Finding Opportunities for Improvement

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Finding Opportunities

- Once you have an idea of where your company's most important environmental impacts are, you will need to take a closer look at your operations and your product's life cycle.

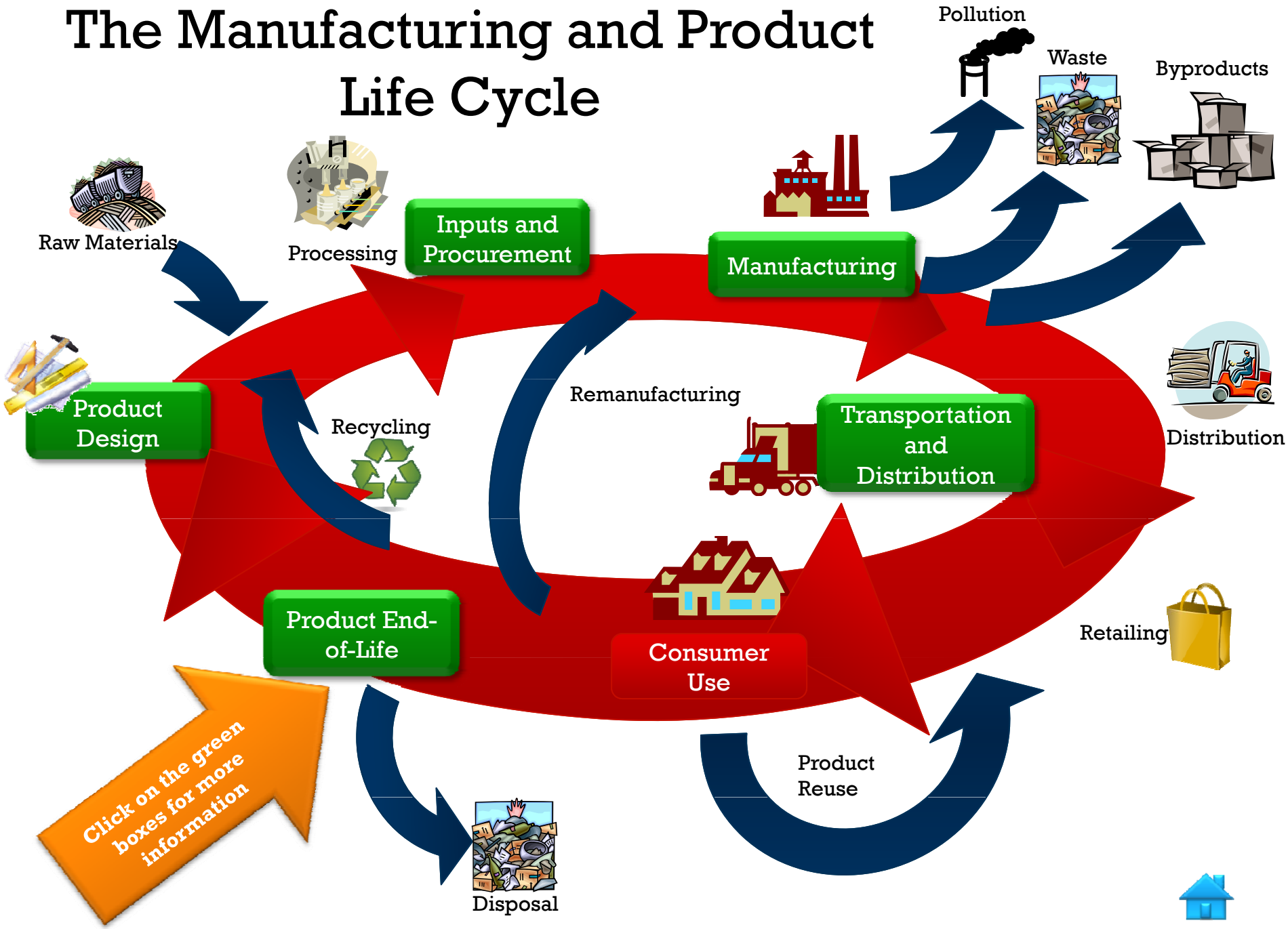
- This will help you identify possible projects that will lower your impact and possibly help your company's competitiveness.

- In this lesson, we will cover in greater detail, specific issues throughout your product's life cycle.

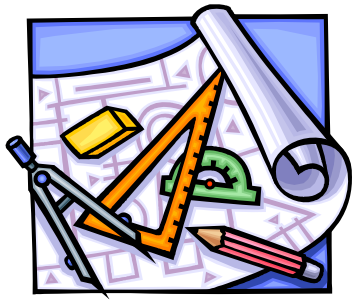
Lesson Organization

- As we discussed in the lesson, Getting Started and Understanding Your Impact, the product life cycle has several stages, including:
  - Product design
  - Inputs and procurement
  - Manufacturing
  - Transportation and distribution
  - Product end-of-life
- **On the next slide is a graphic showing the product life cycle. To learn more about environmental issues in each stage and how they can be addressed, click on the green boxes.**

The Manufacturing and Product Life Cycle



Product Design



- **Just as most of the cost of producing a product is decided in the design phase, so is most of a product's environmental impact.**
- In Design for Sustainability you consider environmental, economic, and social concerns while you are designing the product.[1]
- In addition to lowering the impact of your product, this can result in production cost savings since green design principles lead to increased energy and resource efficiency.
- While designing a new greener product or redesigning a product using green design principles can be difficult and a large investment, it allows you to have the greatest impact on the footprint of your product.

Terms You'll Hear

- **Design for Sustainability**
- **Design for the Environment (DfE)**
- **Green Product Design**
- **Sustainable Design**
- **Design for (Recycling, Energy Efficiency, etc.)**
- **Cradle-to-Cradle**

[1] United Nations Environment Programme and Delft University of Technology "Design for Sustainability A Step-by-Step Approach."

Green Product Design

- You can design a product focusing on its overall lifecycle environmental footprint, but also design for specific attributes such as recycling, energy efficiency, remanufacturing, minimization of hazardous materials.
- To be most successful, sustainability should be fully integrated into a company's design process, and the goals and objectives of sustainable design should be aligned with the overall strategy of the company.[1]

Green Product Design Considers Things Such as:

- the materials, energy and other resources used to make the product
- the energy and resources the product will consume over its lifetime
- how the product will be disposed of

Example

- Sycamore Technology has designed a single blade ceiling fan inspired by the shape of a falling sycamore tree seed pod. The aerodynamic design works at a low operating speed and uses significantly less energy than required by most traditional ceiling fans.[2]

[1] UNEP "Life Cycle Management: A Business Guide to Sustainability"
[2] Ask Nature "Sycamore Technology"

Customer Needs

- Before you start designing a new green product or redesigning your products, you need to think about **what green attributes your customers want**.
- Do they want the product to use less energy? Not contain toxic chemicals? Be easier to recycle? Or is price the primary concern?
- You need to make sure that using green design principles will add value to your product.
- Consumers are demanding more greener products, but it's critical that the products be comparable in performance and price to the less-sustainable alternatives.

Example

- Method produces a line of distinctive, sustainably designed cleaning products. The company focused on the customer desire for cleaning products that work, that are safe and non-toxic, and that have stylish but less environmentally damaging packaging. The products are designed using natural, biodegradable, clean and safe ingredients. Packaging uses minimal materials, is made of recycled or sustainable materials and is recyclable.[1]

[1] Matthew Wheeland, GreenBiz, "The Method Method: Green, Nimble and Disruptive"

Design For Sustainability Approaches

- When designing or redesigning a product, you can use the approaches below. You may want to select only a few approaches to prioritize based on the products major impacts and customer needs.[1]

- The United Nations has created a list of rules of thumb to help you select the appropriate design for sustainability approaches.[2]

Using Low-Impact Materials

Using Fewer Materials

Better Production Processes

Improved Distribution

Use Phase Impacts

Product Lifetime

Product End-of-Life

[1] United Nations Environment Programme and Delft University of Technology "Design for Sustainability A Step-by-Step Approach."
[2] United Nations Environment Programme and Delft University of Technology "Design for Sustainability Rules of Thumb"

Design Approaches

- Let's take a closer look at these design for sustainability approaches and see how they can be implemented when designing a product.[1]

Using Low-Impact Materials

- Use materials that are less toxic, polluting or energy intensive and that are renewable, recycled, or recyclable

Using Fewer Materials

- Design your products to weigh less through better construction and to be easier to transport through lower weights and smaller product volumes (i.e. foldable or nested for shipping).

Better Production Processes

- Design production processes that are cleaner and more efficient, that use less energy, produce less waste, and that create a safe work environment.

[1] United Nations Environment Programme and Delft University of Technology "Design for Sustainability Rules of Thumb"

Design Approaches (continued)

Improved Distribution

- Reduce your product's packaging and make it reusable. Use greener materials for packaging and energy efficient transport. Improve logistics' efficiency.

Use Phase Impacts

- Design your product to use less energy, fewer auxiliary materials (e.g. bag-less vacuum) and to create less waste by ensuring that the customer uses the product properly each time.

Product Lifetime

- Design your product for reliability and durability. Make it easier to repair and maintain. Make it modular so it can be upgraded, and think about a service or maintenance system.

Product End-of-Life

- Make the product reusable, "remanufacturable" or recyclable. Make sure recycling facilities exist. Ensure that it does not contain toxic materials that would be difficult to dispose of.

Product Redesign

You may want to start with an existing product and redesign it.

The United Nations Environment Programme suggests a simplified nine step approach to product redesign.[1]

1. Select the product you want to focus on
2. Gather information about the product into a dossier
3. Learn about the environmental and social issues in your market
4. Think about your product using typical Design for Sustainability approaches
5. Understand where your product's impacts are
6. Define your targets for improvement and which design approaches you will take
7. Come up with redesign ideas
8. Prioritize your ideas
9. Make a business case for redesigning the product

Click here to learn more about the product redesign process.

[1] United Nations Environment Programme and Delft University of Technology "Design for Sustainability A Step-by-Step Approach."

Biomimicry

- An important concept in sustainable design is biomimicry.
- Biomimicry is the process of observing and studying the way nature is designed and operates, then imitating or mimicking this in man-made products and processes.[1]
- In this video, biomimicry expert Janine Benyus discusses biomimicry and how companies are using nature as an inspiration. A second video by Ms. Benyus can be found here.

Example

- Columbia Forest Products developed a formaldehyde-free wood glue after studying the natural protein adhesives used by the blue mussel, which attaches itself to objects underwater. The new wood glue, PureBond, is soy-based and used in making plywood products.[2]

[1] Biomimicry Institute. "What is Biomimicry?"
[2] Ask Nature "PureBond Technology"

Cradle-to-Cradle

- Cradle-to-Cradle is another well-known approach to sustainable design.
- It goes beyond ideas such as eco-efficiency and explores ways industry and the environment can be mutually supportive.
- Cradle-to-cradle design views industry as an ecosystem where materials are nutrients that circulate in the system over and over without waste.
- In this video, William McDonough discusses cradle-to-cradle design.

Certifying Your Green(er) Product

Once you've improved the sustainability of your product, you may want to certify it.

- **Eco-labels are voluntary certifications for a product's environmental performance.**[1]
- They are organized and run by various types of organizations all over the world.
- Certification is usually given by independent, third-party organizations, and labels usually describe one or more product attributes rather than the product's overall impact.
- The International Organization for Standardization (ISO) has classified environmental labeling into three categories:[2]
  - **Type I** – these are voluntary, third-party programs based on multiple criteria. They award labels to products based on their overall environmental performance using life cycle metrics.
  - **Type II** – these are the claims made by the producers of the products on product labels or in advertising.
  - **Type III** – this is the environmental data for a product with parameters based on the ISO 14040 standards series.

Examples of Eco-Labels

Design for the Environment U.S. EPA

energy ENERGY STAR

FSC

[1] Global Ecolabelling Network "What is Ecolabelling?"
[2] Bill Dee "Environmental Labelling Standards in the ISO 14000 Series."

Eco-Labels and Certifications

- There's no national standard eco-label for all products.
- There are many different eco-labels, and they may not be well understood by customers. For example, there were more than 300 labels worldwide in 2010.[1]
- Sometimes industries develop industry-wide product standards.
- Therefore, although there may be many labels to choose from, not all will be appropriate based on your product's attributes.
- Other countries where you export your products may have their own eco-labels that are not recognized in the U.S.

[1] Joshua Saunders. GreenBiz. "Are There too Many Eco-Labels and Green Ratings?"

Marketing Your Green(er) Product

- All advertisements and labels referring to green aspects of your product or package must be truthful, non-misleading, and backed up with competent and reliable evidence.[1]
- You must possess substantiation for every meaning that buyers – both downstream corporate purchasers and ultimate individual consumers – reasonably take away.
- You should avoid vague claims. Specific claims tend to be easier to substantiate
  - The Federal Trade Commission's (FTC) guidance for industry on making non-deceptive green claims is found at Part 260 of Title 16 of the Code of Federal Regulations, and available online at www.ftc.gov/green. It features numerous examples of how to make truthful, non-misleading claims.
  - The FTC is currently reviewing those guidelines. The latest announcements about the review process and proposed changes to the guides also can be found online at the link above.

[2] Federal Trade Commission. "Guides for the Use of Environmental Marketing Claims"

Greenwashing

- Greenwashing happens when companies use untrue, misleading, unsubstantiated, or ineffective environmental marketing claims about their products or company.
- It can range from vague and general claims about being "environmentally friendly," to claims about greener products when the company has a lot of environmental problems, to made up eco-labels, to actual lying.[1]
- Some kinds of greenwashing are regulated by the Federal Trade Commission. To ensure that your company's environmental claims are in compliance with FTC marketing rules, it is important that you become familiar with the FTC's Guides for the Use of Environmental Marketing Claims.

If people believe companies are greenwashing, they are less likely to trust all environmental claims whether those claims are true or not.

In this way, greenwashing by some companies can hurt businesses that are really making environmental improvements.

[1] Rina Horiuchi and Ryan Schuchard. BSR. "Understanding and Preventing Greenwash: A Business Guide"
[2] Business for Social Responsibility "Eco-promising: Communicating the Environmental Credentials of your Products and Services."

Greenwashing and the FTC[1]

- The Federal Trade Commission, in order to maintain fair competition, has the power to investigate any company it believes may be falsely advertising the environmental integrity of their practices or products.
- If the FTC has "reason to believe" that a company is engaging in deceptive advertising practices, the FTC can initiate an "enforcement action", which may include substantial fines.
- The FTC has established four basic principles that should apply to all environmental marketing claims made in the U.S. These include:

Clarity and prominence of any qualifications and disclosures regarding the claim

Clarity on whether the claim applies to the product, package, service or components of any of these

Avoidance of overstating environmental attributes and claims

Clarity of comparative statements

[1] Federal Trade Commission. "A Brief Overview of the Federal Trade Commission's Investigative and Law Enforcement Authority"

Greenwashing Examples[1]

- In its Green Guides, the FTC provides examples of what marketing practices fall within and outside of FTC guidelines.

Greenwashing	Not Greenwashing
• A box of aluminum foil is labeled with the claim "recyclable," without further elaboration. • A pump spray product is labeled "environmentally safe" even though most of the product's active ingredients consist of volatile organic compounds (VOCs). • A manufacturer of home electronics labels its video cassette recorders ("VCRs") as "40% recycled" when, in fact, each VCR contains 40% reconditioned parts. • An advertiser claims that disposal of its product generates "10% less waste" but does not clarify what exactly this means.	• A company labels its soft drink bottle "recycled" and can prove that it is indeed made entirely from recycled materials. • A manufacturer makes claims that its package is compostable, but clearly discloses that the package is not suitable for home composting. • A paper product is labeled as containing "100% recycled fiber." The claim is not deceptive if the advertiser can substantiate the conclusion that 100% by weight of the fiber in the finished product is recycled. • A laser printer toner cartridge containing 25% recycled raw materials and 40% reconditioned parts is labeled "65% recycled content, including 40% from reconditioned parts."

[1] Federal Trade Commission. "Guides for the Use of Environmental Marketing Claims"

Best Practices for Effective Environmental Communication[2]

- Really understand your products' biggest impacts so you can prioritize them
- Be transparent in your communications with your customers
- Seek independent verification of your claims to enhance trust
- Don't make claims "in a vacuum" – claims have to be part of an overall sustainability strategy
- Help your customers act – make greener products more available and use rewards to influence better purchasing
- Understand your customers and their needs so you can target them more effectively
- Anticipate and use new technologies that can help you communicate with your customers
- Play a part in the rule-making process for environmental communication

- This guide from BSR includes checklists and other guidance to help you make sure you're not greenwashing.

[1] Rina Horiuchi and Ryan Schuchard. BSR. "Understanding and Preventing Greenwash: A Business Guide"
[2] Business for Social Responsibility "Eco-promising: Communicating the Environmental Credentials of your Products and Services."

Green Government Procurement

- You may want to sell your greener product in the government marketplace.

- U.S. federal, state and local government expenditures total close to $1 trillion annually. Government agencies often use this considerable buying power to drive the market for green goods and services.[1]

- The U.S. implemented a **federal green government procurement policy** in 1993 via Executive Order. Since then, other Executive Orders have built on this policy, giving preference to products and services that help the federal government reduce its environmental footprint and setting environmental performance goals for federal agencies.[2]

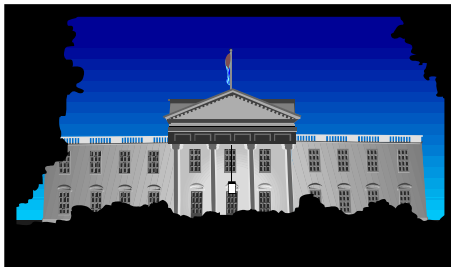
[1] Bloomberg New Energy Finance, "Crossing the Valley of Death"
[2] Environmental Protection Agency. "Environmentally Preferable Purchasing-Program History."

Green Federal Procurement

- Executive Order 13514, "Federal Leadership in Environmental, Energy and Economic Performance", the latest in a series of Executive Orders on green federal procurement, builds on those issued since 1993.

- E.O. 13514 sets energy and resource efficiency goals for the federal government that, among others, include:[1]
  - 28% reduction in direct (Scope 1 and 2) GHG emissions and 13% reduction in indirect emissions (Scope 3)
  - 30% reduction in vehicle fleet petroleum use by 2020;
  - 26% improvement in water efficiency by 2020;
  - 50% recycling and waste diversion by 2015;
  - Implementation of the 2030 net-zero-energy building requirement;

- Meeting these goals and others will require considerable investments in clean technologies, services as well as environmentally preferable consumer products, creating substantial opportunities for U.S. businesses.



[1] White House. "Federal Leadership in Environmental, Energy and Economic Performance - EXECUTIVE ORDER 13514"

Green Government Procurement – Additional Resources

- The General Services Administration has useful information on green procurement of goods and services by the federal government. It also has an environmental section as part of its online procurement system where you can search for green products and services.
- The Small Business Association has many resources for companies looking to begin selling their products to the government.
- The EPA's Environmentally Preferable Purchasing page has information for businesses looking to buy or sell green products.
- The Federal Government and EPA maintain lists of environmentally preferable products by sector and their associated "environmental attribute recommendations."

Green Federal Procurement Efforts

- The federal government administers a host of **environmental certification programs**, designed to both help U.S. consumers to make sound environmental purchasing decisions and assist the federal government in meeting its green procurement obligations. Here are just a few:
  - The Department of Agriculture's BioPreferred program qualifies biobased consumer products.
  - EPA works with the Department of Energy to qualify energy-efficient products and building practices through the ENERGY STAR® program.
  - EPA's Design for the Environment program labels chemical products that have less harmful effects on human health and the environment compared to chemicals in the same class.
  - EPA's WaterSense program labels water efficient products and services.[1]
- Click on any of the above links to find out more about how you can get your product/s certified through these programs.

[1] EPA, Federal EPP Efforts

Green Product Design Checklist

- ✓ Think about the demands your customers have. What attributes would they want in a greener product?
- ✓ Think about what goes into your product, how its made and how its used. Are there opportunities for cost savings or risk mitigation (regulatory, supply chain, brand-related or otherwise)?
- ✓ If redesigning a product, once you've chosen a product to improve, gather information on that product's impacts across its lifecycle.
- ✓ Choose impacts to target for improvement.
- ✓ Select a design for sustainability approach that best addresses your targeted impacts.
- ✓ Determine if a certification would help your product.
- ✓ Ensure that you aren't greenwashing – misleading your customers with your green claims.
- ✓ Consider marketing your greener product to the government
- ✓ Remember that greening is a continuous process. You should always be looking for ways to improve your product and manufacturing process.

Where to Go for Help

- EPA's Design for the Environment (DfE) program and product stewardship program
- EPA has a guide on greening your products
- Check your industry associations to see if your industry has information on green design
- Check colleges and universities that specialize on your industry
- The Federal Trade Commission provides guidance to companies on making green advertising and labeling claims.
- Review UNEP site on sustainable design

Search

- Green Product Design
- How-to Guides

Inputs and Procurement

- Opportunities to enhance environmental performance and reduce costs can be found in both the procurement of inputs and equipment for the production process or for general operations.

- Though much of what ends up in a company's final product is determined in the design stage, there is often room for incorporating sustainability principles in the purchase of product inputs.

- Similarly, for process and operational inputs, thinking about things like total cost of ownership or even employee safety can bring significant long-term cost savings and/or mitigate downside risks.

Example

- Wausau Tile, a tile manufacturer in Wausau, WI, uses post-consumer/post-industrial glass in their architectural products as a way to enhance the attractiveness of their tiles and furnishings. In 2009 alone, the company used 500 tons of used glass and has recently introduced a new line of products using post-industrial porcelain.[1]

[1] OECD. "Sustainable Manufacturing Toolkit"

Product Input Selection[1]

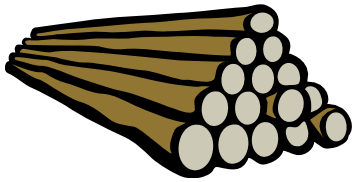
- The OECD's Sustainable Manufacturing Metrics Toolkit breaks product input attributes down into four categories, each of which carry some degree of environmental impact:
  - Finite
    - Non-renewable substances deplete supplies of natural resources and may cause serious environmental damage during extraction.
  - Resource-intensive
    - Large amounts of energy and other resources may be required to produce the inputs.
  - Harmful
    - Substances that are restricted by law or that are toxic to health and the environment.
  - Renewable, recyclable, or reused
    - Tend to have a lower environmental impact.

Possible Approaches	Benefits
• Reduce the use of materials. • Minimize harmful substances. • Substitute harmful materials with less damaging alternatives. • Increase use of renewable and recyclable materials.	• Reduces expenditure on materials. • Reduces costs related to handling, storage and treating waste • Carries a lower regulatory compliance burden • Reduces waste disposal requirements.

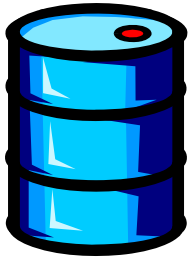
[1] OECD. "Sustainable Manufacturing Toolkit"

Materials Choices

- The choice of materials to make your product is critical
- The U.S. is reliant on nonrenewable materials. In 1900, more than 40% of the materials used in the U.S. were renewable, but only 6% were in 1995.[1]



- It is important to consider the life cycle impacts of the materials you purchase. For example:
  - Does the process of obtaining the materials pollute the water or air?
  - Are the materials acquired through deforestation?
  - Does it require a lot of energy to produce the materials?
  - Is the material itself hazardous?



[1] US Environmental Protection Agency. "Sustainable Materials Management: The Road Ahead"

Materials Impacts

- As we have seen, different materials can have widely different environmental impacts.
- It can sometimes be difficult to determine which materials are better or worse.
- Sustainable Materials Management: The Road Ahead, a 2009 study from the EPA, documented the environmental impacts from 480 materials, processes and services to identify their impacts and identify which ones have the highest impacts.
- The data from that study and the final report are available through the link above.

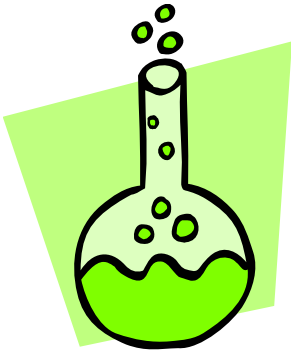
Example

- Acknowledging the impact of many of the materials it uses, Ford Motor Company has worked to develop alternative materials to replace petroleum and mineral-based materials. For example, it developed a foam made from soy that is now used in seat cushions. It is also working on fabrics made from recycled plastics and other plastics that are biodegradable.[1]

[1] GreenBiz, "Ford Explores 'Suede' Fabrics Made From Pop Bottles, Nanotechnology, and More"

Chemicals Considerations & Green Chemistry

Chemicals are in virtually everything we see and touch today. As more and more attention is paid by customers and governments as to what types of substances are in the products we use, it has become increasingly important that manufacturers understand the full impacts of their product inputs.[1]



[1] "Green Chemistry at a Glance." *American Chemical Society.*

Green Chemistry

What is Green Chemistry?

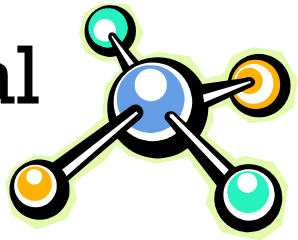
- Green chemistry involves the **design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances.**[1]

Why is green chemistry important for me?

- Though not all manufacturers design the chemicals that go into their products and processes, it's important that all manufacturers understand the impacts of the chemicals and materials they use.

[1] EPA, Green Chemistry

Benefits to Using Greener Chemical Inputs



- Reduced hazardous waste, eliminating costly end-of-the-pipe treatments
- Safer products that stand up to customer and regulatory scrutiny
- Enhanced employee safety
- Improved competitiveness[1]

Example

In 2003, Shaw Industries, Inc. won the EPA's Designing Greener Chemicals Award for developing EcoWorx Carpet Tile. Shaw selected a combination of polyolefin resins from Dow Chemical as the base polymer of choice for EcoWorx™ due to the low toxicity of its feedstocks, superior adhesion properties, dimensional stability, and its ability to be recycled. From its inception, EcoWorx™ met all of the design criteria necessary to satisfy the needs of the marketplace from a performance, health, and environmental standpoint. The cost of collection, transportation, and return to the EcoWorx™ manufacturing process is less than the cost of using virgin raw materials.[2]

[1] "Green Chemistry." *US Environmental Protection Agency*.
[2] " Green Chemistry." *US Environmental Protection Agency*.

12 Principles of Green Chemistry

1. Prevention	• It is better to prevent waste than to treat or clean up waste afterwards.
2. Atom Economy	• Design synthetic methods to maximize the incorporation of all materials used in the process into the final product.
3. Less Hazardous Chemical Syntheses	• Design synthetic methods to use and generate substances that minimize toxicity to human health and the environment.
4. Designing Safer Chemicals	• Design chemical products to affect their desired function while minimizing their toxicity.

Source: "Science Matters- Twelve Principles of Green Chemistry." Environmental Protection Agency.

5. Safer Solvents and Auxiliaries

- Minimize the use of auxiliary substances wherever possible make them innocuous when used.

6. Design for Energy Efficiency

- Minimize the energy requirements of chemical processes and conduct synthetic methods at ambient temperature and pressure if possible.

7. Use of Renewable Feedstocks

- Use renewable raw material or feedstock whenever practicable.

8. Reduce Derivatives

- Minimize or avoid unnecessary creation of derivatives, if possible, because it requires additional reagents and generate waste.

Source: "Science Matters- Twelve Principles of Green Chemistry." Environmental Protection Agency.

9. Catalysis

- Catalytic reagents are superior to stoichiometric reagents.

10. Design for Degradation

- Design chemical products so they break down into innocuous products that do not persist in the environment.

11. Real-Time Analysis for Pollution Prevention

- Develop analytical methodologies needed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

12. Inherently Safer Chemistry for Accident Prevention

- Choose substances and the form of a substance used in a chemical process to minimize the potential for chemical accidents, including releases, explosions, and fires.

Source: "Science Matters- Twelve Principles of Green Chemistry." Environmental Protection Agency.

The Impact of Capital Purchases

- Total Cost of Ownership is a method of estimating both the immediate and long-term costs (including natural resource consumption and/or environmental impacts) of a product or system and is often an important calculation to run prior to making a large capital equipment investment.

- Factoring the long-term cost implications (such as energy efficiency) of a capital investment is important when assessing an investment's true value. Premiums for higher quality equipment sometimes result in greater long-term cost savings.

- The TCO worksheet on the following slide provides one way of estimating the total direct and indirect costs associated with a typical equipment purchase.

Description	Amount
Initial Investment	
Equipment Base Price	$_____
Equipment Options	$_____
Factory Acceptance Test (FAT)	$_____
Platforms	$_____
Spare Parts	$_____
Installation Costs	$_____
Training Costs	$_____
Training Documentation	$_____
Start Up Costs - Technician On-Site	$_____
On-Site Qualification & Verification Support	$_____
Service Contract	$_____
Warranty (beyond standard period)	$_____
Taxes	$_____
Freight Charges	$_____
Total Initial Investment	$_____
Annual Operating and Maintenance Costs (to be aggregated over product's expected lifespan)	
Maintenance Costs	
Spare Parts - Electrical	$_____
Spare Parts - Mechanical	$_____
Technical Service Labor Costs	$_____
Changeover & Downtime Costs	
Downtime for Change Parts	$_____
Expected Service Downtime	$_____
Natural Resource Consumption & Waste Disposal Costs	
Electricity/Energy	$_____
Water	$_____
Line Lubrication	$_____
Solid Waste Handling Cost	$_____
Hazardous Waste Handling Cost	$_____
Wastewater Handling Cost	$_____
Salvage Value At End Of Life	($_____)
Total Cost of Ownership	$_____

Source: Deloitte Consulting LLP and Hartness International

Green Purchasing

- Green purchasing can also apply to any products or technologies used in non-production related operations, which may include things like:
  - Office Equipment
  - Stationery
  - Carpeting
  - Cleaning materials
  - Furniture. [2]

Product Attributes to Look For When Buying Green
• Biobased content
• Biodegradable
• Energy efficient
• Enhanced indoor environmental quality
• Low embodied energy
• Recyclable or reusable components
• Recycled content
• Reduced environmental impact over the lifecycle
• Non-toxic or reduced toxicity
• Reduced waste
• Water efficient[1]

[1] EPA. "Environmentally Preferred Purchasing"
[2] EPA. "Environmentally Preferred Purchasing- Products and Service"

Supplier Engagement

- Engaging your suppliers can play a key role in reducing the environmental footprint of your inputs and equipment.

- By better communicating to your suppliers what you are trying to achieve , they in turn will be in a better position to provide you with the inputs you need.

- The following slides provide some helpful tips for engaging your suppliers in green initiatives.

Helpful Tips for Engaging Suppliers[1]

1. **Clearly communicate your sustainability goals to your suppliers.** The more they understand what you're trying to achieve and what you need to achieve it (be it greener inputs or environmental data), the more likely they will be able to provide it.

2. **Communicate the business case for what you're asking them to do.** If your suppliers understand how your requests for greener products or data can lead to cost savings and/or added value, they may be more inclined to work with you.

3. **Begin by working with the right suppliers.** When starting down the path of green input procurement, identify those suppliers you believe are best positioned to help you reduce your footprint or have green programs themselves.

[1] GreenBiz, "Ten Things to Know About Engaging Suppliers for Green Programs."

Helpful Tips for Engaging Suppliers[1]

4. **For ambitious or large scale supplier engagement, explore partnerships with NGOs and universities.** Partnering with outside entities, particularly on ambitious supplier initiatives, expands the level of expertise you can leverage and may lead to greater product innovation.

5. **Encourage information sharing and collaboration among suppliers.** Some U.S. companies have had success in convening their suppliers to communicate their green supply chain objectives and provide a forum for information exchange between suppliers. This type of collaboration can lead to a more informed and stronger supplier base.

[1] GreenBiz, "Ten Things to Know About Engaging Suppliers for Green Programs"

Where to Go for Help

- EPA's Environmentally Preferable Purchasing Database (what EPP means, lists of products, and standards)
- EPA's Integrating Green Purchasing into Your Environmental Management Systems (a how to guide on improving green purchasing)
- OECD's Sustainable Materials Management Portal (includes expert materials management methodologies and industry case studies)
- EPA's Resource Conservation Challenge (national effort to conserve natural resources and energy by managing materials more efficiently)

Search

- Green Purchasing
- Material Conservation/Waste Minimization
- Pollution Prevention

Manufacturing

For each topic, you will learn:

- Why it is an important sustainability issue
- Important terms and concepts
- An introduction to approaching the issue
- Typical opportunities for improvement
- Examples from real companies
- A checklist to help with implementation
- Search terms for the Sustainable Business Clearinghouse
- Additional resources to help you

Click here to learn about common manufacturing processes that often have environmental opportunities

Click on each of the topics to learn more

Water

Energy

Materials and Waste

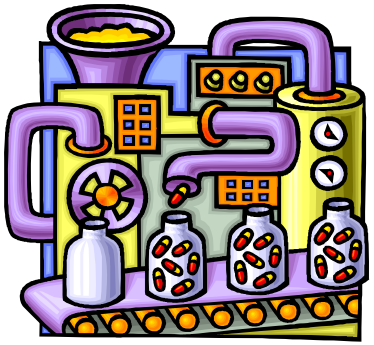
Greenhouse Gases

Air Quality

Packaging

Buildings and Infrastructure

Common Manufacturing Processes With Environmental Opportunities[1]



- Metal Casting
- Materials Treatment
- Metal Fabrication and Machining
- Cleaning and Surface Preparation
- Bonding and Sealing
- Welding
- Metal Finishing and Plating
- Painting and Coating
- Chemical and Hazardous Materials Management
- Waste Management

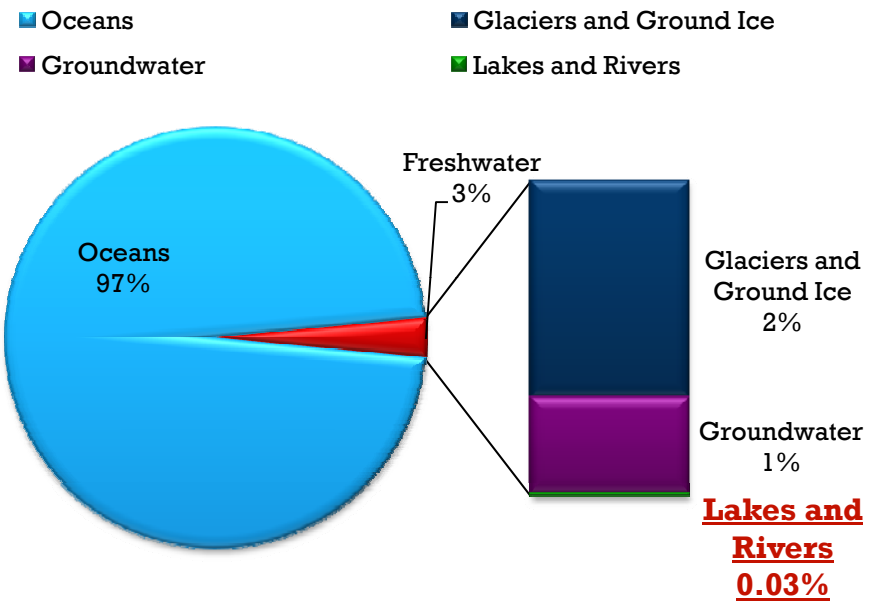
[1] EPA Lean and Environment Toolkit

Water

- Why is water important in manufacturing?
  - Water is used in many manufacturing processes and can be a major expense for companies.
  - Additionally, industry is an important source of water pollutants, which are regulated and impact the quality of water sources.

- Manufacturers need to worry about both the **amount of water they use** and the **water quality** of water before and after it is used.

The World's Water Supply



Only 3% of the world's water is freshwater, and most of that is not easily accessible in lakes and rivers.
Fresh water is also not evenly distributed geographically, so it is scarce in many areas.

[1] Global Environmental Management Initiative, "Water Trends"

The Impact of Water

- Using water more efficiently can save your company money by reducing:
  - purchased water expenditures,
  - costs for treating wastewater,
  - maintenance costs for equipment and
  - also the energy costs from pumping, heating and cooling water.

- Water quality is a issue that many communities, shareholders, and customers care about, so poor water quality can have a negative effect on a company's reputation.

- Let's take a closer look at the basic water cycle to see how water is used.

Common Uses of Water in Manufacturing[2]

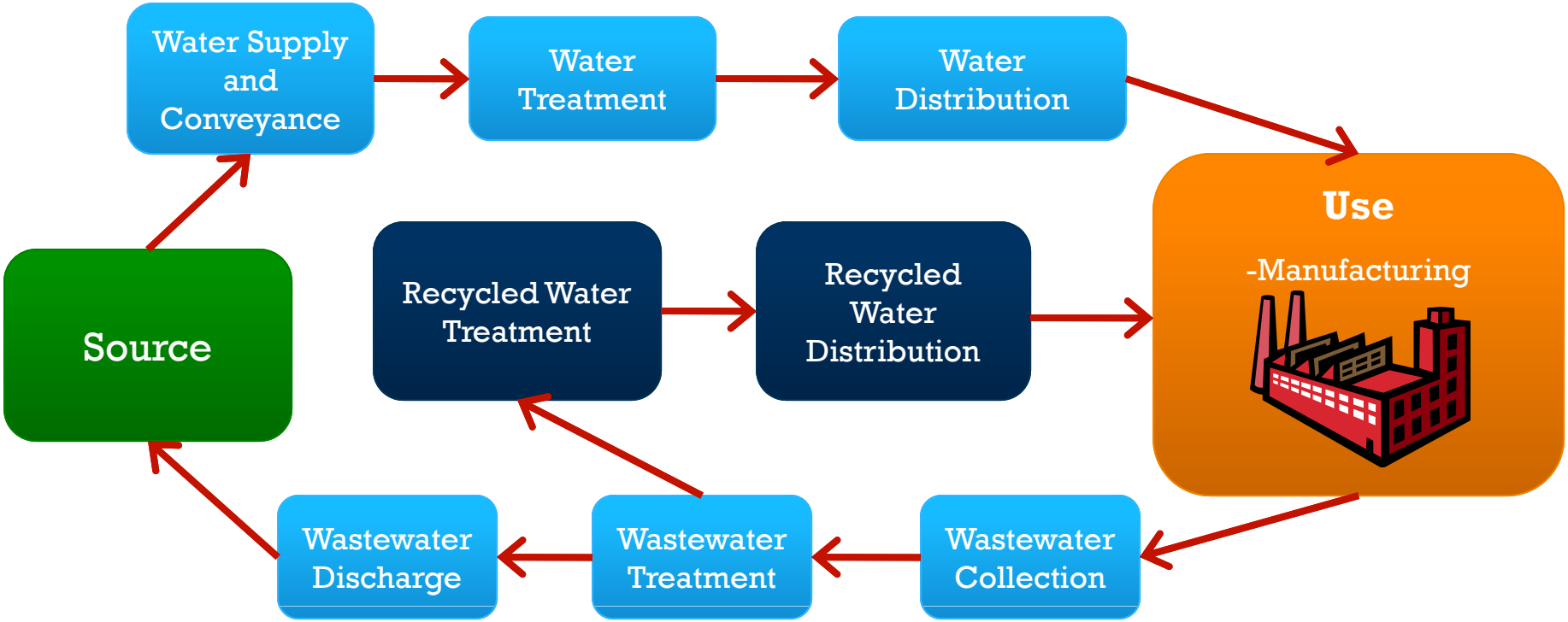
- Cooling
- Process Uses
  - Rinsing
  - Transporting
  - Chemical reactions
  - Input to products
  - Lubricants
  - Sealing
  - Pollution control
- Cleaning
- Employee Sanitation
- Steam Generation

[1] EPA Small Business Division, "Practical Guide to Environmental Management for Small Business"

Basic Water Cycle

This diagram shows the steps of the basic water cycle from source to use.

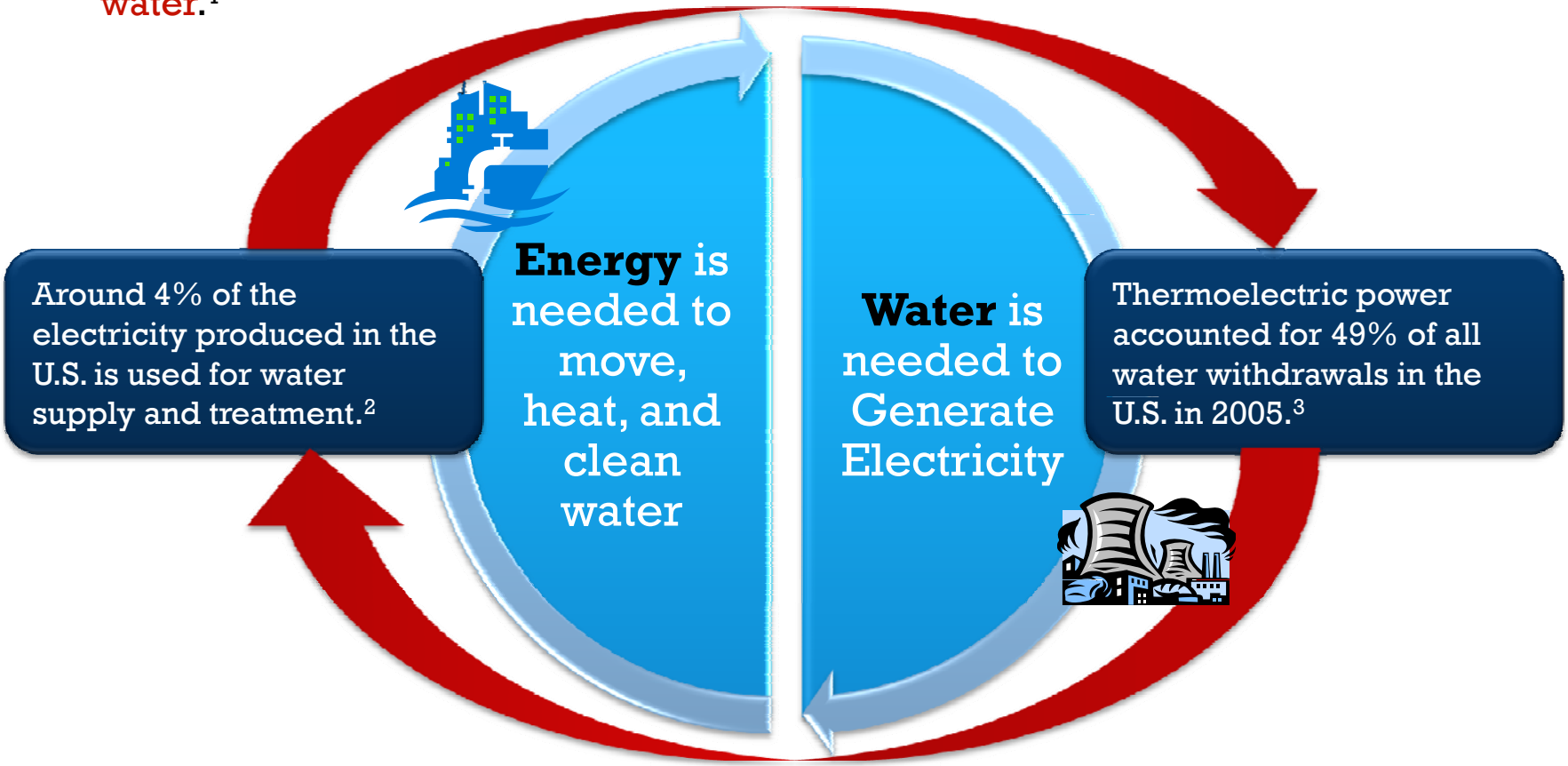
Water supply and conveyance is the most energy intensive step. However, costs at each step can be reduced by reusing water. You will learn more about water reuse and recycling later in this section.[1]



[1] California Energy Commission, "California's Water – Energy Relationship."

Relationship Between Water and Energy

- Water and energy are perpetually intertwined. Energy production is the largest use of water in the U.S. as water cools most thermal power plants and is used to make steam. Conversely, energy is needed to pump, treat, transfer, heat, and recycle water.[1]



[1] California's Water – Energy Relationship." California Energy Commission.
[2] U.S. DOE, "Energy Demands on Water Resources"
[3] U.S. Geological Survey, "Summary of Estimated Water Use in the United States in 2005."

Water Quality

- **Water quality** is "a measure of the suitability of water for a particular use based on selected physical, chemical and biological characteristics."[1]
- Let's take a closer look at some terms related to water quality.

Water Quality Characteristics[1]

- temperature
- dissolved minerals or other substances (sometimes measured by the water's electrical conductivity)
- bacteria levels
- acidity

[1] U.S. Geological Survey, "A Primer on Water Quality"

Water Quality Terms to Know

National Pollutant Discharge Elimination System (NPDES)- A permit program that controls water pollution by regulating point sources (sources that can be traced, like a factory or mine) that discharge pollutants into United States waters.[3]

Clean Water Act (CWA)- uses regulatory and nonregulatory tools to reduce direct pollutant leakage into waterways, finance municipal wastewater treatment facilities and manage polluted runoff.[4]

Biochemical Oxygen Demand (BOD)-the amount of oxygen consumed by microorganisms breaking down organic waste in wastewater treatment plants.[5]

Potable water- water that is safe for drinking. There are many scientific definitions of what this means, some including a limitation on the amount of a variety of pollutants.[2]

Total Suspended Solids (TSS)- accounts for any solids found in water. It is listed as a conventional pollutant in the CWA.[4]

Effluent guidelines- National standards by the EPA based on the performance of treatment and control technologies for wastewater discharges to surface waters and municipal sewage treatment plants.[2]

Grey water- wastewater from residential, commercial, and industrial sources that can be reused onsite for non-potable uses such as irrigation, toilets, or manufacturing purposes. Sources include bathroom sinks, shower drains, and clothes washing equipment. Also known as recycled or reclaimed water.[1]

[1] "Water Recycling and Reuse: The Environmental Benefits." EPA.
[2] "Effluent Limitation Guidelines." EPA
[3] National Pollutant Discharge Elimination System (NPDES)
[4] "Introduction to the Clean Water Act" EPA.
[5] "Dissolved Oxygen and Biochemical Oxygen Demand" EPA.

Getting Started[1]

- You also want to make sure any water project ideas will meet:
  - EPA, USDA, and FDA regulations, and state and local health regulations
  - The requirements of building, safety, and fire codes
  - The quality expectations of your customers
- It is important to involve the utilities that supply your water and treat your wastewater. They may have ideas on how you can save water or programs to support your efforts.

[1] "Water Efficiency Manual for Commercial, Industrial and Institutional Facilities" N.C. Department of Environment and Natural Resources et. Al.

Conducting a Water Audit

- The first step is to understand how your facility uses water.[1]

Breakdown and measure all your water uses

- Perform a water balance.
  - This measures all of the water coming into your facility and how it is used. It can be incorporated into a value stream map.
  - Inflow = outflow + irrigation +evaporation + losses
- Conduct a walk through survey to assess:
  - Equipment
  - Plumbing
  - Flow rates and usage
  - Quality needs in each process
  - Any losses

Understand your water costs

- Look at your:
  - Water and sewer bills
  - Meter and sub-meter data
  - Water heating, cooling, moving
  - How water costs can be allocated to specific processes

[1] "Water Efficiency Manual for Commercial, Industrial and Institutional Facilities" N.C. Department of Environment and Natural Resources et. Al.

Your True Cost of Water Use

You may look at your company's water bill and think that water use isn't an important issue for you, but **the price of water does not include a all of water's related costs**. You need to make sure you know the **total cost of your water use**.

Think about these typical costs related to water use:[1]

- ✓ Purchased water (fixed cost + water rate cost)
- ✓ Wastewater sewerage rates + any surcharges
- ✓ Cost of treatment of incoming water before use
- ✓ Energy for heating water
- ✓ Cost of treatment before discharge (labor, chemicals, energy, disposal of residuals)
- ✓ Maintenance cost
- ✓ Any costs of increasing treatment capacity
- ✓ Energy for pumping
- ✓ Conveyance and Distribution costs (different locations rely on different water sources, causing costs to increase or decrease seasonally)

•A faucet that drips once per second will waste 2,700 gallons of water per year.[2]

When considering improvements related to water use and quality, you need to consider how changes would affect each of these costs.

[1] "Water Efficiency Manual for Commercial, Industrial and Institutional Facilities" N.C. Department of Environment and Natural Resources et. al.
[2] "Manufacturing Introduction" Alliance for Water Efficiency

Areas for Focus

- There are certain systems and processes in your facility that are likely to be good targets for water use reductions. These include:[1]
  - Any cleaning, washing or rinsing processes
  - Painting processes
  - Metal finishing
  - The amount of water in the product
  - Cooling towers and chillers
  - Boilers, hot water and steam systems
  - Equipment and facility cleaning
  - Sanitary uses in the facility
  - Landscaping

[1]"Water Efficiency Manual for Commercial, Industrial and Institutional Facilities" N.C. Department of Environment and Natural Resources et. al. and "Watersmart Guidebook" East Bay Municipal Utility District

Basic Ways to Reduce Water Use

Methods for reducing water use fall into three basic categories:

Reducing Losses

Reducing water use

Reclaiming or recycling water

[1] "Water Efficiency Manual for Commercial, Industrial and Institutional Facilities" N.C. Department of Environment and Natural Resources et. Al.

Reducing Losses

- This involves fixing any leaks in pipes, hoses, or faucets and eliminating water that is wasted without being used.
- Make sure water is turned off when not in use using flow timers or limit switches
- These issues are often addressed by simple housekeeping measures
- Conduct leak inspections to identify opportunities

Example

- During a water audit, Kaspar Wire Works in Shiner, Texas, found that hoses used to fill tanks were left unattended. They often overflowed, resulting in losses. The company trained employees and changed hose set ups, resulting in a 48% reduction in water consumption. These and other water saving measures have reduced water use by more than 90%, saving the company nearly $400,000 annually.[2]

[1] "Water Efficiency Manual for Commercial, Industrial and Institutional Facilities" N.C. Department of Environment and Natural Resources et. Al.
[2] Zero Waste Network, Success Stories, "Kaspar Wire Works, Inc."

Reducing Water Use[1]

There are many strategies for reducing your water use. Here are just a few:

- Eliminate any unnecessary uses of water and use minimum amounts of water for tasks. For example, use dry clean-up practices (a broom) rather than hosing down.
- Recirculate water within processes
- Optimize blowdown and bleedoff in cooling towers and boilers
- Use timers and pressure-reducing valves
- Use chillers, cooling towers or air-cooled equipment instead of cooling water in equipment that is only used once
- Use filtration, conductivity meters, and proper maintenance to extend life of aqueous baths and rinsing processes
- Use closed-loop systems where possible

Example

- A metal machining company switched to a closed loop cleaning system for parts. This lowered water use, eliminated hazardous materials and the associated regulatory costs, and lowered cleaning costs.[1]

[1]"Water Efficiency Manual for Commercial, Industrial and Institutional Facilities" N.C. Department of Environment and Natural Resources et. al. and "Watersmart Guidebook" East Bay Municipal Utility District

Water Recycling and Reuse

- Water **recycling, reclamation or reuse** means reusing treated wastewater for other purposes.
- The treatment used can be tailored to meet the water quality needs of your planned reuse. For example, water for landscape irrigation would need less treatment than water for drinking.[1]
- Water can also be reused sequentially. For example, a process with the strictest water quality requirements would use the water first. The water could then be used by a process with less stringent quality requirements.
- This is why it is important to understand the water quality requirements of each use.

Water reuse and recycling is **illegal in some areas**. Check with your local water utilities and authorities before starting a recycling program.

[1]EPA, "Water Recycling and Reuse: The Environmental Benefits"

Water Reuse

In order to determine whether water can be captured and used, you must first determine the quantity and quality of water you need for each process.[1]

Possible areas for water capture

- rainwater and storm water
- air-conditioner condensate
- filter and membrane reject water
- foundation drain water
- cooling-tower blow down
- on-site treated grey water and wastewater

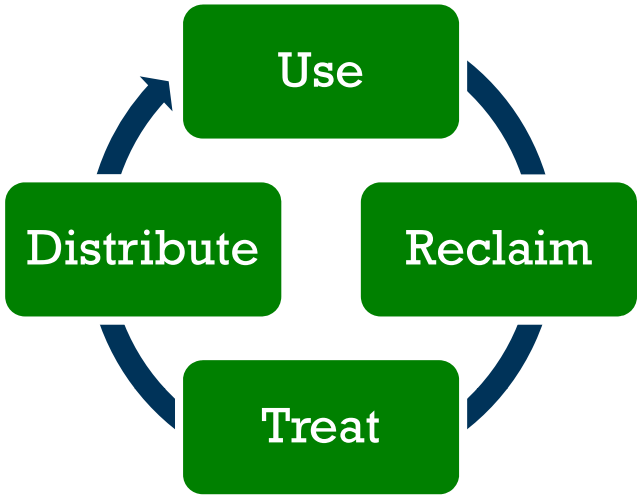
Possible areas for Captured Water Use

- Irrigation
- Cooling-tower makeup
- Toilet and urinal flushing
- Makeup for ornamental ponds, pools, or fountains
- Manufacturing processes
- Any other use not requiring potable water

[1] "Watersmart Guidebook" East Bay Municipal Utility District

How to Recycle Water

1. **Install** technology to reclaim, transport, and treat recycled water
2. **Reclaim** the water through condensation or other methods.
3. **Treat and filter** the water to the appropriate standard outlined by the state or local government (there is no federal standard) for its future use. There are different standards for using water for potable or nonpotable uses. Potable uses necessitate more purification than non.
4. **Distribute** water to the point in the system where it will be used.[1]



Examples of pollutants found in water that may be required to be reduced or eliminated in treatment:

- Organic
  - Benzene (commercial solvent), Polychlorinated Biphenyls (coolant),
- Inorganic
  - Metals, nutrients (Nitrogen, phosphorus), and minerals
- Microorganisms
  - Bacteria (E. Coli) [1]

For more basic information on recycling water, visit the EPA website here.

[1] "Water Reuse and Recycling in Manufacturing." EPA

Intel Case Study-"Water Reuse and Recycling in Manufacturing"[1]

- Intel successfully implemented a water efficiency policy that saved the company hundreds of thousands of dollars a year.
- In 10 years, they have invested $100 million into water conservation efforts and conserved more than 90,000 acre feet of water, or enough for 280,000 homes for a year.

Improvements Implemented

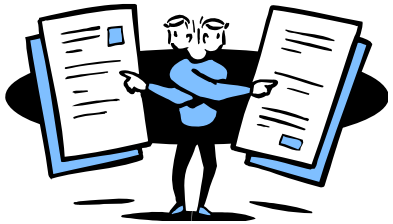
- Internal Water Recycling- Used to resupply the source water
- Underground Aquifer Recharge-3.5 billion gallons of potable water into the Arizona aquifers
- Air Scrubber- Caustic Injectors replaced water
- Cooling Towers- Installed new technology to pre-treat wastewater and received aide from the Cooling Tower Rebate Program
- Intense heat recovery- Reduces the amount of heat given off by cooling towers and increases condensation
- Irrigation- Received aid from program to reduce water used in irrigation through tech improvements

[1] "Water Reuse and Recycling in Manufacturing." EPA

Current Issues with Recycling Water

- There is no federal standard by the EPA for recycled water, but each state has its own standards. Be sure to check what they are in your area to make sure your recycled water treatment system is up to standards.

- Since water recycling technology is still relatively young, it can be expensive to fund and controversial for safety reasons. Certain pollutants cannot easily, if at all, be measured, so it is sometimes difficult to effectively assess the amount of pathogens and microorganisms in the water.[1]



[1] "Water Reclamation and Use Standards". Washington State Department of Health and Ecology.

Water Efficiency – Additional Resources

These sites provide additional information and excellent guidance on water efficiency and quality and are written for businesses. They also include ideas on projects and technologies that are applicable in many manufacturing environments.

- The Lean & Water Toolkit from the EPA
- The Water Efficiency Manual for Commercial, Industrial and Institutional Facilities from the North Carolina Department of Environment and Natural Resources
- The Watersmart Guidebook from the East Bay Municipal Utility District
- The Global Environmental Management Initiative has a Water Sustainability Tool that walks you through the process from assessment to implementation

Water Checklist

- ✓ Make sure your equipment and water use practices meet the various federal, state and local regulatory requirements and customer expectations
- ✓ Work with your local water and sewer utilities throughout the process
- ✓ Determine what the breakdown is for the use of water in your facility - conduct a water audit
  - ✓ Perform a water balance
  - ✓ Walk-through survey talking to employees
- ✓ Make sure you understand all of your water costs – supply, treatment, discharge, heating, pumping, labor etc.
- ✓ Determine water quantity and quality needs for each process and measure the water quality of current effluent streams to identify possible areas of water reuse
- ✓ Identify ways to reduce your water consumption through
  - ✓ Reducing losses through leaks and waste
  - ✓ Reduce quantity of water used through new processes and technologies
  - ✓ Reclaim or recycle wastewater or water from other sources
- ✓ Utilize available tools and technical assistance
- ✓ Contact your industry association to see if there are industry guidelines on water use

"Water Efficiency Manual for Commercial, Industrial and Institutional Facilities" N.C. Department of Environment and Natural Resources et. al.

Where to go for help

- Work with your water utilities (supply and wastewater) – They may be able to help you with water audits or leak detection. Some may even have financial incentives for efficiency projects.
- Look for other technical assistance programs related to water efficiency and pollution prevention
  - EPA – Watersense program from EPA
  - EPA Office of Water
  - National, regional, or state pollution prevention (P2) programs and your state water quality regulators
  - United Nations Environmental Programme's Sustainable Consumption and Production Branch (also includes a specific tool for corporate water accounting)
  - Dept of Energy's Building Life-Cycle Costs Program
- See if your industry associations have any literature on industry-specific water use and quality issues

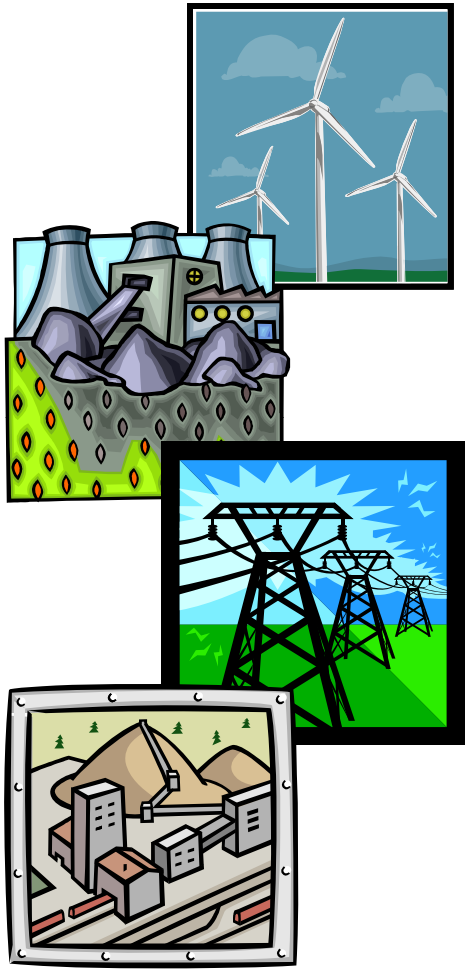
Search Terms

- Water Efficiency
- Water Quality
- Energy Efficiency
- Pollution prevention
- How-to Guides
- Technical Assistance

Energy

Energy use is typically a primary area of focus for manufacturers looking at sustainability for a variety of reasons:

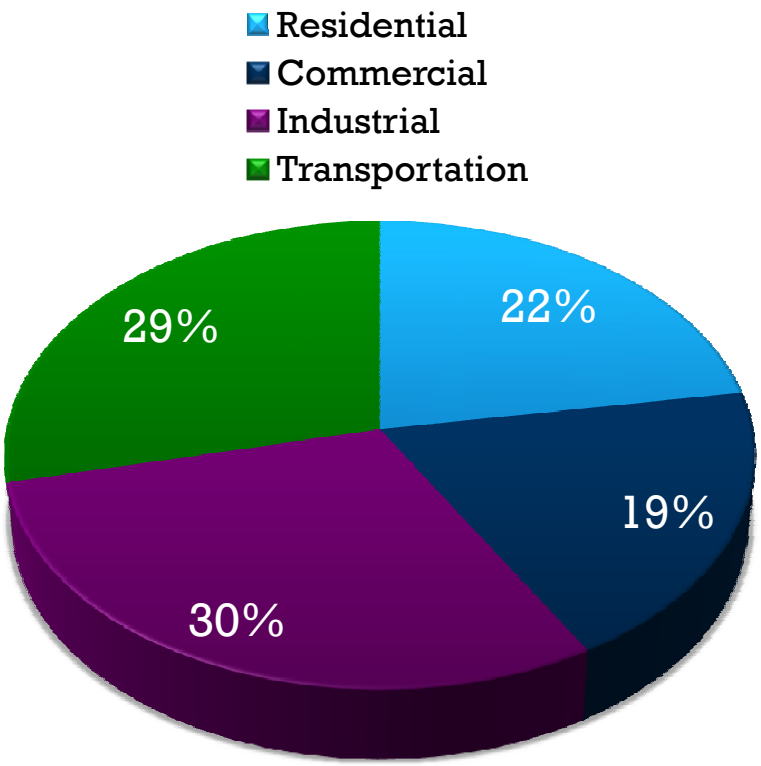
- It is a major cost center for many companies, and energy costs are highly volatile
- It is used throughout manufacturing facilities and comes from various sources
- It is the leading driver of greenhouse gas emissions and other environmental impacts
- It is more visible and easier to measure than some other environmental impacts
- A lot of information and help is available on energy efficiency opportunities and techniques



Energy in Manufacturing

- Industry uses about a third of the energy produced in the U.S.[1]
- Energy is used for a wide variety of activities, from lighting to boiler fuel to process heating.
- Energy sources are also used as feedstocks (material inputs) in manufacturing. These include liquefied petroleum gas (LPG), coal, natural gas, and others.
- A small number of energy-intensive industries – petroleum refining, chemicals, paper, and metal – are responsible for the majority of industrial energy use.

U.S. Energy Consumption by Sector



Source: DOE EIA "Annual Energy Review, 2009"

[1] DOE Energy Information Administration "Use of Energy in the United States Explained"

Lowering the Impact of Energy Use

There are two basic things industry can do to lower the environmental impact of its energy use.

Use Less Energy

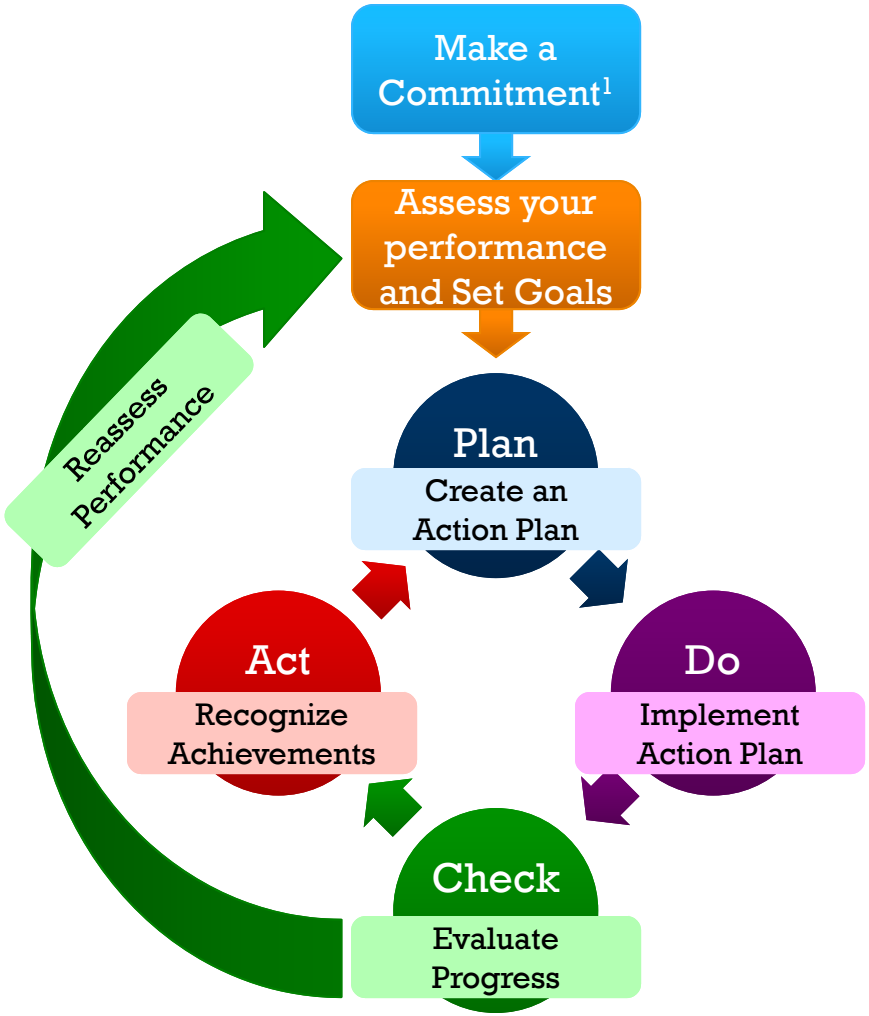
- This means becoming more efficient – using less energy to do the same amount of work.
- Energy efficiency is a key way to lower your impact while reducing costs

Use More Renewable Energy

- Most of the energy in the U.S. comes from the burning of fossil fuels.
- Using renewable energy (i.e. wind, solar, geothermal, biomass) can have a lower environmental impact as well as other business benefits such as improved reputation.

Energy Management

- Just as we discussed using an environmental management system, the same principles apply to energy management.
- Energy management is a framework for understanding energy use and identifying opportunities for improvement. An Energy Management System can be tailored and adjusted to meet your company's needs.
- However, energy management needs to be ingrained across your organization to be successful.
- Please review the lesson on getting started and understanding your impact for information on environmental management systems.



[1] Energy Star "Guidelines for Energy Management Overview"

ISO 50001 – Energy Management Standard

- For companies interested in obtaining international certification in energy management, ISO 50001 provides a framework for industrial plants, commercial facilities or entire organizations to manage energy. The standard covers:

  - Benchmarking, measuring, documenting, and reporting energy intensity improvements and their projected impact on reductions in greenhouse gas (GHG) emissions

  - Evaluating and prioritizing the implementation of new energy-efficient technologies

  - Promoting energy efficiency throughout the supply chain

  - Transparency and communication on the management of energy resources

  - Energy management best practices and good energy management behaviors

[1] ISO site, "ISO Launches ISO 50001 Energy Management Standard"

Energy Management

- The Energy Star program recommends a seven step strategy for energy management in facilities.[1] These steps are similar to those in an Environmental Management System.

1. Make a commitment to continuous improvement
2. Assess your performance
3. Set goals
4. Create an action plan
5. Implement the action plan
6. Evaluate your progress
7. Recognize achievements

[1] Energy Star "Guidelines for Energy Management Overview"

Assessing Your Performance

- An early step in energy management is to assess your performance.
- To do this, you need to follow the steps outlined to the right.[1]
- Let's take a closer look at each of these steps

1. Gather energy data

- Collect your overall energy consumption data by volume and cost from utility bills

2. Establish your baseline

- Determine a starting point from where you will measure future progress

3. Analyze your usage patterns

- Identify which equipment are major energy users and how energy is used in the facility

4. Benchmark

- Compare your energy use to other companies or an industry average

5. Assess for Opportunities

- An assessment or audit by an energy professional will identify areas of opportunity for improvement

[1] Adapted from: Energy Star, "Guidelines for Energy Management," and DOE, "Self-Assessment Workbook for Small Manufacturers"

1. Gathering Energy Data

- The first step is to gather data on how much energy your company or facility is consuming.

- You will want to measure your energy use in two ways:

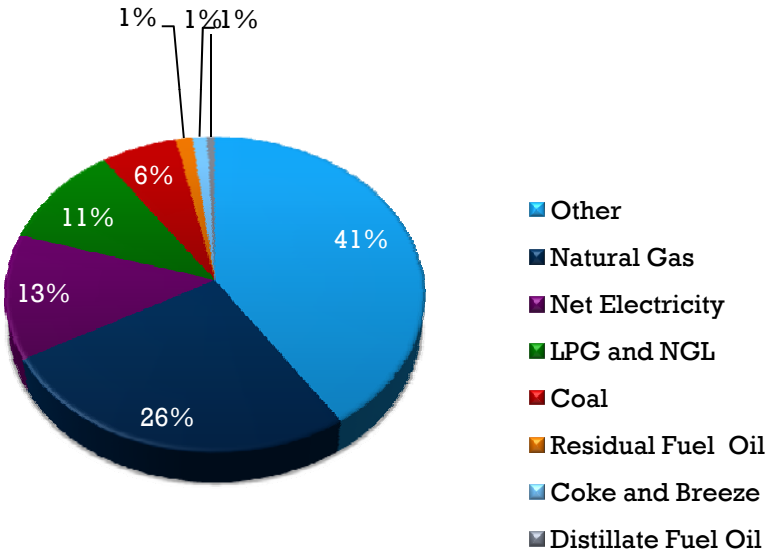
By **Volume**	By **Value**
What is the quantity of each energy source you are using? Convert all energy to same unit (i.e. BTUs) so you can compare.	How do energy volumes translate into costs? Use this to compare costs of different energy sources.

Gathering Energy Volume Data

The most common sources of energy used in manufacturing are natural gas and electricity

First Use of Energy in Manufacturing (2006)

Unit: Trillion Btu.



Source: DOE, EIA, Manufacturing Energy Consumption Survey data for 2006

Energy volume data can be found on invoices and utility bills, through meter readings or other data sources. You also may need to work with your accounting department or utility to get the relevant data.

You should account for all the energy purchased or generated at your facility.[2]

Different energy sources are measured using different units of volume.[1]

For example, natural gas may be measured in cubic feet while coal is measured in tons.

Let's see how you would convert the data to the same units to allow for comparison.

[1] DOE "Self-Assessment Workbook for Small Manufacturers"
[2] Energy Star "Guidelines for Energy Management"

Comparing Energy Volume Data

- To compare different energy sources, you need to convert them them to a standard unit of measure (typically a British Thermal Unit or Btu) using energy equivalents.[1]

- This page from the Department of Energy can help you convert quantities of energy sources to BTUs.

The Btu Equivalent for Typical Energy Sources[2]

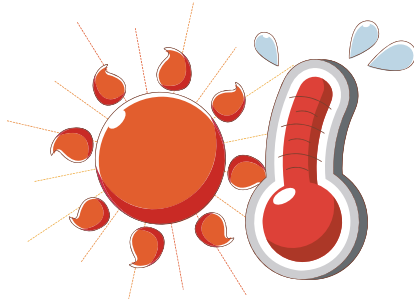
Common Energy Unit	Btu Content
1 gallon of gasoline	124,238 Btu
1 gallon of diesel fuel	138,690 Btu
1 barrel of residual fuel oil	6,287,000 Btu
1 cubic foot of natural gas	1,027 Btu
1 gallon of propane	91,333 Btu
1 short ton of coal	19,953,000 Btu
1 kilowatt hour of electricity	3,412 Btu

What is a British Thermal Unit?

A BTU is a measurement of the **energy content of a fuel**.
It is the quantity of heat you would need to raise the temperature of one pound of water by 1˚F when the water is at its greatest density (39˚F)
Converting your energy volumes to BTUs allows you to compare their energy contents

[1] DOE "Self-Assessment Workbook for Small Manufacturers"
[2] Department of Energy, Energy Information Administration, "Energy Units and Calculators Explained."

Normalizing Data



- Energy use in your facility likely varies for a number of reasons, such as:
  - Seasonal variation in energy demand
  - Other weather issues
  - Opening hours
- You can correct for these impacts by **normalizing** your data.
- This means selecting an appropriate normalization factor and considering your energy use per normalization factor.
- Choice of factor will depend on your unique situation.
- Typical normalization factors are:[1]
  - Output
  - Value of shipments
  - Inputs

[1] Energy Star "Guidelines for Energy Management"

Energy Costs

Your utility bills will contain a variety of charges. Understanding them is key when identifying opportunities for improvement.[1]

Electricity Costs

Consumption Charges

These are the charges for how much electricity you use in kilowatt-hours (kWh).
The charge for each kWh may vary depending on the time of year or the time of day (peak or off-peak times).

Demand Charges

For large electricity consumers, there is a demand charge. This is a charge (per kilowatt) based on each month's peak electricity use. The maximum number of kWh used is multiplied by a demand cost factor, which varies depending on whether the power is being used at peak or off-peak times.

Fuel Costs

Fuel Charges

When you purchase fuels such as natural gas, coal, or oil, you typically pay for the amount of fuel received.

Delivery Charges

When purchasing fuels, you may also pay a delivery charge.

[1] EPA, "Lean and Energy Toolkit"
[2] Department of Energy, "Self-Assessment Workbook for Small Manufacturers"

2. Establishing a Baseline

- Setting a baseline creates a **starting point for setting goals and measuring progress**.[1]
- To establish a baseline, you will first want to select a base year that is normalized.
- You will also want to establish the metrics for energy use that you will use to measure your progress.
- See the lesson on getting started and understanding your impact for more information about choosing metrics.

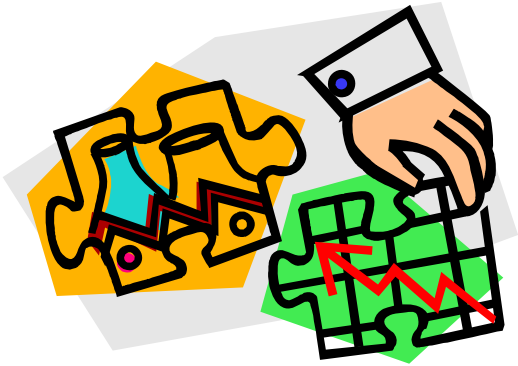
[1] Energy Star "Guidelines for Energy Management"

3. Analyzing Your Usage Patterns

- Once you have an idea of the total amount of energy you are using, you need to identify how that energy is being used in your facility.

- Since energy costs are often put into a central "overhead" account, rather than allocated to different processes and products, it can be difficult to determine which equipment or processes are responsible for which portion of your energy use.[1]

- But it is necessary to understand your energy use to be able to identify opportunities for improvement.



Questions to Answer:

- How much energy is being used in each process?
- By each machine?
- Where is energy being wasted?
- What are the costs associated with the energy use?

[1] EPA Lean and Energy Toolkit

How Energy is Typically Used by Manufacturers

This table summarizes how energy is used for fuel in manufacturing facilities in the U.S.[1]

Indirect use means the energy is used in a boiler and is transformed into steam or hot water.

Process uses are end uses that are specific to manufacturing and aren't found in other sectors

Two major areas of energy consumption in manufacturing are process heating and machine drives

Nonprocess end uses can be found in commercial, residential or other sites.

End Uses of Fuel Consumption by Industry (2006)[2]		
	Fuel Consumption Trillion Btu.	Percent of Total Fuel Consumption
Total	15,658	
Indirect Uses-Boiler Fuel	2,871	18.3%
Conventional Boiler Use	1,547	9.9%
CHP and/or Cogeneration Process	1,324	8.5%
Direct Uses-Total Process	5,597	35.7%
Process Heating	3,288	21.0%
Process Cooling and Refrigeration	239	1.5%
Machine Drive	1,654	10.6%
Electro-Chemical Processes	206	1.3%
Other Process Use	208	1.3%
Direct Uses-Total Nonprocess	1,066	6.8%
Facility HVAC (g)	658	4.2%
Facility Lighting	198	1.3%
Other Facility Support	91	0.6%
Onsite Transportation	65	0.4%
Conventional Electricity Generation	26	0.2%
Other Nonprocess Use	23	0.1%
End Use Not Reported	6,125	39.1%

[1] It does not include energy used as feed stocks or inputs.
[2] DOE, EIA, Manufacturing Energy Consumption Survey data for 2006

Understanding Your Energy Use

Methods for Learning About Your Energy Use:[1]

- Conduct a walkthrough of your facility following each of your processes from beginning to end
- List major energy consuming equipment
- Utilize value stream maps. The Lean and Energy Toolkit has examples of this.
- Start with the major manufacturing systems in your plant. Then look at the subsystems. Also examine energy use by the building and grounds.[2]

If you have trouble determining energy use in a process[1]

- **Install Sub-meters** to track energy use through machinery
  - Flow meters for fuels
  - Electric sub-meters on equipment and process lines
- **Estimate** energy use based on manufacturer's machine specifications

[1] EPA Lean and Energy Toolkit
[2] Department of Energy, "Self-Assessment Workbook for Small Manufacturers"

Major Energy Consuming Equipment

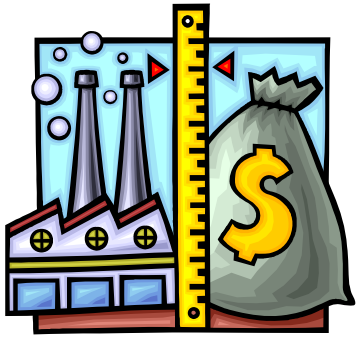
- When analyzing your facility's energy use, a good place to start is with the major energy consuming equipment.
- For each of the large energy users, there are specific questions to consider to determine whether there are opportunities to reduce energy use.
- Review the Self-Assessment Workbook from the Department of Energy for questions to consider.

Likely Major Energy Consumers in your Facility[1]

- Lighting
- Air Compressors
- Boilers
- Motors, belts and drives
- Furnaces
- Chillers
- Cooling Towers
- Fans and pumps
- Steam systems
- Refrigeration systems
- Material handling systems
- Hydraulic systems
- Injection molding or extrusion
- Veneer dryers
- Kiln drying

[1] Department of Energy, "Self-Assessment Workbook for Small Manufacturers"

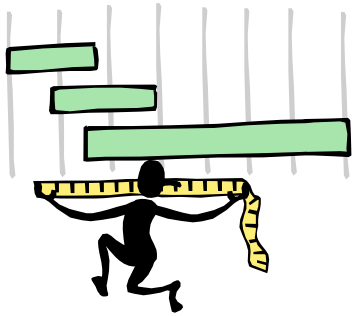
Energy Use Data Tools



There are many ways to track and evaluate your energy use data. Here are some free, online, government tools that can help:

- The Department of Energy's Quick Plant Energy Profiler
- Additional DOE software tools focusing on specific building systems including air compressors, motors, fans, steam systems, pumps, etc.
- Energy Star's The Energy Star program has an Energy Tracking Tool and a Facility Energy Assessment Matrix (xls.)
- It also has a Portfolio Manager tool for commercial buildings.

4. Benchmarking



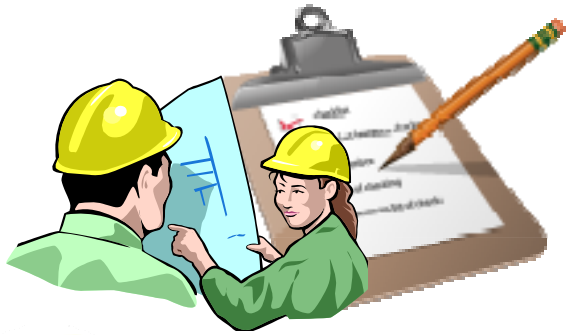
- A good way to rate your company or facility's energy performance is to compare your energy use against:[1]
  - Your past performance
  - An industry average
  - Other companies in your industry that are leaders

- Energy Star provides industry benchmarking data for plants in certain industries. Find out more about these Energy Performance Indicators

- You can also see if any industry associations have collected benchmarking data for your industry.

[1] Energy Star "Guidelines for Energy Management"

5. Assessing for Opportunities



- You were probably able to identify a number of opportunities while assessing energy use in your facility. However, an **energy audit** will help you identify further opportunities to improve your performance.
- An energy audit is a review conducted by an engineer or energy professional.
- Audits evaluate a facility's performance and compare it to how the facility could potentially perform if it were operating as it was designed, or if it employed new technologies.[1]

Example

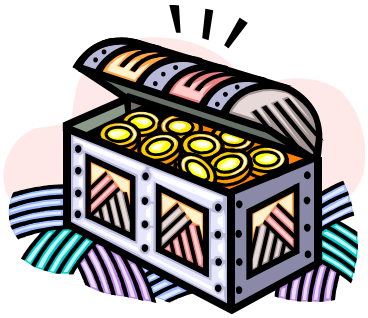
- Cooper Cameron, a maker of oilfield equipment, received an energy assessment from the Department of Energy Industrial Assessment Center at the University of Louisiana. The company implemented all the recommendations from the assessment, changing compressed air systems, lighting, waste and scheduling. These projects saved the facility nearly $800 thousand a year.[2]

[1] Energy Star "Guidelines for Energy Management"
[2] Department of Energy, Industrial Assessment Centers, Industrial Assessment, "Cooper Cameron: An Oilfield Equipment Maker Implements All Recommendations."

Conducting an Assessment – Guides

- There are a number of excellent guides and resources to help you conduct an energy audit:
  - The Department of Energy Self-Assessment Workbook for Small Manufacturers is a good resource if you are unable to obtain technical assistance for an audit.
  - The Bonneville Power Administration Industrial Audit Guidebook provides similar guidance
  - The Washington State University Energy Program Energy Audit Workbook
  - The EPA Lean and Energy Toolkit helps you incorporate energy efficiency into your existing lean program.
  - The Department of Energy also has a lengthy training manual on Modern Industrial Assessments.

Identifying Opportunities – Other Methods



- If you aren't ready to conduct a full-scale energy assessment, there are some other methods you can use to identify opportunities for energy savings:[1]
  - Value Stream Mapping: map out energy use in your facility to find waste
  - Energy Treasure Hunts: have a team of employees conduct a multiday assessment
  - Six Sigma: use these statistical tools to find energy waste
  - Kaizen Events: have employees identify ideas for saving energy

Example

- GE has uses Energy Treasure Hunts as part of its lean system. In a treasure hunt, teams of employees are trained to find wasted energy and other resources in the facility. They conduct walkthroughs of the facility and find ways to make improvements. These treasure hunts have identified more than 5,000 projects that could save more than $110 million, but they've also helped engage and train employees and create a cultural change in the company.[2]

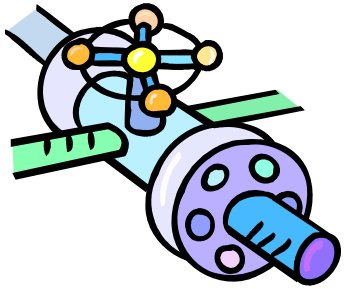
[1] EPA Lean and Energy Toolkit
[2] Gretchen Hancock, GreenBiz, "How GE's 'Treasure Hunts' Discovered More Than $110M in Energy Savings."

Identifying Opportunities – Where to Focus

- Your opportunities for improving energy use will depend on your industry and manufacturing processes
- However, there are a number of systems that are common to most manufacturing operations and that have common opportunities for improvement.
- As we saw in the manufacturing sector energy data, two typical areas of opportunity are process heating and machine drives and motors. Together, these two areas account for more than 30% of total industrial energy consumption and nearly 75% of direct industrial energy consumption.[1]
- Other good areas to target are HVAC systems and lighting.[2]

[1] DOE, EIA, Manufacturing Energy Consumption Survey data for 2006
[2] EPA Lean and Energy Toolkit

Industrial Energy Systems



- When looking for opportunities to improve energy performance, it's a good idea to look at your major industrial energy systems.
- Click on each one for more information:
  - Steam
  - Process heating
  - Motors, Pumps, Fans
  - Compressed Air
- These systems use around 80% of all the energy consumed by industry, and there are usually big opportunities to improve their efficiency.[1]

Example

- An energy assessment conducted at a Louisiana Dow petrochemical plant with a goal of finding savings in the steam system. Opportunities included improving the steam trap and leak repair programs, increasing insulation, and installing a blowdown heat recovery exhanger. Implementing just some of the recommendations resulted in annual savings of 272,000 MMBtu and nearly $2 million.[2]

[1] Department of Energy, Industrial Technologies Program, "Industrial Energy Systems"
[2] Department of Energy, Save Energy Now Program Case Study, "Dow Chemical Company: Assessment Leads to Steam System Energy Savings in a Petrochemical Plant."

Things to Look for When Investigating Your Energy Use

- Below are some questions that will help you understand your energy use and identify opportunities.[1]
  - When you aren't using machines, are they left running?
  - Are there any leaks in the compressed air system?
  - Are process heating systems set at higher temperatures than necessary?
  - Are you using energy efficient lighting?
  - Are you using motors, pumps, and other equipment that are right sized for their jobs?
- The audit guides listed in this lesson include many other questions to ask about your facility when conducting an audit.

[1] EPA Lean and Energy Toolkit

Common Simple Opportunities

- While some energy efficiency projects are more complicated and costly, there are some projects that can be implemented easily with little cost. Here are some common suggestions from experts.
- Click here to see a longer list of easy and common ways to save energy in a manufacturing facility.

Repair any leaks in your steam system.

Recover some of your furnace exhaust heat and use it in processes that require lower temperatures.

Use proper insulation on furnaces or boilers to reduce heat loss.

Minimize the amount of steam that is vented.

Operate boilers and furnaces at their design capacity.

[1] Department of Energy, Industrial Technologies Program, "20 Ways to Save Energy Now," in Energy Matters, Fall 2004.

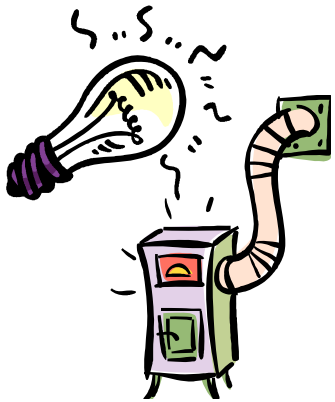
Other Common Opportunities

- These are some of the most commonly recommended projects from the Industrial Assessment Center assessments.[1]

Use more energy efficient cog belts	Use synthetic lubricants instead of petroleum-based	Use stack waste heat to preheat boiler combustion air
Turn off equipment when not in use	Install more efficient lighting	Use insulation on condensate return tank
Install compressor air intakes in coolest locations	Repair leaks in compressed air and inert gas lines and valves	Lower the air pressure from air compressors

[1] Department of Energy, "Self-Assessment Workbook for Small Manufacturers"

Combined Heat and Power



- One important group of technologies in energy management is Combined Heat and Power (CHP) or Cogeneration.[1]
- The basic idea of CHP is to **produce electricity or power onsite while also producing thermal energy that can be used for heating or cooling**.
- Traditionally, when you generate electricity or power at the point of use, it also produces heat. This heat is typically lost, but CHP allows you to capture and use that energy.
- It is more efficient than traditional methods and produces fewer greenhouse gas emissions.
- CHP systems are flexible and can use a variety of fuels.

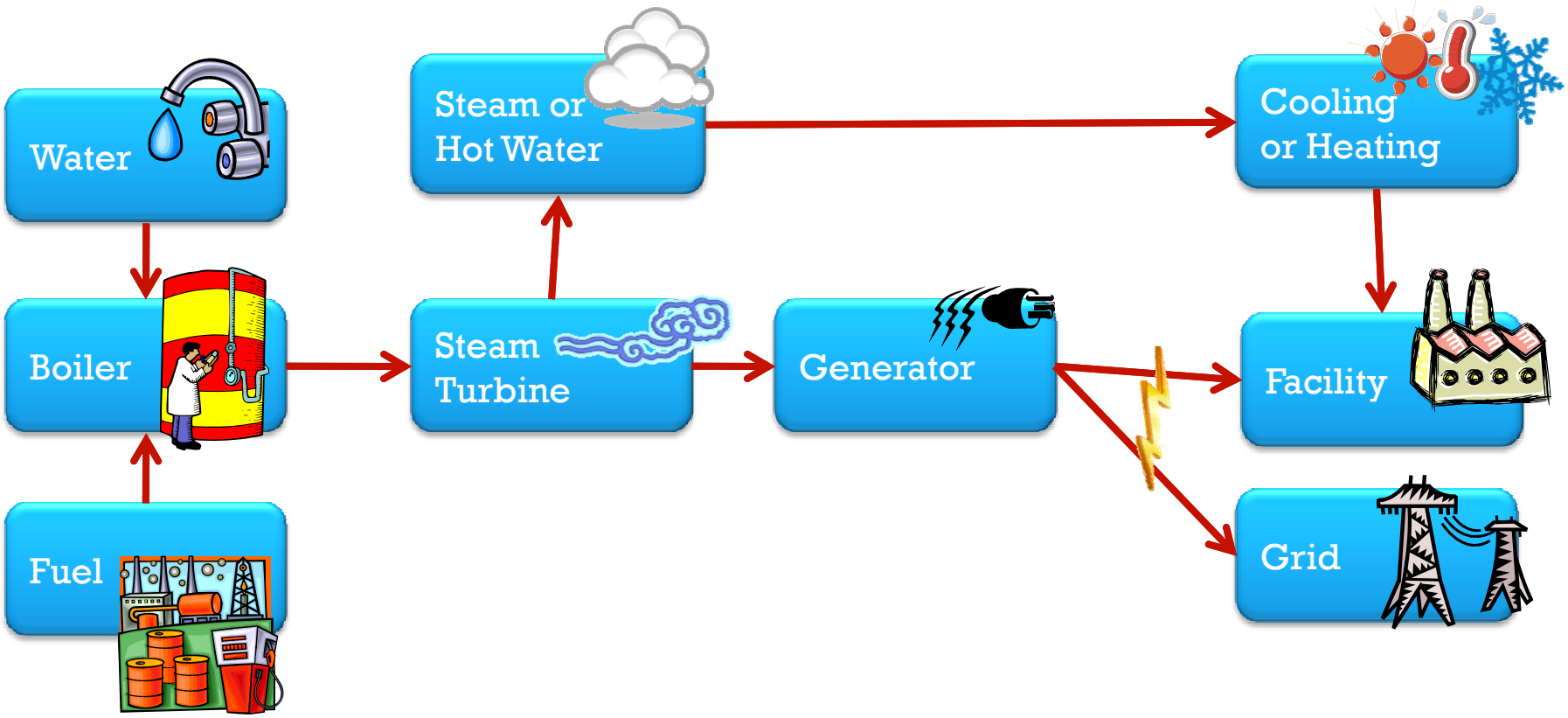
A traditional system with a power plant producing energy and a boiler producing heat has an efficiency of around 45%. For a CHP system, the **efficiency can be around 80%.** [1]

This means less fuel is used to produce the same amount of energy and heat.

[1] Department of Energy, Energy Efficiency and Renewable Energy, "Combined Heat and Power Basics."

How CHP Works

- A CHP system can be set up differently depending on the fuel and technologies used.
- This basic diagram shows how CHP would work with a steam boiler and steam turbine.[1]



[1] EPA, Combined Heat and Power Partnership, "Basic Information."

Combined Heat and Power Resources

- Information on various CHP technologies from the EPA here
- DOE Clean Energy Application Centers that offer assistance for CHP projects.
- This searchable database from DOE has profiles on CHP projects in various sectors.

Example

- The BMW plant in Spartanburg, SC, uses landfill gas as a fuel in its CHP system. The company uses the fuel to produce electricity, and heat from the turbines is used as process steam. The CHP system produces 30% of the electricity needed in the plant and 60% of the steam. It saves the company $5-7 million a year and reduces CO_2 emissions by more than 90,000 tons per year.[1]

[1] Department of Energy, Southeast Clean Energy Application Center, "BMW Manufacturing Co. 11 MW Landfill Gas CHP System."

Identifying Opportunities – Additional Resources

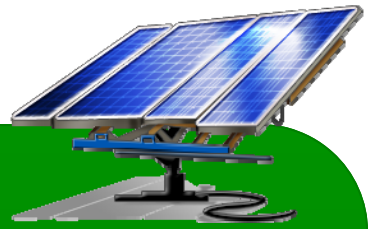
- The Department of Energy Self-Assessment Workbook has questions to help you identify opportunities, suggested solutions and project examples with cost analysis.
- DOE ITP has information on a large number of technologies to save energy in common energy systems and specific energy-intensive industries.
- Department of Energy Industrial Assessment Centers may be able to provide you with an energy audit or technical assistance.
- You can search the recommendations from Save Energy Now large plant assessments and the Industrial Assessment Centers assessments of small and medium plants.

Renewable Energy

Another way to reduce the environmental impacts of your energy use is to increase your use of renewable energy.

Renewable energy is energy generated by sources that can regenerate and be sustained.[1]

Renewable energy sources that aren't from biomass don't directly produce greenhouse gases because there is no combustion.



Sources of Renewable Energy:

Wind
Solar
Biomass
Hydroelectric
Geothermal

[1] Department of Energy, Energy Information Administration, "Renewable Energy Explained"

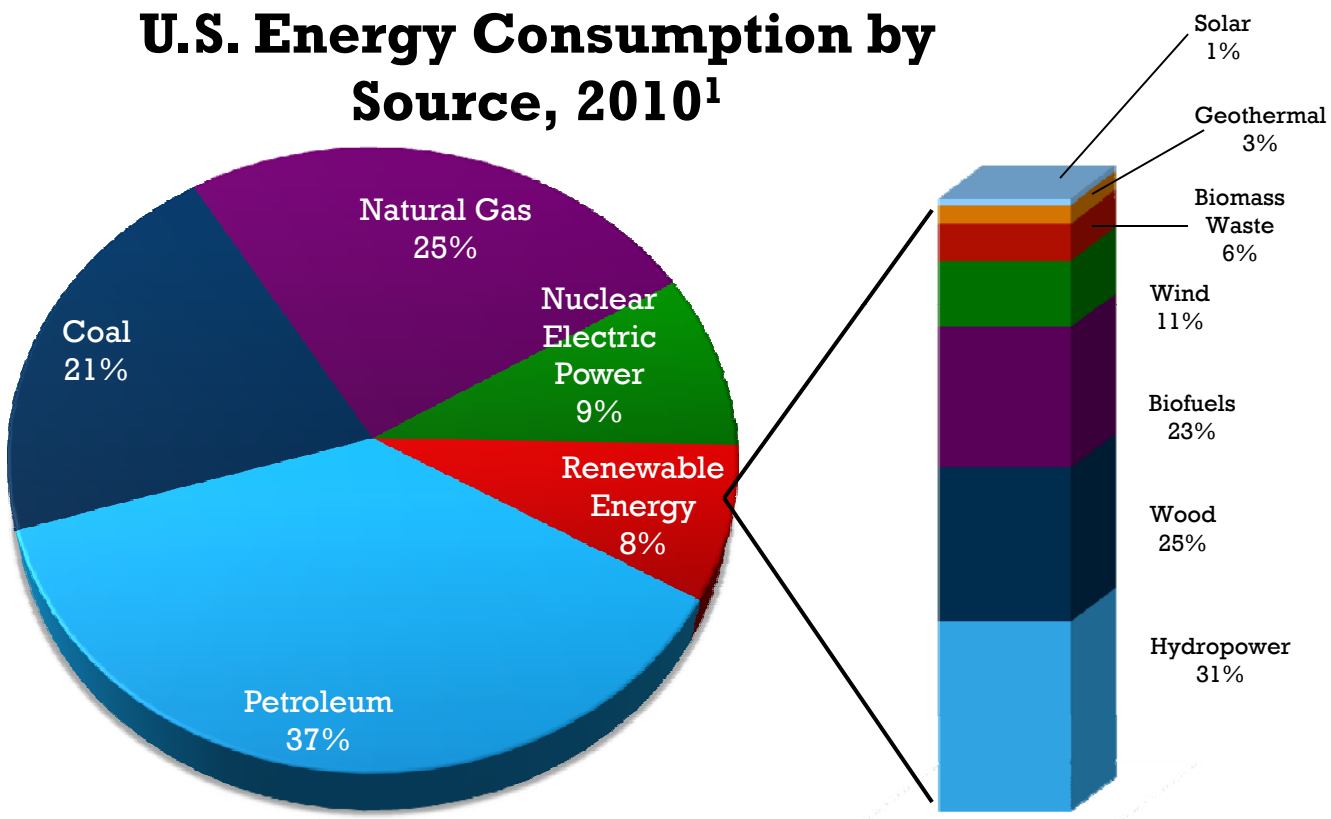
Benefits of Renewable Energy

- In addition to non-biomass renewable energy not producing any direct greenhouse gas emissions, there are many other benefits to purchasing greener power.[1]
  - Price Stability: Purchasing renewable energy may help insulate you from fossil fuel price volatility
  - Fuel Supply Disruption: There is less risk that your fuel supplies will be disrupted
  - Regulation: Renewable energy can help your company prepare for any future regulations related to climate change by reducing your dependence on fossil fuels.
  - Generate Positive Publicity: Buying renewable energy is a clear way of demonstrating your company's commitment to the environment as long as it doesn't appear as greenwashing.

[1] Department of Energy and EPA Green Power Partnership, "Guide to Purchasing Green Power: Renewable Electricity, Renewable Energy Certificates, and On-Site Renewable Generation."

U.S. Consumption of Renewable Energy

- Around 8% of U.S. energy consumed comes from renewables.
- As you can see, more than 50% of renewable energy comes from biomass (wood, biofuels, and biomass waste)



[1] Department of Energy, Energy Information Administration, "Renewable Energy Explained"

Renewable Energy in Manufacturing

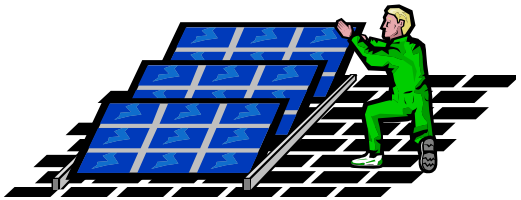
- There is great potential for expanded use of renewable energy in manufacturing.
- It can be an excellent option for facilities and companies looking to reduce greenhouse gas emissions.
- There are numerous incentives for the use of renewables. These will be discussed in greater detail in the next lesson.
- The Department of Energy has information on various renewable energy sources here.

Example

- S.C. Johnson had set the goal of cutting its absolute greenhouse gas emissions by 8% between 2005 and 2010. Instead, it achieved a reduction of more than 27%. It did this by using a variety of renewable sources to power its plants including waste methane from landfills, biomass, and wind.[1]

[1] Bardelline, Jonathan, GreenBiz, "How SC Johnson Cut Its Emissions by 27% in 5 Years."

Increasing Your Use of Renewable Energy



- The Green Power Partnership from the EPA is a national voluntary program that offers advice, tools, and other support for the purchase of renewable energy.
- They have produced a guide to purchasing greener power.
- Check with your utility to see if there are renewable options when you purchase electricity.[1]
  - Fixed energy quantity blocks
  - Percentage of monthly use
  - Long-term fixed price contracts
  - Renewable energy certificates
- You can also consider on-site renewable generation from things like wind turbines, solar panels, and biomass boilers.

[1] Department of Energy and EPA Green Power Partnership, "Guide to Purchasing Green Power: Renewable Electricity, Renewable Energy Certificates, and On-Site Renewable Generation."

Energy Checklist

- Implement an energy management system
- Assess your energy performance
  - Gather energy data
    - By volume (convert to BTUs) and by value
    - Make sure you understand all your energy costs and how they appear on your bill
  - Establish your baseline so you have a point for starting measurement
  - Analyze your usage patterns
    - learn about where you are using the energy and for what purposes
    - Use available data tools to measure your energy use
  - Benchmark
    - Compare your performance to other facilities, companies, or the industry
  - Assess for opportunities
    - Have an energy audit conducted by a qualified energy professional or conduct an energy audit using available guides
    - Focus on areas that use a lot of energy: process heating, machine drives and motors, lighting, HVAC, steam systems and compressed air system
    - There are a number of common opportunities and technology solutions. Refer to DOE assessment databases and guides to learn more about common opportunities for manufacturers.
- Consider using renewable energy as another way of reducing your impact from energy use

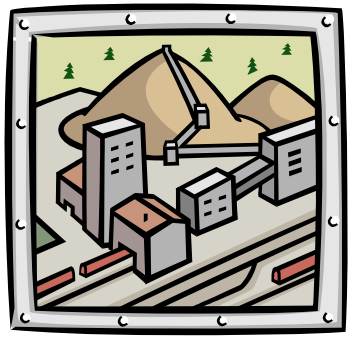
Where to go for Help

- The Department of Energy Industrial Technologies Program has a variety of resources to help you:
  - conduct energy audits,
  - identify opportunities and technologies that can help with energy efficiency,
  - learn about issues that affect specific energy intensive industries and
  - find information on crosscutting issues that affect many industries such as process heating, CHP, motor systems, steam and consumption.
- Local utilities often have energy efficiency programs
- Contact your state's department of energy
- The Green Power Partnership can help you purchase renewable energy

Search

- Energy Efficiency
- CHP
- Technical Assistance
- Metrics/Assessment Tools
- How-to Guides

Materials Use and Waste



- Most of the materials we use are not renewable, and many are wasted before they are even turned into products.
- Any material your company uses that is in excess of what is needed for a product is considered an environmental waste and should be targeted for reduction or elimination.[1]
- Decreasing the amount of material used and the waste created can lower costs through increased efficiency.

Examples of Costs from waste:

- Lost materials
- Tipping fees
- Trucking fees
- Protective gear
- Labor
- Storage and clean-up
- Contracting fees
- Permit fees

[1] EPA, "Lean and Environment Toolkit"

Materials Use in the U.S.

The amount of materials used in the U.S. economy has increased dramatically since 1900 (see figure 4).

At the same time, the percentage of materials used that are nonrenewable has increased over time (see figure 3).

So, over time, the United States has increased its use of materials and particularly, its use of nonrenewable materials.

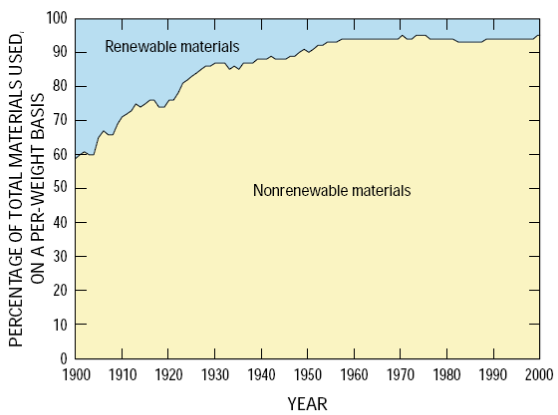


Figure 3. Renewable and nonrenewable materials used in the United States. Use of nonrenewable resources has increased dramatically in the United States during the 20th century (modified from Matos and Wagner, 1998, fig. 2).

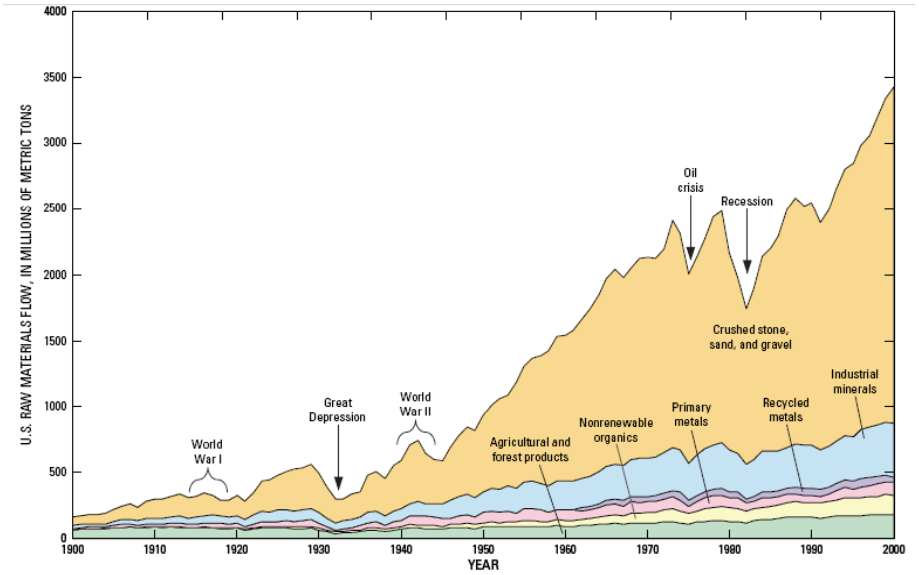


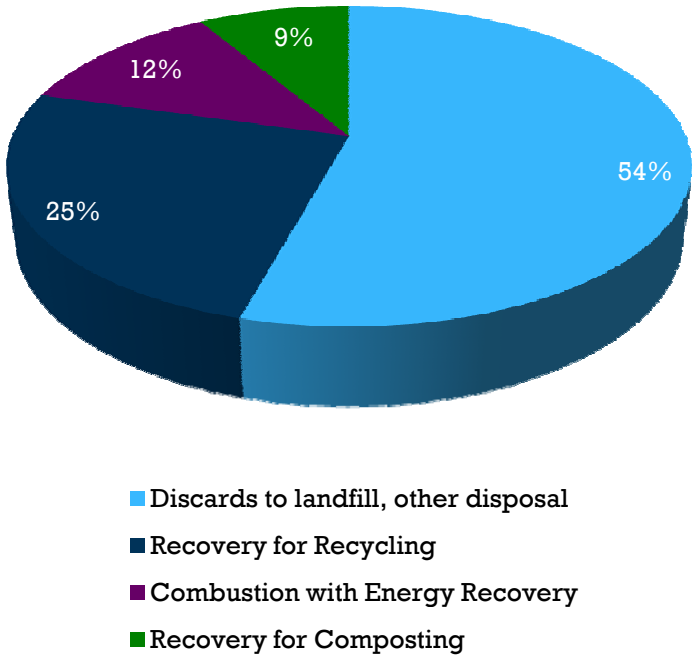
Figure 4. U.S. flow of raw materials by weight, 1900–98. The use of raw materials dramatically increased in the United States throughout the 20th century (modified from Matos and Wagner, 1998, fig. 3).

Figure 3: USGS, Materials in the Economy
Figure 4: USGS, Materials in the Economy

Waste in the U.S.

- In 2009, the U.S. produced more than 240 million tons of municipal solid waste.
- Only 33.8%, or 82 million tons, of the waste was recycled or composted.[1]
- Tipping fees, usually the price per ton to dispose of trash at a landfill vary widely depending on your state. They can range from $15-$96.[3]

Municipal Solid Waste in the U.S. (2009)[2]



[1] US Environmental Protection Agency "Municipal Solid Waste."
[2] U.S. Environmental Protection Agency, "Municipal Solid Waste in the United States: 2009 Facts and Figures."
[3] BioCycle, "The State of Garbage in America."

Conducting a Waste Assessment or Audit

- A first step in reducing waste is conducting a waste assessment. There are several methods of doing this, and each has its benefits.[1]

Records Examination

- Look at records such as purchasing and maintenance logs, supply invoices, waste hauling records, recycling invoices

Walk-through

- Follow your production through a facility, talking with employees, observing types of waste and how it's produced, inefficiencies, and space issues

Waste Sort

- Collect, sort, and measure your waste stream, targeting the entire organization or specific functional areas

[1] U.S. Environmental Protection Agency, "Plan Your Waste Wise Program"

Waste Management Hierarchy

It is important to think of waste management as a hierarchy. Not all waste management methods are created equal.[1]

Prevention (source reduction)

- the best waste management solution. It prevents the generation of waste and pollution at the source and reduces the amount of materials entering the supply stream.

Diversion (recycling or composting)

- a series of activities that includes collecting recyclable materials that would otherwise be considered waste, sorting and processing into raw materials such as fibers, and manufacturing raw materials into new products.

Energy recovery

- the process of obtaining energy from waste through a variety of processes (e.g., combustion).

Disposal

- the least desirable method of managing waste. It means the waste goes to a landfill, incinerator or a similar location.

Let's take a closer look at these methods.

[1] EPA, Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land

Waste Prevention

- You've probably heard the phrase, "an ounce of prevention is worth a pound of cure." It's the same idea with waste prevention. The best waste is the one that is never created.
- Waste prevention, or source reduction, reduces the amount or toxicity of the solid waste you generate.
- Because it involves reducing the amount of material you use (and therefore the amount of waste you produce) it often brings cost savings through increased efficiency and lower materials purchases as well as lower disposal costs.[1]

Examples of Waste Prevention[1]

- Using or manufacturing minimal or reusable packaging
- Using durable equipment and supplies rather than disposable ones
- Reusing products and supplies
- Using materials more efficiently
- Exchanging, selling, or giving away materials and goods for reuse
- Reducing the use of hazardous material inputs
- Reducing paper use

[1] WasteWise Tip Sheet, "Waste Prevention"

Waste Prevention

- When conducting your waste assessment, think about which waste streams can be reduced or eliminated through waste prevention methods.
- You may need to change processes, redesign your products, or work with suppliers and customers.
- Check with your local government and waste handlers to see if there are any waste reduction programs in your area.
- Preventing waste also saves the energy and prevents the pollution that would be used and produced in the production and transport of materials.

Example

- PepsiCo redesigned the packaging for its Aquafina water bottles. New water bottles were thinner, using 50% less plastic. They were also packaged without cardboard bases, eliminating the need for millions of pounds of cardboard. [1]

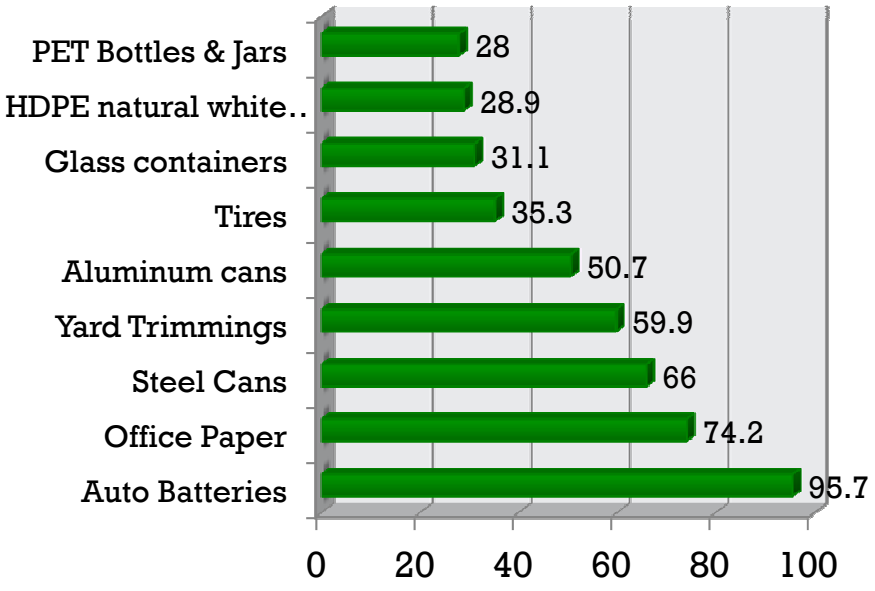
[1] GreenBiz, "PepsiCo Launches Industry's Lightest Water Bottle."

Waste Diversion

- Waste diversion (recycling or composting) is the next most desirable waste management method.
- Although wastes are diverted from landfills, recycling still requires energy and other resources, making it less desirable than prevention.
- Determine which of your waste streams could be recyclable. If a waste stream is not currently recyclable, would changing a process allow it to be recycled?
- For example, would you be able to recycle a metal waste stream if it was sorted from other metals or contaminants?

Recycling rates for various materials vary widely.

Percentage of Materials Recycled[1]



[1] US Environmental Protection Agency "Municipal Solid Waste."

Recycling

- One option for reusing or recycling your waste streams may be to find a materials and waste exchange in your area.
- A materials and waste exchange is a market for buying and selling reusable and recyclable commodities.
- Think about whether some of your waste streams could be used as inputs for other businesses.
- Can any of your waste streams be sold rather than disposed of?

Example

- **Hamilton Beach**
  - In Response to increased production efficiency, disposal costs, and regulatory requirements the company implemented various recycling/reuse projects.
  - Recycling programs divert approximately 1,000 tons of solid waste from the landfill each year and recycle approximately 4,000 tons of scrap metal.
  - The company saves approximately $18,000 each year on landfill fees from its solid waste recycling programs. The recycling of cardboard and scrap metal generates revenues of $6,500 and $300,000 respectively.[2]

[2] North Carolina Department of Environment and Natural Resources, "Case Study: Hamilton Beach/Proctor-Silex, Inc."

Energy Recovery[1]

- Another option for waste management is energy recovery.
- In this case, the waste does not go to a landfill. Instead, it is used as fuel to generate energy (electricity or steam) usually through combustion.
- This process is often called **waste-to-energy**.
- It is a way to avoid putting into a landfill waste that is not recyclable.
- There are around 90 facilities in the U.S. that convert municipal solid waste to energy through combustion.
- Click here for more information on energy recovery from waste.

[1] U.S. Environmental Protection Agency, "Municipal Solid Waste in the United States: 2009 Facts and Figures."

Disposal

- Waste disposal in a landfill or incinerator is the least desirable waste management method.
- Currently, more than half the waste produced in the U.S. goes to disposal.
- There are nearly 2,000 municipal landfills in the United States.[1]
- Click here for more information on landfills.

[1] U.S. Environmental Protection Agency, "Municipal Solid Waste in the United States: 2009 Facts and Figures."

Hazardous Materials and Waste

- Hazardous waste is defined as liquid, solid, contained gas, or sludge wastes that contain properties that are dangerous or potentially harmful to human health or the environment.[1]

- Using hazardous materials can be costly for manufacturers. There are various regulatory compliance costs such as:

  - treatment, storage and disposal costs;

  - costs for protective gear and precautions for workers;

  - cost of monitoring and documentation;

  - product-related regulatory compliance, should hazardous materials end up in final products.

- Substituting non-hazardous materials for hazardous ones can help a company avert these costs, which can add up to considerable sums.

Example

- Computer Circuitry Company installed a new copper plating system into their facility that reduced the company's hazardous waste by 42 tons per year (67% of the company's total waste). The project cost $145,000 and had a payback period of 20.4 months.[3]

[1] U.S. Environmental Protection Agency "Wastes – Hazardous Wastes"
[2] Zero Waste Network. "Success Stories: Computer Circuitry Company"

Hazardous Waste

- There are different kinds of hazardous wastes. They are listed to the right.[1]
- Click here to learn more about how to identify different kinds of hazardous waste.
- You are regulated differently depending on how much hazardous waste you generate.

Listed Wastes

- Wastes listed by EPA as hazardous. F-list wastes are from common manufacturing and industrial processes

Characteristic Wastes

- Not listed wastes but wastes that are ignitable, corrosive, reactive or toxic

Universal Wastes

- There are streamlined regulations for managing waste from batteries, pesticides, mercury, and bulbs

Mixed Wastes

- Wastes that contain both radioactive and hazardous waste components

[1] U.S. Environmental Protection Agency "Wastes – Hazardous Wastes – Waste Types"

Addressing Hazardous Waste

- Before proceeding with any hazardous materials/waste management program/project, it is a good idea to become familiar with the federal and state regulations that may affect you (see the lesson on domestic and international regulations for more on these)
- Identify where you are using hazardous materials. Determine which of your solid wastes are considered hazardous wastes.
- Ask your hazardous waste contractor if there are ways to lower your waste disposal costs. Would using a different size or type of container make it easier to handle? Are there any components to your waste stream that are particularly costly?
- If you are currently producing hazardous wastes, determine what level of generator you are. If you reduce your wastes, could you be regulated as a different kind of generator?
- Are you treating, storing and disposing of hazardous waste in accordance with state and federal standards or better?
- Can you substitute non-hazardous materials for hazardous materials you are currently using? Identify those hazardous wastes that can be recycled or used for energy production.
- Have an emergency plan to deal with releases and the corrective actions you can take to address these should they occur.

[1] U.S. Environmental Protection Agency "Wastes – Hazardous Wastes"

Materials and Waste Checklist

- Conduct a waste assessment or audit to learn about your waste streams and opportunities to reduce them.
- Follow the waste hierarchy
  - Prevention, Diversion, Energy Recovery, Disposal
- Check to see if there are any waste prevention programs or waste exchanges in your state or city
- Identify hazardous waste streams and learn about relevant regulations
- Understand all your costs of waste and hazardous waste generation.
- Remember to get employees involved in any waste management program

Where to go for Help

- EPA's Waste Wise program helps organizations eliminate waste
- EPA's Guide for Industrial Waste Management helps facility managers make better decisions on waste.
- EPA's Hazardous Waste site provides step-by-step assistance to companies who either generate, transport or manage hazardous material
- Pollution prevention – technical assistance from an expert – EPA regional offices or P2 centers –Regional Technical Assistance Programs
- EPA's Lean Manufacturing and the Environment page has a lot of information on how to eliminate waste
- Contact your state environmental agencies and municipal waste agencies

Search Terms

- Hazardous Waste and Materials
- Material Conservation / Waste Minimization
- Pollution Prevention
- Regulations
- Compliance Assistance
- Technical assistance

Greenhouse Gases

- Gases that trap heat in the atmosphere are often called **greenhouse gases** (GHGs).
- Some greenhouse gases, such as carbon dioxide, occur naturally and are emitted to the atmosphere through natural processes and human activities. Other greenhouse gases (e.g., fluorinated gases) are created and emitted solely through human activities.
- The production of GHGs is closely tied to energy use because energy is mainly produced by burning fossil fuels producing GHGs as a byproduct.

Terms You'll Hear

- **Climate Change**
- **Greenhouse Gases**
- **GHGs**
- **CO_2 Carbon Dioxide**
- **Carbon Footprint**
- **Carbon emissions**
- **Carbon Sequestration**
- **Carbon equivalents**
- **CO2 equivalents (CO2e)**
- **Carbon Offsets**

Main Greenhouse Gases

- We often hear about "carbon footprint" or "carbon emissions" but there are really six main GHGs. Carbon Dioxide (CO_2) is the most common one.

- The six main GHGs that enter the atmosphere due to human activity are:[1]

CO_2	Carbon Dioxide
CH_4	Methane
N_2O	Nitrous Oxide
SF_6	Sulfur Hexafluoride
HFCs	Hydrofluorocarbons
PFCs	Perfluorocarbons

Let's take a closer look at these greenhouse gases.

[1] EPA "Greenhouse Gas Emissions," Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008

Main Greenhouse Gases[1]

Carbon Dioxide (CO_2)

- Comes from the burning of fossil fuels, solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement).

Methane (CH_4)

- Emitted during the production and transport of coal, natural gas, and oil, from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

Nitrous Oxide (N_2O)

- Emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

Fluorinated Gases

- Hydrofluorocarbons (**HFCs**), perfluorocarbons (**PFCs**), and sulfur hexafluoride (**SF_6**) are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases ("High GWP gases").

[1] EPA "Greenhouse Gas Emissions," Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008

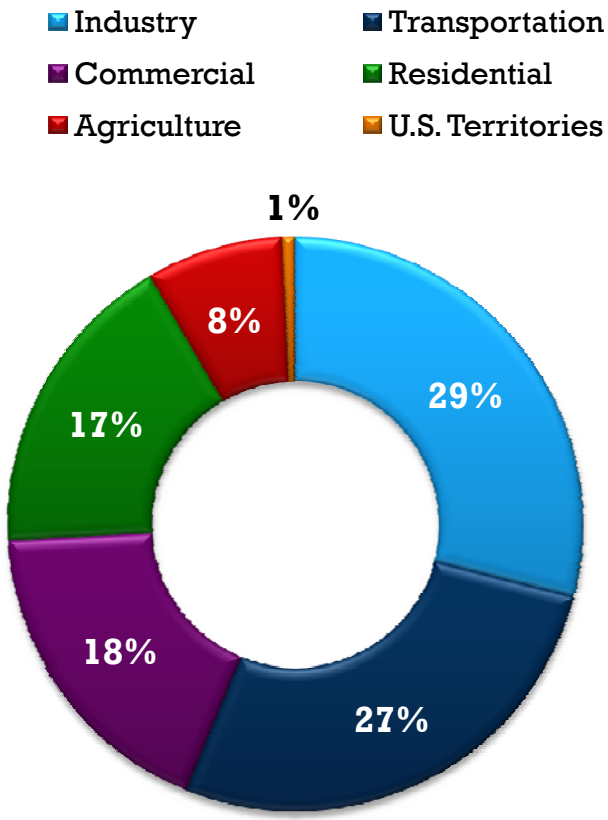
Where do Greenhouse Gases Come From?[1]

- About 35% of U.S. GHG emissions come from the production of electricity, but that energy is ultimately consumed in the other economic sectors. When emissions from electricity are distributed among these sectors, the industrial sector accounts for the largest share of U.S. greenhouse gas emissions.

- Including the GHGs produced from the energy it uses, **industry produces around 29% of U.S. greenhouse gases.**

- More than **94%** of all U.S. greenhouse gas emissions are from **fossil fuel combustion**

U.S Greenhouse Gas Emissions by Economic Sector with Electricity-Related Emissions Distributed (2009, CO_2 Eq.)



[1] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008

Comparing Different Greenhouse Gases

- Emissions of greenhouse gases are typically expressed in a common metric, so that their impacts can be directly compared, as some gases are more potent (have a higher global warming potential or GWP) than others.

- The international standard practice is to express greenhouse gases in **carbon dioxide (CO_2) equivalents**. Emissions of gases other than CO_2 are translated into CO_2 equivalents using **Global Warming Potentials (GWPs)** determined by the Intergovernmental Panel on Climate Change (IPCC)

- Click here for information on the GWPs for main GHGs

Examples of Global Warming Potentials from Selected Greenhouse Gas Emissions[1]

	Global Warming Potential (GWP) over 100 years
Carbon Dioxide (CO_2)	1
Nitrous Oxide (N_2O)	310
Methane (CH_4)	21
HFC-23 (a type of hydroflurocarbon)	11,700

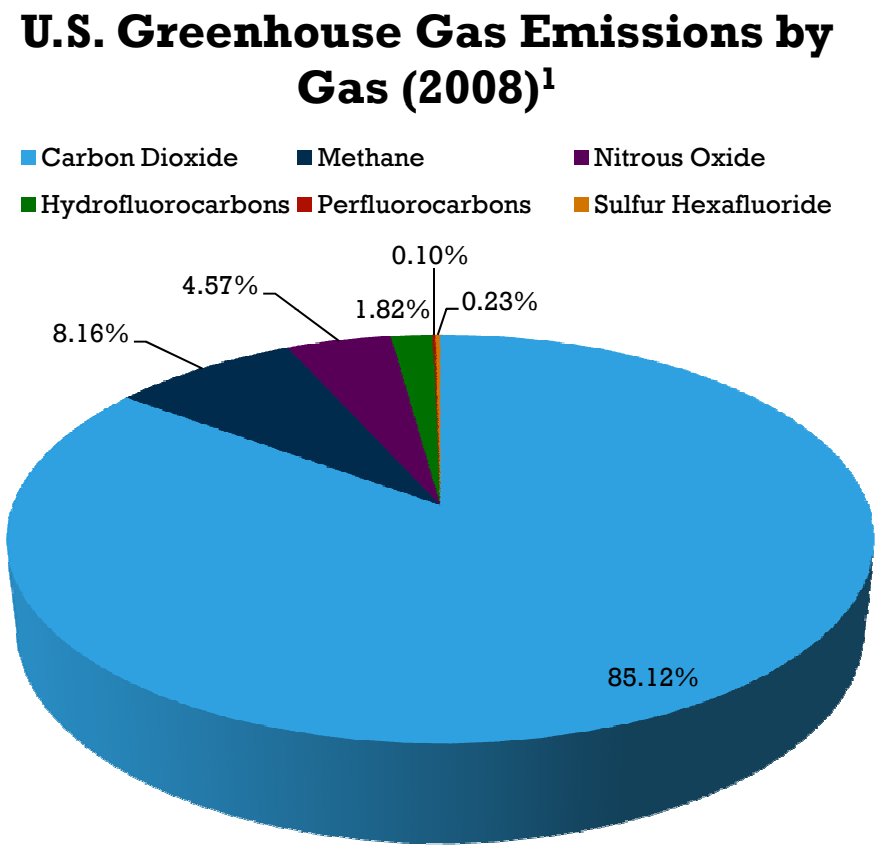
One unit of nitrous oxide has a global warming potential 310 times more powerful than one unit of carbon dioxide.

[1] Intergovernmental Panel on Climate Change

Which GHGs are Most Common

- When you convert the U.S. GHG emissions to carbon dioxide equivalents, you can see that carbon dioxide (CO_2) is responsible for the vast majority of emissions.

- In 2008, the U.S. emitted nearly 6 billion metric tons of CO_2



[1] EPA "Greenhouse Gas Emissions," Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008

Measuring Emissions[1]

- **There are two basic types of emissions**

Direct Emissions

- come from sources under the control or ownership of the company

Indirect Emissions

- Are the result of the company's activities, but are produced by sources that are not owned or controlled by the company

[1] Greenhouse Gas Protocol Initiative: "A Corporate Accounting and Reporting Standard"
[2] EPA Climate Leaders "Design Principles Guidance"

Emissions Scopes

- Emissions are also often discussed in terms of scope:[1]

Scope 1	Scope 2	Scope 3
• These are **direct** emissions that come from things like company boilers, furnaces, company-owned vehicles, or emissions from manufacturing chemical processes	• These are **indirect** emissions from the production of the electricity purchased by the company	• These are all other **indirect** emissions and are more difficult to count. • They come from sources such as the extraction and production of inputs and materials the company purchases, transportation, business travel, waste disposal, any outsourced activities, and the emissions from the use phase of the product.

Scope 1 and 2 Emissions were also together called "Core Emissions" by the EPA Climate Leaders Program because they are the most critical to measure.[2]

Emissions scopes are described in more detail on the next page.

[1] Greenhouse Gas Protocol Initiative: "A Corporate Accounting and Reporting Standard"
[2] EPA Climate Leaders "Design Principles Guidance"

Emissions scopes[1]

Scope 1 and 2 emissions are unique to each company to avoid double-counting. They are also relatively easier to calculate than Scope 3 emissions.

Scope 1

Fuel combustion

Company vehicles

Chemical or Material Processes

Fugitive Emissions

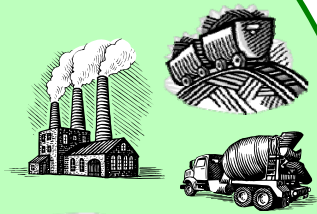
Scope 2

Purchased electricity

Easier to Measure

Scope 3

Extraction and Production of inputs

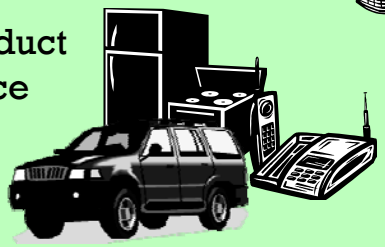


Outsourced activities

Business travel

Waste

Use of product or service



Other Transportation

[1] Greenhouse Gas Protocol Initiative: "A Corporate Accounting and Reporting Standard"

Measuring Your Emissions

- Measuring your GHG emissions is a complicated process, and you should consult additional guidance on how to do it. However, these are the basic steps.

1. Set an organizational and operational boundary for measurement
2. Identify your sources of emissions
3. Select a calculation approach
4. Collect emissions data
5. Quantification Methodology
6. Aggregate data to the corporate level

[1] Greenhouse Gas Protocol Initiative: "A Corporate Accounting and Reporting Standard" and EPA Climate Leaders "Design Principles Guidance"

Setting Boundaries[1]

- Before you start measuring your emissions, you need to set the organizational and operational boundaries that will define what you will measure.

Organizational Boundary

- Every business is structured differently. Some may be just one facility, but others may be larger organizations with joint ventures, subsidiaries, etc.
- The organizational boundary represents the boundary for the company as a whole and can be determined by **equity** (how much the operations are owned by the company) or by **control** (which operations are controlled by the company)

Operational Boundary

- Once you have set organizational boundaries, you can determine your operational boundaries
- This means identifying the emissions related to your operations and categorizing them (i.e. scope 1, 2, or 3).
- Here you decide **which emissions you will include** in your inventory.
- The boundary is applied across the organization to identify the emissions.

[1] Greenhouse Gas Protocol Initiative: "A Corporate Accounting and Reporting Standard" and EPA Climate Leaders "Design Principles Guidance"

Identify Emissions Sources[1]

- The next step is to identify your direct emissions sources.

Stationary Combustion

-boilers

-furnaces

-turbines

-heaters

-anything else that burns fuels and doesn't move

Mobile Combustion

-transport

-trucks

-ships

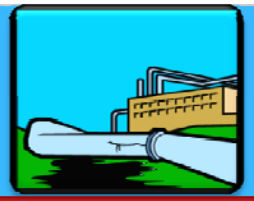
-airplanes

-cars

Process Emissions

-produced by some manufacturing processes

-only occur in certain industries like cement manufacturing



Fugitive Emissions

-can be intentional and unintentional

-leaks

-coal piles

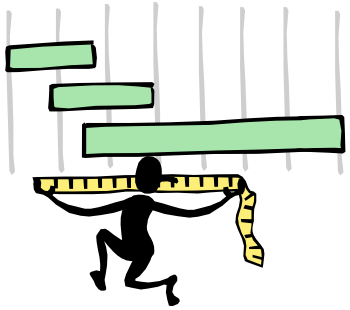
-wastewater treatment

-cooling towers

- You will also want to identify the indirect emissions sources that you want to measure, such as purchased electricity and steam and emissions from your supply chain.

[1] Greenhouse Gas Protocol Initiative: "A Corporate Accounting and Reporting Standard" and EPA Climate Leaders "Design Principles Guidance"

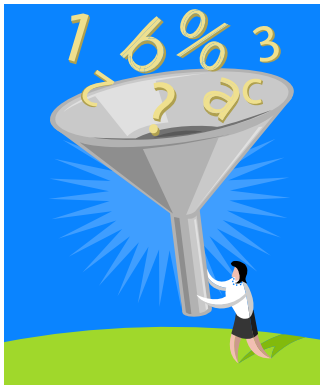
Calculation Approach[1]



- It is unlikely that you will measure your emissions directly through monitoring.
- There are many ways to calculate emissions, but the most common way is to apply emission factors to the various emissions sources (activities).
- An emissions factor is a ratio of the amount of emissions per unit of activity.
- For example, the emission factor for gasoline is about .009 metric tons CO_2 per gallon of gasoline.
- Click here for data related to emission factors from the Department of Energy.
- This calculator from the EPA can help you calculate your emissions from purchased electricity.
- You will need to determine which emissions factors are right for your measurements.

[1] Greenhouse Gas Protocol Initiative: "A Corporate Accounting and Reporting Standard" and EPA Climate Leaders "Design Principles Guidance"

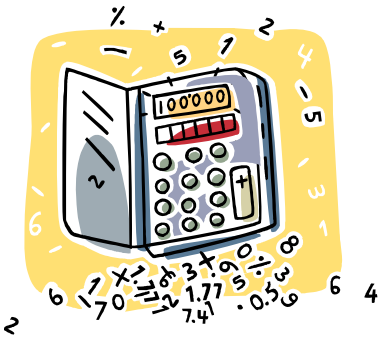
Collecting Data[1]



- Most companies will measure their emissions based on the quantities of fuels purchased, so energy use data on fuels and purchased electricity is important.
- Certain sectors may have more process emissions and may need more detailed data.
- Guidance for specific sectors, such as cement and aluminum manufacturing can be found on the Greenhouse Gas Protocol website here and the EPA here.
- You should also check with your industry associations to see if they provide guidance on collecting data.

[1] Greenhouse Gas Protocol Initiative: "A Corporate Accounting and Reporting Standard" and EPA Climate Leaders "Design Principles Guidance"

Quantifying Results[1]



- Once you have collected your energy use data, you will need to use the emission factors you identified to convert the data into emissions data.

- The Greenhouse Gas Protocol Initiative has toolsets for specific sectors as well as cross sector tools.

- EPA guidance on emissions from sources such as stationary combustion and electricity can be found here.

- You will probably need to use a variety of tools to cover all of your emissions sources. Fortunately, there are many tools that are readily available.

[1] Greenhouse Gas Protocol Initiative: "A Corporate Accounting and Reporting Standard" and EPA Climate Leaders "Design Principles Guidance"

Aggregating Data[1]

- If your company has more than one facility, you may want to aggregate the emissions data at a corporate level.
- There are two basic ways of doing this:
  - Facilities report activity and fuel data and emissions are calculated at the corporate level
  - Facilities calculate their emissions, which are aggregated to create the corporate emissions data
- You will want to plan this carefully to minimize the accounting burden and the risk of errors.
- A good thing to do is to incorporate emissions data into your current data reporting systems.

[1] Greenhouse Gas Protocol Initiative: "A Corporate Accounting and Reporting Standard" and EPA Climate Leaders "Design Principles Guidance"

Measurement – Guidance and Tools Review

- EPA's Climate Leaders Greenhouse Gas Inventory Protocol "Design Principles" document provides guidance on getting started with your GHG inventory.
- Climate Leaders has a variety of other resources and tools including a useful tool for small businesses to help them calculate their footprints.
- The Greenhouse Gas Protocol Initiative also has a variety of guidance documents and tools to help you calculate your emissions.

Once you have identified and measured your greenhouse gas emissions for a base period, you can **set reduction goals** and **identify opportunities** to lower your emissions.[1]

[1] EPA Climate Leaders "Design Principles Guidance"

Reducing Emissions

- To lower an individual company's footprint, emissions can be directly reduced, sequestered or offset[1]

Reduced

- Purchased energy will often be a company's or facility's largest source of emissions, so **energy efficiency** or switching to lower carbon **renewable energy** are the most common way of reducing emissions.

Sequestered

- Carbon dioxide is also removed from the atmosphere (or "sequestered") when it is absorbed by plants or other biological sinks as part of the biological carbon cycle.

Offset

- With offsets, one emitter pays another to either reduce emissions or sequester carbon

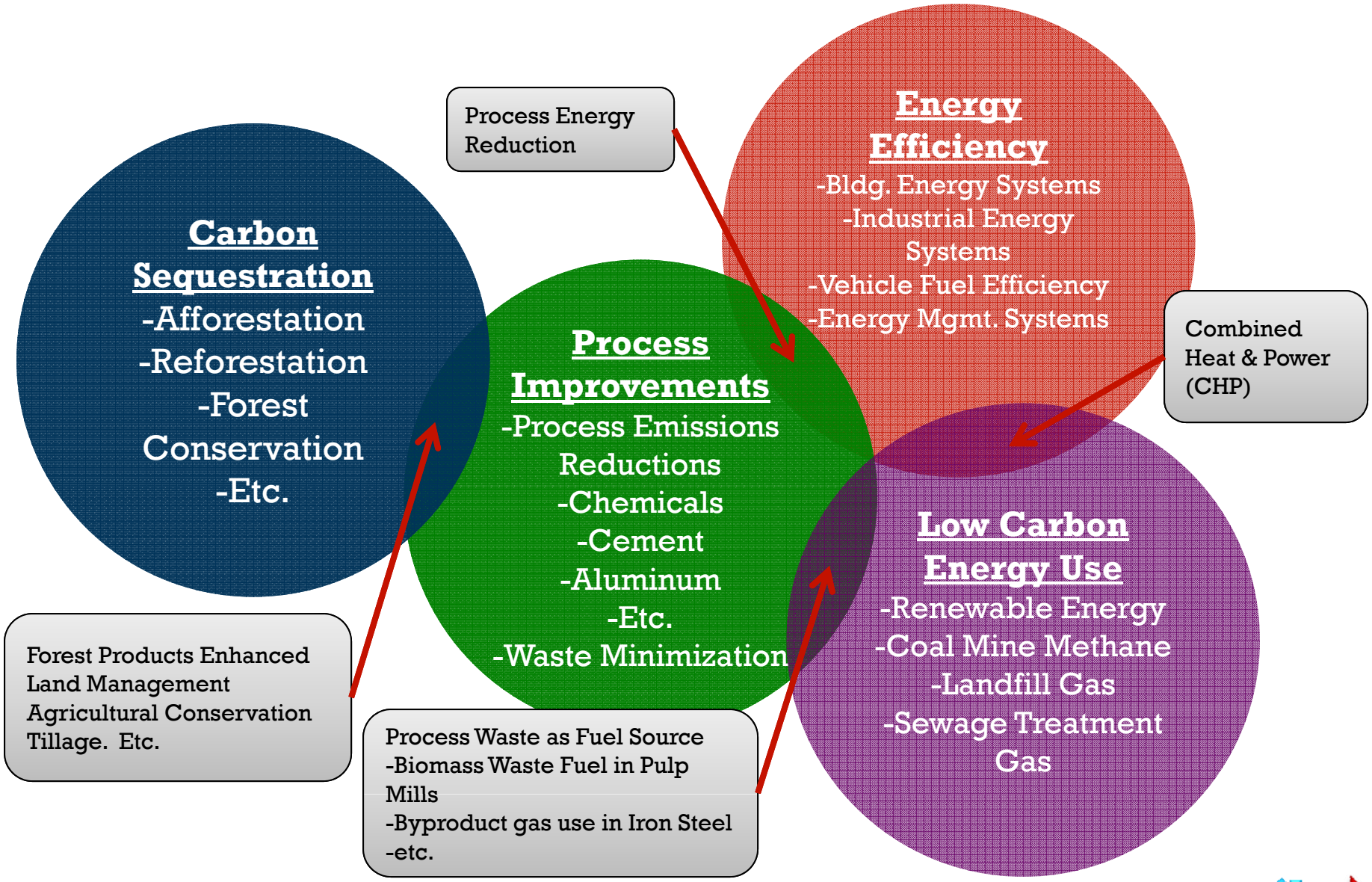
Example

- At Caterpillar's production plant in Mossville, IL, a steam trap leak was identified in the steam delivery system by identifying the steam loss. Once the leak was fixed, the company saved 4,890 MWh of energy and 2,757 MT of CO_2 annually, thereby dramatically reducing the company's energy bill. [2]

Next, you will learn more about opportunities for reducing emissions.

[1] EPA Climate Leaders "Design Principles Guidance"
[2] EPA. "Climate Leaders- Caterpillar"

Common opportunities for reducing GHGs[1]



[1] EPA Climate Leaders "Design Principles Guidance"

Greenhouse Gas Emissions Checklist

- ✓ Determine your company's organizational boundaries defining your businesses operations based on equity or control
- ✓ Set operational boundaries
- ✓ Identify GHG emissions sources
- ✓ Select an emissions calculation approach and select emission factors
- ✓ Collect activity data
- ✓ Apply quantification methodology to estimate GHG emissions
- ✓ Aggregate emissions data to the corporate level
- ✓ Set goals for reduction, either absolute emissions or intensity
- ✓ Identify reduction opportunities.
- ✓ Evaluate and implement projects
- ✓ Measure and report progress

Where to go for help

- Two good places to start are the Greenhouse Gas Protocol and EPA's former Climate Leaders program.
- The EPA Climate Change site provides background and detailed information on climate change and GHGs.
- Since emissions are tied to energy use, it can be helpful to talk to your local energy providers and review the energy section in this lesson.
- Check with your industry associations to see if they have compiled information on GHG issues for your industry.

Search Terms

- Climate Change/GHG Emissions
- Energy Efficiency
- General Information
- How-to Guides
- Metrics/Assessment Tools
- Voluntary or Partnership Programs

Air Quality

- What is Air Quality?
  - According to the Journal of Environmental Quality, air quality is defined as a measure of the condition of air relative to the requirements of one or more species and/or to any human need or purpose. [1]
  - According to the EPA, indoor air quality can be anywhere from 2-5 to even 100 times more polluted than outdoor air quality. [2]
- What does it mean for my business?
  - Air quality is regulated by the federal government, and there are costs associated with meeting air quality regulations. Failure to meet regulations can result in fines.
  - Air pollution can cause a poor relationship between the manufacturer and the community.
  - Since humans breathe in 3,000 gallons of air a day, employees are very susceptible to any change in air quality at your company or facility. When pollutants enter the air supply, they can moderately to severely impact their health. [2]
  - Poor indoor air quality leads to expenses such as gas masks, safety training, and expensive ventilation systems. By reducing the amount of pollutants emitted many of these expenses can be avoided.

[1] Meanings of environmental terms. *Journal of Environmental Quality*
[2] EPA. "Air- Basic Information"

Air Quality

- Companies should be concerned with both **indoor air quality** (inside your facility) and **outdoor air quality**, which is affected by emissions from buildings, products and transportation.
- Air emissions can affect your employee's health, the local area around your location, and even the water quality in your area.
- Air in the atmosphere flows around the globe, so your centralized actions have a global effect.
- Air quality in the United States is regulated at the national level by the Clean Air Act.[1]

[1] EPA, "The Plain English Guide to the Clean Air Act"

The Clean Air Act

- The Clean Air Act is the federal government's regulation to improve U.S. air quality.
- It gives the EPA the authority to sets limits on certain air pollutants and emissions coming from sources like chemical plants, utilities, and steel mills.[1]
- Individual states and tribes must have regulations matching or more stringent than those based on the Clean Air Act. This allows for local regions to effectively regulate emissions based on the conditions of the area.[1]
- The common or criteria air pollutants are always regulated through the air permitting system. The Clean Air Act establishes the National Ambient Air Quality Standards (NAAQS) for this list of air pollutants.[2]

[1] EPA, "The Plain English Guide to the Clean Air Act"
[2] EPA, "What are the Six Common Air Pollutants?"

Common Air Pollutants[1]

The Clean Air Act provides for the regulation of six common air pollutants or "**criteria pollutants**."[2]

Ozone (O_3)

- Emitted at ground level by cars, industrial emissions, gasoline vapors, solvents.

Particulate Matter

- Combination of extremely small particles and liquid droplets. Can be made from acids, organic materials, metals, or soil and dust. There are different categories, depending on size.

Carbon Monoxide (CO)

- Colorless, odorless gas emitted from combustion processes.

Nitrogen Oxides (NO_x)

- Contributes to the creation of ground level ozone.

Sulfur Dioxide

- Produced mainly in fossil fuel combustion at power plants and in industrial sites.

Lead

- Produced mostly by burning leaded gasoline, paint, or industrial sources such as lead smelters.

[1] EPA. National Ambient Air Quality Standards
[2] EPA, "What are the Six Common Air Pollutants?"

Other Air Pollutants

Hazardous Air Pollutants (HAPs) or Air Toxics[1]

- Defined under the Clean Air Act as pollutants that cause or may cause cancer or other severe health effects or adverse environmental and ecological effects.
- There are 187 chemicals and chemical categories regulated under the Clean Air Act as HAPs.
- Hazardous Air Pollutants include chemicals such as benzene, perchlorethlyene, dioxin, asbestos, mercury and chromium.

Volatile Organic Compounds (VOCs)[2]

- VOCs are emitted as gases from certain solids or liquids and are mostly concentrated indoors.
- They are typically emitted during the manufacture or use of everyday products such as cleaning products, adhesives, degreasing, solvents and paints.
- They are a leading cause of ground-level ozone.

[1] EPA "About Air Toxics"
[2] EPA "Volatile Organic Compounds"

Air Quality Permits

- Permits are issued to all large sources ("major" sources) and some smaller sources (called "area" sources, "minor" sources, or "non-major" sources). [3]
  - Each level has a threshold of pollution in tons.
  - Larger or "major" sources emit at least 10 tons per year of any one HAP, or at least 25 tons per year of a combination of HAPs
  - Smaller or "area" sources emit less than 10 tons per year of a single HAP and less than 25 tons per year of all HAPs combined
- Most permits are issued by state or local agencies. [1]
- The EPA has enforcement power on any permits issued under the Clean Air Act, including administrative authority to force a penalty payment or filing a suit in civil court. [1]

What do Permits do?

- set limits on the types and amounts of air pollution allowed
- Set operating requirements for pollution control devices or pollution prevention activities
- Establish monitoring and record keeping requirements. [1]

[1] EPA, Air and Radiation "Permits and Enforcement"
[2] EPA, Air and Radiation "Air Permits Program"
[3] EPA, AirData "About the National Emissions Inventory Database"

Types of Permits

There are three major types of permits required under the Clean Air Act:[1]

Acid Rain Permits

- designed to lower nitrogen dioxide and sulfur dioxide levels (which cause acid rain) in air pollution through a market-based system.

New Source Review (NSR) Program

- require that industrial sources install good pollution control technology when they significantly modify or construct their facilities.

Operating Permits

- legally-enforceable documents designed to improve compliance by clarifying what facilities (sources) must do to control air pollution.
- Most commonly used permit type. They include information on what kind of pollutants and how much a company is emitting and how they can reduce the amount. The cost for each individual permit pays for the activities relating to the permits and acts as an incentive for companies to reduce their pollution amount.

[1] EPA, Air and Radiation "Air Permits Program"

Common Indoor Air Quality Issues in Manufacturing

Problems	Solutions
Dust, particulates - Employees with asthma or allergies might have a hard time breathing [3]	Air purification systems installed above the machinery to remove harmful fumes immediately.
Chemical or Burning smells from parts or cleaners (solvents) - Could severely impair senses of smell if inhaled for a given period of time [2]	Windows - Allow fresh air to flow in and out (might not be feasible for temperature controlled environments
Poor quality air conditioner or heating system.	Filters - Update in air conditioning, ventilation, and heating systems - Environmentally preferable filters can be easily found.
Fuel emissions from "nonroad" transportation vehicles, such as forklifts[1]	Invest in compressed air powered manufacturing parts and minor transportation vehicles
Mold from moisture build up in production area[2] - Can lead to asthma or allergy related hazards for employees working with the machinery.	Keep production areas clean and dry to avoid dust, particulate, or mold build up.[2]

[1] EPA, "The Plain English Guide to the Clean Air Act"
[2] EPA "Taking Toxins out of the Air."
[3] EPA "Air-Main Page"

Outdoor Air Quality Issues

- Pollution from manufacturing that is released into the atmosphere can affect weather and air quality levels and can increase health risks.
- The six criteria air pollutants can all originate from manufacturing, whether through burning fuels or chemicals or other processes that occur on the plant floor.
  - These pollutants cause smog, acid rain, health effects, and can permeate the ground, flesh, or water through the air or precipitation. [1]
- Outdoor air pollutants also lower visibility in both urban and rural areas. For example, the visibility above many of the nation's National Parks has improved after the passage of the Clean Air Act, bringing in more tourists. [1]
- When smog has taken over a city, the community typically demands that local politicians pass laws that would improve air quality and visibility.

Example

- Archer Daniel's Midland Company is a major food manufacturer in Iowa. The company used software to track emissions and reduce waste. The software led to a reduction of 1,600 tons of air pollutants and reuse of 57,700 tons of ash from boilers a year (into cement, concrete, or soil stabilizers) resulting in savings of $57,000 and $250,000 a year respectively from the reduction of raw materials. [2]

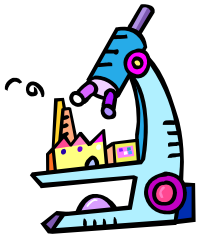
[1] EPA, "The Plain English Guide to the Clean Air Act"
[2] Zero Waste Network "Success Stories: Archer Daniel's Midland Company"

Combustion

- Combustion is a large source of indoor and outdoor air pollutants, from manufacturing facilities.[1,2]
- They are produced in several common ways:
  - Burning Chemicals
    - Different chemicals used in production have unique smells and effects on people, some more dangerous than others. [2]
  - Fuel
    - Mainly release carbon monoxide, nitrogen dioxide, and particles.
  - Boilers
    - Boilers can emit mercury, organic air toxins and dioxins.
  - Incinerators
    - Incinerators can emit mercury, lead, cadmium, nitrogen dioxide and particle pollution, all of which are considered toxic. [1]
- Combustion systems are a key target of air quality improvement strategies.

[1] "Emissions Standards for Boilers and Process Heaters and Commercial/Industrial Solid Waste Incinerators." EPA.
[2] UNEP. "PRE-SME Program"

Air Quality Audits



- By performing an air quality audit, your company can determine whether or not air pollution is an issue on the production line.
- In determining how much of which air pollutants are in the plant, your company can target solutions to those specific pollutants.
- The EPA has guides for how to calculate and determine air quality and air pollutant sources for certain processes here. [1]
- A few easy ways to check your indoor air quality are:
  - Check for mold build ups, leaks, or mishandled chemicals
  - See where more filtration is or is not necessary to determine your company's needs. [2]

[1] EPA, "Air Quality; Tools and Calculators"
[2] EPA. "The Inside Story: A Guide to Indoor Air Quality"

Air Pollution Control Technologies

- Some common air pollution control technologies are:
  - Wet scrubbers
  - Carbon absorption
  - Incineration
  - Condensation
  - Electrostatic precipitators [1]
- Each of these technologies will reduce different types of air pollutants, but they are all end-of-pipe solutions.
- By preventing air pollutants from being emitted in the first place, your company can eliminate the cost of additional end-of-pipe solutions like these as well as all other costs that occur from air pollutants.
- To learn more about these technologies, the EPA has set up a training tool describing what the technologies are, how to use them, performance monitoring, etc. The EPA, partnered with RTI, also has a website that verifies commercial air pollution technologies.
- The Clean Air Technology Center has information on various available technologies.

[1] EPA. "Air pollution Control Technology Series Training Tool"

Lowering Costs by Improving Air Quality

By adding ventilation and/or switching from harsh chemical solvents to water based ones, face masks, other protective gear, and the gear and chemical handling training for employees might not be necessary.[1]

You can avoid additional charges , regulations, and restrictions by staying within a lower source category for permitting. The costs of crossing the threshold are often greater than the technology necessary to stay below the threshold.[1]

Chemicals represent a large cost for manufacturers who rely on them for production uses. By reducing the amount of chemicals and solvents used, and substituting more environmentally preferable methods, companies can reduce this major cost and increase air quality.[2]

Employees who handle or interact with dangerous chemicals (ex: VOCs or HAPs) often have increased health risks due to the fumes released. In reducing chemicals used, companies decrease the health and safety risks.[2]

[1] EPA, Air and Radiation "Air Permits Program"
[2] "PRE-SME Resource Kit" UNEP.

Success Stories

Before 2002, North American Decal had almost exclusively used solvent-based inks which have high levels of volatile organic compounds (VOCs). After rolling out a VOC reduction project they began transferring to less harmful UV curable inks which are of a higher quality, dry faster, and eliminated a printing step. By 2005, they had reduced use of VOCs from 4.24 to 1.99 grams per square foot of printed material and had noted a marked improvement in indoor air quality.[1]

Pwani Oil Products produces edible oils and fats as well as bar soap. Through the use of biofuel pitch to run boilers, installation of an extra deodorizer column, switching from furnace oil to biomass, and installation of feed water pre-heater for boiler flue gases, the company saved over $180,000 and reduced its air emissions by 98%.[2]

Armstrong's Beverly, West Virginia, wood flooring plant received 2008 Most Improved Award from the Department of Environment Protection of West Virginia for renovating its sawdust collection system, a $2.5 million project. By reducing the amount of sawdust in the air of the plant, the air quality increased immensely. The DEP commended the plant for supplying the cleanest air in its 18 years of operation.[3]

International Paper gradually substituted elemental chlorine for chlorine dioxide (a criteria pollutant). The substitution reduced chloroform emissions by 410,000 lbs to below reporting standards, chlorine air emissions from 39,000 lbs to 7 lbs, and dioxin emissions are now non-detectable.[4]

[1] Environment Canada. "Raw Materials Substitution"
[2] UNEP. "PRE-SME Resource Kit"
[3] Armstrong. "Awards and Certifications"
[4] Zero Waste Network. "Success Stories: International Paper"

Air Quality Checklist

- ✓ **Check** federal, state and local emissions standards to see if you are in compliance with the most up to date versions.
  - ✓ Determine whether your state is the "control authority" for air permits on the EPA website
  - ✓ Also check potential building codes, safety requirements, or customer expectations.
- ✓ **Investigate and implement** improvements that would reduce or reclaim emissions and increase air quality.
  - ✓ Perform an air quality audit to inspect the total amount of pollutants and their source.
  - ✓ Identify any guides, information, or technologies specific to your industry. Does your industry association have information on air quality?
  - ✓ The EPA has many calculators and tools to help choose the right pollution prevention method for your company.
  - ✓ Choose technology that can meet or exceed air quality standards in the Clean Air Act and for your source qualification (see permits page)
  - ✓ Conduct a cost analysis on any proposed efficiency measures.
  - ✓ Substitute chemical based solvents and cleaners for safer water based ones.
- ✓ **Review and publicize** emissions reductions.
  - ✓ Check your state's law to see if additional permits can be sold to offset costs or even make a profit.
- ✓ **Repeat.** The more improvements made, the happier the shareholders and customers will be.

[1] EPA, "The Plain English Guide to the Clean Air Act"
[2] "Taking Toxins out of the Air." EPA
[3] EPA, "What are the Six Common Air Pollutants?"
[4] "Volatile Organic Compounds" EPA

Where to go for help

- EPA air website, including their web training and The Plain English Guide to the Clean Air Act.
- The National Association of Clean Air Agencies (For state-specific information)
- Local Universities (Such as MIT's lecture program)
- Air Pollution Control Technology Center (Tips for which technologies can help improve air quality)
- The Occupational Safety and Health Administration's Indoor Air Quality in Commercial and Institutional Buildings Publication

Search Terms

- Regulations
- Compliance Assistance
- Metrics and Assessment Tools

Packaging

- Packaging can be an important source of cost savings for a company as well as a source of unnecessary waste.
- Packaging is also a visible representation of your company to your customers and can affect the company's reputation.
- The role of packaging is to protect and promote the product, provide information on the product, enable convenient transportation of the product, and allow for efficient handling of the product. Sustainable packaging deals with how to do this with minimal materials and environmental impacts. [1]

•In most parts of the developed world, packaging constitutes as much as one-third of the non-industrial solid waste stream. [2]

•An EPA study estimated that reducing the use of packaging in the U.S. by 50% could potentially reduce total U.S. greenhouse gas emissions by up to 105 million metric tons (CO_2 equivalent) a year. [3]

[1]:Global Packaging Forum. 'The Global Language of Packaging and Sustainability'
[2] EPA Product Stewardship – Packaging
[3] EPA"Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices"

Sustainable Packaging

The Sustainable Packaging Coalition defines sustainable packaging as:

- Beneficial, safe, and healthy for individuals and communities throughout its life cycle;
- Meets market criteria for both performance and cost;
- Sourced, manufactured, transported, and recycled using renewable energy;
- Optimizes the use of renewable or recycled source materials;
- Manufactured using clean production technologies and best practices;
- Made from materials healthy in all probable end of life scenarios;
- Physically designed to optimize materials and energy;
- Effectively recovered and utilized in biological and/or industrial closed loop cycles [1]

[1] Sustainable Packaging Coalition. 'What is sustainable packaging?'

Total Cost of Packaging

Companies need to consider the total cost of packaging the same way they consider the total costs associated with their products and processes.

Total Potential Cost Areas - Packaging

• Materials costs
  • Product casing
  • Front-facing packaging
  • Packing and padding materials
  • Tape/other wrapping, adhesives
  • Product Instructions & Promotional Materials
  • Labeling
• Shipping Costs (typically measured by weight)
• Labor costs
  • A reduction in materials used can mean less time spent by workers
• Energy costs
  • To produce packaging and package the products themselves
• Facility storage space
• Disposal Costs [2]

Example

- Carrier Corporation in Texas needed a better system to sort the nuts and bolts used to produce air conditioners that didn't waste cardboard packaging. The new system involved making metal "chicken feeders" out of metal ducts, which were weighed and bar coded for the particular part. These feeders are sent directly to the distributor and Carrier then buys all components by weight, thereby eliminating all cardboard waste. The system eliminated 36,000 pounds of waste and a savings of $360,000/year (including waste, labor, injuries, and storage space).[1]

[1] Global Packaging Forum. "Metrics"
[2] Zero Waste Network. Carrier Corporation.

Making Packaging More Sustainable

- Packaging can be made more sustainable by applying the principles of product stewardship. This means:
  - Eliminating toxic constituents
  - Using less material
  - Making packaging more reusable
  - Using more recycled content
  - Making it more readily recyclable[1]

Example

- Texas Eastman, a chemical manufacturer, had previously used multiwall paper bags as packaging for their products. The bags were lined with plastic, which they replaced with recyclable polyethylene. The salvaged bags are collected, stored, and sold to Bonar Packaging at 5¢ per pound to be recycled. The company reduced the amount of packaging in landfills by 1,000 cubic feet (with an additional 15,000 cubic feet saved if all customers recycle), saves $2,000/year, and receives $500-1000 from Bonar for the sale of its recycled packaging.[2]

[1] EPA Product Stewardship – Packaging
[2] Zero Waste Network. Texas Eastman.

Where to go for help

- EPA's Waste Wise and Product Stewardship programs (Includes information on how to reduce material waste, with specific pages dedicated to packaging.)

- Sustainable Packaging Coalition (Nonprofit industry working group that provides a range of resources that support sustainable packaging efforts.)

Search

- Packaging
- Material Conservation/Waste Minimization
- Recycling

Buildings & Infrastructure

In the United States, buildings account for:

- 68% of electricity consumption
- 39% of energy use
- 38% of all carbon dioxide (CO_2) emissions
- 26% of non-industrial waste generation (construction and demolition)
- 12% of total water consumption[1]

For an individual building in the U.S.:

- Energy costs represent 30% of a typical building's annual operating budget
- Energy is the single largest operating cost and largest controllable cost [2]

1 EPA. "Why Build Green?"
2 EnergyStar, "Working with Different Groups in the Community"

Is My Building "Green"?

- A great deal of this 101 module deals with greening various aspects of your manufacturing processes, all of which take place in a facility or building.
- "Greening your building" typically refers to improvements to your facility that improve its overall performance – not just the manufacturing processes that take place within it.
- These improvements can include efficiency retrofits to HVAC systems, adopting water-efficient appliances in restrooms and maximizing the level of sunlight that enters the facility, among many other things.
- This section of the module takes you through the various things green building certification bodies typically look for when assessing the "green-ness" of a building or facility and provides links to actual green building certification programs.

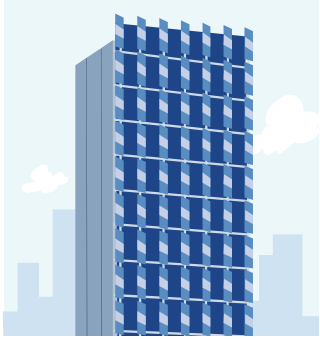
Green Building Overview

The U.S. EPA defines a green building as "one that is designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation"[1]

[1] EPA, Green Buildings – Basic Information

Energy Efficiency & Renewable Energy



- The previous "Energy" section of this chapter discusses energy management plans, energy efficiency strategies as well as on-site renewable energy, all of which are core elements to most green building certifications.

- As the largest operating cost of a typical building or facility, green building rating organizations and certifiers tend to award points for the following:
  - % of renewable energy created onsite and/or sourced offsite
  - Building-wide energy efficiency improvements (i.e. in HVAC systems, lighting, appliances, etc.)
  - Refrigerant management
  - Enhanced commissioning for building energy systems

Energy Efficiency & Renewable Energy

Green building-specific energy efficiency strategies include the use of:[1]

- High-efficiency windows and insulation
- Window placement strategies to maximize solar gain
- Solar water heating
- Green roofs
- Rooftop solar panels
- Onsite wind turbines

[1] DOE, "Commerical Building Initiative"

Water Efficiency

- Manufacturers are large fresh water consumers. Though users of this module should refer to the Water portion of this chapter to learn how you can improve your water efficiency, it's good to be aware of those water-related aspects of many green building certifications:
  - Implementing best available, water efficient technologies
  - Building-wide water use reductions and optimizing onsite water recycling
  - Water efficient landscaping

Water Efficiency

Green building-specific water efficiency strategies include the use of:[1]

- Water recycling technologies
- Dual plumbing systems
- Water-efficient appliances (i.e. low flow faucets, ultra-low flush toilets, etc.)
- Point of use water treatment
- Greywater for on-site use

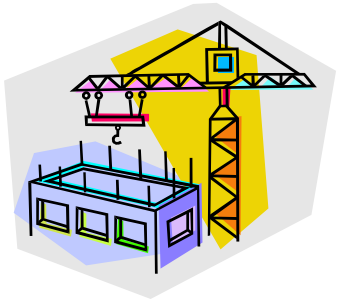
[1] CalRecycle, "Green Building Basics"

Sustainable Building Materials

- For companies planning to construct new facilities or make renovations to existing facilities, the materials you or your architect select will have a bearing on the "green-ness" of your building.

- During this process, you'll want to consider many of the same issues addressed on Slides 28-29 (Materials Choices & Impacts).

Sustainable Building Materials



- Building materials widely considered to be "green" include:[1]
  - Rapidly renewable materials (i.e. bamboo, straw)
  - Sustainably forested wood
  - Recycled industrial materials (i.e. stone, metals, coal combustion products, foundry sand, etc)
  - Recyclable materials (i.e. adobe, clay, cork, etc)

- Materials extracted and manufactured locally will typically receive higher scores on green building rating scales

[1] CalRecycle, "Green Building Basics"

Indoor Air Quality

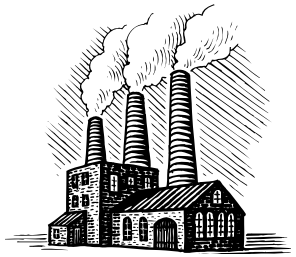
- Indoor air quality (covered previously in this chapter) is another important aspect of green buildings, which prioritize the health and productivity of building occupants.

- Green building certifiers typically look at things such as:[1] [2]

  - Levels of ventilation in a building
  - Use of low-emitting materials (from adhesives to paints to carpets)
  - Systems controllability (for lighting, heating, etc)
  - Existence of indoor air quality management plans

[1] CalRecycle, "Green Building Basics"
[2] USGBC, "Existing Buildings: Operations & Maintenance

Indoor Air Quality



Green building-specific air quality strategies include the use of:

- Passive or mechanically-powered ventilation systems providing adequate building ventilation
- Materials with little to no VOCs
- Moisture accumulation/water intrusion control
- Well-insulated building envelopes
- Solid wood flooring

[1] DOE, "Commerical Building Initiative"

Sustainable Siting

- For those companies planning on building a new facility, a first order, green building consideration is deciding where to build it and to what extent its location and design will affect the building's environmental impact.

- Things certifiers tend to look for here include:[1] [2]
  - the extent to which a building is connected to an existing community
  - whether or not it has been built on a redeveloped brownfield
  - access to public transportation
  - if it protects or restores a habitat
  - how effectively it handles and filters stormwater

Example

- The Half-Moon Outfitters Distribution Center developed a brownfield site utilizing efficient landscaping, low flow fixtures, and greywater reducing potable water use 78%. Energy efficient lighting, occupancy sensors, split system heat pumps, and other measures made their facility 46% more efficient than a traditional building.[3]

[1] CalRecycle, "Green Building Basics"
[2] USGBC, "Existing Buildings: Operations & Maintenance
[3] LEED. "Half Moon Outfitters-Case Study"

Certification Bodies

For those companies interested in obtaining green building certification in the U.S., there are a variety of non-profit and government certification programs available to you. These include:

- EPA and the U.S. Department of Energy's ENERGY STAR® Green Buildings program
- US Green Building Council - LEED
- Living Building Challenge
- International Green Construction Code

Other Places to Go for Help

- Energy Star for Industry (Specific information for energy savings for small to medium sized manufacturers)
- Energy Star Portfolio Manager (Helps your company manage and audit water and energy use)
- EPA's Green Building (General information about green building)
- Department of Energy's Industrial Assessment Centers (provide SMEs with no cost energy assessments)
- Building Owners and Managers Association (BOMA) (Provides free articles and a Building Energy Efficiency Program)

Search Terms

- Green Building

Transportation and Distribution

- For manufacturers, transporting goods can be a major source of costs and greenhouse gas emissions.
- Mobile sources, such as cars, trucks and trains are major producers of air pollutants such as greenhouse gases, particulates, and carbon monoxide. [1]
- The term '**Green Logistics**' is often used in relation to transportation and distribution. It is defined as supply chain management strategies and practices that reduce environmental and energy footprints of freight distributions, focusing on material handling, waste management, packaging and transport. [2]

[1] EPA. "SmartWay Basic Information"
[2] Hofstra University. "Green Logistics"

Reducing the Impact of Transportation

- There are many ways you can reduce the environmental impact of transportation:

Action	Result
Use less packaging	Lowers the weight of your product, leading to lower fuel consumption to transport
Purchase locally	Inputs have a shorter distance to travel to your facility, needing less fuel for transport
Use higher efficiency fleet vehicles and low carbon transportation overall.	More efficient vehicles can travel farther using the same amount of energy. Some methods of transportation are less energy efficient and produce more greenhouse gases.
Reduce or eliminate idle running of vehicles	Idling causes wasted fuel that could be used to move goods
Lower the weight of your cargo or the distance it has to travel	Decreasing the weight of your products means there is less fuel consumption
Partner with other manufacturers to share trucks and backhaul when appropriate	This allows you to save space and transportation costs.

Let's take a closer look at some common methods of improving efficiency in transportation.

Space Efficiency

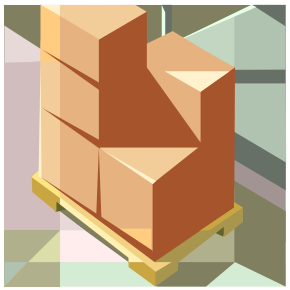
- Right sizing products and designing them for shipping- By designing a product with the idea of sustainable packaging in mind (see Packaging lesson), a company can transport more products per trip, saving costs and reducing emissions. [1]
  - By shipping in lower volume packaging, more products can fit into a single shipment, reducing energy used. [1]
  - Also make sure that the right size truck is used for the shipment size, potentially reducing costs by reducing truck size. [2]

Example

- Meijer, Inc, a Midwest superstore, was awarded an award from the EPA's SmartWay Program for their reduction in idle time for their fleet trucks and for transporting goods for other companies on routes that would otherwise lead to empty trucks. [3]

[1] Packaging Corporation of America. "Responsible Business Practices"
[2] American Logistics. "Secure Transportation"
[3] US Department of Energy. "Medium/Heavy Duty Fleet Experiences."

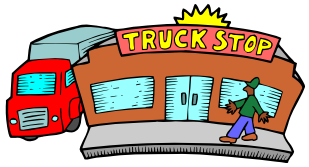
Space Efficiency



- Another option is to share vehicles with other companies that have the same destination or one that is en route. Both companies can share the costs of the shipping, reducing the total costs.
- If there are no such products, then make sure to employ backhauling, use the vehicles to bring back shipments of another product or materials for your company or another as appropriate.
- **The main idea with space efficiency is to maximize the usage of the transportation vehicle. In other words-it never ships empty or emptier than necessary.** [4]

[4] Hofstra University. "Green Logistics"

Fleet Management



Idle Reduction

- Excess idling not only increases gas costs, but it puts unnecessary wear on the engine and could cause health issues for drivers from the fumes. [1]
  - If an engine burns about a gallon an hour while idling, idles about 6 hours a day, and runs 300 days a year, then 1800 gallons of gas are wasted a year, which can easily cost thousands of dollars. [1]
- Newer engines have been designed to reduce the amount of gas used to restart, making it more economical to restart the engine rather than leave it running while stopped. [1]

-EPA's SmartWay program has information on financing options and incentives to reduce idling.

Green Logistics

- Reduce distance traveled per shipment.
  - Better trip planning can decrease the amount of miles driven, thereby reducing the amount of gas needed to transport the same amount of goods from point A to B.
- Reduce Empty Vehicles
  - Companies participating in Take-Back Programs (see End of Life lesson) can use the input vehicle to bring back recyclable, reusable, or remanufacturable products to the company, thereby eliminating the empty space.

Example

- Wal-Mart was able to deliver 77 million more cases while cutting 111 million miles driven by reducing the number of miles driven per route. The goal is to double the fleet efficiency by 2015. [3]

[1] EPA. "What You Should Know About Truck Engine Idling"
[2] EPA. "SmartWay Basic Information"
[3] Wal-Mart. "Energy Commitments"

External Transportation

Use efficient contractors

- If you contract your transportation and distribution of products with an external company, be sure to choose the most environmentally responsible one who uses space efficiency and fleet management.

Choose efficient shipping

- Many shipping companies choose the most efficient option when they are transporting a package. But there are companies that go the extra step in their environmental goals.[1,2]
- Both FedEx and UPS are switching to hybrid trucks, improving their aircraft, and stepping towards a carbon neutral path.
- UPS now offers carbon neutral shipping, which will only cost 5 cents more for one ground shipped package. [1]

[1] UPS. "Sustainability at UPS 2009"
[2] Greenbiz. "FedEx launches Three-Point Green Plan"

Which Way of Shipping is Greenest?

- The lowest impact shipping method will depend on what you are shipping and geography.
- It's important to fully understand all of your transportation options and their relative impacts.
- The chart to the right compares greenhouse gas emissions factors for selected transportation methods. Each one shows the emissions from moving one ton of freight one mile.[1]

Vehicle	Emissions (CO_2 Eq/ton-mile
Truck	.299
Rail	.025
Waterborne Craft	.049
Aircraft	1.543

[1] EPA Climate Leaders, "Optional Emissions from Commuting, Business Travel and Product Transport."

Transportation Checklist

- ✓ Check your transportation and distribution's environmental impact
  - ✓ Make sure your fleet is within federal, state, and local regulations.
  - ✓ Do you use an older mode of transportation that can be updated with a more fuel efficient model?
  - ✓ Do your vehicles carry the maximum amount of product to reduce the number of shipments?
  - ✓ Or can you use a smaller vehicle to ship your product?
  - ✓ Can you share your fleet with other companies, thereby reducing costs and total emissions?
  - ✓ Does your shipping company have green options?
- ✓ Decide which is the best improvement for your company
  - ✓ Hybrid vehicles? No idling policy? New right-size design? Smaller vehicle size? Switching to a greener shipping company?

Where to Go for Help

- SmartWay (includes case studies, financial assistance, and data on many types of transportation based improvements)
- US Department of Energy- Federal or State Incentive Programs and their Fleet Program (information about alternative fleet options)
- Clean Ports (includes tools, case studies, and financing options help)
- EPAct Transportation Regulatory Activities (established many state and federal regulatory transportation measures)

Search

- Regulations
- Compliance Assistance
- Metrics and Assessment Tools

Product End-of-life Issues

- Eventually, your customers will finish using your products. A product's lifetime may be short, like a stick of gum, or very long, like a piece of machinery.

- Often, products are not designed with the end of the product's useful life in mind. Nor are they disposed of in a way that minimizes their impact on the environment.

- However, product end-of-life is sometimes one of the most visible environmental issues companies deal with. If a stakeholder or customer sees a product on the side of the road or piling up in a landfill, it can negatively affect the company's public image.

Basic things that can happen to a product at the end of its useful life:

1. Reuse
2. Remanufacturing
3. Recycling or Composting
4. Disposal

Design and End-of-Life

- Although you may not have any direct control over what customers do with your product at the end of its life, these end-of-life impacts can be addressed first through the product design process.
- As we discussed in the section of this lesson on product design, there are a number of things you can do in the design stage to minimize your product's end-of-life impacts.[1]

Extend the Product's Life

- Make the product more durable, reliable, repairable, upgradeable, and reusable
- Extending product life prevents waste because it keeps the product from being disposed of for longer

Minimize end of Life Impacts

- Make sure the materials in the product aren't harmful and won't need special disposal
- Make the product reusable, remanufacturable, recyclable, or compostable
- Design for disassembly and recovery and include instructions on disposal

[1] United Nations Environment Programme and Delft University of Technology "Design for Sustainability Rules of Thumb"

Take Back Programs

- One way your company can have a direct effect on how your products are disposed of is by collecting your products for recycling or remanufacturing.

- Take-back programs give manufacturers the physical responsibility for products and/or packaging at the end of their useful lives. By accepting used products, manufacturers can acquire low-cost feedstock to remanufacture, reuse, or recycle into new products, and offer a value-added service to the buyer. [1]

- Not all products are suitable for take back programs, but programs are popular for many electronic devices (cell phones, printer cartridges, etc) and carpeting, but can be utilized for any product that can be reused or recycled for materials. [2]

- While most take-back programs in the U.S. are voluntary, states are increasingly mandating, and placing the financial burden of, recycling electronics, packaging and waste on the manufacturer. Hence, those companies with the most effective recycling/take back programs will stand to benefit in the long run.

Example

- Caterpillar offers a remanufacturing take-back program. Companies can return their end-of-life product for a remanufactured one or buy remanufactured items for a fraction of the cost with new warranties. [3]

[1] EPA. "Product Stewardship for Manufacturers"
[2] UC Berkley. "An Introduction to Product Takeback"
[3] Caterpillar "Remanufacturing-The New Era of Profitability

Take Back Programs

- To have a take-back program, companies need to consider their "reverse supply chain"
  - It's the series of activities required to retrieve a used product from a customer and either dispose of it or reuse it.[1]
- Take back programs using a reverse supply chain can be complicated and difficult to implement, and may not be practical for all products.
- Look at some products with successful take back programs before you consider one for your products.

Example

- Interface's ReEntry program collects post-consumer carpet for recycling, preventing the carpet from going to the landfill. Nylon fiber from is sent to a fiber supplier, where it is recycled into new carpet fiber. Carpet backing is recycled into new backing material.[2]

[1] Harvard Business Review. "The Reverse Supply Chain "
[2] Interface, "Sustainability – Our Progress - Manufacturing"

Remanufacturing

- Remanufacturing is the process of restoring non-functioning, discarded, or traded-in products to like-new performance, therefore keeping them from being discarded as waste.
- Remanufactured goods are disassembled, refurbished, and tested to the same standards as if they were brand new.
- Similar to the challenges of recycling in house, establishing effective "reverse logistics" is key to the success of any remanufacturing program. This involves gaining a clear understanding of where your products end up and establishing logistics protocols with the appropriate entities.[1]
- For example, an auto parts distributor of remanufactured parts would want to establish relationships with auto shops, who deal with end-of-life auto parts regularly.

[1] EPA. "Wastewise update: Remanufactured Products: Good As New"

Remanufacturing (Cont.)

- -Simple sources of reclaiming goods to remanufacture include trade-ins, salvage, returned rental units, and defective items returned during a warranty period.
- -Export laws make it difficult to sell remanufactured products outside of the United States, but a robust market exists domestically for remanufactured goods.
- -A remanufactured product typically costs 45-65% of the price of a comparable new product, as it forgoes the expense of using virgin materials and requires significantly less processing.
- -Even if your company doesn't have a source for end-of-life, recyclable inputs, you can use remanufactured materials in your production (such as printer cartridges, computers, electrical equipment, or auto parts for transportation)[1]

[1] Reference for Business. "Remanufacturing"

Recycling

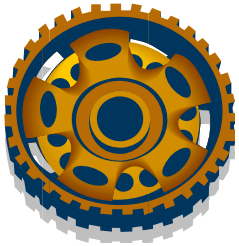
- Recycling reduces pollution and conserves natural resources by reducing the need for material extraction and processing. [1]
- It also saves energy by reducing the need to extract and process "virgin" raw materials to manufacture new products.[2]
- If you recycle your products in house, it can help ensure a supply of raw materials for your company.
- One important thing to consider before you label your product as recyclable is whether facilities exist to recycle the product.

Example

- Nokia promotes cell phone recycling at any of their recycling point locations. According to their website, if every cell phone user recycled one used cell phone, it would reduce the amount of raw materials needed to produce phones by 370,000 tons.[3]

[1] EPA. "*U.S. Recycling Economic Information (REI) Study*"
[2] EPA "Recycling"
[3] Nokia. "Devices and Services"

Remanufacturing vs. Recycling



- **How does remanufacturing save more materials and energy than recycling?**

- Remanufacturing is reuse of an entire product or individual part, whereas recycling involves the reuse of the raw materials used in that product or part. These raw materials can be used to make the same product as before (closed loop recycling) or made into new ones (open loop recycling).[1]

- Remanufacturing can capture more of the value added of a product. Value added is the cost of labor, energy, and manufacturing operations that are added to the basic cost of raw materials in the manufacture of a product. For all but the most simple durable goods, value added is by far the largest element of cost.

- For a product such as an automobile, the value of the raw materials that can be recovered by recycling is only around 1.5% of the market value of the new car. Value added is embodied in the product. Recycling destroys that value added, reducing a product to its elemental value—its recoverable raw material constituents.[2]

- Together, however, recycling and remanufacturing are said to account for over $100 billion in revenue.[3]

[1] Centre for remanufacturing and reuse. "Remanufacturing News; Singapore- Caterpillar opens remanufacturing facility."
[2] Reference for Business. "Remanufacturing"
[3] EPA. "Economic Benefits of Recycling and Remanufacturing"

Regulations on End of Life

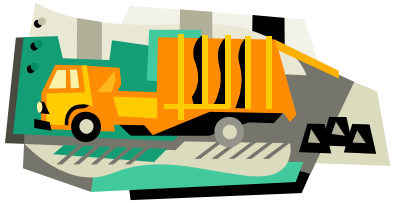
- Manufacturers need to be aware of regulatory requirements when considering their product's end of life scenarios.
  - The number of new regulations applied to a product's entire lifecycle is increasing.
  - Some states have laws that hold the manufacturer legally responsible for the product's end of life – **extended producer responsibility**.
- Understanding where a product and its components from manufacturing to disposal is key to regulatory compliance
  - What are the components found in the product?
  - Do regulations exist regarding the disposal of those components?
  - How does regulation impact the manufacturer's responsibility for their product's disposal?

European Union Waste Electrical and Electronic Equipment (WEEE)[2]

- Aims to prevent the generation of electrical and electronic waste and to promote re-use, recycling and other forms of recovery in order to reduce the quantity of waste discarded.
- Sets out collection requirements and a minimum collection targets.
- The **producers of equipment used by private households are responsible for providing financing for the collection, treatment, recovery, and environmentally-sound disposal of WEEE deposited at collection facilities.**
- Producers of equipment used by others than private households are financially responsible for the costs of collection, treatment, recovery and environmentally-sound disposal.

[1] Remanufacturing - An American Perspective
[2] Europa "Questions and answers on the revised directive on waste electrical and electronic equipment (WEEE)".

Waste Disposal



- Products and components that have a short "lifespan" or can't be recycled/reused/remanufactured must either be composted or sent to landfill.
- With the exception of biodegradable products, non-recyclable/non-reusable products can be more expensive to produce in the long-run as a) no value can be recaptured from these products once they reach their end-of-life stage and b) such products are increasingly subject to greater regulation and disposal costs.
- For such goods, as well as goods that might be difficult for customers to recycle, clear communication of the waste's properties, as well as instructions on how best to dispose of (or even better, recycle the waste), will help minimize regulatory and brand-related risk.
  - Does your product contain any hazardous materials? If so, your end-of-life products may be subject to RCRA Subtitle C regulations (see Section VII for more on RCRA).
  - Does the product have any recyclable qualities?
    - If so, is there labeling to advise of proper disposal, or does the company have a take back program (discussed later) to dispose of the product themselves or to take actions to extend the product's end of life?
- What are the added costs of disposal?
  - The average price to bury a ton of municipal solid waste (MSW) in U.S. landfills is $43.99[1]

[1] Solid Waste and Recycling
[2] EPA. "Basic Information of Wastes"

Examples of End-of-Life Issues

Mercury
Switches in Car Trunks

- Found in junk yards, the fumes and pollution from the mercury switches in old cars (used to toggle trunk lights) were becoming a large environmental hazard. The clean up included not just hazardous waste handling, but required a search through junk yards country-wide to discover which cars had the switches and ensure that the hazard was completely dealt with. [1]

Paper Recycling

- According to Greenstar North America, 45% of paper still goes to landfills as waste. At 83 million tons a year produced, that means 37.35 million tons of paper are being thrown away rather than recycled and reused by paper mills and companies.[2]

[1] EPA "Mercury Containing Equipment"
[2] EPA and Greenstar North America. "Reducing Emissions Across a Business"

End-of-Life Management

Sun Chips

- Sun Chips came out with an environmentally preferable bag that would compost fully in 14 weeks. Initially, the bag was a huge success, proving that people were interested in environmentally preferable products. However, complaints about the bag being too loud forced the company to re-design their compostable bags. Their website also includes tips on how to home compost not only the bag but other products as well. [1]

Kodak

- Kodak was awarded by WasteWi$e for their recycling and reuse habits. Between 1990 and 2005, they recycled 650 million of their disposable cameras, 14 million pounds of movie film annually, and over 90 million pounds of PET annually. Over 3 million pounds of polystyrene parts and 4 million pounds of camera electronics (or 1 million pounds per year) have been remanufactured. Their film container collecting program diverted 87 million pounds of waste from landfills from 1991-2005. The company reports that they have reduced their costs by approximately $9 million per year through these recycling, reuse, and remanufacturing programs. [3]

[1] Sun Chips. "Compostable bag" and "Compost 101"
[3] EPA. "Kodak and WasteWi$e: Beyond Recycling"

Product End-of-Life Checklist

- ✓ **Consider** whether end-of-life impacts are a priority issue for your company or facility
- ✓ **Check** to see if your product is within federal, state and local end of life regulations or if it is affected by international regulations.
  - ✓ Hazardous materials clean up.
  - ✓ Some states might have stricter regulations or require companies to be responsible for the end of life clean up
- ✓ **Decide** which approach would be best for your company
  - ✓ Reuse, remanufacture, recycle, or disposal
  - ✓ Different materials require different end of life options. Some have to be considered waste because of their composition or hazardous nature.
  - ✓ Consider take back programs and reverse supply chain issues
  - ✓ Are your products really recyclable?

Where to Go for Help

- EPA's Product Stewardship Website provides guidance on end-of-life issues.
- EPA's Waste Website and Remanufacturing Guide
- EPA's Design for the Environment (DfE) program and product stewardship program
- EPA has a guide on greening your products
- Review UNEP site on sustainable design
- Check with your industry associations to see if they have guidance on end-of-life issues

Search

- Recycle
- Remanufacture
- Reuse
- End-of-Life
- End-of-Life Design