

Make Every Day Green

LESSON FOUR

All About The Waste-to-Energy Plants

Grade Levels: 3-5

Sunshine State Standards

- **Body of Knowledge: The Nature of Science**
 - Big Idea 1: The Practice of Science
- **Body of Knowledge: Life Science**
 - Big Idea 17: Interdependence
- **Body of Knowledge: Earth & Space Science**
 - Big Idea 6: Earth Structures

Key Concepts

- To introduce students to the principles of waste-to-energy through combustion.
- To explain the difference between waste-to-energy incineration and just open burning.
- To understand how a Wheelabrator plant works and how it benefits Broward County.

Vocabulary

- **pollution control technologies:** Equipment designed to reduce pollution and the adverse environmental and health effects of waste combustion.
- **scrubber:** Anti-pollution device that uses a liquid or slurry spray to remove acidic gases and particles from municipal waste combustion facility.
- **filters:** A material with tiny holes, or pores, through which a liquid or a gas is passed to remove impurities or potentially polluting substances.
- **Waste-to-Energy Plant:** Combustors that convert heat from the combustion of raw municipal waste into steam, which can be used to provide power for homes and industry.

Background

As waste leaves homes, businesses, and industries, it has to go somewhere. Recycling, reusing, and reducing helps decrease the amount of garbage destined for landfills. However, there are other options for safe disposal to meet Broward County's waste management needs. Waste-to-energy plants are part of an integrated system of waste management, and have three primary functions: to provide environmentally safe and cost-effective solid waste disposal, to recover energy and recyclable ferrous (iron) and non-ferrous metals, and to reduce the amount of waste sent to landfills.

The basic operating principle of a waste-to-energy plant is very straightforward; incoming trucks deliver trash to a waste-to-energy plant which uses negative pressure to reduce odors. The trucks are weighed, and then the waste is tipped into a concrete pit. Overhead cranes move the waste into the boiler's feed hoppers, and large objects that can't be combusted are removed. All air used in the combustion is taken from within the facility itself, and this prevents the seepage of dust and odor from the building. The furnace operates at a minimum temperature of 1,800 degrees Fahrenheit; which allows for complete combustion. The hot gas produced is sent to boiler tubes, to produce steam, and turns turbines that create electricity. The emissions are controlled by dry scrubbers, which remove acid gases, heavy metals, and organic pollutants. Next, it passes through a bag house, full of fabric filters. This acts just like a vacuum cleaner, collecting particles produced in the boiler and scrubber. These control systems clean emissions to meet environmental standards. Iron and other metals are separated from the residue and recycled, and the remaining ash is landfilled in areas adjacent to the plants in mounds called monofills.



Broward County's two waste-to-energy Wheelabrator plants are capable of processing 4,500 tons of waste per day, and reduce 90% of the volume of waste that must be landfilled. At full capacity, the plants can generate more than 66 megawatts of electrical energy, enough energy to supply the electrical needs of 75,000 homes and businesses.

Time

45 minutes

Materials

- Graphic handouts & charts
- Pencil & Paper
- A large onion
- Knife
- Small electric fan



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Introduction

1. Students understand the need to reduce waste production; but living things can't just stop producing waste altogether. After reviewing the previous lessons in this guide, students will understand that there is a need for dealing with the garbage that can't be recycled, composted, or reused.
2. Where does this garbage go?
 - Review the results of the garbage placed in the model landfill and dump. Could some of those items be used in another way?

Procedures

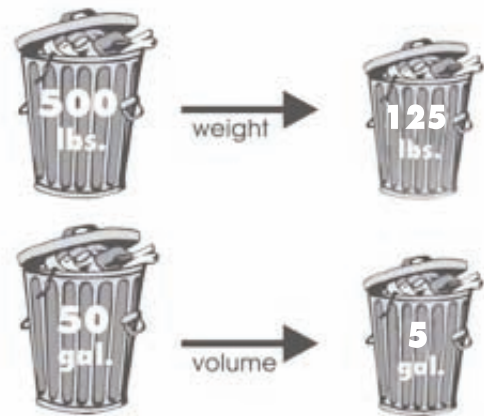
Landfills are necessary, but there is one last step for trash to take before it reaches them.

1. Introduce the graphic of the waste-to-energy plant. A solution is to burn the trash. In the process of combustion, heat energy is produced.
 - When we use coal, oil, or natural gas to produce energy, the chemical bonds within the substance break down and rearrange into more stable bonds. This change results in the formation of different products, such as carbon dioxide and water, and a release of energy.
 - Some types of energy plants use coal to produce heat energy to boil water to create steam. The steam turns the turbines and produces electricity.
2. What would you think if I told you that there are energy plants that burn garbage to make energy?
 - Garbage does not contain as much heat energy as coal. It takes one ton (2,000 pounds) of garbage to equal the heat energy in 500 pounds of coal.



Courtesy of www.need.org

3. The amount of trash that reaches landfills is reduced.
 - Burning trash reduces its weight by 75% and its volume by 90%.



Courtesy of www.need.org

4. Some student's responses "But Garbage stinks!"
 - Explain to students that the plant contains and cleans the air used in the combustion process. There are 90 waste-to-energy plants in the US, and Broward County employs two of them.
5. **Demonstrate how burning trash without the use of a waste-to-energy plant can spread odors and dangerous gases.**
 - Ask 5 children to be "air monitors" and represent different populations of people who would live in a city that burns its trash.
 - Tell them that the onion will represent burning trash in an open pit, and the fan will be the wind.
 - The students who are air monitors are to raise their hands when they can smell the onion's scent spread by the fan.
 - Ask a student to be a time keeper, and count the seconds between each air monitor raising his or her hand.
 - Place the fan near one wall of the classroom, and the air monitors should be varying distances away.
 - Turn on the fan and peel the onion in front of the air current.
 - Have the time keeper record on the board how fast the smell traveled and the order of each air monitor's response to the smell.



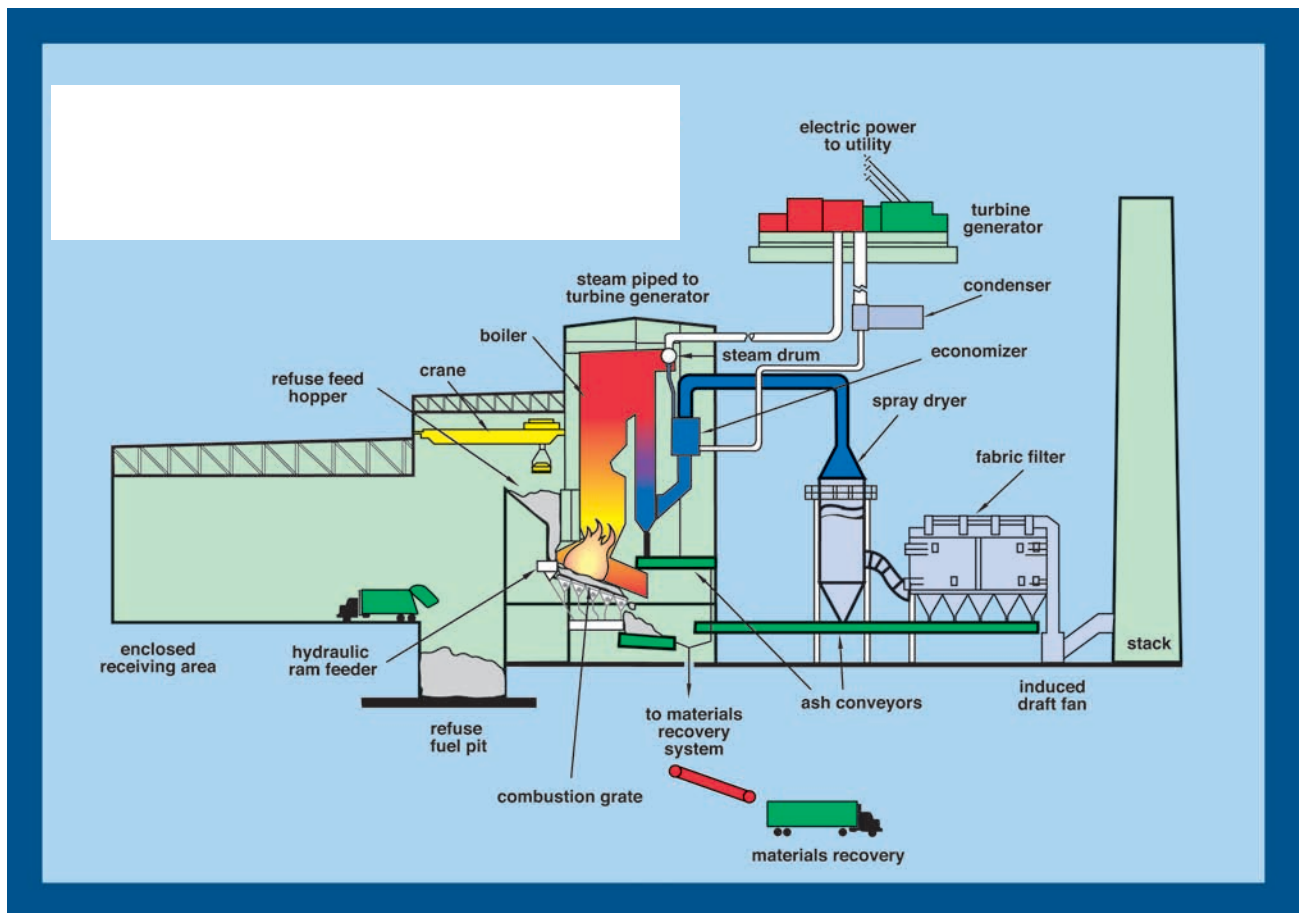
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- Review with the students the result of the experiment.
 - How long did it take the smell to travel to each air monitor?
 - Do you think air pollution affects everyone, or was it contained to a small area?
 - The Environmental Protection Agency (EPA) has strict environmental rules on air emissions. Waste-to-energy plants use anti-pollution devices, such as scrubbers, activated carbon, fabric filters, and

electrostatic precipitators to meet EPA standards. The EPA wants to make sure these harmful gases aren't being released into the air:

- The high temperatures in the furnace of a waste-to-energy plant break down complex chemicals into simple, less harmful compounds.
- Use the Graphic of a Waste-to-Energy Plant with your students to trace the path of garbage through the plant.



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:

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



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Reflection/Response

- Remind students that there's a new "All-In-One" system for recycling that allows them to mix paper, plastic bottles, metal and glass recyclables together in the same container at home.
- How can our recycling program work alongside the waste-to-energy plant?
 - Cities with both recycling programs and waste-to-energy plants know which materials to recycle and which ones are more useful to burn. For example:
 - Aluminum is more valuable when recycled. Also, it melts at a lower temperature and can clog up grates in the waste-to-energy plant.

The Energy Values of Different Materials When Incinerated

- Source: Council of Plastics and Packing in the Environment
- BTU stands for British Thermal Unit and is defined as the amount of heat required to raise the temperature for one pound of water one degree (Fahrenheit)

Material	BTU per pound
Plastics	11,000—20,000
Rubber	10,900
Newspaper	8,000
Corrugated Boxes (paper)	7,000
Yard Wastes	3,000
Food Wastes	2,600
Average for Municipal Solid Waste (MSW)	4,500

A "kilowatt-hour" is a method of measuring amounts of electricity. Assuming that 3,142 BTUs will generate 1 kilowatt-hour, how many kilowatt-hours of electricity would be generated from 100 tons of municipal solid waste?

How to find the answer:

- Average for municipal solid waste = 4,500 BTU's per pound
 - 1 short ton = 2000 pounds
 - 100 tons of MSW = $(100)(2,000)(4,500) = 900,000,000$ BTU's
 - $900,000,000 \div 3,142 = 286,441$ KWH
 - Ask your parents about your family's electrical usage. How many kilowatt-hours a month do you use? How many months would your house be able to run on the electricity generated by 100 tons of MSW?
- For Grades 4 & 5. Use the chart to help find the answer.

Extension

- Go on a field trip to one of the two Wheelabrator plants in Broward County. Ask students to come up with their own questions to ask. Here are some questions to get your student's thinking.
 - How much solid waste does the plant take in a day? In a year?
 - Why was this location chosen for the waste-to-energy plant?
 - What types of solid waste are burned in the Wheelabrator plant?
 - What is the "tipping" fee for the plant?
 - How much electrical energy does the plant produce? Who buys the electricity?
 - Where does the plant send the ash produced?

