MODULE III

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

Environmental Management System ("EMS")

An Environmental Management System ("EMS") is a tool that is continuously growing in importance for companies. An Environmental Management System (EMS) is a framework that helps an organization achieve its environmental goals through consistent review, evaluation, and improvement of its environmental performance.

EMS – "Tool that enables an organization to control impact of its activities, products or services on the natural environment."

Advantages:

• Serves as a tool to provide a systematic way of managing an organization's environmental affairs.

• Focuses on continual improvement of the system.

• Restrict and regulate overexploitation of natural resources.

• Set targets to reduce the use of energy and water and waste going to landfill.

• Set environment friendly purchasing procedures.

The three primary processes of a management system include:

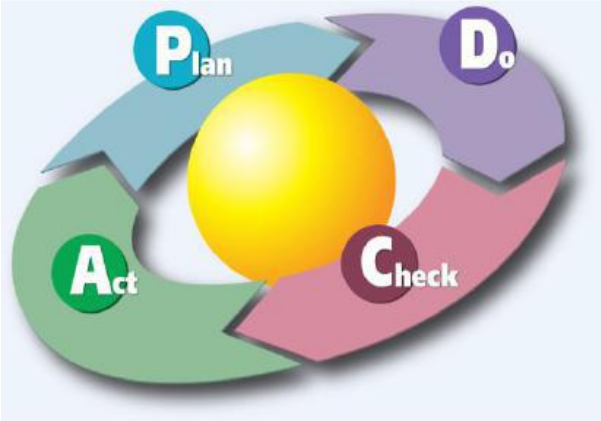
1. Core processes, their outputs, and the identification of significant environmental aspects and impacts
2. Key supporting processes, such as those for maintaining awareness of legal requirements, ensuring competency of employees, providing infrastructure, communicating EMS information, and monitoring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

Basic Elements of an EMS include the following:

- Reviewing the organization's environmental goals;
- Analyzing its environmental impacts and legal requirements;
- Setting environmental objectives and targets to reduce environmental impacts and comply with legal requirements;
- Establishing programs to meet these objectives and targets;
- Monitoring and measuring progress in achieving the objectives;
- Ensuring employees' environmental awareness and competence; and,
- Reviewing progress of the EMS and making improvements.

Basis EMS framework

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



Plan-Do-Check-Act

Plan	Planning, identifying environmental aspects and establishing goals in accordance with the organizations environmental policy
Do	Implement the planned processes which includes training and operational controls
Check	Checking (monitoring) and corrective actions
Act	Reviewing, includes progress reviews and actions to make needed changes which continually improve performance of the environmental management system

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

Environmental Management Standards

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

ISO 14000 series

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

The core of the ISO 14000 family of standards is ISO 14001:2015, but there are related standards to help you implement, evaluate, and improve your ISO 14001 Environmental Management System.

Organizations do not become certified in the ISO 14000 series, they ONLY register to ISO 14001:2015. The other documents will help an organization implement an EMS, audit properly, etc.

ISO 14001:2015

ISO 14001:2015 is the international standard that states requirements for an effective environmental management system, otherwise referred to as EMS.ISO standards provide a framework for organizations to follow. All ISO standards are voluntary; organizations can decide whether or not to comply with these standards.
ISO 14001:2015 is the document which defines the requirements for the EMS and provides guidance for its use.

The standard requires your organization to:

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

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

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

BENEFITS OF ISO 14001

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

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

- **Environmental Benefits**: The main reason to implement ISO 14001:2015 is to reduce your environmental impact. .ISO 14001 certificate serves as a driver and reminder that it is everyone's job to protect the environment by preventing pollution and continually improving the air we breathe, the water we drink, and the earth we inhabit
- **Legislative and Regulatory Benefits**: Meeting ISO 14001:2015 requirements also ensure that you meet any legislative or regulatory requirements. This will reduce your organization's potential to pay liability fees, while also improving your organization's efficiency.
- **Customer Satisfaction**: Customer Satisfaction is a key reason for organizations to become certified to ISO 14001. There has been a huge push in the two decades by consumers for companies to adopt better environmental management systems. Implementing ISO 14001 can lead to improved public perceptions, and give organizations a competitive advantage to operate in the international marketplace

ISO 14001 FRAME WORK

1.Context of the organization

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

i)Understanding the organization and its context:

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

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

b) the external cultural, social, political, legal, regulatory, financial, technological, economic, natural and competitive circumstances, whether international, national, regional or local;

c) the internal characteristics or conditions of the organization, such as its activities, products and services, strategic direction, culture and capabilities (i.e. people, knowledge, processes, systems

ii)Understanding the needs and expectations of interested parties

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

- Employees
- Contractors n Clients/Customers
- Suppliers
- Regulators
- Shareholders
- Neighbours
- Non-Governmental Organizations (NGOs)
- Parent organizations

iii) Determining the scope of the environmental management system

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

2. Leadership

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

i)Leadership and commitment

This clause encompasses a range of key activities which top management need in order to "demonstrate leadership and commitment with respect to the management system".

ii)Environmental policy

The Environmental Policy is an important document because it acts as the driver for the organization. It provides the direction and formally establishes goals and commitment. Top management should ensure that the policy is appropriate, compatible with the strategic direction and not a bland statement that could apply to any business. It should provide clear direction to allow meaningful objectives to be set that align with it.ment to engage more fully with the critical aspects of the quality management system.

iii)Organizational roles, responsibilities and authorities

For a system to function effectively, those involved need to be fully aware of what their role is. Top management must ensure that key responsibilities and authorities are clearly defined and that everybody involved understands their roles. Defining roles is a function of planning, ensuring awareness can then be achieved through communication and training.

3.Planning

This clause is an excellent addition to ISO 14001:2015, introducing the concept of risk (and opportunity)

i) Actions to address risks and opportunities
ii) Environmental objectives and planning to achieve them :This clause requires the organization to establish environmental objectives and plans, ensuring that these are clear, measurable, monitored, communicated, updated and resourced.

4.Support:.

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

- Resources
- Competence
- Awareness
- Communication
- Documented Information

5.Operation

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

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

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

6. Performance evaluation

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

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

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

7. **Improvement**

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

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

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

LIFE CYCLE ANALYSIS(LCA)

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

Generally LCA has four stages or components:

1. Goal and scope

2. Inventory

3. Impact assessment

4. Improvement assessment

1.Goal and scope of an LCA

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

This is also the point where you ask what data do you need, what are your data quality requirements, what methods will you use to assess impact, to interpret, and how you will report it.

Another task at this point involves "screening", which is the preliminary execution of the LCA and any adjustment in the plan.

2. Inventory

Every LCA has an inventory. This is the data that you are collecting. The inventory includes things like emissions, energy requirements and material flows for each process involved. These are the flows into and out of the system you are studying. The data of these are adjusted depending on the functional unit you're looking at.

This is known as a Life Cycle Inventory (LCI)

This can be extremely complex because it can involve dozens of separate processes, as well as hundreds of tracked substances. This is where most of the complexity of an LCA is involved

3. Impact Assessment

The Life Cycle Impact Assessment (LCIA) is where the impacts on the environment are calculated. The categories of impacts are chosen and the impacts on them based on the flow of emissions, energy and material from the inventory, are assessed.

There are lots of different types of impacts (depletion of abiotic resources, global warming, ozone layer depletion, acidification, etc) so this stage accounts for all the different impacts that have been chosen.

4. Improvement Assessment

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

What does an LCA actually look at?(LCA PROCESS)

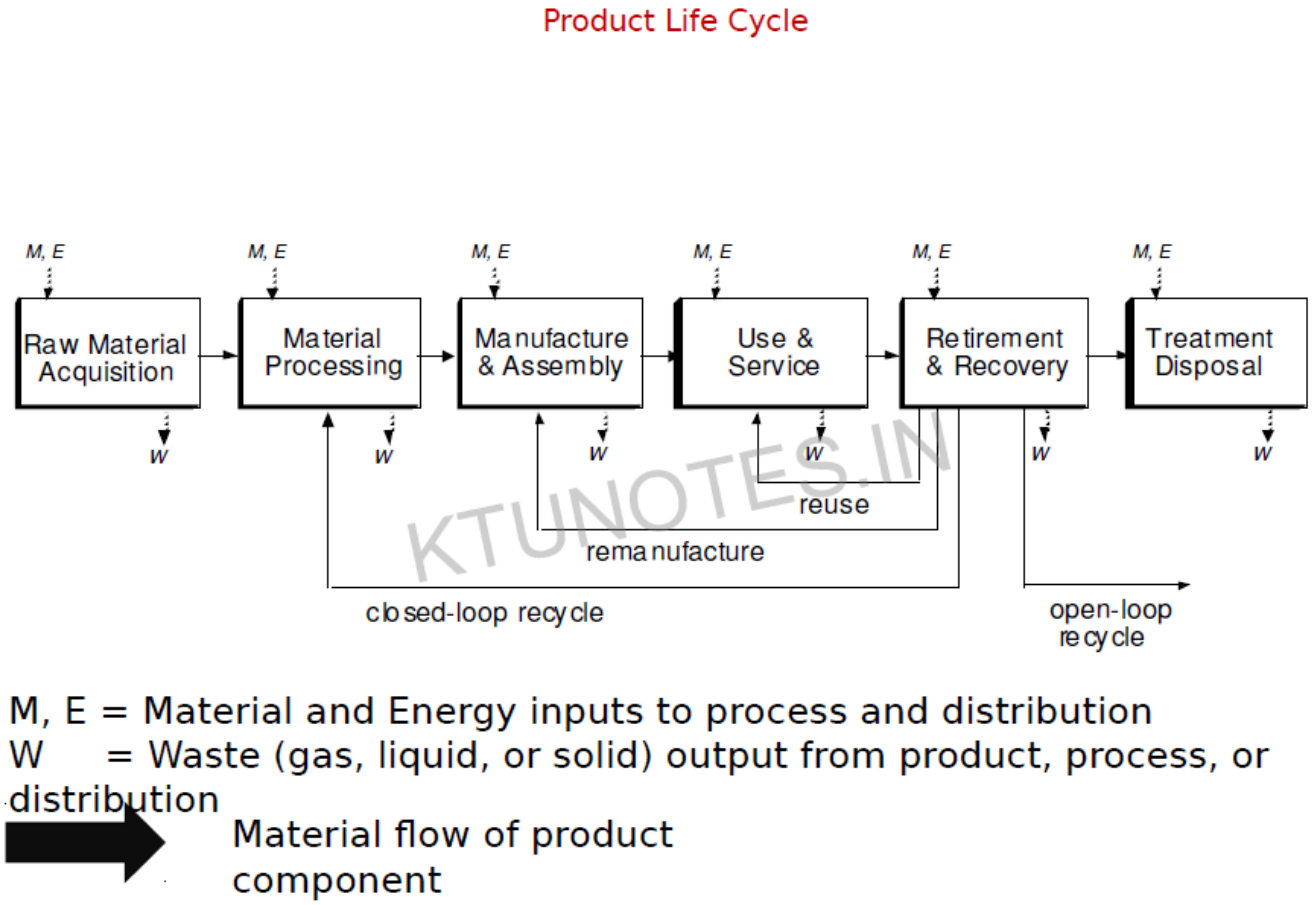
At the life cycle inventory stage is where you're breaking product system and getting data on all the elements. The materials and energy that go into these five processes:

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

These are then looked into their impacts in terms of:

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

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



Limitations of LCAs

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

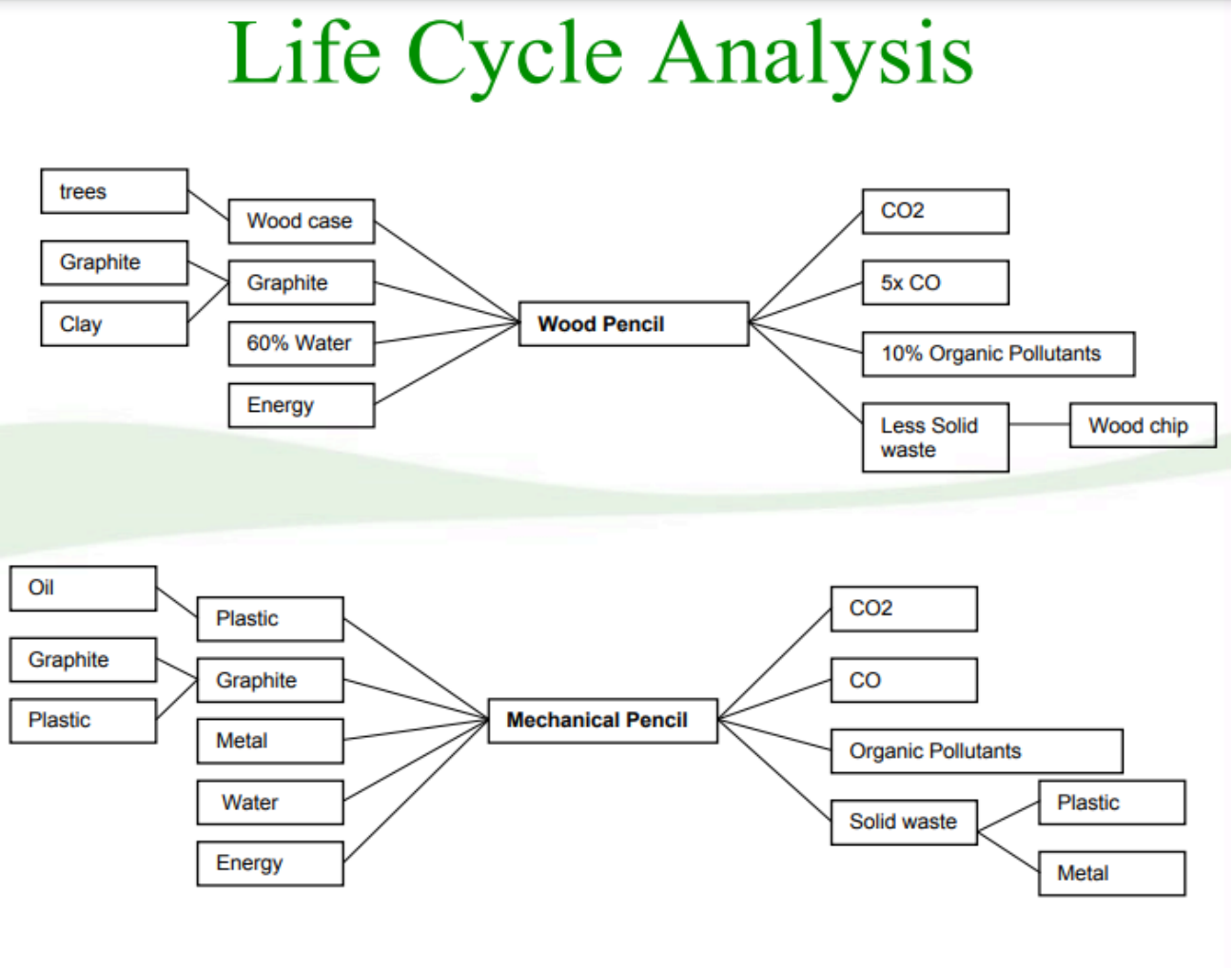
- Studies relate to normal operations, rather than where incidents occur, which must be understood through separate risk assessments
- The quality of the available data: obviously this is what determines the validity of the whole LCA
- Reliability of the environmental scores is dependent on the skill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

EXAMPLE

1. WOODEN PENCIL VS MECHANICAL PENCIL

Renewable Vs Reusable

- Wood is a renewable resource, plastic is not
- Wooden pencils have a limited lifespan
- Plastic pencils can be refilled and reused for years
- Life limited only by misplacement and destruction – Writing instrument manufacturers association
- Over 3 billion wooden • 550 million mechanical
- What's better overall? – Renewable materials or reusable product



Life Cycle Analysis

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

• Plastic pencils

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

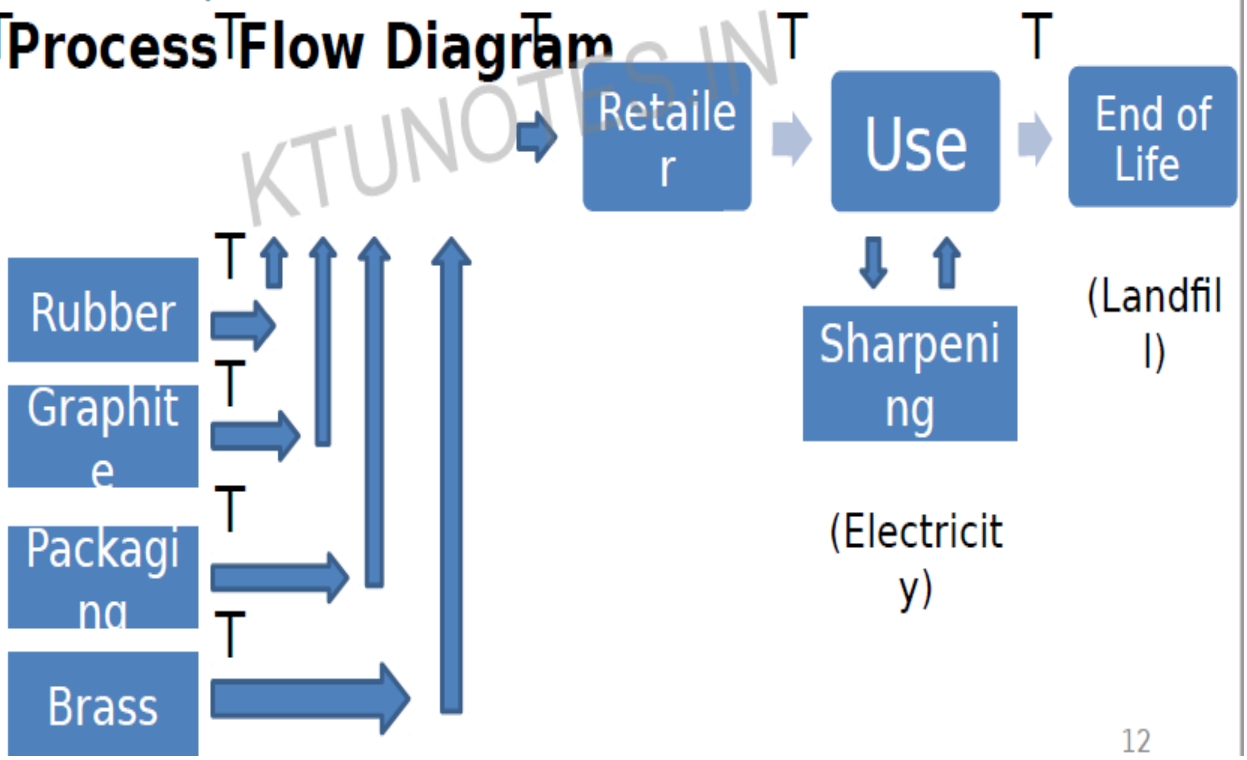
Goal and Scope

Wooden Pencil vs. Mechanical Pencil

Goal = Compare 2 writing utensils for classroom use.

Scope: Wooden Pencil (T = Transportation)

Process Flow Diagram



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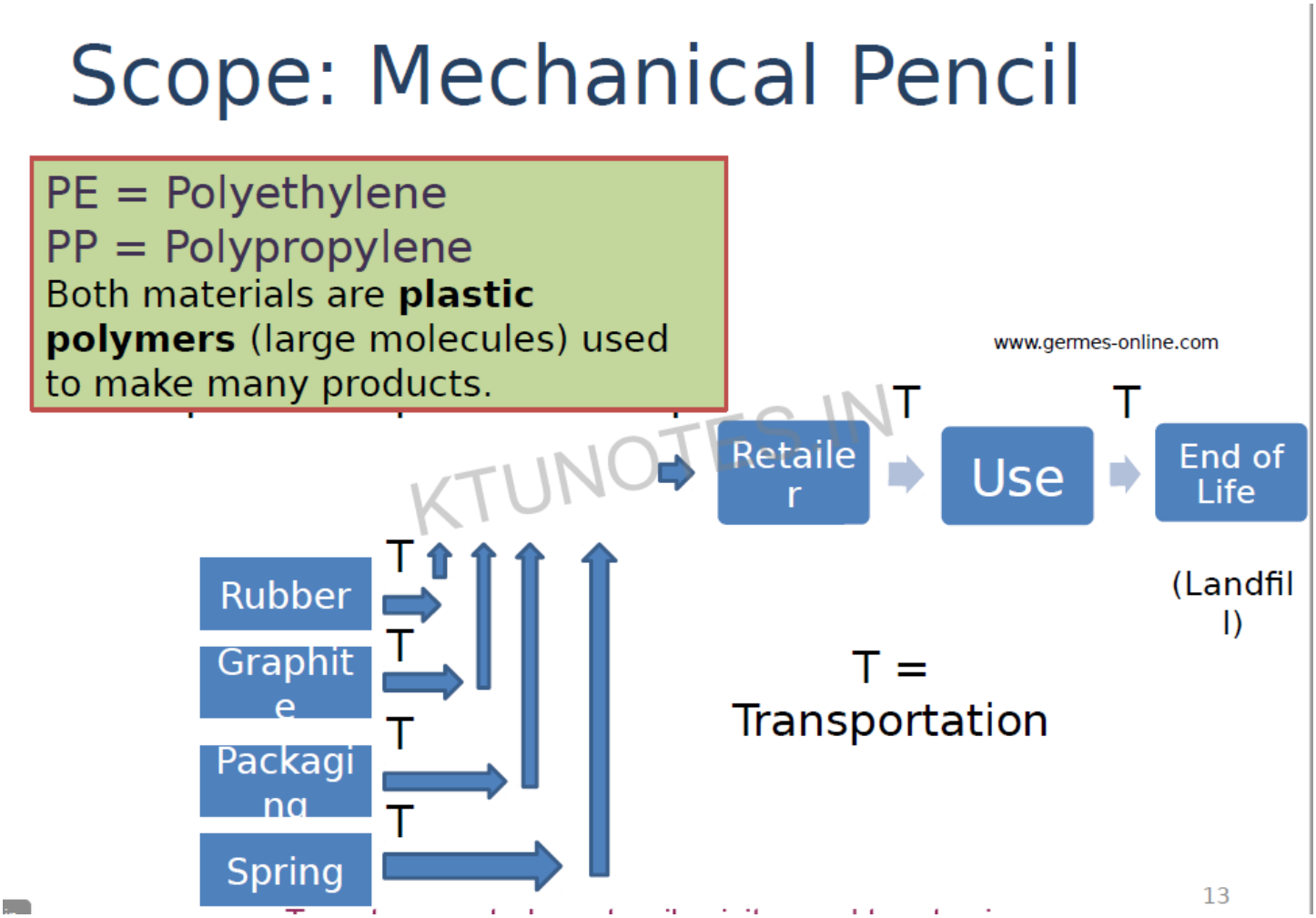


A Better Solution

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

• Reduce wastes – Minimize packaging

Circular economy

A circular economy is an economic system of closed loops in which raw materials, components and products lose their value as little as possible, renewable energy sources are used and systems thinking is at the core

The circular economy refers to an economic model whose objective is to produce goods and services in a sustainable way, by limiting the consumption and waste of resources (raw materials, water, energy) as well as the production of waste.

It is based on three principles:

- Design out waste and pollution
- Keep products and materials in use
- Regenerate natural systems

It is breaking with the model of the linear economy, based on a take-make-consume-throw away pattern, by proposing to transform waste into recycled raw material for product design or other uses.

The circular economy model fits directly into the more general framework of sustainable development. It is part of a global strategy that also uses, among other things, the principles of the green economy, industrial ecology, eco-design or the economy of functionality.

Circular economy principles

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

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

Circular economy Benefits

- **ENVIRONMENTAL**

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

- **ECONOMIC**

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

- **SOCIAL**

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

BIO-MIMICRY

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

– bios, meaning "life" + mimesis, meaning"to imitate"
Biomimicry = to imitate life

BI-O-MIM-IC-RY
Biomimicry as having three components with ¬

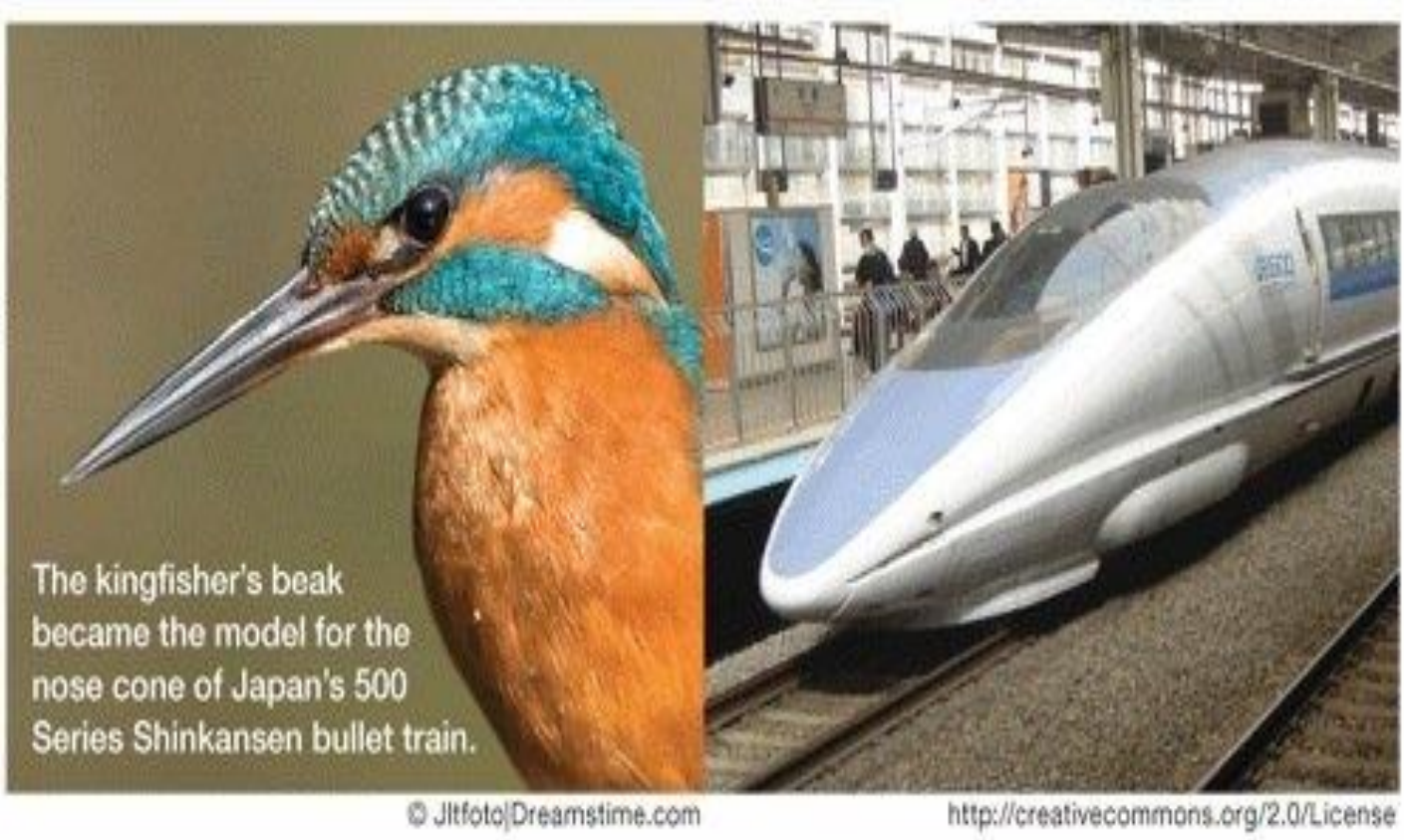
- Nature as model: Biomimicry is a new science that studies Nature's models and then imitates or takes inspiration from these designs and processes to solve human problems. ¬
- Nature as measure: Biomimicry uses an ecological standard to judge the sustainability of our innovations. After billions of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

Biomimicry Principles

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

BIOMIMICRY EXAMPLES

1. *Kingfisher-Inspired Bullet Train*



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

2.*Termite den = Office building*.

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

3.Birds = Jets

Birds have been able to boost the distance they're able to fly by more than 70 percent though the use of the V-shape. Scientists have discovered that when a flocks takes on the familiar V-formation, when one bird flaps its wings it creates a small updraft that lifts the bird behind. As each bird passes, they add their own energy to the stroke helping all the birds maintain flight. By rotating their order through the stack, they spread out the exertion.

A group of researchers at Stanford University thinks passenger airlines could realize fuel savings by taking the same tactic. The team, lead by Professor Ilan Kroo, envisions scenarios where jets from West Coast airports meet up and fly in formation en route to their East Coast destinations. By traveling in a V-shape with planes taking turns in front as birds do, Kroo and his researchers think aircraft could use 15 percent less fuel compared to flying solo.

4.Whale = Turbine

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

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

ENVIRONMENTAL IMPACT ASEESSMENT (EIA)

WHAT IS EIA?

- It is defined as an activity designed to identify and predict the impact of legislative proposals, policies, programmes, projects and operational procedures on the bio- geophysical environment and on the health and well being of human beings and to interpret and communicate information about the impact.
- EIA is intended to identify the impacts (both beneficial and adverse) of proposed public and private development activities. Often, the focus is dominantly environmental (biophysical).
- EIA is mainly used at the level of specific developments and projects such as dams, industrial plants, transport infrastructure (eg airport runways and roads), farm enterprises, and natural resource exploitation (eg sand extraction).
- EIA focuses on problems, conflicts or natural resource constraints that could affect theviability of a project.
- It also examines implications of a project that might harm people, their homeland or their livelihoods, or other nearby developments.
- After predicting the problems, a EIA identifies measures to minimize the problems and outlines ways to improve the project's suitability for its proposed environment.

Main goals of EIA:

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

Environmental impact statement (EIS):

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

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

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

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

Need for EIA

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

In order to predict environmental impacts of any development activity and to provide an opportunity to mitigate against negative impacts and enhance positive impacts, the environmental impact assessment (EIA) procedure was developed in the 1970s. An EIA may be defined as:
A formal process to predict the environmental consequences of human development activities and to plan appropriate measures to eliminate or reduce adverse effects and to augment positive effects.

EIA thus has three main functions:

• to predict problems,
• to find ways to avoid them, and
• to enhance positive effects.

The third function is of particular importance. The EIA provides a unique opportunity to demonstrate ways in which the environment may be improved as part of the development process. The EIA also predicts the conflicts and constraints between the proposed project, programme or sectoral plan and its environment. It provides an opportunity for mitigation measures to be incorporated to minimize problems. It enables monitoring programmes to be established to assess future impacts and provide data on which managers can take informed decisions to avoid environmental damage.
EIA is a management tool for planners and decision makers and complements other project studies on engineering and economics. Environmental assessment is now accepted as an essential part of development planning and management. It should become as familiar and important as economic analysis in project evaluation.
The aim of any EIA should be to facilitate sustainable development. Beneficial environmental effects are maximized while adverse effects are ameliorated or avoided to the greatest extent possible. EIA will help select and design projects, programmes or plans with long term viability and therefore improve cost effectiveness.
It is important that an EIA is not just considered as part of the approval process. Volumes of reports produced for such a purpose, which are neither read nor acted upon, will devalue the process. A key output of the EIA should be an action plan to be followed during implementation and after implementation during the monitoring phase. To enable the action plan to be effective the EIA may also recommend changes to laws and institutional structures.

EIA Process and Procedures

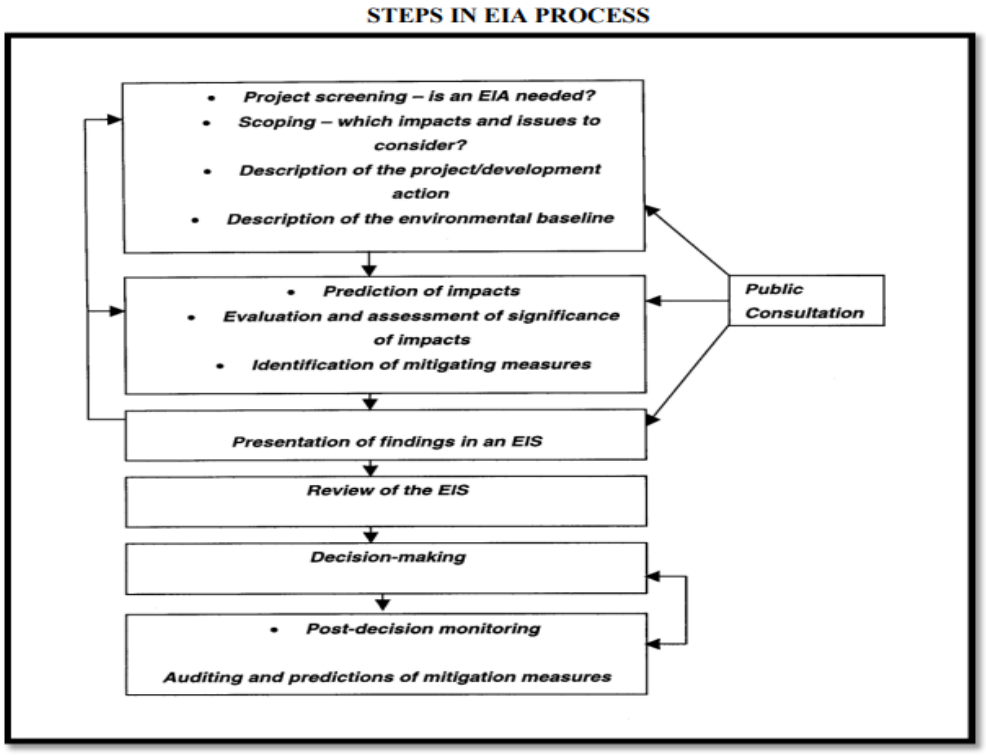
Steps in EIA process

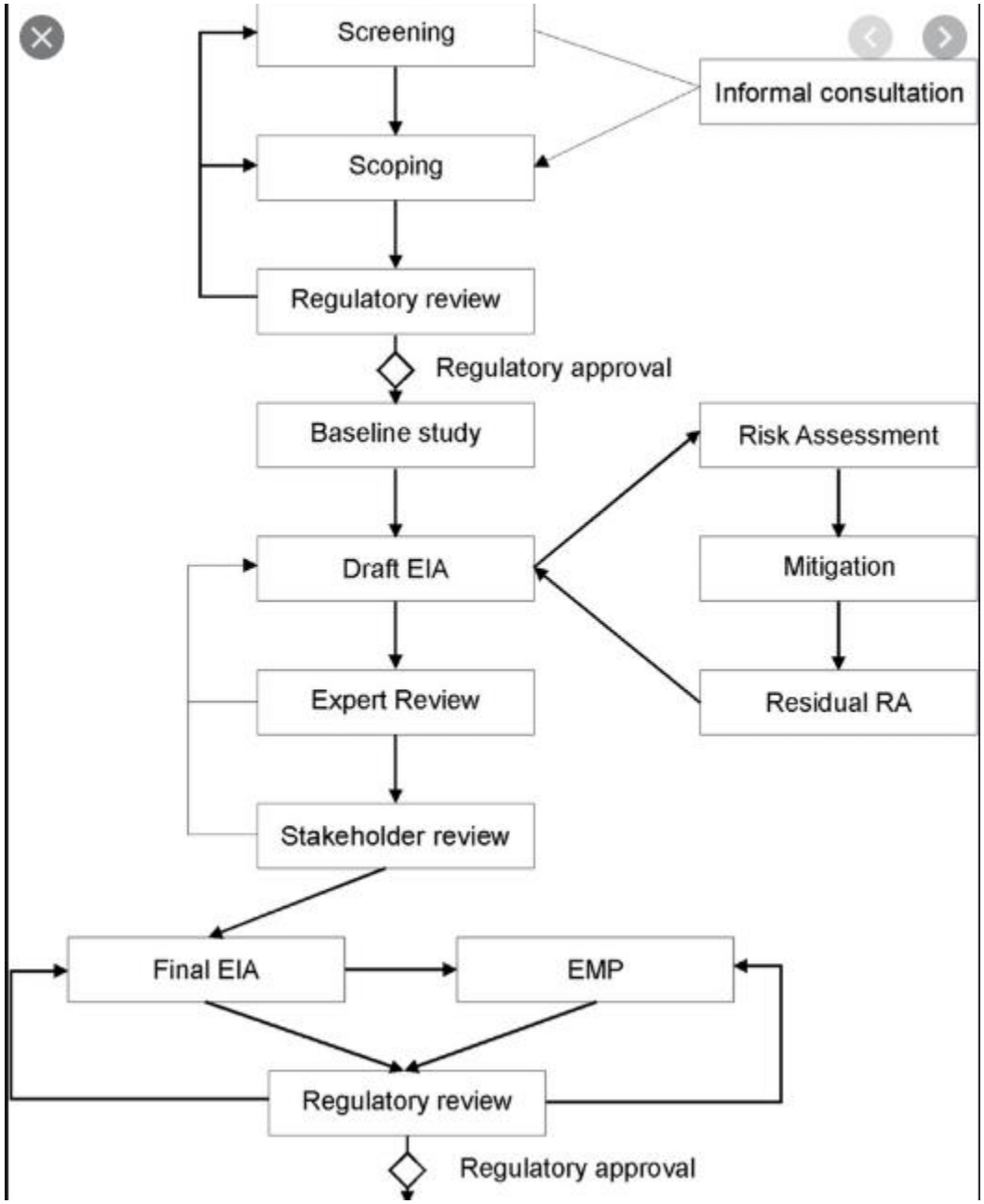
- EIA involves the steps mentioned below. However, EIA process is cyclical with interaction between the various steps.
- **Screening:** The project plan is screened for scale of investment, location and type of development and if the project needs statutory clearance.
- **Scoping:** The project's potential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

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

Steps in Preparation of EIA report

- Collection of baseline data from primary and secondary sources;
- Prediction of impacts based on past experience and mathematical modelling;
- Evolution of impacts versus evaluation of net cost benefit;
- Preparation of environmental management plans to reduce the impacts to the minimum;
- Quantitative estimation of financial cost of monitoring plan and the mitigation measures.





Benefits of EIA

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

INDUSTRIAL ECOLOGY (IE)

Industrial ecology (**IE**) is the study of material and energy flows through industrial systems. The global industrial economy can be modelled as a network of industrial processes that extract resources from the Earth and transform those resources into commodities which can be bought and sold to meet the needs of humanity. Industrial ecology seeks to quantify the material flows and document the industrial processes that make modern society function. Industrial ecologists are often concerned with the impacts that industrial activities have on the environment, with use of the planet's supply of natural resources, and with problems of waste disposal. Industrial ecology is a young but growing multidisciplinary field of research which combines aspects of engineering, economics, sociology, toxicology and the natural sciences.
Industrial ecology is concerned with the shifting of industrial process from linear (open loop) systems, in which resource and capital investments move through the system to become waste, to a closed loop system where wastes can become inputs for new processes.

Much of the research focuses on the following areas

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

INDUSTRIAL SYMBIOSIS

- **Industrial symbiosis** a subset of industrial ecology. It describes how a network of diverse organizations can foster eco-innovation and long-term culture change, create and share mutually profitable transactions—and improve business and technical processes.
- Industrial symbiosis is the process by which wastes or byproducts of an industry or industrial process become the raw materials for another.
- Application of this concept allows materials to be used in a more sustainable way and contributes to the creation of a circular economy. The transition to such an economy is the goal of the Europ ean Commission's Circular Economy Action Plan as it will result in the increase of Europe's e conomic competitiveness, sustainability, resource efficiency and resource security
- Industrial symbiosis creates an interconnected network which strives to mimic the functioning of ecol ogical systems, within which energy and materials cycle continually with no waste products produ ced. This process serves to reduce the environmental footprint of the industries involved. Virgin raw materials are required to a lesser degree, and the need for landfill waste disposal is reduced. It als o allows value to be created from materials that would otherwise be discarded and so the mater ials remain economically valuable for longer than in traditional industrial systems. .
- It also contributes to the reduction of greenhouse gas (GHG) emissions. Industrial symbiosis creates an interconnected network which strives to mimic the functioning of ecological systems, within which energy and materials cycle continually with no waste products produced. This process serves to reduce the environmental footprint of the industries involved. Virgin raw materials are requir ed to a lesser degree, and the need for landfill waste disposal is reduced. It also allows value to

be created from materials that would otherwise be discarded and so the materials remain econo mically valuable for longer than in traditional industrial systems. Examples of industrial symbiosis are wide ranging and include the use of waste heat from one industry to warm greenhouses for foo d production, the recovery of car tyre shavings for use in construction materials, and the use of sl udge from fish farms as agricultural fertiliser. Industrial symbiosis has been applied for waste mana gement and valorisation in Lahti, Finland, and Pécs, Hungary. Kujala Waste Centre, Lahti, Finland

Key Benefits

Some key benefits of industrial symbiosis are outlined below:

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