

# Introduction to Sustainable Manufacturing

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Manufacturing and Services  
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# Why is manufacturing becoming more environmentally conscious?

Ask yourself the following questions:



Is your company trying to cope with increasing environmental regulation?



Are your customers demanding better environmental performance and data?



Do you want to lower your energy and materials costs?



Are you interested in producing and marketing greener products?

Sustainable manufacturing has both benefits and costs, but it can help make your company more competitive. Let's discuss sustainability in manufacturing in more detail.



# What is Sustainability?

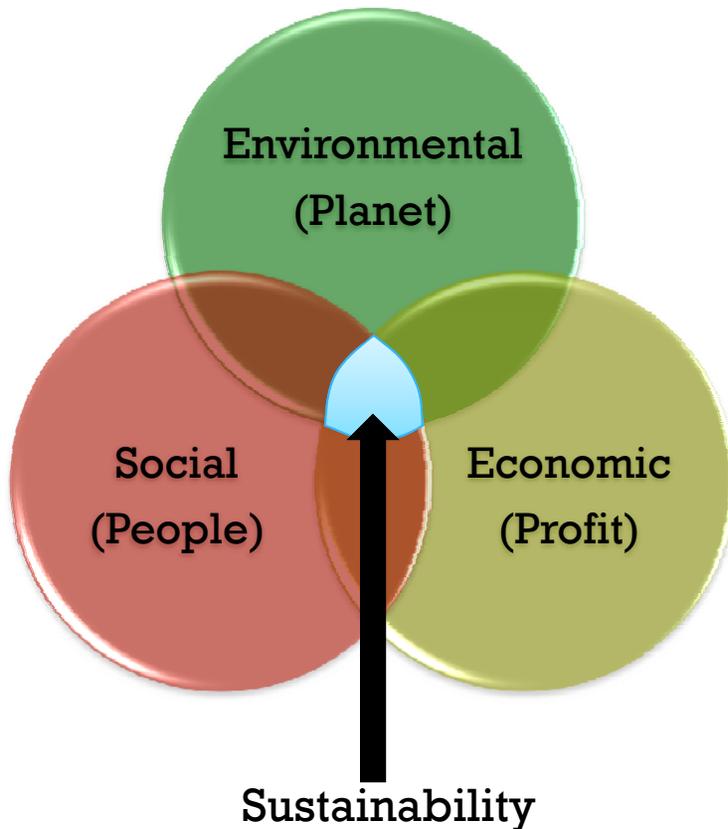
A common definition of sustainable development is that of the UN Brundtland Commission:

*“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”<sup>1</sup>*

You will also hear about the **Triple Bottom Line**<sup>2</sup>

This concept suggests that, in addition to its **economic** performance, a company must also account for and focus on its **environmental** and **social** performance to be truly sustainable.

Another common way of saying this is “**people, planet, profit**”<sup>2</sup> Sustainability is the intersection of these three concepts.



<sup>1</sup> Brundtland Commission of the United Nations

<sup>2</sup> John Elkington, *Cannibals with Forks: the Triple Bottom Line of 21<sup>st</sup> Century business*



# The Environment and Manufacturing: Important Concepts

The intersection of the environment and manufacturing is discussed in many different ways, often using terms that are not always clearly defined.

These ideas can be confusing, and it may be difficult to tell how they apply to your business.

Here we will learn how to distinguish among several common concepts.

Click on each of the boxes to learn more:

**Sustainable  
Manufacturing**

**Clean  
Technologies**

**Green Products**



# Sustainable Manufacturing

- The Green Suppliers Network (DOC/EPA) defines clean manufacturing as *“a systematic approach to eliminating waste by optimizing use and selection of resources and technologies, thereby lessening the impact on the environment.”*<sup>1</sup>
- Sustainable manufacturing focuses on both **how** the product is made as well as the **product’s attributes**. This includes the inputs, the manufacturing processes, and the product’s design.
- Sustainable manufacturing includes things such as making products using less energy and materials, producing less waste, and using fewer hazardous materials as well as products that have greener attributes such as recyclability or lower energy use.
- Sustainable manufacturing practices can range from very simple process improvements to large investments in new technologies and product redesign.



## Terms You’ll Hear

- **Green Manufacturing**
- **Cleaner Production**
- **Industrial Ecology**
- **Closed Loop Production**
- **Sustainable Production**
- **Eco-efficiency**
- **Green Productivity**
- **Clean Manufacturing**

<sup>1</sup> Green Suppliers Network training



# Clean Technologies

- Clean or Environmental Technologies are technologies associated with things like environmental protection, assessment, compliance with environmental regulations, pollution control and prevention, waste management, remediation of contaminated property, design and operation of environmental infrastructure, and the provision and delivery of environmental resources.<sup>1</sup>
- Renewable energy technologies are also considered to be clean technologies.
- Examples of clean technologies include technologies for *wastewater treatment, recycling, solid waste management, solar panels and wind turbines*.
- Many clean technologies can be used to green the manufacturing process and are therefore important to sustainable manufacturing.



Terms You'll Hear

- **Environmental Technologies** (envirotech)
- **Green Technologies** (greentech)
- **Clean Technologies** (cleantech)

<sup>1</sup> U.S. Department of Commerce Office of Energy and Environmental Industries



# Green Products

- Making “green products” can be seen as part of sustainable manufacturing, and we will discuss it in more detail later in the module.
- A green product can be *any product that is designed to reduce its environmental impact*. A key concept is that environmental concerns and impacts are taken into account **from the beginning of the product design process**. This is important because most of a product’s environmental impact is determined in the design phase.
- The product may be made of recycled materials, designed so that it can be easily recycled, made without hazardous materials, or produced with less packaging.<sup>1</sup>
- There are no accepted standards for what constitutes a “green product,” although there are rules from the Federal Trade Commission about making environmental marketing claims.
- There are also many eco-labeling programs that are used to identify and market green products, some of which are discussed in this module.



## Terms You'll Hear

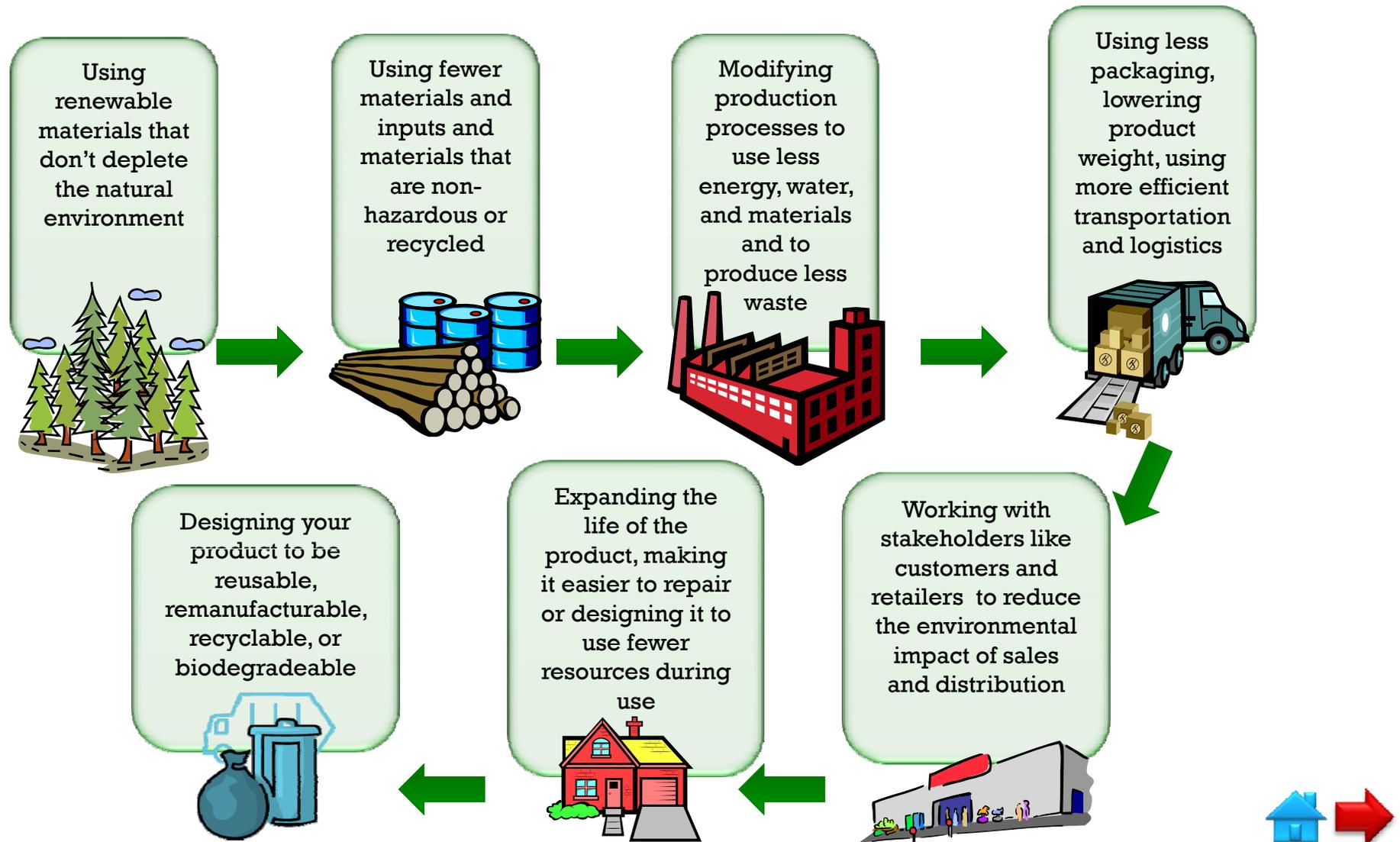
- Life Cycle Design
- Life Cycle Assessment (LCA)
- Cradle-to-Cradle
- Cradle-to-Grave
- Environmentally-Sustainable Design
- Design for the Environment (Dfe)
- Sustainable Product Design
- Design for Eco-efficiency
- Eco-design
- Design for Sustainability (D4S)

<sup>1</sup>United Nations Environment Programme and Delft University of Technology “Design for Sustainability A Step-by-Step Approach.”



# So What does Sustainable Manufacturing Mean in Practice?

Click on the images for some examples of sustainable manufacturing along the life cycle.



# Sustainability is a Journey, not a Destination



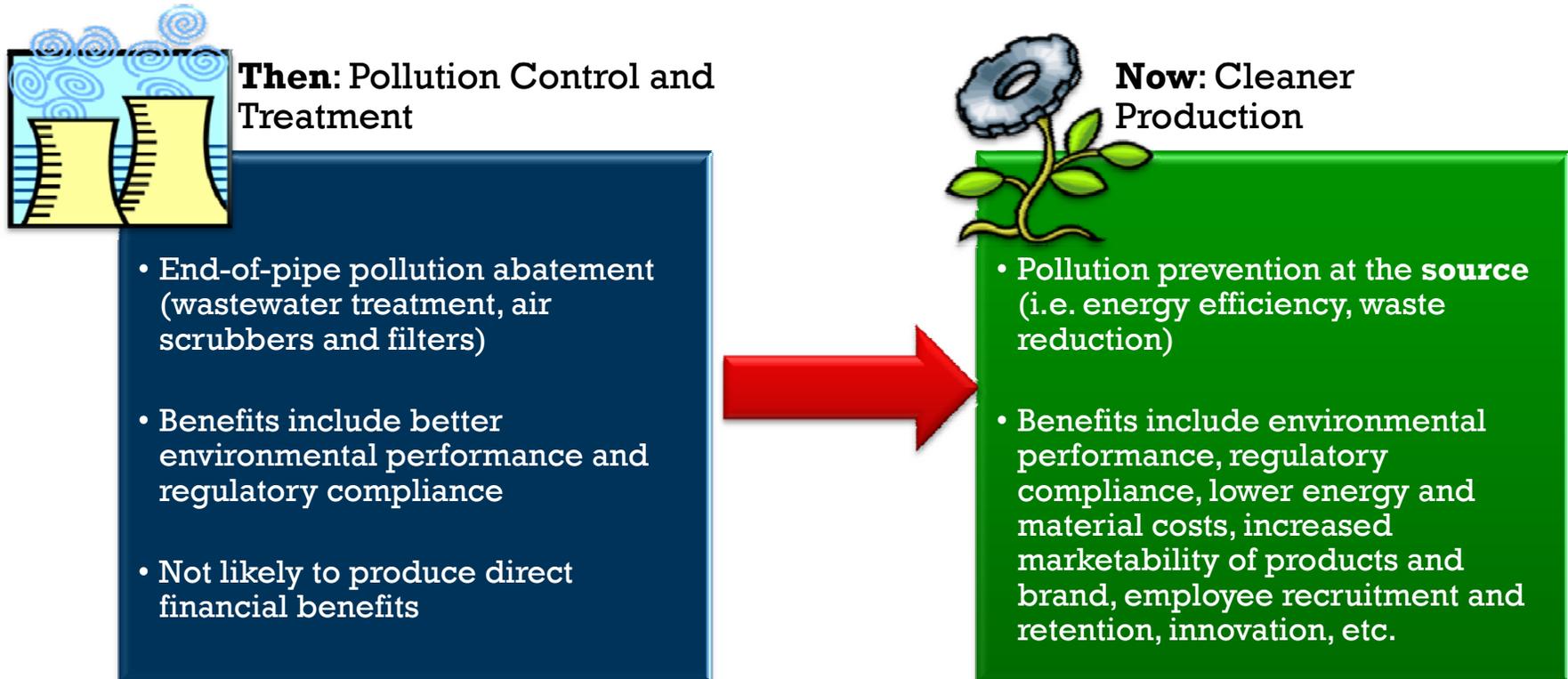
- Remember there is no such thing as a company with no environmental impact. **There is no sustainability “destination”.**
  - Your goal should be **continuous improvement** – making constant advances in your company’s overall sustainability performance.



# Evolution of Sustainable Manufacturing

For many years, the main environmental focus with regards to manufacturing was **pollution abatement**—preventing the pollution that has been created from getting into the environment.

The attention has shifted to cleaner production and **pollution prevention**. With cleaner production, there are many opportunities for cost savings and other financial benefits for companies.<sup>1</sup>



<sup>1</sup> “Government Strategies and Policies for Cleaner Production.” United Nations Environmental Programme and “Eco-Innovation in Industry: Enabling Green Growth” OECD

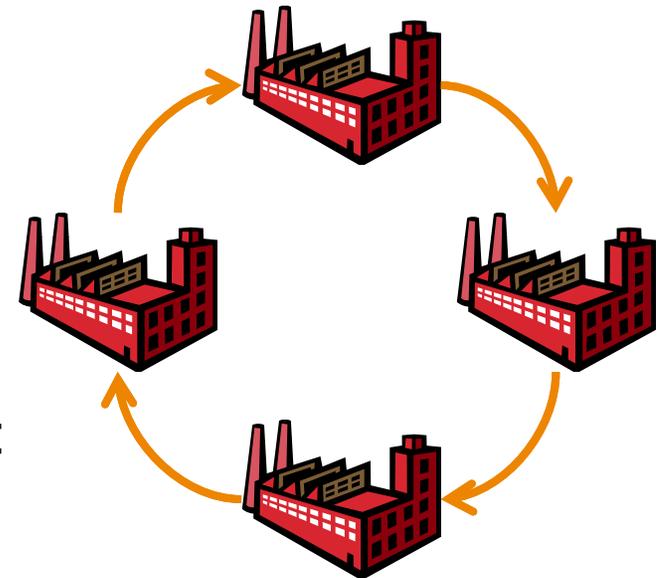


# The Future: Industrial Ecology

- What is industrial ecology?

*“the study of the physical, chemical, and biological interactions and interrelationships both within and between industrial and ecological systems”<sup>1</sup>*

- It is based on systems thinking – industry is an interdependent part of the overall ecosystem.
- It studies the material and energy flows through the system to find inefficiency and waste.



<sup>1</sup> Garner, Andy and Keoleian, Gregory A, Ph.D. National Pollution Prevention Center for Higher Education, “Industrial Ecology: An Introduction.”

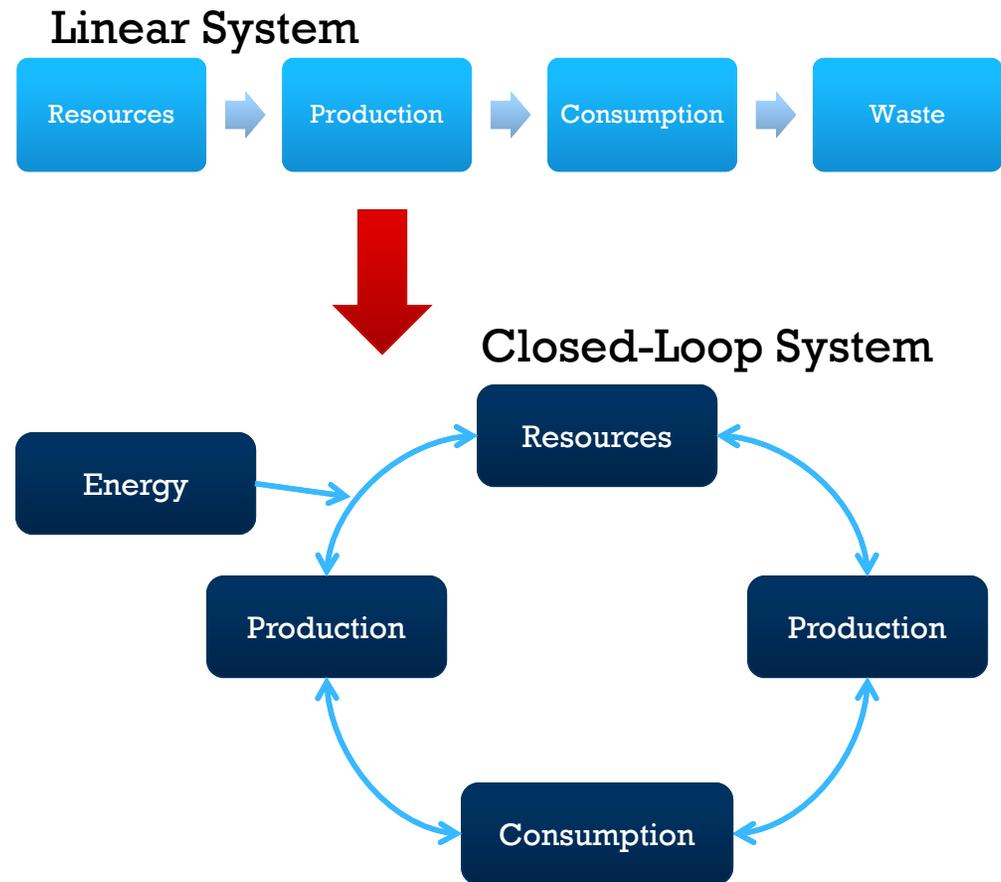


# Industrial Ecology: Towards a Closed Loop System

One of the goals of industrial ecology is to **move industry from a linear to a cyclical or closed system** where waste is used as an input rather than disposed of.<sup>1</sup>

An advanced version of this would be an **Eco-Industrial Park** where companies design their products and processes to use fewer virgin materials and use each other's byproducts, coproducts, or wastes as inputs.<sup>2</sup>

*Does your company produce byproducts that could be used by another company?*



<sup>1</sup> Garner, Andy and Keoleian, Gregory A, Ph.D. National Pollution Prevention Center for Higher Education, "Industrial Ecology: An Introduction."

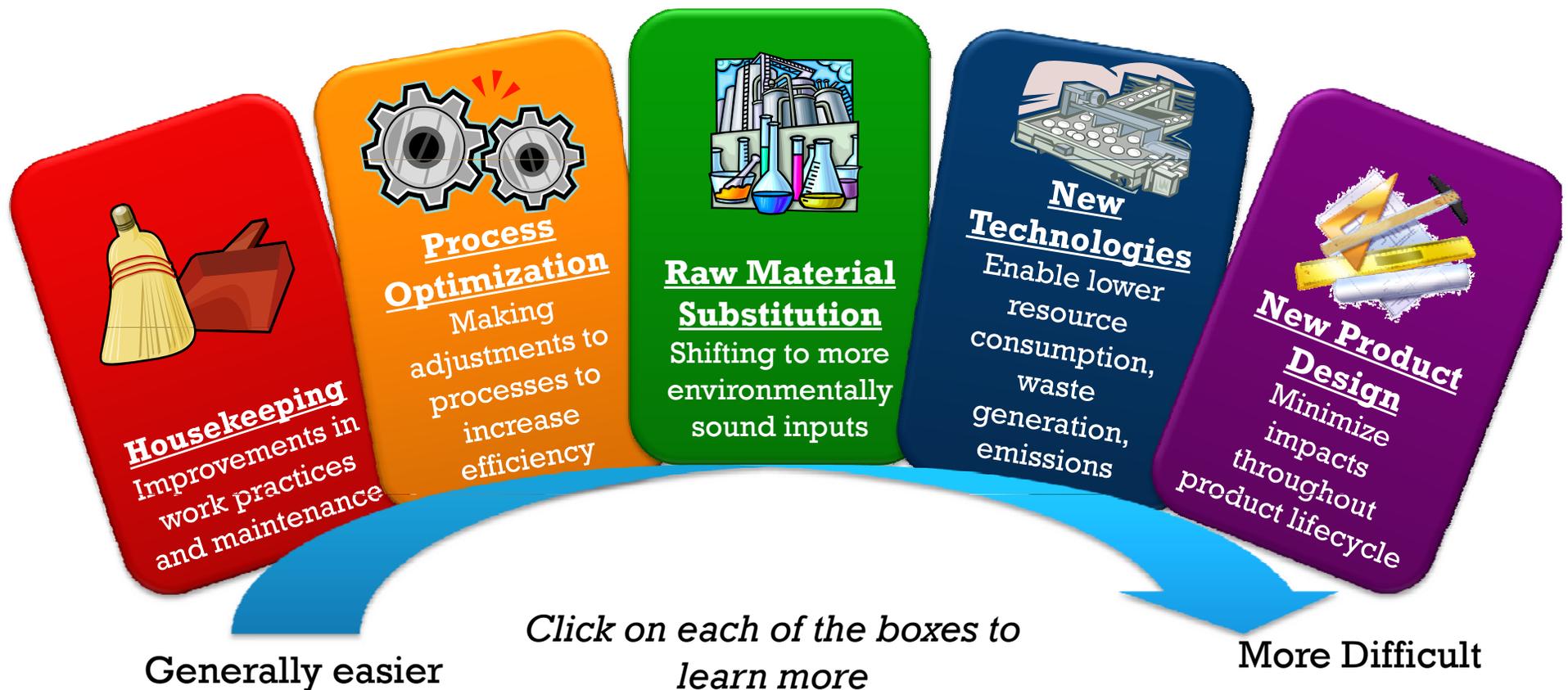
<sup>2</sup> "Eco-Innovation in Industry: Enabling Green Growth" OECD



# How do you Implement Sustainable Manufacturing?

It can be overwhelming to think about all the work that would be required to make your company more sustainable.

However, there is a spectrum of efforts you can make towards sustainable manufacturing. Some involve more effort and investment than others.<sup>1</sup>



<sup>1</sup> "Government Strategies and Policies for Cleaner Production." United Nations Environmental Programme and "Eco-Innovation in Industry: Enabling Green Growth" OECD



# Housekeeping



- Housekeeping is the simplest method of implementing sustainable manufacturing practices.<sup>1</sup>
- Housekeeping can be as simple as better inventory management, better monitoring and scheduling of the production process, reducing loss from leaks, spillage, and drag-out, and making sure equipment is maintained properly.
- It can also involve training your employees about sustainable manufacturing.



## Example

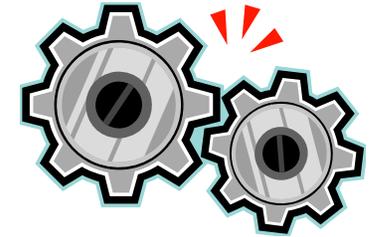
- Arctic Cat Inc., a snowmobile manufacturer based out of Minnesota, ran three 200hp and one 30hp multipurpose air compressors that cost more than \$105,000 to operate annually. They identified and fixed over 400 leaks in the compressed air lines and started to shut down the compressors at the end of the work days. Together, these efforts saved \$21,400 per year and reduced energy use by 390,000 kWh annually.<sup>2</sup>

<sup>1</sup> “Government Strategies and Policies for Cleaner Production.” United Nations Environmental Programme and “Eco-Innovation in Industry: Enabling Green Growth” OECD

<sup>2</sup> “Arctic Cat Inc. Reduces Water, Energy, and Chemical Use.” Minnesota Technical Assistance Program.



# Process Optimization



- Process optimization involves changing your manufacturing process to minimize waste, conserve raw materials, and capture and reuse waste materials.<sup>1</sup>
- There may be simple things you can do to change your production process to become more sustainable.
- Maybe you can collect metal shavings for recycling, change the steps in a painting process to use less paint, or rearrange your machines to minimize movement.



## Example

- Texas Tile Manufacturing LLC, a vinyl flooring manufacturer, conducted an assessment of its production processes and identified numerous areas to conserve energy and cut costs. Replacing traditional pilot lights in material heaters with spark igniters, they were able to save approximately \$213,000 yearly on natural gas costs and through less required maintenance on conveyor belts.<sup>2</sup>

<sup>1</sup> “Government Strategies and Policies for Cleaner Production.” United Nations Environmental Programme and “Eco-Innovation in Industry: Enabling Green Growth” OECD

<sup>2</sup> “Vinyl Flooring Texas Tile Manufacturing LLC, Additional Savings are a Pleasant Surprise.” DOE Industrial Technologies Program.



# Raw Material Substitution



- Although it is challenging, you may be able to find ways to substitute greener materials for hazardous materials, chemicals with high environmental or health impacts, materials that are non-renewable, or those that are scarce.<sup>1</sup>
- You may also be able to find ways to eliminate materials that are used during your production process but don't remain in the final product.
- Example: use water-based solvents rather than chemical solvents.
- If the materials you are eliminating are considered hazardous, this can help you avoid regulatory costs associated with storage and disposal of materials.



## Example

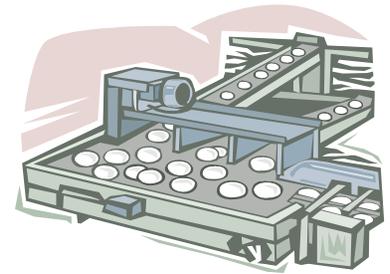
- North American Decal had used solvent-based inks which have high levels of volatile organic compounds (VOCs), a significant air pollutant. The company began transferring to less harmful UV curable inks which are of a higher quality, have a longer shelf life, and cure faster. Switching to UV curable inks lowered maintenance costs, eliminated a printing step, and even improved indoor air quality for the company's employees.<sup>2</sup>

<sup>1</sup> "Government Strategies and Policies for Cleaner Production." United Nations Environmental Programme and "Eco-Innovation in Industry: Enabling Green Growth" OECD

<sup>2</sup> "Raw Material Substitution: North American Decal" Environment Canada.



# New Technologies



- Utilizing new technologies involves incorporating more environmentally responsible technologies and equipment into your production process.<sup>1</sup>
- This can involve capital investments to purchase equipment that uses less energy or materials or alternative energy production.
- For example, you might invest in more energy-efficient production equipment, systems that reuse heat and energy, or more advanced water treatment systems.



## Example

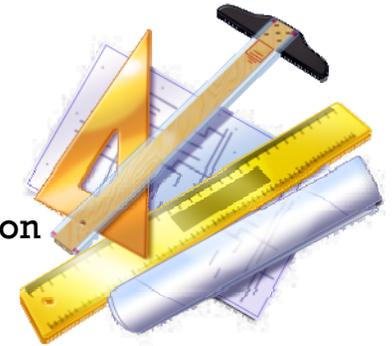
- Harbec Plastics, a small injection molding company in Ontario, New York, switched its traditional hydraulic injection molding presses to electric ones. This technology change has resulted in up to 50% energy savings over hydraulic presses, reduced noise, and shorter changeover and startup times.<sup>2</sup>

<sup>1</sup> “Government Strategies and Policies for Cleaner Production.” United Nations Environmental Programme and “Eco-Innovation in Industry: Enabling Green Growth” OECD

<sup>2</sup> “Economic Opportunities of Sustainable Manufacturing” Bob Bechtold, HARBEC Plastics, Inc.



# New Product Design



- Design your product to be greener from the ground up.<sup>1</sup> This concept touches on all of the previous sustainable manufacturing concepts. It can even include redesign involving rethinking how your product is used, and may involve:
  - Using recycled materials instead of new ones
  - Using renewable materials
  - Designing for easy disassembly, for recycling, or for remanufacturing
  - Using less packaging and more recycled or recyclable packaging
- Green product design can have the same benefits as other aspects of sustainable manufacturing, including improved resource efficiency.



## Example

- Herman Miller used design-for-the-environment principles when it redesigned its well known Aeron chair. The chairs are now made up of up to 53% recycled materials and are 94% recyclable. They are easily disassembled, contain no PVC, and emit very low levels of VOCs.<sup>2</sup>

<sup>1</sup> “Government Strategies and Policies for Cleaner Production.” United Nations Environmental Programme and “Eco-Innovation in Industry: Enabling Green Growth” OECD

<sup>2</sup> “Environmental Product Summary: Aeron Chair” Herman Miller



# The Relationship Between Lean & “Green”: (a.k.a. *Lean and Clean*)



- If your company already uses lean manufacturing practices, you may find it is easier to integrate environmental principles into the lean process.
- Although lean does not traditionally focus on environmental issues, Lean’s focus on eliminating waste can be adapted to look for environmental waste.
- The Green Suppliers Network (GSN) calls this “Lean and Clean” manufacturing. GSN found that **companies could save up to 30% more by implementing lean and clean than if they implemented lean manufacturing alone.**<sup>1</sup>

<sup>1</sup> Green Suppliers Network training



# Environmental Waste

- EPA's Lean and Environment Toolkit describes environmental waste as *“any unnecessary use of resources or a substance released into the air, water, or land that could harm human health or the environment.”*<sup>1</sup>
- Environmental Waste includes:
  - Any energy, water, or other materials used that are more than what is really needed to meet the customer’s needs
  - Hazardous materials and substances
  - Pollutants, residuals, and other material wastes released into the environment (air emissions, wastewater discharges, hazardous wastes, solid wastes)
- As mentioned previously, adding “clean” to lean can result in significantly greater returns for your company. The following chart outlines how lean wastes have an environmental impact.

## Traditional Wastes Addressed by Lean:<sup>2</sup> DOWNTIME

- **D**efects
- **O**verproduction
- **W**aiting
- **N**on-utilized Resources
- **T**ransportation
- **I**nventory
- **M**otion
- **E**xtra Processing

- **E**xtra Processing
- **M**otion
- **I**nventory

<sup>1</sup>“Lean and Environment Toolkit,” EPA

<sup>2</sup>“Green Suppliers Network Training” Green Suppliers Network.



# Adding Clean to Lean<sup>1</sup>

## Lean Waste

## Environmental Impact

### **Defective Products or Components**

- Energy and materials are consumed to make defective products, and defective products need to be disposed of.

### **Overproduction of Components or Final Products**

- Materials and energy are consumed to make unnecessary products. Products may spoil or become obsolete. Products may require hazardous materials

### **Waiting**

- Materials may spoil or become damage. Downtime wastes energy for heating, cooling, and lighting.

<sup>1</sup> "Lean and Environment Toolkit," EPA



# Adding Clean to Lean (Cont.)

## Lean Waste

## Environmental Impact

### **Unnecessary Transport or Motion**

- Energy is used for transport and produces emissions. Transport can cause damage or spills. More space is needed for additional motion, requiring heating and cooling.

### **Excess Inventory**

- More packaging and space is needed for excess inventory. Storage could cause deterioration of products and waste. Requires energy to heat, cool, and light inventory space.

### **Extra Processing**

- If processing is unnecessary, increases waste and energy use. Consumes more parts and raw materials.



# Where to Go for Help



- For definitions of other common sustainable manufacturing terms, please see [this](#) guide from the UN Environment Program.
- The EPA also has a [Terms of Environment](#) page with definitions for a variety of sustainability terms.
- [This](#) site from the Pollution Prevention Resource Exchange (P2Rx) has collected a list of sites where you can find case studies on pollution prevention.
- More information on how sustainability can be incorporated into existing lean efforts can be found from the [EPA](#) and the [Green Suppliers Network](#).



## Search

- Case Studies/Success Stories
- General Information
- How-to Guides



# Conclusion



- In this lesson you have learned:
  - about some of the **important concepts** related to sustainable manufacturing,
  - how sustainable manufacturing has **evolved**,
  - how it can be **implemented** in a manufacturing company, and
  - how it can be **integrated** with existing lean efforts.
- In the next lesson we will discuss the **business case** for sustainable manufacturing.

