

# SUSTAINABLE MANUFACTURING CURRICULUM

GREENING THE FUTURE BY EDUCATING TOMORROW'S WORKFORCE



## MODULE 2 LEAN MANUFACTURING AND POLLUTION PREVENTION



### FACILITATORS GUIDE



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## LEARNING OBJECTIVES

By the end of this session, students will be able to:

- “ Define “pollution prevention” and explain how it impacts you.
- “ Identify significant environmental regulations that apply to the manufacturing sector.
- “ Define waste.
- “ Connect common lean manufacturing strategies with corresponding environmental wastes.
- “ Use value stream mapping techniques to identify raw inputs and waste outputs for a manufacturing process.
- “ List the waste management hierarchy from top to bottom.
- “ Propose approaches for better waste management at home and at work.

## APPROVED RESOURCE MATERIALS

Throughout the workshop, you will see references to approved materials not included in Appendix C which include:

*Why Should You Care About Preventing Waste?*

<http://www.epa.gov/p2/pubs/MainBooklet.pdf>

*How Does Waste Affect Our Natural Resources*

<http://cwmi.css.cornell.edu/TrashGoesToSchool/HowDoes.html>

Pollution Prevention Act of 1990 <http://www.epa.gov/lawsregs/laws/ppa.html>.

*Lean and Environment Toolkit*

<http://www.epa.gov/lean/environment/toolkits/environment/ch2.htm>.

Green Suppliers Network's videos on effective value stream mapping:

*Part 1:* [http://www.greensuppliers.gov/materials/online\\_training/flash/With-sound-ValueStreamChapter1\\_2\\_rev.html](http://www.greensuppliers.gov/materials/online_training/flash/With-sound-ValueStreamChapter1_2_rev.html)

*Part 2:*

[http://www.greensuppliers.gov/materials/online\\_training/flash/ValueStreamChapter%203\\_4i.html](http://www.greensuppliers.gov/materials/online_training/flash/ValueStreamChapter%203_4i.html)

## Glossary Terms

*Clean manufacturing*—a systematic manufacturing approach to eliminating waste by optimizing use and selection of resources and technologies while lessening environmental impact.

*Composting*—a controlled biological decomposition of organic wastes (e.g., certain kitchen wastes, and yard trimmings) into a stable product that can be used as a natural soil amendment.

*Cycle time*—the time it takes to complete a process.

*Disposal*—the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into the environment (land, surface water, ground water, and air).

*Ecological overshoot*—when society's demand on natural resources exceeds the biosphere's supply.

*Environmental wastes*—1) energy, water, or raw materials consumed in excess of what is needed to meet customer needs. 2) pollutants and material wastes released into the environment, such as air emissions, wastewater discharges, solid and hazardous wastes.

*Hazardous waste*—waste that is dangerous or potentially harmful to our health or the environment.

*Landfill*—a regulated facility that can properly handle the treatment of municipal solid waste via temporary or permanent storage that typically includes land-based burial of waste.

*Lean manufacturing*—a systematic manufacturing approach to identify and eliminate waste through continuous improvement.

*Materials line*—a line located on the bottom of a value stream map that shows the amount of raw materials used by each process in the value stream and the amount of materials that end up in the product and add value from a customer's perspective.

*Municipal solid waste (MSW)*—common garbage or trash generated by industries, businesses, institutions, and homes. Also called *non-hazardous waste*.

*Non-hazardous waste*—common garbage or trash generated by industries, businesses, institutions, and homes. Also called *municipal solid waste*.

*Pollution prevention (P2)*—identifying areas, processes, and activities which create excessive waste products or pollutants in order to reduce or prevent them through alteration or eliminating a process.

## Glossary Terms

*Recover*—obtaining energy from non-hazardous waste.

*Recycle*—a series of activities that includes collecting recyclable materials, sorting and processing recyclables into raw materials such as fibers, and manufacturing the raw materials into new products.

*Reject*—opting against the use of products containing toxic substances or chemical components that have a particularly negative impact on the environment.

*Resource conservation*—conserving natural resources and energy use by managing materials more efficiently.

*Rethink*—taking a closer look at the product components or steps in a manufacturing process to identify opportunities to further reduce waste generation.

*Reuse*—using items again by repairing, donating, or selling them.

*Solid waste*—any solid, semi-solid, liquid, or contained gaseous materials discarded from industrial, commercial, mining, or agricultural operations, and from community activities.

*Source reduction*—reducing or eliminating waste at the source before it is generated. See *waste prevention*.

*Takt time*—derived from the German word taktzeit, means to set the pace to a speed at which a process runs smoothly.

*Treatment*—the removal of a pollutant from a waste stream.

*Value stream*—the set of specific actions (value-added and non-value added) taken to bring a product through three critical management tasks of any business: problem solving, information management, and physical transformation.

*Waste-to-energy (WTE)*—the process of burning solid waste, landfill gas, tires, or other forms of waste to produce heat or electricity. Forms of energy could include heat or electricity from incineration and biogas that results from controlled decomposition.

*Waste*—the unnecessary use of resources or a substance released to the air, water, or land that could harm human health or the environment.

*Waste prevention*—reducing or eliminating waste at the source before it is generated. See *source reduction*.

*Waste reduction*—using source reduction, recycling, or composting to prevent or reduce waste generation.

*Waste stream*—the total flow of solid waste from homes, businesses, institutions, and manufacturing plants that is recycled, burned, or disposed of in landfills or segments thereof such as the “residential waste stream” or the “recyclable waste stream.”

## MODULE-AT-A-GLANCE

Duration & Elapsed Time	Module 2 Topics	Assets
10 minutes <i>10 minutes</i>	Introduction	Facilitator Notes PowerPoint Slides Flipchart Handouts Activities 1 and 2
10 minutes 20 minutes Á	P2 through Environmental Laws & Regulations	Facilitator Notes PowerPoint Slides Images Activity 3
15 minutes <i>35 minutes</i>	Lean and Clean Manufacturing	Facilitator Notes PowerPoint Slides Images
20 minutes <i>55 minutes</i>	Value Stream Mapping	Facilitator Notes PowerPoint Slides Images Videos Activity 4
15 minutes <i>1 hour, 10 minutes</i>	Waste Management Hierarchy	Facilitator Notes PowerPoint Slides Images
15 minutesÁ <i>1 hour, 25 minutes</i>	Moving Beyond the Traditional 3 R's	Facilitator Notes PowerPoint Slides Video Activities 5 and 6

## MODULE-AT-A-GLANCE (continued)

Duration	Module 2 Activities	Materials
10 min	Activity 1: Know, Want to Know, Learned (K-W-L) chart	Handout
10 min	Activity 2: How Does Waste Affect Our Natural Resources	Handout
5 min	Activity 3: EPA's Envirofacts Tool	Website
20 minutes	Activity 4: Using Value Stream Mapping To See Wastes	Presentation Slide
20 minutes	Activity 5: The Reduce, Reuse, Recycle Hierarchy's Been Turned On Its Head	Handout
10 minutes	Activity 6: EPA's Recycle City	Website
<b>TOTAL TIME: 2 HOURS, 40 MINUTES</b>		



# Step-by-Step Instructions

## Facilitator Icon Key



### Instructions to the Facilitator

This icon means there are specific instructions for the facilitator. This content should not be read aloud.



### Background for the Facilitator

This icon indicates that there is background information the facilitator should be aware of when covering this topic. This information is for the facilitator only.



### Facilitator Says

This icon means the facilitator should read the content nearly verbatim, interjecting his/her thoughts when appropriate.



### Key Point

This icon indicates an important point that the facilitator should communicate to the audience in his/her own words.



### Questions

This icon means the facilitator should allow time for the audience to ask questions or the facilitator should ask the audience questions.



### Activity

This icon indicates an activity that the facilitator should explain. The activity can be either a group or individual activity.



### Assessment

This icon indicates the facilitator will conduct an assessment.



### Multimedia

This icon indicates the facilitator will have students watch a video.



### Computer

This icon indicates the facilitator will have students visit an online resource.



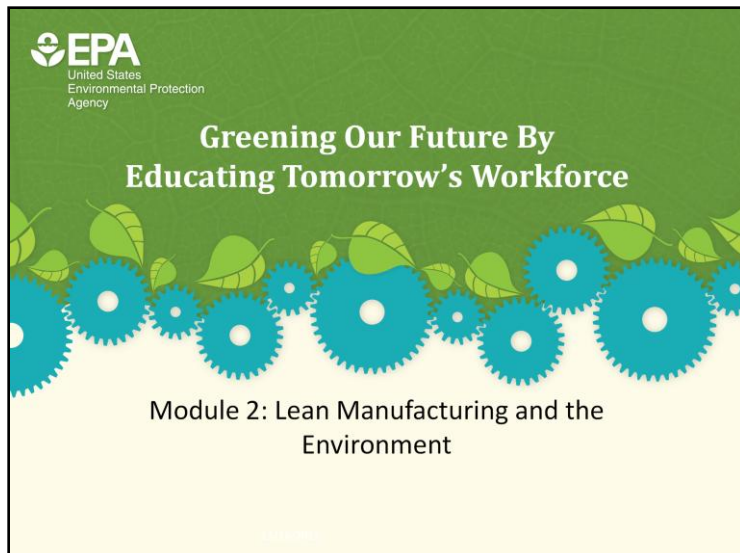
### Handouts or Resource Materials

This icon indicates the facilitator will give students a handout or other resource material.



### Transition

This icon indicates the facilitator will provide a transition from one topic to another.



## Topic

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Introduction  
10 minutes

## Learning Objective

---

Define "pollution prevention" and explain how it impacts you.

## Notes for the Facilitator

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As a class or in small groups, ask students to brainstorm what they already know about pollution prevention and what they would like to know.



Pass out the *Know, Want to Know, Learned* (K-W-L) chart.



Have students begin a K-W-L chart. The K-W-L strategy allows students to take inventory of what they already know and what they want to know. This chart is to be completed by the end of the module.

Possible homework assignments: add "how we can learn more?" (H) to the K-W-L chart and ask students to select a related topic to research and present to the class.

## Module 2: Lean Manufacturing and the Environment

### What You Will Learn From This Module:

- Definitions of key terms.
- Environmental laws and regulations related to P2.
- Lean and clean manufacturing.
- How traditional Lean wastes relate to environmental Wastes.
- Using value stream mapping to identify environmental wastes.
- EPA's waste management hierarchy and moving beyond the traditional "3R's."



### Topic

---

Introduction  
10 minutes

### Learning Objective

---

Define "pollution prevention" and explain how it impacts you.

### Notes for the Facilitator

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Share the learning objectives with the students.



Another big part of our training philosophy is that you are responsible for your own learning. Now that you've seen the objectives, I'm going to ask you to please think about your expectations. Is there anything that's missing; anything you thought we would be going over or you wanted to go over that is not covered in the objectives?



Record all answers on a flipchart.



Thank you for your input on this topic. Some of these topics are the out of the scope of this course, but I'll see if I can find some resources for you or if we can fit it in if we have time.

## Pollution Prevention

EPA defines *pollution prevention* as:

- Source reduction.
- Use of non-toxic or less-toxic alternatives.
- Implementing conservation techniques.
- Re-using materials rather than putting them into the waste stream.



### Topic

Introduction  
10 minutes

### Learning Objective

Define "pollution prevention" and explain how it impacts you.

### Notes for the Facilitator



The term "source reduction" means reducing or eliminating waste where it is generated. It does not include any practice which alters the physical, chemical, or biological characteristics or the volume of a pollutant.

The use of non-toxic alternatives is considered a pollution prevention measure because it reduces the risk of a pollutant release.

Resource conservation is a key pollution prevention practice because ecosystems where a resource is depleted or stressed are more sensitive to pollution and susceptible to environmental impacts. An example of this sensitivity is the overall reduction in water quality during severe droughts. Water quality is reduced when the resource is depleted because pollution levels become more concentrated as water evaporates.



Discuss additional terms including: resource conservation, waste, waste stream, non-hazardous waste, hazardous waste, and ecological overshoot.



Watch video entitled *What is Ecological Overshoot?*

[http://www.footprintnetwork.org/en/index.php/GFN/page/video\\_overshoot\\_explained](http://www.footprintnetwork.org/en/index.php/GFN/page/video_overshoot_explained)



Distribute "Why Should You Care About Preventing Waste?" and have the class read the brochure: <http://www.epa.gov/p2/pubs/MainBooklet.pdf>

In class or as homework, complete the activities from "How Does Waste Affect Our Natural Resources" developed by the Cornell Waste Management Institute:

<http://cwmi.css.cornell.edu/TrashGoesToSchool/HowDoes.html>

## Pollution Prevention Act of 1990

Established the national policy that pollution should be prevented or reduced at the source whenever feasible.

States that recycling, energy recovery, treatment, and disposal are **NOT** included within the definition of pollution prevention.



### Topic

P2 Through Environmental Regulations  
10 minutes  
(Elapsed Time: 20 minutes)

### Learning Objective

Identify significant environmental regulations that apply to the manufacturing sector.

## Notes for the Facilitator



The Pollution Prevention Act of 1990 defines pollution prevention as any practice that reduces the amount of any pollutant from entering any waste stream or otherwise released into the environment. Common pollution prevention techniques include equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training, or inventory control.

Under the Pollution Prevention Act, some practices commonly described as "in-process recycling" may qualify as pollution prevention. Recycling that is conducted in an environmentally sound manner shares many of the advantages of prevention—it can reduce the need for treatment or disposal, and conserve energy and resources.



As part of the Pollution Prevention Act, EPA is mandated to develop and implement a strategy to promote source reduction. EPA is also mandated to establish a database that contains information on source reduction.

EPA is given the authority to provide grants to the states to promote source reduction by businesses.

More information on the Pollution Prevention Act of 1990 is available on the following website: <http://www.epa.gov/lawsregs/laws/ppa.html>.

## Emergency Planning and Community Right to Know Act (EPCRA)

- National environmental legislation for community safety.
- Designed to help local communities protect public health, safety, and the environment from chemical hazards.
- Primary purpose is to inform citizens of toxic chemical releases in their areas through the publicly available Toxic Release Inventory (TRI).



### Topic

P2 Through Environmental Regulations  
10 minutes  
(Elapsed Time: 20 minutes)

### Learning Objective

Identify significant environmental regulations that apply to the manufacturing sector.

## Notes for the Facilitator



The Emergency Planning & Community Right-to-Know Act (EPCRA) was enacted by Congress as the national legislation on community safety.



One of EPCRA's primary purposes is to inform citizens of toxic chemical releases in their areas. EPCRA Section 313 requires EPA and the states to collect data annually on releases and transfers of certain toxic chemicals from industrial facilities and make the data available to the public through the Toxics Release Inventory (TRI).

EPCRA includes an emergency planning requirements for pollution and fire control. Facilities covered under EPCRA must have ready Material Safety Data Sheets (MSDS) for all chemicals and must complete hazardous chemical inventory forms. Owners and operators of facilities covered under EPCRA must complete a toxic chemical release form.

More information on the EPCRA is available on the following website:  
<http://www.epa.gov/lawsregs/laws/epcra.html>.

## Toxic Release Inventory (TRI)



Provides communities with information about toxic chemical releases and waste management activities to support informed decision making by industry, government, non-governmental organizations, and the public.



### Topic

P2 Through Environmental Regulations  
10 minutes  
(Elapsed Time: 20 minutes)

### Learning Objective

Identify significant environmental regulations that apply to the manufacturing sector.

### Notes for the Facilitator



TRI is a database containing data on disposal or other releases of over 600 toxic chemicals from thousands of U.S. facilities and information about how facilities manage those chemicals through recycling, energy recovery, and treatment.

More information on the TRI is available on the following website:

<http://www.epa.gov/tri/index.htm>.



Use EPA's Envirofacts tool to determine what hazardous substances are used in your area: <http://www.epa.gov/enviro/index.html>.



Once the Envirofacts tool opens, have students click on the "Toxics" button to use the TRI search feature. Have each enter a nearby zip code to see what companies use toxic materials and where potential releases occur. Find the closest location to campus where toxic substances are being used.



## Resource Conservation and Recovery Act (RCRA)



Law that established the framework for the proper management of hazardous and nonhazardous solid waste. RCRA gives EPA the authority to control hazardous waste from the "cradle-to-grave."



### Topic

P2 Through Environmental Regulations  
10 minutes  
(Elapsed Time: 20 minutes)

### Learning Objective

Identify significant environmental regulations that apply to the manufacturing sector.

### Notes for the Facilitator



Under the Resource Conservation and Recovery Act (RCRA), EPA must establish waste management guidelines. Additionally, EPA may assist Indian tribes in waste management.

RCRA establishes hazardous waste requirements for owners and operators of facilities that produce hazardous wastes, including the following:

- “ Generators must certify in shipping manifests that they have a plan to reduce waste.
- “ Generators must also submit a biennial report indicating their efforts to reduce volume and toxicity of wastes.
- “ A permit is required for the treatment and storage of hazardous wastes.

EPA shall provide financial assistance to federal, state, and local agencies that are researching, investigating, or providing in areas of waste management and minimization. Grants are appropriated to the states for assistance in the development of hazardous waste programs.



EPA can make facilities describe their waste reduction program and inspect them to determine whether a program is actually in place.

More information on the RCRA is available on the following website:

<http://www.epa.gov/lawsregs/laws/rcra.html>.

## Clean Water Act

- Establishes the foundation for regulating discharges of pollutants into the waters of the United States and regulating quality for surface waters.



### Topic

P2 Through Environmental Regulations  
10 minutes  
(Elapsed Time: 20 minutes)

### Learning Objective

Identify significant environmental regulations that apply to the manufacturing sector.

### Notes for the Facilitator



The basis of the Clean Water Act (CWA) was enacted in 1948 and first called the Federal Water Pollution Control Act, but the Act was significantly reorganized and expanded in 1972. "Clean Water Act" became the Act's common name after amendments in 1977.

Under the CWA, EPA has implemented pollution control programs such as setting wastewater standards for industry and water quality standards for contaminants in surface waters.

The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained. EPA's National Pollutant Discharge Elimination System (NPDES) permit program controls discharges. Point sources are discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. EPA can put additional restrictions on permits (not included in the Act).



CWA has a national goal to eliminate the discharge of pollutants into navigable waters. EPA coordinated with federal, state, and local agencies and industries to develop programs for preventing, reducing, or eliminating the pollution of the navigable waters and ground waters and improving the sanitary condition of surface and underground waters.

EPA is given authority to make grants to states for pollution control revolving fund for the implementation of management and conservation plans.

More information on the CWA is available on the following website:  
<http://www.epa.gov/lawsregs/laws/cwa.html>.

## Clean Air Act

- Regulates air emissions from stationary and mobile sources.
- Authorizes EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and public welfare and to regulate emissions of hazardous air pollutants.



## Topic

P2 Through Environmental Regulations  
10 minutes  
(Elapsed Time: 20 minutes)

## Learning Objective

Identify significant environmental regulations that apply to the manufacturing sector.

## Notes for the Facilitator



The Clean Air Act encourages cooperation amongst the federal departments, states, and local governments for prevention and control of air pollution. Under the Clean Air Act, EPA sets limits on certain air pollutants and general emission standards to protect public welfare and the environment. Individual states or tribes may have stronger air pollution laws, but they may not have weaker pollution limits than those set by EPA. EPA was mandated to establish a national research and development program for prevention and air pollution control.

EPA must facilitate coordination amongst air pollution prevention and control agencies. EPA must approve state, tribal, and local agency plans for reducing air pollution. If a plan does not meet the necessary requirements, EPA can issue sanctions against the state and, if necessary, take over enforcing the Clean Air Act in that area. EPA can make grants to air pollution prevention and control agencies.



EPA may establish record keeping, inspections, and monitoring for all facilities that emit pollutants. Facilities that reduce their emission of toxics into the air by 90 to 95 percent can qualify for permit waivers.

More information on the Clean Air Act is available on the following website:  
<http://www.epa.gov/lawsregs/laws/caa.html>.



This is only an introduction to environmental regulations that apply to the manufacturing sector, but you can see there are many P2 mandates throughout the federal statutes.



The quote above and the following comment can be used to transition the next slide. We are now going to turn to the idea of "lean." Lean manufacturing is a business model and collection of tactical methods that emphasize eliminating non-value added activities (waste) while delivering quality products on time, at least cost, and with greater efficiency.

## What Is Waste?

So how does Toyota define *waste*?

“Waste is anything other than the minimum amount of raw materials, parts, space, equipment, and workers’ time that are absolutely necessary to add value to the product.”

—Shoichiro Toyoda, Toyota Motor Company  
Chairman and President (1982-1999)



## Topic

Lean and Clean Manufacturing  
15 minutes  
(Elapsed Time: 35 minutes)

## Learning Objective

Define waste.

## Notes for the Facilitator



Many industry leaders credit Toyota’s Production System with the inception of Lean manufacturing philosophy and terminology. To understand how lean manufacturing can be used to identify environmental wastes, we only need to look to the definition of waste. Toyota defines waste as...



Read the slide aloud.

## What Is Waste?

EPA defines **waste** as the unnecessary use of resources or a substance released to the air, water, or land that could harm human health or the environment.

- Environmental wastes can occur when companies use resources to provide products or services to customers or when customers use and dispose of products.



### Topic

Lean and Clean Manufacturing  
15 minutes  
(Elapsed Time: 35 minutes)

### Learning Objective

Define waste.

### Notes for the Facilitator



Now let's look at how EPA defines environmental waste.



Read the slide aloud.



Ask the class these questions to guide the discussion:

- “ How are Toyota's and EPA's definitions of waste similar?
- “ How are they different?
- “ If both define waste so similarly, how does lean relate to reducing environmental wastes?
- “ How does a company's profits relate to it's wastes?



If class doesn't provide ideas on how the two relate, proceed to next slide to guide discussion.

## What Is Waste?

What is an environmental waste?

- Energy, water, or raw materials consumed in excess of what is needed to meet customer needs.
- Pollutants and material wastes released into the environment, such as air emissions, wastewater discharges, and solid and hazardous wastes.
- Use of hazardous substances in products that adversely affect human health or the environment during.



## Topic

Lean and Clean Manufacturing  
15 minutes  
(Elapsed Time: 35 minutes)

## Learning Objective

Define waste.

## Notes for the Facilitator



So what exactly is an environmental waste?



*Hazardous waste*—waste that is dangerous or potentially harmful to our health or the environment. Hazardous wastes can be liquids, solids, gases, or sludge. They can be discarded commercial products, like cleaning fluids or pesticides, or the by-products of manufacturing processes.

*Non-hazardous waste*—commonly known as trash or garbage, non-hazardous (or municipal solid waste) consists of items used and then thrown away, such as product packaging, byproducts, scrap, yard waste, food waste, and construction/demolition debris.

## Why Combine Lean and P2?

Traditional lean manufacturing strives to eliminate

### **DOWNTIME:**

- Defects
- Overproduction
- Waiting
- Non-utilized resources
- Transportation
- Inventory
- Motion
- Extra-processing

*Where are the  
environmental  
wastes?*



### Topic

Lean and Clean Manufacturing  
15 minutes  
(Elapsed Time: 35 minutes)

### Learning Objective

Connect common lean manufacturing strategies with corresponding environmental wastes.

## Notes for the Facilitator



Read the slide aloud.



Lean manufacturing uses a systematic approach to identify and eliminate waste through continuous improvement.



Ask the class these questions to guide the discussion:

- ~ What is continuous improvement?
- ~ So where are the environmental wastes?



Lean initiatives are commonplace in today's manufacturing industries. Lean strives for optimized and efficient manufacturing processes by eliminating non-value-added steps and the use of non-value-added materials and energy. Manufacturers implement Lean initiatives because they see efficiency as necessary to compete in an already competitive marketplace.



The following question can be used to transition the next slide. "As you can see, the traditional lean wastes don't account for environmental wastes such as water, energy or hazardous wastes. But do any of these relate to environmental wastes?"

## How Lean Relates to Environmental Wastes

Optimize Material Use → Less Scrap = **Reduced Solid Waste**

Reduce Inventory → Less Chemical Spoilage = **Reduced Hazardous Waste**

Reduce Overproduction → Less Runtime = **Energy Savings**

Reduce Defects → Causes Rework and Unusable Products = **Energy Savings and Reduced Solid Waste**

Reduce Transportation → Less Fuel Consumption = **Reduced Air Emissions**



## Topic

Lean and Clean Manufacturing  
15 minutes  
(Elapsed Time: 35 minutes)

## Learning Objective

Connect common lean manufacturing strategies with corresponding environmental wastes.

## Notes for the Facilitator



Let's look closer at a few traditional lean goals to see if they result in any reductions in environmental wastes:

- “ Materials overuse creates scrap that generates solid waste and consumes unnecessary resources and energy.
- “ Keeping large inventories can lead to stockpiles of obsolete parts or chemical spoilage that turn into unnecessary solid or hazardous waste.
- “ Overproduction causes longer equipment run times and is an inefficient use of energy.
- “ Defects waste raw materials and use unnecessary energy in rework. Defects can also generate unnecessary solid and/or hazardous waste.
- “ Transportation consumes fuel and generates air pollutant emissions.
- “ Despite these relationships between lean “deadly wastes” and environmental wastes, lean manufacturing efforts often overlook opportunities to prevent or reduce environmental wastes.



Print off handout provided for *Environmental Impacts related to Lean's Deadly Wastes* and distribute to class. Environmental impact handout from Lean and the Environment Toolkit (**Chapter 2**) available at <http://www.epa.gov/lean/environment/toolkits/environment/ch2.htm>.



## Lean and Clean Manufacturing

Clean manufacturing strives for **NO WASTE**:

- Non-toxic substitutes
- Optimized raw material use
- Water and wastewater reductions
- Air emission reductions
- Solid and hazardous waste reductions
- Transport packaging optimization
- Energy efficiency



### Topic

Lean and Clean Manufacturing  
15 minutes  
(Elapsed Time: 35 minutes)

### Learning Objective

Connect common lean manufacturing strategies with corresponding environmental wastes.

### Notes for the Facilitator



Read the slide aloud.



Review these two key points:

- “ Clean manufacturing is a systematic approach to eliminating waste by optimizing use and selection of resources and technologies while lessening environmental impact.
- “ Manufacturers realize that striving for no waste, as described on the slide, also results in reduced production costs and increased profitability.



The following question can be used to transition to the next slide. “How do you pinpoint ways to improve the manufacturing process and achieve clean manufacturing?” One available tool is value stream mapping .

## Value Stream Mapping

The purpose of a value stream map is to:

- Identify major sources of *non-value added* time in a value stream.
- Envision a *less wasteful* future state.
- Develop an implementation plan for *improvements*.



### Topic

Value Stream Mapping  
20 minutes  
(Elapsed Time: 55 minutes)

### Learning Objective

Use value stream mapping techniques to identify raw inputs and waste outputs for a manufacturing process.

## Notes for the Facilitator



Value stream mapping (VSM) is a lean process mapping method for understanding the sequence of activities and information flows used to produce a product or deliver a service.



*Value stream*—the set of specific actions (value-added and non-value added) taken to bring a product through three critical management tasks of any business: problem solving, information management, and physical transformation. VSM is used as a communication tool, a business planning tool, and a management tool.



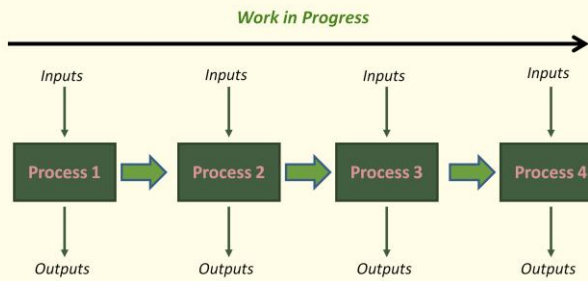
For an overview of VSM and an easy-to-understand example, show the Green Suppliers Network's videos on how to effectively value stream map:

Part 1: [http://www.greensuppliers.gov/materials/online\\_training/flash/With-sound-ValueStreamChapter1\\_2\\_rev.html](http://www.greensuppliers.gov/materials/online_training/flash/With-sound-ValueStreamChapter1_2_rev.html)

Part 2:

[http://www.greensuppliers.gov/materials/online\\_training/flash/ValueStreamChapter%203\\_4i.html](http://www.greensuppliers.gov/materials/online_training/flash/ValueStreamChapter%203_4i.html)

## Value Stream Mapping



### Topic

Value Stream Mapping  
20 minutes  
(Elapsed Time: 55 minutes)

### Learning Objective

Use value stream mapping techniques to identify raw inputs and waste outputs for a manufacturing process.

### Notes for the Facilitator



Value stream mapping is a way to “see” all inputs and outputs of a process or product line.

## Value Stream Mapping

When used in lean manufacturing, value stream maps traditionally look at:

- Inventory
- Takt Time
- Downtime
- Cycle Time
- Changeovers
- Movement/motion
- Rework
- Information Flow



### Topic

Value Stream Mapping  
20 minutes  
(Elapsed Time: 55 minutes)

### Learning Objective

Use value stream mapping techniques to identify raw inputs and waste outputs for a manufacturing process.

### Notes for the Facilitator



Read the slide aloud.



Ask the class if anyone can define the terms *takt time* and *cycle time*. If no one knows the definitions, review the definitions in the glossary terms.

## Value Stream Mapping

Five ways value stream maps can be used to see environmental wastes:

- Use icons to identify environmental impacts in processes.
- Include environmental metrics in value stream maps.
- Use a “materials line” to track resource use versus need.
- Expand focus of value stream map to track energy or water resource flows.
- Find environmental improvements in future state maps.



### Topic

Value Stream Mapping  
20 minutes  
(Elapsed Time: 55 minutes)

### Learning Objective

Use value stream mapping techniques to identify raw inputs and waste outputs for a manufacturing process.

### Notes for the Facilitator



Read the slide aloud.



Resources are available in EPA's *Lean and Environment* toolkit and can be modified into handouts for this section.

<http://www.epa.gov/lean/environment/toolkits/environment/>

## Timelines and Materials Lines

Traditional lean value stream maps include timelines used to show takt time and cycle time.

Timelines can be modified into materials lines to show you:

- Overall difference between raw material amounts used versus what's actually needed.
- Largest sources of waste for prioritizing improvement efforts.
- Where alternative materials may be an effective option.



## Topic

Value Stream Mapping  
20 minutes  
(Elapsed Time: 55 minutes)

## Learning Objective

Use value stream mapping techniques to identify raw inputs and waste outputs for a manufacturing process.

## Notes for the Facilitator



Value stream maps typically examine the time it takes to produce a product and the proportion of that time that is value added.



A materials line is a line located on the bottom of a value stream map that shows the amount of raw materials used by each process in the value stream and the amount of materials that end up in the product and add value from a customer's perspective.

## Materials Lines

Materials lines can show you:

- Overall difference between amounts *used* versus what's actually *needed*.
- Largest sources of waste for *prioritizing improvement* efforts.
- Where *alternative materials* may be an effective option.



## Topic

Value Stream Mapping  
20 minutes  
(Elapsed Time: 55 minutes)

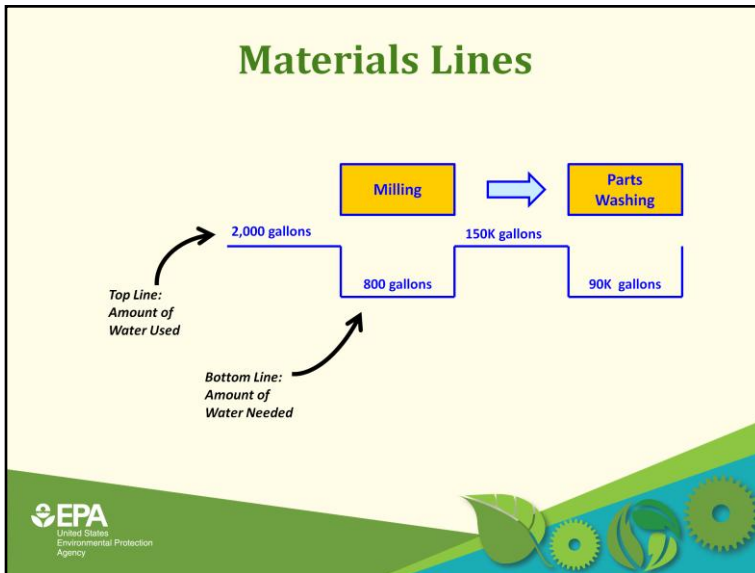
## Learning Objective

Use value stream mapping techniques to identify raw inputs and waste outputs for a manufacturing process.

## Notes for the Facilitator



A materials line focuses on the resources consumed and wasted in the development of that product. Since raw materials are often a large source of a product's costs, looking explicitly at the material flows in a value stream is another way to leverage greater gains.



### Topic

Value Stream Mapping  
20 minutes  
(Elapsed Time: 55 minutes)

### Learning Objective

Use value stream mapping techniques to identify raw inputs and waste outputs for a manufacturing process.

### Notes for the Facilitator



What do we learn from this simple materials line?

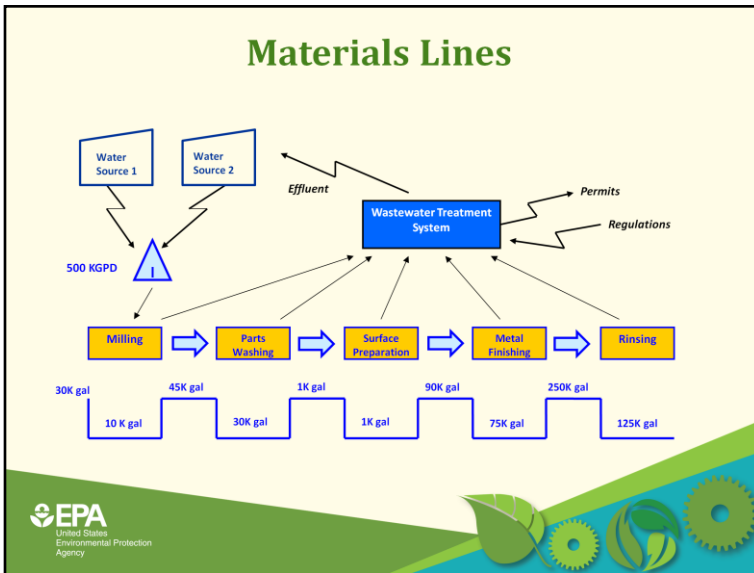
Amount of Water Used = 152,000 gallons

Amount of Water Needed = 90,800 gallons

Amount of Water Wasted = 62,200 gallons



## Materials Lines



### Topic

Value Stream Mapping  
20 minutes  
(Elapsed Time: 55 minutes)

### Learning Objective

Use value stream mapping techniques to identify raw inputs and waste outputs for a manufacturing process.

### Notes for the Facilitator



This materials line shows process water use throughout this manufacturing facility. The top of the line shows the amount currently being used while the bottom of the line shows only what is absolutely needed to manufacture the product.

## Future State Maps

What does the future state look like?

- A future state map does not need to be a mirror image of the current state.
- Can remove cost capital limitation and assume no investment is too large to make.
- It's a chance to redesign the operation to what it would look like in a perfect scenario—fully optimized and efficient.



## Topic

Value Stream Mapping  
20 minutes  
(Elapsed Time: 55 minutes)

## Learning Objective

Use value stream mapping techniques to identify raw inputs and waste outputs for a manufacturing process.

## Notes for the Facilitator



What does the future state look like? We don't need to have psychic powers or be Nostradamus to predict what an improved manufacturing process can look like. We simply need to learn to see what an opportunity for improvement looks like.



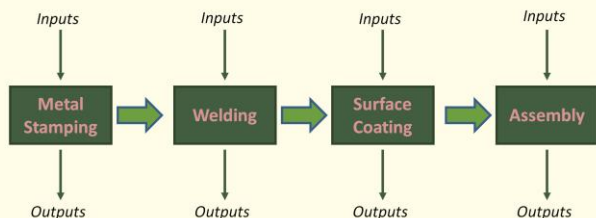
When developing a future state map, students/companies should ask questions like:

- “ What could it be?
- “ What could it look like?
- “ Does it have to be done this way?
- “ Do we need to use this much?
- “ How do our competitors do it?
- “ What is high tech?



The goal is to help the environment, conserve resources, and improve productivity to help the business succeed financially.

## Using Value Stream Maps to Identify Waste



### Topic

Value Stream Mapping  
20 minutes  
(Elapsed Time: 55 minutes)

### Learning Objective

Use value stream mapping techniques to identify raw inputs and waste outputs for a manufacturing process.

### Notes for the Facilitator



Have students get into groups and list out raw inputs and waste outputs for one or all of the common automotive manufacturing processes displayed on this slide. If students have difficulties naming inputs or outputs, refer back to the Green Suppliers Network videos on effective value stream mapping for ideas.

Reconvene the class after ample time is provided to the students to complete the lists of inputs and outputs. Have groups report back to the class in order to develop a completed value stream map with all the possible inputs and outputs for the displayed product line.

## Quiz #1



### Topic

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Value Stream Mapping  
20 minutes  
(Elapsed Time: 55 minutes)

### Learning Objective

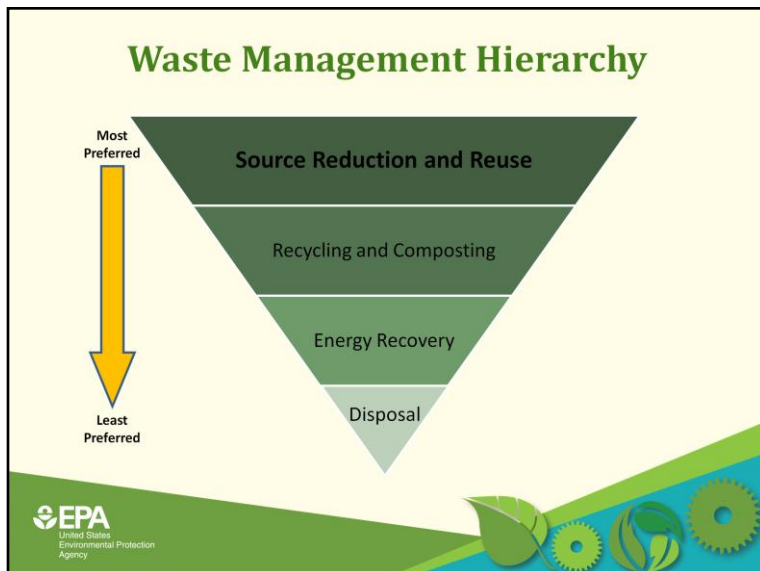
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### Notes for the Facilitator

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This quiz can serve as the end or the beginning a classroom session. The material covered in the rest of module 2 builds upon the material covered in this quiz. See Appendix B for sample quiz and answer key.



## Topic

Waste Management Hierarchy  
15 minutes  
(Elapsed Time: 1 hour, 10 minutes)

## Learning Objective

List the waste management hierarchy from top to bottom.

## Notes for the Facilitator



The waste management hierarchy is designed to show the most environmentally preferable options for waste management. It places emphasis on reducing, reusing, and recycling the majority of wastes and recognizes that waste is not simply trash. Waste can contain valuable commodities such as paper, cardboard, aluminum, steel, and energy.



*Waste reduction*—using source reduction, recycling, or composting to prevent or reduce waste generation.



An easily-understood example of how we can use the waste management pyramid in every day decision-making is by applying it to a bottle of water. Recall the bottled water video located on page 32 of Module 1. If your class has not viewed it yet, do so now.



“ When you drink a bottle of water, you can *dispose* of the bottle in the trash destined for the landfill. This represented by the bottom row of the pyramid.

“ It would be better is if the bottle goes to a waste-to-energy facility because the petroleum used to make the bottle can be used to generate *energy*.

“ Better yet, you can *recycle* so the raw materials can be used to make another bottle or another product with similar composition.

“ Even better still, you can *reuse* the same bottle throughout the day so you don't generate as many waste bottles. Or the best option for you, as a consumer, is to refuse to buy bottle water, and opt to buy a *reusable* water bottle that you can refill an unlimited number of times.



## Topic

Waste Management Hierarchy  
15 minutes  
(Elapsed Time: 1 hour, 10 minutes)

## Learning Objective

List the waste management hierarchy from top to bottom.

## Notes for the Facilitator



Reducing solid waste generation and reuse are the most effective ways to address waste management costs and prevent the use of virgin materials and is therefore located at the top of the waste management hierarchy.



The images on this slide show a drop box for donating shoes to the needy and a reusable grocery bag. Both are ways to prevent waste from being generated.

*Source reduction or waste prevention*—designing products to reduce the amount of waste that will later need to be thrown away and also to make the resulting waste less toxic.

*Reuse*—using items again by repairing, donating, or selling them.



## Topic

Waste Management Hierarchy  
15 minutes  
(Elapsed Time: 1 hour, 10 minutes)

## Learning Objective

List the waste management hierarchy from top to bottom.

## Notes for the Facilitator



Capturing the material value of solid waste through recycling can be considered next making waste management decisions and is therefore listed second on the waste management hierarchy. For example, source-separated yard waste can be composted aerobically to produce a soil conditioner product or used in landfills, in place of soil, as alternative daily cover.



The images on the top of the slide show containers for separating recyclables. Proper source separation is key to a successful recycling program. The bottom image shows food scraps and organics destined for compost.

*Recycle*—series of activities that includes collecting recyclable materials, sorting and processing recyclables into raw materials such as fibers, and manufacturing the raw materials into new products.

*Composting*—a controlled biological decomposition of organic wastes (e.g., certain kitchen wastes, and yard trimmings) into a stable product that can be used as a natural soil amendment.

## Waste Management Hierarchy

Energy Recovery

Waste to Energy Plant Diagram

Pollution Control System

- Nitrogen Oxide Removal System
- Mercury Removal System
- Acid Gas Removal System
- Particulate Removal System
- Pollution Control Test

14 Megawatt Electricity

Steam Turbine Generator

Flue Gases

Water Vapor & Cleaned Flue Gases

Tipping Hall

Trash Storage Bunker

Ash Conveyor Belt

Landfill

Source: ecomaine.

### Topic

Waste Management Hierarchy  
15 minutes  
(Elapsed Time: 1 hour, 10 minutes)

### Learning Objective

List the waste management hierarchy from top to bottom.

### Notes for the Facilitator



Combustion or gasification with energy recovery, or waste-to-energy (WTE), is the environmentally preferable route for mixed solid wastes that are neither recyclable nor compostable.



*Waste-to-Energy (WTE)*—process of burning solid waste, landfill gas, tires, or other forms of waste to produce heat or electricity. Forms of energy could include heat or electricity from incineration and biogas that results from controlled decomposition.





## Topic

Waste Management Hierarchy  
15 minutes  
(Elapsed Time: 1 hour, 10 minutes)

## Learning Objective

List the waste management hierarchy from top to bottom.

## Notes for the Facilitator



In the waste management hierarchy, disposal is often accomplished by landfilling. From an environmental standpoint, landfilling municipal solid waste is the least preferred option for waste management. However, community decisions are based both on environmental and economic factors.



*Disposal*—the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into the environment (land, surface water, ground water, and air).

*Landfill*—a regulated facility that can properly handle the treatment of municipal solid waste via temporary or permanent storage that typically includes land-based burial of waste.

*Treatment*—the removal of a pollutant from a waste stream.



## Topic

Moving Beyond the Traditional 3R's  
15 minutes  
(Elapsed Time: 1hour, 25 minutes)

## Learning Objective

Propose approaches for better waste management at home and at work.

## Notes for the Facilitator



By now, everyone should at least be aware of the 3 R's of waste management. Reduce, reuse, recycle are terms that are used in pop culture and engrained into our social conscience. But what if I told you that there are three more "R" words that take waste management beyond these basic concepts?



Ask the class examples of source reduction, reuse, and recycling. Good examples of each are:

- ~ Reduce: Choosing option "a" over "b."
- ~ Reuse: Fabric grocery bags, Nalgene water bottles, empty printer cartridges.
- ~ Recycle: Cans, plastic bottles, newspaper, transforming yard waste into mulch or food scraps into compost.

*Recycle*—to start the product's life cycle over or to make raw materials usable again after additional reprocessing.

*Reduce*—to limit or make smaller the amount of waste generated.

*Reuse*—to put to use again; use after original intention.



Watch any of these videos related to the 3 R's:

*Reduce Reuse Recycle*: <http://www.youtube.com/watch?v=G1yBQv1hLRY>

*Reduce Reuse Reduce*: <http://www.youtube.com/watch?v=eBNDU6dwM7c>

*Recycle Day at Honda Manufacturing of Alabama*:

[http://www.youtube.com/watch?v=-5z\\_zeJRx-U](http://www.youtube.com/watch?v=-5z_zeJRx-U)



After watching at least one video, complete *The Reduce, Reuse, Recycle Hierarchy's Been Turned On It's Head* activities found in Appendix C.

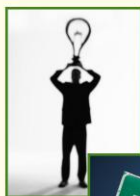
## Moving Beyond the Traditional 3R's

Three new "R's"

Rethink

Reject

Recover



### Topic

Moving Beyond the Traditional 3R's  
15 minutes  
(Elapsed Time: 1 hour, 25 minutes)

### Learning Objective

Propose approaches for better waste management at home and at work.

### Notes for the Facilitator



**Reject.** Opt against the use of products containing toxic substances or chemical components that have a particularly negative impact on the environment. For example, instead of using household products that come in cans containing a propellant, you could choose to use products that come in manual spray bottles.

**Rethink.** A fifth "R" word that is associated with the solid waste management process is "rethink." To rethink refers to the taking a closer look at the product components or steps in manufacturing process to identify opportunities to further reduce waste generation. Examples of ways to "rethink" waste generation is through life cycle analysis or through lean kaizen events. The root cause of waste can sometimes be as simple as being closed minded to continuing to implementing improvements.

**Recover.** Source reduction and recycling are important parts of managing our solid waste, but even with our best efforts we'll still need means of getting rid of trash. Solid waste contains energy stored in biomass materials like paper, cardboard, food scraps, grass clippings, leaves, wood, leather products, and other non-biomass combustible materials like plastics and other synthetic materials made from petroleum. These waste streams can be burned in special waste-to-energy plants to generate steam to heat buildings or to generate electricity. Solid waste sent to landfills can be a source of energy. Anaerobic bacteria that live in landfills decompose organic waste to produce a gas called biogas that contains methane. Landfills can collect the methane gas, treat it, and then sell it as a commercial fuel. It can then be burned to generate steam and electricity.



Read the slide aloud.



Ask students to get into small groups and define each term with examples. Record answers on a flipchart.



## Topic

Moving Beyond the Traditional 3R's  
15 minutes  
(Elapsed Time: 1 hour, 25 minutes)

## Learning Objective

Propose approaches for better  
waste management at home  
and at work.

## Notes for the Facilitator



Students will remain in these same small groups for the activity below.



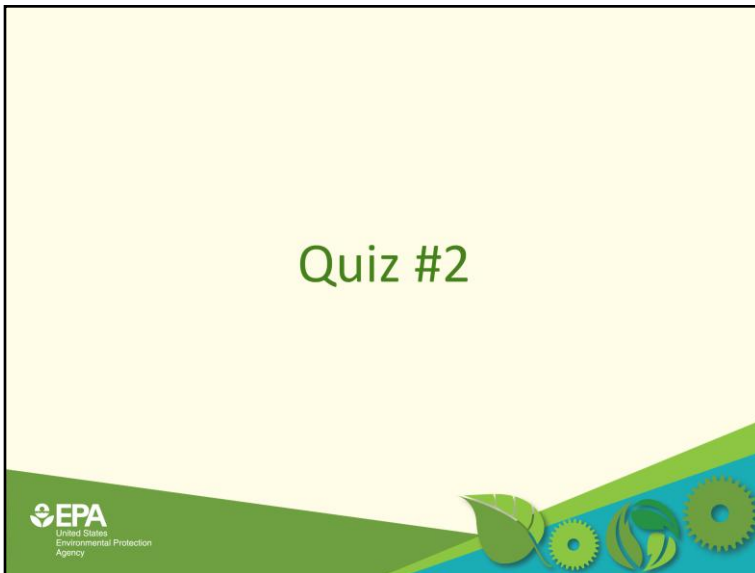
Visit EPA's Recycle City—Widget Manufacturer at:  
<http://www.epa.gov/recyclecity/factory.htm>.



Ask students to propose other ways the Widget Company could reduce waste and energy. Record on flipchart.



Extend the activity by proposing ways to reduce waste and energy in the following scenarios:  
EPA's Recycle City—Auto Wrecker: <http://www.epa.gov/recyclecity/wrecker.htm>  
EPA's Dumptown Game: <http://www.epa.gov/recyclecity/dumptown.htm>



**Topic**  
\_\_\_\_\_

**Learning Objective**  
\_\_\_\_\_

**Notes for the Facilitator**

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This quiz can serve as the end or the beginning a classroom session. See Appendix B for sample quiz and answer key.

## APPENDIX A: Video Resource List

*What is Ecological Overshoot?:*

[http://www.footprintnetwork.org/en/index.php/GFN/page/video\\_overshoot\\_explained](http://www.footprintnetwork.org/en/index.php/GFN/page/video_overshoot_explained)

Green Suppliers Network's Value Stream Mapping Videos

Part 1: [http://www.greensuppliers.gov/materials/online\\_training/flash/With-sound-ValueStreamChapter1\\_2\\_rev.html](http://www.greensuppliers.gov/materials/online_training/flash/With-sound-ValueStreamChapter1_2_rev.html)

Part 2:

[http://www.greensuppliers.gov/materials/online\\_training/flash/ValueStreamChapter%203\\_4i.html](http://www.greensuppliers.gov/materials/online_training/flash/ValueStreamChapter%203_4i.html)

*Reduce Reuse Recycle:* <http://www.youtube.com/watch?v=G1yBQv1hLRY>

*Reduce Reuse Reduce:* <http://www.youtube.com/watch?v=eBNDU6dwM7c>

*Recycle Day at Honda Manufacturing of Alabama:*

[http://www.youtube.com/watch?v=-5z\\_zeJRx-U](http://www.youtube.com/watch?v=-5z_zeJRx-U)

## **APPENDIX B: Module Quizzes**

# Pollution Prevention Quiz #1

**1. Match the environmental regulation (left column) with its primary focus (right column). Identify the correct focus by placing its letter next to the name of the regulation:**

***Environmental Regulation***

***Primary Focus***

\_\_\_ Emergency Planning and  
Community Right to Know Act

A) Pollution should be prevented or reduced at the source whenever feasible.

\_\_\_ Clean Water Act

B) Provides communities with information about toxic chemical releases and waste management activities.

\_\_\_ Pollution Prevention Act of 1990

C) Regulates discharges of pollutants into the waters of the United States.

\_\_\_ Toxic Release Inventory

D) Protects public health, safety, and the environment from chemical hazards.

\_\_\_ Resource Conservation and  
Recovery Act

E) Regulates air emissions from stationary and mobile sources.

\_\_\_ Clean Air Act  
waste.

F) Framework for management of hazardous and nonhazardous solid

**2. What waste does lean manufacturing traditionally overlook?**

A) Motion waste.

C) Environmental waste.

B) Over-production waste.

D) None of the above

**3. Traditional value stream maps differ from lean and green value stream maps because they omit what?**

A) A timeline.

C) External information flow.

B) Arrows showing product movement.

D) Environmental metrics.

**4. Explain the relationship between lean and clean.**

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# Pollution Prevention

## Quiz #2

Think about all the waste that is generated at school. Identify 15 types of waste that are most likely being thrown away and propose a preferable waste management solution.

	<b>Waste</b>	<b>Alternate Solution</b>
Example:	Paper in trash can	Recycle paper instead.
1)		
2)		
3)		
4)		
5)		
6)		
7)		
8)		
9)		
10)		
11)		
12)		
13)		
14)		
15)		

# Pollution Prevention

## Quiz #1

### (Answer Key)

1. Match the environmental regulation (left column) with its primary focus (right column). Identify the correct focus by placing its letter next to the name of the regulation:

**Environmental Regulation**

**Primary Focus**

**D** Emergency Planning and Community Right to Know Act

A) Pollution should be prevented or reduced at the source whenever feasible.

**C** Clean Water Act

B) Provides communities with information about toxic chemical releases and waste management activities.

**A** Pollution Prevention Act of 1990

C) Regulates discharges of pollutants into the waters of the United States.

**B** Toxic Release Inventory

D) Protects public health, safety, and the environment from chemical hazards.

**F** Resource Conservation and Recovery Act

E) Regulates air emissions from stationary and mobile sources.

**E** Clean Air Act

F) Framework for management of hazardous and nonhazardous solid waste.

2. What waste does lean manufacturing traditionally overlook?

**C) Environmental waste.**

3. Traditional value stream maps differ from lean and green value stream maps because they omit what?

**D) Environmental metrics.**

4. Explain the relationship between lean and clean.

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**Pollution Prevention  
Quiz #2  
(Answer Key)**

Think about all the waste that is generated at school. Identify 15 types of waste that are most likely being thrown away and propose a preferable waste management solution.

	<b>Waste</b>	<b>Alternate Solution</b>
Example:	Paper in trash can	Recycle paper instead.
1)		
2)		
3)		
4)		
5)		
6)		
7)		
8)		
9)		
10)		
11)		
12)		
13)		
14)		
15)		

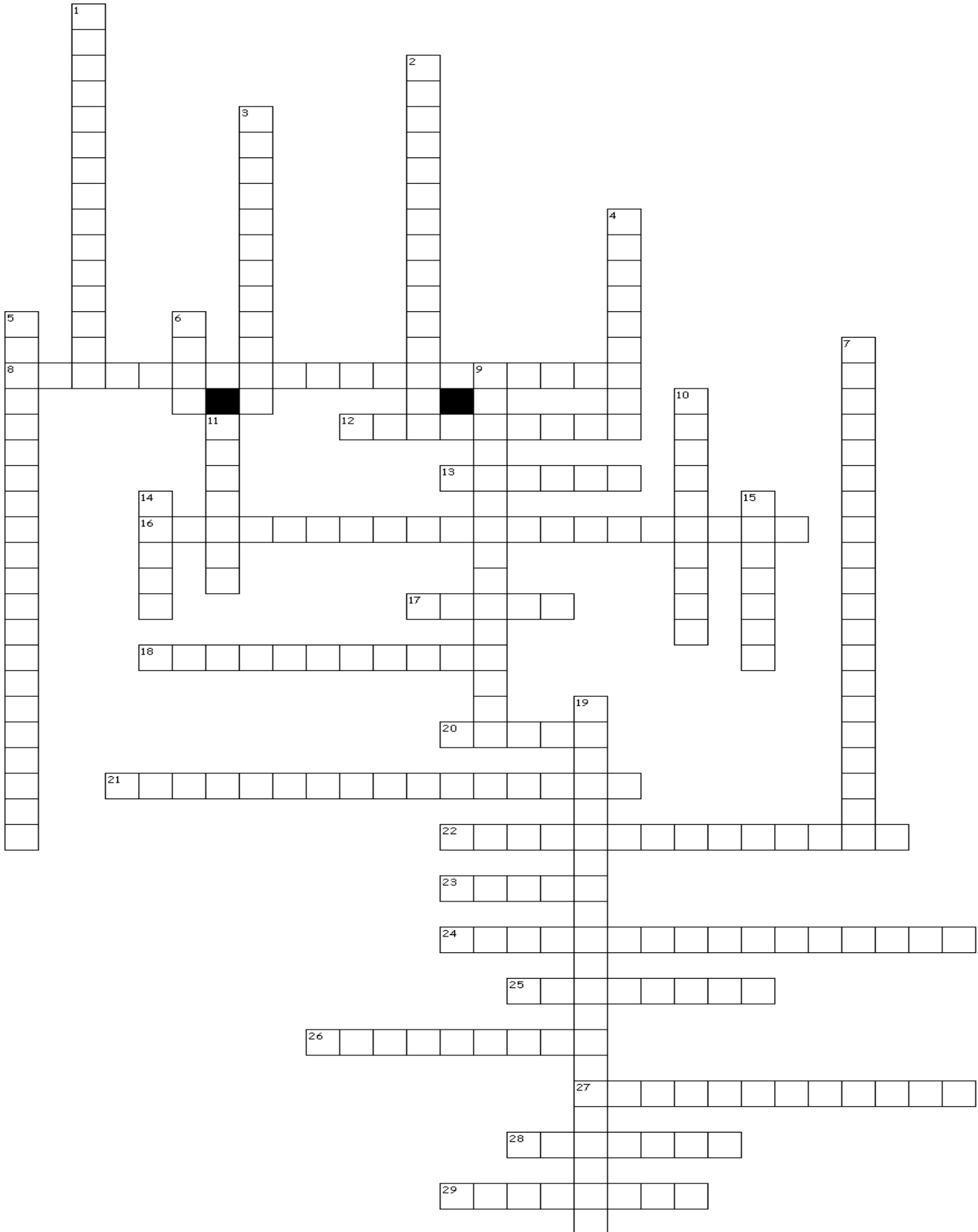
## APPENDIX C: Facilitator Materials

## KWL Chart

<b>What do I know?</b>	<b>What do I want to find out?</b>	<b>What did I learn?</b>

# Environmental Terms Crossword

## Pollution Prevention



**Across**

8. Also known as municipal solid waste. [Two words]
12. When society's demand on natural resources exceeds the biosphere's supply.
13. Opting against the use of products containing toxic substances or chemical components that have a particularly negative impact on the environment.
16. Energy, water, or raw materials consumed in excess of what is needed to meet customer needs. [Two words]
17. A systematic manufacturing approach to eliminating waste by optimizing use and selection of resources and technologies while lessening environmental impact.
18. Any materials discarded from industrial, commercial, mining, or agricultural operations, and from community activities. [Two words]
20. time The time it takes to do a process.
21. Another term for source reduction. [Two words]
22. A line located on the bottom of a value stream map.
23. The unnecessary use of resources or a substance released to the air, water, or land that could harm human health or the environment.
24. Reducing or eliminating waste at the source before it is generated. [Two words]
25. A regulated facility that can properly handle the treatment of municipal solid waste via temporary or permanent storage.
26. To set the pace to a speed at which a process runs smoothly. [Two words]
27. The set of specific actions (value-added and non-value added) taken to bring a product through three critical management tasks of any business. [Two words]
28. Taking a closer look at the product components in manufacturing process to identify opportunities to further reduce waste generation.
29. The discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into the environment.

**Down**

1. Using source reduction, recycling, or composting to prevent or reduce waste generation. [Two words]
2. Waste that is dangerous or potentially harmful to our health or the environment. [Two words]
3. The total flow of solid waste. [Two words]
4. The removal of a pollutant from a waste stream.
5. Common garbage or trash generated by industries, businesses, institutions, and homes. [Three words]
6. A systematic manufacturing approach to identify and eliminate waste through continuous improvement.
7. Identifying areas, processes, and activities which create excessive waste products or pollutants in order to reduce or prevent them through, alteration, or eliminating a process. [Two words]
9. The process of burning solid waste to produce heat or electricity.
10. A controlled biological decomposition of organic wastes into a stable product that can be used as a natural soil amendment.
11. Obtaining energy from non-hazardous waste.
14. Using items again by repairing, donating, or selling them.
15. A series of activities that includes collecting recyclable materials, sorting and processing recyclables into raw materials such as fibers, and manufacturing the raw materials into new products.
19. Conserving natural resources and energy use by managing materials more efficiently. [Two words]

## How Does Waste Affect Our Natural Resources?

*Adapted from A-way With Waste: A Waste Management Curriculum for Schools, 2nd ed., by State of Washington, Dept of Ecology*

[Back to Trash Goes To School](#)

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**GRADE LEVELS:** 9-12

**SUBJECT AREAS:** environmental science, social science

**CONCEPT:** Natural resources are limited.

**OBJECTIVE:** Students will compare estimated life expectancies of some nonrenewable natural resources and will understand the role recycling and careful use play in extending the availability of these resources.

**MATERIALS:**

handouts: [Selected Nonrenewable Natural Resources](#) (PDF file) and [Worksheet: Nonrenewable Resources](#)

**KEYWORDS:** static use, reserve base

**BACKGROUND:** The global demand for and consumption of most major nonfuel mineral commodities is projected to increase three to five percent annually, slightly more than doubling by the year 2000. There is a limit to how long an increasing population can continue to make increasing demands on our finite resources. Concentrated, easily mined reserves of nonrenewable resources are being depleted. The availability of these resources can be extended by careful use and recycling.

**PROCEDURE:**

1. Distribute copies of the table [Selected Nonrenewable Natural Resources: Their Life Expectancies and Prime Consumers](#) (PDF file). Have students complete the [worksheet](#) and/or discuss the questions in class.
2. Discuss three alternate depletion patterns for a nonrenewable resource:
  - A. If we mine it, use it, and throw it away,
  - B. If we recycle it, or
  - C. If we reduce per capita use and recycle what is used.

What would a graph look like of the depletion of a nonrenewable resource under these three scenarios? (*Under Scenario A, the curve would rise steeply, peak sharply, and then fall steeply when supplies are used up. Under Scenario B, the peak would be lower and less sharp, and farther to the right, indicating longer term availability of the resource. Under the third scenario, the peak is further flattened, and availability of the resource is extended even farther into the future.*)

How can we determine how long a given resource might last? Any projections are based on two major sets of assumptions: (1) We must estimate the potentially available supply at existing (or future) acceptable prices and with existing (or improved) technology, and (2) We must estimate the annual rate at which the resources may be used.

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### Worksheet: Nonrenewable Resources

Name \_\_\_\_\_ Date \_\_\_\_\_



**Examine the table "Selected Nonrenewable Natural Resources: Their Life Expectancies and Prime Consumers." Then answer the following questions:**

1. Which column under the heading "Life Expectancy in Years" do you think is more accurate in estimating the length of time our nonrenewable resources will last?
2. What are some factors leading to the accelerated use of resources?
3. Examine the "static use" column under the heading "Life Expectancy in Years." Which nonrenewable natural resource will be used up first?
4. Which countries have the highest reserves of this resource? Locate these countries on a world map.
5. Why does the U.S. need to be concerned with the depletion of this resource?
6. Which nonrenewable resource will last the longest according to the static index?
7. According to the projected rates index?
8. Which countries have the highest reserves of this resource?
9. With which countries will the U.S. need to cooperate in order to get the amount of this resource it needs?

[Back to top](#)

## Selected Nonrenewable Natural Resources: Life Expectancies and Prime Consumers

Resource	1986 Reserve Base	Countries or Areas with Highest Reserves	Prime Consumers (1974)	Life Expectancy in Years		U.S. % Recycled (1984)
				Static Use (1976)	Use Growing at Projected Rates	
Bauxite	23.2 billion metric tons (metric ton= 2,200 lbs.)	Guinea 26% Australia 21% Brazil 15% Jamaica 6%	U.S.A. 42% U.S.S.R. 12%	31	63	Aluminum 25%
Copper	525 million metric tons	Chile 19% U.S.A. 18% U.S.S.R. 7% Zambia 6%	U.S.A. 33% U.S.S.R. 13% Japan 11%	63	36	42%
Gold	1,450 million troy ounces	S. Africa 53% Socialist Economies 20% U.S.A. 8%				35% Refinery production from scrap
Iron in Ore	98 million short tons (short ton= 2,000 lbs.)	U.S.S.R. 29% Brazil 20% Australia 18% Canada 9% U.S.A. 5%	U.S.A. 28% U.S.S.R. 24% W.Germany 7%	172	62	Iron and steel - 23%
Lead	143 million metric tons	U.S.A. 21% Australia 16% Canada 15%	U.S.A. 25% U.S.S.R. 13% W.Germany 11%	37	25	49%
Silver	10.8 billion troy ounces	U.S.A. 21% Canada 19% Mexico 13%	U.S.A. 26% W.Germany 11%	20	17	23% Refinery production from scrap

Tin	3 million metric tons	Indonesia 16%	U.S.A. 24%	41	31
		China 15%	Japan 14%		
		Thailand 12%			
		Malaysia 12%			

Chromium	7.5 billion short tons (1985)	S. Africa 83%
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Platinum	1.2 billion troy ounces (1985)	S. Africa 81%
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## Environmental Impacts of Deadly Wastes

Waste Type	Environmental Impacts
Overproduction	<ul style="list-style-type: none"> <li>• More raw materials and energy consumed in making the unnecessary products</li> <li>• Extra products may spoil or become obsolete requiring disposal</li> <li>• Extra hazardous materials used result in extra emissions, waste disposal, worker exposure, etc.</li> </ul>
Inventory	<ul style="list-style-type: none"> <li>• More packaging to store work-in-process (WIP)</li> <li>• Waste from deterioration or damage to stored WIP</li> <li>• More materials needed to replace damaged WIP</li> <li>• More energy used to heat, cool, and light inventory space</li> </ul>
Transportation and Motion	<ul style="list-style-type: none"> <li>• More energy use for transport</li> <li>• Emissions from transport</li> <li>• More space required for WIP movement, increasing lighting, heating, and cooling demand and energy consumption</li> <li>• More packaging required to protect components during movement</li> <li>• Damage and spills during transport</li> <li>• Transportation of hazardous materials requires special shipping and packaging to prevent risk during accidents</li> </ul>
Defects	<ul style="list-style-type: none"> <li>• Raw materials and energy consumed in making defective products</li> <li>• Defective components require recycling or disposal</li> <li>• More space required for rework and repair, increasing energy use for heating, cooling, and lighting</li> </ul>
Over processing	<ul style="list-style-type: none"> <li>• More parts and raw materials consumed per unit of production</li> <li>• Unnecessary processing increases wastes, energy use, and emissions</li> </ul>
Waiting	<ul style="list-style-type: none"> <li>• Potential material spoilage or component damage causing waste</li> <li>• Wasted energy from heating, cooling, and lighting during production downtime</li> </ul>



Despite these relationships between Lean “deadly wastes” and environmental wastes, Lean implementation efforts often overlook opportunities to prevent or reduce environmental wastes. Your company can enhance its Lean performance by ensuring that environmental wastes are explicitly identified during Lean events and activities. This can be done by extending Lean waste identification activities to consider wasted materials, pollution, and other non-product outputs.

# The Reduce, Reuse, Recycle hierarchy's been turned on its head

*Recycling receives overwhelming attention; reuse and reduce take a back seat.*

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- **Grade level:**  
High School
- **Subject areas:**  
Science, Social Studies, Language Arts
- **Estimated duration:**  
Preparation time: 20 minutes  
*Part one:* 5 minutes to introduce assignment, 25-30 minutes for groups to read through and plan their presentations  
*Part two:* 5-15 minutes/group to present (estimate 50 minutes total)
- **Setting:**  
Classroom
- **Skills:**  
Inferring, interpreting data, recording, presenting data and interpretations to a larger group

## Summary

By exploring and learning about topics in small groups and then preparing a presentation, students will understand the difference between recycling, reuse and waste reduction. They will also learn about waste generated and discarded in the U.S., and will discover that Iowa's legislators identified waste reduction as the preferred waste management strategy.

## Objectives

Students will:

- Develop an understanding of the waste hierarchy and various waste management strategies
- Creatively present their information to classmates, building on the knowledge learned from prior group presentations.

## Materials

- Any materials needed to help students depict the concepts shared with the larger group, such as pop can, newspaper, coffee can, hand-me-down t-shirt, etc. Other helpful materials may include markers, the blackboard, and the Internet.
- *Consumption and Waste*, published in 2004 by Perfection Learning Corporation, Logan, Iowa (Group 3)
- *Stuff: The Secret Lives of Everyday Things*, by John C. Ryan and Alan Thein Durning (Group 4)

## Background

Waste reduction has been largely overlooked as a waste management strategy, yet Iowa's legislators have identified it as the most preferred method of waste management. This lesson helps students understand this management strategy. It serves as an introduction to a unit on waste reduction.

## Procedure: *The Activity*

**Part One:** Briefly introduce the lesson, and break students into 5 groups. Provide supplemental materials as needed to various groups. Allow each group 25-30 minutes to prepare their presentation.

**Part Two:** Have student groups present in sequential order, encouraging each group to build on the information presented by the prior group. Conclude by reviewing the main points of the lesson, including the definitions of recycling, reuse and reduction: Recycling: To use again after re-processing; Reuse: To use again in original condition; Reduction: To prevent the generation of waste.

Then, review why waste reduction is the most preferred method for managing waste.

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## Group 1: 230 Million Tons of Trash

Your task is to help your peers understand:

- 1) **The difference between waste generated and waste discarded** (see \* and \*\* under the waste statistics listed below)
- 2) **Trends in waste generated and waste discarded (both per capita and nationally) in the past four decades**

Be creative! Use lecture as a last resort.

The U.S. is creating more waste, but—fortunately—we are also recycling more. However, recycling alone is not keeping up with increased consumption and waste. In 2000, 100% more waste was sent to landfills and/or incinerators than in 1960. (The population increased by 57% during that time.)

**Here are waste statistics:**

### **Pounds of waste generated\* and discarded\*\* per person per day**

**Generated**—1960: 2.7                      1980: 3.7                      2000: 4.5

**Discarded**—1960: 2.5                      1980: 3.3                      2000: 3.2

*\*before recycling and composting*

*\*\*after recycling and composting*

### **Total waste generation\***

1960: 88.1 million tons/year                      1980: 151.6 million tons/year                      2000: 232 million tons/year

*\*accounts for increase in waste generation and increase in population*

### **Total discards\***

1960: 82.46 million tons/year                      1980: 137 million tons/year                      2000: 164.3 million tons/year

*\*after recycling and composting*

Retrieved from *Municipal Solid Waste in the US:1999 Facts and Figures* at [www.epa.gov/garbage/mswfinal.pdf](http://www.epa.gov/garbage/mswfinal.pdf), p. 2-3. Also retrieved from [[www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw2001.pdf](http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw2001.pdf)], p. 2, 4. Some figures derived from tables "Total recovery" and "Total waste generation."

This lesson plan, titled *The Reduce, Reuse, Recycle Hierarchy's Been Turned On Its Head*, may be found at [www.uni.edu/ceee/wastereduction/lesson\\_plan\\_summaries.htm](http://www.uni.edu/ceee/wastereduction/lesson_plan_summaries.htm).

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## Group 2: Reasons for increased waste

Your task is to:

- 1) **Pick up where Group #1 left off. Among other things, they will discuss trends in waste generated and waste discarded (both per capita and nationally) in the past four decades.** For example, in 1960, 82.46 million tons/year were discarded, and by the year 2000, 164.3 million tons/year were discarded in the U.S. That's a 100% increase in disposal rates. During that time, the population in the U.S. increased 57%.\*
- 2) **Help your peers understand reasons for the increase in waste generated and waste discarded. Brainstorm, expand on the information below, explore the ideas!**  
Be creative. Use lecture as a last resort.

Tip: Several reasons for the increase in waste generated and waste discarded may include:

- 1) Economic boom in the 1990s, leading to more spending and increased consumption per person
- 2) Busier lives, more convenience foods, therefore more over-packaged products. Could this also lead to more cars/household? Are there other waste consequences as a result of busier lives?
- 3) More people living alone
- 4) More technologies available (how many TVs, computers, phones, etc. are in the average household compared to 40 years ago?)
- 5) Bigger homes (Average square foot of new construction, residential housing was 1,500 in 1970 and 2,225 square foot in 1999)\*\*
- 6) Advertising expenditures continue upward (\$12 Billion in 1960; \$129 Billion in 1990; retrieved from *The Concise Encyclopedia of Economics*, <http://www.econlib.org/library/Enc/Advertising.html>) Note: This increase has remained at about 2% of GNP during this timespan.

What other factors might be involved?

\*Retrieved from *Municipal Solid Waste in the US: 1999 Facts and Figures* at [www.epa.gov/garbage/mswfinal.pdf](http://www.epa.gov/garbage/mswfinal.pdf), p. 2-3. Also retrieved from [[www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw2001.pdf](http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw2001.pdf)], p. 2, 4. Some figures derived from tables "Total recovery" and "Total waste generation."

\*\*Retrieved October 31, 2005 from *Statistical Abstract of the United States*, "#1197, Characteristics of New Privately Owned One Family Houses Completed 1970-1999," page 714, at <http://www.census.gov/prod/2001pubs/statab/sec25.pdf>.

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## Group 3: What is recycling? What is reuse?

Your task is to:

- 1) **Pick up where Group #2 left off.** They will talk about reasons for increased waste generation.
- 2) **Help your peers understand AND remember the difference between recycling and reuse.**  
Tip: The working definitions are the easiest to comprehend and remember, though the other definitions may give you ideas and more depth.
- 3) **Help your peers understand trends in recovery rates over the last four decades.**

Be creative! Use lecture as a last resort.

### Recycling

**Working definition:** To use again after re-processing

**Formal definition:** The process of collecting, sorting, cleansing, treating and reconstituting materials that would otherwise become solid waste, and returning them into the economic mainstream in the form of raw material for new, reused, or reconstituted products which meet the quality standards necessary to be in the marketplace. Retrieved 6/3/03 at

<http://eetd.LBL.gov/EA/Buildings/BNordman/C/consmain.html>, p. 11.

**Examples:** Newspapers and plastic milk jugs are examples of materials that are readily recyclable.

Note: For more information about recycling, refer to pages 16-19 in *Consumption and Waste*, published in 2004 by Perfection Learning Corporation, Logan, Iowa.

### Reuse

**Working definition:** To use again in original condition

**Formal definition:** A form of disposal that uses a discard item again as itself. Reuse generally thrives in decentralized locations that serve local markets. Nearly everything reusable can be scrapped, but once it is scrapped, it can no longer be reused. Retrieved 6/3/03 at

<http://eetd.LBL.gov/EA/Buildings/BNordman/C/consmain.html>, p. 14.

**Examples:** Hand-me-down clothes and coffee cans used to store nails are examples of reuse.

### Total recovery (includes recycling and composting)

1960: 6.4%

1980: 9.6%

2000: 29.2%

Retrieved from *Municipal Solid Waste in the US: 1999 Facts and Figures* at [www.epa.gov/garbage/mswfinal.pdf](http://www.epa.gov/garbage/mswfinal.pdf), p. 2-3. Also retrieved from [[www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw2001.pdf](http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw2001.pdf)], p. 2, 4. Some figures derived from tables "Total recovery" and "Total waste generation."

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## Group 4: What is waste reduction?

Your task is to:

- 1) **Pick up where Group #3 left off.** They will help peers understand the difference between recycling and reuse.
- 2) **Help your peers understand the meaning of waste reduction, and how it differs from recycling and reuse. You may need to review the definitions discussed by Group #3** (recycling: to use again after re-processing; reuse: to use again in original condition).

Be creative! Use lecture as a last resort.

### Waste Reduction

What does it mean to "reduce waste?" Simply, it's *preventing* the generation of waste. Just as maintaining good health (or *preventing* illness) reduces the need for treatment of disease, waste prevention reduces the need for handling and processing of garbage. Here are a few examples:

- Soft drink can manufacturers have reduced aluminum waste by redesigning cans to use less aluminum. (See *Stuff: The Secret Lives of Everyday Things*, by John C. Ryan and Alan Thein Durning, page 64)
- When we use canvas bags at the grocery store, we are reducing paper or plastic waste by voluntarily changing our behavior.
- When we use non-toxic cleaning supplies, we are reducing the need, and therefore the production, of toxic constituents.
- Most bottles, cans and jars are produced with fewer materials today than 30 years ago. For example, one 2-liter bottle is 51 grams today, but was 68 in 1977. This change alone has kept 250M pounds of plastic out of the waste stream (*Consumption and Waste*, © Perfection Learning Corporation, Logan, Iowa, page 15).

What is the best way to address the waste problem? Stop waste before it starts.

**Working definition:** Prevent generation of waste

**Formal definition:** Any action that avoids the creation of waste by reducing waste at the source, including redesigning of products or packaging so that less material is used; making voluntary or imposed behavior changes in the use of materials; or increasing durability or reusability of materials. Also includes reduction of the use of toxic constituents. This action is intended to conserve resources, promote efficiency, and reduce pollution. Retrieved 6/3/03 at

<http://eetd.LBL.gov/EA/Buildings/BNordman/C/consmain.html>, p. 11-13.

**Other terms:** Source reduction, waste reduction, volume reduction at the source

**Examples:** Lightweighting of plastic bags and aluminum cans, not buying a t-shirt or TV based on identified needs, rationing of coffee, buying products with less packaging (such as cereal in a 15-oz. bag instead of cereal in individual serving sizes), and using baking soda or vinegar to clean instead of bleach are examples of waste reduction.

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Group 5: What is the waste hierarchy?

**Your task is to:**

- 1) **Pick up where the other groups left off. They will talk about waste and the difference between recycling, reuse and reduction.**
- 2) **Help your peers understand AND remember the waste management hierarchy, as set by Iowa's state legislators.**
- 3) **Using information learned from the other groups, identify why it is important to know and practice the hierarchy.**

Be creative! Use lecture as a last resort.

## **Code of Iowa: 455B.301A Declaration of policy.**

1. The protection of the health, safety, and welfare of Iowans and the protection of the environment require the safe and sanitary disposal of solid wastes. An effective and efficient solid waste disposal program protects the environment and the public, and provides the most practical and beneficial use of the material and energy values of solid waste. While recognizing the continuing necessity for the existence of landfills, alternative methods of managing solid waste and a reduction in the reliance upon land disposal of solid waste are encouraged. In the promotion of these goals, the following waste management hierarchy in descending order of preference, is established as the solid waste management policy of the state:

- a. Volume reduction at the source. (Author's note: Volume reduction is the same as waste reduction.)
  - b. Recycling and reuse.
  - c. Other approved techniques of solid waste management including, but not limited to, combustion with energy recovery, combustion for waste disposal, and disposal in sanitary landfills.
2. In the implementation of the solid waste management policy, the state shall:
- a. Establish and maintain a cooperative state and local program of project planning, and technical and financial assistance to encourage comprehensive solid waste management.
  - b. Utilize the capabilities of private enterprise as well as the services of public agencies to accomplish the desired objectives of an effective solid waste management program.

87 Acts, ch 225, §405; 94 Acts, ch 1177, §1

(Retrieved 10/31/2005 from

<http://nxtsearch.legis.state.ia.us/NXT/gateway.dll/moved%20code/2005%20Iowa%20Code/1?f=templates&fn=default.htm>)

This lesson plan, titled *The Reduce, Reuse, Recycle Hierarchy's Been Turned On Its Head*, may be found at [www.uni.edu/ceee/wastereduction/lesson\\_plan\\_summaries.htm](http://www.uni.edu/ceee/wastereduction/lesson_plan_summaries.htm).