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# Environmental Manufacturing: An Introduction

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**Unit:** Emerging Technologies

**Problem Area:** Environmental Manufacturing

**Lesson:** Environmental Manufacturing: An Introduction

- **Student Learning Objective.** Instruction in this lesson should result in students achieving the following objective:

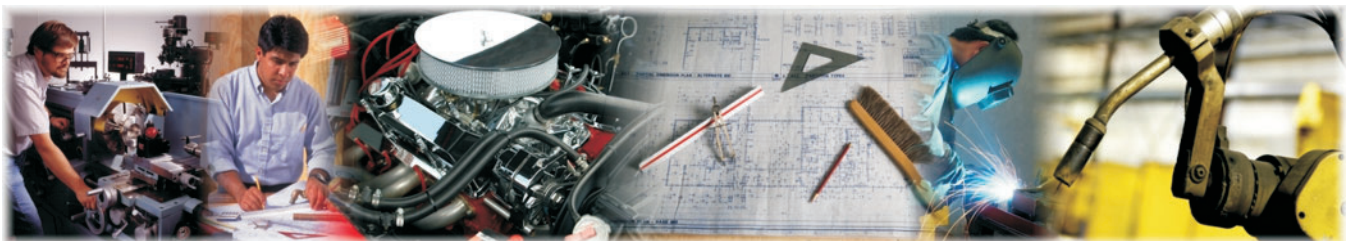
**Describe environmental manufacturing.**

- **Resources.** The following resources may be useful in teaching this lesson:

Madu, Christian N. *Handbook of Environmentally Conscious Manufacturing*. Kluwer Academic, 2001.

Myer, Kutz. *Environmentally Conscious Manufacturing*. Wiley, 2007.

National Research Council of National Academies. *Retooling Manufacturing: Bridging Design, Materials, and Production*. The National Academies Press, 2004.



## ■ **Equipment, Tools, Supplies, and Facilities**

- ✓ Overhead or PowerPoint projector
- ✓ Visuals from accompanying masters
- ✓ Copies of sample test, lab sheet, and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials

## ■ **Key Terms.** The following terms are presented in this lesson (shown in bold italics):

- ▶ energy expenditure
- ▶ environmental manufacturing
- ▶ International Organization for Standardization (ISO)
- ▶ IO relations
- ▶ transporters

## ■ **Interest Approach.** Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations.

*Let the students know how important environmental manufacturing is becoming. This will continue to increase as national and international organizations set up standards and governments set regulations. It is becoming more consumer-driven; so this complete strategy of manufacturing will become standard across all industries.*

# CONTENT SUMMARY AND TEACHING STRATEGIES

**Objective 1:** Describe environmental manufacturing.

**Anticipated Problem:** What is environmental manufacturing?

- I. Environmental manufacturing
  - A. ***Environmental manufacturing*** is a manufacturing process that takes into consideration its impact on the natural environment, energy use, materials, and sustainability. In general, it is concerned with creating optimized energy efficiency throughout the production process. It has a minimal impact on the environment.
    1. As a basic concept for products, this includes creating a connection between design and manufacturing that address issues of material, energy usage in production and delivery, waste products, and maintenance.

2. Environmental manufacturing includes sustainable product design, development, and manufacturing.
- B. Sustainable and lifecycle manufacturing is becoming a critical element of environmental manufacturing.
1. This aspect addresses the machines and processes of manufacturing in terms of construction, material, and lifecycle. It can include the entire process and organization of machining within a facility.
  2. Many smart grid fixtures are becoming available for use in manufacturing facilities. These fixtures can automatically control the complete range of a building's energy use of products or systems.
  3. Sustainable manufacturing addresses how products are tooled with various jigs or fixtures. Criteria can be set up to determine how long they last, how much energy they require, and how much waste they produce through their design.
  4. The recycling or reusing of heat can be a significant source of energy in many manufacturing plants. This reuse of energy can benefit a range of local buildings or be used to generate electricity.
  5. Recycling or reusing material waste is a critical issue in environmental manufacturing. The manufacturing process can be designed to create minimal waste; discarded waste can be recycled within the facility or sent to other manufacturers to use.
- C. The standards for performance and regulations in terms of environmental manufacturing are still being developed. These standards are necessary for internal and external assessment of manufacturing processes and facilities.
1. Environmental manufacturing is influenced by government regulations and rating systems. Given the impact of large manufacturing internationally, standards are required with an exact set of criteria that the world can use. One such organization is the **International Organization for Standardization (ISO)**, which is a group of representatives from various standard organizations around the world that develops and administers worldwide industrial and commercial standards that can relate to the procedures and performance of product design and development.
  2. These standards can be used by local governments to create laws or criteria for evaluation of procedures with an environmental index or reference. They are being used to establish international environmental regulations that steer business plans and production.
  3. The standards for environmental manufacturing are used for internal monitoring. This allows companies to specifically relay to consumers and shareholders how they are environmental manufacturers.
  4. Many performance standards, internally driven or by government codes, require specific environmental business plans. Traditional business plans usually had a limited set of criteria, such as maximum profit with minimum cost. However, environmental manufacturing takes into consideration layers and layers of criteria to determine business goals.

- D. Manufacturing that considers the environment also requires alternative product and production plans.
1. The use of green technology within product design and production addresses environmental issues on many levels. All of the technology required for manufacturing and production should be considered in terms of efficiency in energy, material use, and waste.
  2. The actual energy required or used by the final product is an important consideration.
  3. Product maintenance needs to be considered in long-term environmental production plans. This includes the maintenance of the final product being manufactured as well as the equipment being used in manufacturing.
  4. The product and production plans need to be organized around how manufacturing can utilize the most efficient use of energy and material.
  5. This requires creating a model that can quantify input-output (IO) relations. **IO relations** are relationships that examine every stage of the manufacturing process relative to the input (e.g., materials, supplies, fuels, and maintenance) and the output (e.g., final product, recoverable and non-recoverable byproducts, heat, and waste emissions).
- E. Environmentally benign manufacturing is an approach that minimizes the impact specific manufacturing steps have on the environment. If necessary, some steps may need to be replaced with steps that have less hazardous results. These steps include machining processes (e.g., metal casting, metal forming, metal joining, and plastics injection molding). They potentially could include all aspects of manufacturing.
- F. In environmental manufacturing, the entire resource and supply chain needs to be taken into consideration.
1. The energy required to collect the raw resources and to ship them and the energy to deliver all necessary supplies should be considered. The energy required to distribute manufactured products to consumers is also a consideration.
  2. In the manufacturing industry, various tier one and tier two suppliers can exist. The main manufacturer must qualify its environmental performance. Its role in the supply chain must instill responsible means.
  3. **Transporters** are people or businesses that move supplies and products from one point to the next in the supply chain. They are closely looked at for **energy expenditure** per unit of delivery, which is the amount of total energy used for each unit delivered per transportation mode. This requires analyzing energy use and cost between highway, rail, air, water, and pipeline.
  4. The material resources used in the manufacturing process, whether natural or artificial, are chosen relative to their effects on the environment. Some of the standards used assess the material's sustainability, embodied energy, and any physical effects to the environment from harvesting.

- G. A general category used in environmental manufacturing is a rating system of the overall environmental impact created from a specific manufacturing process.
1. The amount of emissions released into the air compared to the number of products made can provide data for analyzing some of the potential hazards to the environment.
  2. The total carbon data can be collected in terms of the complete energy and material used, lost, or replaced during the life of the product.
  3. Many manufacturing facilities require large amounts of water. They can pollute water supplies. Water use and pollution can be directly monitored and analyzed to insure minimal impact on the environment.
  4. Waste products can have layers of effect on the environment over time. Some waste products are burnt, and some are sent to landfills. Both have negative consequences. Some of these products are non-biodegradable, and some release toxic chemicals into the earth. Environmental manufacturing takes these issues into consideration while trying to have the least negative impact on the natural world.

**Teaching Strategy:** Have the students do individual reports on a company that has, in recent years, turned its business into one that uses environmental manufacturing practices.

- **Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the ends of chapters in the textbook may also be used.
- **Application.** Use the included visual masters and lab sheet to apply the information presented in the lesson.
- **Evaluation.** Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

## ■ **Answers to Sample Test:**

### **Part One: Completion**

1. Smart grid fixtures
2. supplies and products
3. environmental manufacturing
4. Product maintenance
5. government regulations
6. energy expenditure

## Part Two: True/False

1. T
2. F
3. T
4. T
5. F
6. T

## Part Three: Short Answer

Answers will vary. See “Content Summary”: I.F.1 through 5.



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## ► Part One: Completion

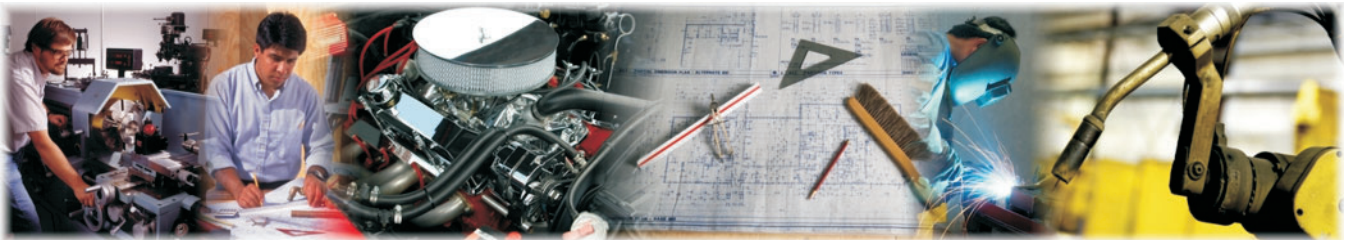
**Instructions:** Provide the word or words to complete the following statements.

1. \_\_\_\_\_ can automatically control the complete range of a building's energy using products or systems.
2. Transporters are people or businesses that move \_\_\_\_\_ from one point to the next in the supply chain.
3. Recycling or reusing material waste is a critical issue in \_\_\_\_\_.
4. \_\_\_\_\_ needs to be considered in long-term environmental production plans.
5. Environmental manufacturing is influenced by \_\_\_\_\_ and rating systems.
6. Transporters are closely looked at for \_\_\_\_\_ per unit of delivery.

## ► Part Two: True/False

**Instructions:** Write *T* for true or *F* for false.

- \_\_\_\_\_ 1. Environmental manufacturing includes sustainable product design, development, and manufacturing.
- \_\_\_\_\_ 2. Energy expenditure per unit of delivery requires analyzing energy cost only between highway and rail.
- \_\_\_\_\_ 3. Waste products can have layers of effect on the environment over time.



- \_\_\_\_\_ 4. In environmental manufacturing, the entire resource and supply chain needs to be taken into consideration.
- \_\_\_\_\_ 5. Sustainable and lifecycle manufacturing is not a critical element of environmental manufacturing.
- \_\_\_\_\_ 6. The use of green technology within product design and production addresses environmental issues on many levels.

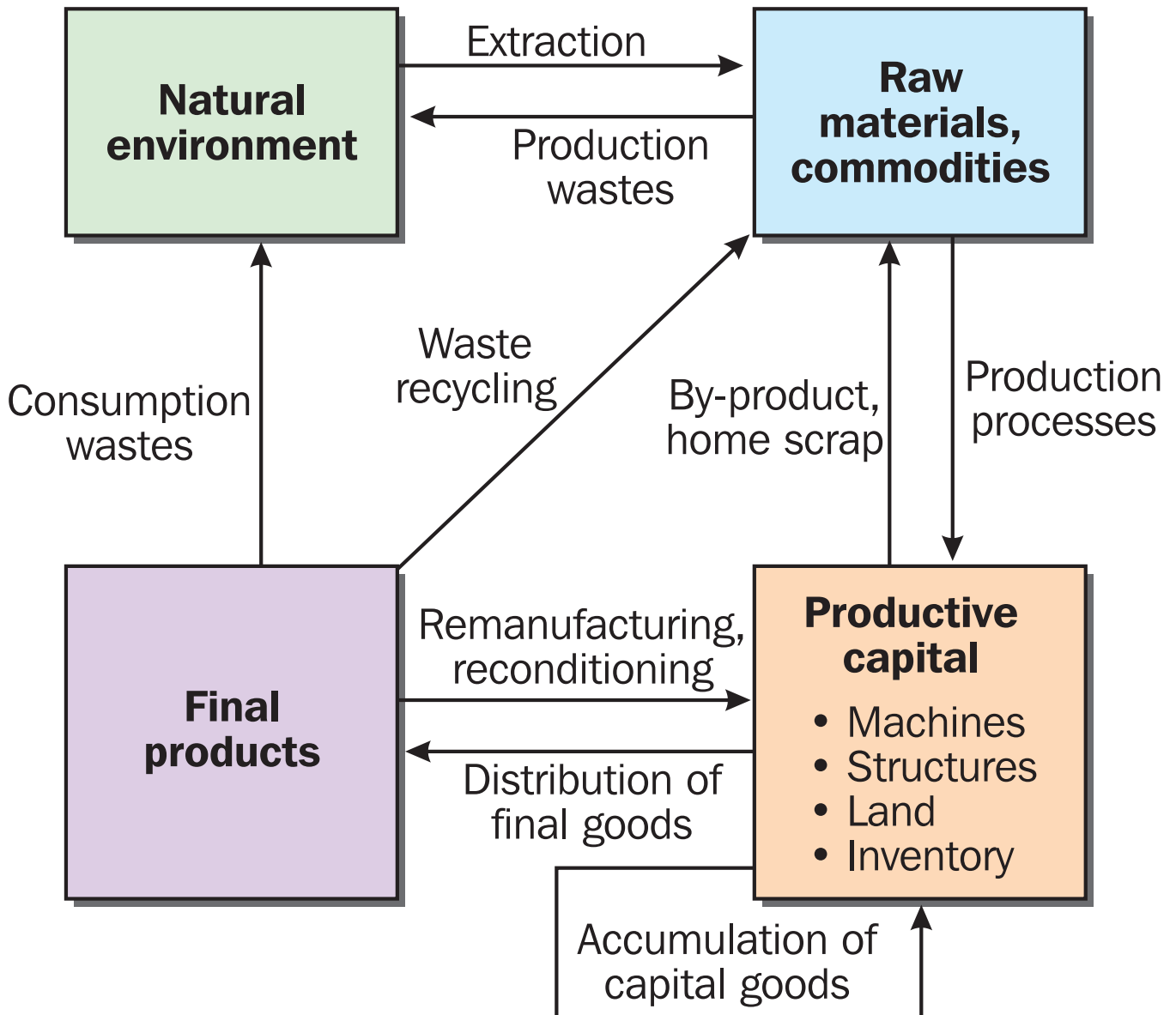
► **Part Three: Short Answer**

**Instructions:** Answer the following.

In environmental manufacturing, how is the entire resource and supply chain taken into consideration?

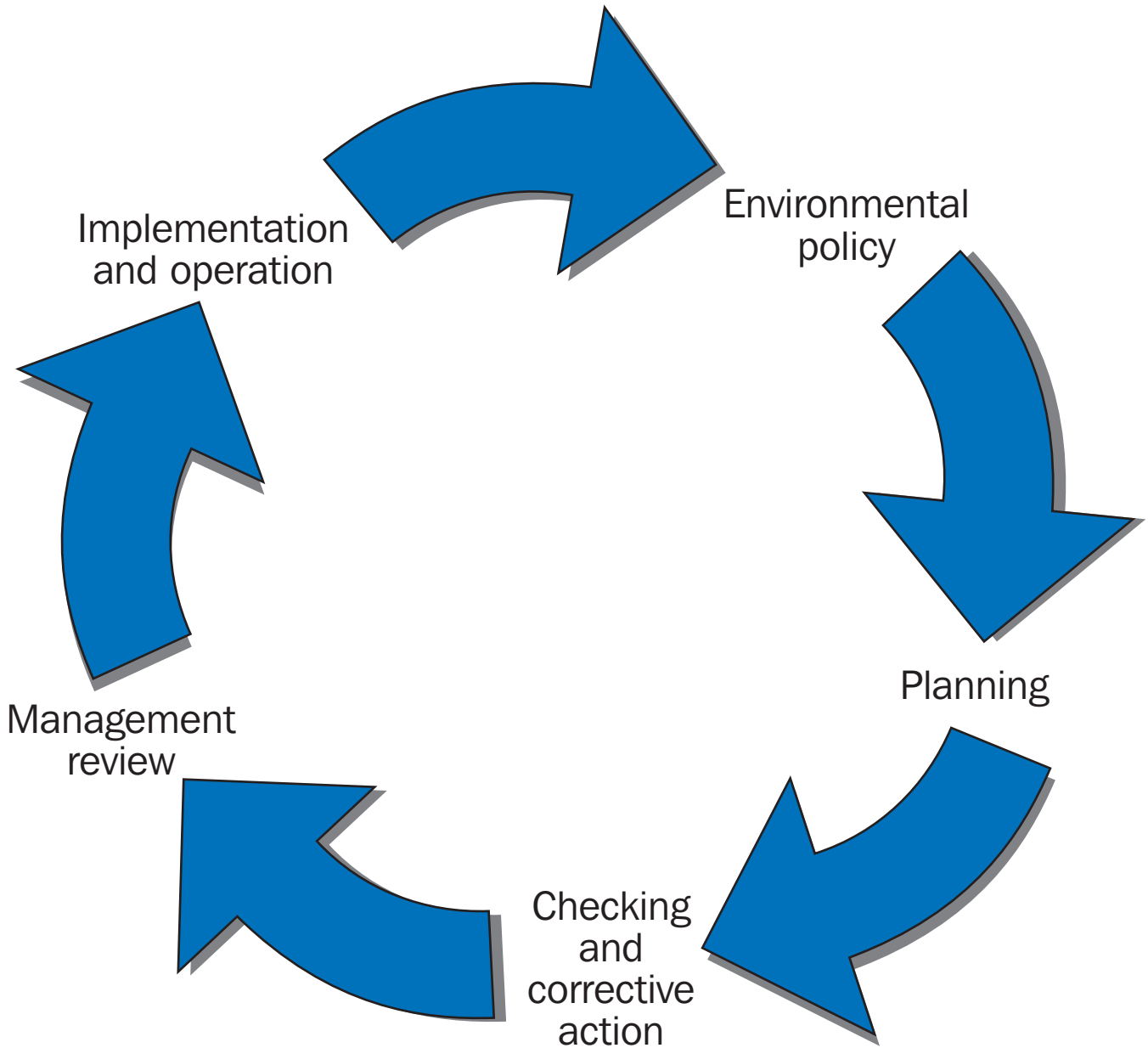


# DIAGRAM OF INDUSTRIAL MATERIAL CYCLE

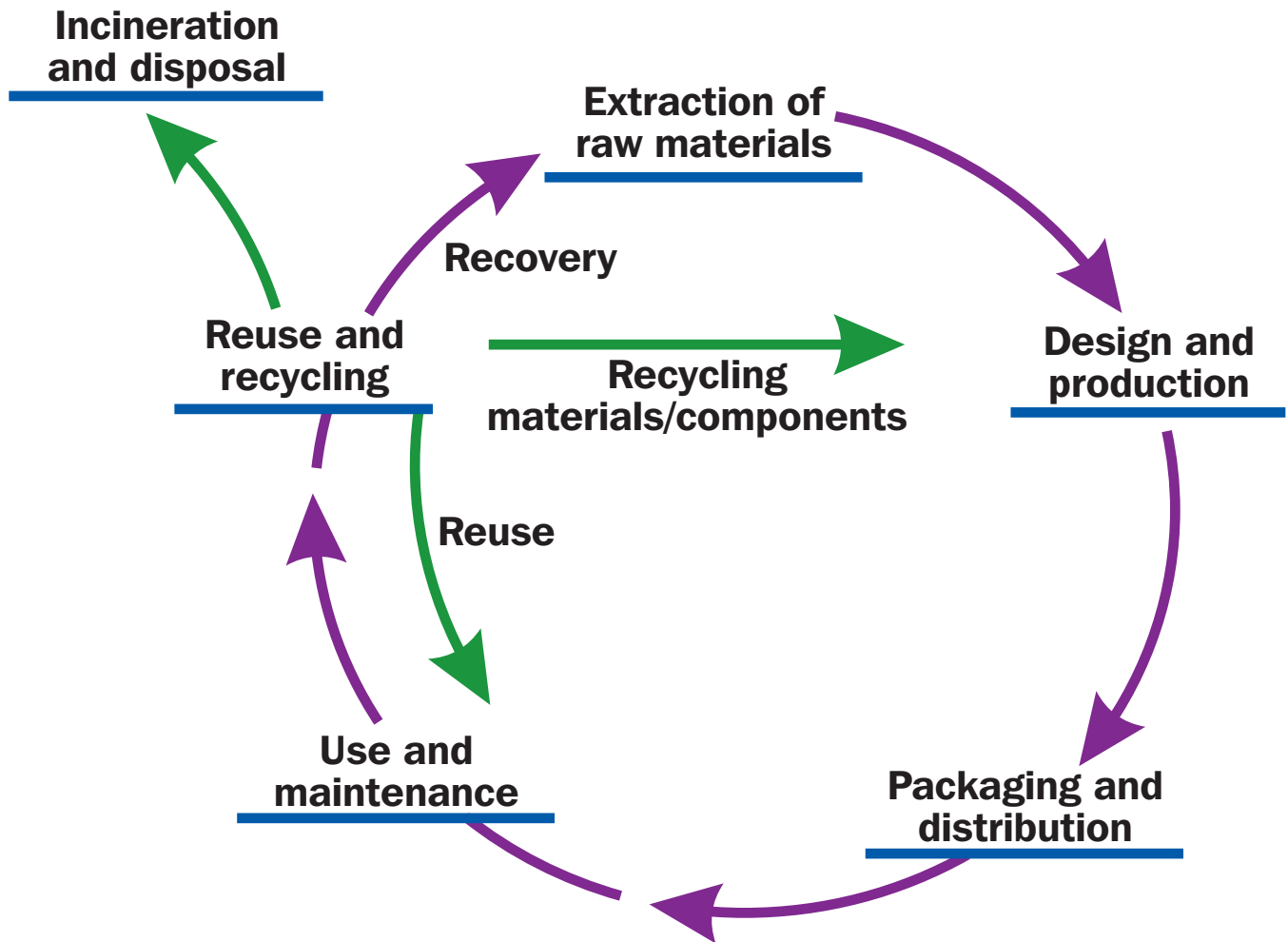


# ENVIRONMENTAL MANUFACTURING PRODUCT PLANNING DIAGRAM

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# ENVIRONMENTAL RECYCLING PLAN DIAGRAM



# Environmental Manufacturing

## Purpose

The purpose of this activity is to develop an understanding and knowledge of environmental manufacturing.

## Objectives

1. Describe elements of environmental manufacturing.
2. Analyze the importance of environmental manufacturing.

## Materials

- ◆ lab sheet
- ◆ paper
- ◆ writing utensil

## Procedure

1. List the different categories or aspects of manufacturing affected by environmental design. In addition, describe them.
2. List four of the six general categories of environmental manufacturing discussed.
3. Briefly describe each one of these categories.
4. Explain why they are important aspects for environmental manufacturing.

