MUSEUM OF SOLID WASTE & ENERGY

EFFICIENCY CONSERVATION

GRADE LEVEL
6—12

SUBJECT AREAS
Science
Social Studies
Math
Language Arts
Technology

Students explore the relationship between trash and energy by constructing and presenting exhibits on different aspects of solid waste including recycling, source reduction, landfilling, and waste-to-energy plants.

NEED 2009-2010
Putting Energy into Education
NEED Project PO Box 10101 Manassas, VA 20108 1-800-875-5029 www.NEED.org

Teacher Advisory Board

Teacher Advisory Board Vision Statement

NEED Mission Statement

The mission of the NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

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NEED

Putting Energy into Education

Correlations to National Science Standards

(Bolded standards are emphasized in the unit.)

INTERMEDIATE (GRADES 5-8) CONTENT STANDARD-E: SCIENCE AND TECHNOLOGY

2. Understandings about Science and Technology

a. Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technological solutions are temporary; technologies exist within nature and so they cannot contravene physical or biological principles; **technological solutions have side effects; and technologies cost, carry risks, and provide benefits**.

d. Perfectly designed solutions do not exist. **All technological solutions have trade-offs**, such as safety, cost, efficiency, and appearance. Engineers often build in back-up systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology.

e. Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics.

INTERMEDIATE STANDARD-F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

1. Personal Health

g. Natural environments may contain substances (for example, radon and lead) that are harmful to human beings. Maintaining environmental health involves establishing or monitoring quality standards related to use of soil, water, and air.

2. Populations, Resources, and Environments

b. Causes of environmental degradation and resource depletion vary from region to region and from country to country.

3. Natural Hazards

b. Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.

4. Risks and Benefits

d. Important personal and social decisions are made based on perceptions of benefits and risks.

5. Science and Technology in Society

c. **Technology influences society through its products and processes.** Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development.

g. Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others.

SECONDARY (GRADES 9-12) STANDARD-C: LIFE SCIENCE

4. The Interdependence of Organisms

e. Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

SECONDARY STANDARD-E: SCIENCE AND TECHNOLOGY

2. Understandings about Science and Technology

d. Science and technology are pursued for different purposes. Scientific inquiry is driven by the desire to understand the natural world, and technological design is driven by the need to meet human needs and solve human problems. Technology, by its nature, has a more direct effect on society than science because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations. Technological solutions may create new problems. Science, by its nature, answers questions that may or may not directly influence humans. Sometimes scientific advances challenge people's beliefs and practical explanations concerning various aspects of the world.

SECONDARY STANDARD-F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

3. Natural Resources

a. Human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations.

b. The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and it depletes those resources that cannot be renewed.

4. Environmental Quality

b. Materials from human societies affect both physical and chemical cycles of the earth.

5. Natural and Human-induced Hazards

b. Human activities can enhance potential for hazards. Acquisition of resources, urban growth, and waste disposal can accelerate rates of natural change.

Introduction to the Activity

WHAT'S INCLUDED IN THIS BOOKLET

- Teacher's Guide with Museum Survey
- Eight Museum Backgrounders on solid waste and energy issues
- Eight student Station Guides to accompany Museum Backgrounders

ABOUT THE MUSEUM

The **Museum of Solid Waste and Energy** is a cooperative learning activity. Your students will work together in small groups (no more than two to four students) to complete their project. Each group will study one solid waste and energy topic, and create a museum station to teach others about it.

GRADE LEVELS

This activity is geared for students in grades 6-12. The activity is ideally suited for the intermediate teacher who has a self-contained classroom, but also works well when older students use it to teach younger students.

TIME NEEDED

Your students can complete this activity in five days. You may add an extra day or two if you think your students need more time to prepare their museum exhibits.

USING THE MUSEUM

This activity has been designed for classroom teachers who want their students to create the museum for the classroom. But there is a lot more you can do with this very important activity! Here are a few ideas:

School Activity

Invite all the students in your school (or in one or two grades) to tour your students' museum. You may set up the museum in the gym, cafeteria, or hallway. Divide the visiting students into eight groups and rotate the groups through the stations. This will avoid a situation in which everyone is crowded around one station.

NEED Day Activity

Celebrate NEED Day (National Energy Education Day) with the **Museum of Solid Waste and Energy**. NEED Day is always the second to last Friday in March.

Community Presentation

Make your museum move! Take your museum to another school, community center, PTA meeting, or shopping mall. Teach others in your community about solid waste and energy and show you care! Administer the survey to see what your community knows and thinks about some important solid waste topics.

Teacher Guide

STUDENTS CREATE MUSEUM STATIONS ON EIGHT SOLID WASTE AND ENERGY TOPICS. STUDENTS ENHANCE THEIR READING, WRITING, PUBLIC SPEAKING AND ARTISTIC SKILLS.

ASSIGN STUDENTS TO GROUPS

Assign your students to the eight stations. Don't put all your artistic students in one group; spread the talent! Ideally, each station should have a good leader/speaker, a good writer, and a good artist.

Station 1 – Introduction to Solid Waste
Station 2 – Source Reduction
Station 3 – Introduction to Recycling
Station 4 – Recycling Plastics
Station 5 – Recycling Metals
Station 6 – Recycling Paper & Glass
Station 7 – Waste-to-Energy
Station 8 – Landfilling

MAKE STATION FOLDERS

Make a folder for each station that includes:

- the station's museum backgrounder (one copy per student)
- the station's guide sheet (one copy per student)
- the graphic organizer (one copy per student, plus one copy per group)
- special materials you have collected

COLLECT ART SUPPLIES AND RECYCLED GARBAGE

Collect equipment/art supplies for students to use in making their exhibits.

- overhead projector
- transparency film
- posterboard, stencils
- construction paper, tissue paper
- empty cardboard boxes, cans, bottles
- plastic wrap, newspapers, aluminum foil
- colored markers, crayons, paints

Lesson Plan for Day 1

Materials: *One museum survey for each student; station folders.*

1. **Introduce the activity to students.**

   Topics you may want to cover in your introduction include:

   - General overview of America's solid waste problem
   - The solid waste topics your students will be studying (the eight stations)
   - How students should work together in small groups
   - A timetable for working on the museum stations

2. **Administer the museum survey as a pre-test.**
3. **Divide students into stations.**

   Hand out the station folders.
4. **Go over student instructions.**

   Ask your students to take out their Museum Backgrounders, Station Guides, and Station Organizers. Review the Student Guides and point values with them and answer any questions.
5. **Monitor group work.**

   Students begin working on their stations. Monitor the groups' progress by reviewing the organizers. Students should complete Step 1 of their Student Guides.

Lesson Plan for Day 2

Materials: *Station folders*

1. **Monitor group work.**

   Students should complete Steps 2 and 3 of their Station Guides. Review the group organizers.
2. **Check work.**

   At the end of class time, ask the groups to hand in rough drafts of their museum scripts.

Lesson Plan for Days 3 and 4

Materials: *Art supplies/equipment*

1. **Monitor group work.**

   Students use Days 3 and 4 to work on their museum stations and to refine their scripts.
2. **Review schedule for presentations.**

   Take a few minutes on Day 4 to go over the schedule for Day 5 (Presentation Day) with your students.
   - Your students need to know that they must set up their exhibits quickly tomorrow so that all the groups will have enough time to complete their presentations.
   - After the museum presentations, they will take the museum survey again.

Lesson Plan for Day 5

Materials: *One museum survey for each student.*

1. **Set up exhibits.**

   Today is the big day!
2. **Student presentations.**

   Station One should begin, followed by Station Two and so on.

Evaluation

1. **Administer the museum survey as a post-test.**
2. **Use the point system on the Student Guides and the individual and group organizers to evaluate student performance.**

Museum Survey Answers

1. D 2. B 3. D 4. Opinion 5. A 6. A 7. B 8. C 9. B 10. Opinion 11. Opinion 12. B

Technology Connection

Instead of exhibits, have the students create PowerPoint presentations.

Museum Survey

Directions: Choose the letter of the response that answers the question or best reflects your own opinion. Choose "I Don't Know" if you cannot make a good guess. Circle your response.

1. The major method of disposing of the nation's solid waste is by...
   A. composting. **B. recycling.** **C. burning.** **D. landfilling.** **E. I Don't Know**

2. By weight, which material accounts for about 35 percent of the nation's solid waste, almost three times as much as the second leading solid waste material?
   A. Plastic **B. Paper** **C. Glass** **D. Metals** **E. I Don't Know**

3. Source reduction means reducing the amount of waste we produce in the first place. Which of the following products have manufacturers targeted for most of their source reduction efforts?
   A. Food products
   B. Nondurable goods (clothing, disposable diapers, etc.)
   C. Durable goods (washing machines, toasters, etc.)
   D. Containers & Packaging
   E. I Don't Know

4. Laws should be passed requiring people to recycle.
   A. Strongly Agree **B. Agree** **C. Disagree** **D. Strongly Disagree** **E. Undecided**

5. In a closed-looped recycling system, a used product is...
   A. made into the same product.
   B. made into a different product.
   C. used as an energy source to make the same product.
   D. landfilled after one use.
   E. I Don't Know

6. Containers made from which material are coded to help recyclers sort them?
   A. Plastics **B. Glass** **C. Paper** **D. All Three** **E. I Don't Know**

7. Which of the following materials is the most valuable to recycle?
   A. Aluminum **B. Steel** **C. Plastic** **D. Glass** **E. I Don't Know**

8. How much of our trash do Americans recycle today?
   A. 11 percent **B. 21 percent** **C. 31 percent** **D. 41 percent** **E. I Don't Know**

9. When biodegradable garbage is buried in a landfill, the garbage degrades (rots)...
   A. quickly. **B. slowly.** **C. stays the same.** **D. I Don't Know**

10. Waste-to-energy plants burn garbage and use the heat energy to make electricity. Waste-to-energy plants produce some air pollutants, but they also reduce the amount of waste that must be landfilled. The nation should build more waste-to-energy plants.
    A. Strongly Agree **B. Agree** **C. Disagree** **D. Strongly Disagree** **E. Undecided**

11. If a new landfill were needed in your area, how would you feel? I would...
    A. actively work to support its construction.
    B. support its construction but remain silent.
    C. oppose its construction but remain silent.
    D. actively oppose its construction.
    E. Undecided

12. When a photodegradable plastic is exposed to sunlight, the strength of the plastic...
    A. increases. **B. decreases.** **C. stays the same.** **D. I Don't Know**

STATION 1 BACKGROUNDER

INTRODUCTION TO SOLID WASTE

GARBAGE TIME

You might think you have little in common with the typical young person of 2,000 or even 200 years ago. But chances are that both you and your ancient counterpart have heard the same request from a parent, "Please take out the garbage!"

Deciding what to do with garbage is not a new problem. People have wrestled with the trash problem ever since they left their nomadic ways behind some 10,000 years ago. The Greek city-state of Athens opened the first municipal dump more than 2,500 years ago.

During the Middle Ages, European city dwellers threw their garbage out the door and onto the street. The people of the time didn't understand that many diseases are caused by filthy environmental conditions.

Then, in the late 1700s, a report in England finally linked disease to unsanitary waste disposal. The age of sanitation was launched. Cities began collecting waste to get it off the streets and out of public waterways. By the late 1800s, Europeans were even burning their waste and using the energy from it to produce electricity.

GARBAGE BY ANY OTHER NAME

People who study garbage use the term *municipal solid waste* (called MSW) to describe our trash.

Municipal solid waste is the food you didn't eat for dinner, old shoes, the empty jar of peanut butter, or the wrapper from your candy bar.

The situation was a little different on this side of the Atlantic. To the early colonists, America offered a seemingly endless supply of land and natural resources. So when dumping on city streets became intolerable, they simply took their waste to a dump outside of town, using the spot until it was filled before moving on to another site.

As America's population grew and people left the farms for life in the city, the amount of waste increased. But the method of getting rid of the waste did not; we continued to dump it. Today, about 55 percent of our garbage is hauled off and buried in sanitary landfills.

GARBAGE HISTORY

500 BC First city dump opened in Athens, Greece.

1388 English Parliament bans waste disposal in public waterways and ditches.

1400 Garbage piles up so high outside Paris gates that it interferes with the city's defenses.

1690 Paper is made from recycled fibers at a mill near Philadelphia.

1842 A report in England links disease to filthy environmental conditions.

1874 In Nottingham, England, the "destructor" burns garbage and produces electricity. Eleven years later, the first American incinerator opens in New York.

1900s Pigs are use to help get rid of garbage in several cities. One expert said 75 pigs could consume one ton of garbage a day.

1904 First aluminum recycling plants open in U.S.

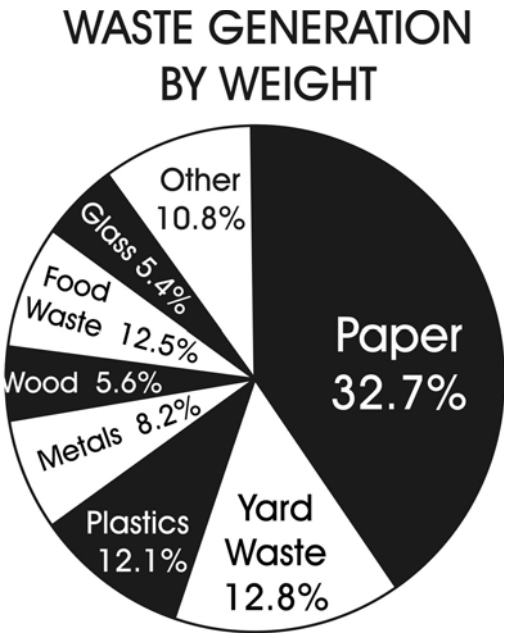
1920s Landfilling becomes most popular way to get rid of garbage.

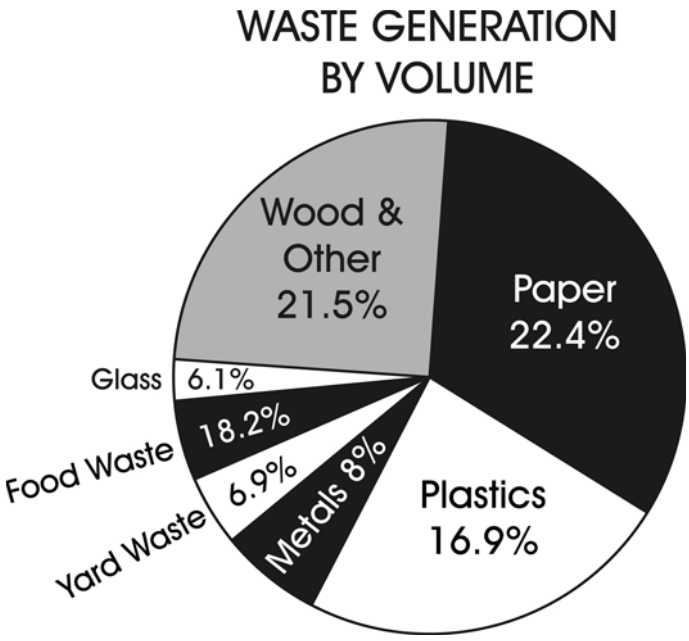
1959 The first guide to sanitary landfilling is published.

1965 Congress passes the first set of solid waste management laws.

1987 A garbage barge circles Long Island with no place to unload its cargo.

1997 First "America Recycles Day."





ALL KINDS OF GARBAGE

Municipal solid waste is garbage that comes from homes, businesses, and schools. Municipal solid waste does not include construction waste, industrial waste, or sewage waste. Municipal solid waste can be classified in two ways:

- **By Material—**what the waste is made of. Waste may be plastic, paper, metal, rubber, food waste, or yard waste. A plastic toy and a plastic yogurt carton would be in the same materials category because they are both made of plastic.
- **By Product—**what the waste was used for originally. The waste may be an old potato chip bag, a worn-out shoe, or a broken toy. A plastic beverage container and an aluminum beverage container would be in the same product category because they are both used as containers.

MORE ABOUT WASTE

Which material do you think makes up most of the municipal solid waste in this country? Paper? Plastics? Metals? If you said plastics are number one, then you agree with most Americans on this question. The correct answer is paper. By weight, paper accounts for 32.7 percent of the municipal solid waste stream. Plastics account for 12.1 percent by weight.

Sometimes people who study garbage find it more useful to know what waste was used for, instead of what it was made from. They put waste in five product categories:

- **Containers/Packaging**: This includes cans, jars, bags, bottles, boxes, and wrapping materials. Containers and packaging form the biggest product category.
- **Nondurable consumer goods**: These goods are called nondurable because they are not meant to last a long time. This category includes many paper products such as newspapers, magazines, and paper towels. This category also includes clothing and disposable dinner plates.
- **Durable consumer goods**: The goods in this category are called durable because they are meant to last a long time. This category is made of many bulky and oversized items like washing machines, old furniture, and rubber tires.
- **Yard wastes**: This category is made mostly of grass clippings, but it also includes dead plants and bushes, branches blown down by the wind, and even dirt!
- **Food wastes**: This is what you didn't eat for dinner, or the mysterious green gunk in the dish in your refrigerator.

MEASURING MSW

Until 1990, government reports always tabulated the amount of waste produced in this country by one measure—weight. People use weight to measure MSW because it is the most accurate measurement available. After all, the weight of the waste taken by trucks to landfills is the same as the weight of the waste buried in the landfills.

To figure out how long a landfill will be functional, however, weight doesn't matter. It is the volume of the trash that is important, not how much the trash weighs. As one researcher said, "Landfills don't close because they're overweight; they close because they have reached their volume capacity."

As a case in point, look at the amount of container and packaging waste that is produced in the United States. On one hand, studies tell us that the total weight of containers and packaging in the solid waste stream has decreased in recent years. But what about the volume?

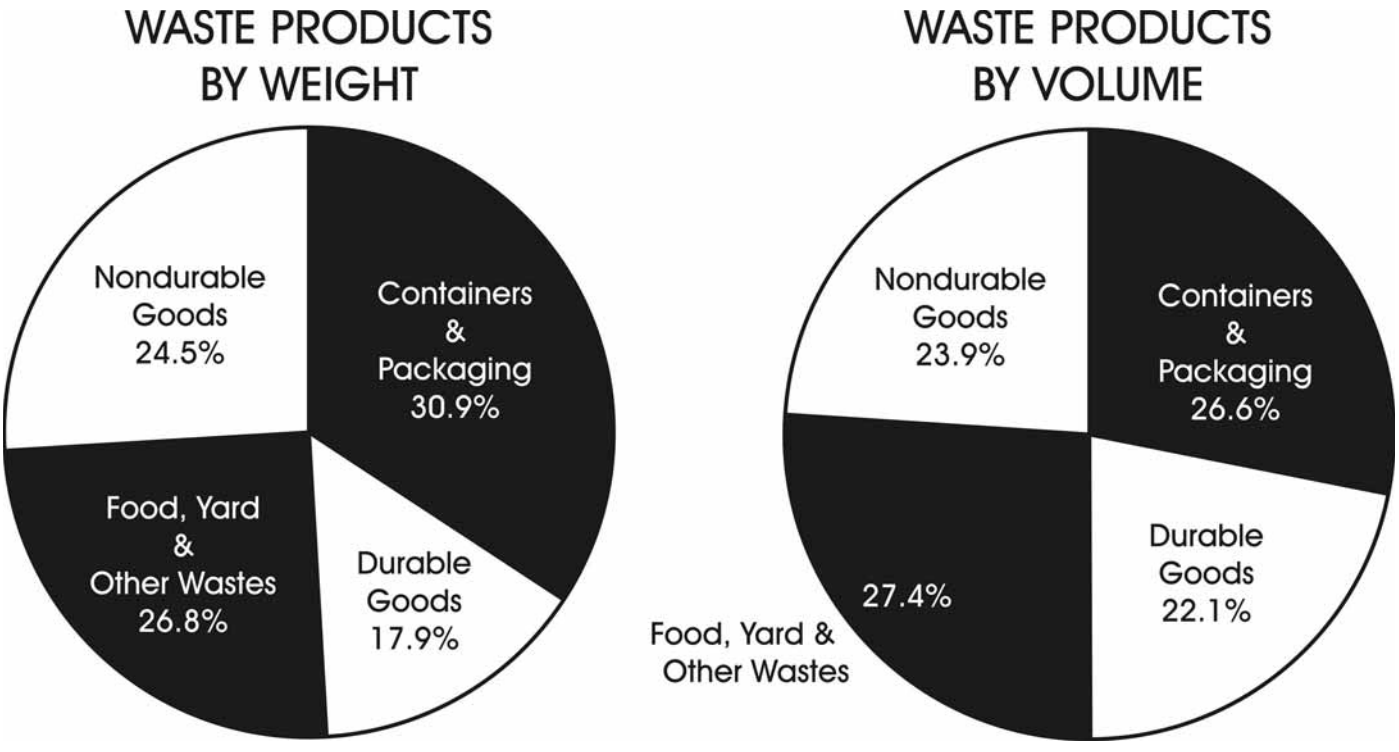
If you take a look at the products lining America's grocery store shelves, you might doubt the studies! Is there really less packaging as the studies suggest?

The explanation is simple. Product manufacturers are using lightweight aluminum and plastic containers, replacing heavier steel and glass containers. There aren't fewer containers on America's grocery store shelves, they just weigh less.

That's great, but do these lightweight containers take up less space in a landfill? Not necessarily. Studies show that a plastic ketchup bottle takes up more space in a landfill than a glass ketchup bottle. So a better question may be whether the volume of containers and packaging has decreased in recent years. And the answer to that question is no.

Why would a plastic ketchup bottle take up more space in a landfill than a glass ketchup bottle? Heavy bulldozers crush and compact landfill waste and then bury it under layers of clay and topsoil. Some waste materials can be compressed more than others. Yard and food waste, which contain a lot of water, become very compact in a landfill.

The glass ketchup bottle smashes into fine pieces, taking up less space than the plastic bottle, which is compressed but probably remains whole.



WASTE DISPOSAL

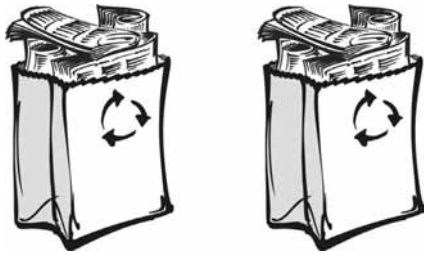
How can we solve America's waste disposal problem? There is no single answer. Most experts agree that we should use four steps to manage our waste problem in this order:

1. SOURCE REDUCTION

Reducing the waste we produce in the first place.

2. RECYCLING

Using old products to make new products.

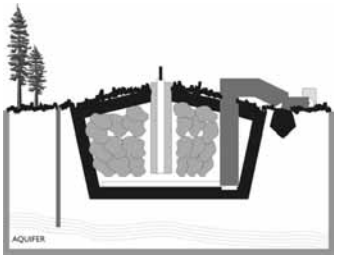


3. WASTE-TO-ENERGY

Burning trash to produce steam and electricity.

4. LANDFILLING

Burying waste that should not be burned or recycled.

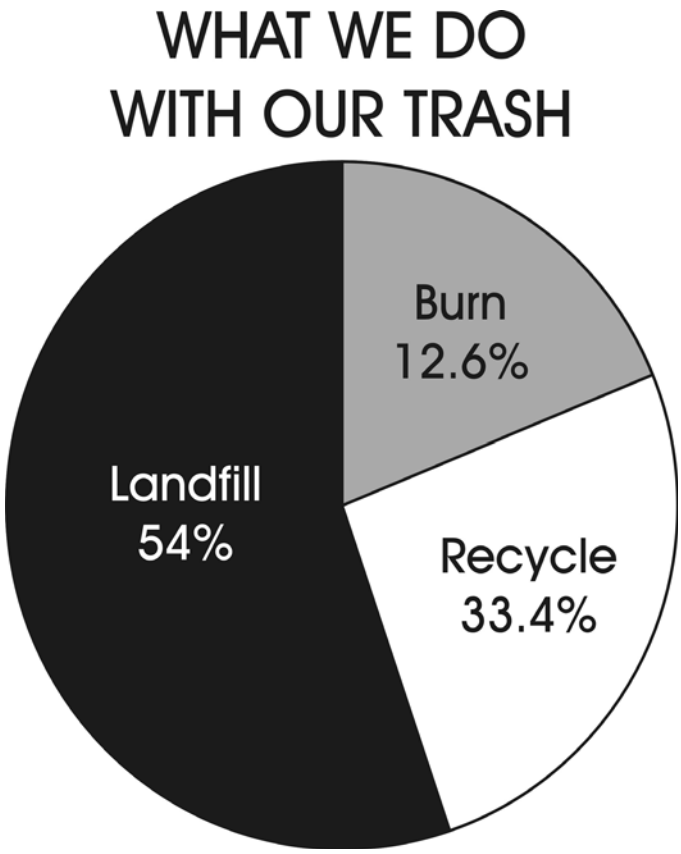


A GROWING PROBLEM

Americans are producing more waste with each passing year. Over the past 30 years, the waste produced in this country has more than doubled, from 88 million tons in 1960 to about 254 million tons in 2007. Some of this increase is linked to U.S. population growth. After all, there are more Americans today than there were in 1960. But that doesn't account for the whole increase.

Our lifestyle has changed, too. People are buying more convenience items and more disposables, and they choose from a wider variety of products. Today, the average American generates 4.6 pounds of trash every day. That's 1.8 pounds more trash than the average American produced in 1960.

For the next few years, the government predicts the average American will continue to generate about 4.5 pounds of trash per day. Source reduction, like composting and reduced packaging, will play a major role in this leveling.



SOURCE REDUCTION

FOUR POUNDS + OF GARBAGE

"Got up, got out of bed, dragged a comb across my head," the song goes. But what if a couple of comb teeth break off? Why, just throw the comb out and buy a new one.

Then it's downstairs for breakfast. Perhaps you'll have a microwavable pancake breakfast on a throwaway plastic tray. Or maybe you'll take along an individually-wrapped pastry and a juice-in-a-box to eat on the way to school.

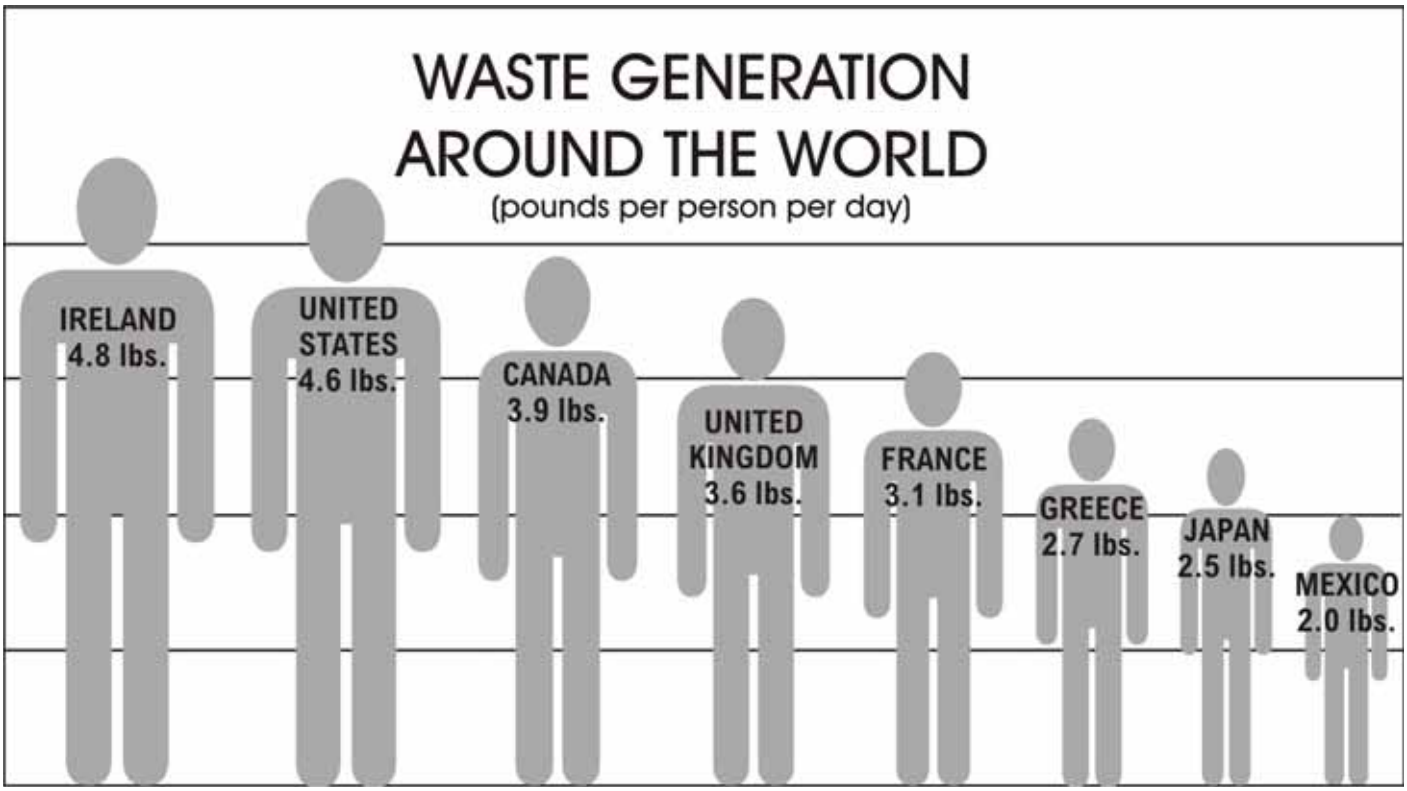
Rrring! The school bell signals the start of school. First period English class begins, and you pull out your disposable pen and throwaway spiral notebook.

Later it's time for lunch in the school cafeteria. You finish eating today's entrée and toss the disposable utensils, cup, and plate in the trash. You wipe your mouth on a disposable napkin. You wash your hands, then dry them on a disposable paper towel.

After school, you stop by the mall to buy a new video game. When you open the cardboard box, you notice the film is also packaged in a plastic canister. And so the day goes.

Imagine this scenario played out every day by young Americans across the country. You and every American adult and child generate over four and one half pounds of waste every day of your life, more waste than citizens of any other country.

Given the hectic lifestyle of many modern families, Americans are unlikely to give up the comfort and convenience of disposables. More municipal solid waste is the price we pay for products that are time saving, convenient, and disposable. Unless we are prepared to make significant changes in our life-styles and attitudes, we need to ask ourselves, "What are we going to do with all that trash?"



REDUCING FROM THE START

Source reduction should be the first step in any waste management program. Source reduction means reducing the amount of material that enters the waste stream in the first place.

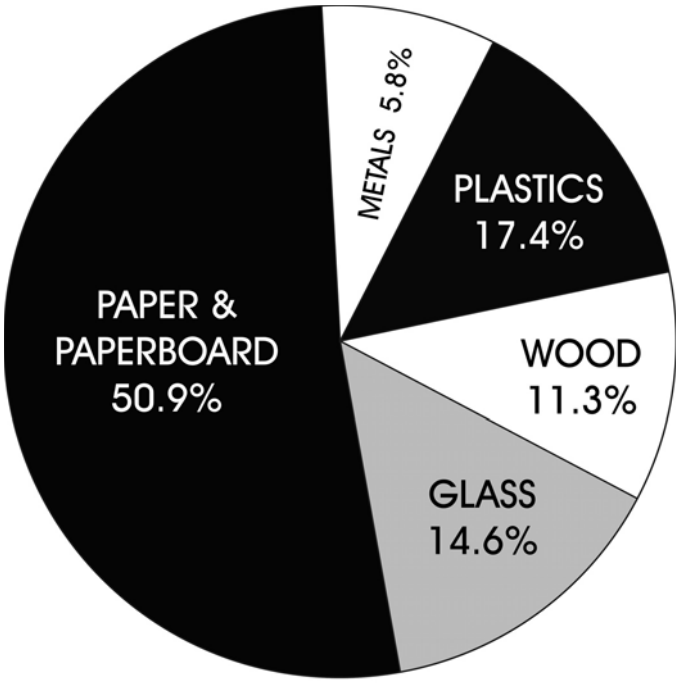
Common sense tells us that reducing the amount of waste we produce is the easiest way to solve America's mounting garbage problem. It avoids disposal and pollution problems right from the start, and it conserves natural resources and energy. Reducing waste at the beginning means there will be less waste to be recycled, burned, or landfilled.

THE WRAP ON PACKAGING

Packaging—the stuff companies wrap or box consumer products in—has become the target of most source reduction efforts. Why? Because packaging is the single largest product in the waste stream by weight.

Just look at the products lining grocery store shelves. Bread is wrapped in a plastic bag. Soup comes in a can. Cookies are arranged on plastic trays that are slipped inside paper or plastic bags. Six bottles of cola are wrapped together in plastic.

PACKAGING



Containers and packaging make up 30.9 percent of our trash by weight, 26.6 percent by volume. They are made of these materials.

Sometimes even apples are arranged on a cardboard or foam tray and then wrapped in plastic. As one person put it, "The list is as long as the supermarket aisle."

Yet packaging serves many useful purposes. The bread wrapper keeps the bread fresh and clean. The soup can keeps the soup fresh for months on grocery store shelves. The cookie tray keeps the cookies from getting crushed. The plastic wrapping around soft drinks makes it easy to grasp six bottles of cola in one hand. The wrapped apples mean less time selecting food. Without a doubt, packaging provides a convenient and sanitary way to store and transport food and other products.

Sometimes, though, packaging is more a marketing ploy—the purpose being to make the product look bigger and better than its competitors. This packaging does not come free. Americans pay a price for all the wrapping and glitter. Eleven percent of the money ($11 of every $100) your family spends on groceries winds up in the garbage bin!

And it had better be a big garbage bin. Packaging makes up 30.9 percent of the municipal solid waste stream by weight, or 26.6 percent by volume. At first glance, many Americans may think the percentage for containers and packaging is very high. Packaging—particularly food packaging—gets a lot of attention because we bring it into our homes, because we see it in our trash every day, and because it is noticeable.

However, it's important to consider some of the items we don't see in our trash, thanks to packaging. For example, a recent study found that residents of Mexico City produce 40 percent more garbage than their American counterparts. One of the reasons is the use of less packaging. Mexican waste contains far more spoiled food than found in U.S. landfills. Indeed, food spoilage in the U.S. averages less than three percent. Thanks to this low spoilage rate, the U.S. has the world's least expensive food supply.

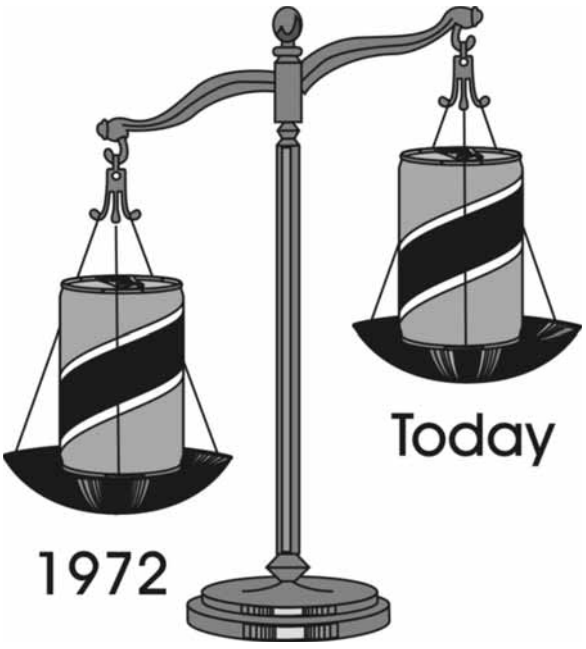
In less developed countries such as Mexico, where packaging is minimal, food spoilage rates can reach 50 percent. With crude packaging and distribution systems, many parts of the world still have a serious problem with food safety, supply, and spoilage.

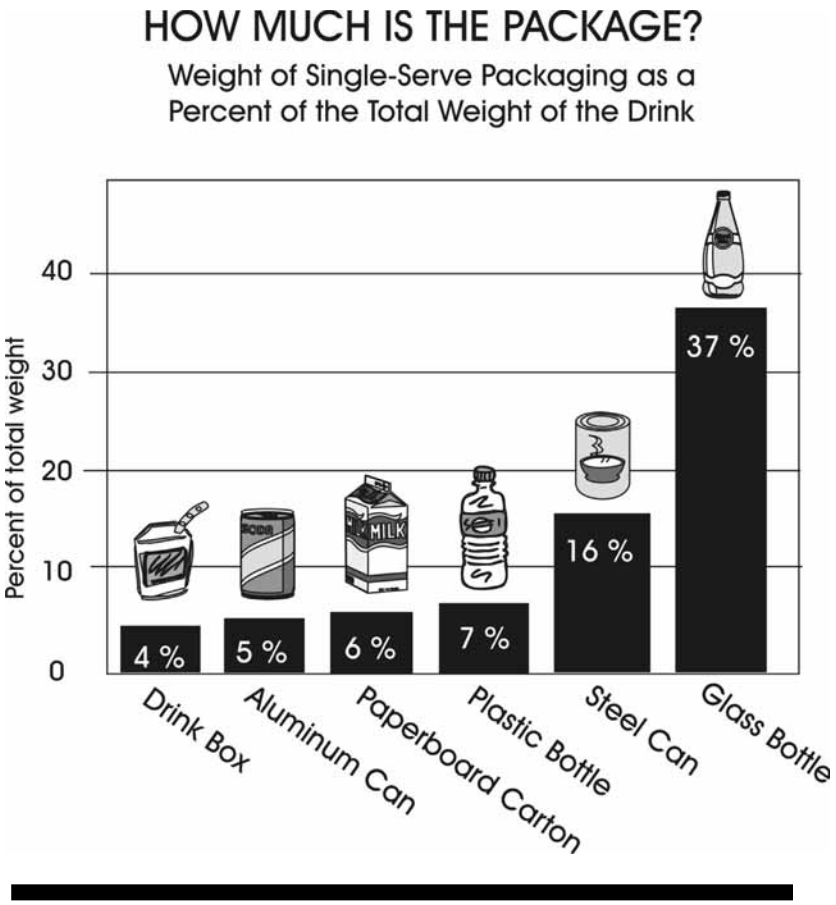
CHANGES IN PACKAGING

There is some good news about packaging. The Environmental Protection Agency—an agency of the federal government—reports that manufacturers are reducing the amount of waste in consumer products.

Companies that make consumer products are doing several things to reduce waste. For one, they are redesigning products so they need less packaging. Consumers can now buy fabric softener concentrate in small paperboard cartons, instead of buying big plastic jugs every time. Concentrated products can reduce packaging by 75 percent.

Second, companies are using fewer materials to package products. Compact discs (CDs) are a good example. Just a few years ago, CDs were packaged in cardboard containers twice the size of the actual CDs. When young people and recording artists demanded a change in the way CDs were packaged, the recording industry responded. Today, most new CDs are sold in shrink-wrapped jewel boxes.





In addition, virtually all manufacturers are using less material to make bottles, jars, and cans. The soft drink industry, for example, is making thinner bottles and cans. Today's two-liter plastic bottles are 25 percent lighter than when they were introduced in 1977. Glass jars are 43 percent lighter than they were in 1970. There are now 34 cans per pound of aluminum, up from 22 in 1972.

Other industries are doing their part, too. Disposable diapers are thinner than before, keeping babies dry with half as much material. Ice cream cartons weigh 30 percent less because of changes to the materials and design. And when McDonald's made its drinking straws 20 percent lighter, it eliminated one million pounds of solid waste per year.

Companies can reduce waste by using less packaging to bring a product to market. Intel Corporation, for example, changed their individual packaging for network cards, saving 320,000 pounds of plastic a year. The new style also reduced the size of the bulk boxes needed, saving 270,000 pounds of corrugated packaging a year. Finally, because the packages are smaller and lighter, less energy is needed to transport the cards to market.

The benefit of all these efforts by industry is less waste—less waste to put into a landfill, recycle, or burn.

TAKING ACTION

WHAT YOU CAN DO

You can help reduce waste at home by learning basic waste-saving habits. You can buy products that come in concentrated forms or products that use minimal packaging. And you can reuse, repair, recycle, or compost products that would otherwise be thrown away.

REDUCE

- Buy the largest size package and products that do more than one thing—for example, shampoos that include conditioners.
- Buy concentrated products or compact packages, such as frozen juices and fabric softeners you mix with water at home.
- Look for products with minimal packaging. You will be using fewer natural resources, and you'll have less to throw away.
- Leave grass clippings on the ground instead of bagging them when you mow your lawn. Grass clipping decompose quickly, adding nutrients to the soil.

REUSE

- Buy reusable products such as rechargeable batteries.
- Pass on magazines, catalogues, and books to neighbors, hospitals, schools, and nursing homes.
- Reuse plastic or glass containers for food storage, nails, and so on.
- Reuse plastic shopping bags, boxes, and lumber.
- Reuse wrapping paper, gift bags, and bows. Use the Sunday comics for wrapping children's birthday presents.

REPAIR

- Try to repair before you consider replacement of lawn mowers, tools, vacuum cleaners, and TVs.
- Donate items you can't repair to local charities or vocational schools.
- Keep appliances in good working order. Properly maintained appliances are less likely to wear out or break and will not have to be replaced as frequently.

RECYCLE

- Shop for items that are recyclable or are made from recycled materials.
- Recycle newspapers, plastics, glass, and cans.
- If a recycling program does not exist in your community, work with community officials to help establish one.

COMPOST

- Compost yard and kitchen waste. Compost makes an excellent fertilizer and improves the soil.
- If there's no room for a compost pile, offer compostable materials to community composting programs or garden projects near you.

STATION 3 BACKGROUNDER

INTRODUCTION TO RECYCLING

WHAT IS RECYCLING?

Recycling means using something again. Newspapers can be used to make new newspapers. Aluminum cans can be used to make new aluminum cans. Glass jars can be used to make new glass jars. There are several reasons why recycling makes sense. Let's take a look.

Recycling Saves Landfill Space.
Americans are producing more waste with each passing year, most of which is hauled off and buried in landfills. What's wrong with that? Well, it's expensive and usually controversial to dig new landfills or to build new incinerators. Recycling is one way to reduce the amount of waste that is landfilled.

Recycling Reduces the Cost of Waste Disposal.
Getting rid of trash isn't a free proposition. Garbage trucks must pay to dump their waste at a landfill. The payment is called a **tipping fee**, and it is based on the weight or volume of the garbage.

Tipping fees vary in different areas. In Vermont, one landfill charges about $65 a ton for the waste it receives. Recycling reduces landfill costs because less waste is landfilled. In 2007, recycling and composting diverted 85 million tons of material from landfills.

Recycling Saves Energy.
It almost always takes less energy to make a product from recycled materials than it does to make it from new materials. Using recycled aluminum scrap to make new aluminum cans, for example, uses 95 percent less energy than making aluminum cans from bauxite ore, the raw material used to make aluminum.

One exception to the "recycling-always-saves-energy" rule is plastics. Sometimes it takes more energy to recycle plastic than it does to use all new materials to produce the same product.

Recycling Saves Natural Resources.
Natural resources are riches provided courtesy of Mother Nature. Natural resources include land, plants, minerals, and water.

By using materials more than once, we conserve natural resources. In the case of paper, recycling saves trees and water. Making a ton of paper from recycled stock saves up to 17 trees and uses 50 percent less water.

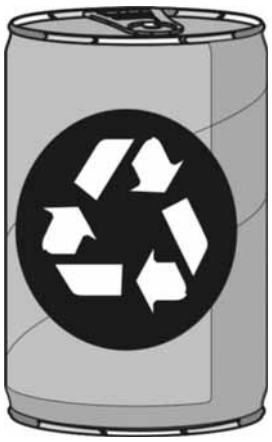
Recycling Reduces Air and Water Pollution.
Using aluminum scrap instead of bauxite ore to make new aluminum products cuts air and water pollution by 95 percent. If you want to do something for the environment, recycle those aluminum cans!

Recycling Creates Jobs
Recycling is estimated to create almost five times as many jobs as waste disposal. Recycling requires businesses that collect, haul, and process recyclables, as well as businesses that manufacture products from recycled materials. People employed in the recycling industry may be material sorters, truck drivers, sales representatives, process engineers, or chemists. The National Recycling Coalition reports that recycling supports 1.1 million jobs in the U.S.

CLOSED LOOP RECYCLING

Closed loop recycling is making an old product into the same thing again. It means turning old aluminum cans into new aluminum cans, or old glass jars into new glass jars.

Turning plastic milk jugs into flower pots is not closed loop recycling because a different product is made.



Closed loop recycling is ideal because there is already a market for the recycled product; manufacturers don't have to hope that people will buy aluminum cans, they know people will. That may not be true for recycled plastic flower pots, though.

WHERE TO RECYCLE

Many people think the United States should recycle more of its waste. Even the experts disagree on the best way to go about it. Should communities pick up residents' recyclables? Or is this practice too expensive for over-stretched city budgets? Does community recycling deprive the traditional picker-uppers (Boy Scouts, high school groups) of the opportunity to raise money for their clubs? Let's take a look at some ways recyclables can be collected.

Curbside Collections

Residents leave their recyclables at the curb or in some other designated place where regular trash is picked up. Communities may require residents to sort their recyclables—such as aluminum cans, newspapers, glass—into separate containers or they may be mingled together.

Curbside collection programs boast the highest recycling rates. Some experts say curbside recycling nationwide could reduce the volume of solid waste by 15 to 25 percent.

Drop-Off Centers

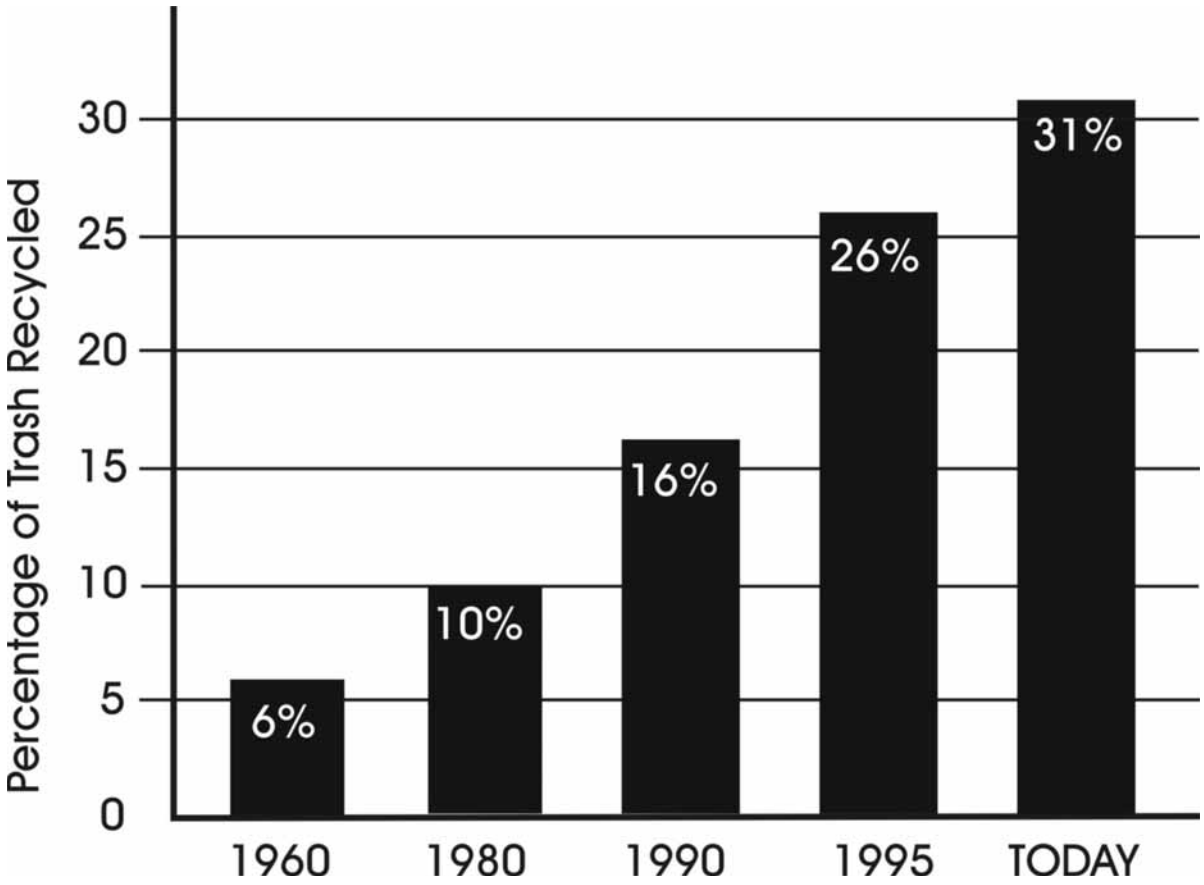
In some areas, people bring their recyclables to collection centers. This saves the community the cost of curbside collection but relies on residents willing to drive to the center for little or no payment. And they usually must crush, sort, and clean them.

Reverse Vending Machines

In many places, there are machines that accept used beverage containers and reimburse the depositor on the spot. Reverse vending machines are convenient because they are usually located inside or outside grocery stores.

RECYCLING FEVER

Recycling programs are growing across the United States. The media and the environmental movement have focused attention on our mounting waste problem. Now recycling has become the 'in' thing to do. Americans recycled just six percent of their waste in 1960 and 16 percent in 1990, but we recycle about 31 percent today.



Deposits
Several states impose a five or ten–cent deposit on returnable bottles and cans. Consumers get their deposits back when they return the containers to the store for recycling. These so-called "bottle-bill" states originally passed deposit laws to combat litter problems. Now they are one step ahead of the game. Deposits help solid waste disposal problems, too.

Pick-Up by Volunteers
This is recycling the old-fashioned way. Community groups, such as church groups and the Boy Scouts, collect recyclables to raise money for their clubs. These groups usually just pick up aluminum and newspapers because their scrap value is higher than other recyclables.

KEYS TO SUCCESS
No one questions the importance of recycling. Yet the experts debate whether Americans should be asked to recycle their waste (a voluntary program), or whether they should be required by law to recycle their waste (a mandatory program).

Mandatory Recycling
Some communities have passed laws or ordinances mandating that citizens recycle at least some of their trash. Typically, residents in these communities separate their newspaper, aluminum, glass, and other recyclables from the rest of their trash.

Other communities may only require that newspapers be separated for recycling. Residents who do not comply with local recycling laws may be fined, or their trash may not be picked up.

In an effort to encourage recycling, many communities have adopted pay-as-you-throw programs. Residents are charged by the number of trash containers they set out for collection.

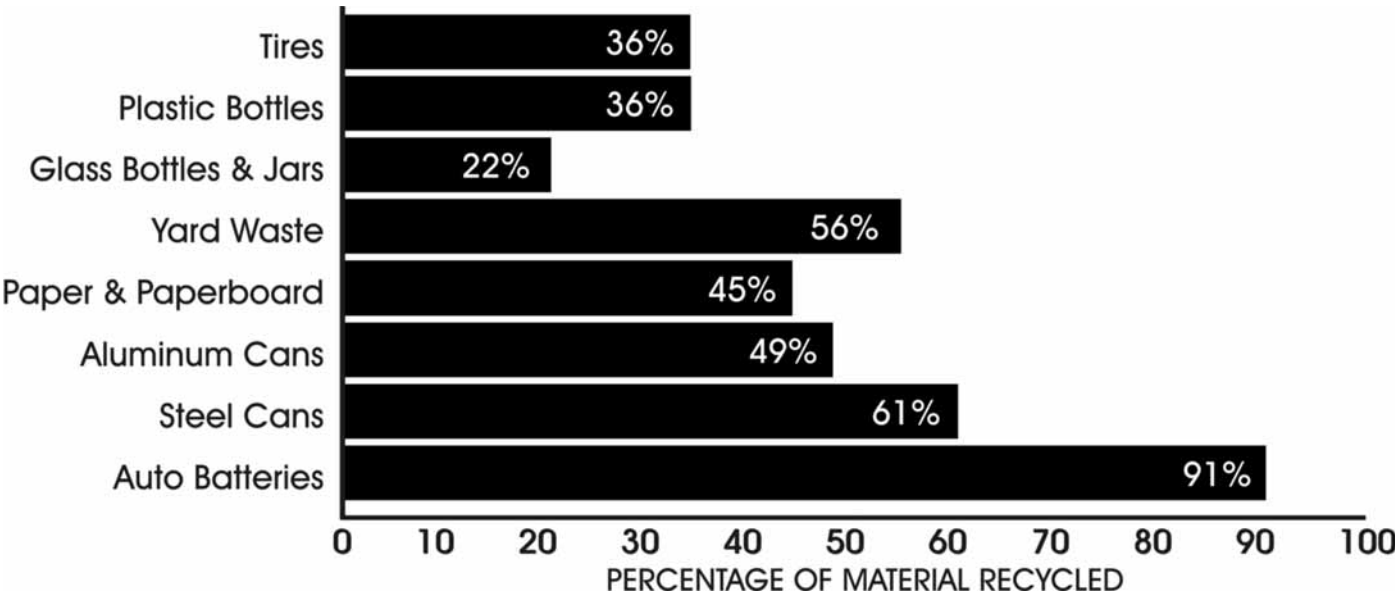
In Seattle, Washington, the amount residents pay for garbage pick-up is based on the size of their garbage cans. Usually, the cost of pick-up for one small 12-gallon can is about $16 per month, while the cost for two large 32-gallon cans is almost $50 per month. Residents who are serious about recycling end up paying far less for their garbage disposal.

Voluntary Recycling
Under a voluntary recycling program, residents are encouraged to recycle their waste, but they are not required to do so. Residents who choose not to recycle their waste are not fined or penalized in any way.

Are mandatory programs better at recovering recyclables than voluntary programs? The statistics show that mandatory programs are more successful.

In voluntary programs, about one-third of the community recycles. In mandatory programs, about one-half of the community recycles. Why don't more people recycle under mandatory recycling programs?

THINGS WE RECYCLE



RECYCLING GUIDE

MATERIAL	CAN BE RECYCLED	CAN'T BE RECYCLED	HOW TO DO IT
GLASS	Jars, bottles clear, green, amber	Light bulbs, dishes, pyrex, crystal	Rinse, remove lids & separate by color. Labels can stay.
PAPER	Newspapers, boxes, egg cartons, phone books, white office paper	Waxed, glued, plastic, or foil coated	Keep clean and dry.
ALUMINUM	All aluminum—cans, pie pans, foil wrap, old windows, lawn furniture	All is recyclable. (Aluminum does not stick to a magnet.)	Rinse and crush.
STEEL	Steel (tin) food and drink cans, cast iron, sheet metal	All is recyclable. (Steel does stick to a magnet.)	Rinse, crush if possible. Labels can stay.
PLASTICS	All plastics (Usually milk jugs and 2-liter bottles)	Check with your recycler.	Rinse & remove lids. Labels can stay.

The answer is simple. Enforcing the laws is impractical. It means going from trash can to trash can to find out who is recycling. In 2006, Seattle began enforcing its recycling program. Residential garbage cans that contain more than 10 percent recyclables are not emptied, but left at the curb full of garbage. Tags are left on the garbage cans saying why they were not emptied and explaining how to separate out the recyclables for pick-up the following week. Business owners who do not recycle can receive $50 fines.

In any case, new studies suggest that successful recycling programs are those that make it easy for people to recycle. The most successful recycling programs provide residents with special containers for sorting their waste and collect the recyclables weekly along with the rest of the trash. Ease and convenience are the keys to success.

WHEN TO RECYCLE

Recycling always makes sense, right? No, not always. Recycling sounds great, but recycling costs money and uses energy, too. Recyclables have to be collected, sorted, shipped to manufacturing plants, and then made into new products.

Collecting recyclables is only the first part of the story. We can be good citizens and recycle our trash, but if nobody wants to buy the recyclables, we haven't accomplished much. In other words, somebody has to want to buy old newspapers because it is cheaper to use them to make a new paper product than it is to use virgin paper stock.

What happens when nobody wants to buy recyclables? The East Coast experienced this problem about 15 years ago when there was a glut of old newspapers. Communities on the East Coast collected newspapers for recycling, but nobody wanted to buy them. The newspapers sat around in warehouses waiting to get a second life.

That is not recycling. Recycling means to make something old into something new. Collection is only the first step. There is good news for the East Coast, though. Thanks to consumer demand for recycled paper products, the newspaper glut has disappeared. Today, many recyclers are eager to get their hands on as much used paper as possible.

RECYCLING PLASTICS

IT'S PLASTIC!

Americans seem to have a love–hate affair with plastic. We look down on plastic imitations of natural products and fibers. They are cheap, we say. We all want real leather, for example, rather than imitation plastic.

Yet we are using plastic products more than ever before. We cover our food in plastic wrap, drink coffee from Styrofoam® cups, wear clothes made from man-made fibers like nylon, polyester, and rayon, and even buy our plastic things with plastic credit cards! We use plastic hundreds of times every day.

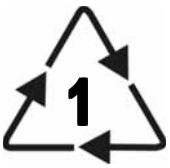
WHAT IS PLASTIC?

Plastic is a versatile product. Plastic can be flexible or rigid; transparent or opaque. It can look like leather, wood, or silk. It can be made into toys or heart valves. Altogether there are more than 10,000 different kinds of plastics.

The basic raw materials for plastic are petroleum and/or natural gas. These fossil fuels are sometimes combined with other elements, such as oxygen or chlorine, to make different types of plastic.

Plastics are not the waste and energy culprits that some people think they are. Plastics are really very energy efficient. It takes 20–40 percent less energy to manufacture plastic grocery bags than paper ones. And, since plastics are lightweight and take up so little space, it is much more efficient to transport them. It takes seven trucks to deliver the same number of paper bags as can be carried in one truckload of plastic bags.

DECODING PLASTICS



PET ***Polyethylene Terephthalate***

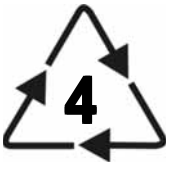
Two-liter beverage bottles, mouthwash bottles, boil-in-bag pouches

HDPE ***High Density Polyethylene***

Milk containers, trash bags, detergent bottles

PVC ***Polyvinyl Chloride***

Cooking oil bottles, pipes, packaging around meat

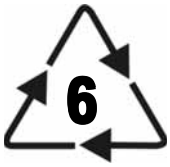


LDPE ***Low Density Polyethylene***

Produce bags, food wrap, bread bags

PP ***Polypropylene***

Yogurt containers, shampoo bottles, straws, margarine tubs, diapers



PS ***Polystyrene***

Hot beverage cups, egg cartons, meat trays, CD cases

Other **All other types of plastics or packaging made from more than one type of plastic**

DISPOSING OF PLASTIC

Is plastic trash choking the Earth with Styrofoam® cups and fast-food plates? Not really. That's just another misconception.

By weight, plastics make up about 12 percent of America's municipal solid waste. In comparison, paper makes up about 33 percent. Of course, plastics are generally very lightweight. When plastics are buried in a landfill, they occupy about 17 percent of the space.

Putting plastics into landfills is rarely the best disposal method. There are two better alternatives, recycling and incineration.

These methods recover some of the value from the plastic. Recycling recovers the raw material, which can then be used to make new plastic products. Incineration recovers the chemical energy, which can be used to produce steam and electricity.

Landfilling plastics does neither of these things. The resource and energy value of landfilled plastic is buried forever.

RECYCLING PLASTICS

Recycling plastics is easy. First, you should learn what types of plastics can be recycled and only give your collector those types of plastics. Resist the temptation to slip plastics that recyclers don't want into the recycling bin.

Plastics have different formulations and should be sorted before they are recycled to make new products. Mixed plastics can be recycled, but they are not as valuable as sorted plastics because the recycled plastic's physical properties, such as strength, may vary with each batch.

Once you know what kinds of plastics your recycler wants, you should follow the *wash and squash* rule—rinse the container and squash it. You may leave the paper labels on the container, but throw away the plastic caps. Plastic caps are usually made from a different type of plastic than the container and cannot be easily recycled.

ANOTHER LOOK

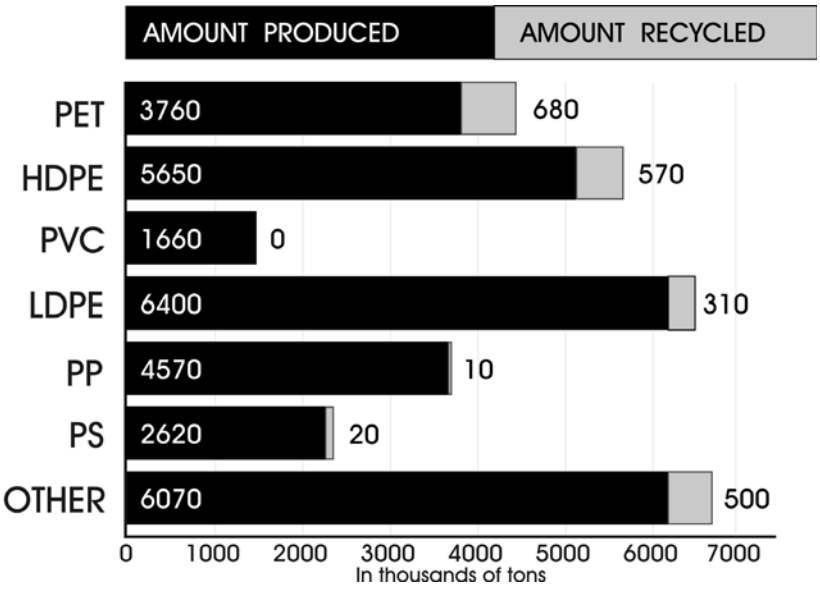
Today, Americans recycle about seven percent of all the plastics produced in this country. Why aren't we recycling more plastics? There is no simple answer.

Part of the issue in recycling plastics is the cost. To remain competitive in the global marketplace, manufacturers usually choose the cheapest option for making products. New plastic resin, or virgin resin, often costs less than recycled plastic. Until recently, when the U.S. experienced a series of massive hurricanes, virgin resin was cheaper than recycled plastic. Due to the hurricanes, supplies of oil and natural gas—the building blocks of virgin resins—became limited and more expensive. Prices for virgin resin soared, and the demand for recycled plastics increased.

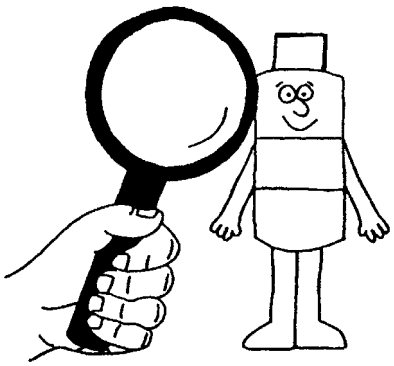
Another important consideration is human behavior. Surveys conducted by Proctor & Gamble and other companies show that while most people expect their plastic to be recycled, they won't go out of their way or pay a few cents more to buy products made of recycled plastic. Consumers need to create a demand by purchasing only recycled plastics. As demand grows, the incremental cost will decrease.

There are success stories in plastics recycling, nonetheless. Soft-drink bottles made of polyethylene terephthalate (PET) can be melted down and made into carpet, t-shirts, stuffing for ski jackets, or molded into bottles again.

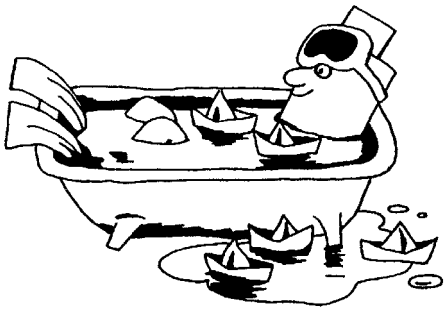
PLASTICS PRODUCED & RECYCLED



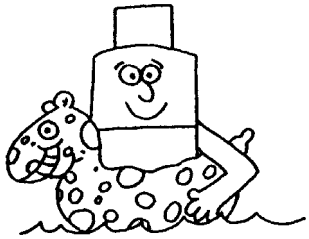
STEPS IN RECYCLING PLASTIC



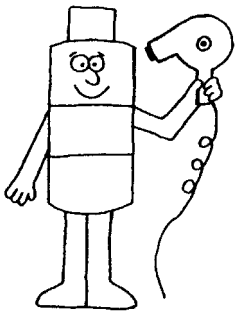
1. Inspection
Workers inspect the plastic trash for contaminants like rock and glass, and for plastics that the plant cannot recycle.



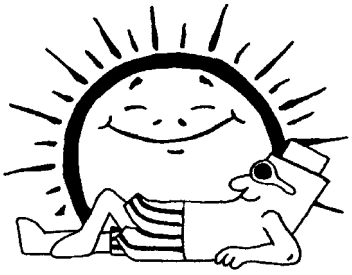
2. Washing & Chopping
The plastic trash is washed to remove any contaminants and chopped into flakes.



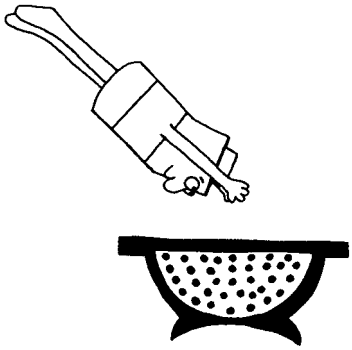
3. Flotation Tank
If mixed plastics are being recycled, they are sorted in a flotation tank, where some types of plastics sink and others float.



4. Drying
The plastic flakes are dried in a tumble dryer.



5. Melting
The dried flakes are fed into an extruder in which heat and pressure melt the plastic. Different types of plastics melt at different temperatures.



6. Filtering
The molten plastic is forced through a fine screen to remove any contaminants that remain after the washing process. The molten plastic is then formed into long strands.

7. Pelletizing
The strands are cooled in water, then chopped into uniform pellets. Manufacturing companies buy the plastic pellets from recyclers to make new products. Recycled plastics also can be made into flower pots, lumber, and carpeting.

ENERGY TO BURN

Because plastics are made from fossil fuels, you can think of them as another form of stored energy. Pound for pound, plastics contain as much energy as petroleum or natural gas, and much more energy than other types of garbage. This makes plastic an ideal fuel for waste-to-energy plants.

Waste-to-energy plants burn garbage and use the heat energy released during combustion to make steam or electricity. They turn garbage into useful energy.

So, should we burn plastics or recycle them? It depends. Sometimes it takes more energy to make a product from recycled plastics than it does to make it from all-new materials. If that's the case, it makes more sense to burn the plastics at a waste-to-energy plant than to recycle them.

Burning plastics can supply an abundant amount of energy, while reducing the cost of waste disposal and saving landfill space.

PAPER OR PLASTIC?

A paper cup or a plastic cup? Should you choose paper cups over plastic cups since the paper cups are made from natural wood products and will degrade? Maybe not.

A study by Canadian scientist Martin Hocking shows that making a paper cup uses as much petroleum or natural gas as a polystyrene cup. Plus, the paper cup uses wood pulp. The Canadian study said, "The paper cup consumes 12 times as much steam, 36 times as much electricity, and twice as much cooling water as the plastic cup." And because the paper cup uses more raw materials and energy, it also costs 2.5 times more than the plastic cup.

But the paper cup will degrade, right? Probably not. Modern landfills are designed to inhibit degradation so that toxic wastes do not seep into the surrounding soil and groundwater. The paper cup will still be a paper cup 20 years from now.

DEGRADABLE PLASTIC?

Degrade is another word for rot. It's nature's way of getting rid of dead plants and animals or the things made from them. Of course, plastics are man-made materials, but scientists have figured out two ways to make plastics degrade: biodegradation and photodegradation.

Biodegradable plastics are made with five percent corn starch or vegetable oil. The idea is that hungry bacteria will devour the starch or oil in the plastic, causing the plastic to disintegrate into a fine dust. That is the idea, but does it really work?

No, say both environmentalists and plastics manufacturers. Nothing degrades quickly in a modern landfill, not even organic wastes like paper and food scraps, so there is no reason to think that the corn starch in biodegradable plastics will disappear overnight either. Modern landfills are designed to inhibit degradation, not promote it. The idea is to keep wastes in, so landfill contaminants do not seep into the surrounding environment. In addition, biodegradable plastics cannot be recycled because the starch or oil additive compromises the quality of recycled plastics.

Photodegradable plastics are a different matter. They use no organic additives. They are made with a special type of plastic that breaks down and becomes brittle in the presence of sunlight. Of course, that means photodegradable plastics do not break down when they are covered by leaves or snow, or when they are buried in a landfill.

The maker of the plastic six-ring carrier that is used to attach six cans of soda, juice, and other beverages, says its photodegradable carrier loses 75 percent of its strength when exposed to sunlight after just a few days, and totally disintegrates within a matter of weeks. This means if an animal were to become entangled in the six-ring carrier, it could rip through the weakened pack to free itself. Since photodegradable plastics contain no organic additives, they can also be recycled, unlike their biodegradable cousins.

STATION 5 BACKGROUNDER

RECYCLING METALS

PRECIOUS METALS

Precious metals—such as gold, silver, brass, and copper—are so valuable that they are rarely thrown away. They do not create a waste disposal problem. But aluminum and steel do.

ALUMINUM & STEEL

Americans use over 100 million steel cans and 200 million aluminum beverage cans every day. What should we do with this metal waste? Should we burn it in waste-to-energy plants? Should we landfill it? Or should we recycle it?

After source reduction (using less aluminum to make a can, for example), recycling is the best way to deal with aluminum and steel waste.

Burning metal trash in waste-to-energy plants is not the best option because, unlike paper and plastics, metals do not provide any heat energy. Instead, aluminum melts and steel just gets very hot.

Magnets can be used to collect steel scrap at waste-to-energy plants, though, and then the scrap can be shipped to steel plants for recycling.

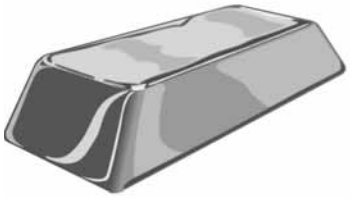
Landfilling is usually not a good alternative either. Aluminum, in particular, is so valuable as a scrap material that it simply does not make sense to bury it. And yet millions of aluminum cans are thrown in the trash every year to be buried in landfills.

THE ALUMINUM CAN CYCLE

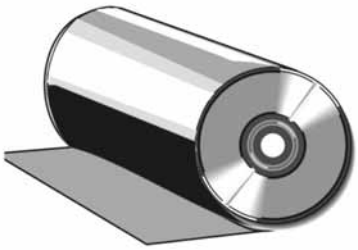
1. You enjoy your favorite beverage in an aluminum can.

2. You are a good "sort." You put the aluminum can into a bag or bin for recycling.

3. A recycling company takes the cans to a recycling plant. The aluminum is shredded and melted.



4. The molten aluminum is gradually hardened into ingot form.



5. The ingots are made into flat sheets of aluminum that can companies buy.

6. The aluminum sheets are made into new cans, and the cycle begins again.

RECYCLING ALUMINUM

Like most metals, aluminum is an ore. An ore is a mineral that is mined for a valuable material contained within it. Bauxite, a reddish clay-like ore, is rich in aluminum compounds.

The tricky thing about aluminum—unlike copper, iron, and other common metals—is that it only exists in combination with other elements, usually oxygen. Combined with oxygen, aluminum forms an extremely hard material known as alumina.

To free the aluminum, the alumina must be stripped or reduced of its oxygen. This process is done at a reduction plant, or smelter. The alumina is put into large pots at the reduction plant. First, it is dissolved in a molten (or liquid) salt. Then, a powerful electric current is run through the liquid to separate the aluminum from the oxygen. The molten aluminum sinks to the bottom of the pots. The reduction process requires a tremendous amount of electrical energy.

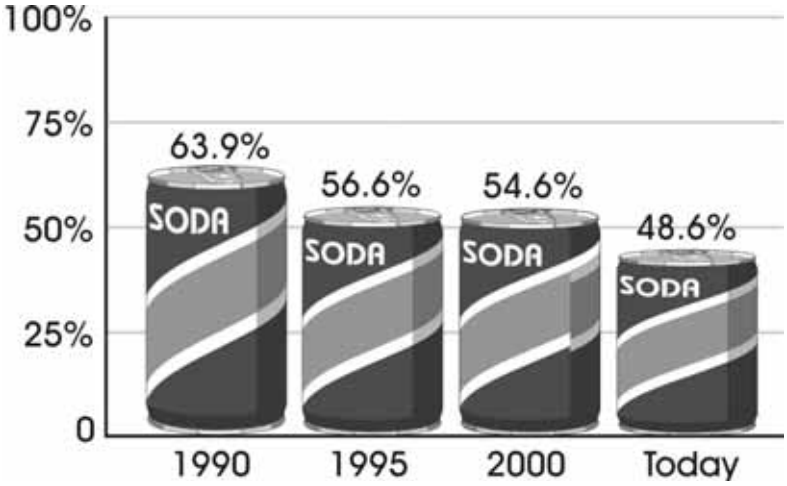
That is why recycling aluminum makes sense. It saves energy—a lot of energy. Today, aluminum can recycling saves about 11.5 billion kilowatt-hours (kWh)—enough electricity to light a city the size of Pittsburgh for six years.

As you probably know, energy is expensive! Just take a look at your parents' electric bill, or note the price of a gallon of gasoline the next time you see a gas station. Making a pound of aluminum from bauxite ore (a pound is about the weight of 34 aluminum beverage cans) takes 7.5 kilowatt-hours of electricity.

Making aluminum from recycled aluminum scrap, on the other hand, takes only five percent of the energy—just one-third of a kWh. Recycling four aluminum cans saves as much energy as the energy in one cup of gasoline. That is also why used aluminum has a high scrap value. Aluminum manufacturers save energy as well as money using recycled aluminum, so they will pay you for your old cans—about a penny for every can.

Perhaps more than any other type of garbage, putting aluminum in a landfill is like burying money. Why do you think the rate of recycling aluminum cans is declining?

ALUMINUM CAN RECYCLING



OLD CANS TO NEW CANS

After you have done your part by taking your old aluminum cans to a recycling center or putting them in the recycling bin at the curb for pick-up, what happens next?

The old aluminum cans are taken to an aluminum reclamation plant. The cans are shredded into potato chip sized pieces and fed into a melting furnace. The molten aluminum is gradually hardened into rectangular slabs, called ingots, and then formed into thin sheets of aluminum.

The metal from recycled aluminum cans is usually made into new aluminum cans. This is called closed-loop recycling because the old cans are turned into the same thing again. Aluminum beverage containers can be recycled into new cans and put back onto store shelves within 60 days!

Aluminum also can be recycled over and over again. It does not lose its quality, and recycling it saves energy every time.

STEEL RECYCLING

Steel is the most recycled material in the U.S. Steel dominates the recycling mix because every year the steel industry recycles huge amounts of steel scrap from cars, appliances, and torn-down buildings and bridges. Today, all steel products are made with some recycled steel.

In 1998, the amount of steel that was recycled decreased for the first time in many years. Foreign countries were selling their steel so cheaply that the recycling industry suffered a decline. Today, it is increasing again.

You can do your part at home by recycling steel cans. A steel can is the can your soup comes in, or your dog's food, or your mom's coffee, or the whip cream you squirt on top of an ice-cream sundae. In fact, most food containers are made of steel. You have probably heard many people call a steel can a tin can. Steel cans are often called tin cans because they are usually coated with a thin layer of tin. Tin protects the food that is stored in the can.

THE ABCs OF STEEL

Steel and aluminum are both mined from ores, and are made in a similar way. The essential ingredient in steelmaking is iron ore. Iron ore is plentiful, but we cannot use it as it occurs in nature. Iron is usually combined with oxygen, or with other elements, like carbon and sulfur. We must smelt the iron ore—strip or reduce it of its oxygen—to get to the iron.

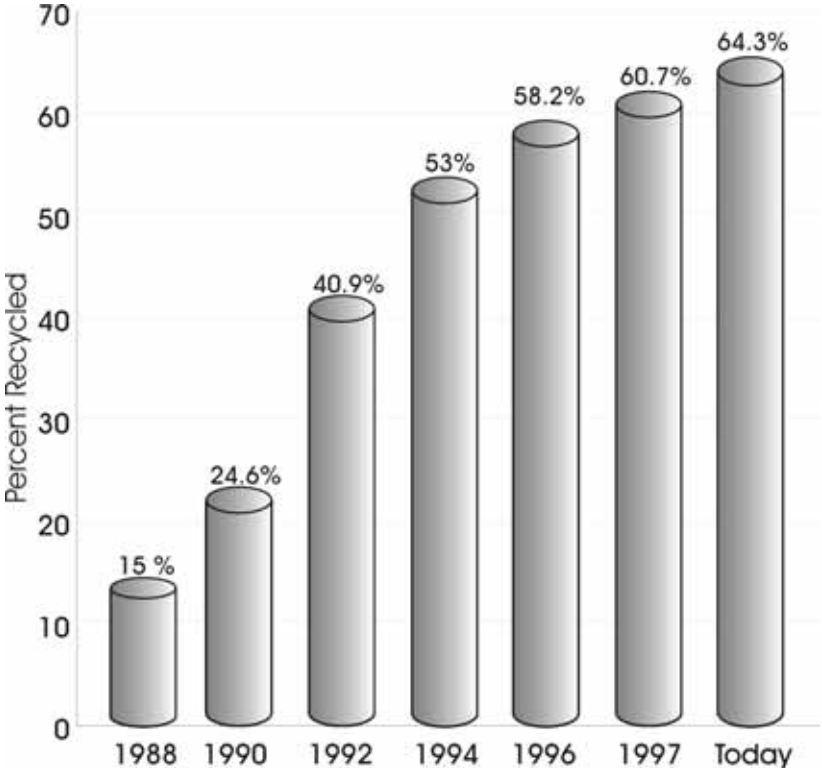
It takes a great deal of energy to reduce iron oxides. An **oxide** is a compound with oxygen and some other element. The reduction takes place in a very hot blast furnace. A chemical reaction takes place in the blast furnace, and the iron is freed from the oxygen. This free iron (called *pig iron* by steelmakers because it forms a pattern that looks like tiny piglets surrounding their mother) is used to make steel.

Steel recycling saves a lot of energy. It is much more energy efficient to use steel scrap to make new steel than to mine the iron ore and then smelt it in a blast furnace. It takes about 60 percent less energy to make steel from recycled materials than it does from iron ore. That's why today's steelmakers always use some steel scrap to make new steel products.

MAGNET POWER

Unlike other recyclables, steel is attracted to a magnet. This property makes steel easy to separate from the rest of the solid waste stream and easy to recycle.

STEEL CAN RECYCLING



Steel is probably the easiest material to separate from the rest of the solid waste stream. Steel is attracted to magnets, so special magnetic belts can be used to separate steel cans from other recyclables. This is a much more efficient method than the labor-intensive hand-sorting necessary with other recyclables, such as plastics.

Recycling your used steel cans at home is easy, too. All you need to do is rinse the food from the cans. That's it. Years ago, scrap dealers asked people to remove the paper labels and the tops and bottoms from cans. This is no longer necessary.

If you're not sure which cans are steel and which are aluminum, use a magnet to separate them. Steel will stick to the magnet; aluminum will not.

If you come across a can with a steel body and an aluminum top—called a bimetal can—put the can with the steel recyclables. Steel recyclers can accept all types of steel cans, even those containing aluminum. Aluminum recyclers can only accept 100 percent aluminum cans.

After steel scrap is collected from homes, recycling centers, or waste-to-energy plants, it is shipped to one of the companies that buy old steel—steel mills, iron and steel foundries, scrap dealers, and detinners. Detinners remove the layer of tin from old steel cans. This tin is valuable and can be sold.

Steel can recycling follows almost the same process as aluminum can recycling. Steel cans, along with other steel scrap, are melted in a furnace and then poured into casters that continuously roll and flatten the steel into sheets.

Recycled steel cans can be made into new cars, girders for buildings, or new food cans. In the U.S., steel cans and other steel products contain at least 25 percent recycled steel, with some containing nearly 100 percent recycled steel.

Like aluminum, steel can also be recycled again and again. It does not lose any of its strength or quality in the recycling process. It can be a never-ending process that continues to save energy and resources.

SAVING ENERGY BY RECYCLING STEEL

The average family in the United States uses 90 pounds of steel cans a year. Recycling that steel would save:

144 kWh of electricity

63 lbs of coal

112 lbs of iron

5.4 lbs of limestone

STEEL PRODUCTS

Many things we use every day are made of steel that can be recycled again and again.

RECYCLING PAPER & GLASS

RECYCLING PAPER

What is the number one material in the solid waste stream? Before you say plastics, look around your classroom. What do you see? Posters? Notebooks? Cardboard boxes? Textbooks? Paper is everywhere!

Paper is the number one material that we throw away. For every 100 pounds of trash we throw away, 35 pounds is paper. Newspapers take up about 14 percent of landfill space, and paper in packaging accounts for another 15 to 20 percent.

Paper has many forms. It can be glossy or ragged, thin or thick. It can be the stuff of newspapers or the stuffing of diapers. Most paper products are made from trees that have been cut and pulped, though paper can also be made from old cloth or grass.

HOW PAPER IS MADE

Papermaking uses one of America's abundant, natural, renewable resources—trees! The first step in papermaking is harvesting the trees. Paper companies plant trees specifically for papermaking, much like an apple farmer grows apple trees to produce apples. If one tree is cut down for paper, another is planted to replace it.

After the trees are harvested, they are delivered to a paper mill. Paper mills use every part of the tree so nothing is wasted. The bark and roots are burned and used for energy to run the paper mill.

The rest of the tree is chopped into small chips for pulping. Pulping is a chemical process that separates the wood fibers from lignin and other wood parts.

Pulp is the soft, spongy part of a tree. Lignin is the glue that holds a tree together. If lignin is left in a paper product, the paper turns yellow and brittle when it's exposed to light. You have probably noticed that newspapers turn yellow very quickly. Lignin is usually left in newsprint, since newspapers are only meant to last a day or so.

After pulping, paper is the color of grocery bags. High quality papers are whitened with chlorine bleach and sometimes coated with clays and adhesives to give them a glossy finish.

Paper mills need a lot of energy to produce paper. About 50 percent of their energy comes from wood scraps that cannot be used to make paper. The rest of the energy is purchased from local power companies or generated on site by the mill using other energy sources.

HISTORY OF PAPER

(This information about papermaking is provided by S.D. Warren Research, a division of Warren Paper, in its brochure, "Papermaking and Our Small Planet.")

At one time if someone wanted to leave a message for the world, he had to use a cave wall, a stone tablet, or an animal bone. Now people have their choice of a wide variety of paper products.

When paper was first invented in China, in 105 A.D., it was made mostly from rags, linen, or bamboo.

In 1719, a Dutch naturalist noticed that wasps' nests were made of a material that resembled paper. He observed the wasps chewing wood filaments and mixing them with their own saliva. This gave him the idea that paper could be made from wood fiber and led to the growth of the papermaking industry.

RECYCLED PAPER

Recycled paper is made from waste paper, usually mixed with fresh wood pulp. If the paper contains ink, the paper must be **deinked**. Deinking also removes fillers, clays, and fiber fragments.

Almost all paper can be recycled today, but some types are harder to recycle than others. Papers that are waxed, pasted, or gummed—or papers that are coated with plastic or aluminum foil—are usually not recycled because the process is too expensive.

Even papers that are recycled are not usually recycled together. Waste papers should be sorted. High-grade papers with long fibers, such as office and resume paper, is recycled separately from low-grade papers with short fibers, such as newspaper.

Different grades of paper are recycled into different types of new products. Old newspapers are usually made into new newsprint, egg cartons, or paperboard. Old corrugated boxes are made into new corrugated boxes or paperboard. High-grade white office paper can be made into almost any new paper product—stationery, newsprint, or paper for magazines and books.

Sometimes recyclers ask you to remove the glossy inserts that come with newspapers. The newsprint and glossy inserts are different types of paper. Glossy inserts have a heavy clay coating that some paper mills cannot accept. Besides, a paper mill gets more recyclable fibers from a ton of pure newsprint than it does from a ton of mixed newsprint that is weighed down with heavy clay-coated papers.

NOT ALWAYS RECYCLABLE

Unlike most other recyclables, paper cannot be recycled over and over again. Eventually the fibers become too weak and short to be used again. That is why virgin paper fiber is usually mixed with recycled paper when new paper products are made. Most cardboard boxes are a mixture of 50 percent new and 50 percent recycled fibers.

SAVING ENERGY

So does paper recycling save energy? Yes it does. A paper mill uses 40 percent less energy to make newspaper from recycled paper than it does to make newspaper from fresh lumber. However, a recycling mill may consume more energy from fossil fuels than a paper mill.

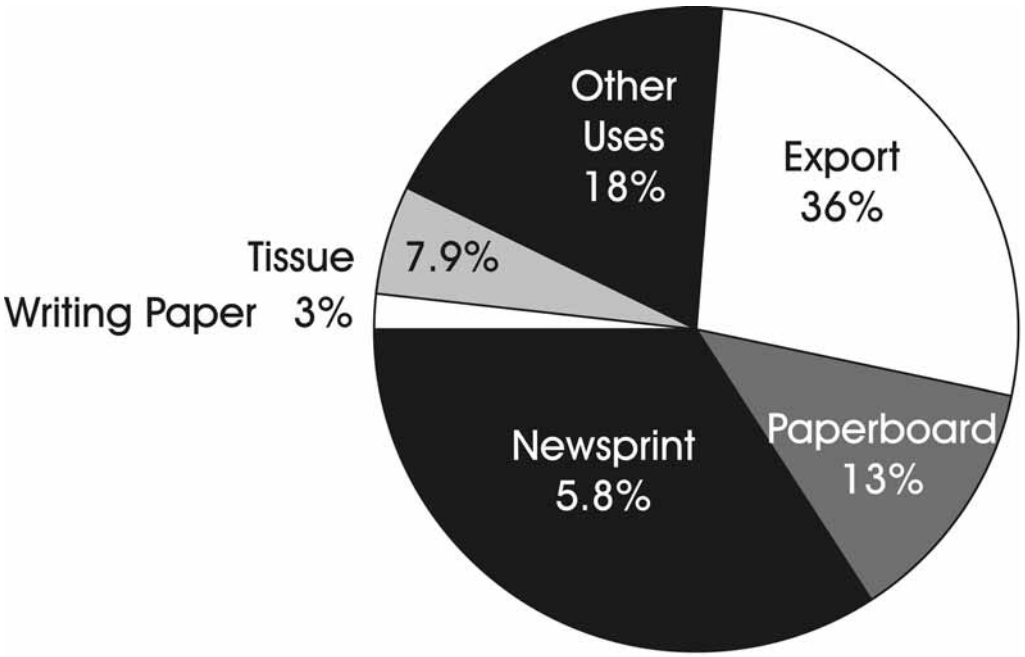
NEWSPAPER RECOVERY

Today, the paper industry in the U.S. is recovering 54.5 percent of all paper.

By achieving this mark, 45 million tons of paper were recovered and not sent to landfills.

The paper industry has set a new goal of recovering 60 percent of used paper by 2012.

Old corrugated boxes account for 50 percent of the total paper that is recycled.



WHAT HAPPENS TO RECOVERED PAPER

Paper mills generate much of their energy from waste wood, but recycling mills purchase most of their energy from local power companies or use on-site cogeneration facilities.

Making recycled paper does require fewer chemicals and bleaches than making all-new paper, and spent chemicals are often burned to produce energy for use at the plant. Although recycled paper is less polluting than paper made from wood fiber, both processes produce different by-products.

Paper mills may emit more sulfur dioxide, but recycling mills may produce more sludge. Deinking at Cross Pointe's Miami, Ohio mill results in 22 pounds of sludge for every 100 pounds of wastepaper recycled.

Paper recycling does mean fewer trees are used to make paper, but all-new paper is almost always made from trees specifically grown for papermaking. A tree harvested for papermaking is soon replaced by another, so the cycle continues.

"We are not talking about the rain forest or old growth in the Pacific Northwest," says Champion Paper's Martin Blick. "Most of the trees cut for paper come from fifth or sixth generation pulp-wood forests."

ALWAYS RECYCLE PAPER?

Between 1990 and 1993, there was a glut of old newspapers on the East Coast. People in some communities diligently collected newspapers for recycling, only to have stacks of them grow and grow until they had to pay someone to haul them away—sometimes to a landfill!

In these situations, it may be better to burn the paper in a waste-to-energy plant than to recycle. The heat energy produced from burning the paper can be used to make steam and electricity.

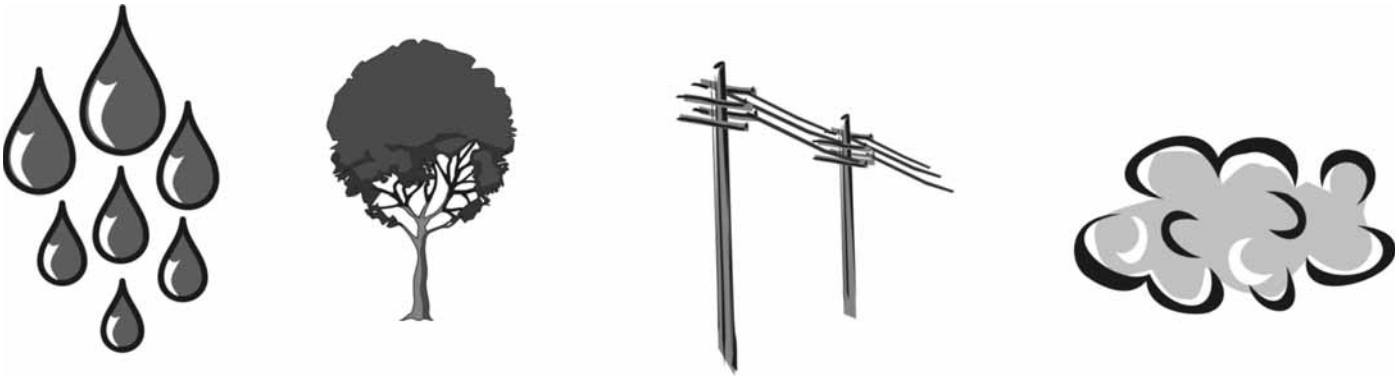
During the last few years, the demand for recycled paper has caught up to the supply. More than 85 new paper mills with recycling capabilities have been built in the United States. Today, many paper companies are eager to get their hands on as much used paper as possible.

Most newsprint producers were using at least some recycled newsprint by 1995. Now they are worried that there may not be enough old newspapers to meet their demand.

America's forest and paper companies have met their goal to recover 50 percent of all the paper used. They have set a new goal of 60 percent recovery by 2012.

CONSERVING RESOURCES AND ENERGY THROUGH PAPER RECYCLING

A ton of paper made from recycled fibers instead of virgin fibers conserves:



7,000 gallons of water

17–31 trees

4,000 kWh of electricity

60 pounds of air pollutants

RECYCLED GLASS

Using recycled glass to make products consumes 40 percent less energy than making products from all new materials. Today, almost 24 percent of the glass containers we produce are recycled.

THE WORLD OF GLASS

Glass is used to package many food products: juices, jellies, vegetable oils, baby food, and so on. Glass makes up about five percent of the municipal solid waste stream by weight, two percent by volume.

SHOULD I TOSS IT?

After source reduction (using less glass to make a glass jar, for example), the best way to deal with glass trash is recycling.

Unlike paper, burning glass in waste-to-energy plants is not a good alternative to recycling. Glass does not provide any heat energy for making steam or electricity. Paper burns in a waste-to-energy plant; glass just melts.

Landfilling glass recovers none of its value either. So, recycling is usually the best choice.

Recycling glass is a relatively good energy saver. Using recycled glass to make new glass products requires 40 percent less energy than making it from all new materials. It saves energy because crushed glass, called cullet, melts at a lower temperature than the raw materials used to make glass. New glass is made from sand, soda ash, and limestone.

Old glass is easily made into new glass jars and bottles or into other glass products like fiberglass insulation. And unlike paper, glass jars and bottles can be recycled over and over again. The glass doesn't wear out. Glass containers can be recycled into new jars and be on store shelves in as little as 30 days!

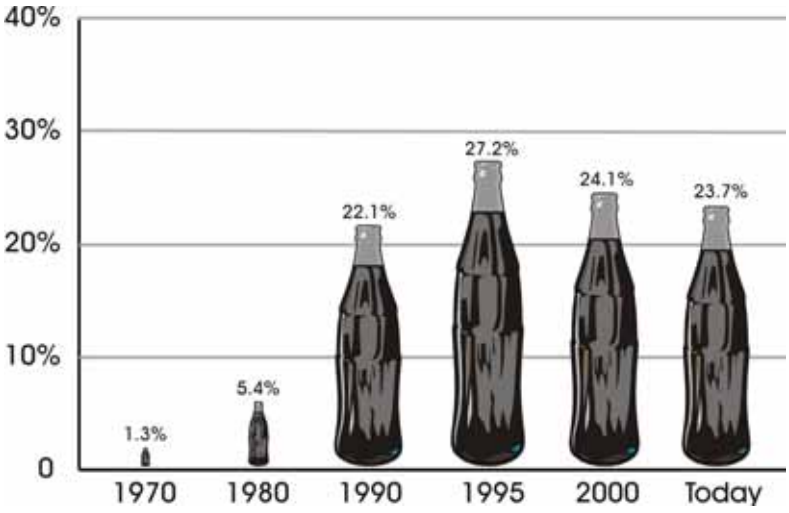
HOW TO RECYCLE GLASS

Preparing your used glass containers for recycling is easy. All you need to do is remove their lids or caps and rinse the containers in water. You don't need to scrub off the labels, since they will burn up when the glass is melted down for recycling.

Most recyclers ask you to sort glass containers by color—clear, green, or amber (golden brown). Once glass has been colored, the color cannot be removed. That means a maker of clear glass jars cannot use colored cullet. Why do some manufacturers package their foods and beverages in green or amber colored glass containers? The colored glass protects some sensitive foods and beverages from light.

You cannot recycle all glass products. Light bulbs, ceramics, glass mirrors, window panes, and dishes are not made with the same materials as glass jars and bottles, so they should not be mixed in with glass recyclables. Still, it's the bottles and jars that we throw away every day, not the light bulbs and dishes, that make up most of our trash.

GLASS BOTTLE RECYCLING



WASTE-TO-ENERGY

JUST BURN IT!

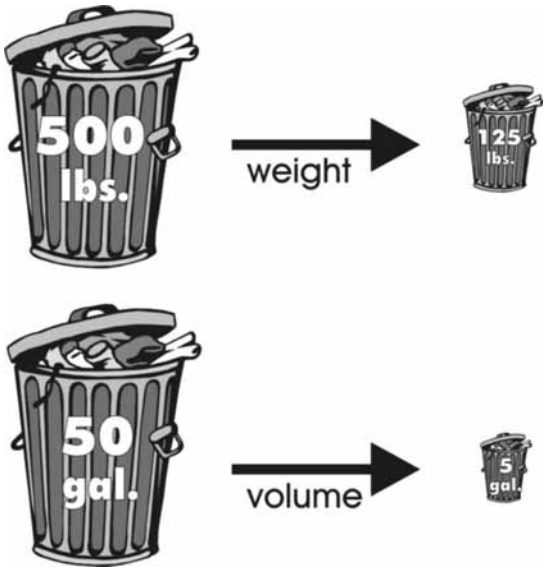
Americans are producing more and more waste with each passing year. In 1960, the average American threw away 2.7 pounds of trash a day. Today, the average American throws away 4.6 pounds of trash every day! What are we going to do with all that trash?

One solution is to burn it. (Burning is sometimes called **combustion**.) All organic waste contains energy. Organic waste is waste that is made from plant or animal products.

People have burned one type of organic material for millions of years. Can you guess what that material is? It's wood. Ancient people burned wood to keep them warm and to cook their food. In many parts of the world, wood is still the number one source of energy.

Today, we can burn garbage and use its heat energy to make steam to heat buildings or to generate electricity. This may sound amazing, but it is really nothing new. Most electric power companies already burn another type of material to make electricity. That material is coal. Coal is a mineral that was formed from the remains of plants that died millions of years ago.

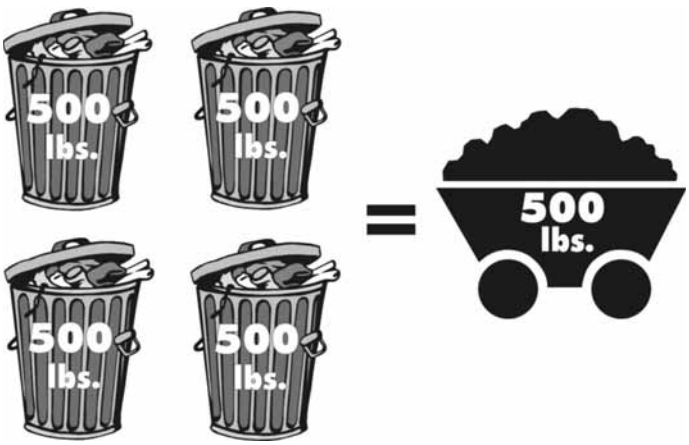
BURNING TRASH



Burning trash reduces its weight by 75 percent and its volume by 90 percent.

THE ENERGY IN GARBAGE

It takes 2,000 pounds of garbage to equal the heat energy in 500 pounds of coal.



Power companies use the heat energy in coal to make electricity. Garbage does not contain as much heat energy as coal, though. It takes one ton (2,000 pounds) of garbage to equal the heat energy in 500 pounds of coal.

Today, there are 87 waste-to-energy plants in 25 states. Plus, there are solid waste incinerators. These old-style incinerators simply burn trash to get rid of it. They do not use the heat energy to make steam or electricity. Today, the U.S. burns 14 percent of its solid waste.

WHY BURN GARBAGE?

Waste-to-energy plants generate enough electricity to supply almost three million households. But, providing electricity is not the major advantage of waste-to-energy plants. In fact, it costs more to generate electricity at a waste-to-energy plant than it does at a coal, nuclear, or hydropower plant.

The major advantage of burning waste is that it reduces the amount of garbage we bury in landfills. Burning waste reduces the amount of trash going to landfills by 75 percent. Waste-to-energy plants dispose of the waste of more than 40 million people.

The average American produces more than 1,600 pounds of waste a year. If all this waste were landfilled, it would take more than two cubic yards of landfill space. That's the volume of a box three feet long, three feet wide, and six feet high. If that waste were burned, the ash residue would fit into a box three feet long, three feet wide, but only nine inches high!

Why is reducing the amount of waste buried in landfills so important? Some communities in the congested Northeast may be running out of land for new landfills. And, since most people don't want landfills in their backyards, it has become more difficult to obtain permits to build new landfills. Taking the country as a whole, the United States has plenty of open space, of course, but it is expensive to transport garbage a long distance to put it into a landfill.

Some people are concerned that burning garbage may harm the environment. Like coal plants, waste-to-energy plants produce air pollution when the fuel is burned. Burning garbage releases chemicals and substances found in the waste. Some chemicals can be dangerous to people and the environment if they are not properly controlled.

BURNING TRASH ENVIRONMENTALLY SPEAKING

AIR EMISSIONS

The Environmental Protection Agency (EPA)—an agency of the federal government—applies strict environmental rules to waste-to-energy plants. The EPA requires waste-to-energy plants to use anti-pollution devices, including scrubbers, fabric filters, and electrostatic precipitators. The EPA wants to make sure that harmful gases and particles are not going out the smokestack into the air.

Scrubbers clean chemical gas emissions by spraying a liquid into the gas stream to neutralize the acids. Fabric filters and electrostatic precipitators remove particles from the emissions. The particles are then mixed with the ash that is removed from the bottom of the waste-to-energy plant's furnace when it is cleaned.

Waste-to-energy plants also have a kind of built-in anti-pollution device. A waste-to-energy furnace burns at such high temperatures (1,800 to 2,000 degrees Fahrenheit) that many complex chemicals naturally break down into simpler, less harmful compounds.

ASH DISPOSAL

Another challenge is the disposal of the ash after combustion. Ash can contain high concentrations of various metals that were present in the original waste. Textile dyes, printing inks, and ceramics, for example, contain the metals lead and cadmium.

Separating waste before combustion can solve part of the problem. For instance, because batteries are the largest source of lead and cadmium in the solid waste stream, they should be taken out of the mix and not burned.

Ash from waste-to-energy plants is tested by the EPA to make sure it is not hazardous. The testing looks for chemicals and metals that would contaminate ground water through *leachate*, or water trickling through a landfill. Ash that is safe can be reused for many applications. About one-third of all the ash produced is used in landfills as a daily or final cover layer, to build roads, to make cement blocks, and even to make artificial reefs for marine animals.

EXAMPLE OF ASH PELLETS

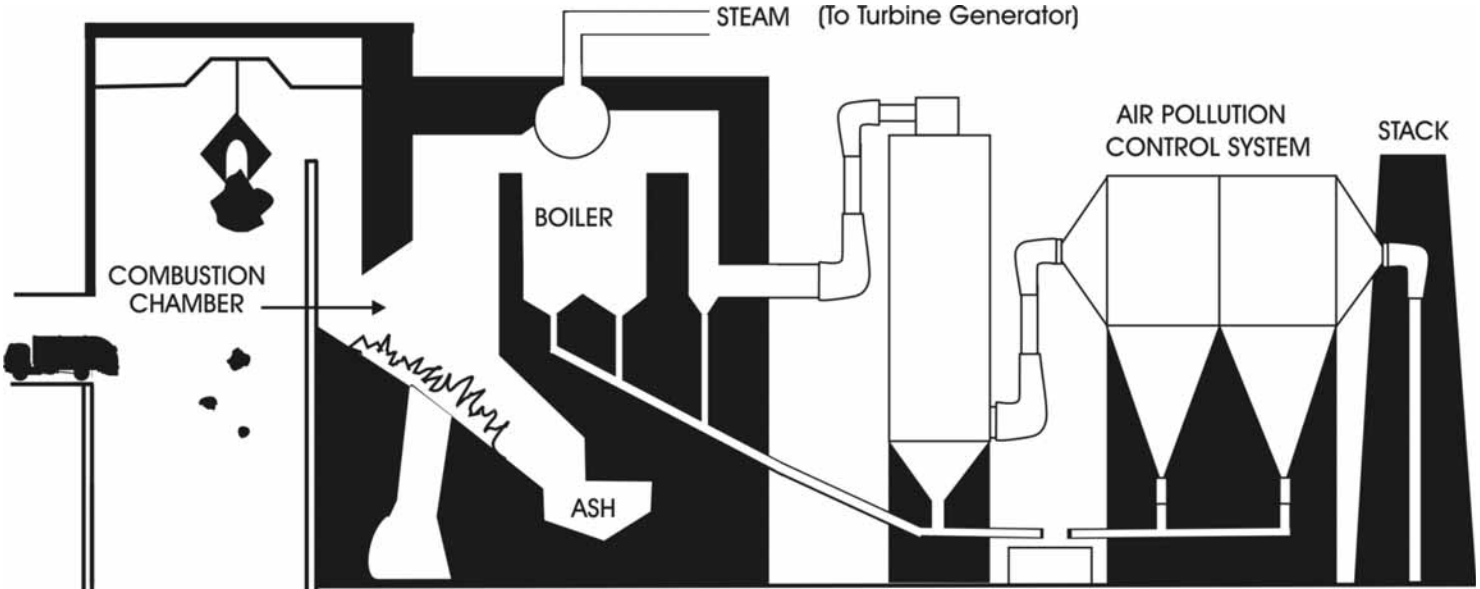
WASTE—TO—ENERGY PLANTS

Waste-to-energy plants work very much like coal-fired power plants. The difference is the fuel. Waste-to-energy plants use garbage—not coal—to fire an industrial boiler. The same steps are used to make electricity in a waste-to-energy plant as in a coal-fired power plant:

1. **The fuel is burned in a boiler, releasing heat.**
2. **The heat superheats water into steam.**
3. **The very high pressure of the steam turns the blades of a turbine generator to produce electricity.**
4. **A utility company sends the electricity along power lines to homes, schools, and businesses.**

You can think of garbage as a mixture of energy-rich fuels. In 100 pounds of typical garbage, more than 80 pounds can be burned as fuel to generate electricity at a power plant. Those fuels include paper, plastics, and yard waste. A ton of garbage generates about 525 kilowatt-hours (kWh) of electricity, enough energy to heat a typical office building for one day.

The high-temperature incinerator in a waste-to-energy plant burns most of the waste. All that is left is a substance called ash. Ash is the solid residue left over when something is burned. It's like the ash left over from a wood fire in the bottom of a fireplace. In a waste-to-energy plant, 2,000 pounds (one ton) of garbage is reduced to 300–600 pounds of ash.



WASTE-TO-ENERGY PLANT

TO BURN OR NOT TO BURN?

Some critics of waste-to-energy plants are afraid that burning waste will hamper recycling programs. If everyone sends their trash to a waste-to-energy plant, they say, there will be little incentive to recycle.

Recently, a study of cities that have both recycling programs and waste-to-energy plants showed higher recycling rates than other cities in the U.S. Why would these cities recycle more when they burn their trash? The results showed that people living in cities with waste-to-energy plants are more educated about municipal solid waste and strongly support their recycling programs.

So, while at first glance, recycling and waste-to-energy seem to be at odds, they can actually complement each other. That's because it makes good sense to recycle some materials, and better sense to burn others.

Let's look at aluminum, for example. Aluminum ore is so expensive to mine that recycling aluminum more than pays for itself. Burning it produces no energy. Also, because aluminum melts at a low temperature, it can clog up the works in a waste-to-energy plant. Aluminum is valuable to recycle and not useful to burn.

Paper, on the other hand, can either be burned or recycled—it all depends on the price the used paper will bring. Around 15 years ago, the East Coast experienced a glut of old newspapers. Some East Coast communities were paid almost nothing for the paper they collected. And some communities couldn't find anyone who wanted to buy their old newspapers, so they ended up paying a trucking company to haul the newspapers to a landfill!

In these cases, burning the newspapers for their energy value would have been a good alternative. Other types of paper, such as those using colored inks and glossy finishes, are not easily recycled and usually should be burned for their energy content.

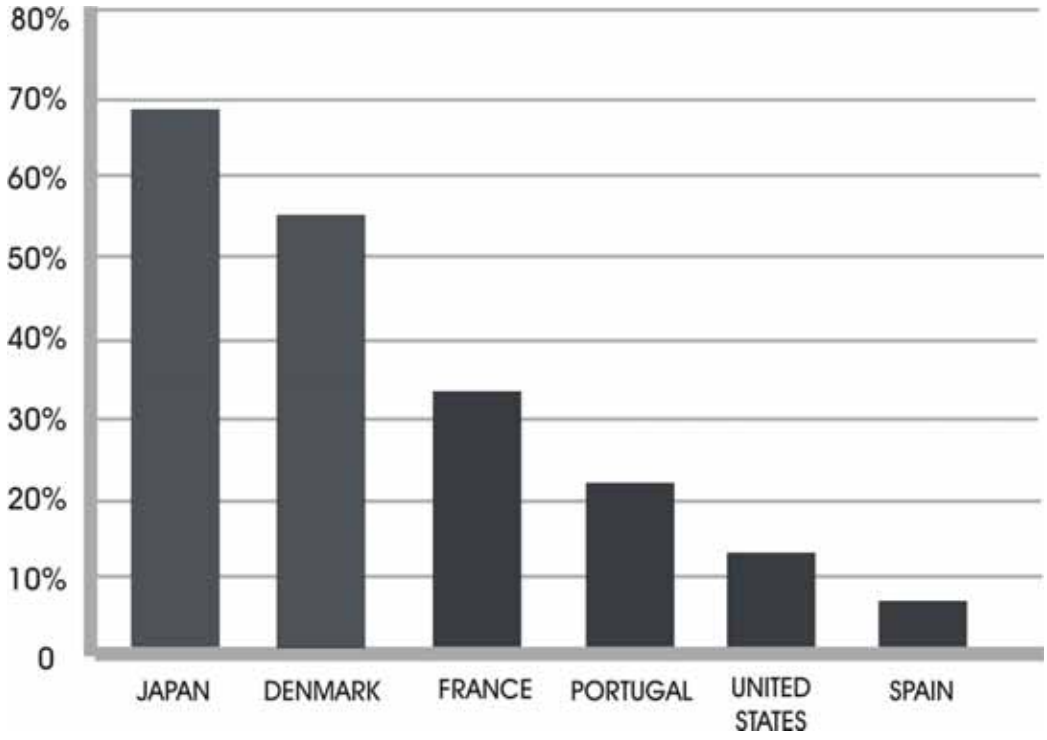
Plastics are another matter. Because plastics are made from petroleum and natural gas, they are excellent sources of energy for waste-to-energy plants. This is especially true since plastics are not as easy to recycle as steel, aluminum, or paper. Plastics almost always have to be hand sorted and making a product from recycled plastics may cost more than making it from new materials. To burn or not to burn is not really the question. We should use both recycling and waste-to-energy as alternatives to landfilling.

WASTE-TO-ENERGY AROUND THE WORLD

Many countries have built waste-to-energy plants to capture the energy in their trash. There are more than 700 waste-to-energy plants in 35 different countries around the world.

For example, the use of waste-to-energy plants in some European and Asian countries has grown, in part because they have little open space and few energy resources.

The U.S. burns almost 13 percent of its trash in waste-to-energy plants. Japan, on the other hand, burns 70 percent.



LANDFILLING

YESTERDAY AND TODAY

For hundreds of years, people have used garbage dumps to get rid of their trash. Yesterday's garbage dump was nothing more than a pit or field just outside of town where people left their garbage.

People tossed all sorts of waste into these dumps. The dumps were breeding grounds for disease-carrying pests such as flies, mosquitoes, and rats. Rainwater flushed filthy, and sometimes poisonous, liquids from the dump into nearby streams and groundwater supplies that people used for drinking, bathing, and clothes washing.

Later, some towns spread dirt to contain the dumped waste and to discourage pests. This helped, but it was little more than a cover-up for unsanitary dumping.

Today, we still bury our garbage, although not in the open dumps of yesterday. About 55 percent of our garbage is hauled off in garbage trucks and packed into sanitary landfills—making landfilling America's number one way of getting rid of its trash. (The other 45 percent is either recycled or burned.)

Although the nation as a whole has plenty of space to build landfills, some areas in the Northeast may be running out of room for new landfills.

Obtaining permits to build new landfills has become increasingly difficult because of public opposition—people don't want landfills built in their backyards. And besides, a new landfill costs up to $10 million to build.

That's why some communities are looking for new ways to deal with solid waste—recycling and burning, for instance. But there will always be a need for landfills. Why? Because not all waste can be recycled or burned. How do you recycle a broken light bulb, and why burn it if it doesn't provide any heat energy?

Landfill burial is the only feasible way to dispose of some types of waste, and sometimes it's the safest way, too. Generally, the best disposal method for hazardous wastes—batteries, paints, pesticides, and the like—are state-of-the-art landfills. These landfills are designed to prevent hazardous wastes from seeping into underground water supplies.

Now that open dumping is illegal, deciding where to put a landfill requires careful planning. Skilled engineers inspect potential landfill sites. They look at a number of things including:

- the geology of the area
- the nature of the local environment
- how easy the site is to reach
- how far the site is from the area that generates the waste.

Work on a landfill site begins only after it passes strict legal, environmental, and engineering tests. It is not a quick procedure; landfills can take five years to complete.

TRASH FLASHBACK

"Thither were brought the dead dogs and cats, the kitchen garbage and the like, and duly dumped. This festering, rotten mess was picked over by rag-pickers and wallowed over by pigs—pigs and humans contesting for a living in it, and as the heaps increased, the odors increased also, and the mass lay corrupting under a tropical sun, dispersing the pestilential fumes where the winds carried them."

The Rev. Hugh Miller Thompson, "Disposal of City Garbage at New Orleans," Sanitarian, November 1879.

A MODERN LANDFILL

Today's landfills are very different from the open dumps of the past. For one thing, new landfills are situated where clay deposits and other land features act as natural buffers between the landfills and the surrounding environment.

Second, the bottom and sides of modern landfills are lined with layers of clay or plastic to keep the liquid waste, called **leachate**, from escaping into the soil. A network of drains collects the leachate and pumps it to the surface where it can be treated. Ground wells are also drilled into and around the landfill to monitor water quality and to detect any contamination. These safety measures keep groundwater, which is the main source of drinking water in many communities, clean and pure.

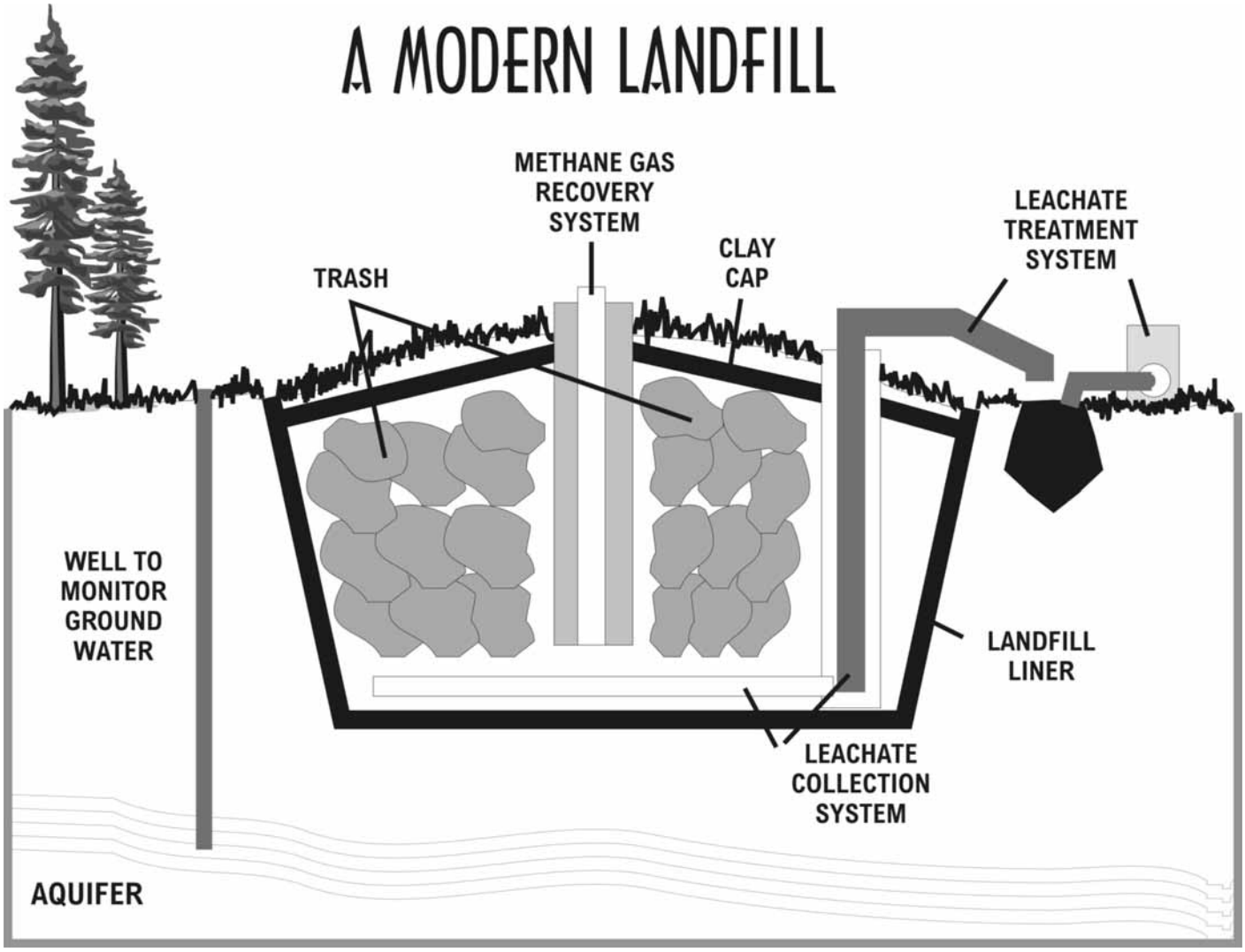
To protect the environment even more, the landfill is divided into a series of individual cells. Only a few cells of the site (called the working face) are filled with trash at any one time, minimizing exposure to wind and rain.

At the end of each day's activities, workers spread a layer of earth—called the daily cover—over the waste to reduce odor and control pests. The workers fill and cap each cell with a layer of clay and earth, and then seed the area with native grasses.

A FULL LANDFILL

When a landfill is full, workers seal and cover the landfill with a final cap of clay and dirt. Workers continue to monitor the ground wells for years after a landfill is closed to keep tabs on the quality of groundwater on and around the site.

Old landfill sites can be landscaped to blend in with their surroundings, or specially developed to provide an asset to a community. Closed landfills can be turned into anything from parks to parking lots, from golf courses to ski slopes. Building homes and businesses on these sites is generally not permitted, though, since it can take many years for the ground to settle.



USING CLOSED LANDFILL SITES

Once landfills are closed and sealed, they can be used for many community purposes, such as parking lots and golf courses.

BIODEGRADATION

You have probably seen all sorts of consumer products, from paper bags to egg cartons, claim that they are biodegradable. What does **biodegradable** mean and are the claims true?

Biodegradation is a natural process. It happens when micro-organisms, such as fungi or bacteria, secrete enzymes that chemically break down or degrade dead plants and animals. In other words, biodegradation is when waste decays or rots.

Most organic wastes are biodegradable under normal environmental conditions. Given enough time, the waste will disintegrate into harmless substances, enriching the soil with nutrients.

A landfill is not a normal environmental condition, though, nor is it intended to be. Instead, a landfill is more like a tightly sealed storage container. A landfill is designed to inhibit degradation to protect the environment from harmful contamination.

Deprived of air and water, even organic wastes—like paper and grass clippings—degrade very slowly in a landfill.

BIOREACTOR LANDFILLS

A new approach to landfills is designing them so that organic waste is allowed to biodegrade. These landfills, called bioreactors, are different than most landfills used today.

One type of bioreactor is aerobic (with air). Leachate is removed from the bottom layer of the landfill and put into storage tanks. The leachate is then pumped back into the landfill, allowing it to flow over the waste repeatedly. Air is then added to the landfill. This type of bioreactor models normal air and moisture environmental conditions better than other landfills and encourages the natural process of biodegrading.

Another bioreactor is anaerobic (without air). In this type of landfill, air is not added, but the leachate is collected and pumped back into the landfill. Additional liquids may also be added to the leachate to help the waste biodegrade. Because the waste is broken down without oxygen, anaerobic bioreactors produce landfill gas, or methane, which can be used as an energy source.

Bioreactor landfills have advantages over traditional landfills. They reduce the cost of removing and disposing of leachate, which is used on site. Anaerobic bioreactors begin producing methane much more quickly than landfills designed to inhibit degradation. Bioreactors also gain space as the waste degrades, meaning more waste can be added.

LANDFILL GAS AS AN ENERGY SOURCE

Did you know that landfills can be sources of energy? Organic waste produces a gas called methane as it decomposes, or rots. Methane is the same energy-rich gas that is in natural gas, the fuel sold by natural gas utility companies. Methane gas is colorless and odorless. Natural gas utilities add an odorant so people can detect seeping gas, but it can be dangerous to people or the environment. New rules require landfills to collect methane gas as a pollution and safety measure.

Some landfills simply burn the methane gas in a controlled fashion to get rid of it, but the methane can be used as an energy source. Landfills can collect the methane gas, treat it, and then sell it as a commercial fuel, or they can burn it to generate steam and electricity. In 2003, East Kentucky Power Cooperative began recovering methane gas from three landfills. The utility uses the landfill gas to generate 8.8 megawatts of electricity, enough to power 7,500-8,000 homes.

Today, there are almost 400 operating landfill gas energy projects in the United States. California has the most projects in operation with 73, followed by Illinois with 36 and Michigan with 27. The United States Environmental Protection Agency examined landfill conditions throughout the nation and almost every state has at least one landfill that would likely produce methane gas for energy use.

TRASH FROM THE PAST

Archaeologists are trained to dig up trash from the past, so when William L. Rathje, Professor Emeritus at the University of Arizona, learned that no one had ever dug into an American landfill, he formed the Garbage Project to discover just what was inside one.

After digging into three landfills in Arizona, California, and Illinois, Rathje found out that there are a lot of garbage myths. He and his team discovered that it takes a lot longer for paper and other organic wastes to decompose than people previously thought.

Rathje and his team found newspapers from the late 1970s that were still readable. He found "organic debris—green grass clippings, a T-bone steak with lean and fat, and five hot dogs—[that] looked even better!"

Rathje's research suggests that for some kinds of organic garbage, biodegradation goes on for a while and then slows to a standstill. For other kinds, biodegradation never gets under way at all.

"Well-designed and well-managed landfills, in particular, seem to be far more apt to preserve their contents for posterity than to transform them into humus or mulch," says Rathje. "They are not vast composters; rather, they are vast mummifiers."

Rathje also discovered that disposable diapers, fast-food packaging, and expanded polystyrene foam take up less landfill space than people generally believe.

People in a poll estimated that disposable diapers occupy somewhere between five and 40 percent of landfill space. But Rathje's study showed that diapers were less than one percent by weight or 1.5 percent by volume of the waste in landfills, far less than people assumed.

The same poll showed that Americans believe fast-food packaging takes up between 20 and 30 percent of landfill space, and expanded polystyrene foam between 25 to 40 percent. However, the Garbage Project found that fast-food packaging accounts for no more than one-third of one percent of the total volume of the average landfill. Expanded polystyrene foam—used for egg cartons, meat trays, coffee cups, and packing peanuts—accounts for no more than one percent of the volume of landfilled garbage.

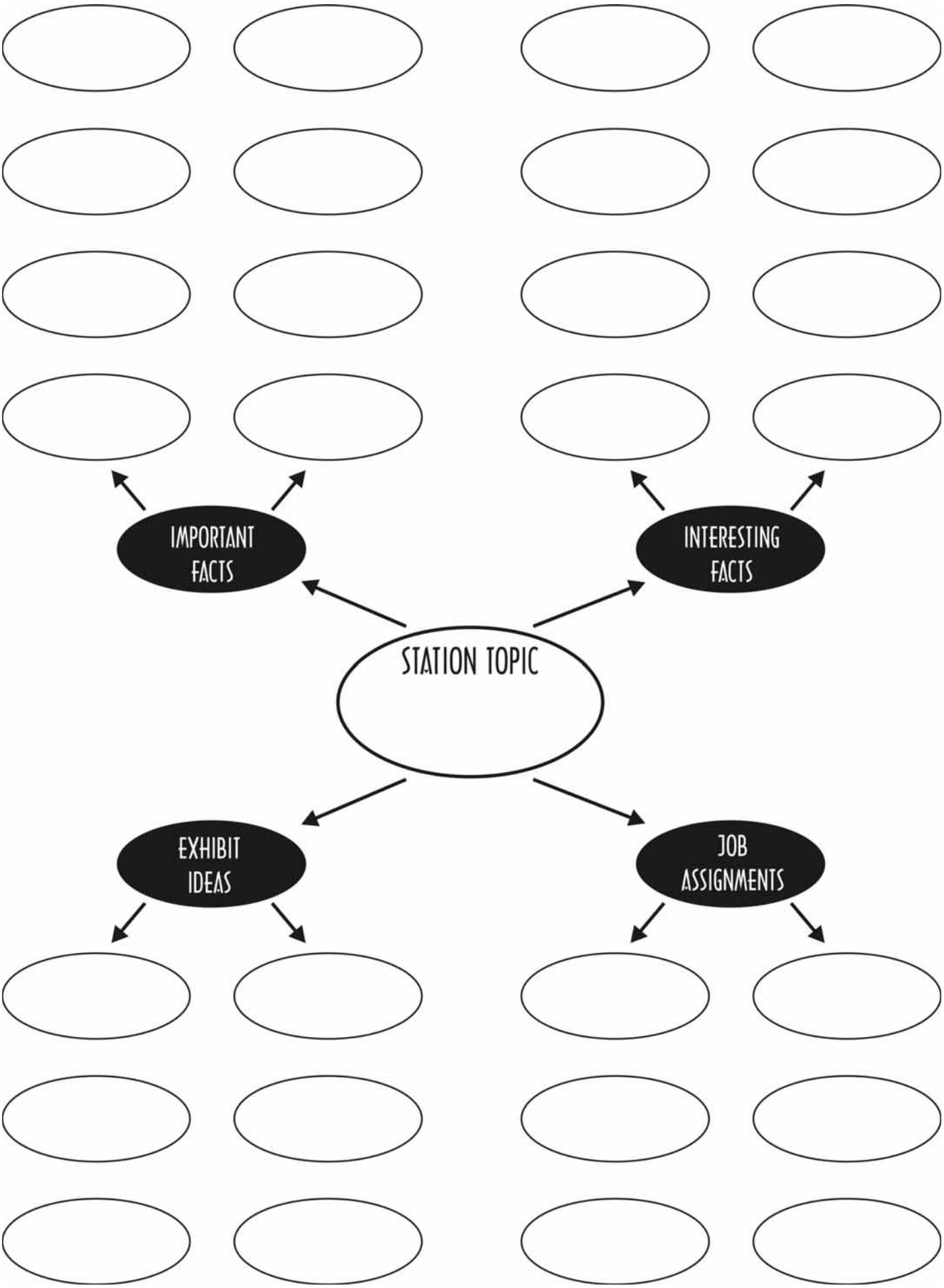
"Expanded polystyrene foam, nevertheless, has been the focus of many vocal campaigns to ban it outright," says Rathje. "It is worth remembering that if such foam were banned, the relatively small amount of space that it takes up in landfills would not be saved. Eggs, hamburgers, coffee, and stereos must still be put in something."

What is filling our landfills then? According to Rathje, it's paper, especially newspaper. Rathje concluded that recycling newspapers could significantly lengthen the life of a landfill.

Rathje and his team of archaeologists have completed more than 20 landfill digs since the project began.

"It's not a pleasant task," Rathje says, "but someone has to do it."

MUSEUM STATION ORGANIZER



STATION 1: INTRODUCTION TO SOLID WASTE

STUDENT GUIDE TO CREATING A MUSEUM STATION

Step 1-Learn about Solid Waste

(1-5 pts) **Individually, read your backgrounder and list the important and interesting facts on your individual organizer.**

(1-5 pts) **As a group, decide which facts you want to teach others and list them on your group organizer. Make sure you answer these questions:**

What is trash?

How can garbage be classified?

How is garbage measured?

What do we do with our trash?

How should we manage our waste disposal?

Step 2-Plan Your Exhibit

(1-5 pts) **As a group, make a list of the items you can use to make your exhibit interesting on your group organizer. Here are some suggestions:**

Label a piece of paper, a glass bottle, a plastic bottle, and an aluminum soda can with the percent of waste by weight they contribute to total waste generated.

Make an expanded garbage timeline.

Make a graph showing what we do with our trash.

Step 3-Use Your Talent

(1-5 pts) **As a group, decide who will do which jobs and list them on your group organizer. You can have more than one person working on each job. Be sure to cover the following jobs:**

Script Writer

Display Creator

Materials Collector

Presenter

(1-5 pts) **Write a three minute script using the list of facts your group generated.**

Step 4-Create Your Exhibit

(1-5 pts) **Create an interesting display with pictures, graphs and hands-on materials. Make sure the display and the script cover the same information.**

(1-5 pts) **Practice the script so that you won't have to read it. Use notecards with the important facts listed on them.**

Step 5-Teach Others

(1-5 pts) **Give a presentation of your exhibit to others.**

STATION 2: SOURCE REDUCTION

STUDENT GUIDE TO CREATING YOUR MUSEUM STATION

Step 1-Learn about Source Reduction

(1-5 pts) **Individually, read your backgrounder and list the important and interesting facts on your individual organizer.**

(1-5 pts) **As a group, decide which facts you want to teach others and list them on your group organizer. Make sure you answer these questions:**

How much waste does each American make every day?

What does source reduction mean?

Why is packaging a target for source reduction?

Why don't we eliminate packaging all together?

What does it mean to reduce, reuse, repair, recycle and compost?

Step 2-Plan Your Exhibit

(1-5 pts) **As a group, make a list of the items you can use to make your exhibit interesting on your group organizer. Here are some suggestions:**

Make and label boxes with the correct weight inside to show the amount of waste generated each day in different countries.

Bring in samples of items that have been reused or repaired.

Make a graph showing the difference in weight between today's glass, plastic and aluminum drink containers and those made in the 1970s.

Step 3-Use Your Talent

(1-5 pts) **As a group, decide who will do which jobs and list them on your group organizer. You can have more than one person working on each job. Be sure to cover the following jobs:**

Script Writer

Display Creator

Materials Collector

Presenter

(1-5 pts) **Write a three minute script using the list of important facts your group generated.**

Step 4-Create Your Exhibit

(1-5 pts) **Create an interesting display with pictures, graphs and hands-on materials. Make sure the display and the script cover the same information.**

(1-5 pts) **Practice the script so that you won't have to read it. Use notecards with the important facts listed on them.**

Step 5-Teach Others

(1-5 pts) **Give a presentation of your exhibit to others.**

STATION 3: INTRODUCTION TO RECYCLING

STUDENT GUIDE TO CREATING YOUR MUSEUM STATION

Step 1-Learn about Recycling

(1-5 pts) **Individually, read your backgrounder and list the important and interesting facts on your individual organizer.**

(1-5 pts) **As a group, decide which facts you want to teach others and list them on your group organizer. Make sure you answer these questions:**

What is recycling?

What is closed loop recycling?

What are some benefits to recycling?

How do different communities recycle?

What materials can be recycled?

Step 2-Plan Your Exhibit

(1-5 pts) **As a group, make a list of the items you can use to make your exhibit interesting on your group organizer. Here are some suggestions:**

Have an empty soda can and a full one to show closed loop recycling. Have an empty plastic bottle and a plastic flower pot to show non-closed loop recycling.

Make a graph showing how much Americans have recycled over the years.

Have samples of items that can be recycled.

Step 3-Use Your Talent

(1-5 pts) **As a group, decide who will do which jobs and list them on your group organizer. You can have more than one person working on each job. Be sure to cover the following jobs:**

Script Writer

Display Creator

Materials Collector

Presenter

(1-5 pts) **Write a three minute script using the list of important facts your group generated.**

Step 4-Create Your Exhibit

(1-5 pts) **Create an interesting display with pictures, graphs and hands-on materials. Make sure the display and the script cover the same information.**

(1-5 pts) **Practice the script so that you won't have to read it. Use notecards with the important facts listed on them.**

Step 5-Teach Others

(1-5 pts) **Give a presentation of your exhibit to others.**

STATION 4: PLASTICS RECYCLING

STUDENT GUIDE TO CREATING YOUR MUSEUM STATION

Step 1-Learn about Recycling Plastics

(1-5 pts) **Individually, read your backgrounder and list the important and interesting facts on your individual organizer.**

(1-5 pts) **As a group, decide which facts you want to teach others and list them on your group organizer. Make sure you answer these questions:**

What is plastic?

How much plastic by weight and volume is in the waste stream?

How is plastic recycled?

Should we always recycle plastics?

What is degradable plastic?

Step 2-Plan Your Exhibit

(1-5 pts) **As a group, make a list of the items you can use to make your exhibit interesting on your group organizer. Here are some suggestions:**

Have samples of items made from the different types of plastics.

Make a diagram showing the steps to recycling plastic.

Have sample plastic and a paper grocery bags.

Step 3-Use Your Talent

(1-5 pts) **As a group, decide who will do which jobs and list them on your group organizer. You can have more than one person working on each job. Be sure to cover the following jobs:**

Script Writer

Display Creator

Materials Collector

Presenter

(1-5 pts) **Write a three minute script using the list of important facts your group generated.**

Step 4-Create Your Exhibit

(1-5 pts) **Create an interesting display with pictures, graphs and hands-on materials. Make sure the display and the script cover the same information.**

(1-5 pts) **Practice the script so that you won't have to read it. Use notecards with the important facts listed on them.**

Step 5-Teach Others

(1-5 pts) **Give a presentation of your exhibit to others.**

STATION 5: RECYCLING METALS

STUDENT GUIDE TO CREATING YOUR MUSEUM STATION

Step 1-Learn about Recycling Metals

(1-5 pts) **Individually, read your backgrounder and list the important and interesting facts on your individual organizer.**

(1-5 pts) **As a group, decide which facts you want to teach others and list them on your group organizer. Make sure you answer these questions:**

Why should aluminum and steel be recycled?

How are aluminum and steel made?

How are aluminum and steel recycled?

How much energy is saved by recycling aluminum and steel?

How can you separate aluminum and steel cans?

Step 2-Plan Your Exhibit

(1-5 pts) **As a group, make a list of the items you can use to make your exhibit interesting on your group organizer. Here are some suggestions:**

Have an aluminum can, a steel can and a magnet.

Have 25 aluminum cans and a measuring cup. Fill the cup with fake gasoline (rubbing alcohol, flat cherry 7-Up, or water). Ask the guests how many cans would need to be recycled to equal the energy in the cup of gasoline.

Make a graph showing how much steel and aluminum are recycled in the U.S.

Step 3-Use Your Talent

(1-5 pts) **As a group, decide who will do which jobs and list them on your group organizer. You can have more than one person working on each job. Be sure to cover the following jobs:**

Script Writer

Display Creator

Materials Collector

Presenter

(1-5 pts) **Write a three minute script using the list of important facts your group generated.**

Step 4-Create Your Exhibit

(1-5 pts) **Create an interesting display with pictures, graphs and hands-on materials. Make sure the display and the script cover the same information.**

(1-5 pts) **Practice the script so that you won't have to read it. Use notecards with the important facts listed on them.**

Step 5-Teach Others

(1-5 pts) **Give a presentation of your exhibit to others.**

STATION 6: RECYCLING PAPER AND GLASS

STUDENT GUIDE TO CREATING YOUR MUSEUM STATION

Step 1-Learn about Recycling Paper and Glass

(1-5 pts) **Individually, read your backgrounder and list the important and interesting facts on your individual organizer.**

(1-5 pts) **As a group, decide which facts you want to teach others and list them on your group organizer. Make sure you answer these questions:**

What is the number one material in the solid waste stream?

How is paper recycled?

Can paper always be recycled?

How is glass recycled?

Can glass always be recycled?

Step 2-Plan Your Exhibit

(1-5 pts) **As a group, make a list of the items you can use to make your exhibit interesting on your group organizer. Here are some suggestions:**

Make a poster with 100 little garbage bags. Color the correct number of bags to illustrate how much paper is in every 100 pounds of trash.

Show the kinds of paper that cannot be recycled.

Show the kinds of glass that can be recycled and the kinds that cannot.

Step 3-Use Your Talent

(1-5 pts) **As a group, decide who will do which jobs and list them on your group organizer. You can have more than one person working on each job. Be sure to cover the following jobs:**

Script Writer

Display Creator

Materials Collector

Presenter

(1-5 pts) **Write a three minute script using the list of important facts your group generated.**

Step 4-Create Your Exhibit

(1-5 pts) **Create an interesting display with pictures, graphs and hands-on materials. Make sure the display and the script cover the same information.**

(1-5 pts) **Practice the script so that you won't have to read it. Use notecards with the important facts listed on them.**

Step 5-Teach Others

(1-5 pts) **Give a presentation of your exhibit to others.**

STATION 7: WASTE-TO-ENERGY

STUDENT GUIDE TO CREATING YOUR MUSEUM STATION

Step 1-Learn about Waste-to-Energy

(1-5 pts) **Individually, read your backgrounder and list the important and interesting facts on your individual organizer.**

(1-5 pts) **As a group, decide which facts you want to teach others and list them on your group organizer. Make sure you answer these questions:**

What is waste-to-energy?

Why burn solid waste?

Is burning trash environmentally safe?

How does a waste-to-energy plant work?

Will burning trash reduce how much is recycled?

Step 2-Plan Your Exhibit

(1-5 pts) **As a group, make a list of the items you can use to make your exhibit interesting on your group organizer. Here are some suggestions:**

Get five lunch bags. Write 500 pounds on each bag. Label four of the bags as garbage and one as coal.

Make a poster of the types of trash that can be burned in a waste-to-energy plant and the types of trash that cannot.

Step 3-Use Your Talent

(1-5 pts) **As a group, decide who will do which jobs and list them on your group organizer. You can have more than one person working on each job. Be sure to cover the following jobs:**

Script Writer

Display Creator

Materials Collector

Presenter

(1-5 pts) **Write a three minute script using the list of important facts your group generated.**

Step 4-Create Your Exhibit

(1-5 pts) **Create an interesting display with pictures, graphs and hands-on materials. Make sure the display and the script cover the same information.**

(1-5 pts) **Practice the script so that you won't have to read it. Use notecards with the important facts listed on them.**

Step 5-Teach Others

(1-5 pts) **Give a presentation of your exhibit to others.**

STATION 8: LANDFILLING

STUDENT GUIDE TO CREATING YOUR MUSEUM STATION

Step 1-Learn about Landfilling

(1-5 pts) **Individually, read your backgrounder and list the important and interesting facts on your individual organizer.**

(1-5 pts) **As a group, decide which facts you want to teach others and list them on your group organizer. Make sure you answer these questions:**

What is a landfill?

How much garbage do we landfill?

What are the benefits of landfilling?

What are the problems with landfilling?

What new technologies exist for landfills?

Step 2-Plan Your Exhibit

(1-5 pts) **As a group, make a list of the items you can use to make your exhibit interesting on your group organizer. Here are some suggestions:**

Create a poster of a modern landfill.

Make a display of the materials that should be landfilled and the materials that should not be landfilled.

Step 3-Use Your Talent

(1-5 pts) **As a group, decide who will do which jobs and list them on your group organizer. You can have more than one person working on each job. Be sure to cover the following jobs:**

Script Writer

Display Creator

Materials Collector

Presenter

(1-5 pts) **Write a three minute script using the list of important facts your group generated.**

Step 4-Create Your Exhibit

(1-5 pts) **Create an interesting display with pictures, graphs and hands-on materials. Make sure the display and the script cover the same information.**

(1-5 pts) **Practice the script so that you won't have to read it. Use notecards with the important facts listed on them.**

Step 5-Teach Others

(1-5 pts) **Give a presentation of your exhibit to others.**

MUSEUM OF SOLID WASTE & ENERGY

Evaluation Form

State: _____ Grade Level: _____ Number of Students: _____

1. Did you conduct the entire activity?	Yes	No
2. Were the instructions clear and easy to follow?	Yes	No
3. Did the activity meet your academic objectives?	Yes	No
4. Was the activity age appropriate?	Yes	No
5. Were the allotted times sufficient to conduct the activity?	Yes	No
6. Was the activity easy to use?	Yes	No
7. Was the preparation required acceptable for the activity?	Yes	No
8. Were the students interested and motivated?	Yes	No
9. Was the energy knowledge content age appropriate?	Yes	No
10. Would you use the activity again?	Yes	No

How would you rate the activity overall (excellent, good, fair, poor)?

How would your students rate the activity overall (excellent, good, fair, poor)?

What would make the activity more useful to you?

Other Comments:

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NEED Project
PO Box 10101
Manassas, VA 20108
FAX: 1-800-847-1820

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