

Don't Throw Away Energy

Students analyze the energy used to make a product and identify alternatives (reduce, reuse, recycle) to throwing away the product and its energy.

Grade Level: 5–8

Subject Areas: Family and Consumer Science, Science, Social Studies, Technology Education

Setting: Classroom

Time:

Preparation: One to two hours

Activity: One week

Vocabulary: Embodied energy, Potential energy, Recycle, Reduce, Reuse, Solid waste, Stored energy

Major Concept Areas:

- Quality of the environment
- Management of energy resource use

Getting Ready: This activity is divided into two parts. The second part includes three activities related to energy and waste management (reduce, reuse, recycling). Based on your classroom needs, you may have students participate in one part, all parts, or any combination.

If time allows, have students keep a tally of what they throw away for a day or a week and bring the information to class (see **Orientation**).

Objectives

Students will be able to

- explain that energy consumption includes products and materials they use (Part I); and
- develop a plan that outlines how they can save energy by reducing, reusing, or recycling items they normally throw away (Part II).

Rationale

The energy used to develop, transport, and market a product is often overlooked as a component of consumers' energy consumption. Having students learn about these "hidden" energy uses, and analyze ways to reduce the amount of waste these uses generate, introduces them to another aspect of energy conservation.

Materials

- Can of soda
- Materials listed on the following pages (these activities are optional):
 - *Generating Less Household Waste: Reduce*
 - *Once Is Never Enough: Reuse*
 - *Something New from Something Old: Recycle*
- Copies of **Sample Decision-Making Grid** (optional)
- Find additional resources related to this activity on keepprogram.org > Curriculum & Resources

Background

As consumers and citizens, we should be aware of the flow of energy throughout the environment and within our industrial society. Just as a tree or human cannot grow without energy, human-created materials such as pencils, airplanes, school lunch bags, and television sets cannot be created or used without expending energy.

The total amount of energy needed to make and transport a product is called embodied energy. Think about a lawn chair, it doesn't look like it has energy but large amounts of energy resources and conversions were used to create the chair and get it to its current location. Energy was used during mining, transporting, and producing. Resources such as gasoline and coal were burned to power machines and trucks. Combining processed metal with other raw material to make a finished product draws on even more energy. All the energy used in these

processes is used once and is unavailable for future use. Even after the product is created, energy is used. Energy is needed to produce the packaging and to ship the product to the retailer. Selling the product involves energy use. Depending on the purpose of the product, the consumer may expend energy when using it. Finally, the product is thrown away, which also requires energy.

People in Wisconsin throw out everything from toothpaste tubes to old television sets, food scraps to plastic milk jugs, jelly jars to paper. If you add up all the waste from your house, from the store where you shopped, and from the restaurant where you ate, it would amount to five pounds (2.25 kg) per person of municipal solid waste thrown into the trash every day. Fortunately, Wisconsin residents recycle about 1.25 pounds (0.56 kg) of waste per day. If you multiply the remaining 3.75 pounds (1.69 kg) by 365 days per year, then by five million Wisconsin citizens, your results will show that Wisconsin citizens still throw away more than 3.4 million tons (3.06 million metric tons) of stuff each year!

When a product is thrown away, it is the end of the line for the energy flow history of the product. The embodied energy used to create the product is lost as waste heat and never available for use again. Clearly, we need to develop ways to reduce the amount of embodied energy used during production, to allow the saved energy to be used for alternative purposes. In addition, we should consider the energy that is stored within the product. Wood, plastics (made from petroleum), and glass all have energy stored within their chemical bonds. Wisconsin's trash contains enough energy to heat more than 300,000 homes a year.

So, what else can we do with waste besides send it to a landfill? The approaches most often recommended to decrease the amount of waste we generate are labeled the Three Rs (Reduce, Reuse, Recycle). See student pages for more information about these options. While people reduce, reuse, and recycle many products, some items should be used only once and then put into a landfill or incinerated. These items include hospital waste such as syringes.

Some communities in Wisconsin have built waste-to-energy plants to deal with solid waste materials. This approach involves using solid waste, specifically the chemical energy stored in the waste, as a fuel source. Waste is burned and the heat produced is used to generate electricity. Each ton of solid waste has the

energy equivalent of 70 gallons (265 l) of gasoline — enough energy to drive a small car from coast to coast. However, toxic substances are often released into the air when waste products are burned, and burning also results in the production of a toxic ash. Another drawback to burning waste is that some of the materials that burn the best or contain the most stored energy (paper, plastic) are also the best candidates for recycling and reuse, resulting in greater embodied energy savings compared to the stored energy received from burning.

None of these approaches is the sole solution to our waste disposal problem. In 1990, Wisconsin passed Act 335, the Waste Reduction and Recycling Law, which banned certain items from Wisconsin's landfills and required communities to establish effective recycling programs. Wisconsin currently reuses, recycles, or composts more than 25% (by weight) of its municipal solid waste each year. These actions reduce the need for landfill space and help save energy, sending a message to manufacturers and waste disposal managers that we, as consumers, are serious about conserving energy resources for future generations.

Procedure

Orientation

Open a can of soda and take a sip of it. Ask students to identify ways you just used energy. If students do not mention the aluminum can and its contents, introduce the term embodied energy (the total energy required to produce and transport a product). Explain that large amounts of energy are needed to produce aluminum (about 98,000 Btu/lb.). (See **Aluminum Production**.)

Ask students what they normally do with an aluminum can after they are finished with it.

Students may say they recycle the can, and some may say they throw it away (especially if a recycling bin is unavailable).

Prompt students to consider things they throw away on a typical day or over a period of a week. It may be helpful to develop a chart (see **Inventory of Things Typically Thrown Away**) to categorize the trash (more than one category can be checked if applicable).

Steps

Part I—Embodied Energy

1. Share some of the Wisconsin trash statistics with

Aluminum Production

Which of these steps involve energy? (They all do!)

The raw material for aluminum is bauxite. Nearly 99 percent of our bauxite is imported from countries such as Australia, Jamaica, and Guinea. Most bauxite is mined in open pits called strip mines. Trees and other plants, rocks, and soil are first cleared from the area. Then the bauxite ore is extracted from the earth and taken to processing centers.

After crushers mash bauxite ore into small bits, the ore is heated to remove as much water as possible. Then the ore goes to a refinery. At this stage, a waste product called red mud is left behind.

By going through a series of chemical reactions in a refinery, bauxite is refined into a fine white powder called alumina. The refining process also creates a waste called red mud, which is made of silica, iron oxides, and other impurities from the bauxite ore. Processing bauxite produces high volumes of red mud, for which there is currently no use. Additionally, the mud must be contained to keep it from contaminating water and other environmental resources.

Smelters or reduction plants transform white alumina powder into molten aluminum. First, the powder is dissolved in a hot, liquid salt solution in a large pot. Then an electrical current flows into the pot, causing aluminum to settle to the bottom, where it is removed.

This process makes producing aluminum very energy intensive.

Molten aluminum is almost always alloyed (mixed with other metals and elements) to make it stronger. Then it is poured into molds to form ingots. Ingots may be long rods, huge slabs weighing 20 tons (18,144 kg), or small bricks weighing only 4 pounds (1.8 kg).

Ingots are melted and turned into products. Huge slabs of aluminum are usually rolled into sheets of varying thickness for products such as aluminum foil, airplanes, and beverage cans. Smaller ingots of aluminum may be melted and poured into molds, creating tea kettles, automobile parts, and other products.

See also [*Steps in Making Aluminum Products from Raw vs. Recycled Materials*](#)

students (see **Background**). Discuss the connection between energy and solid waste. Emphasize the following:

- Each time something is produced, energy is required (embodied energy).
- When products are bought and used inefficiently or tossed away prematurely, the energy that was used to produce the product is essentially wasted.
- Many products contain stored energy (chemical energy) that is unavailable when the product enters a landfill.

2. Divide the class into small groups. Have the group select one product (and/or its packaging) from ***Inventory of Things Typically Thrown Away*** charts to analyze (see **Orientation**). If possible, students should choose a locally produced item. For example, bicycles are made in Waterloo; batteries and bologna in Madison; soy sauce in Walworth; shoes in La Crosse; beer in Milwaukee; glass in Burlington; and paper, cheese, and plastics in many Wisconsin towns.

3. Have students compile a report on the product that includes the following:
- Raw materials used during production (optional)
 - Production steps and energy resources required to make the product (embodied energy)
 - Information about potential energy that is stored in the chemical bonds of the product
 - Energy-related problems associated with throwing away the product (should relate to embodied energy and/or stored energy)
 - How creating the product may affect the environment (optional)

This report can be based on practical knowledge, background reading, or contacts with or visits to the manufacturer to obtain more information about the process.

Part II—Save Energy through Waste Management

1. Involve students in one or more of the following activities to introduce them to alternatives to throwing things away, often called the Three Rs (Reduce, Reuse, Recycle):
- **Generating Less Household Waste: Reduce**
 - **Once Is Never Enough: Reuse**
 - **Something New from Something Old: Recycle**
2. Have students identify which approach(es) might work as alternatives to disposing of their product

Inventory of Things Typically Thrown Away

Types of material	Composition of material						
	Paper	Plastic	Aluminum	Steel	Glass	Organic Matter	Other
Durable goods (products used three years or more; e.g., furniture, tires, appliances)							
Nondurable goods (products used three years or less; e.g., disposable items, paper, some clothing, food)							
Packaging							

(they may also want to include other options such as choosing not to purchase, incinerating, landfilling, etc.). Instruct students to evaluate each alternative they identified and use the evaluation to select one approach. Students can use a decision-making grid to help decide (for more information see **A Decision-Making Model – A Tool for Analysis**).

Closure

Have each group conduct a presentation about their product (how it is made and used), focusing on the energy involved. The group should discuss how development and disposal of their product relates to energy use. Next, the group should present disposal alternatives they evaluated and chose (or did not choose, if landfilling was the only viable option). The summary of the presentation should emphasize how their chosen action helps conserve energy.

Assessment

Formative

- Can students explain the connection among energy use, prudent shopping, and waste disposal

practices? (Part I)

- Are students able to provide examples of how to reduce, reuse, and recycle household waste? (Part II)

Summative

Challenge students to develop a classroom plan to address a waste generation problem. Most likely this plan will involve limiting the amount of paper that is used and thrown away. Their plan should report how much energy is used to make paper (from both virgin resources and recycled). Each of their proposed solutions should highlight the energy that could be saved by the action.

Related KEEP Activities

To help students appreciate how goods and services involve energy use within all community sectors, see K-5 Energy Sparks for Theme I: “Energy Use in Wisconsin.” “Advertising Energy” can be used to help students analyze how commercials influence their purchasing habits. In addition to the waste reduction strategies described within the activity, students can look into those outlined in the Action Ideas.

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A Decision-Making Model – A Tool for Analysis

There are a variety of decision making models and frameworks teachers and students can use in school-based lessons and projects. The following Decision-Making Grid to help analyze alternative solutions to a problem. Use abbreviations if necessary.

1. Define the problem. Analyze the situation. What is the core of the problem? Gather important facts.
2. List important criteria. What are some of the important values and goals that will influence the outcome? Which of these are the most important to those involved? List the criteria below and in the top row of the grid.
3. List alternative solutions. What are some practicable alternatives for solving the problem? List alternative solutions below and in far left column of the grid.
4. Evaluate the alternative solutions. Use evaluation marks (a rating scale or pluses and minuses) in each cell of the grid to indicate how well the solution fits or addresses the criteria. It helps to write a brief comment in each cell justifying the logic of the marking.
5. Choose the best alternative (make a decision!). Your analysis (the marked grid) gives you an idea of the problem and helps identify viable and popular solutions. You will need to consider the value of the criteria along with the rating of the solutions to decide the best approach.

Sample Decision-Making Grid

Alternatives	Criteria				
	Convenient	Saves Energy	Protects the Environment	Sanitary	Inexpensive
Reduce: Buy ball point pens that are not packaged					
Reduce/Reuse: Purchase fountain or cartridge pen					
Reduce: Contact manufacturer to ask for less packaging					
Incinerate					
Landfill					

Generating Less Household Waste: Reduce

“Reduce” is one of the three Rs when it comes to addressing the solid waste problem. Reducing essentially means less waste in the first place. There are a variety of things consumers can do to reduce the amount of material they contribute to the waste stream; many of these focus on selective and prudent purchasing practices (see also **Once Is Never Enough: Reuse**).

One way a consumer can reduce waste generation is to avoid buying products that are excessively packaged. A large portion (around 35 percent) of the waste we generate is packaging. There are many benefits of packaging: fewer damaged goods, product preservation, and organizing and presenting contents. However, items can sometimes be overpackaged (such as wrapped in many layers of plastic and paper, large containers for small products, single-sized serving containers packaged together). Because energy is needed to produce packaging as well as to produce the product, many companies are making efforts to conserve energy by improving their packaging practices.

The following are other ways consumers can help reduce the amount of waste generated:

- Ask yourself, “Do I really need this item?”
- Buy long-lasting products rather than items that have a shorter life span and end up as waste sooner
- Buy goods in returnable or recyclable containers
- Invent new uses for old materials

Individuals can also contact the manufacturers of products they buy and persuade them to use less energy during the production process. Decreasing the number of steps or the materials needed to create a product or its packaging means less energy is needed to produce and transport materials. In other words, the product’s embodied energy is reduced.

Saving time and money are among the many reasons industries strive to improve the efficiency of their production processes. The less energy they use, the less energy they have to pay for. Such practices are especially important as the price of energy increases.

Paper production is one example of an industry that has reduced its energy use. The paper industry has decreased the amount of energy it needs to produce a ton of paper by 27 percent since 1972.



Illustrating the Waste Alternative

1. Ask students to bring to class various containers used to package food. Have students classify the predominant type of material (glass, aluminum, steel, paper, etc.) used in the packaging. If a package is made out of different types of materials (like cardboard and plastic), have students separate the package into different material.

Caution: Students may need to wear protective gloves and to use scissors.

2. For each package, instruct students to weigh each type of material.

Generating Less Household Waste: Reduce

Material	kcal/lb	kcal/oz	kcal/gm	BtUs/lb	BtUs/gm
Paper	5,131	321	11.4	20,373	44.9
Glass	1,918	120	4.2	7,611	16.6
Steel	3,724	233	8.3	14,778	32.6
Aluminum	24,837	1,552	54.7	98,560	217.1
Plastic	4,670	292	10.3	18,532	40.8

Source: "Energy Used By Packaging Materials" p. 157 in Washington State Department of Ecology. *A-Way With Waste: A Waste Management Curriculum for Schools*, 3rd Edition. Bellevue, Wash.: Washington State Department of Ecology, 1990. Used with permission. All rights reserved.

- Have students use the data from the chart to calculate how many kilocalories or kcal (1 kcal = 1,000 calories = 1 food Calorie) were used to produce the packaging. If more than one material was used in the packaging, they should determine the energy needed for each material and total the results.

Example: Calculate how much energy was used to make a steel can that weighs 2 ounces.

$$\frac{2 \text{ ounces}}{\text{steel can}} \times \frac{233 \text{ kcal}}{\text{ounce}} = \frac{466 \text{ kcal}}{\text{steel can}} \text{ [466 kcal to produce a 2-oz. steel can]}$$

- Compare the amount of energy used to make the containers from the different packaging materials with the amount of energy in the packaged food. Ask students what they think about the energy values for the packaging and for the food.
- Students can find similar food items packaged in different ways and compare the energy costs to package each type. For example, have students compare a six-pack of applesauce snack desserts to a glass jar of applesauce. How might these findings affect their purchasing decisions?

Once is Never Enough: Reuse

Another approach to generating less household waste is to throw less away. But what do you do with something after you use it? Use it again! This component of waste reduction, called Reuse, is often overlooked, but is perhaps the best alternative for saving energy and protecting resources. When you reuse something, that means energy is not needed to create a new product to replace the one that was thrown away. Here is a list of ideas to try:

- Buy products in returnable containers
- Reuse plastic or paper grocery bags (or buy a canvas bag and reuse it)
- Give old furniture, clothes, and household items to charities
- Buy furniture, clothes, and household items from thrift shops, charities, and yard sales
- Fix something instead of throwing it away
- Make creative crafts (bird feeders out of milk cartons, magazine storage containers out of cereal boxes)
- Carefully remove gift wrapping and reuse (or use the Sunday comics from the newspaper to wrap gifts)
- Use both sides of a sheet of paper

Illustrating the Waste Alternative

1. Share *New Versus Pre-owned Clothing* with students.
2. Have students identify the energy-consuming steps required at each stage of producing new clothes. Help students identify the steps that probably use nonrenewable resources such as coal or oil. Students may also identify other energy uses not included in the diagram (such as the consumer driving to and from the store).
3. Propose to students clothes can be reused instead of thrown away.
4. Have students discuss advantages and disadvantages of buying used clothes. Record their suggestions in a two-column chart on the board.



Something New from Something Old: Recycle

There is a way for people to throw away things without adding materials to the landfill. This is to throw things into a different stream: the recycling stream. Recycling is another one of the Three Rs listed as a solution for dealing with solid waste. Recycling involves taking discarded items and transforming or remanufacturing them into similar or different products.

Items that are commonly recycled include paper, steel, glass, aluminum, and plastic containers. Recycling saves energy because energy is not needed to locate, obtain, and process raw materials. However, there are alternative energy costs. The basic steps of recycling are separation of recyclable from non-recyclable materials, collection of materials, processing (breaking or melting materials into their basic material, such as paper into pulp), and remanufacturing. These steps, along with transportation to retailers, all use energy. Although recycling has its own energy costs and there are some pollution issues with recycling, there is evidence that recycling paper can save energy.

Recycling 1 ton of	Saves
Glass	10 gallons of oil
Plastic	1,000 to 2,000 gallons of gasoline
Newspaper	100 gallons of gasoline
Aluminum	2,350 gallons of gasoline. This is equivalent to the amount of electricity used by the typical Wisconsin home over a period of ten years
Iron	1 ton of coal

Source: Wisconsin Department of Natural Resources. *Recycling Facts and Figures*.

Many states, including Wisconsin, are concerned about finding space to store solid waste and want to promote better use of our resources. Below is data on proportions of solid waste the United States generates and recovers through recycling.

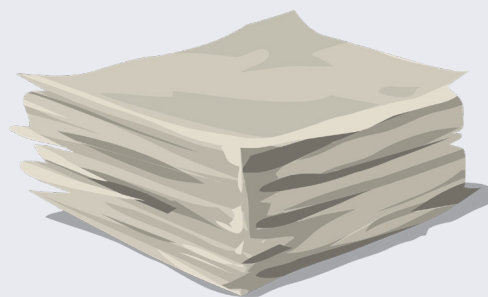
Product	Generated	Recovered
Paper and paperboard	68.62	44.36
Steel	16.8	5.55
Aluminum	3.58	0.71
Plastics	31.75	2.80
Glass	11.57	3.20
Rubber/Leather	7.53	1.35

Source: U.S. Municipal Solid Waste Characterization Reports: 2012 Facts and Figures. U.S. Environmental Protection Agency, February 2014. EPA-530-F-14-001.

Something New from Something Old: Recycle

Illustrating the Waste Alternative

Provide students with a copy of *Recycling Old Paper*. Help students understand that recycling paper avoids many of the energy-consuming steps needed to make paper from wood (cutting down trees, transporting to the mill, debarking the tree, turning the wood into pulp). Recycling paper also has energy costs because the paper needs to be separated and turned into pulp. Removing ink and other foreign materials and disposing of these materials requires energy as well and also affects the environment. Involve students in a debate in which they discuss the pros and cons of recycling paper. Invite speakers from a lumber company, a paper manufacturer, and a paper recycling plant to speak to the class or take students on a tour of such facilities. Have students look for the recycling symbol on recycled paper products and packaging. What could the prevalence of this symbol mean for energy and natural resource savings?



An alternative is to show students the page *Steps in Making Aluminum Products from Raw vs. Recycled Materials* and to compare energy uses between aluminum manufacturing and recycling.



New Versus Pre-Owned Clothing

Buying used clothes from consignment stores is an energy and money-saving alternative to buying new clothes. No new materials or energy go into producing used clothes, so buying quality second-hand items is a wise 3R's choice.

New Clothing Pathway...



Cotton planting begins in mid-September through October



Cotton is harvested in late February through April with either a spindle picker or stripper harvester



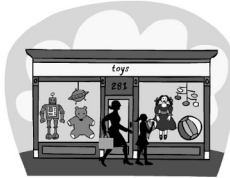
Once the cotton has been harvested it is shipped to factories where laborers produce the clothing items we see in retail stores



Products produced by factory laborers are packaged and prepared for shipment



Clothing produced from the cotton yields is then shipped to the market and retail stores



The clothing products are available for purchase at market and retail stores



Consumer travels to market and retail stores for the purchase of new clothing items



Dispose of clothing to landfill

PRE-Owned Clothing Pathway...



The clothing products are available for purchase at market and consignment retail stores



Consumer travels to market and retail stores to purchase energy saving, low input clothing items

Energy Efficiency and Clothing? List 6 ways in which pre-owned clothing is an energy saving alternative to buying new clothes.

_____	_____
_____	_____
_____	_____

Recycling Old Paper

Here Is What You Will Need

- Paper to be recycled (Newspaper, scraps of construction paper, facial tissue, and paper towels will work. Avoid glossy paper. Notebook paper may also be difficult to use.)
- Water
- Blender, egg beater, or mixer
- Piece of window screen (slightly larger than the size you want the paper to be)
- Tub, basin, or cake pan (larger than the window screen)
- Liquid starch (optional—this helps strengthen the paper)
- Materials to decorate paper, such as dried flowers, pine needles, pieces of construction paper (optional)
- 3 or 4 pieces of blotting paper or towels
- Rolling pin
- Iron (optional)



Directions

1. Tear the paper into tiny pieces. Decide if you want to mix colors or keep paper mainly white (a small piece of construction paper adds a lot of color).
2. Soak the torn paper in hot water for at least an hour (the longer the better). If you used newspaper, you may want to rinse it to remove some of the ink.
3. Fill the blender about half full of water and add the soaked paper; blend until it's a smooth pulp mixture, adding more water as necessary (the finer the mixture, the smoother your paper will be). You may add a few tablespoons of liquid starch (optional).
4. Put the window screen on the bottom of the tub, basin, or pan.
5. Pour the pulp mixture over the screen and carefully lift the screen and allow excess water to drain. Place the screen on a blotter or towel. You can add decorations at this time.
6. Cover the screen and paper with another piece of blotting paper or towel and use a rolling pin to squeeze out the water.
7. Carefully remove the recycled paper from the screen and lay it flat on another piece of blotting paper or towel to dry (or leave the paper on the screen until it is nearly dry). Make sure the new paper remains flat. You can also sandwich the paper between two sheets of blotting paper or towel and iron it until it is dry.

Use the paper to send a letter to a friend!

Steps in Making Aluminum Products from Raw vs. Recycled Materials

STEPS IN MAKING ALUMINUM PRODUCTS FROM RAW MATERIALS

Open Pit Mining. Bauxite ore is loaded into trucks.



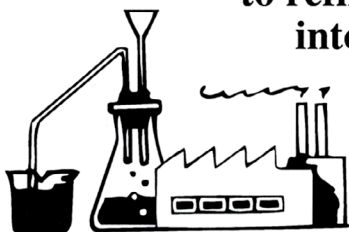
1

Processing Plant. Bauxite is crushed and washed.



2

Refinery. Chemicals are used to refine bauxite into alumina.



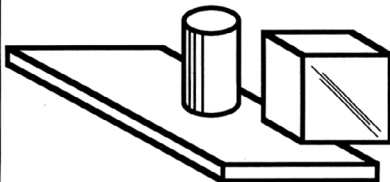
3

Smelter. Alumina is melted. Other metals are added to molten aluminum to strengthen it.



4

Mold. Molten aluminum is poured into molds of cylinders, sheets or squares.



5

Products. The castings are remelted, hammered, or rolled into various items.



6

Steps in Making Aluminum Products from Raw vs. Recycled Materials

STEPS IN MAKING RECYCLED ALUMINUM PRODUCTS

Recycling Center. Aluminum is collected and crunched into bales.



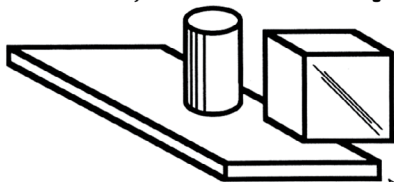
1

Melting Furnace. The baled aluminum is melted.



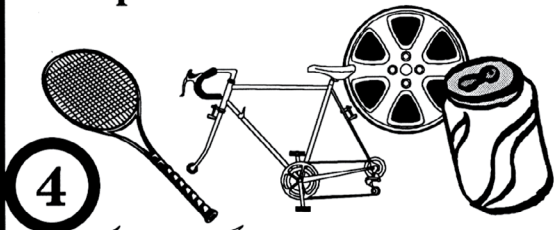
2

Molds. Molten aluminum is poured into molds to form sheets, blocks and cylinders.



3

Products. The castings are reshaped into useful items.



4

RECYCLED ALUMINUM REDUCES:

- * Water Consumption by 95%
- * Energy Use by 95%
- * Air Pollutants by 95%

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