

MODULE: 3

LIFE CYCLE ANALYSIS

Asst. Prof. Vishnu Sankar
Department of Mechanical Engineering
Rajagiri School of Engineering & Technology (RSET)

Life Cycle Analysis - LCA

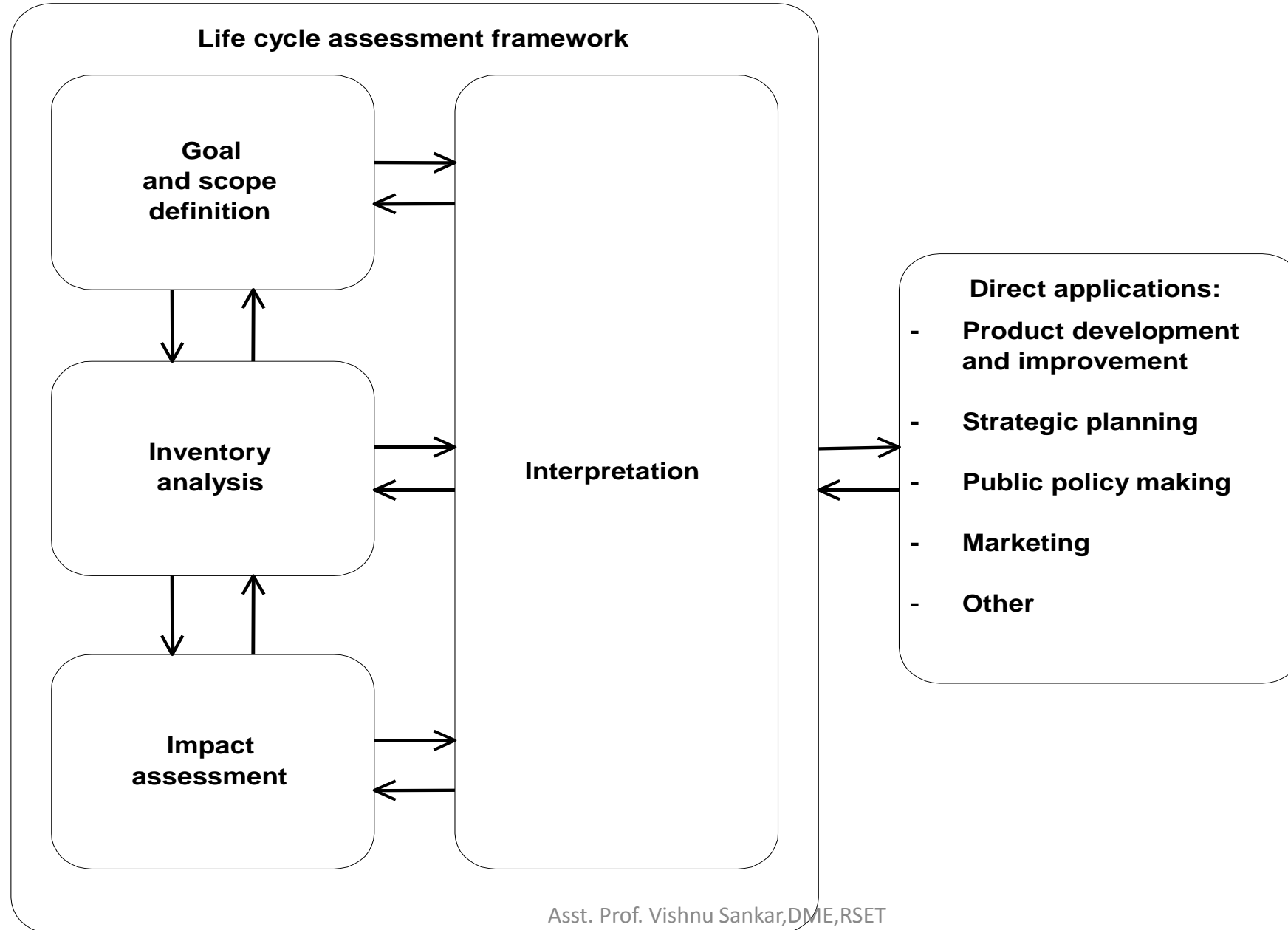
- **Life-cycle assessment (LCA, also known as life-cycle analysis, eco-balance, and cradle-to-grave analysis)** is a technique to assess **environmental impacts** associated with all the stages of a product's life from cradle to grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling). Designers use this process to help critique (detailed analysis and assessment) their products.

Significance of LCA

LCAs can help avoid a narrow outlook on environmental concerns by:

- Compiling an inventory of relevant energy and material inputs and environmental releases;
- Evaluating the potential impacts associated with identified inputs and releases;
- Interpreting the results to help make a more informed decision

Four basic phases of conducting a LCA



4 basic phases/stages of LCA

1. Goal definition (ISO 14040):

- The basis and scope of the evaluation are defined.

2. Inventory Analysis (ISO 14041):

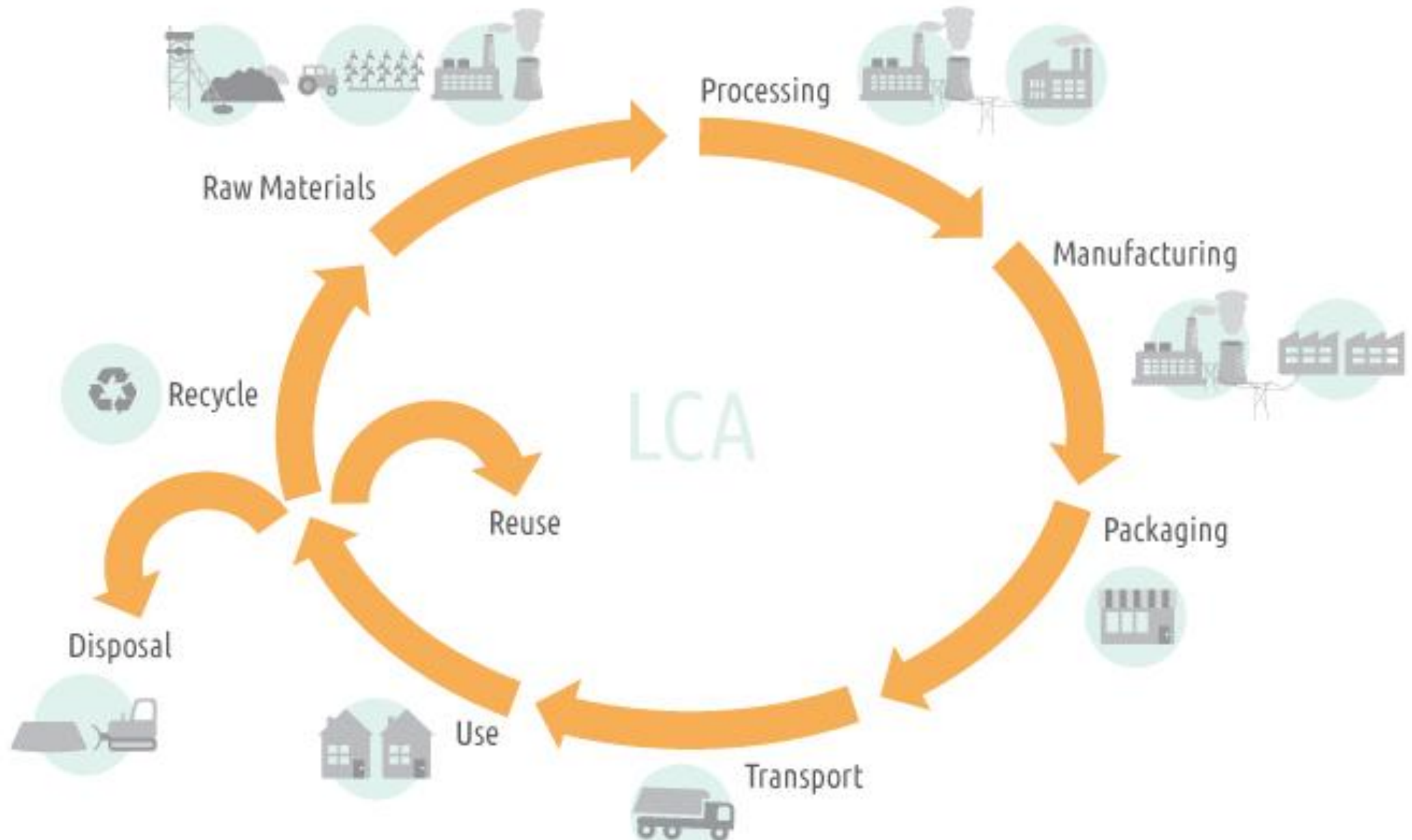
- Create a process tree in which all processes from raw material extraction through waste water treatment are mapped out and connected and mass and energy balances are closed (all emissions and consumptions are accounted for).

3. Impact Assessment (ISO 14042):

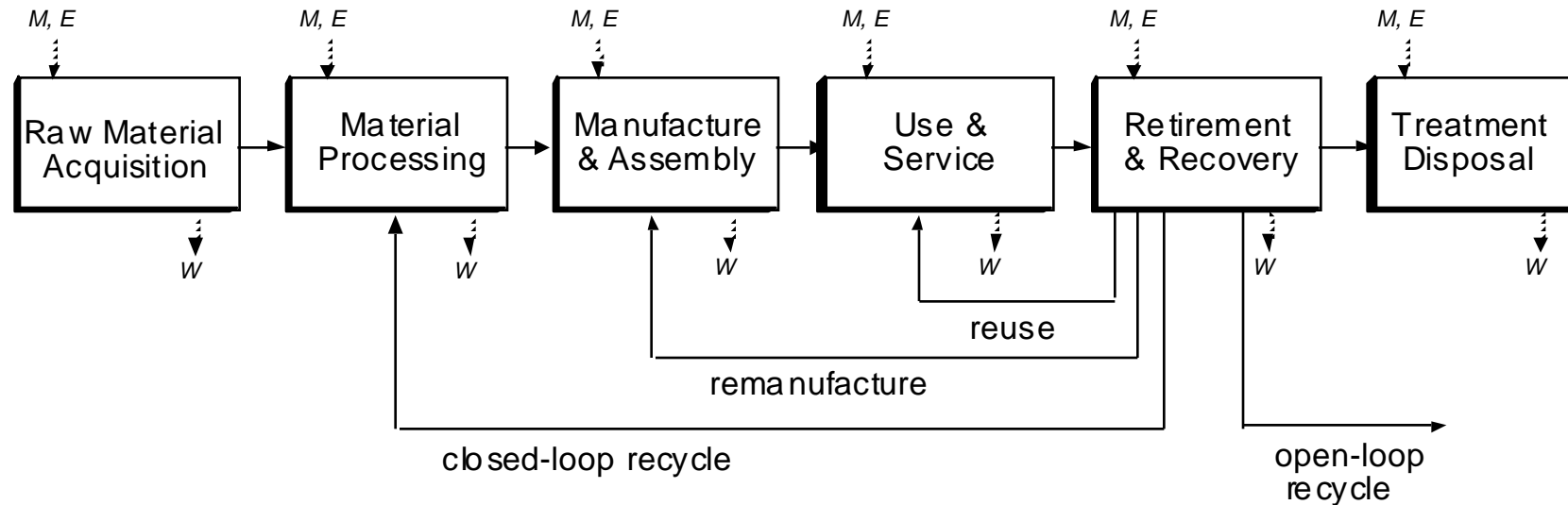
- Emissions and consumptions are translated into environmental effects. The environmental effects are grouped and weighted.

4. Improvement Assessment/Interpretation (ISO 14043):

- Areas for improvement are identified.



Product Life Cycle



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

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



Material flow of product component

What Makes Up LCA

- Goal & Scope Definition

1. What is the purpose of the LCA and who is the audience?

- Inventory Analysis (LCI)

1. What is the function & functional unit?
2. Where are the boundaries?
3. What data do you need?
4. What assumptions are you making?
5. Are there any limitations?

- Impact Assessment (LCIA)

What are the environmental, social, and economic effects?

- Interpretation

Ways to reduce environmental impacts.

What conclusions can you draw from the study?

What recommendations can be made?

Goal and Scope

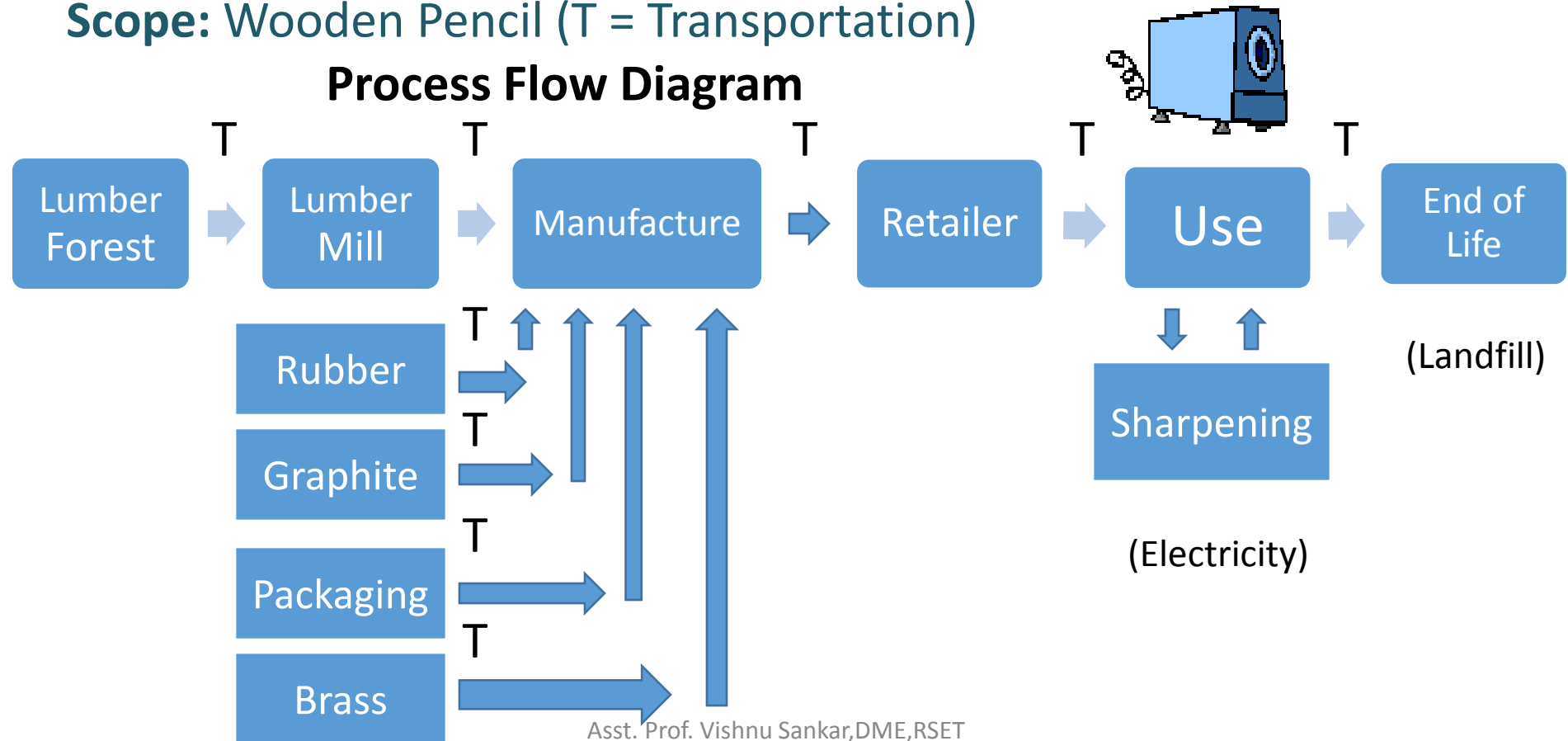
Wooden Pencil vs. Mechanical Pencil



Goal = Compare 2 writing utensils for classroom use.

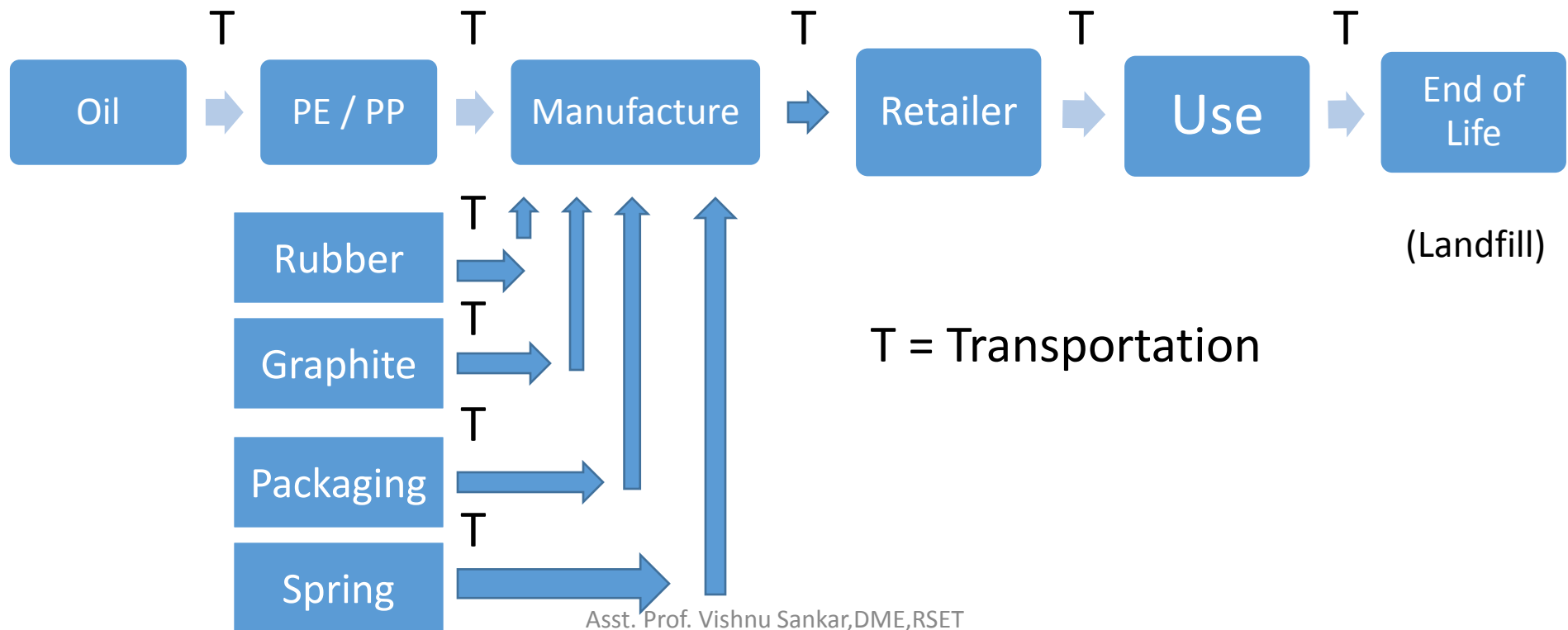
Scope: Wooden Pencil (T = Transportation)

Process Flow Diagram



Scope: Mechanical Pencil

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



Function & Functional Unit

Function

- Service provided by a system
- What it does!

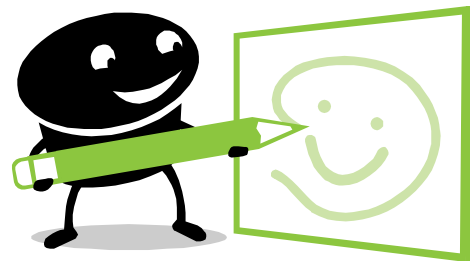
Functional Unit

- Gives the function a number value
- Allows comparison between products
- Reference point

Example

Wooden Pencil vs. Mechanical Pencil

- Function = “Writing”
- Functional Unit = “1 meter of writing”



Items To Consider??

Inputs

What is needed to make the substance!

1. Energy
2. Materials
3. Labor

Outputs

What comes out of the system!

1. Products (electricity, materials, goods, services)
2. Waste
3. Emissions
4. Co-products

Data Collection

Life Cycle Inventory Analysis

1. Time-sensitive = past 5 years
2. Geographical = does it match the location from the goal
3. Technology = best available technology for process
4. Representativeness = reflects population of interest
5. Consistency = matches the procedure
6. Reproducibility = another person could find it

Data Analysis

Environmental Impact Categories

Global Warming Potential

- Gases in the atmosphere that absorb and emit radiation
- Trap heat from the sun
- Water vapor, CO₂, CH₄, ozone, NO₂

Abiotic Depletion

- Consumption of non-living resources

Human Toxicity Potential

- Value that shows harms to humans from chemicals

Land Use

- How much land is needed

Environmental Impact Categories

Continued

Eutrophication

- Increase in chemical nutrients containing nitrogen or phosphorus
- land or water
- overgrowth of plants
- killing organisms at bottom of water

Water Use

Mercury

Acidification

- caused by pollution from fuels & acid rain
- low pH

Smog (Winter or Summer)

Energy Use

Solid Waste

Oil

. AND MANY MORE!!

Where Do We Go From Here?

- What is the purpose of all this data??
- Scientists can make recommendations of choices that are less impactful
- Scientists can analyze a particular impact and focus on a solution

- Industry & Individuals can take a closer look at how they can make a difference

Class Project

Evaluate 2 products using the LCA method and make change!

Advantages of doing LCA

- Evaluation of the environmental consequences associated with a given product
- Comparative quantification of environmental releases from different stage of the life cycle of a product or process.
- Gathering of information, making comparisons between competing products or evaluate modifications to make a more environmentally friendly product.
- Independent third party certification can assess the company's dedication to safer and environmentally friendlier products.

Limitations of LCA

- High cost and large time requirements
- Energy efficiency is the only consideration in LCA
- Lack of comprehensive database needed to gather information
- Works on assumptions
- LCA will not determine which product or process is most cost effective.

Purpose of LCA

- The primary purpose of LCA is to steer decision-makers towards more sustainable products and services, but LCA results are used in a variety of marketing, design and operational contexts:
- LCA results are used to communicate the environmental performance of products, processes or services (i.e. it is a popular tool in marketing).
- LCA is an important tool for the standardized communication of environmental information between customers and suppliers, for example EPDs (**Environmental Product Declarations**).
- Comparative LCA is used to determine the relative environmental performances of competing products or services, e.g. a paper book vs. an iPad.
- Within a specific company, LCA results may be applied in benchmarking against competitors, or to create greater awareness with clients or shareholders around a product's environmental performance.

Purpose of LCA

- LCA results may be used to identify risks and opportunities in the product value chain (e.g. across suppliers, retailers and distributors).
- LCA is used in the improvement of products and manufacturing processes, by identifying the points in the value chain with the greatest scope for improvement (such as energy and resource efficiency improvements, substitutions in suppliers/materials, and reductions in emissions and waste generation).
- Screening LCA is a popular tool for eco-design and in product development, where LCA results are used to identify environmental hot spots and to determine the origins of environmentally unfavorable performance, preferably at the design stage, where amendments can still easily be made.