Loss of biodiversity
- Destruction natural habitats etc….

THE THREE PILLARS OF SUSTAINABILITY



SOCIAL- ENVIRONMENTAL AND ECONOMIC SUSTAINABILITY CONCEPTS

The three pillars of sustainability are a powerful tool for defining the complete sustainability problem.

This consists of economic, social, and environmental pillars. If anyone pillar is weak then the system as a whole is unsustainable. Two popular ways to visualize the three pillars are shown.

THE THREE PILLARS OF SUSTAINABILITY

Environmental Sustainability

Environmental sustainability means that we are living within the means of our natural resources. To live in true environmental sustainability, we need to ensure that we are consuming our natural resources.

Economic Sustainability:

Economic sustainability requires that a business or country uses its resources efficiently and responsibly so that it can operate in a sustainable manner to consistently produce an operational profit.

Social Sustainability:

Social sustainability is the ability of society, or any

NEED OF SUSTAINABILE DEVELOPMENT

Sustainability is important for many reasons including:

1. Environmental Quality – In order to have healthy communities, we need clean air, natural resources, and a nontoxic environment.
2. Growth – Population is growing, so we require more resources such as energy, water, and space. Sustainability aims to use our resources efficiently to benefit our campus and community.
3. Healthcare – Sustainability and healthcare are intricately related since the quality of environment affects public health.

For example, many health issues are directly related to air, water and soil quality.

4. Rapid economic growth and industrialisation have

NEED OF SUSTAINABILE DEVELOPMENT

5. There is fear of complete exhaustion of these natural resources.
6. In the process of economic growth, damage is being caused to environment and ecology which ultimately will create insecurity for human beings.
7. Mother nature's resources are limited and are to be used judiciously.

Origin and evolution of sustainability

The idea of **sustainability** dates back to the early 20th century in the era of industrial revolution when two opposing factions had emerged within the environmental movement: the conservationists and the preservationists

Origin and evolution of sustainability

The International Union for Conservation of Nature (IUCN) was founded in October 1948 following an international conference in France. Its promoter's sought to ensure that any use of natural resources is equitable and ecologically sustainable.

Sustainable development was a key theme of the United Nations Conference on the Human Environment in Stockholm in 1972. The concept was coined explicitly to suggest that **it was possible to achieve economic growth and industrialization without environmental damage**.

Since 1995, United Nations Framework Convention on Climate Change (UNFCCC) conducts yearly conferences known as Conference Of Parties (COPs) to assess progress in dealing with climate change

Year	Venue	Year	Venue
1995	Berlin	2006	Nairobi, Kenya
1996	Geneva, Switzerland	2007	Bali, Indonesia
1997	Kyoto, Japan	2008	Poznan, Poland
1998	Buenos Aires, Argentina	2009	Copenhagen, Denmark
1999	Bonn ,Germany	2010	Cancun, Mexico
2000	Hague, Netherlands	2011	Durban, South Africa
2001	Bonn ,Germany	2012	Doha, Qatar
2002	Marrakech ,Moroco	2013	Warsaw, Poland
2003	New Delhi, India	2014	Lima, Peru
2004	Buenos Aire, Argentina	2015	Paris , France
2005	Montreal, Canada	2016	Expected to be conducted at Morroco

NEXUS BETWEEN TECHNOLGY AND SUSTAINABLE DEVELOPMENT

- Science and technology are considered amongst the most effective means to enhance growth and socio-economic development of nations
- Technology has offered the promise of a better world through the elimination of disease and material improvements to standards of living.
- Resource extraction and pollution of air, water and soil and caused irreversible damage to the biosphere.
- Relatively littlie attention has been given to understanding the sustainability challenges and efforts to solve them.
- Hence, it is essential that research on the relationships between science, technology and society be integrated into the border sustainability research agenda.

NEXUS BETWEEN TECHNOLGY AND SUSTAINABLE DEVELOPMENT

The areas where technologies can play a major role in sustainable development are:

1. To improve productivity and soil and water conservation, and maintain reasonable costs of food and fibre.
2. To increase soil fertility.
3. To improving water availability and efficiency of use.
4. To reducing food losses.
5. To enable farmers to modernize their farming practices and this becomes feasible to them.
6. Technologies to provide and improve energy services for developing world populations.
7. More efficient biomass stoves to reduce fuel use and reduce the hazardous smoke emissions.

NEXUS BETWEEN TECHNOLGY AND SUSTAINABLE DEVELOPMENT

7. More efficient biomass stoves to reduce fuel use and reduce the hazardous smoke emissions.
8. Simple motor-driven systems for pumping water or grinding grain to reduce the burden of these physically demanding tasks on women.
9. Energy-efficient pumps, fertilizers, and mechanical traction to improve agricultural productivity.
10. For many developing countries, provision of basic water, sewer, and refuse disposal services are major environmental priorities.
11. Developing countries need more sanitary services systemsserving rural and urban areas.

MILLENNIUM DEVELOPMENT GOALS (MDGS)

The **Millennium Development Goals** (**MDGs**) were eight international development goals for the year 2015 that had been established following the Millennium Summit of the United Nations in 2000, following the adoption of the United Nations Millennium Declaration. The Sustainable Development Goals (SDGs) succeeded the MDGs in 2016.

MILLENNIUM DEVELOPMENT GOALS (MDGS)

All 191 United Nations member states, and at least 22 international organizations, committed to help achieve the following Millennium Development Goals by 2015:

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
8. To develop a global partnership for development

SUSTAINABLE DEVELOPMENT GOALS (SDGS)

The **Sustainable Development Goals** (**SDGs**) are a collection of 17 global goals designed to be a "blueprint to achieve a better and more sustainable future for all". The SDGs, set in 2015 by the United Nations General Assembly and intended to be achieved by the year 2030, are part of UN Resolution 70/1, the 2030 Agenda.

The 17 SDGs are:

1. **Poverty** - End poverty in all its forms everywhere
2. **Food** - End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. **Health** -Ensure healthy lives and promote well-being for all at all ages
4. **Education** - Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. **Women** - Achieve gender equality and empower all women and girls
6. **Water** - Ensure availability and sustainable management of water and sanitation for all
7. **Energy** - Ensure access to affordable, reliable, sustainable and modern energy for all

The 17 SDGs are:

8. **Economy** - Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. **Infrastructure** - Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10. **Inequality** - Reduce inequality within and among countries
11. **Habitation** - Make cities and human settlements inclusive, safe, resilient and sustainable
12. **Consumption** - Ensure sustainable consumption and production patterns
13. **Climate**-Take urgent action to combat climate change and its impacts, ensuring that both mitigation and adaptation strategies are in place

The 17 SDGs are:

14. **Marine-ecosystems** - Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. **Ecosystems** -Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16. **Institutions** - Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. **Sustainability** - Strengthen the means of implementation and revitalize the global partnership for sustainable development.

CLEAN DEVELOPMENT MECHANISM (CDM)

The Clean Development Mechanism (CDM) is a United Nations-run carbon offset scheme allowing countries to fund greenhouse gas emissions-reducing projects in other countries and claim the saved emissions as part of their own efforts to meet international emissions targets.

CLEAN DEVELOPMENT MECHANISM (CDM)

It is one of the three Flexible Mechanisms defined in the Kyoto Protocol. The CDM, defined in Article 12 of the Protocol, was intended to meet two objectives:

1. To assist non-Annex I countries (predominantly developing nations) achieve sustainable development and reduce their carbon footprints; and

2. To assist Annex I countries (predominantly industrialized nations) in achieving compliance with their emissions reduction commitments.

SUSTAINABLE ENGINEERING

Module 2

Pollution

Any substance present in the environment in harmful concentration, which adversely alters the environment by damaging the growth rate of a species and by interfering with the food chains, is toxic and affects the health, comfort and property etc. is considered as a pollutant.

Classification of Pollution

Depending upon the area or the part of environment affected, pollution may be of the following types:

1. Air pollution
2. Water pollution
3. Land pollution
4. Noise pollution
5. Pollutants


Air Pollution

Air pollution

Air pollution is the introduction of particulates, biological molecules, or other harmful gases into Earth's atmosphere causing.

- **Disease,**
- **Death to humans,**
- **Damage to other living organisms such as food crops etc.**

Air pollution may come from

- **Anthropogenic or**
- **Natural sources.**

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Classification of Air Polutants

The classification of pollutants is done from different points of view:

Depending upon their existence in nature pollutants are of two types.

Quantitative Pollutants:

These are those substances normally occurring in the environment, who acquire the status of a pollutant when their concentration gets increased due to the unmindful activities of man. For example, carbon dioxide, if present in the atmosphere in concentration greater than normal due to automobiles and industries, causes measurable effects on humans, animals, plants or property, then it is classified as a quantitative pollutant.

Qualitative Pollutant:

These are those substances which do not normally occur in nature but are added by man, for example, insecticides.

(ii)Depending upon the form in which they persist after being released into the environment, the pollutants are categorized into two types.

(a)Primary Pollutants:

These are those which are emitted directly from the source and persist in the form in which they were added to the environment. Typical examples of pollutants included under this category are ash, smoke, fumes, dust, nitric oxide, sulphur dioxide, hydrocarbons, radioactive compounds etc.

(a)Secondary Pollutants:

These are those which are formed from the primary pollutants by chemical interaction with some constituent present in the atmosphere. Examples are: Sulphur trioxide, nitrogen dioxide, aldehydes, ketones, ozone etc.

(ii)From the ecosystem point of view, i.e., according to their natural disposal, pollutants are of two types:

(a)Bio-degradable Pollutants:

These are the pollutants that are quickly degraded by natural means. Heat or thermal pollution, and domestic sewage are considered in this category as these can be rapidly decomposed by natural processes or by engineered systems such as municipal treatment, plants etc.

(a)Non-degradable Pollutants:

These are the substances that either do not degrade or degrade very slowly in the natural environment. These include mercury salts, long chain phenolic chemicals, DDT and Aluminium cans etc.

(ii)Classification of pollutants on the basis their physical state:

(a) Gaseous pollutants

CO, CO_2, SO_2, SO_3, H_2S, oxides of nitrogen etc.

(b) Liquid pollutants

Domestic sewage, industrial effluents, acid rains, run-off from the lands, oil pollutants from cargos etc.

(c)**Solid pollutants**

Smoke, dust, smog, fog, aerosols, particulates, pollen grains.

MAJOR AIR POLLUTANTS

(a)Carbon dioxide

Carbon dioxide is one of the major gases which contribute towards air pollution. It is mainly produced during the combustion of fuel in factories, power stations, household etc.

(a)Sulphur dioxide

It is produced by the burning of coal in power houses and automobiles (car, trucks etc.). It causes chlorosis and necrosis of plants, irritation in eyes and injury to the respiratory tract (asthma, bronchitis) in humans responsible for discoloration and deterioration of buildings.

Carbon monoxide

Carbon monoxide is produced as a result of incomplete combustion of fossil fuels like coal, petroleum and wood charcoal. Automobiles using diesel and petroleum are the major sources of carbon monoxide which gets added to the atmosphere.

Fluorides

Upon heating,, rocks, soils and minerals that contain fluorides, give out hydrogen fluoride gas.

Oxides of nitrogen

A few oxides of nitrogen, such as nitric oxide (NO), nitrous oxide (N2O) and nitrogen dioxide (NO2) are produced by natural processes as well as from thermal power stations, factories, automobiles and aircrafts due to burning of coal and petroleum

Smog

Smog is a mixture of smoke, dust particles and small drops of fog.

Aerosol spray propellants

Suspended fine particles in the air are known as aerosols. Aerosols contain chlorofluoro carbons (CFCs) and fluorocarbons used in refrigerants and aerosol cans. They cause depletion of the ozone layer.

Domestic air pollutants

Smoke from cigarettes, *bidi*, cigar and other such objects using burning tobacco, burning of coal, firewood, cow dung cakes, kerosene oil and liquefied gases are major domestic pollutants.

Effects of Air pollution

In general effects of the polluted atmosphere can be classified under the following four heads:

1. Effect on certain materials
2. Effect on plants
3. Effect on animals
4. Effect on human health
5. Effect on physical features on the atmosphere

Effect on certain materials

In general effects of the polluted atmosphere can be classified under the following four heads:

Air pollutants affect certain materials by the following five ways:

1. Abrasion
2. Deposition and removal
3. Direct chemical attack
4. Indirect chemical attack
5. Corrosion

Effect on certain materials

It causes deterioration of building material.

It causes corrosion and incrustation of metals

It causes discolouration of paints, cement colour etc.

It causes reduction of strength of materials

ii. **Effect of air pollutants on plants**

Air pollution has long been known to have adverse effect on plants. Air pollutants affecting plants are:

Sulphur dioxide

2. Hydrogen fluoride

3. Hydrogen chloride

4. Chlorine

5. Ozone

6. Oxides of nitrogen

7. Ammonia

8. Mercury

9. Ethylene

10.Hydrogen sulphide

11.Hydrogen cyanide

12.PAN (Peroxyacetyl nitrate)

13.Herbicides

14.Smog

ii. **Effect of air pollutants on plants**

- The most obvious damage caused by air pollutants to plants and vegetation occur is the leaf structure.
- The stomata (tiny opening or void) of leaf gets clogged thereby reducing intake of CO_2 and thus affecting photosynthesis.
- The adverse effect is range from reduction in growth rate to death of the plant. T
- he concentration of nitrogen dioxide, sulphur dioxide and ozone may damage plants, vegetables, fruit trees, and forest areas.

ii. **Effect of air pollutants on plants**

Some of the typical effect on vegetation is as follows.

i. Plants may be dried up, the yield of crop may decrease, the quality of crops may decline or may be affected by diseases.

ii. The growth of vegetables may stop, the quality may be inferior or may be affected by diseases. 19 Proof 1

iii. The quality of fruits may become inferior or the quantity may also decrease.

iv. The forest area may get destroy gradually. The growth of tree may become stunted or they may dry up completely.

iii. Effect on animals

The effect of pollutants on farm animals takes place in two steps

(i) accumulation of air pollutants in the vegetation, plants and forage, and (ii) subsequent poisoning of the animals when they eat the contaminated vegetation. Important contaminants that affect the livestock are (a) fluorine, (b) arsenic and (c) lead. These pollutants originate either from the industries situated nearby, or from dusting and spraying. Out of these contaminants, fluorine contamination is most prominent since cattle and sheep are found to be more susceptible to it. Symptoms of advanced fluorosis include lac of appetite, general ill health due to malnutrition, lowered fertility, reduced milk production and growth retardation. Arsenic in dusts or sprays on plants can cause to poisoning of cattle leading to salivation, thirst, vomiting, uneasiness, feeble and irregular pulse and respiration.

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iv. Effect on human health

1. Ear, nose and throat irritation.
2. Irritation of respiratory tract
3. Odour nuisance due to hydrogen sulphide, ammonia mercaptans, even at low concentrations.
4. Chronic pulmonary diseases (such as bronchitis, asthma) etc. 20 are aggravated by high concentrations of SO_2 , NO_2 , particulate matter and photochemical smog.
5. Pollens etc. initiate asthmatic attacks.
6. Carcinogenic agents cause cancer.
7. Respiratory disease is caused by dust particles. Silicosis is caused by silica dust of cement factories and asbestosis is caused by asbestos plants.
8. Lead poisoning is caused due to entry of lead through the lungs.

iv. Effect on human health

9. Bone fluorosis and mottling of teeth is caused by hydrogen fluoride.
10. Carbon monoxide may cause death by asphyxiation. It also increases stress on persons suffering from cardiovascular and pulmonary diseases.
11. Air pollution in general is cause increase in mortality rate and morbidity rate.
12. Rdio-active fallout may cause cancer, shortening of life span

v. Effect of air pollutants on physical features on the atmosphere

The physical effects of pollutants on the atmosphere can be classified under three heads:

1. Effects on visibility.
2. Effects on urban atmosphere and weather conditions.
3. Effects on atmosphere constituents.
4. Effects on visibility: The visibility is reduced due to the concentration and physical properties of particulate pollutants present in the atmosphere.


Water Pollution

Water pollution

Water pollution may be defined as “any change in the physical, chemical and biological properties of water as well as contamination with any foreign substance, which would constitute a health hazard or otherwise decrease the utility of water”.

It may also be defined as addition of excess of undesirable substance to water that make it harmful to man, animal, and aquatic life or otherwise causes significant departures from the normal activities of various living communities in or around water.

The indications of water pollution are:

Bad taste of drinking water.

b) Offensive odours from lakes, rivers and ocean beaches.

c) Unchecked growth of aquatic weeds in waterbodies.

d) Decrease in number of fish in fresh water, river water and seawater.

e) Oil and grease floating on water surfaces.

The above conditions disturb the normal use of water for:

Drinking purposes.

Recreation

Fish, other aquatic life and wildlife

Agriculture.

Industry.

Causes water pollution

Sewage

Agricultural Pollution

Oil Pollution

Radioactive Substances

River dumping

Marine Dumping

SOURCES OF WATER POLLUTION

Point source water pollution refers to contaminants that enter a waterway from a single, identifiable source, such as a pipe or ditch. Examples of sources in this category include discharges from a sewage treatment plant, a factory, or a city storm drain. This type of discharges can be controlled easily. Water pollution caused by these sources can be minimised if the effluent from these sources is controlled, treated up to acceptable levels and disposed off.

Point sources

Non-point sources

Nonpoint source pollution refers to diffuse contamination that does not originate from a single discrete source. This type of pollution is often the cumulative effect of small amounts of contaminants gathered from a large area. A common example is the leaching out of nitrogen compounds from fertilized agricultural lands.

TYPES OF WATER POLLUTANTS

(1) Organic pollutants,
(2) Pathogens,
(3) Nutrients and agriculture runoff,
(4) Suspended solids and sediments (organic and inorganic),
(5) Inorganic pollutants (salts and metals),
(6) Thermal Pollution, and
(7) Radioactive pollutants.

Levels of Wastewater Treatment

Wastewater treatment is closely related to the standards and/or expectations set for the effluent quality. Wastewater treatment processes are designed to achieve improvements in the quality of the wastewater. The various treatment processes will reduce:

- **Primary (mechanical)**
- **Secondary (biological)**
- **Tertiary (or advanced).**


SOLID WASTE

SOLID WASTE

Solid waste means any garbage, refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded materials including solid, liquid, semi-solid, or contained gaseous material, resulting from industrial, commercial, mining and agricultural operations, and from community activities.

SOLID WASTE

Examples of solid wastes include the following materials when discarded:

- Waste tires
- Scrap metal
- Furniture and toys
- Garbage
- Appliances and vehicles
- Oil and anti-freeze
- Empty aerosol cans, paint cans and compressed gas cylinders
- Construction and demolition debris, asbestos

Sources of Solid Waste

Source	Typical waste generators	Types of solid wastes
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes.).
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants.	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes.
Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes.
Institutional	Schools, hospitals, prisons, government centers.	Same as commercial.
Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants.	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge.
Process (manufacturing, etc.)	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing.	Industrial process wastes, scrap materials, tailings.
Agriculture	Crops, orchards, vineyards, dairies, farms.	Spoiled food wastes, agricultural wastes, hazardous wastes (e.g., pesticides).

Impacts of Solid Waste

1. Hazardous gas emissions
2. Water Quality/Contamination
3. Energy Consumption
4. Natural Habitat Degradation
5. Disposal Costs

Zero Waste

Zero Waste is a goal that is ethical, economical, efficient and visionary, to guide people in changing their lifestyles and practices to emulate sustainable natural cycles, where all discarded materials are designed to become resources for others to use.

And it means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them.

Implementing Zero Waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health.

3R

The popular and well-known concept of "3R" refers to **reduce, reuse and recycle**, particularly in the context of production and consumption.

Reduce

"Reduce" means using fewer resources in the first place. This is the most effective of the three R's and the place to begin.

Reuse

To reuse is to use an item again after it has been used. This includes **conventional reuse** where the item is used again for the same function, and **creative reuse** where it is used for a different function. In contrast, recycling is the breaking down of the used item into raw materials which are used to make new items.

- A jam jar can store leftovers.
- Food scraps can become compost.
- An old shirt can become a pajama top.
- An opened envelope can become a shopping list.
- A magazine can be shared. DVDs can be traded.
- A dishwasher can be repaired.
- A computer can be upgraded.
- A car can be resold.
- A cell phone can be donated.
- Returnable bottles can be, well… Returned.

Recycle

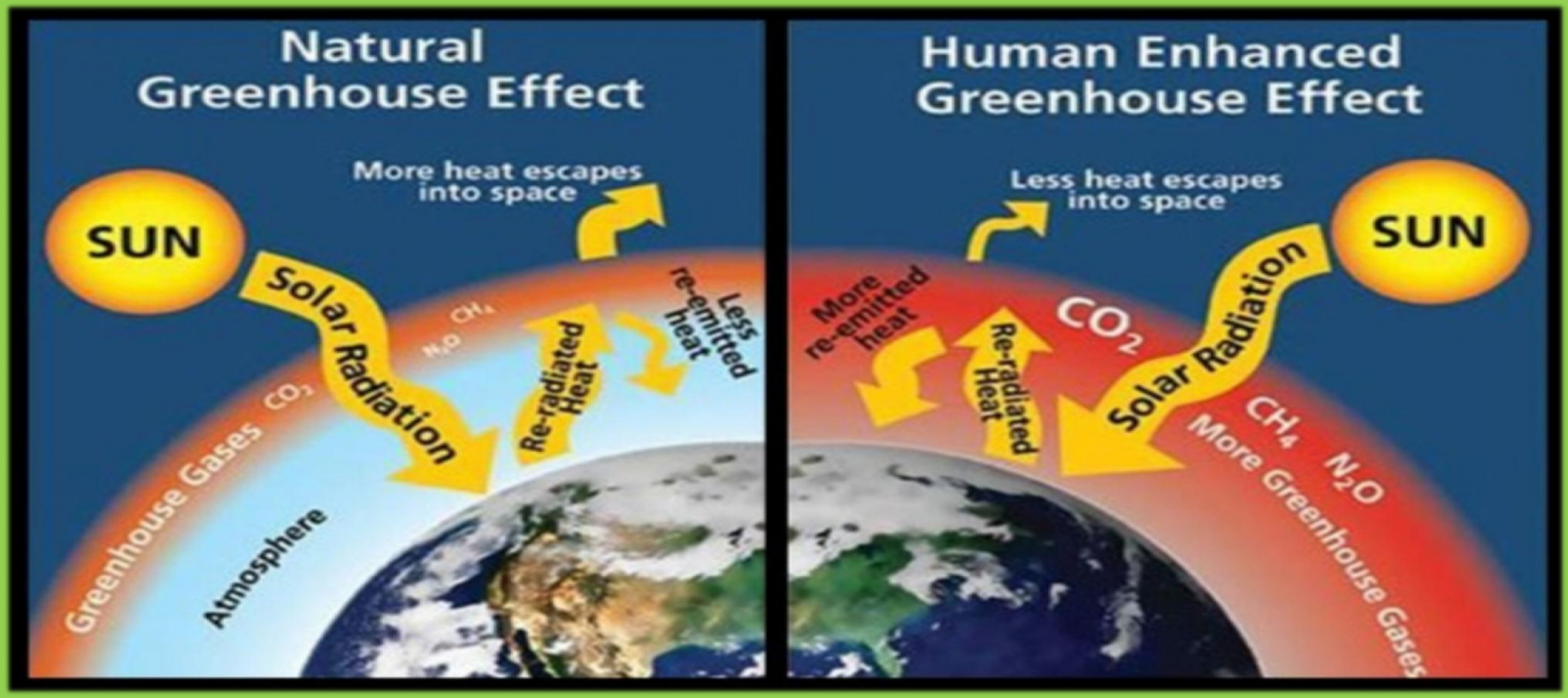
Recycling is a process to change waste materials into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution and lower greenhouse gas emissions.

Global Environmental Issues

1. **Environmental degradation:** Environmental degradation is the deterioration of the environment through depletion of resources such as air, water and soil; the destruction of ecosystems and the extinction of wildlife.

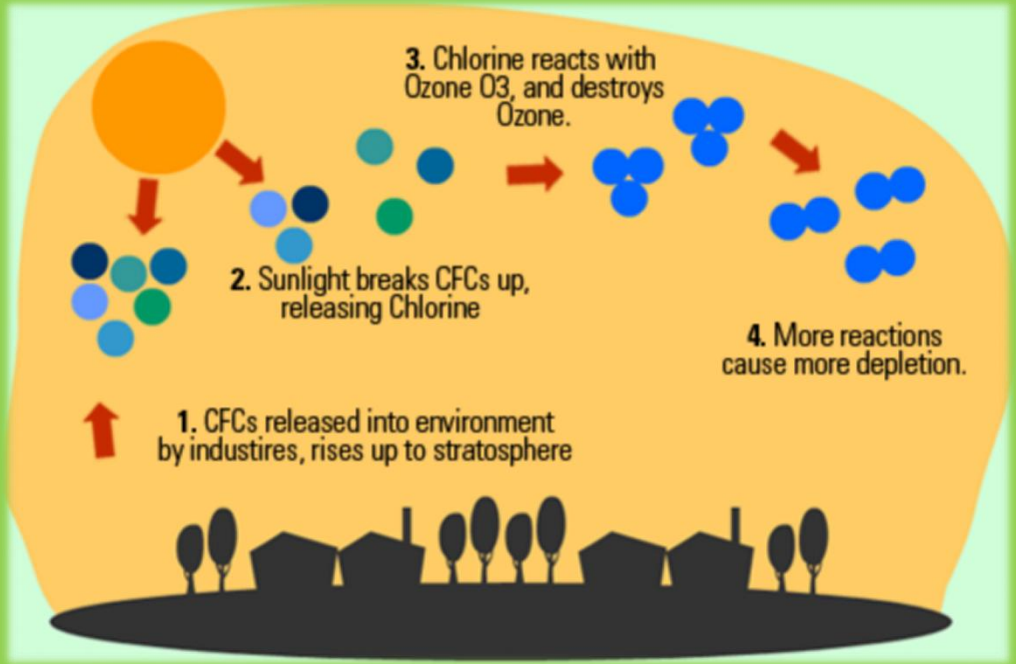
2. **Greenhouse effect**: The combustion of large quantities of fossil fuels like coal and oil in thermal power plants, industries, and automobiles emits excessive quantities of carbon dioxide and nitrogen oxides into the atmosphere. The greenhouse effect is the heating effect caused by gases such as carbon dioxide (CO_2), methane (CH_4) and oxides of nitrogen (NO_x) in the atmosphere.

Global Environmental Issues



Global Environmental Issues

3. **Global Warming:** Global Warming is the increase of Earth's average surface temperature due to effect of greenhouse gases, such as carbon dioxide emissions from burning fossil fuels or from deforestation, which trap heat that would otherwise escape from Earth. This is a type of greenhouse effect.
4. **Ozone depletion:** Ozone layer depletion, is simply the wearing out (reduction) of the amount of ozone in the stratosphere.



Consequences of Global warming

1. Rise in sea level
2. Climate change

Consequences of Global warming

Change in climate can also cause several other problems, such as:

- Drying of surface water bodies
- Fall in ground water table
- Serious water shortage
- Desertification of vast areas, which were fertile and productive lands
- Crop pattern change and reduced agricultural yields
- Increased growth of pathogenic microorganisms and spread of diseases
- Problem of unsanitary condition
- Change in vegetation pattern give rise to uncontrollable weeds and insects
- Melting of polar ice and oceanic expansion which results in flooding of coastal areas.
- Increase in number and severity of tropical storms and cyclones.
- Saltwater intrudes in groundwater zones

Control of Global warming

- Reduction in CO_2 emissions by developing alternative sources of energy.
- Energy conservation through introduction of mass transportation in cities.
- Development of energy efficient devices.
- Cutting transmission losses in electric lines and economic use of energy.
- Upgradation of industrial process to minimize the release of greenhouse gases as possible.

Carbon credit and carbon trading

A permit that allows the holder to emit one ton of carbon dioxide. Credits are awarded to countries or groups that have reduced their green house gases below their emission quota. Carbon credits can be traded in the international market at their current market price.

For example, if an environmentalist group plants enough trees to reduce emissions by one ton, the group will be awarded a credit. If a steel producer has an emissions quota of 10 tons, but is expecting to produce 11 tons, it could purchase this carbon credit from the environmental group. The carbon credit system looks to reduce emissions by having countries honor their emission quotas and offer incentives for being below them.

Carbon Footprint

The total amount of greenhouse gases produced directly and indirectly to support human activities, usually expressed in equivalent tons of carbon dioxide (CO_2).

When you drive a car, the engine burns fuel which creates a certain amount of CO_2, depending on its fuel consumption and the driving distance. (CO_2 is the chemical symbol for carbon dioxide). When you heat your house with oil, gas or coal, then you also generate CO_2. Even if you heat your house with electricity, the generation of the electrical power may also have emitted a certain amount of CO_2. When you buy food and goods, the production of the food and goods also emitted some quantities of CO_2.

Your carbon footprint is the sum of all emissions of CO_2 (carbon dioxide), which were induced by your activities in a given time frame. Usually a carbon footprint is calculated for the time period of a year.

Uses of Carbon footprints

1. For publicly reporting greenhouse gas emissions.
2. For setting a target for reducing emissions (in order to set a reductions target it is necessary to know what current emissions are).
3. To identify which activities contribute the most to a footprint (in order to identify the important areas for reduction efforts).
4. In order to measure changes in emissions over time, and to monitor the effectiveness of reduction activities.
5. To offset emissions (in order to offset emissions it is necessary to know how many reductions credits to purchase).

Legal Provisions for Environmental Protection

The need for protection and conservation of environment and sustainable use of natural resources is reflected in the constitutional framework of India and also in the international commitments of India. The Constitution under Part IVA (Art 51A-Fundamental Duties) casts a duty on every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife, and to have compassion for living creatures. Further, the Constitution of India under Part IV (Art 48A-Directive Principles of State Policies) stipulates that the State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country.

Legal Provisions for Environmental Protection

After the Stockholm Conference, the National Council for Environmental Policy and Planning was set up in 1972 within the Department of Science and Technology to establish a regulatory body to look after the environment-related issues. This Council later evolved into a full-fledged Ministry of Environment and Forests (MoEF).

Legal Provisions for Environmental Protection

- Some of the important legislations for environment protection are as follows:
- The National Green Tribunal Act, 2010
- The Air (Prevention and Control of Pollution) Act, 1981
- The Water (Prevention and Control of Pollution) Act, 1974
- The Environment Protection Act, 1986
- The Hazardous Waste Management Regulations, etc.

The National Green Tribunal Act, 2010

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

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

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

To counter the problems associated with air pollution, ambient air quality standards were established under the Air Act. The Air Act seeks to combat air pollution by prohibiting the use of polluting fuels and substances, as well as by regulating appliances that give rise to air pollution. The Air Act empowers the State Government, after consultation with the SPCBs, to declare any area or areas within the Sate as air pollution control area or areas. Under the Act, establishing or operating any industrial plant in the pollution control area requires consent from SPCBs. SPCBs are also expected to test the air in air pollution control areas, inspect pollution control equipment, and manufacturing processes.

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

The Water Prevention and Control of Pollution Act, 1974 (the "Water Act") has been enacted to provide for the prevention and control of water pollution and to maintain or restore wholesomeness of water in the country. It further provides for the establishment of Boards for the prevention and control of water pollution with a view to carry out the aforesaid purposes. The Water Act prohibits the discharge of pollutants into water bodies beyond a given standard, and lays down penalties for non-compliance. At the Centre, the Water Act has set up the CPCB which lays down standards for the prevention and control of water pollution. At the State level, SPCBs function under the direction of the CPCB and the State Government.

The Environment Protection Act, 1986

The Environment Protection Act, 1986 (the "Environment Act") provides for the protection and improvement of environment. The Environment Protection Act establishes the framework for studying, planning and implementing long-term requirements of environmental safety and laying down a system of speedy and adequate response to situations threatening the environment. It is an umbrella legislation designed to provide a framework for the coordination of central and state authorities established under the Water Act, 1974 and the Air Act. The term "environment" is understood in a very wide term under s 2(a) of the Environment Act. It includes water, air and land as well as the interrelationship which exists between water, air and land, and human beings, other living creatures, plants, micro-organisms and property.

The Environment Protection Act, 1986 cont……

Under the Environment Act, the Central Government is empowered to take measures necessary to protect and improve the quality of environment by setting standards for emissions and discharges of pollution in the atmosphere by any person carrying on an industry or activity; regulating the location of industries; management of hazardous wastes, and protection of public health and welfare. From time to time, the Central Government issues notifications under the Environment Act for the protection of ecologically-sensitive areas or issues guidelines for matters under the Environment Act.

Hazardous Wastes Management Regulations

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

There are several legislations that directly or indirectly deal with hazardous waste management. The relevant legislations are the Factories Act, 1948, the Public Liability Insurance Act, 1991, the National Environment Tribunal Act, 1995 and rules and notifications under the Environmental Act.

In addition, there are many other laws relating to environment, namely –

- **The Wildlife Protection Act, 1972**
- **The Forest Conservation Act, 1980**
- **Public Liability Insurance Act, 1991**
- **The Biological Diversity Act, 2002**
- **Coastal Regulation Zone Notification**

SUSTAINABLE ENGINEERING
Module 3

ENVIRONMENTAL NANAGEMENT SYSTEMS (EMS)

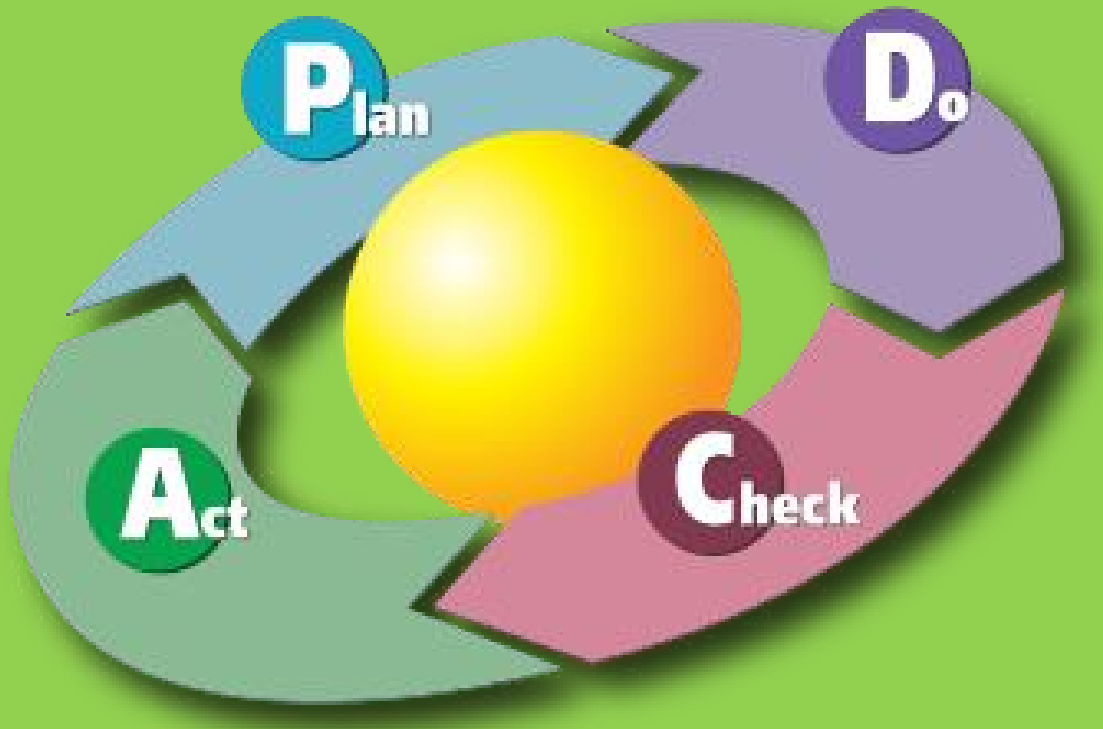
Environmental Management System (EMS) is a tool that enables an organisation to control impact of its activities, products or services on the natural environment.

Implementation of an EMS is a voluntary approach for improving environmental performance.

Over the years, many public and private sector organizations have implemented EMS, and their numbers are growing on daily basis

BASIC EMS FRAMEWORK

The basic EMS frame work follows a Plan-Do-Check-Act (PDCA) cycle. If this cycle is adhered to constantly, it leads to continuous improvement of the system. The figure shown below is the EMS cycle which is an abstract description of different components.



BASIC EMS FRAMEWORK

The four phases in the Plan-Do-Check-Act Cycle involve:

Plan : Identifying and analyzing the problem.

Do : Developing and testing a potential solution.

Check : Measuring how effective the test solution was, and analyzing whether it could be improved in any way.

Act : Implementing the improved solution fully.

ENVIRONMENTAL MANAGEMENT STANDARDS & ISO 14000

In September 1996, the International Organization for Standardization (ISO) published the first edition of ISO 14001, the internationally accredited Environmental Management Systems Standards.

This is an international voluntary standard describing specific requirements for an Environmental Management System (EMS)

ENVIRONMENTAL MANAGEMENT STANDARDS & ISO 14000

ISO 14001 is a specification standard to which an orgenisation may receive certification or registration and is considered as the foundation document of the entire ISO 14000 series

This is an international voluntary standard describing specific requirements for an Environmental Management System (EMS)

A second edition of ISO 14001 was published in the year 2004, updating the earlier standards

ENVIRONMENTAL MANAGEMENT STANDARDS & ISO 14000

ISO 14001 is the dominant environmental management system (EMS) standard in the world and is the most widely used and accepted EMS standard.

This standard is voluntary, certifiable and is accepted by stakeholders across the world as the preferred model for environmental management.

PRINCIPLES OF ISO14001

Prevention of environmental pollution

Compliance with environmental regulations

Continuous improvement of environmental performance

The subjects covered under the various ISO

Range of ISO	Subject
ISO 14000-14009	Environmental Management System
ISO 14010-14019	Environmental Auditing
ISO 14020-14029	Environmental Labeling
ISO 14030-14039	Environmental Performance Evaluation
ISO 14040-14049	Life Cycle Assessment
ISO 14050-14059	Terms and Definitions
ISO 14060	Environmental Aspects in Product Standards

ISO 14001

ISO 14001 is applicable to any organisation aiming at

- Implementing, maintaining and improving an environmental management system.
- Ensuring its conformance with its stated environmental policy.
- Demonstrating such conformance to others

LIFE CYCLE ANALYSIS or LIFE CYCLE ASSESSMENT (LCA)

Life cycle assessment (LCA) is a multi-step procedure for calculating the lifetime environmental impact of a product or service.

The complete process of LCA includes goal and scope definition, inventory analysis, impact assessment, and interpretation.

Why do life-cycle assessment?

- Minimize the magnitude of pollution
- Conserve non-renewable resources
- Conserve ecological systems
- Develop and utilize cleaner technologies
- Maximize recycling of materials and waste
- Apply the most appropriate pollution prevention and/or abatement techniques

4 Steps in LCA

Generally, a LCA consists of four main activities:

1. Goal definition (ISO 14040): The basis and scope of the evaluation are defined.

2) Life-cycle inventory- Determine the emissions that occur and the raw materials and energy that are used during the life-cycle of a product.

2) Life-cycle impact assessment- Assess what the impacts of these emissions and raw material depletions are.

3) Life cycle improvement analysis--Interpret the results of the impact assessment in order to suggest improvements. When LCA is conducted to compare products this step may consist of recommending the most environmentally desirable product.

Summary of LCA

- LCAs are a tool for assessing and minimizing the impact of human activities.
- Life-cycle stages of a product include raw material acquisition, manufacturing , use, and disposal.
- LCA techniques have been adopted in industry and the public sector to serve a variety of purposes.
- Choices made during the planning phase of an LCA have a profound impact on the results obtained. The choice of functional unit, particularly when LCAs are conducted to compare products, is especially influential.

CIRCULAR ECONOMY

The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the **life cycle of products is extended.**

In practice, it implies **reducing waste** to a minimum. When a product reaches the end of its life, its materials are kept within the economy wherever possible. These can be productively used again and again, thereby **creating further value.** This is a departure from the traditional, *linear* economic model, which is based on a take-make-consume-throw away pattern. This model relies on large quantities of cheap, easily accessible materials and energy. Also, part of this model is planned obsolescence, when a product has been designed to have a limited lifespan to encourage consumers to buy it again.

CIRCULAR ECONOMY

Benefits of Circular Economy

Following are the key benefits of Circular Economy:

1. Creation of new green industries and jobs
2. Reduced dependence on importation of raw materials
3. Avoidance of environmental damage caused by resource extraction
4. Less pollution entering the earth's life support systems
5. Save business, customers, and suppliers money
6. Capture more value from your materials and resources
7. Develop new markets and gain new customers
8. Build loyalty with customer base
9. Satisfy changing customer needs and expectations
10. Increase the security and price stability of your supply chain
11. Attract, retain, and engage your employees
12. Build your brand and reputation as an innovative organisation
13. Exceed government regulations and stay ahead of new requirements
14. Provide more return and lower risk to your investors

BIOMIMICKING

Biomimicry is a way of viewing and valuing nature, based not on what we can extract from the natural world, but on what we can learn from it.

Bios—life or living things

Mimicking—imitation

It is the imitation of the models , systems and elements of nature for the purpose of solving complex human problems.

Nature has solved engineering problems such as self-healing abilities, environmental exposure tolerance and resistance, hydrophobicity, self-assembly and harnessing solar energy.

BIOMIMICKING

Eastgate Centre, ZimBabswe

- Inspired by self-cooling mounds of African termites
- Termites build gigantic mounds inside of which they farm a fungus ,their primary food source, must kept at exactly 87 degrees F, while the temp. outside range from 35 to 104 degree F.
- It is achieved by constantly opening and closing a series of heating and cooling vents throughout the mound.

BIOMIMICKING

Passive Cooling

Eastgate Centre, ZimBabswe

- Inspired by self-cooling mounds of African termites
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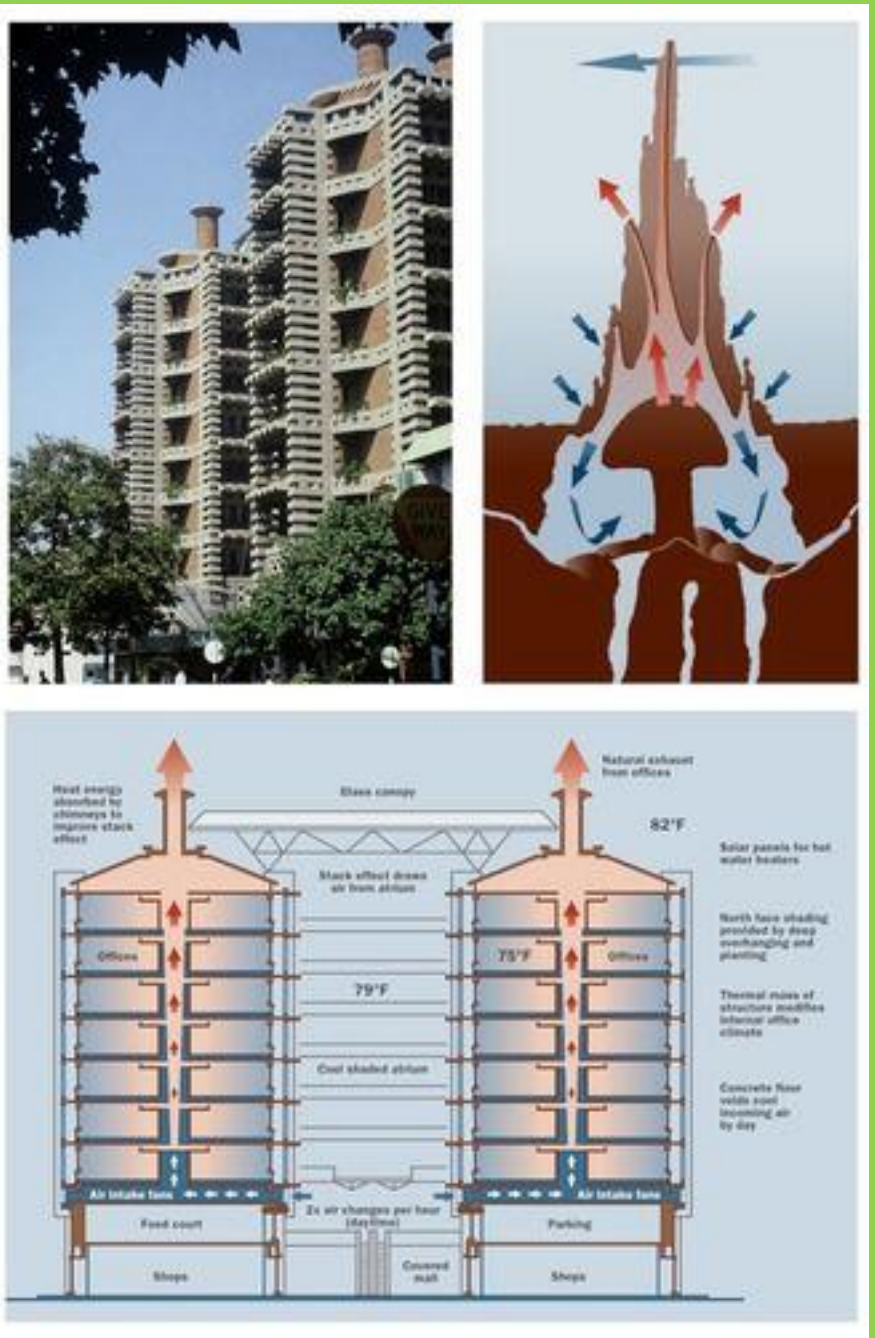
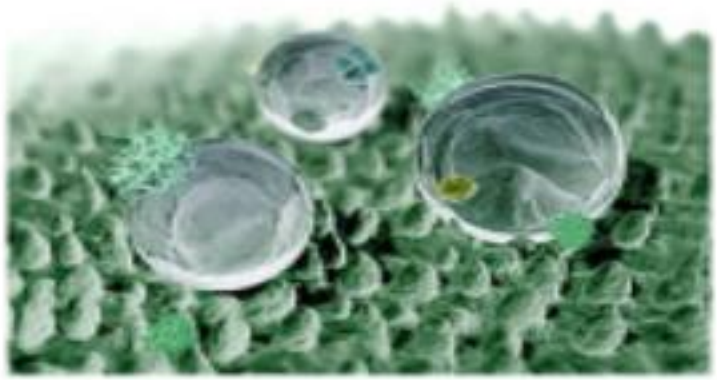
BIOMIMICKING



Friction-Reducing Sharkskin

Inspired by the evolved ability of shark's skin to reduce drag by manipulating the boundary layer flow as the fish swims, researchers are developing coatings for ship's hulls, submarines, aircraft fuselage, and even swimwear for humans. Based on the varying shape and texture of shark's skin over its body, Speedo's Fastskin FSII swimsuits made their appearance at the Bejing Olympics and may have helped US swimmer Michael Phelps to his record eight gold medals in that competition, and the rest of the team as well. And now there are the new suits (43 world records at the 09 word championships)!

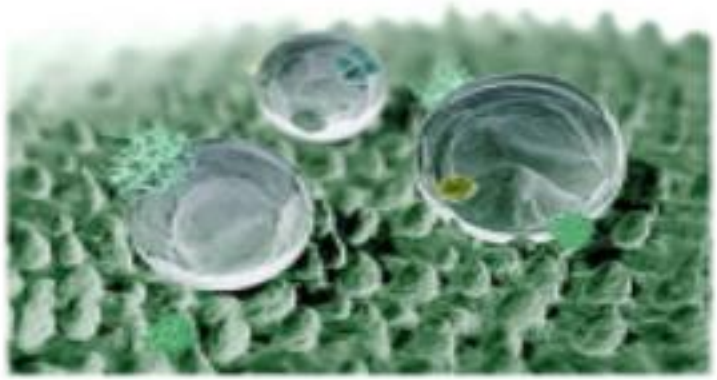
Lotus Effect Hydrophobia



When a liquid drop on its leaves, it rolls and cleans off the contaminants that are on its surface. Inspired by this fact, many artificial super hydophobic surfaces have been designed.

A German paint company has developed a biomimicry inspired exterior coating with water repellent surface based on that of the lotus leaf.

Lotus Effect Hydrophobia



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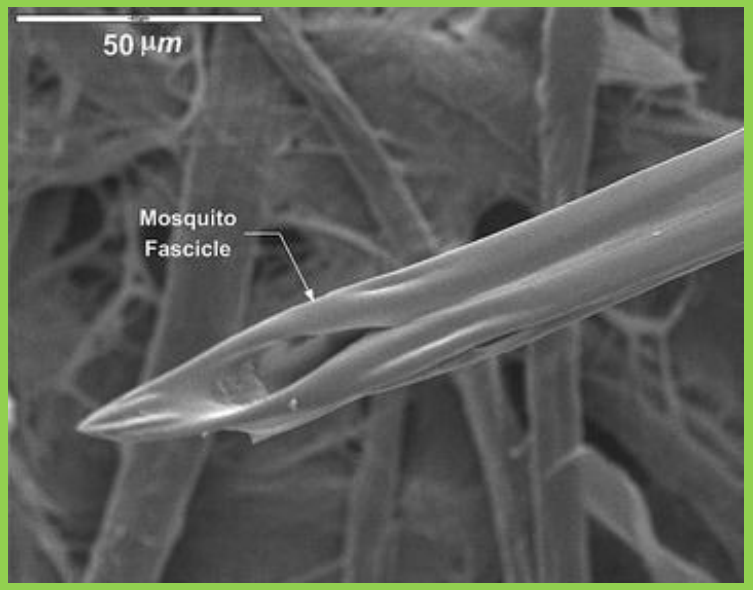
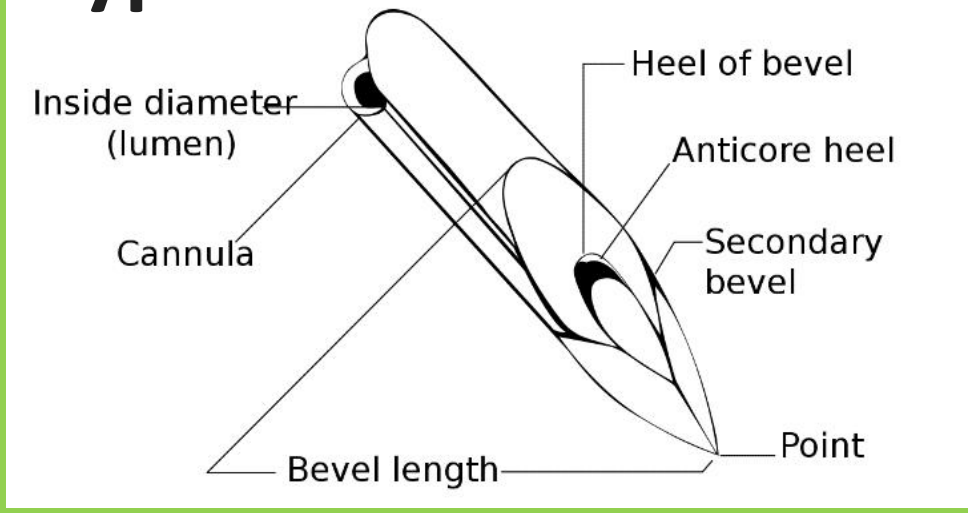


Hypodermic needle



The mosquito's annoying ability to painlessly and unnoticeably suck blood and get away with it has inspired Japanese scientists to create a hypodermic needle that is equally painless. The key to less pain is the serrated proboscis of the mosquito, which reduces the surface area of skin that the proboscis comes into contact with. Less contact translates to less pain. We've been able to produce similarly-designed harpoon-like needles that have been implemented in small biomedical devices such as blood-glucose monitors for diabetic patients.

EIA-Environmental Impact Assessment

It is the process of identification, evaluation and mitigation of potential impact of proposed projects, plans and programs prior to decision making.

Objectives of EIA

To predict environmental impacts of projects

To find ways and means to reduce adverse impacts

To Refine/shape the proposed project to suit the local environment

To present the predictions and options before the decision makers

Evolution of EIA

Prior to 1994, developmental projects were based on

- Technical feasibility
- Cost-benefit analysis

Under Environmental Protection act (EIA) 1986, An EIA notification was promulgated on 27th January 1994, making environmental clearance mandatory for expansion or modernization of any project or for setting up new projects.

PROCEDURES OF EIA IN INDIA

The processes involved in EIA are listed below

1. Screening
2. Scoping and consideration of alternatives
3. Impact prediction, assessment
4. Mitigation measures
5. Preparation of EIA report
6. Public hearing
7. Reviewing the EIA report & decision making
8. Monitoring the clearance conditions

PROCEDURES OF EIA IN INDIA

The processes involved in EIA are listed below

The environment impact assessment consists of eight steps with each step equally important in determining the overall performance of the project. The eight steps of the EIA process are presented in brief below:

Screening: First stage of EIA, which determines whether the proposed project, requires an EIA and if it does, then the level of assessment required.

PROCEDURES OF EIA IN INDIA

Scoping: This stage identifies the key issues and impacts that should be further investigated. This stage also defines the boundary and time limit of the study.

Impact analysis: This stage of EIA identifies and predicts the likely environmental and social impact of the proposed project and evaluates the significance.

Mitigation: This step in EIA recommends the actions to reduce and avoid the potential adverse environmental consequences of development activities.

Reporting: This stage presents the result of EIA in a form of a report to the decision-making body and other interested parties.

PROCEDURES OF EIA IN INDIA

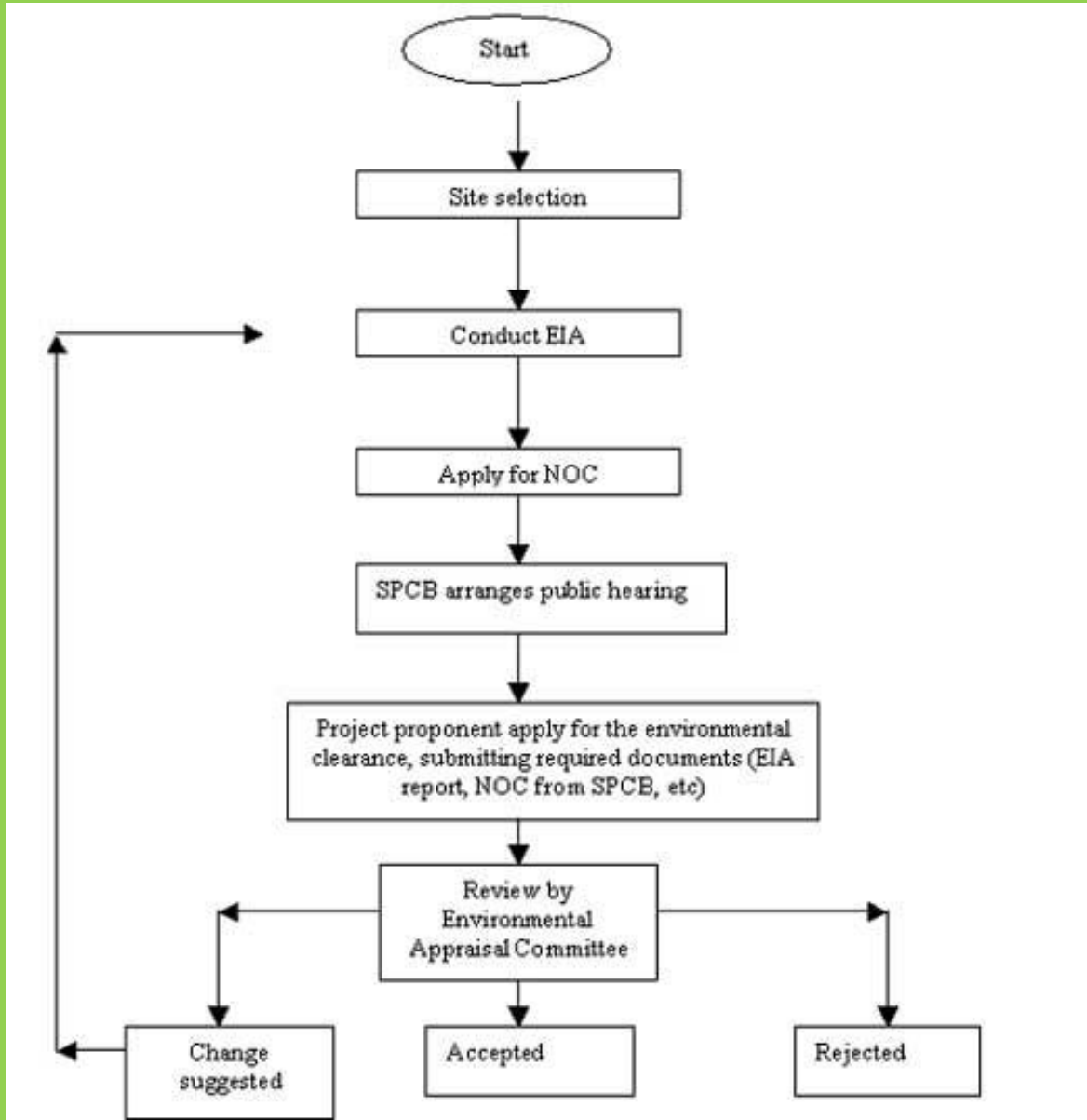
Review of EIA: It examines the adequacy and effectiveness of the EIA report and provides the information necessary for decision-making.

Decision-making: It decides whether the project is rejected, approved or needs further change.

Post monitoring: This stage comes into play once the project is commissioned. It checks to ensure that the impacts of the project do not exceed the legal standards and implementation of the mitigation measures are in the manner as described in the EIA report.

PROCEDURES OF EIA IN INDIA

Generalised process flow sheet of the EIA process



SUSTAINABLE INDUSTRIALISATION

Sustainable industrialisation (SI) is a process of development that strives to promote economic growth through increased capacity to produce goods and provide services whilst improving all peoples' livelihoods without compromising the needs of future generations.

Sustainable industrialization

Sustainable industrialisation is a long-term process of transformation towards a desired vision of an industrialised economy.

It contributes to wealth creation, social development and environmental sustainability.

NECESSITY OF INDUSTRIALIZATION

- Applying technological progress
- Driving and diffusing innovation
- Developing new skills and attitudes
- Stimulating modern services

CLASSIFICATION OF INDUSTRIES

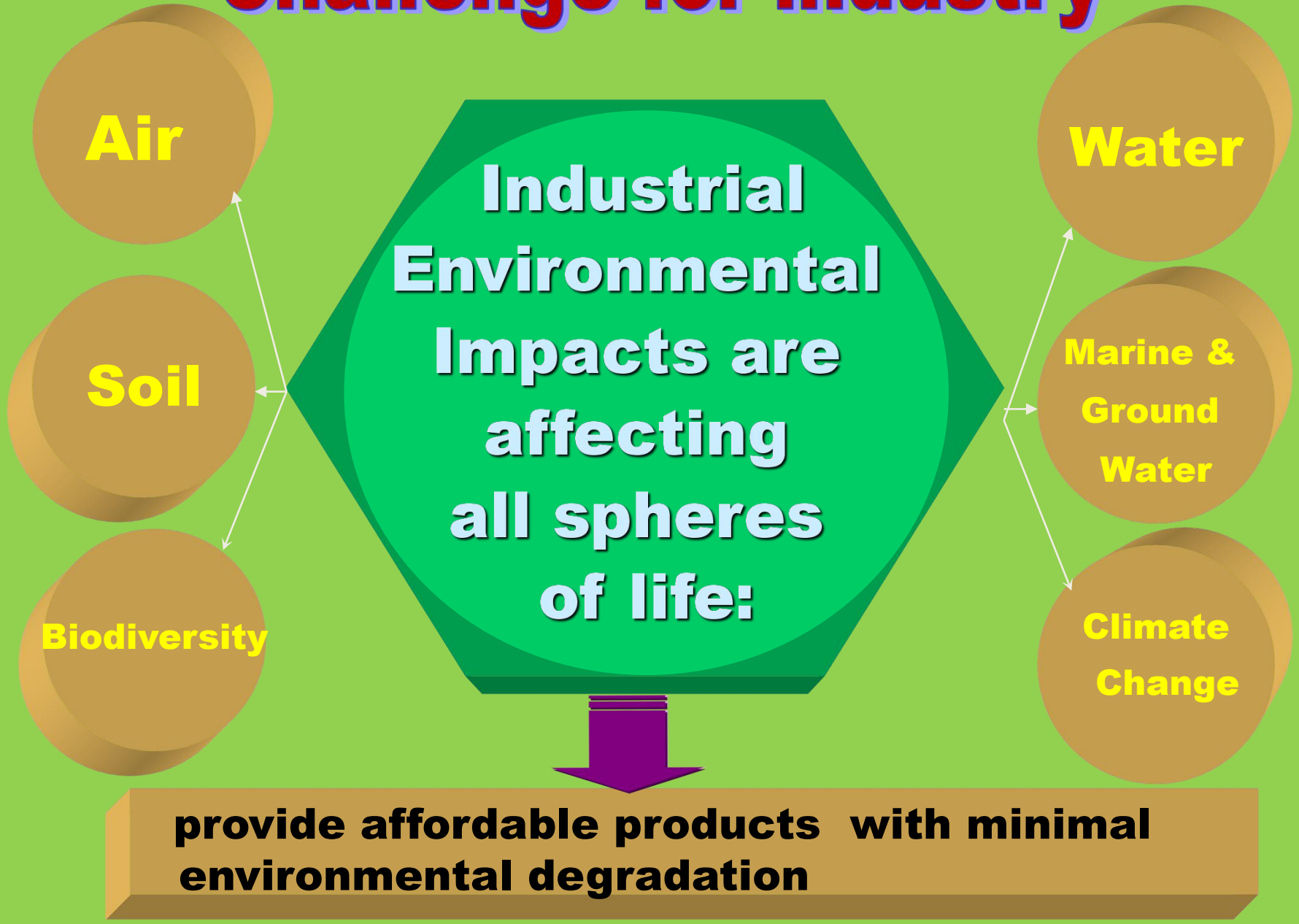
- Resource-based industries (processed food, wood, leather, refined petroleum & rubber products);

- Low technology industries (textiles, garments, footwear, furniture, glassware, toys);

- Medium technology industries (automotive industry, chemicals, metal products, machinery)

- High technology industries (electronics, pharmaceuticals, biotechnology, precision instruments, aerospace).

Challenge for industry



CRITICAL ISSUES FOR INDUSTRIALIZATION

POPULATION OF EARTH

i) 2011 POPULATION ~ 6.93 billion

Ii) Population may reach in 2050, ~ 10 billion

iii) Today, The richest 20% of population (1.2 billion) Consume 75% of energy and resources

CRITICAL ISSUES FOR INDUSTRIALIZATION

Crises of Energy

6.2.1 Consumable Energy (fossil)

i) Oil Consumption 3x faster than discovery
ii) Brings all people up to top 20% lifestyle?
iii) Exhaust coal, oil, shale, natural gas by 2050

6.2.2 Consumable Energy (nuclear)

i) Fission power plants exist, fusion plants not yet.
ii) Brings 10 billion people up to top 20% lifestyle?
Need 8,000 additional uranium plants
Exhaust all uranium fuel in 10 years
iii) If we use breeder reactors
Uranium then adds plutonium and thorium to fuel cycle
Uranium will last 700 years (2x life of coal)

CRITICAL ISSUES FOR INDUSTRIALIZATION

Crises of Resources

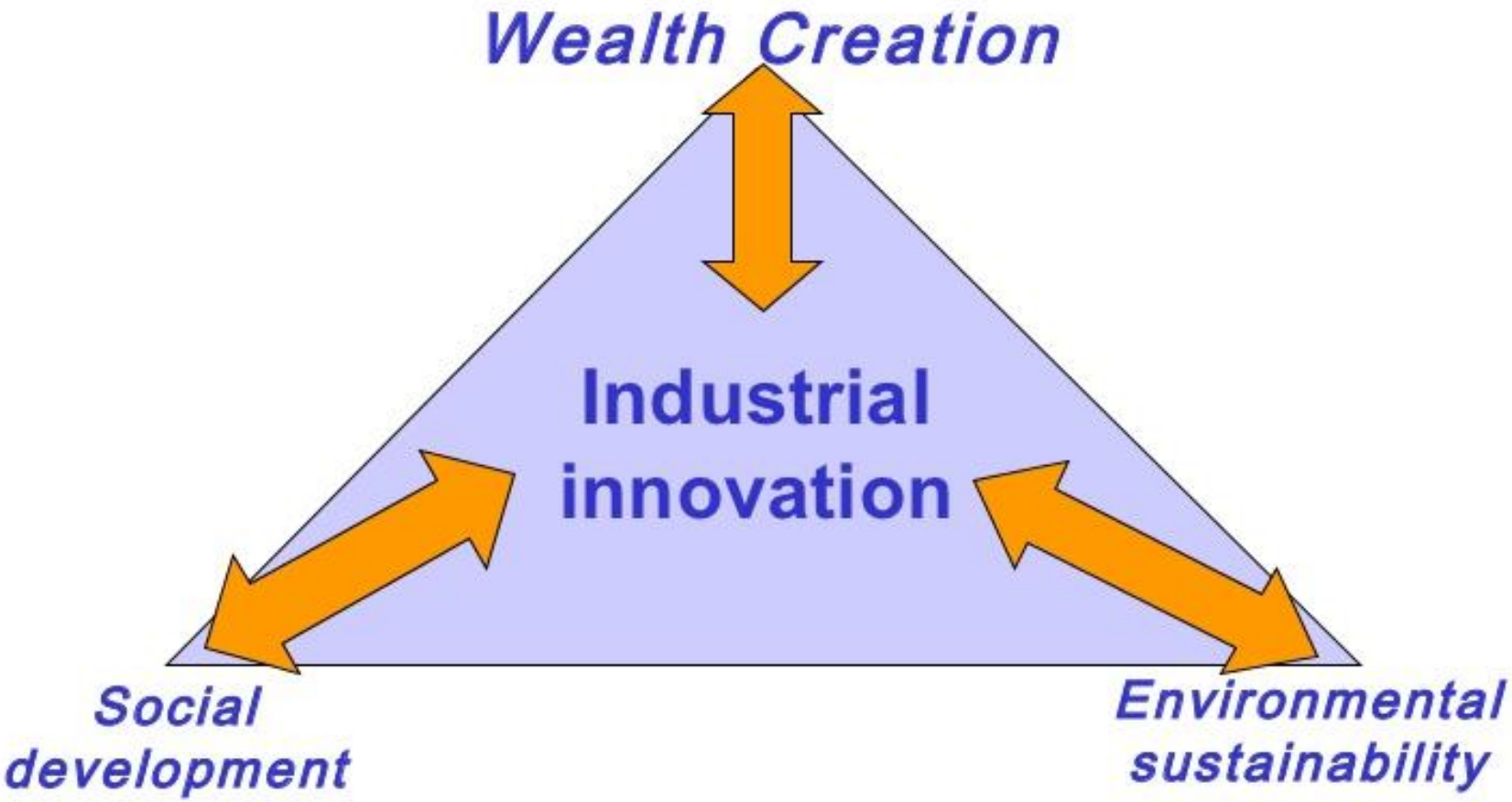
i) **Need Mineral Resources**

ii) **Need productive land on earth**

iii) **Additional land needed for disposal**

iv) **Need money**

7. The Sustainable Industrialization Triangle



GLOBAL TRENDS AND ISSUES: INDUSTRIALIZATION

- Very high level of wealth creation and improvement in quality of life during the last 50 years but not everywhere and not for everybody.
- Globalization of financial, trade, investment and knowledge flows
- Rapid and accelerating technological progress with many applications for product and process technologies: ICT; biotechnology; new materials; fuel cells; nano technologies etc…
- Emergence of a global network society and new consumption patterns
- Global governance with new international treaties, regulations and standards (trade, quality, labor, environment, intellectual property rights, etc..) and new actors (global corporations, civil society, media)
- However, alarming and unsustainable trends: poverty, environment, social development, economic marginalization,

Technical Progress & sustainability

Promise of the Science-Technology Enterprise

Promise = Development = Progress

- **Eliminate Toil**
- **Eradicate Disease**
- **Prosperity**
- **Increase Lifespan**
- **Move Faster**
- **High Security**
- **Instant Communication**
- **Increased Consumption**
- **MORE is MORE….**

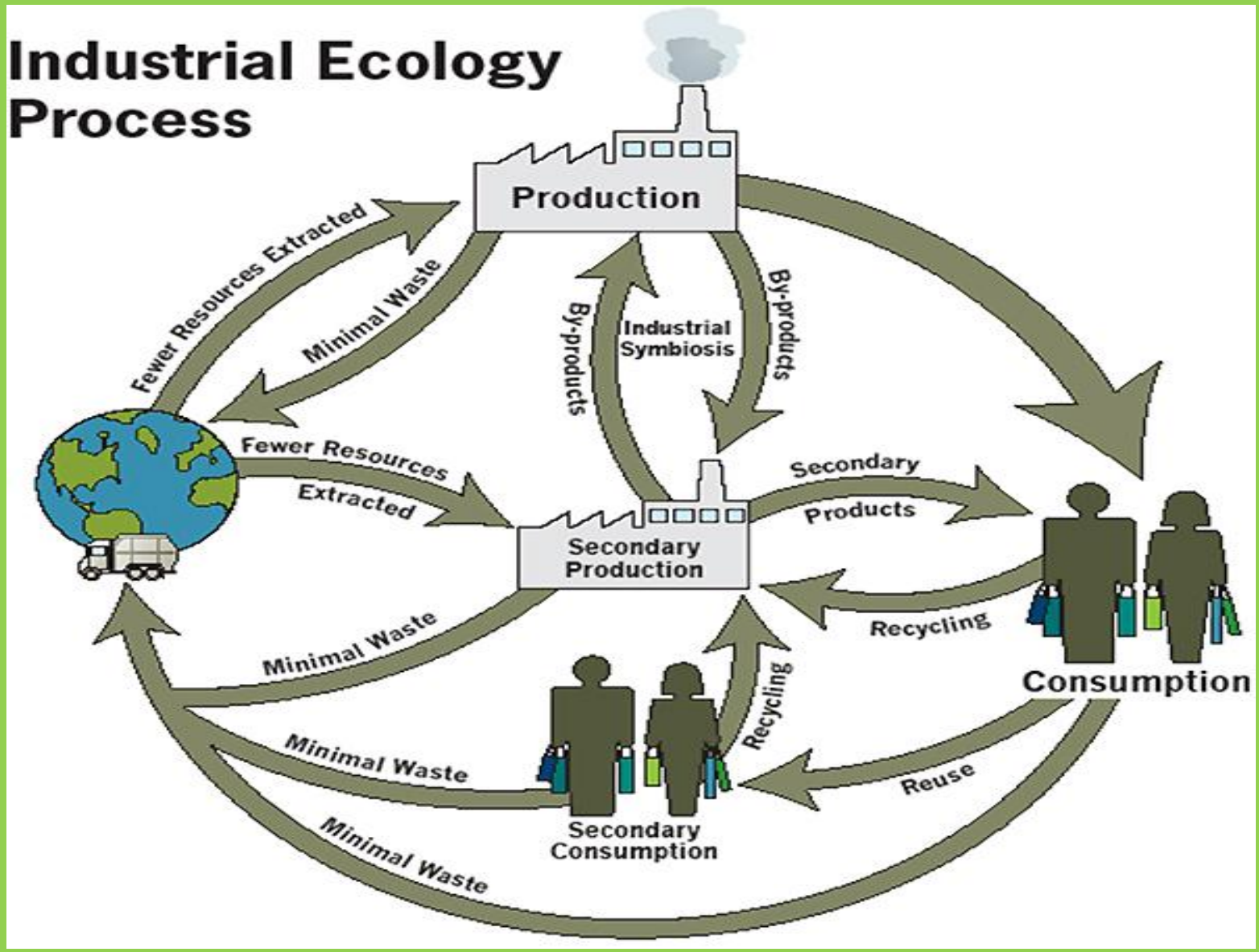
INDUSTRIAL ECOLOGY

Industrial ecology (IE) is the study of material and energy flows through **industrial** systems. The global **industrial** economy can be modeled 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

It is the study of industrial systems aimed at identifying and implementing strategies that reduce their environmental impact. Industries, such as manufacturing and energy plants, extract raw materials and natural resources from the earth and transform them into products and services that meet the demands of the population.

INDUSTRIAL ECOLOGY



INDUSTRIAL SYMBIOSIS

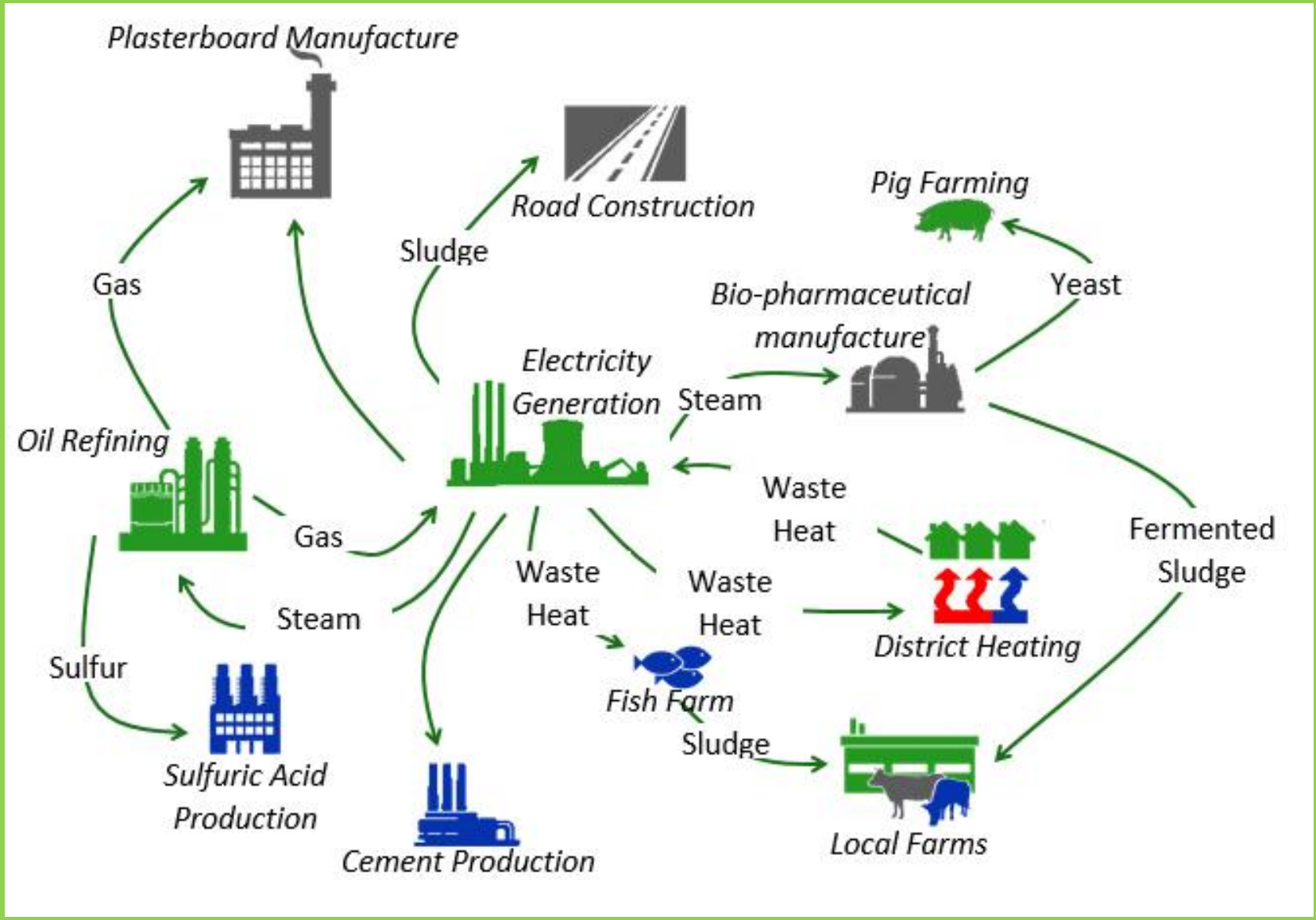
Industrial symbiosis is the sharing of services, utility, and by-product resources among **industries** in order to add value, reduce costs and improve the environment.

Industrial symbiosis is a subset of **industrial** ecology, with a particular focus on material and energy exchange.

INDUSTRIAL SYMBIOSIS

- One company's waste is another company's raw material.
- A sustainable and interactive way to exploit all resources best possible in a network of different companies.

INDUSTRIAL SYMBIOSIS



SUSTAINABLE ENGINEERING

MODULE 4

RENEWABLE ENERGY SOURCES

RENEWABLE ENERGY SOURCES

- **Non Conventional Energy Sources**

  Resources which are yet in the process development over past few years: *Solar, Wind, Tidal, Biogas, Biomass, Geothermal ....*

- **Conventional Energy Sources**

  The sources of energy which have been in use at present for a long time: *Coal, Petroleum, Natural Gas and Water power ...*

- **Note: *The above said non conventional energy sources were conventional energy sources before the invention of steam engine in 18th Century***

Conventional v/s Non-Conventional Sources of Energy

Conventional Sources of Energy	Non-Conventional Sources of Energy
Coal, Petroleum, Natural Gas And Water Power.	Solar, Wind, Tidal, Biogas, And Biomass, Geothermal.
Exhaustable except water.	NOT exhaustable
Environment pollution like smoke, ash, chemicals...	Pollution free
Power transmission is expensive	Local power generation and use.
Waste Disposal Problems	Environment friendly waste
Planet Heat imbalance	Balanced Heat

NON Renewable Energy Source	Renewable Energy Source

RENEWABLE (NON CONVENTIONAL)ENERGY

Energy Sources to be focused:

- **Solar**
- **Fuel Cells**
- **Wind**
- **Tidal**

SOLAR ENERGY

"Solar" is the Latin word for sun. and solar power is the energy from the sun.

Solar energy technology comprises of two different categories viz., thermal conversion and photo-conversion.

Photovoltaic: Sunlight directly converts into electrical energy.

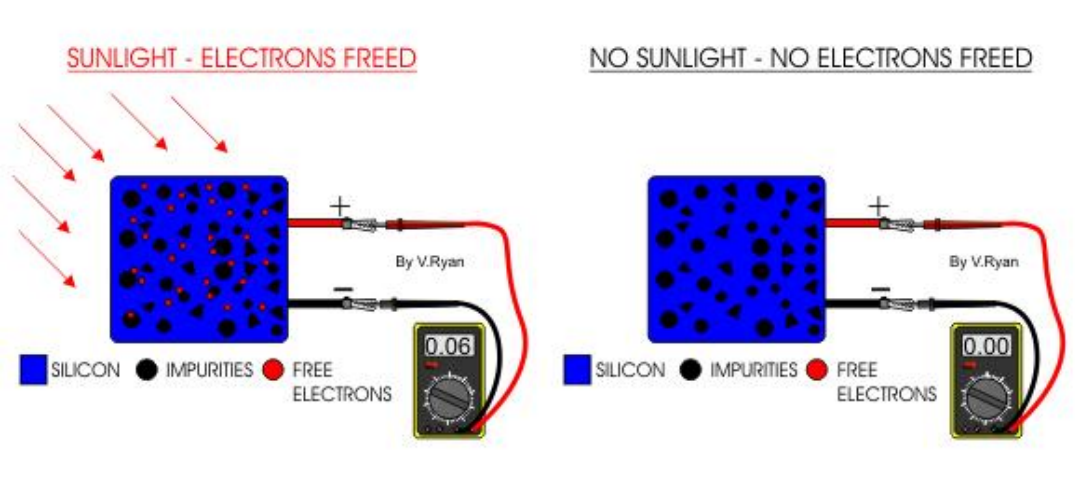
Thermal Energy: Sunlight focuses to thermal receptors and converts water to steam by turbines then rotary power produces electricity.

PHOTOVOLTAIC

Photovoltaic: Photovoltaics is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity.

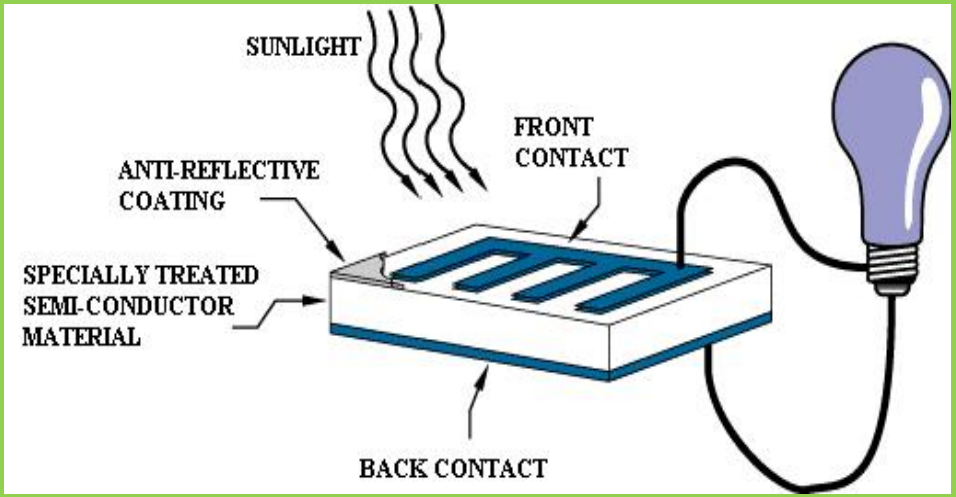
PHOTOVOLTAIC

Silicon is a material known as a ‘semiconductor’ as it conducts electricity and it is the main material for photovoltaic cells. Impurities such as boron or phosphorus are added to this base material. These impurities create the environment for electrons to be freed when sunlight hits the photovoltaic panel. The freeing of electrons leads to the production of electricity.



The diagram above shows a basic photovoltaic cell. The blue represents the main material, silicon. The black round and irregular shapes represent the impurities of boron or phosphorous. As the sun/light strikes the cell the impurities free up electrons which ‘bounce’ around at incredible speeds. This creates an electrical charge.

PHOTOVOLTAIC



Photovoltaic: The diagram above illustrates the operation of a basic photovoltaic cell, also called a solar cell. Solar cells are made of the same kinds of semiconductor materials, such as silicon, used in the microelectronics industry. For solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current -- that is, electricity. This electricity can then be used to power a load, such as a light or a tool.

SOLAR ENERGY

There are number of solar techniques which provides a broad number of applications, of which some of them are listed below.

- **Solar water heating**
- **Solar air conditioning**
- **Solar drying**
- **Solar green-house**
- **Solar desalination**
- **Solar refrigeration**
- **Solar cooking**
- **Solar furnace**
- **Solar electricity (Photovoltaic)**
- **Solar electricity (Thermal)**

SOLAR ENERGY

Advantages of Solar Energy

Solar energy is free

Solar energy does not cause pollution

It can be used in remote areas where it is too expensive to extend electricity power grid.

Calculators ad other low power consuming devices can be powered by solar energy effectively.

World's oil reserves will last for 40 to 50 years. On the other hand, solar energy is infinite (forever)

FUEL CELLS

A fuel cell is a device that generates electricity by chemical reaction.

For any type of fuel cell, there are mainly three segments

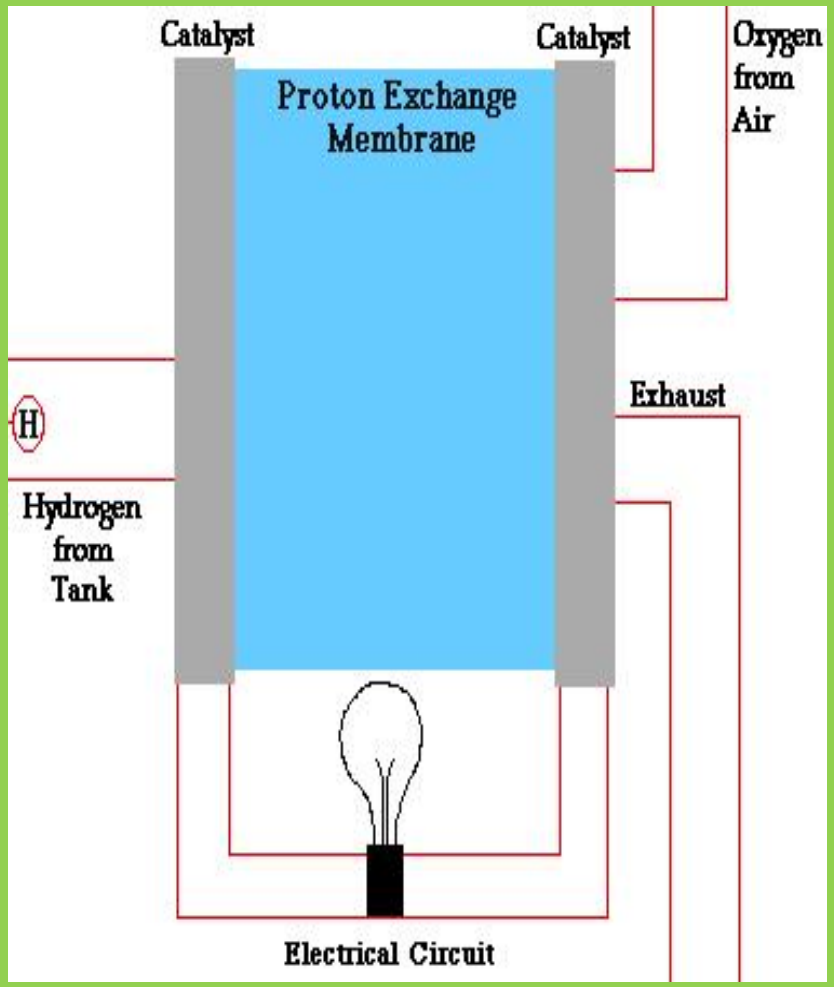
Anode
Cathode
Electrolyte and catalyst

Every fuel cell has two electrodes, one positive (Anode) and the other negative (Cathode).

Every fuel cell also has an electrolyte, which carries electrically charged particles from electrode to the other, and

Catalyst, which speeds the reactions at electrodes

FUEL CELLS



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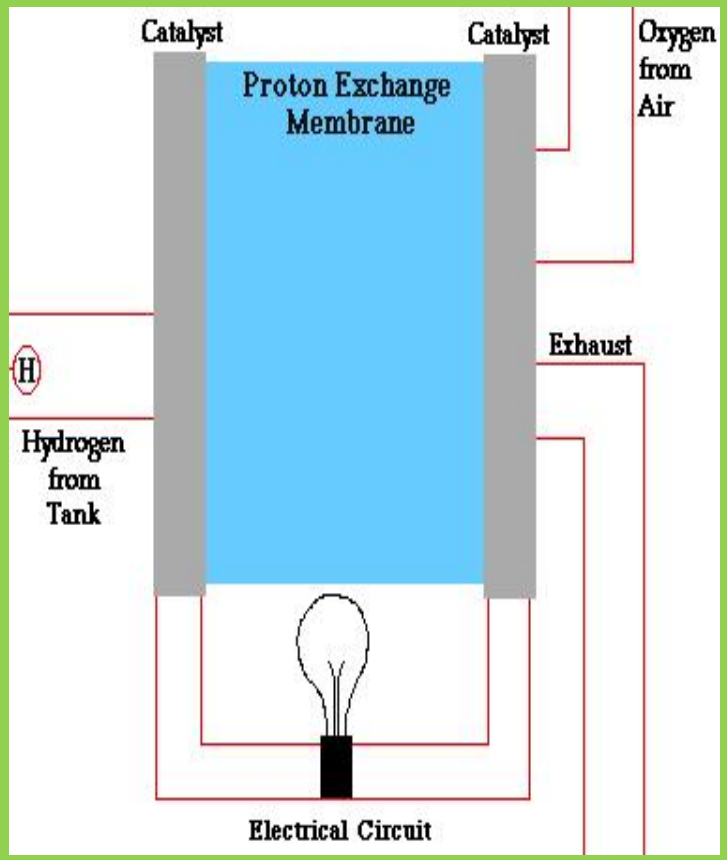
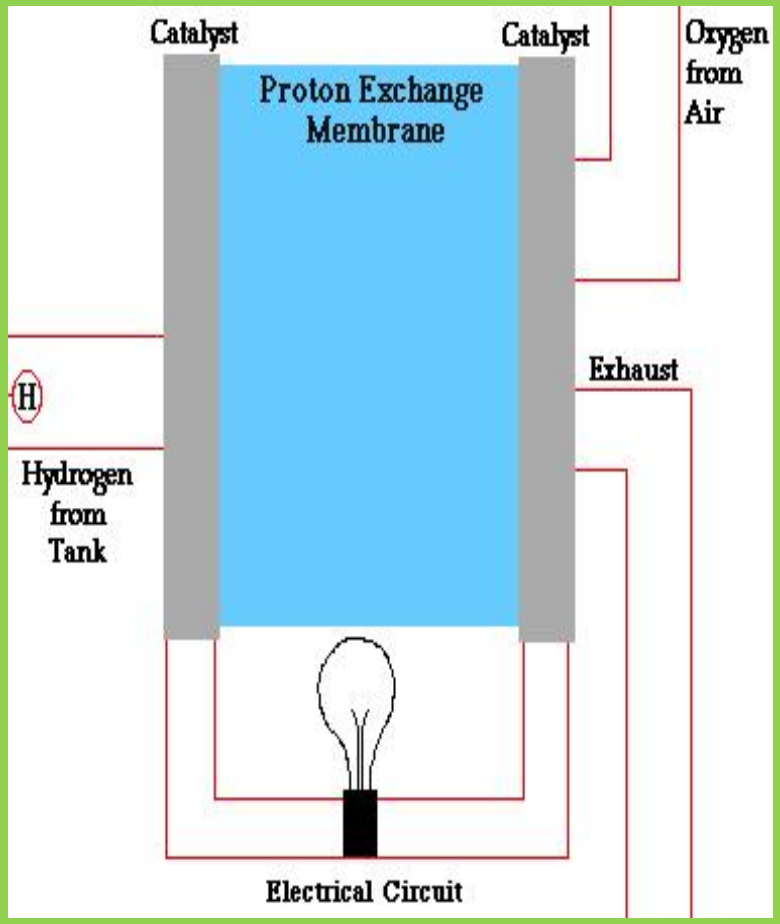


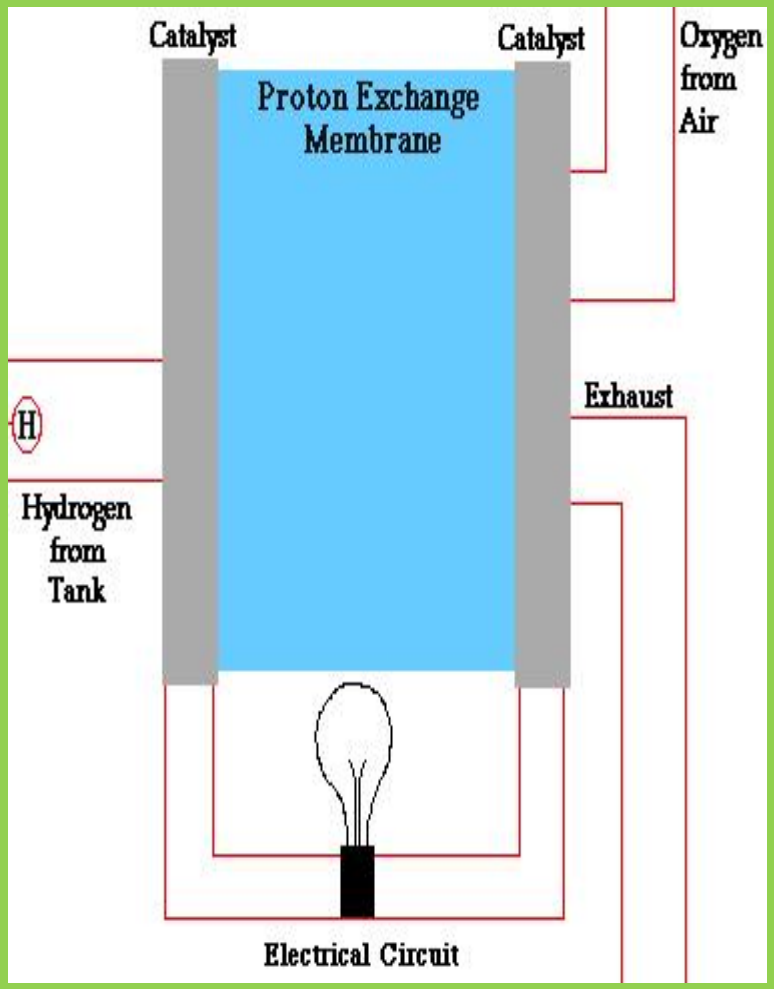
Hydrogen atoms enter a fuel cell at the anode where a chemical reaction strips them of their electrons. The hydrogen atoms are now "ionized," and carry a positive electrical charge. The negatively charged electrons provide the current through wires to do work. If alternating current (AC) is needed, the DC output of the fuel cell must be routed through a conversion device called an inverter.

FUEL CELLS



Oxygen enters the fuel cell at the cathode and, in some cell types (like the one illustrated above), it there combines with electrons returning from the electrical circuit and hydrogen ions that have traveled through the electrolyte from the anode. In other cell types the oxygen picks up electrons and then travels through the electrolyte to the anode, where it combines with hydrogen ions.

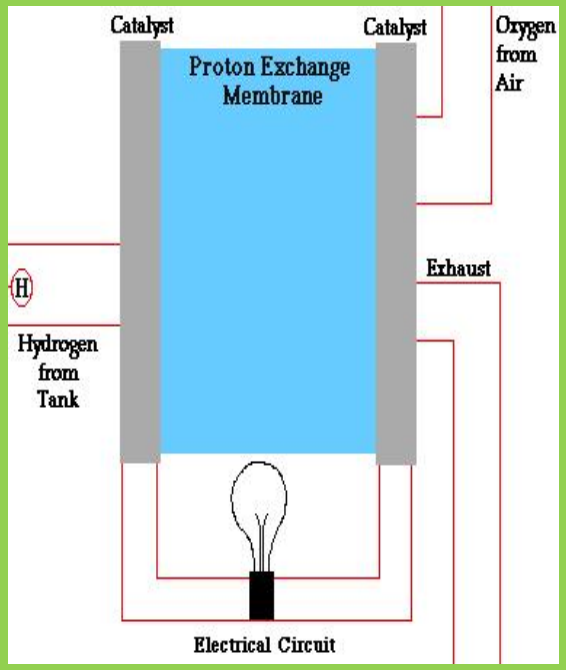
FUEL CELLS



The electrolyte plays a key role. It must permit only the appropriate ions to pass between the anode and cathode. If free electrons or other substances could travel through the electrolyte, they would disrupt the chemical reaction.

Whether they combine at anode or cathode, together hydrogen and oxygen form water, which drains from the cell. As long as a fuel cell is supplied with hydrogen and oxygen, it will generate electricity.

FUEL CELLS



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Every fuel cell also has an electrolyte, which carries electrically charged particles from electrode to the other, and

Catalyst, which speeds the reactions at electrodes

FUEL CELLS OVER HEAT ENGINES

- High Efficiency.
- Virtually silent.
- No Pollutant emissions
- Power plants located near the consumer
- Provides electric power and heat as by-product.
- Heat is transferred to Heat Exchanger provides hotwater supply or for desalination of sea water.
- Electric transmission lines are not required and hence reduces transmission loss.

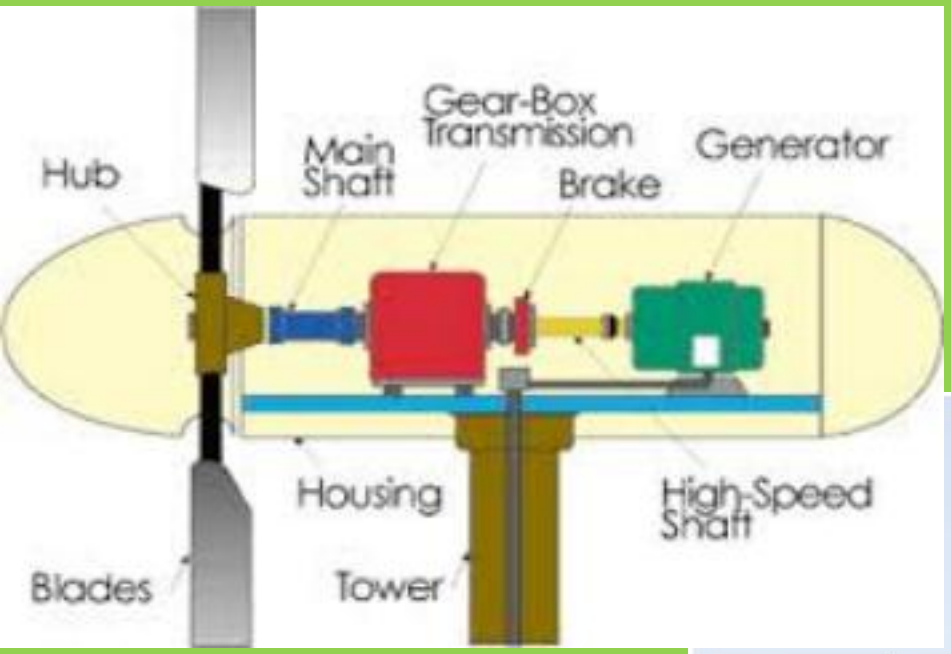
WIND ENERGY

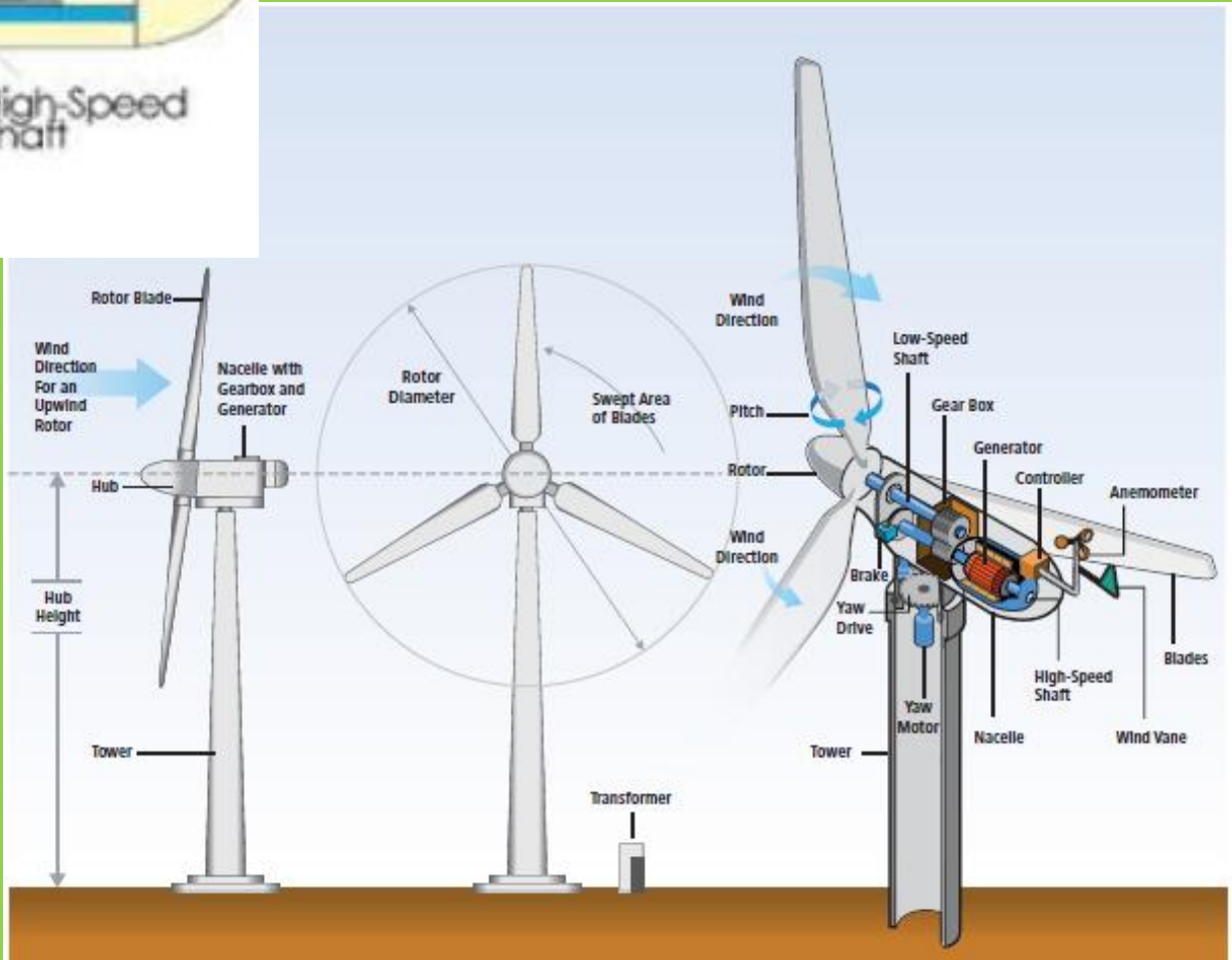
WIND: Atmospheric Air in motion

The origin of the Wind Energy is from the sun. When sun's ray falls on our planet, it's surface gets heated up and as a consequence unevenly winds are formed.

We can use the energy in the wind by building a tall tower, with large propeller on the top. The wind blows the propeller round, which turns a generator to produce electricity.

COMPONENTS OF WIND MILLS





WIND ENERGY

Refers to production of electricity from wind using wind turbines.

When wind flows through the blades of a turbine, they rotate and spin powering a rotor inside the generator, produce electricity.

Multiple turbines are working independently.

The electricity from each turbine flows through cables and combines with energy from other turbines , power conditioned and then distributed.

ADVANTAGES OF WIND ENERGY

Wind energy is a renewable resource, so it will never run out

Has little direct effect on the environment as there has NO green house gas (GHG) problems

Modern turbines available upto 1MW and wind farms of 100 to 150 MW installed.

Individual turbines are repairable and no need of farm shutdown.

The farm land can be used for agriculture or farming activities – means ecofriendly and promotes tourism.

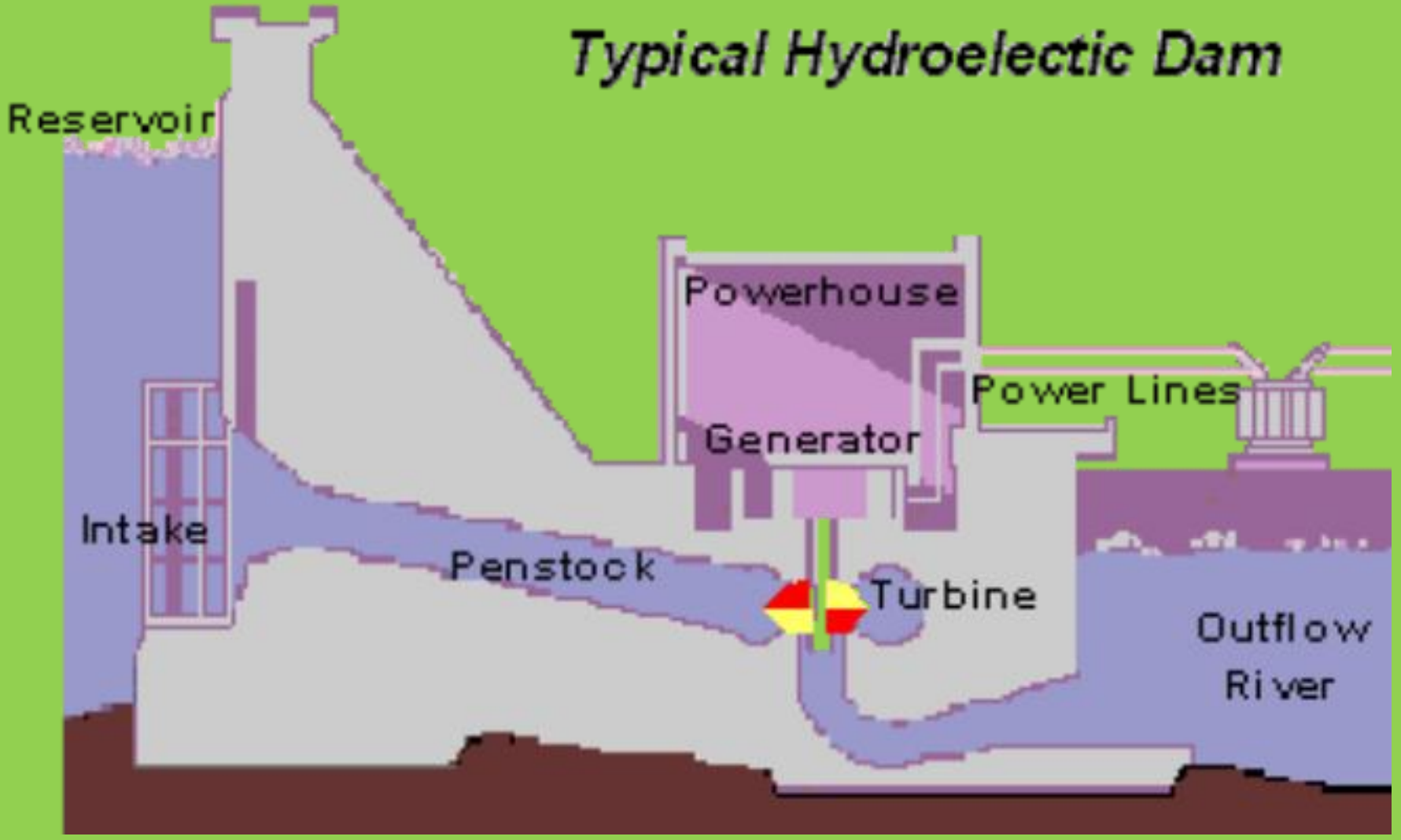
DISADVANTAGES OF WIND ENERGY

- It cover large areas usually on ridges and hill tops.
- They are noisy.
- Need huge amount of cabling and complex Electrical Engineering technology.
- Generation of waste materials from damaged wind mills.
- Regular monitoring and recurring repair of electronics.

HYDRO-ELECTRIC POWER

Hydroelectricity is the term referring to electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing water. It is the most widely used form of renewable energy, accounting for 16 percent of global electricity generation.

HYDRO-ELECTRIC POWER



SMALL HYDRO POWER (SHP)

Small hydropower can provide clean, renewable and relatively inexpensive energy.

Unlike large hydropower schemes, small hydropower does not necessitate a reservoir.

They can be constructed in any location where there is enough water flow and head to make energy generation viable.

Since, no reservoir is created on the upstream, there is minimal impact on nearby communities with respect to displacement.

ADVANTAGES OF SHP

SHP is a clean energy source, producing no water or air pollution

As a non-consumptive water use, small hydropower is a renewable energy source.

There is minimal impact on the environment.

Long useful life and low running cost

DISADVANTAGES OF SHP

To be economical, energy consumers need to be located near the hydropower scheme.

Seasonal variation in stream flow causes variation and disturbance in energy supply.

The stream flow limits the power generation’

BIOMASS

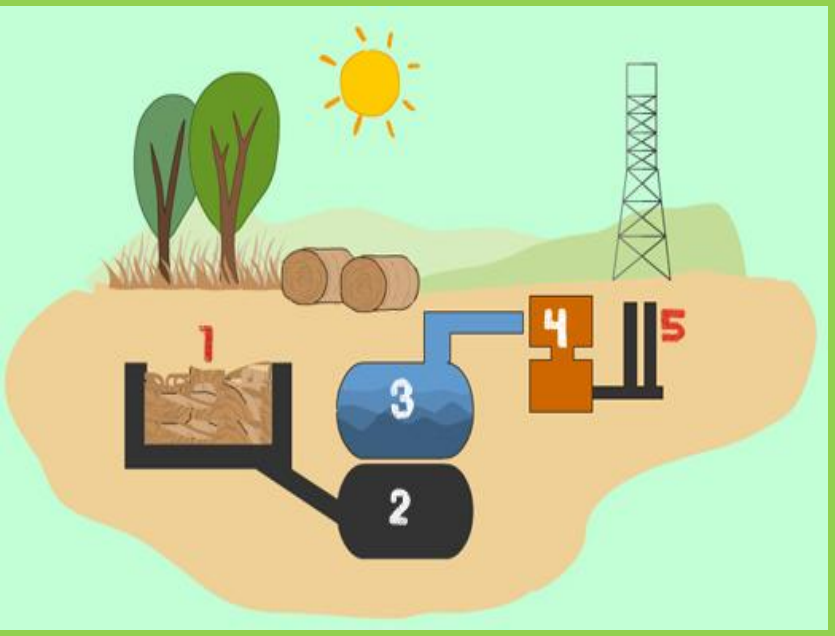
Biomass fuels come from things that once lived: wood products, dried vegetation, crop residues, aquatic plants and even garbage.

Plants used up a lot of the sun's energy to make their own food (photosysnthesis).

They stored the foods in the plants in the form of chemical energy. As the plants died, the energy is trapped in the residue.

This trapped energy is usually released by burning and can be converted into biomass energy.

BIOMASS



1.Energy from the sun is transferred and stored in plants. When the plants are cut or die, wood chips, straw and other plant matter is delivered to the bunker.

2. This is burned to heat water in a boiler to release heat energy (steam).

3. The energy/power from the steam is directed to turbines with pipes.

4. The steam turns a number of blades in the turbine and generators, which are made of coils and magnets.

5. The charged magnetic fields produce electricity, which is sent to homes by cables.

BIOMASS

Biomass falls into three categories

Biomass in traditional form (Wood and Agricultural residue is burnt to produce energy)

Biomass in non-traditional form (Biomass converted to ethyl alcohol and methyl alcohol to be used as liquid fuels in engine.)

Biomass for domestic use: Organic waste is decomposed anaerobically to produce a mixrure of gases (Biogas) namely methane, Carbondioxide, Hydrogen Sulphide etc. Biogas is a good biofuel used for cooking and lighting)

METHODS TO CONVERTING BIOMASS TO ENERGY

Burning:- Direct burning of biomass is the simple method of energy production. Wood and other forms of biomass burned for thousand years, to warm, to cook food, and forge weapons and other tools.

Alcohol Fermentation:- In alcohol fermentation, the starch in organic matter is converted to sugar. This sugar is then fermented by yeast. The resulting ethnol is distilled and then blended with another fuel. The end product “Gasohol” has been used successfully in various countries as an alternative to regular gasoline.

METHODS TO CONVERTING BIOMASS TO ENERGY

Anaerobic Digestion:- Anaerobic digestion converts biomass, especially waste products, into methane and carbon dioxide. The biomass is mixed with water and stored in an airtight tank.

Pyrolysis:- Pyrolysis involes the heating of biomass in the absence of oxygen. Biomass such as wood or agriculture waste is heated to around 1000^{o} F and allowed to decompose into gas and charcoal. The major advantage of pyrolysis is that carbon dioxide is not produced.

BIOGAS

Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter such as garbage and sewage by anaerobic bacteria.

Biogas is a fuel gas, consisting of 65% methane and about 30-35% CO_2 and 2% other gases.

It is a renewable resource of energy resulting from biomass.

ENERGY DERIVED FROM OCEANS

Marine energy refers to the energy carried by ocean waves, tides, salinity, and ocean temperature differences.

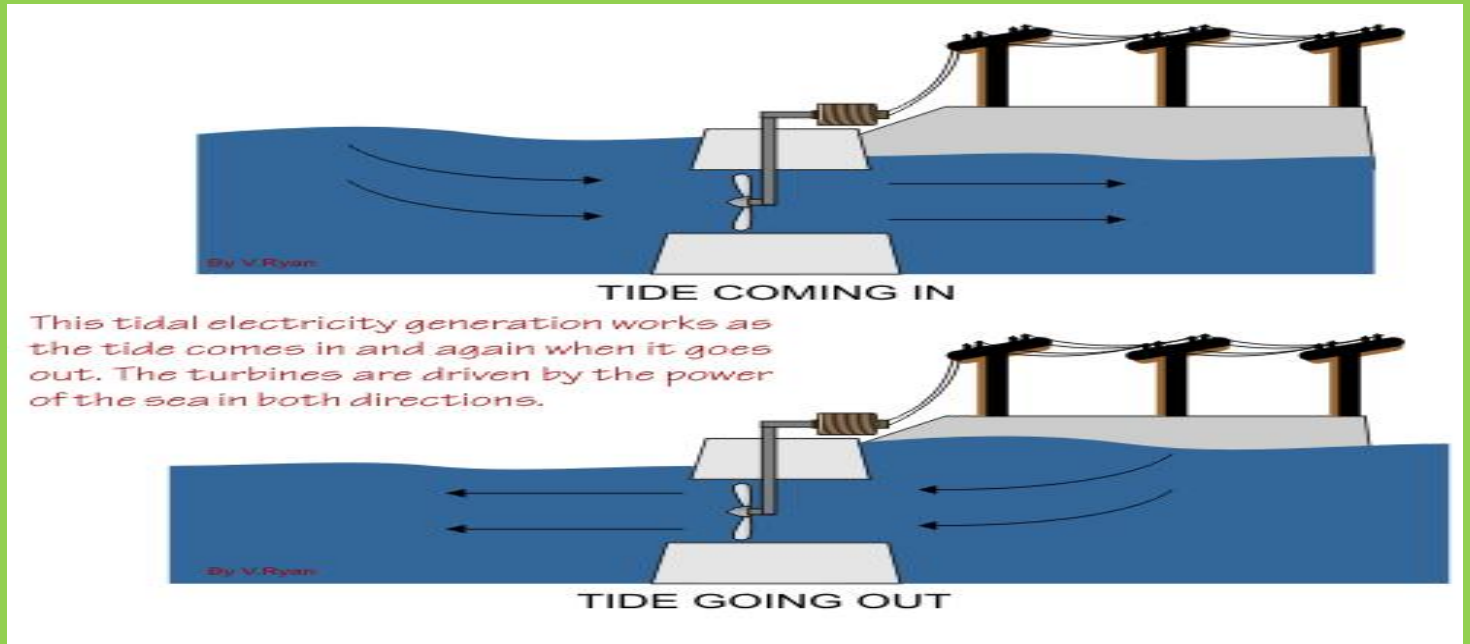
The movement of water in the world's oceans creates a vast store of kinetic energy, or energy in motion. This energy can be harnessed to generate electricity to power homes, transport and industries.

WAVE POWER

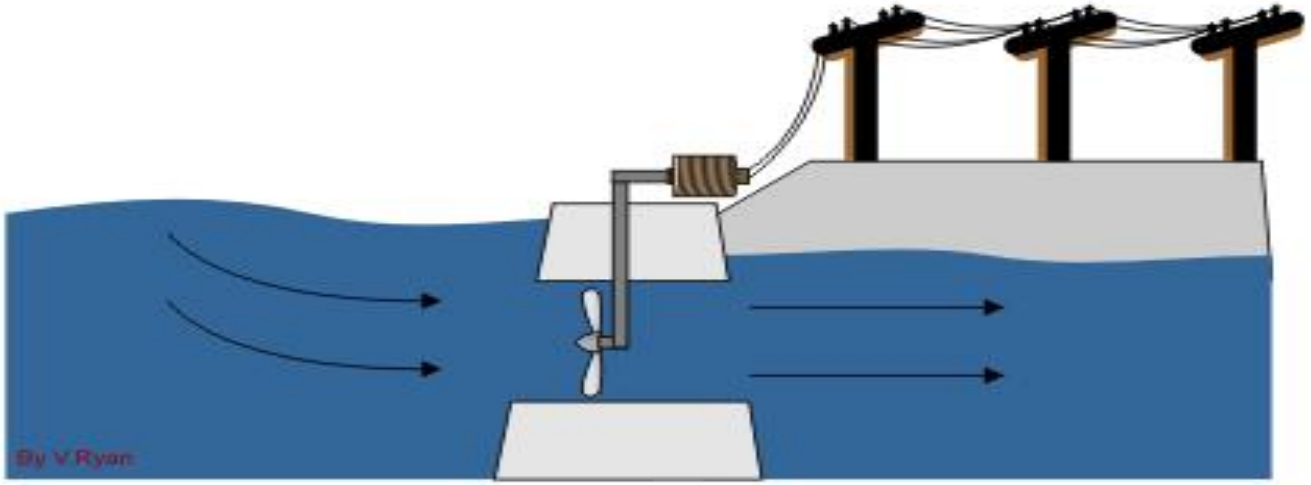
Wave power is the transport of energy by ocean surface waves, and the capture of that energy to do useful work – for example, electricity generation, water desalination, or the pumping of water (into reservoirs). A machine able to exploit wave power is generally known as a wave energy converter (WEC).

TIDAL POWER

Tidal power is taken from the Earth's oceanic tides; tidal forces are periodic variations in gravitational attraction exerted by celestial bodies. These forces create corresponding motions or currents in the world's oceans. Due to the strong attraction to the oceans, a bulge in the water level is created, causing a temporary increase in sea level. When the sea level is raised, water from the middle of the ocean is forced to move toward the shorelines, creating a tide.

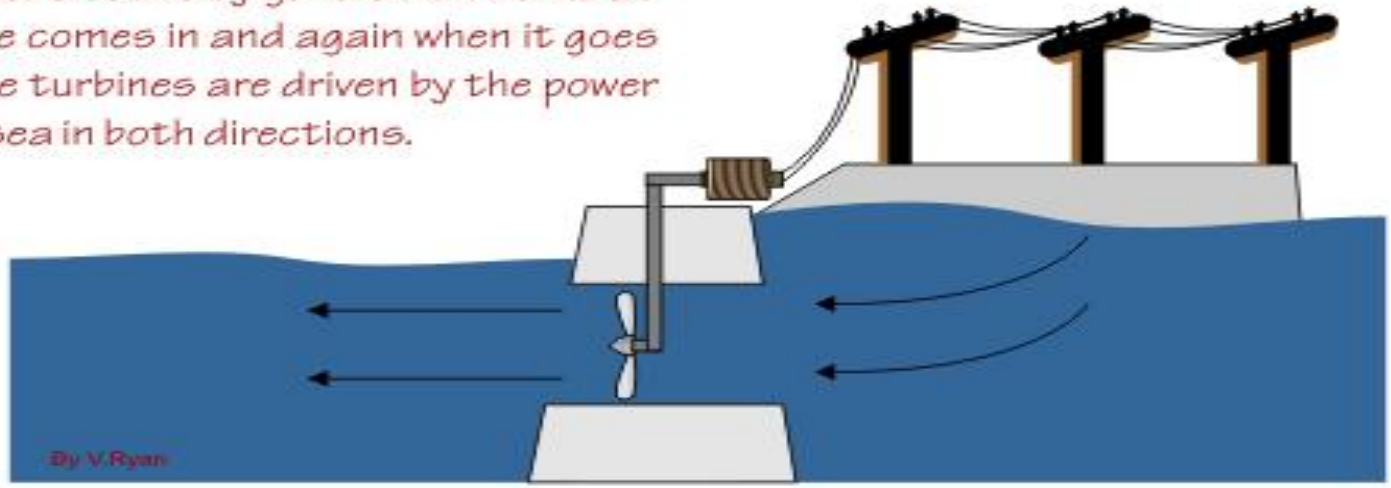


TIDAL POWER



TIDE COMING IN

This tidal electricity generation works as the tide comes in and again when it goes out. The turbines are driven by the power of the sea in both directions.



TIDE GOING OUT

TIDAL POWER

Advantages

- The energy generated is free – no fuel needed, no waste produced

- Not expensive to operate and maintain

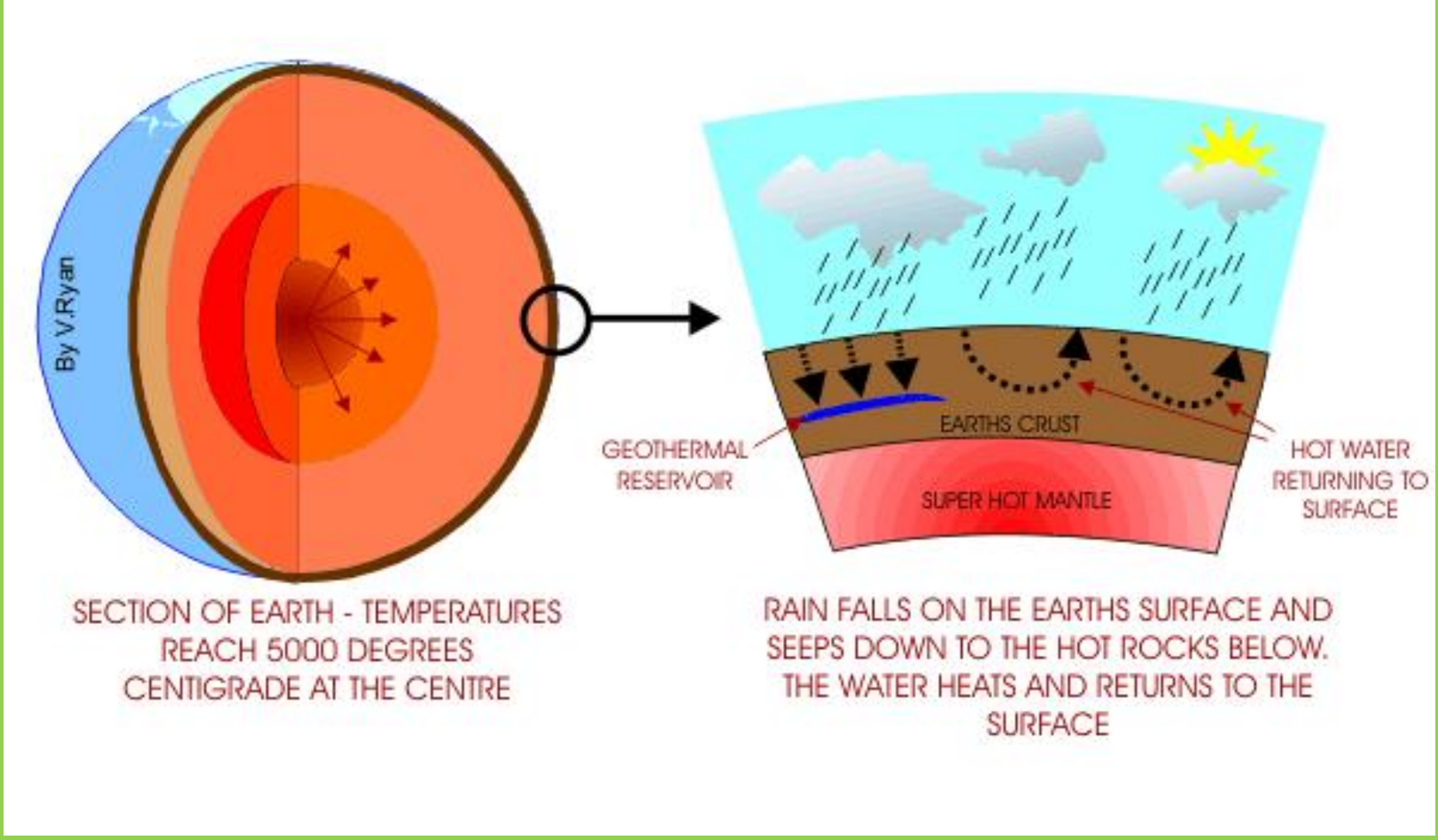
Disadvantages

- The energy generated is free – no fuel needed, no waste produced

- Not expensive to operate and maintain

GEOTHERMAL ENERGY

The term Geothermal originates from two Geek words 'GEO' and 'THERM'. The Greek word ‘geo’ means the earth and ‘thermal’ means heat.



GEOTHERMAL ENERGY

Geothermal energy is energy derived from the heat of the earth. The earth's centre is a distance of approximately 4000 miles and is so hot that it is molten. Temperatures are understood to be at least 5000 degrees centigrade. Heat from the centre of the earth conducts outwards and heats up the outer layers of rock called the mantle. When this type of rock melts and becomes molten it is called magma. Magma can reach just below the earths surface.

Rain water sometimes seeps down through geological fault lines and cracks becoming super heated by the hot rocks below. Some of this super heated water rises back to the surface of the earth where it emerges as hot springs or even geysers. Sometimes the hot water becomes trapped below the surface as a geothermal reservoir

GEOTHERMAL ELECTRICITY

One way of producing electricity from geothermal energy is by drilling wells into the geothermal reservoirs. The hot water that rises emerges at the surface as steam. The steam is used to drive turbines producing electricity. If the water is not hot enough to produce steam, it can still be used to heat homes and businesses, saving gas/electricity.

A GEOTHERMAL ELECTRICITY PLANT IN ICELAND

ADVANTAGES OF GEOTHERMAL POWER

1. Geothermal energy is relatively environmentally friendly. Pollution in the form of fumes are not produced although usually drilling of the earths surface takes place. The surrounding environment is not harmed with the exception of the land required for the power plant and transport links.

2. Unlike wind power, geothermal power can be relied on as it provides constant power.

3. The use of conventional polluting fuels such as oil and coal can be reduced if geothermal and other alternative energy forms are used (reducing pollution).

4. Geothermal power can take different forms. For instance, it can be used to produce electricity or the hot water can be used directly to heat homes and businesses.

DISADVANTAGES OF GEOTHERMAL POWER

1. Not available in many locations

2. Not much power per vent

SUSTAINABLE ENGINEERING

MODULE V

GREEN ENGINEERING

Sustainable Practice

Sustainable practices are the processes services employ to maintain the qualities that are valued in the physical environment. Living sustainably is about living within the means of natural systems (environment) and ensuring that our lifestyle doesn't harm other people (society and culture). In this respect, sustainable practices relate not only to the natural world but also to other important issues, such as poverty, consumption, community and health.

Sustainable practices empower children to gain knowledge, understanding and appreciation of the environment as it relates to our society. It is through positive childhood experiences that the foundations are laid for the development of environmentally responsible adults.

Sustainable Habitat

A sustainable habitat is an ecosystem that produces food and shelter for people and other organisms, without resource depletion and in such a way that no external waste is produced. Thus the habitat can continue into future tie without external infusions of resource. Such a sustainable habitat may evolve naturally or be produced under the influence of man.

A sustainable habitat that is created and designed by human intelligence will mimic nature, if it is to be successful. Everything within it is connected to a complex array of organisms, physical resources and functions. Organisms from many different biomes can be brought together to fulfill various ecological niches.

Sustainable Habitat

For maintaining our natural habitat, we should:-

1. Promote energy efficiency
2. Promote the use of eco-friendly fuels. (e.g. LPG, CNG, etc.)
3. Better manage municipal solid waste
4. Better manage the sewage disposal system
5. Promote public transport

ENERGY EFFICIENCY IN BUILDINGS

More than 90 per cent of our time is spent in buildings i.e. either in the office or at home. Energy used in buildings (residential and commercial) accounts for a significant percentage of a country's total energy consumption. This percentage depends greatly on the degree of electrification, the level of urbanization, the amount of building area per capita, the prevailing climate, as well as national and local policies to promote efficiency.

ENERGY EFFICIENCY IN BUILDINGS

Energy efficiency simply means using less energy to perform the same task – that is, eliminating energy waste. Energy efficiency brings a variety of benefits: reducing greenhouse gas emissions, reducing demand for energy imports, and lowering our costs on a household and economy-wide level.

Energy Saving Concepts

Some of the energy saving concepts are discussed below:

1. **Site Selection- Although site selection is usually based on price, a poor decision can exclude several sustainable features.**

2. **Orientation**- Proper orientation allows for passive solar gain and day lightning. In the northern hemisphere, south facing windows have the greatest exposure to the sun. West facing windows need to be carefully designed, as the low angle of the setting can cause overheating.

3. **Walls, and Roof-** **It is essential to build with proper insulation and technique. The envelop of a building determines the amount of energy needed to heat and cool it.**

4. Window and ventilation technology: A variety of blinds, shutters and windows are used for shading, heat preservation and heat insulation. Thermal insulated materials are used outside the window to insulate the heat. Ventilation should be provided fresh air, remove moisture, odors and pollutants. Stale air is usually extracted from rooms such as kitchens and bathrooms, and warmed fresh air supplied to living rooms and bedrooms.

5. Energy Efficient Appliances- **Use of energy efficient and eco-friendly appliance reduces utility cost. While purchasing new electrical appliances always look for BEE (*Bureau of Energy Efficiency*) star rating. More stars indicate more efficiency. The small additional initial installation cost will be compensated many times over by the savings and the occupants comfort.**

6.Heating, Air-Conditioning and Ventilation-

Reducing the heat load of the structure allows for the installation of a smaller heating and cooling system. The importance of high-quality ventilation systems is often overlooked during the design phase, but is a fundamental consideration in green building.

7.Material used- Easily recycle and reused materials which are selected looking in to their local availability, benefits, cost and durability. Making the approach towards waste utilization and environment friendly.

8. Waste reduction- Green architecture also seeks to reduce waste of energy, water and materials during construction. One goal should be to reduce the amount of material going to landfills. Well-designed buildings also help reduce the amount of waste generated by occupants as well, by providing on-site solution such as compost bins to reduce matter going to the landfills.

GREEN ENGINEERING

Green engineering is the design, commercialization, and use of processes and products in a way that reduces pollution, promotes sustainability, and minimizes risk to human health and the environment without sacrificing economic viability and efficiency.

Principles of Green Engineering

Green engineering follows nine guiding principles:

1.Holistically use systems analysis and integrate environmental impact assessment tools.

2.Conserve and improve natural ecosystems while protecting human health and well-being.

3.Use life-cycle thinking in all engineering activities.

4.Ensure that all material and energy inputs and outputs are as inherently safe and benign as possible.

5.Minimize depletion of natural resources.

6.Strive to prevent waste.

7.Develop and apply engineering solutions, while being cognizant of local geography, aspirations, and cultures.

8.Create engineering solutions beyond current or dominant technologies; improve, innovate, and invent (technologies) to achieve sustainability.

9.Actively engage communities and stakeholders in development of engineering solutions

SUSTAINABLE URBANISATION

Sustainable urbanism is both the study of cities and the practices to build them, that focuses on promoting their long-term viability by reducing consumption, waste and harmful impacts on people and place while enhancing the overall well-being of both people and place.

Objectives of Sustainable urban projects

Following are the objectives of responsible and sustainable urban development project:

1. The conservation of identity, strengthening of neighbourhood and encouragement of its cultural diversity and distinctiveness;
2. The expansion of public transport and its interconnection with existing and new developments;
3. The wise use of resources, minimising additional land take up, and the encouragement of moderate degrees of urban density;

4. Safeguarding and interconnecting green spaces with networks working towards quality standards and the conservation of public spaces;
5. The assurance of social harmony and advancement of social and functional interaction;
6. Safeguarding existing jobs and creating new and innovative ones;
7. Advancing a culture of discourse;
8. Creating long-term partnerships between the community, and the public and private sectors;
9. Participation in lifelong learning processes, seeing urban life in its wider context.

Benefits of sustainable urban development

Environmental Benefits

1.Improved air quality: Walking, biking, and public transit can cut transportation emissions, which account for more than 30 percent of the PM 2.5 pollution.

2.Smaller carbon footprint: Better urban design can reduce carbon pollution from the transportation sector, which accounts for nearly a quarter of the planet's energy-related greenhouse gas emissions.

3.Decreased car dependence: Bike-sharing programs and dedicated lanes provide alternatives to private vehicles.

Economic Benefits

1. **Lower cost for residents:** Households can save money through more energy efficient travel due to mode shifting, easier access to goods in mixed-use developments, and lower parking costs.
2. **Reduced congestion costs:** Employing The 8 Principles can deliver mobility with density and reduce the economic waste associated with traffic.
3. **Higher property values:** Studies from around the globe show that walkability and accessibility to transit increase real estate values.

4. **Improved productivity:** Density boosts productivity and innovation through network effects; by contrast, congestion and pollution harm economic activity and human health.
5. **Higher government revenues:** By choosing smart development strategies, governments can cut capital, labour, and maintenance costs.

- **Social Benefits**

1. **Improved public health:** Mixed-use, transit-oriented development increases physical activity, whereas failure to mix land-uses and increased car ownership are associated with higher risks of obesity and colon cancer. Sustainably designed communities also offer

Social Benefits

1.Improved public health: Mixed-use, transit-oriented development increases physical activity, whereas failure to mix land-uses and increased car ownership are associated with higher risks of obesity and colon cancer. Sustainably designed communities also offer safer streets and reduce traffic-related injuries.

2.Greater human mobility: Greater mobility saves time wasted in traffic jams and expands economic and lifestyle choices for urban dwellers.

3.Increased equality of access: In a car-centric framework, low-income residents are often left out of the planning calculus. By building better public transit, sidewalks, and biking paths, those who cannot afford to drive gain greater access to the city.

SUSTAINABLE CITES

Sustainable city is a city designed with consideration for social, economic, environmental impact, and resilient habitat for existing populations, without compromising the ability of future generations to experience the same. The UN Sustainable Development Goal 11 defines sustainable cities as those that are dedicated to achieving green sustainability, social sustainability and economic sustainability.

Most cities today are struggling with environmental degradation, traffic congestion, inadequate urban infrastructure, in addition to a lack of basic services, such as water supply, sanitation, and waste management. A sustainable city should promote economic growth and meet the basic needs of its inhabitants, while creating sustainable living conditions for all. Ideally, a sustainable city is one that creates an permanent way of life across the four domains of ecology, economics, politics and culture.

Some of the major problems of Cities in India are

1. Urban Sprawl
2. Overcrowding
3. Housing
4. Unemployment
5. Slums and Squatter Settlements
6. Transport
7. Water
8. Sewerage Problems
9. Waste Disposal
10. Urban Crimes
11. Problem of Urban Pollution

Six Characteristics and Key Features of a Sustainable City

Smart cities are creating sustainable places with clean technology, parks and pathways, and urban sustainability principles. See the list of key eco city characteristics to learn how to achieve sustainable cities and communities.

Cities can do a number of things to support sustainable practices:

1.Make it easy to get around without a car

2.Add Electric Vehicle charging stations

3.Provide access to public resources and green spaces

4.Improve water conservation and wastewater management

5.Support urban farming

6.Implement green architecture

SUSTAINABLE TRANSPORT

Sustainable Transportation refers to any means of transportation that is 'green' and has low impact on the environment. Sustainable transportation is also about balancing our current and future needs.

SUSTAINABLE TRANSPORT

Examples of sustainable transportation include:

Walking,

Cycling,

Transit,

Carpooling,

Car sharing, and

Green vehicles.

Sustainable transport can save money, improve health and reduce environmental footprint.

1. Public alternative transportation ways

Public transport reduces traffic and pollution in the city. They have many advantages: more ecological, more economical. They bring more calmness because there is much less risk of accidents. There are 6 different ways of public alternative transportation:

i) The tramway
ii) The train
iii) Bio bus
iv) The bus
v) The electric bus
vi) The hybrid bus

2. Carpooling

Thinking about carpooling for daily trips related to leisure or tourism is an economic and ecological reflex allowing to reduce its carbon footprint. It is an increasingly popular mode of transport due to environmental and budgetary concerns linked to fuel prices. Car sharing also reduces stress and fatigue related to driving while allowing users to enjoy the comfort of a car. It is also an excellent way to meet new people and to travel in good company.

3. Car sharing

The mobility solution represented by car-sharing offers numerous non-negligible advantages, both for the environment and for the individual. First, the economic benefits: This system makes it possible in particular to remove the weight of the costs linked to the personal car: not only there is no cost to purchase, but there is also no maintenance cost (repair, remission level, etc.). Most importantly, car sharing is an effective eco-friendly alternative transportation mode. The environmental consequences are beneficial: less greenhouse gas emissions and less carbon footprint.

4. Electric cars

The electric car is often presented as the solution to pollution, and the high cost of fuel. Overall, the impact of electric vehicles on the environment and public health is much better than that of thermal models. It would make it possible to get out of all-oil while making our cities cleaner. On an electric vehicle, the wearing parts to be changed regularly are limited, tires, and that's it. Since brake pads are normally used much less!

5. The bicycle

Besides the fact that the bicycle is a great green alternative transportation mode, it is a solution to increase our physical activity and reduce the risk of illness due to our excessively rich diet and our sedentary lifestyle. Indeed, reducing travel by motorized vehicles is largely feasible. Most of the trips we make are less than 3 kilometres away and can easily be replaced by the bicycle. Increasing the number of trips by bike, therefore, reduces emissions of pollutants and in particular greenhouse gases.

6. The bicycle taxi

This new mode of transport “Ecolo-Chic” is developing in the largest cities in the world and provides a solution adapted to our traffic and environmental problems. So, imagine a taxi that offers you the advantages of proximity service without the disadvantages of using the car. Taxi bicycle are relatively slow, yes, but they are faster than a taxi in a traffic jam with zero pollution. The bicycle taxi has a substantial sympathy capital; it conveys extremely positive values such as sustainable development.

7. River shuttles

You don’t always have to opt for clean means of transportation that run on land. Indeed, if you live or pass in a city close to the sea, you could very well opt for a mode of travel that is both ecological and original. An alternative transportation mode that combines comfort with economy and energy, river shuttles are a preferred option for preserving the environment. Kind of water bus, they leave from the shore of a maritime or river city to reach another destination of the same type.

8. Walking

Walking will always be the most economical and ecological way to get from one point to another. Besides, you will not have to spend money on fuel or the like. You could, for example, walk to do your shopping, go to the cinema, go to the office, if it is nearby, go to a restaurant or an important meeting. Walking is, therefore, an excellent way to preserve your health, avoid gaining too much weight but also to reduce polluting emissions from cars.

Benefits

1. Reduced traffic congestion
2. Reduced air pollution and related risks such as asthma
3. Reduced greenhouse gas emissions
4. Reduced dependence on non-renewable energy sources
5. Reduced transportation costs
6. Increased physical activity
7. Increased social interaction
8. Support for local businesses and a vibrant economy
9. Healthier lifestyles and a better quality of life

10.Green Driving.

- Drive smoothly. Stopping and starting uses more fuel.
- Open your window rather than using your air conditioner when travelling at under 70 kilometres per hour. Air conditioning can increase fuel consumption by ten per cent. At speeds above this, the drag caused by having your window down will use more fuel than the air conditioning.
- Screw on your fuel cap firmly to avoid evaporation and leaks when turning corners.

10.Green Driving.

- Travel light. Don't use your car to store heavy equipment for long periods of time, an extra 50 kilograms of weight increases fuel consumption by two per cent.
- Remove roof racks and anything fixed to the outside of your car when they are not in use to minimise wind resistance.

Thank You