**Title**: Land Fill Gas (LFG) a Source of Energy?
**Grade**: Middle School
**Subjects**: Social Studies, Science, Math, Language Arts
**Time**: 60 minutes

**Objectives**:

- Identify and describe the problems and concerns people have about burying trash in landfills and justify their position on the matter.
- Identify and define the pros and cons landfill gas use.
- Write a well-constructed opinion on the use of landfills and justify their position with details from research, observations and data.

**Standards**:
Geography Standard 18: Understand global development and environmental issues.

- Benchmark # 2: Understand the possible impact that present conditions and patterns of consumption, production and population growth might have on the future spatial organization of Earth.
- Benchmark # 4: Understand why different points of view exist regarding contemporary geographic issues (e.g., some communities find the recycling and incineration of waste too costly or impractical, and use a landfill solution as one of their primary methods of disposal)

Technology Standard 3: Understand the relationship among science, technology, society and the individual.

- Benchmark # 3: Know ways in which technology has influenced the course of history (e.g., improvements in sanitation and waste management- incorporating LFG collection systems in landfills).

Health Standard 2: Know environmental and external factors that affect individual and community health.

- Benchmark # 3: Know ways local, state, federal and international efforts to contain an environmental crisis and prevent recurrence (e.g., solid waste contamination/air pollution).

Language Arts Standard 1: Use the general skills and strategies of the writing process.

- Benchmark # 6: Write expository compositions (e.g., state a thesis or purpose, present information that reflects knowledge about the topic of report, organize and present info in a logical manner, including an intro and conclusion, use their own words to develop ideas, use common expository structures, such as compare and contrast or problem-solution).
- Benchmark # 11: Write compositions that address problems/solutions (e.g., identify and define a problem, describe at least one solution, present logical and well-supported reasons).

Language Arts Standard 8: Use listening and speaking strategies for different purposes.

- Benchmark # 5: Use grade level appropriate vocabulary in speech (e.g., specialized language).

**Materials**:

- Pencils and paper
- Index cards
- Reference materials: dictionaries, encyclopedias, glossaries, the Internet
- Vocabulary handout provided below

**Overview**: Approximately 55% of the solid waste produced in the US is disposed of in landfills located across the country. Landfills are a long-term disposal solution that requires that trash be buried under ground. The EPA has identified eight categories of waste that are typically buried in landfills. These




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categories include: paper, yard trimmings, food scraps, plastics, metals, textiles-rubber- leather, glass and wood.

While decomposition is slowed considerably in landfills due to the lack of light, air and moisture, as the waste slowly breaks down over time it produces a by-product, known as landfill gas (LFG). The composition of this gas varies from one landfill to another based on the type and amounts of waste buried in a specific location, and LFG production usually levels off at somewhere between five to seven years. LFG consists of approximately 40-60% methane, 40-60% carbon dioxide and small amounts of nitrogen, oxygen, sulfides, ammonia, hydrogen, carbon monoxide and any number of contaminates referred to as "non-methane organic compounds" (NMOCs). NMOCs typically account for less than 1% of landfill gas, but should be considered in any plan for managing LFG, as many of them have the potential to recombine into highly toxic compounds under certain circumstances involving combustion.

Once LFG is produced it expands and moves, following the path of least resistance. It typically moves in an upward position, but its escape route can be blocked by tightly compacted waste, causing it to migrate horizontally, until it finds its way beyond the borders of the landfill and into the environment. Instead of allowing LFG emissions to escape most landfills are equipped with a methane collection systems that consist of a group of wells and a vacuum system. This type of system captures the LFG, so it can be processed. Once the LFG is collected it can be handled in a variety of ways, including: a) flared, b) used in a boiler, dryer, greenhouse or kiln to make heat, c) used in an internal combustion engine, gas turbine or fuel cell to make electricity, d) used directly to evaporate leachate, or e) separated and converted into methanol (methane) or dry ice (carbon dioxide). There are, of course, pros and cons for each method of handling LFG and each has its advocates and protestors.

**Kid's Speak**: People throw away all sorts of materials every day, and seldom think about where they go or what happens to them. The most common types of waste items include: paper, yard trimmings, food scraps, plastics, metals, textiles-rubber-leather, glass and wood. While waste buried in landfills does not break down quickly, some of it does decompose over time. As this process takes place it creates a gas that can be harmful to people and the environment if it is allowed to escape from the landfill. As a precaution landfills are now equipped with a collection system. Once the gas is collected it can be burned or used to provide energy. There are various ways landfill gas can be handled, but as with many things there are pros and cons for each and people continue to disagree about which is the most safe and effective method.

**Eco-Fact**: Municipal solid waste landfills are the second largest source of methane emissions attributed to human actions in the United States.

**Procedures**:
**Before Conducting the Lesson**:

- Review the structure of a MSW landfill with students. Introduce the students to the concept of landfill gas and provide them with background information on it, how it can be collected and converted for use.

**Conducting the Lesson**:

- Divide students into pairs. Provide each pair with a set of blank cards and the vocabulary handout provided at the end of this lesson. Students should be given access to resource materials (dictionaries, encyclopedias, glossaries for environmental science, etc.) and the Internet.

- Students will work in pairs to locate a definition for each term as it relates to landfill gas, write the term on one side of a card and the definition on the reverse.

- Once the students have developed their own word bank of terms they will use the cards to sort and classify, creating lists of terms that relate to each of the following questions:




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- What are four components of landfill gas? (methane, carbon dioxide, oxygen, NMCOs)
- How is landfill gas produced? (chemical reaction, bacterial decomposition and volatilization)
- What organisms are present during the decomposition process when the landfill becomes a neutral environment? (anaerobic bacteria, methanogenic bacteria)
- What are some of the conditions that affect landfill gas production? (age of refuse, waste composition, oxygen)
- How does landfill gas migrate? (diffusion, pressure, permeability)
- What are some ways LFG can be handled once it is collected? (incineration/flared, used in an internal combustion engine, gas turbine or fuel cell to make electricity, separated and converted into methanol)

**After the Lesson**:

- Students will use the word bank to write a description of landfill gas, including:
  - Its composition,
  - How it is formed
  - The conditions that affect its production
  - How it moves
  - How it is collected
  - How it is handled after collection

- Students will prepare a statement voicing their opinions on the use of landfills in the US and the world and justify their position based on the evidence and observations collected.

**Adaptations**:

- Students can work independently on the terms, locating appropriate definitions as a homework assignment.

**Extensions**:

- Students can research the pros and cons of converting landfill gas into energy and take a position on the issue of whether or not it should be considered a green energy source.




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