BioFutures

A Biomass Energy Efficiency Education Supplement to the KEEP *Energy Education Activity Guide*

Wisconsin K-12 Energy Education Program (KEEP)
College of Natural Resources
University of Wisconsin-Stevens Point

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BioFutures is a supplement to the KEEP Energy Education Activity Guide and Doable Renewables. The supplement can be used as a stand-alone unit, but will be enriched if used in conjunction with the KEEP Energy Education Activity Guide and Doable Renewables. References to the guide and suggested complementary activities are provided throughout this supplement. If you are interested in participating in a KEEP professional development opportunity, please contact the KEEP office at 715.346.4770 or Email keep@uwsp.edu for more information.

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What is the Wisconsin K–12 Energy Education Program?

The Wisconsin K-12 Energy Education Program (KEEP) was created to help promote energy education in Wisconsin. In 1993, the Wisconsin Center for Environmental Education (WCEE) proposed that a comprehensive guide to K–12 energy education in Wisconsin be developed. In 1995, the Energy Center of Wisconsin (ECW), a nonprofit energy efficiency research organization based in Madison, agreed to fund the project. The Wisconsin Environmental Education Board and the University of Wisconsin-Stevens Point also provided support.

In 2000, the ECW (now Seventhwave), worked with KEEP staff to ensure long-term financial support through Focus on Energy, Wisconsin's Public Benefits Program, a public-private partnership offering energy information and services to energy utility customers throughout Wisconsin. The partnership with Focus on Energy ended in May 2012. Recognizing KEEP's value, Wisconsin's six major utilities have continued their funding for KEEP on an annual basis.

For more than twenty years, the Wisconsin K–12 Energy Education Program (KEEP) has been working with teachers, administrators, and energy resource managers to increase and improve energy education in Wisconsin schools. The KEEP curriculum and other services and support materials provide Wisconsin students of every grade level the opportunity to receive a logically sequenced, comprehensive education about energy.

Vision

Communities making informed energy choices now and for a sustainable future.

Mission Statement

The mission of KEEP is to initiate and facilitate the development, dissemination, implementation, and evaluation of energy education programs within Wisconsin schools.

Goal

The goal of KEEP is to leverage teacher education to improve and increase energy literacy in Wisconsin's K-12 communities as a means of contributing to statewide energy savings.

KEEP Accomplishments

A Conceptual Guide to K–12 Energy Education in Wisconsin: Identifies important energy concepts that students should know and understand.

KEEP *Energy Education Activity Guide* and Supplemental Guides: Contain hands-on, interdisciplinary lessons that are aligned with Wisconsin's academic standards, Next Generation Science Standards and Common Core State Standards and make energy relevant to students' lives.

Professional Development Courses and Workshops for K–12 educators: Provide educators with hands-on experience teaching lessons from the KEEP *Energy Education Activity Guide* and supplements and introduce them to additional energy-related teaching resources. These offerings increase teachers' energy literacy and increase the likelihood that they will implement KEEP materials in their classrooms.

Web-based Energy Literacy Courses: Energy education via the Internet; the content of two interactive courses is available at no charge to teachers year-round via the KEEP website.

Renewable Energy Education: Activities, support materials, and inservice courses provide teachers with background information about renewable energy they can share with students.

Statewide Network of Energy Educators: KEEP provides continued support for teachers via online newsletters, the website, social media, and conferences, and through the lending of hands-on resources, tools, and take-home activities for students as they develop 21st century skills.

Partnerships in Energy Education: Working collaboratively with Focus on Energy, utilities, and various energy resource professionals, KEEP promotes energy education and efficiency in homes, schools, and communities.

Over 6,700 teachers throughout the state have participated in KEEP professional development offerings. These teachers are in turn increasing the quality and quantity of energy education for thousands of Wisconsin K–12 students. These teachers report that they now have the knowledge and experience to teach about energy, and that their classroom teaching includes more activities and lessons about energy.

A Rationale for Biomass Energy Education

Energy education can help students of today handle many of the energy resource issues and opportunities our nation faces. We have challenging energy decisions ahead of us, and the solutions will include a mix of energy efficiency measures, new technologies, and renewable resources. These decisions will need to be made by educated individuals who have a solid understanding of energy basics, including the pros and cons of both renewable and nonrenewable resources.

Understanding energy issues can help students prepare for the future in Wisconsin, the United States, and global communities. Wisconsin does not contain oil, coal, or natural gas reserves and thus, relies on other states and nations for our energy needs. As the shift to renewable energy increases, Wisconsin must take stock of the renewable resources that are available. The most utilized renewable energy resource in Wisconsin is wood burning in homes and industry.

Wisconsin is rich in biomass resources including closed landfills, animal manure, crops such as corn and soybeans, and forested land. Biogas is currently being produced at waste water treatment facilities, closed landfills, and large dairy farms. The use of ethanol, an alternative fuel made from corn, is increasing due to the increased cost of gasoline and pollution regulations placed on six southeastern counties in Wisconsin. Biodiesel is being made in large facilities and by motivated individuals throughout the state for their own use. The uses of more biomass energy forms are likely to increase as time passes.

Maria Boardman, the program coordinator for the Wisconsin Alternative Fuels Task Force, stated that, “development of a curriculum to educate our youth is a step forward in including everyone in the effort to increase awareness on our state’s energy, economic, environment, public health, and transportation needs.” Boardman is specifically interested in the development of activities that increase student awareness about biodiesel and the ethanol fuel blend E85.

Don Wichert, the Director of the Focus on Energy Renewable Energy Program, said, “it is important to educate students today about using this locally available resource.” Before working with Focus on Energy, Wichert was the Chief of the Energy Resources section of the Wisconsin Division of Energy and is considered one of the foremost experts on renewable energy in Wisconsin.

The Wisconsin Department of Administration (DOA), Division of Energy worked with KEEP to apply for a United States Department of Energy grant relating specifically to biomass. KEEP and the DOA proposed to develop a biomass activity guide along with a bookmark contest and public service announcement contest with a biomass theme. The grant was awarded to the DOA and KEEP.

Development of *BioFutures*

A Biomass Energy Education Supplement to the KEEP *Activity Guide*

In 1997, KEEP developed a conceptual framework for energy education. This framework identified key concepts in energy education that students should learn and understand to become energy literate. They were divided into four themes, with the first theme focusing on fundamental concepts and subsequent themes building on the first and each other toward effective energy resource management practices. For more information about the conceptual framework and its development, visit the KEEP Web site and select Resources.

In 2002, KEEP decided additional concepts addressing renewable energy were needed. Focus groups consisting of teachers and energy resource managers determined that while the first theme adequately covered concepts needed for renewable energy literacy, additional concepts were needed for the remaining three themes.

Using the Delphi process, energy resource managers from around the state helped identify and validate concepts for the revised conceptual framework. The process involved participants reviewing and ranking the proposed list of additional concepts. Their responses were used to prioritize and revise the concepts. The experts then reviewed the list again and agreed that the revised framework effectively addressed the needs of renewable energy education literacy.

The KEEP framework includes renewable energy education concepts in Themes II, III, and IV. This framework directed the development of *BioFutures*. To develop the supplement, teachers participated in a scope and sequence workshop and identified activities that addressed renewable energy concepts in the framework (for Themes II, III, and IV). Given the grade level emphasis appropriate for each of the themes (see below), the activity selection process resulted in activities geared mainly for middle and high school students. Understanding the details of biomass energy development, consumption, and management involves higher level skills more appropriate for older students. Therefore, while there are activities included for elementary students in the supplement, most of the activities are for secondary education teachers.

It is very important, however, that students experience activities related to concepts in Theme I to understand renewable energy and biomass energy concepts. Moreover, it is crucial that students gain an appreciation for renewable energy resources at an early age. This early awareness will support their further explorations of biomass energy resource development and use. *BioFutures* includes several activities that will support awareness of biomass energy resources. Finally, the KEEP *Activity Guide* contains a number of Theme I activities. Teachers can contact the KEEP office to learn how to obtain this guide if they would like a copy.

Following is a further explanation of the development of *BioFutures*.

The development of *BioFutures* occurred in six stages. Each of these stages included an evaluation process to ensure that the supplement successfully promotes renewable energy education.

Stage 1: Conceptual Framework. A review of the KEEP Conceptual Framework was conducted to assess if additional concepts were needed for the development of a biomass energy curriculum. The environmental educators and energy resource managers that reviewed the document determined that the existing framework had the necessary concepts for the development of a biomass energy curriculum.

Stage 2: Scope and Sequence. KEEP conducted a Biomass Energy Scope & Sequence Workshop, involving K–12 teachers. These educators expanded the conceptual framework into a scope and sequence, identifying the grade levels and subject areas in which the concepts should be introduced, developed, and mastered. These teachers also reviewed existing energy curriculum and activity guides to identify potential activities to fit within the scope and sequence.

Development of *BioFutures*

Stage 3: Activity Format. The activity format for *BioFutures* is based on the KEEP *Energy Education Activity Guide* and Doable Renewables format that was previously developed, reviewed, and evaluated.

Stage 4: Activities. *BioFutures* activities were selected based on reviews of published energy education resources. The reviews were conducted by Wisconsin K–12 teachers. KEEP staff drafted, reviewed, and revised activities.

Evaluation Process: Content Review. After activities were drafted, they were reviewed for content accuracy. Professionals in a field relevant to the concepts in the activity evaluated its Background and Procedure for content thoroughness and accuracy. Activities were revised based on these professionals' recommendations.

Piloting and Teacher Review. Each activity was given to two or three classroom teachers to pilot in a classroom. Teachers were given a review form that guided them in assessing the activity for grade-level appropriateness, ease of accomplishment, and success in achieving intended objectives. KEEP staff once again revised the activities based on the reviewers' suggestions.

Stage 5: Supplement Design. After the activities were revised, they were put in table of contents order. The KEEP staff then drafted the front and back matter for the supplement (Introduction and Appendix).

Evaluation Process. Biomass energy and educational professionals conducted a comprehensive review of the supplement. The purpose of this review was (1) to examine the extent to which important energy concepts were covered in the activities and (2) to assess the supplement's cohesiveness and level of organization. KEEP staff then made final revisions to the supplement.

Stage 6: Pilot and Revise. The first publication of *BioFutures* was piloted by K–12 teachers throughout Wisconsin.

Evaluation Process: *BioFutures* was piloted with Wisconsin K–12 educators to assess the effectiveness.

Dissemination of *BioFutures*

BioFutures is being disseminated through KEEP's Website: **keepprogram.org.** Select **Curriculum** for the link to *BioFutures*.

Contents

Introduction

BioFutures, the KEEP biomass energy supplement provides K–12 teachers in a variety of subject areas with easy-to-use, hands-on, minds-on activities designed to promote energy literacy in Wisconsin students. The Wisconsin Department of Public Instruction's Academic Content and Performance Standards were referenced during the development of this supplement.

Grade Levels and Theme Emphasis

Concepts within all the themes from the KEEP *Conceptual Framework* are relevant to teachers at any grade level and in a variety of subject areas (see Cross-Reference Charts: Grade Levels and Subject Areas in Appendix). However, when building a K–12 renewable energy education program, certain themes can be stressed at different grade levels. For more information about the KEEP *Conceptual Framework*, visit the KEEP Web site and select *Resources*.

Participating in activities from **Theme I: We Need Energy** provides students with a fundamental knowledge about energy. The concepts within this theme are the foundation upon which concepts in the other three themes are built. Therefore, *We Need Energy* should be emphasized in grades K–5. The KEEP *Activity Guide* as well as KEEP's *Renewable Energy* Web site offer a variety of lessons and ideas for supporting student learning of Theme I energy concepts.

Activities and teaching ideas from **Theme II: Developing Energy Resources** have students identify and look at different sources of energy. These concepts are appropriate for the elementary grades, especially grades 3–5. However, other concepts within this theme require higher level thinking skills because students must interpret and examine the process of energy resource development. Therefore, many of the activities from this theme pertain to students in middle school.

Awareness of how renewable energy use positively and negatively affects quality of life, economic activity, and the environment can begin during the primary grades; however, because of the complexity of many issues, these concepts may be better introduced at a later stage. The majority of the activities within **Theme III: Effects of Energy Resource Development** are appropriate for the middle school years. High school students can take what they have learned earlier and use the knowledge and skills to conduct special projects (see Appendix). Educators can teach younger students the importance of renewable energy use. However, younger students may not comprehend the reasoning behind these efforts until they learn to think more abstractly.

The higher level thinking skills (such as linking economic activity and energy flows, linking environmental impacts and energy flows, and extrapolating how today's actions could affect the availability of energy resources tomorrow) are best suited for more mature students. Consequently, most of the activities from **Theme IV: Managing Energy Resource Use** are designed for middle and high school students. By the time students graduate from high school, they should have mastered the concepts and learned lessons from the world around them. These competencies will enable them to make wise decisions regarding energy choice, to understand the workplace and career opportunities and associated school-to-career elements, and to take actions that reflect their personal ethic and knowledge of energy.

Types of Activities

Activities in *BioFutures* are fully developed activities that provide educators with background information, explicit objectives, a detailed procedure, and assessment strategies. They are designed to be self-contained lessons. Background information is usually found within the activity; occasionally other sections of the guide may be referenced. Most activities require some preparation time to locate and set up materials; however, this time should decrease with successive uses. For the most part, the materials for the activity should be available in local stores or within the school.

Introduction

Integrating Energy Concepts

Concepts in *BioFutures* are applicable to teachers of Science, Mathematics (Math), Social Studies (SS), English/Language Arts (ELA), Technology Education (TE), Environmental Literacy & Sustainability (ES), and Family and Consumer Education (FCE), or to anyone who wants to promote energy as part of their curriculum. Educators can use KEEP Cross Reference Charts to identify activities relevant to a variety of their teaching needs, such as *Subject Areas* and *Grade Level*. KEEP activities can be used to address the Academic Content and Performance Standards developed by the Wisconsin Department of Public Instruction. These standards identify what students should understand and how they should demonstrate achieved learning. For more information about state standards, contact the
Wisconsin Department of Public Instruction,
P.O. Box 7841, Madison, WI 53707-7841
https://dpi.wi.gov/

In addition to the various Cross Reference Charts, educators and curriculum developers can refer to the *Suggested Scope and Sequence* in the Appendix that provides guidelines showing when and to what extent energy concepts could be integrated into school curricula. For example, teachers can use the Scope and Sequence to identify the concepts appropriate for their subject and grade level. The next step for educators is to determine which of these concepts are already included in and which are lacking from their curricula. Activities found within *BioFutures* provide teachers with opportunities to bring these energy concepts into their curricula.

Assessing Student Learning

BioFutures provides several approaches for assessing student learning. It is helpful to assess students' current understandings and misconceptions about energy. Orientation of each activity procedure provides suggestions for ascertaining what students know about the upcoming lesson. Formative and Summative Assessment ideas are located within each theme activity. Formative Assessment points out times during the activity when educators can check their students' achievement of the objectives. Summative Assessment takes place near the end of the activity or after the activity's completion. The aim of Summative Assessment is to determine if students can take what they have learned and apply it to a different experience.

Activity Format

Summary:
Briefly describes student learning and activity procedure.

Objectives
Knowledge and skills students will acquire as a result of doing the activity.

Materials
Items needed for the activity. Any necessary preparation of materials is described in *Getting Ready*.

Background
Description of energy topics and concepts addressed in the *Procedure*.

Procedure
Orientation
Discussion topics that can be used to relate forthcoming concepts to students' lives and to assess what students currently know about the concepts in the activity.

Steps
Suggested strategy for completing the activity. Written instructions and materials for students are found on separate *Student Activity Sheets* directly following the activity.

Closure
Discussion topics that can be used to conclude the activity and to assess what students have gained from participating in the activity.

Assessment
Formative
Questions about student actions that occurred during the activity.

Summative
Suggested activities that have students applying learned information or skills to new situations.

Extensions
Variations and additions to the activity.

Grade Level:
Suggested grade levels: K–4, 5–8, 9–12

Subject Areas:
Relevant subject areas.

Setting:
Recommended location.

Time:
Preparation: Approximate time needed to review background information and set up materials.

Activity: Average class time needed to conduct the activity.

Vocabulary:
Key terms introduced or used in the activity.

Major Concept Areas:
Lists the major concepts covered in this activity.

Getting Ready:
Directions for preparing materials or setting up demonstrations prior to conducting the activity with students.

Academic Standards:
A list of standards that can be tied to the activity.

Resources:
A list of books or Web sites that relate to the activity.

Related KEEP Activities:
Theme activities that can precede, supplement, or follow this activity.

Activities

Summary:
Students simulate the process of photosynthesis through a whole-body demonstration

Photosynthesis Promenade

Grade Levels: (K-2) 3-4

Subject Areas: Dance, Environmental Literacy, Language Arts, Life Science, Mathematics

Setting: Classroom

Time:
Preparation: One-two hours
Activity: Three 50-minute periods

Vocabulary: Carbohydrate, Carbon dioxide, Chemical potential energy, Chlorophyll, Glucose Greenhouse, Heat, Light, Light energy, Molecule, Oxygen, Photosynthesis, Solar energy, Sun, Synthesis, Thermal energy

Standards Addressed:
Common Core ELA:L.K.4.A, L.K.5.A&D, L.K-2.6, L.1.4, L.1.5.A-B, L.2.3, L.2.4.A-E, L.2.5.A-B, L.3-4.3, L.3.4.A-D, L.3.5.B, L.4.4.A-B, RI.2-4.3, RI.3.4, RL.4.5, SL.K.1.A, SL.K.3-4&6, SL.1.1.A-C, SL.1.4, SL.2.1.A-C, SL.2.2, SL.3.1.A-B&D, SL.3.3&6, SL.4.1.A-D, W.K.2&8, W.2.7

Common Core Math: MP5, 2.MD.1, 2.MD.2

NGSS: 2-LS2-1
SEP: Planning and Carrying Out Investigations
DCI: LS2.A: Interdependent Relationships in Ecosystems
CCC: Cause and Effect
EL&S: Connect: C1.A.i, C1.B.e
Explore: EX2.A.e, EX2.A.i, EX4.A.e, EX4.A.i

WI Env Literacy & Sustainability: C1.A.i, C1.B.e, EX2.A.e, EX2.A.i, EX4.A.e, EX4.A.i

Materials:
- Picture or drawing of an animal such as a rabbit (optional)
- Growing plants that have turned their leaves toward the light (optional)

Continued next page

Objective
Students will be able to illustrate how plants use the sun's energy to make food.

Background
Photosynthesis is the process by which green plants use sunlight to produce carbohydrates such as glucose, other nutrients, and oxygen from simple compounds such as water and carbon dioxide. In energy terms, photosynthesis converts solar energy into chemical potential energy that is stored in carbohydrates.

Photosynthesis occurs when water is absorbed by the roots of the plant and is then carried to the leaves. Carbon dioxide then enters the plant through the leaves and goes into the plant cells that contain chlorophyll. Chlorophyll is the green pigment found in the chloroplasts of plants that are essential for producing carbohydrates by photosynthesis.

Photosynthesis gives off oxygen and takes in carbon dioxide while people take in oxygen and give off carbon dioxide. This makes photosynthesis a great example of how people and plants depend on each other.

Procedure
1. Ask the class for one volunteer to share with the class what they ate that day or the previous day. Write the name of the student on the board and then write the things the student ate around it. Pick one of the foods the student ate (fruits or vegetables are easiest) and discuss with the class where that food came from. For example, if the student lists an apple, draw an apple tree on the board. Then ask students what the apple needs to grow. As students list things draw them on the board as well. The key item students should identify is the sun.

2. Put a picture of a rabbit on the board (or write the word) and ask students to complete a food chain around the rabbit. For example, they might show the rabbit eating a carrot that gets its energy from the sun and list a predator, such as a hawk, that eats the rabbit.

3. Have students explain what is happening between the links of the food chain, starting between the predator and the prey. They will probably be able to describe how the hawk eats the rabbit and the rabbit eats carrots, but how do they explain the connection between the sun and the carrot (or any plant)?

4. Ask students how they know plants need sunlight. Have students share their observations and thoughts about plants needing the sun. For example, students may have noticed how some plants turn their leaves toward the light. To fully address the science standards in this lesson, involve students in an investigation in which they prove plants need sunlight to survive. See *Suggested Sun Test Procedure* on the next page for ideas.

5. Students might know that plants need sunlight, but do they know how plants use the light? Have students provide explanations for how they think plants use sunlight. List their responses on the board.

6. Explain to students that sunlight helps the plant take air particles (carbon dioxide) and water and recombine them to build sugar particles (or molecules). Oxygen that we breathe is also created in the process.

7. Introduce the term photosynthesis. Students should recognize the root word "photo." Ask what they think it means. Help them understand that it means light. Students might also have heard the word synthesis or a related term, such as synthetic. Explain that to synthesize means to create or to make. See if students can use these explanations to develop a definition for photosynthesis. Make sure water, air, sun, sugar, and oxygen are included in the definition.

8. Have samples of fruit and vegetables handy that students can eat to taste the sweetness. Show students some plants and explain that plants use the sugar they create and other minerals from the soil to build their body structures (roots, stems, leaves, and fruit).

9. Explain that most plants are green because they contain a chemical called chlorophyll. This chemical helps the plant use the sun's light to make sugar out of water and air. If one is available, show students a picture of a magnified leaf cell with chlorophyll, or ask a biology teacher to let students look through a microscope at a leaf. You'll need to use a thin leaf such as one from a water plant or an elodea.

10. Involve students in simulating how water and air particles are recombined into sugar. Younger students can gain insight into the process of how materials are recombined to create something new through the *Chocolate Chip Demonstration*. Older students can participate in the *Photosynthesis Promenade*.

11. Have students revisit the food chain they created at the beginning of the lesson. Ask them to explain what is happening between each link, especially between the sun and the plant. Listen to see if they use the term photosynthesis.

Assessment

- Have students revisit the food chain they created at the beginning of the lesson. Ask them to explain what is happening between each link, especially between the sun and the plant. Listen to see if they use the term photosynthesis.
- Ask students to define and describe photosynthesis.
- Have students draw a picture or write a simple story about the role of the sun or the life stages of a plant. Check to see if students describe how the sun helps the plants make food out of carbon dioxide and water. out of carbon dioxide and water.

- Fruits and vegetables
- Photographs of magnified leaf cells showing chlorophyll (optional)
- Props and materials for Photosynthesis Promenade (optional)
- Ingredients and equipment for making chocolate cookies (optional)

Related KEEP Activities:

Use "Photosynthesis Promenade" to enhance the KEEP activities "Food Chain Game" and "Energy from Food" (KEEP Energy Education Activity Guide) and to help students have a better understanding of how energy is stored in food and is transferred to humans when we eat. Available at keepprogram.org.

Resources:

www.sheppardsoftware.com/content/animals/kidscorner/foodchain/photosynthesis.htm

www.biology4kids.com/files/plants_photosynthesis.htmll

www.teachers-tools.com/photosynthesis-poster.html

https://ed.ted.com/lessons/the-simple-but-fascinating-story-of-photosynthesis-and-food-amanda-ooten

www.youtube.com/watch?v=zSDbts3i0Ak

Suggested Sun Test Procedure

Ask students how they can prove that a plant will die without sunlight. If they suggest shutting a plant in a dark closet, what other things might the plant not get that could contribute to the plant's death? Help them to understand that if the plant is not watered or if it does not get air, it will also die. Students need to make sure they are testing for only one item or variable. Encourage students to develop their own test to show that plants need sunlight. Below is one procedure they might follow.

Plant seeds (bean or pea plants are recommended) and grow them to a few inches in height. Then allow one plant (the control) access to sunlight, water, and air. Have another plant get air and water, but no sunlight (put the plant in a dark closet). Let the third plant get sunlight and water, but no air (cover the plant with a plastic bag). Provide the fourth plant with sunlight and air, but no water. Make careful observations of what happens to each plant over a few days time. Then place plants in different situations/environments. Students should continue to collect daily height measurements and compare them to determine which plant is in the best environment to support growth.

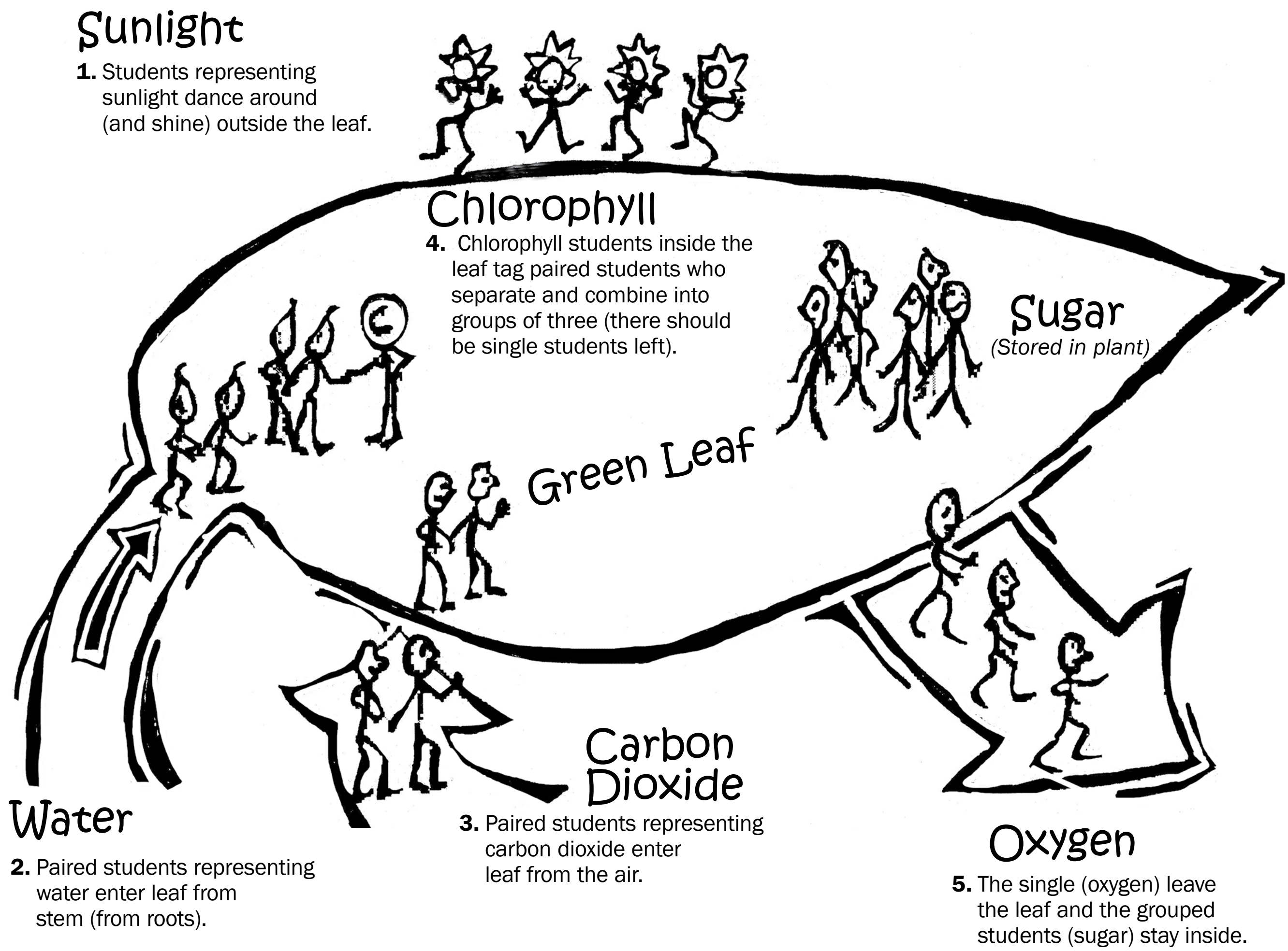
Chocolate Chip Demonstration:

To help students appreciate how air and water are recombined to create sugar, show students a chocolate chip cookie and ask them how they think it is made. Describe how a cookie is prepared from scratch (or involve students in baking cookies). Explain (or show) that the different ingredients such as butter, flour, chips, sugar, water, etc. are combined, but that they do not actually become cookies until thermal energy (heat) is added. This process is much like a plant using sunlight to recombine carbon dioxide and water to make sugar.

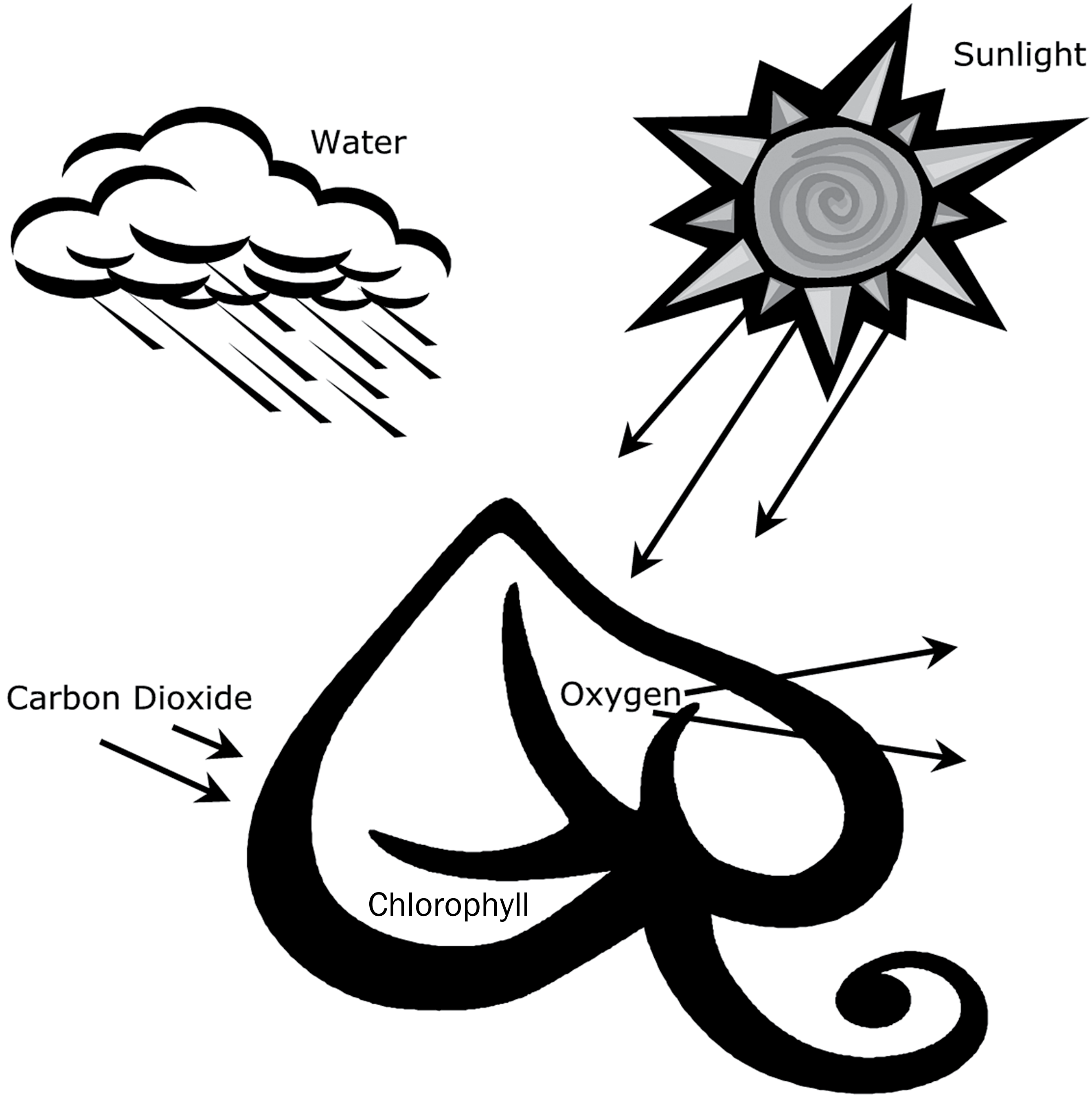
How to do the Photosynthesis Promenade

For the promenade, students might be interested in adapting the simulation into a dance or play with costumes and props. For example, students representing chlorophyll can be dressed in green (or use colored name-tags) and those representing the sun can be dressed in yellow and carry flashlights. A simple stage can be created to represent the leaf. Make sure students understand that this is a simple demonstration and does not represent the actual chemical process, which is very complex. If you do the simulation as a dance, consider playing music.

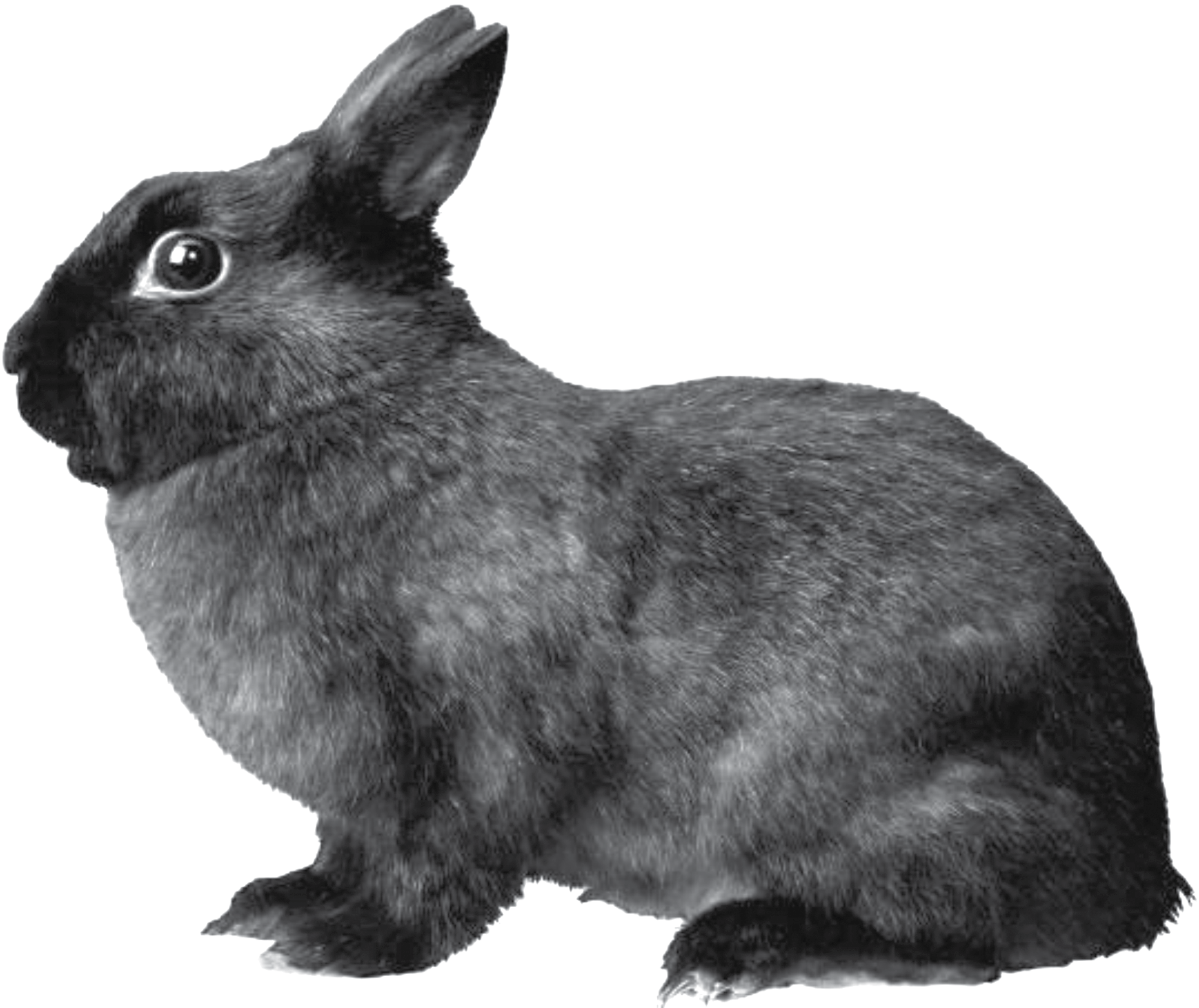
- Designate one section of the room as the leaf of the plant.
- Divide the class in half and have each half stand on either side of the leaf. Instruct students to stand in pairs. Pull out a few extra students to play the sunlight and chlorophyll. Direct the chlorophyll student(s) to stand inside the leaf area.
- Tell half the students they are air particles and the other half they are water that is coming to the leaves from the roots (drawn up from the plant's stem). It might be helpful to give them signs labeling them as water or air molecules (particles).
- Instruct students to file as pairs into the leaf area.
- Provide the students representing sunlight with a flashlight and tell them to stand outside the leaf and shine the light on the students who are chlorophyll. Students should shine the light during the whole next step; they might want to dance about to music while shining the light. (Be sure students so not shine the light in other students' eyes.)
- The chlorophyll students gently tag the air and water pairs once they enter the leaf. When paired students are tagged, they separate. If signs are being used, the chlorophyll students should take these away. When all the students are milling about into singles, instruct the chlorophyll students to recombine students into groups of three; there should be some single students left over.
- Direct the single students to leave the leaf.
- Ask students to suggest what the recombined group and single students are. The groups are sugar molecules and the single students represent the oxygen molecule (which is actually composed as two oxygen atoms). New signs can be distributed to these two groups.»



Photosynthesis



Rabbit Image for Activity



Would You Heat With Wood?

Summary Part One: Students write and illustrate a story about burning wood to demonstrate how energy comes from wood.

Objective

Students will be able to write and illustrate a story about burning wood for energy.

Background

Almost everyone has used wood to provide heat and light, whether it was a bonfire, a wood burning stove, or a fireplace in their home. While we often use fire because it is aesthetically pleasing, it also provides us with energy in the form of heat and light.

The uses of fire are varied depending on what apparatus the fire is burned in. When we use a bonfire, it is often for light when it is dark, to keep us warm, and to cook food to provide us with energy. Fireplaces are used to provide heat and to add a "glow" for ambiance. Wood burners and pellet stoves are two other examples of apparatuses that burn wood. A wood burner is often seen in residential homes, cabins, or hunting shacks. These can be used for heat and to cook on. Before homes had central heating systems, wood stoves were the primary place for heat for warmth and cooking. A pellet stove uses compressed pieces of leftover wood and paper products that are automatically fed into the apparatus.

Not only are the uses of the apparatuses different, but they also have different levels of efficiency. A campfire is the most inefficient method of burning wood because there is little control of the amount of air the fire receives. A fireplace can be controlled more, but can still be inefficient due to the air that comes in from the chimney into the open room. Wood stoves are more efficient than fireplaces because they are closed systems and the amount of air that gets into the system can be controlled by the operator. A pellet stove is the most efficient of the apparatuses mentioned for several reasons. Putting the fuel (wood pellets) into the stove does not require opening the door. (It can be manually or automatically fed so there is not energy lost from opening the door.) Like the wood burner, the operator has control over the amount of oxygen the pellet stove receives. Most of the energy from a fire comes from burning, and the pellet stove takes advantage of this far more than the other apparatuses.

NOTE: Many manufacturers or companies that use wood products also use the wood by-products, such as sawdust and scraps, to provide heat and electrical energy for their facilities.

Procedure

Orientation

Tell students that they are going to be learning about energy that is made from a renewable resource—wood. Explain to students that renewable energy is energy that can be quickly replenished. Review the vocabulary words with the students and post them in the classroom.

Steps

Part I (Classroom or outside)

1. Show students a picture of a tree. Ask students what the picture is of. Show students a picture of a piece of wood. Ask them what the picture is of. After they have identified both, ask the students what the difference is between the two. Students should identify that one is alive and the other has been cut down or harvested.

2. Ask students why we harvest wood. If they have trouble identifying things made from wood, ask them to look around the classroom.

3. If they did not identify burning the wood as a reason for harvesting trees, show them a picture of a wood burner and/or a fireplace and ask the students if any of them have wood burners and/or fireplaces in their homes or cabins.

4. Ask students to raise their hands if they have ever sat by a fire before. Ask students if their families have rules for when they have a fire. If so, what are they NOTE: See sidebar on **Safety**.

Grade Level: 3–5

Subject Areas: Art, Environmental Education Mathematics, Science

Setting: Classroom (possibly outside)

Time:
Preparation: 50 minutes
Activity: Two 50-minute periods

Vocabulary: Efficiency, Energy, Fuel, Harvest, Heat, Light, Light energy, Pellet stove, Renewable, Thermal energy, Wood, Wood burner

Academic Standards:
Common Core Math: MP6, 3.MD2,

NGSS: K-ESS3-3, 4-ESS3-1, 5-ESS3-1
SEP: Obtaining, Evaluating, and Communicating Information
DCI: ESS3.A: Natural Resources, ESS3.C: Human Impacts on Earth Systems
CCC: Cause and Effect, Systems and System Models

WI Env Literacy & Sustainability: C1.A.i, EX2.A.e, EX2.A.i, EX4.A.i, EN6.A.e, EN6.A.i, EN6.B.e, EN7.A.e

Materials

- Book about wood burning (see **Getting Ready**)
- Log (optional)
- Pictures of tree, wood, fireplace, bonfire, wood burner, pellet stove
- Paper and art supplies
- Copies of ***Efficiency Worksheet***
- Wood pellets (optional)

Continued next page

Summary Part Two: Students review the efficiency of different wood-burning apparatuses.

Getting Ready:

Obtain one of the following books or a book of your choice.

- *Central Heating: Poems About Fire and Warmth*, Marilyn Singer
- *Safety Around Fire*, Lucia Raatma
- *Nature and Science of Fire,* Jane Burton, Kim Taylor
- *Science of Fire,* Rennay Craats

Related KEEP Activities:

Energy Divide"–KEEP *Activity Guide*. "Renewable Candy Resources"–*Doable Renewables*

Safety:

When operating any type of wood burning system, it is important to understand how to use the system safely. Children should never start fires unless it is a controlled area (fire ring, fireplace, wood burner) with an adult helping them. Fires are hot and should not be touched. All those near a fire should remain a safe distance from the flame. If you live in a home with a fireplace or a wood burning stove, it is important to clean the system, which includes the chimney and stovepipe, and also to set up your system safely, which involves proper floor and wall protection and proper clearance.

5. Hold up the picture of the bonfire and ask students what the picture is of. Tell them what that kind of fire is used for (see **Background**) and what the pros and cons are for this system.

6. Repeat Step 5 for fireplaces, wood stoves, and pellet stoves.

7. Tell students that they are going to write a story about burning wood.

8. Provide students with paper and art supplies so they can write and draw the pictures for their story. (Students who are too young to write the story may draw pictures of how they have used fire.)

9. When the stories are finished, let the class share their stories with each other.

Steps

Part II

1. Explain to students what the definition of energy is and discuss energy efficiency. Efficiency is accomplishing a task with a minimum of effort and waste. The different kinds of fires the class discussed in part one all have different levels of efficiency.

2. Explain to students that when a fire is efficient, there is not a lot of ash or smoke. Ash and smoke are waste products that show that all of the energy in the wood or wood pellet was used up.

3. Work with the students to identify how much ash and smoke are produced by a bonfire, fireplace, wood burner, and pellet stove. See **Background** and **Resources**. Draw on student experiences and insert any missing information. Tell students that the fire burning methods that are exposed to more air are usually less efficient and the ones that are more controlled (air and source of fuel) are usually more efficient.

Closure

Provide each student with the ***Efficiency Worksheet***. Students should draw a face in the circle next to the picture to show whether it is efficient (smile) or not efficient (frown). Review the answers with the students.

KEY: Most efficient to least efficient: pellet stove, wood burner, fireplace, bonfire.

Assessment

Formative

- Did students' stories and pictures show evidence of energy, i.e. heat and light?
- Were students able to match the pictures?

Summative

Experiment with various ways to create and contain fires. For example, bonfire, fireplace, wood stove, pellet stove. Create tin can replicas. Obtain four metal cans. Leave one can as it is and use a nail and hammer to poke a different amount of holes in the remaining cans. Collect small pieces of wood and burn it in each of the cans. Consider obtaining a piece of metal to use as a lid as well (remember to use a pot holder or insulated gloves). Have students predict which can will burn most efficiently. Observe and record how much ash and smoke was given off by each can. The amount of ash in each can should be weighed. This measurement will provide the evidence necessary to determine which can was most efficient. Have students align their can model with a real life wood burner to declare best efficiency.

Efficiency Worksheet

Instructions: You are going to draw a face in the circle next to the picture to show whether it is efficient (smile) or not efficient (frown). Each face should be different based on how efficient the item in the picture is.

Wood Burner

Pellet Stove

Fireplace

Bonfire

Pellet Stove

Fireplace

Bonfire

Wood Burner

Summary: Students evaluate and categorize advertisements that promote the development and consumption of energy and then design their own advertisement for biodiesel.

Advertising Biodiesel

Grade Level: 6–8, (9–12)

Subject Areas: Art, Environmental Education, Family and Consumer Education, Language Arts

Setting: Classroom, Computer lab

Time:
Preparation: Up to two weeks
Activity: Four 50-minute periods

Vocabulary: Advertising, Alternative fuels, Biodiesel, Diesel, Methane, Nonrenewable resource, Renewable resource

Academic Standards:
Common Core ELA: RL.6-12.1&4, RI.6-12.1&4&8, W.6-12.1&2&4&8, SL.6-12.2&3

NGSS: MS-ESS3-3, MS-ESS3-4, MS-ESS3-5
SEP: Constructing Explanations and Designing Solutions, Engaging in Argument from Evidence
DCI: ESS3.A: Natural Resources, ESS.C: Human Impacts on Earth Systems, ESS3.D: Global Climate Change
CCC: Cause and Effect, Engineering and Technology on Society and the Natural World

WI Env Literacy & Sustainability: C1.B.m, Ex2.C.i, EX3.B.i, EX3.B.m, EX4.B.i, EX4.B.m, EN6.B.e, EN6.C.i, EN6.C.m, EN7.B.i

Materials

- Advertisements from newspapers or magazines (not-energy related)
- Energy-related advertisements
- Art supplies or graphic designing software

Continued next page

Objectives

Students will be able to

- analyze the effectiveness of energy related ads;
- explain what biodiesel is;
- explain why alternative fuels are necessary; and
- design an advertisement that encourages the use of biodiesel.

Background

Advertising

You see them in newspapers and magazines, hear them on the radio, watch them on television, and nowadays, click on their icons on the Internet. Wherever mass media appears, advertisements are almost sure to follow; each one waiting for a break in the action or for a page to be turned; each one persuading us to buy a product, adopt an opinion, vote for a candidate, or support a cause. Since every product we buy involves the development and consumption of energy, it should come as no surprise that advertising influences our purchases, our actions, and, ultimately, the way we develop energy use.

Advertising has a purpose. This purpose can entail any one, or any combination, of the following:

- To increase awareness of a product or its benefit;
- To enhance comprehension of some aspect of the product;
- To promote conviction or desire so that consumers will be eager to purchase the product; and/or
- To ensure action, resulting in the customer purchasing and using the product.

With energy, the "product" is often a source (oil, natural gas, batteries, solar panels, propane), a service (retrofitting your home, bringing natural gas to your home, installing solar panels), or a device that uses energy (furnace, automobile, stove). All of these products involve the development or consumption of an energy resource; therefore energy advertisements promote the development and consumption of energy resources because their aim is to sell energy-related products.

The types of advertisements that involve energy usually fall into three categories. The first includes "type of energy source" ads that aim to convince people one source of energy is better than another (for example, advertisements promoting use of natural gas over electricity, or renewable energy resources over the use of fossil fuels). The second category, which is the most common, is the "customer product" ad (for example, an oil company persuading drivers to buy its brand of gasoline, a utility-sponsored trade organization promoting the use of electricity, a battery manufacturer claiming that its batteries last longer than those made by the competition). The final category is the "public relations" ad.

The main emphasis of the public relations ad is to increase awareness and comprehension of the product. Energy companies frequently use public relations ads to highlight their contributions to the well-being and prosperity of the community. Sometimes they merely want to produce "good feelings" about the company, without any specific reference to a product or service. These ads also help to communicate a positive position on issues or incidents that might otherwise bring a company unfavorable attention. Advertisements in this category may describe a company's efforts to protect the environment; support the arts, education, or the community; or promote technological advances which may eventually benefit its customers. The ads may also be used to defend a controversial position, such as the use of nuclear power, or to respond to an event or incident the company may have been involved in, such as a power outage, an oil spill, or a discrimination suit.

Different advertising strategies are used in each category. Rarely does an advertisement simply say, "buy this brand of fuel," "install these energy-efficient light bulbs," or "drive this kind of car." Instead, more subtle approaches are used to get and keep people's attention. Advertisers use these various strategies as well as creative artwork, imagery, and graphic design to be noticed (see ***Strategies in Advertising***). Artwork pertains to visual as well as auditory techniques (for example, music in television and radio commercials). Advertisers use a variety of strategies and creative designs because they know there is no such thing as a mass audience. While some people like humor, others prefer tenderness.

People in the United States, including Wisconsinites, are becoming more interested in alternative fuels. This interest is mainly because the prices of gasoline and diesel fuel are increasing and more people are learning about the environmental impact of using diesel and gasoline. Therefore, many fuel companies and services are making and advertising fuel blends that increase the ratio of alternative fuels to gasoline or diesel.

Advertising which appeals to people's emotions and desires may not provide enough information about a service or product. It may also obscure critical issues, such as energy resource depletion, environmental effects, social justice, or long-term economic security, that may be related to the use of a product or service. Some advertisements deliberately omit or mislead people on these issues, while some make an effort to address them. Citizens, including students, need to develop a critical sense of how advertising is used to promote products and energy services. They can do so by learning how advertisements are designed to influence desires and emotions, and by getting additional information about services or products from independent sources. Doing so will help citizens make choices that will benefit not only them, but also their community and the environment.

Diesel

Transportation is a very important part of our lives. Not very many communities in Wisconsin have widely used mass transit systems such as buses or subways, which makes individual transportation even more necessary.

We depend on transportation to bring us goods from other areas. For example, where does a cotton shirt come from? If you start at the beginning, the cotton had to be grown on a farm, which means that tractors were used to plant, apply fertilizers/herbicides/pesticides, and harvest the cotton. Then the raw cotton was shipped to where it was made into thread and fabric. After the fabric was made it was shipped to the shirt manufacturer where it was made into a shirt. The shirt was then shipped to a store near

Getting Ready:

Try to obtain energy-related advertisements. (Make sure to obtain advertisements on transportation or for products that are transported from different parts of the world.) This can also be a student assignment (see Orientation).

You may want to store the ads in folders or a three-ring binder, filing similar ads together. For example, advertisements related to transportation can be photocopied on the same colored paper or placed in the same folder. Ads can be laminated or stored within clear plastic protectors.

Resources:

National Biodiesel Board
www.biodiesel.org

Make Your Own Biodiesel
http://journeytoforever.org/biodiesel_make.html

Veggie Van
www.veggievan.org

Strategies in Advertising

- Claims superiority without comparison to competition
- Claims superiority with comparison to competition (no brand name mentioned)
- Positions product or service directly against the competition cites other brand name)
- Appeals to a common culture (i.e. nostalgia, the wild west, the computer age)
- Focuses on cost-saving qualities and economic improvement
- Emphasizes emotion (i.e. love, fear, sadness, joy)
- Promotes feelings of comfort and well-being
- Appeals to certain values, such as environmental concerns or health and safety concerns
- Utilizes humor, fun, or both
- Connects to people

you. You traveled to and from the store with the shirt.

All of the transportation of the goods is done in diesel trucks. Diesel is used in trucking, agriculture and irrigation, construction, and railroads.

Effects of Using Diesel
The exhaust from gasoline and diesel vehicles adds to the growing problem of air pollution which can be an environmental and health problem. According to the International Agency for Research on Cancer (IARC) – part of the World Health Organization, diesel exhaust is a carcinogen. This means exposure to diesel exhaust fumes can cause cancer in humans. Diesel exhaust contains carbon (soot), nitrogen, water, carbon monoxide, aldehydes, nitrogen dioxide, sulfur dioxide, and polycyclic aromatic hydrocarbons (PAHs). Pollution from diesel vehicles can be seen easily in large cities. There have been many rules and regulations put in place to reduce the amount of harmful emissions from burning diesel fuel.

In larger cities, this pollution is thick and can be seen as smog. The consequences of using nonrenewable resources can be experienced throughout the world. Global climate change has become a hot topic in the news and politics. Global climate change is an interconnected chain of climactic events brought about by an increase in trapped heat in the atmosphere. The trapped heat alters atmospheric processes and their interaction with the oceans and the land. The climate—the product of that interaction—changes as well, causing altered weather patterns that bring unexpected rain or dry spells, sudden severe storms, and temperature changes.

The graph below shows the difference in the pollution from emissions between diesel and biodiesel (B100 = 100% biodiesel).

Other Issues to Consider

- Foreign policy—how does the use of diesel/petroleum affect the United States' foreign policy?
- Car culture (consumerism, convenience, debt accumulation, and poverty)

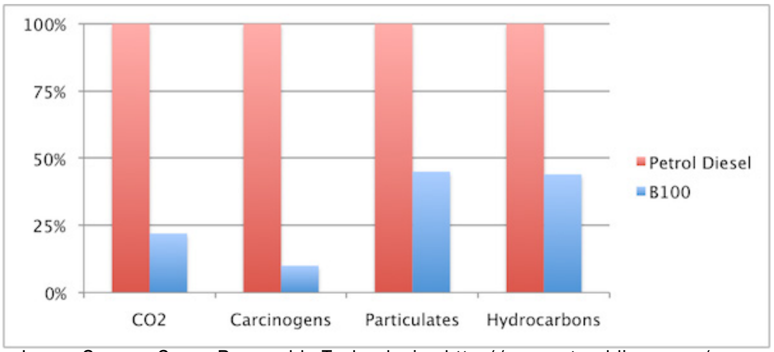


Image Source: Green Renewable Technologies http://www.grtmaldives.com/products_services.php

- Petroleum use in pesticides, plastics, pharmaceuticals
- Consequences of resource depletion

Biodiesel
The supply of diesel fuel is limited because it is a nonrenewable resource. There are alternative fuel options that can be used as a substitute for diesel fuel, which will prolong the life of diesel resources. Biodiesel is a cleaner-burning alternative to diesel that comes from vegetable oils, animal fats, and recycled restaurant grease. Currently, there are only a few large-scale producers of biodiesel, but there are many small-scale producers. Many of these people make biodiesel for their own use in their diesel automobiles. Biodiesel can be mixed with diesel fuel or used on its own. Depending on how the biodiesel is made, some modifications may need to be made to the car in order to use biodiesel. In most cases, the vehicle should not need to be altered. Biodiesel users should always consult with the OEM and engine warranty statement before using biodiesel.

Procedure

Orientation
Show students sample advertisements that are not necessarily related to energy. Ask them to identify what is being sold. Have the class create a list of the advertising strategies used (see Background). Review the purpose of advertising and discuss reasons for advertising and its importance. Do students think energy resources need to be advertised? Have students suggest reasons for advertising energy. NOTE: Students may work in groups in this activity.

Steps

1. Show students samples of energy-related advertisements. Identify the types of products that are usually found in energy advertisements. Review the different categories of advertisements (see *Background*) and help students place the samples in one or more categories.

2. Ask students if they know what diesel is. Have they heard of biodiesel? What do they think it is? Provide students with a definition for diesel and biodiesel. Write these definitions on the board or have students write them in their notes for future reference. NOTE: See *Glossary* for definition of biodiesel.

3. Have students research biodiesel and create a list of facts from their research. As a class, review the facts that were gathered and create a class fact sheet that can be used in Step 6.

4. Ask students to list the types of vehicles that use diesel fuel (they should list semi trucks, buses, heavy machinery, some automobiles). Ask students if diesel fuel is something they use. If students answer no, ask them if they grow all of their own food. If they don't, remind them that most of the goods we buy are shipped to us and transportation, many times, uses diesel.

5. Explain that gasoline and diesel cause pollution and are nonrenewable resources. Biodiesel, on the other hand, is a renewable resource that causes less pollution than diesel. Diesel fuel now comes with a mixture of biodiesel in it to extend the remaining diesel available and to reduce pollution.

6. Have students work individually or in groups to design their own advertisement for biodiesel. Make sure students refer to the purposes of advertising as well as advertising strategies. Provide each student or group with the fact sheet developed by the class in Step 3 to assist them with their ads.

7. Students may use the computer to design or draw their ad. All ads should be in color and fit on an 8 ½" by 11" piece of paper.

Closure

When the ads are turned in, place them on a bulletin board. As a class, discuss what ads stand out. What was the purpose of the ad? Did it achieve its purpose?

Assessment

Formative

- Can students explain the purpose of advertising?
- Were students able to identify strategies used to sell energy products?
- To what extent did students thoughtfully complete their own ads?

Summative

Have a group of students create a service, product, or company that uses or sells biomass energy. Instruct groups to exchange their creations with each other. Challenge the groups to design an advertisement for the imaginary service, product, or company that promotes efficient use of biomass energy.

Extension

Have students focus their advertisements on current energy innovations in the transportation sector. This does not need to be limited to diesel/biodiesel but can be expanded into any energy efficiency or alternative fuel technology.

Summary: Students identify current energy use practices and incorporate the use of energy from methane into community design. NOTE: This activity is best used as a conclusion to additional renewable energy or biomass energy lessons.

Community Design: It's a Gas

Grade Level: 5–8 (9–12)

Subject Areas: Environmental Education, Language Arts, Science, Social Studies

Setting: Classroom, Computer lab, Library

Time:
Preparation: One–two hours
Activity: One week

Vocabulary: Anaerobic digestion, Biogas, Biomass, Methane

Academic Standards:
Common Core ELA: SL.6-8.4

NGSS: MS-ESS3-3
SEP: Constructing Explanations and Designing Solutions
DCI: ESS3.A: Natural Resources, ESS.C: Human Impacts on Earth Systems
CCC: Cause and Effect, Engineering and Technology on Society and the Natural World

WI Env Literacy & Sustainability: C1.B.e, C1.B.m, EX2.B.m, EX2.C.i, EX3, A.m, EX3.B.m, EX4.A.i, EX4.B.i, EX4.B.m, EX5.B.m, EN6.A.i, EN6.B.i, EN6.B.m, EN6.C.i, EN7.B.i

Materials

- Tag board or a map of the city
- Drawing utensils or 3-D models of trees, hills, roads, homes, etc.

Getting Ready:

In the days before you introduce this activity, make sure you are familiar with your community resources. Does your community have a landfill? Where is the wastewater treatment facility? How many large farms are in the area?

Objectives

Students will be able to

- identify possible sources of methane gas;
- discuss the benefits of using methane; and
- discuss the limitations of incorporating the use of methane into their community as it currently exists.

Background

Community Planning

In the not-so-distant past, humans developed buildings and communities with renewable energy in mind. The availability of sources of fuel was included in the decision-making process. In modern society, these considerations have often dropped. In a time of growth, community planners are faced with the task of balancing multiple objectives, including economic feasibility, governmental regulations, social and cultural conditions, professional ethics, and environmental and architectural principles. The added planning and up-front costs that are incurred when using renewable energy in the design can often hinder its use.

Some planners recognize the environmental and economic benefits of including renewable energy as a consideration. They address wind patterns, solar access, the availability of unobstructed, direct sunlight, and energy efficiency. By designing a community with renewable energy in mind, residents can save money while reducing energy costs and living in a naturally comfortable home environment.

This activity will focus on methane (CH_4), a form of biomass energy that is generated from multiple sources. Methane can be used in much the same way as natural gas, but makes use of resources that are renewable. Methane can be made from cow, pig, or poultry waste, wastewater treatment facilities, and/or closed landfills. Many Wisconsin communities have agriculture, treatment facilities, and landfills near them. The production of biogas happens in an anaerobic system, or a system without oxygen. This happens in natural areas such as swamps, large bodies of water, and even in the stomach of large animals.

Methane from Animal Waste

Farms that have large herds of cows (over 500 head), pigs, or poultry can economically convert the manure into methane gas. Currently farms with small herds are not able to take advantage of this technology unless they work together and combine their resources. Research is being conducted to make this process work on smaller farms as well as large farms.

The animal waste is collected and dumped into the digester, which can be above or below ground. There are two types of digesters—batch and continuous. A batch digester is loaded with the waste, left to digest, and is then emptied and the process starts over again. A continuous digester is continuously fed with waste.

Useful by-products of this process are biogas (methane) and a solid material that can be used as fertilizer or bedding for animals. One of the added benefits of using a digester is that the smell of the animal waste is greatly reduced, which improves air quality for homes near the farm.

Methane from Wastewater Treatment Facilities

Wastewater treatment facilities treat the water that "goes down the drain." This wastewater includes our showers, sinks, and toilets. The treatment facilities are responsible for removing organic matter from the water, removing odor, and restoring the water to a higher quality than when it came in. As our communities grow, the demands on these facilities grow. One way the treatment facility can take advantage of the growing amount of wastewater is to use that waste to generate energy. The energy that is generated is sometimes used to power the wastewater treatment facilities. This can lower their energy bill, and since the residents of the community pay for the energy bill with tax money, it benefits not only the facility but the community as well. Some of the other benefits are the reduction of odors and the reduced production of solid waste. The solid waste that is produced can be used as a soil amendment after being processed.

Methane from Landfills

Most communities have a landfill nearby. When a landfill is filled up, it is then sealed off. Once the landfill is sealed, an anaerobic situation is created. The waste in the landfill breaks down in the absence of oxygen and gives off gases which are harmful to people and the environment. In order to prevent the release of the gases into the atmosphere the landfill gas is collected and flared. If you drive by a landfill at night, you can sometimes see the flares burning. One of the gases released is methane. Instead of burning the gas and not using it for the useful purpose, the gas can be burned to create electricity or used as fuel for heating.

See the activity “Roadside Renewables” for additional background information.

Procedure

Orientation

Talk about the principles and issues involved in community planning. Ask students what considerations they should address in designing the home plots and open spaces for a small community. Have them share ideas with the class. Encourage them to reflect on what comes into a community (electricity, water, fuel) and what leaves a community (waste, trash, heat). Consider other community needs such as transportation, recreation, privacy, etc.

Challenge students to identify which of the community activities are energy-related. Discuss which energy resources are currently used by most communities and how they enter and leave the community. Review costs and benefits of current energy use practices.

Introduce the topic of energy from alternative sources such as biomass. Can they name sources of biomass? Explain that there are many different ways biomass can be used to generate heat or electricity. Explain what methane is and how it can be made and used.

NOTE: This activity addresses one renewable resource—biomass from methane—which can be utilized in the development of a sustainable community. Refer to the activity “Sustainable Communities” in *Doable Renewables: A Renewable Energy Education Supplement* to the KEEP *Activity Guide* for an activity that includes all renewable energy resources.

Steps

1. Explain that the mayor of town X has requested information about biogas energy systems and is interested in developing more energy resources for his/her community. NOTE: Town X can be a fictional town or students can select an actual community such as their own. Other options include providing a map of a city for students or providing them tag board with pre-marked physical features such as rivers; wooded, plain, and wetland areas; topographical features; and existing structures (farms, homes, landfills, wastewater treatment facilities, power lines, etc.).

2. Inform the class that the goal is to assess a city for the potential of utilizing biogas energy technologies.

3. Establish teams of three or four students. If you are having students assess their own city, give them a few days to document the significant environmental and physical features, etc.

4. Explain that biogas energy technologies are often left out of the design of a city. Use the following questions to pose ideas for incorporating biogas into the students’ site design:

- What nonrenewable resources are currently heavily used?
- Is there a renewable energy source being utilized for heat or electricity?
- Are there options for incorporating biogas energy sources into active systems?
- Which options seem the most cost effective?

5. Assign student groups the task of incorporating biogas energy technologies into their city. Give students a week to establish their design.

Closure

Have students present their findings to the entire class and lead a discussion on how they decided to lay out their city. The discussion should include benefits and drawbacks to developing methane systems in the community. Have other students critically analyze each subdivision, making recommendations for improvement. Have students redesign their subdivision after student presentations and critiques. How do the designs change over time?

Assessment

Formative

- Were students able to identify the many ways a community can utilize bioenergy in the form of methane?
- Were students able to show the benefits and drawbacks to developing a community utilizing renewable energy?

Summative

Take students on a tour of a landfill or wastewater treatment facility. Have each student prepare a question to ask their guide. Review the questions to assess understanding of methane production from solid waste.

Extension

Explain to students what biomass is and ask students to list some sources of biomass energy. Take them on a tour of a wastewater treatment facility or a farm. Explain to students what happens with animal and human waste and what could be done in the future.

Have students do the same activity and try to incorporate additional biomass energy technologies (alternative fuels, using wood as a source of fuel, industries that use wood products can burn their wood waste to generate heat and/or steam) into the design of the city. See the other activities and fact sheets to get more ideas.

Don’t Waste Waste

Summary: Students “harvest” celery to demonstrate waste accumulation from timber practices and brainstorm uses for the waste products.

Grade Level: 5–8 (K–4)

Subject Areas: Environmental Education, Language Arts, Mathematics, Science

Setting: Classroom

Time:
Preparation: 30–60 minutes
Activity: One week

Vocabulary: Bioenergy, Biomass, Industrial wood residue

Materials

- Scale (see Getting Ready)
- Each group of students will need the following:
- A bunch of celery
- Two or three plastic knives
- A ruler
- Two large trays
- Calculators
- Copies of ***Don’t Waste Waste – Recording Page*** (optional)

Getting Ready:

Before the lesson, clean and weigh each bunch of celery and calculate the total. Determine the weight of each tray or zero out the scale.

Academic Standards:

Common Core ELA: RST.6-8.7

Common Core Math: MP1, MP5, MP6, MP7, 2.MD, 3.MD2, 3.NBT2, 3.OA7, 6.RP3c

NGSS: 5-LS2-1,
MS-LS1-6, MS-LS2-3
SEP: Constructing Explanations and Designing Solutions, Developing and using models
DCI: ESS3.A: Natural Resources, ESS.C: LS1.C: Organization for Matter and Energy Flow in

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Objectives

Students will be able to

- describe the parts of a tree;
- define biomass;
- identify alternative uses of the wood that is left behind after harvesting; and
- explain how biomass can be used to create energy.

Background

Biomass is defined as any plant-derived organic matter available on a renewable basis, including dedicated energy crops and trees, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, animal wastes, municipal wastes, and other waste materials. Biomass can provide energy in the form of electricity, heat, steam, and fuels. Bioenergy is the energy which can be generated from the use of biomass. Because biomass uses crops that are available on a renewable basis, it is considered a renewable energy source like sun, wind, water, and the heat from the earth (geothermal energy). According to the United States Department of Energy, biomass has been the largest source of renewable energy every year since 2000. Agricultural crops can be grown solely for bioenergy production, or the agricultural by-products can be used to create bioenergy.

According to the Department of Tourism, Wisconsin’s history is tied closely with the history of its forests. Before Wisconsin was admitted into the Union in 1848, approximately 63-86 percent of Wisconsin was covered with forests. Between 1859 and 1930, more than half of Wisconsin’s forests were cut down. It is during this time that Wisconsin became a world leader in logging. Since then, many of our forests have been restored, but Wisconsin still generates income from logging and the use of its forests. Forests are used by industry and individuals for various purposes including profit and recreation.

Wisconsin’s industrial sector is already using bioenergy from wood wastes and residues. Companies are able to use wood to produce heat (thermal energy) and electricity. According to the United States Department of Energy, the forest products industry uses 85% of the wood waste available to generate heat energy and electricity. Due to technological improvements, the amount of wood wasted when converting a log into a product has greatly improved. Some companies generated over half of their energy from biomass. Industrial wood residue or wood waste is any part of the tree that is not used for the primary product such as paper or timber. This can include leaves, branches, stumps, or any other part of the tree that is determined unusable by the company. Sawdust and wood chips can also be utilized to generate bioenergy. The wood residue can be used to heat a substance such as water or air. This heated water or air can then be used, for example, to maintain the temperature of an on-site kiln used for drying the wood products. Wood residue can also be burned to create steam, which then turns a turbine and creates energy.

NOTE: This activity calls the wood left after logging “waste.” That “waste” is actually a very important part of the ecosystem. The organic materials such as leaves, branches, and twigs that remain after a harvest act as shelter for some animals. This material also decomposes as it lies on the forest floor and nutrients are released into the soil, making it better suited for the current trees and the trees to come in future years.

Procedure

Orientation

Ask students to think of things that they throw away, but that could be used/reused. Paper that has been printed on one side can be used for scratch paper. An aluminum can may be used to store things on a desk. A plastic bottle can be used as a water bottle. Tell students that there are other things that are considered waste that can be used for a second purpose.

Organisms, LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
CCC: Energy and Matter

WI Env Literacy & Sustainability: C1.A.m, C1.B.e, EX2.A.e, EX2.A.m, EX2.B.e, EX2.B.i, EX4.A.i, EX4.A.m, Ex4.B.i, EX4.B.m, EX5.C.e, EX5.C.i, EN6.B.e, EN6.B.i, EN6.C.i, EN6.C.m

Related KEEP Activities:

"Roasted Peanuts"– *KEEP Energy Education Activity Guide.* "So You Want to Heat Your Home"—*KEEP Energy Education Activity Guide.* "Photosynthesis Promenade"– *BioFutures.* "Corn in Your Car"– *BioFutures*

Divide the class into groups of two to four students each. Ask students to list the parts of a tree and use a stalk of celery to show those parts. Draw the tree on the board as the students name the parts of the tree. Tell the groups that their assignment is to harvest trees. Celery will represent the trees. Hand out bunches of celery to each group of students along with a ruler, plastic knives, trays, and calculators.

Provide each group with a copy of the ***Don't Waste Waste–Recording Page***. Have each group weigh their celery bunch and record date before they begin cutting. Students should predict the weight of celery they will be able to harvest before cutting and record their estimates. Students should then cut straight pieces of celery that are three inches (7.6 cm) long. Walk around the room making sure the pieces are straight and accurately measured. Instruct the groups to put their cut pieces on one tray and the leftovers on another. Stop working on the data sheet and go to Step 1 below.

Steps

1. Inform the class that the celery-cutting exercise simulated a forestry project where trees were harvested and cut for lumber.

2. Point out that the groups successfully produced lumber, but what about the leftovers?

3. Use the ***Don't Waste Waste–Recording Page*** to record their findings and comments for Step 2. Ask groups to weigh their accumulated waste (subtracting the weight of the tray from the total if you did not zero out the scale). Provide the class with the weight of the celery before it was "harvested." Instruct the class to calculate what percentage of their harvest was "waste" (divide the weight of the leftover celery by the weight of the pre-cut celery). Discuss the results.

4. Explain that when trees are harvested, there is waste material as well. Have the class list the parts of a tree that might be leftover as a result of timber production (leaves, branches, bark).

5. Explain that the waste from industrial use of timber is called industrial wood residue and is a form of biomass. Ask the class what they think biomass is and help them develop a definition (see *Background*).

6. Ask the class to list what they think happens or should happen to this waste material. List student ideas on the board, noting if they mention using the biomass as an energy source. Introduce the term bioenergy and explain its role in industrial energy production (see *Glossary*).

7. Have students explore the Internet and other sources to learn more about the use of industrial timber waste for bioenergy. Ask students to list benefits and drawbacks of using timber waste for energy.

Closure

Draw a picture of a tree on the board and have students list the many ways humans use it as a resource. Make sure they include energy.

Clean the celery and use it as a healthy snack for the class.

Assessment

Formative

- Were students able to do the math to figure out how much of the celery was actually wasted?
- Were students able to draw a connection between using the waste and creating energy as a biomass source?

Summative

Throughout the activity, we have been referring to the wood not used by the timber company as "waste." This wood is not really wasted, even if it is left on the forest floor. As it decomposes, it adds valuable nutrients that are important to the ecosystem. Ask students if they can think of a new term for this wood.

Examples include: secondary materials, wood residue, co-products.

Take students on a field trip to a local company who utilizes wood products (paper company, timber company) and uses biomass energy or invite a representative from that company to come to the classroom to discuss how they use biomass as an energy source.

Extensions

Have the class participate in a role play about the fate of a clear cut forest, debating the pros and cons of using the industrial waste for bioenergy.

Research the idea of a zero-waste product—a product that has no waste from the production aspect. Are there companies that do this? If so, how do they do it? (Example: some utilities use cogeneration – combined heat and power.)

For younger students, you can simplify the lesson by just looking at the piles of waste and seeing how much there is instead of calculating actual percentages.

Don't Waste Waste Recording Page

1. What is the total weight of the timber (celery) harvested? ______________ grams (the whole class).

2. Estimate how much of the "forest" is usable and how much is waste.

Usable __________________ % (Usable weight / total weight)

Waste__________________ % (Leftover weight / total weight)

3. Cut the celery into straight "logs" that are three inches (7.6 cm) long. Then, weigh the logs and the leftover (waste) material. Record your data in the first row of the table below.

Group	Usable	Waste	Total
Your Group's Harvest	**(g)**	**(g)**	**(g)**
Harvest total from other groups:			
1.	(g)	(g)	(g)
2.	(g)	(g)	(g)
3.	(g)	(g)	(g)
4.	(g)	(g)	(g)
5.	(g)	(g)	(g)
6.	(g)	(g)	(g)
7.	(g)	(g)	(g)
8.	(g)	(g)	(g)
Total	**(g)**	**(g)**	**(g)**

4. Gather the findings of the other groups' harvest and fill in the table.

5. In the table above, add the class total of usable and waste timber.

Usable __________________ **grams**

Waste__________________ **grams**

6. Find the average usable timber percentage (total usable divided by the weight in Question 1. *(Remember to move the decimal point to get the percentage.)*

______________________ %

7. Find the average waste timber (total waste divided by the weight in Question 1. *(Remember to move the decimal point to get the percentage.)*

______________________ %

Grasses for the Masses

Summary: Students will learn that different types of grass produce varying amounts of biomass by planting varieties of grasses and measuring their growth rate and leafy content.

Objectives

Students will be able to

- describe what biomass is;
- explain how biomass is produced;
- understand what makes a good biomass fuel; and
- consider which biomass fuels to use for optimum energy output.

Background

The term bioenergy, or biomass energy, means any plant-derived organic matter available on a renewable basis, including dedicated energy crops and trees, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, animal wastes, municipal wastes, and other waste materials. These sources can provide energy in the form of electricity, heat, steam, and fuels. (See the activity "*Biomass Gazette*" for more background information on biomass.)

Biomass is a renewable resource—it can be replaced fairly quickly without permanently depleting Earth's natural resources. By comparison, fossil fuels, such as petroleum and coal, require millions of years of natural processes to be produced. Drilling for petroleum is considered a nonrenewable process because it depletes Earth's resources for thousands of generations.

There is more to consider than just energy input and output (the balance of energy put into growing and making a product compared to the amount of energy the fuel provides when used) when deciding which biomass fuel to use. Non-native plants may be an attractive biomass fuel to consider, however, the impact on the surrounding environment, on native animals, and other plants could be devastating and not worth the risk. Introducing non-native species always has a negative impact on ecosystems.

Current land use should also be considered. What exists on the land now and how would planting biomass fuels change the landscape or value of the land?

Grasses are an option for biomass fuels. Grasses are also used as food for livestock and are also processing into food and beverages for human consumption. According to the Wisconsin Department of Agriculture and Trade unmilled cereals such as corn, wheat, rye, and oats make up $256.8 million in exports for Wisconsin.

Economics Versus Sustainability

The use of biomass energy can lessen our dependence on fossil fuels. Nearly every source of energy, including renewable, comes with some kind of trade off. The main debate surrounding the use of bioenergy is the economic advantages versus the environmental/sustainability disadvantages.

For example, ethanol, an alternative fuel, is being made from corn in Wisconsin. The advantage to this is that the use of ethanol means that we use less foreign oil. This can strengthen national security. By increasing the supply of fuel for transportation, we also increase supply, which, in turn can steady the rises and slumps in fuel prices. The supply and demand would also help farmers get a better price for the corn they are harvesting.

On the other hand, the corn that is currently grown in Wisconsin is energy intensive and, depending on cultivation practices, there can be a number of environmental concerns. There can be run-off, which carries topsoil into waterways where the water becomes turbid (muddy) and this can threaten fish populations. The more corn we need for fuel, the more corn we will grow. This can create a monoculture of corn. A monoculture reduces diversity and can become a threat to the security of the crop. If a pest or disease becomes resilient to protective measures, a whole crop can be lost, which would mean the loss of not only a source of fuel but a source of food as well.

Grade Level: 5–8

Subject Areas: Agriculture, Environmental Education, Science

Setting: Classroom or laboratory

Time:
Part I–approximately two weeks, Part II–two hours

Vocabulary: Biomass, Btu, Dry weight, Energy input, Energy output, Fresh weight, Light energy, Native and non-native species, Photosynthesis

Academic Standards:

Common Core Math: MP5, MP6, 6.SP.5a&b

NGSS: MS-LS1-5, MS-LS1-6, MS-LS1-7
SEP: Planning and Carrying Out Investigations
DCI: ESS3.A: Natural Resources, ESS.C: LS1.B: Growth and Development of Organisms, LS1.C: Organization for Matter and Energy Flow in Organisms
CCC: Energy and Matter

WI Env Literacy & Sustainability: C1.A.m, C1.B.i, C1.B.m, EX2.A.m, EX2.B.m, EX2.C.i, EX3.B.m, EX4.A.i, EN6.C.m

Materials

- 3 half-gallon milk cartons (large ice cream cartons work well also)
- Seeds: wheat or rye seed, corn seed, and oat seeds (whole seeds only, not milled)
- Potting soil
- Fluorescent grow lamp (optional) or window for plants to be near
- Copies of ***Plant Growth and Development Chart***
- Scale (balance or kitchen)
- Copies of ***Weight Chart***
- Dehydrator or oven

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Resources:

Biomass Resources Center
www.biomasscenter.org/

Pellet Fuels Institute
www.pelletheat.org

United States Department of Energy
www.energy.gov/science-innovation/energy-sources/renewable-energy/bioenergy

Related KEEP Activities:

"Corn in Your Car"–*BioFutures.*
"BioFuel Beliefs"–*BioFutures*

Credits:

Adapted with permission from the Department of Energy's National Renewable Energy Laboratory. "Activity 9: Which Grass Produces More Biomass" p. 61 in Renewable Energy Activities–Choices for Tomorrow: Teacher's *Activity Guide* for Middle Level Grades 6-8. Golden, CO. Used with permission.

Procedure

Orientation

Ask students how they feel if they do not eat. Do they feel tired? How do they feel after they eat? Do they have more energy? Tell students when we eat our bodies use the energy stored in food to keep our bodies functioning.

Once students have determined that plants do indeed contain energy, ask them if they think plants could replace fossil fuels such as oil, natural gas, or coal. What plants do the students think contain the most energy? The larger, more dense plants probably have the most energy due to their mass.

Now ask the students how humans can get the energy from the plants. Some possibilities include eating the plants and burning the plants, which are both correct answers.

Explain the term biomass to your students and ask if any of them have a fireplace, wood stove, or pellet stove in their home. Discuss the fuels that are burned in fireplaces and distinguish between wood and wood pellets. There may be other fuels that students' families burn as well. Brainstorm why different fuels exist and what the differences may be between one fuel source and another. Discuss why some people may choose one fuel over another. Possibilities include size, mass, ease of use, availability, amount of heat produced, cost, etc.

Steps

Part I

1. Divide the class into groups. Provide each group with planting material and provide the class with the following instructions. Cut the milk cartons in half and fill them with potting soil.

2. Plant the same number of seeds in each milk carton and keep the soil moist. Plant different varieties of seeds in separate milk cartons. Plants will take approximately two weeks to grow (leave an extra week to be sure that the plants have plenty of time to grow).

3. Keep track of growth rates in the ***Plant Growth and Development Chart***. If one of the days falls on a weekend, feel free to change the measuring schedule. Make sure to measure each species of plant on the same day.

Steps

Part II

1. After the plants have grown for the same amount of time (14 days or longer), pull them out of the soil by the roots.

2. Wash off all of the dirt on the plants and dry them with a paper towel.

3. Weigh the plants and record the data in the ***Weight Chart***.

4. Place the grasses on separate pieces of paper and let them dry out. You can use a dehydrator or an oven to speed up the process.

5. Weigh the dry plants and record the data in the ***Weight Chart.*** Ask the students which plant has the most mass and discuss why it has the most mass.

6. Ask students to form a hypothesis on the relationship between the mass of the plant and the amount of energy that the plant contains. NOTE: There is a direct correlation between the dried mass of the plant and the amount of energy it will produce.

7. Take the grasses that were grown in this activity and burn the same weight of each variety to discover which grass possesses the most energy (the one that burns the longest or produces the most heat). Answer these questions: Was their hypothesis correct? Would the plants hold more energy if they were allowed to mature? Do other types of grasses (or plants) produce more biomass?

Closure

Have students discuss the pros and cons to using agricultural crops such as wheat and oats as a source of energy. Consider using the Viewpoints Chart from the activity "*BioFuel Beliefs.*"

Assessment

Formative

- How well did the students conduct their experiments?
- Did the students use the scale and fill out their charts correctly?
- Can they make a conclusion as to what plant would work best for a biomass fuel and explain why?

Summative

Invite a guest speaker who uses biomass at home or in a business to present to the class. A list of guest speakers can be found on the KEEP Web site at www.keepprogram.org. Have each student prepare at least one question for your visitor. Also, have your students discuss their class experiment with the speaker. Make sure to ask the speaker why he/she chose the fuel he/she did.

Extensions

Have each student bring in a different plant seed and their own milk carton. Each student will be responsible for caring for their own plant species. Have each student graph the growth of their plant every two days. Have two or more students grow the same plant to see if their plants grow at the same rate. Possibly put the same plant species in different areas of the classroom to expose them to different growing conditions. Decide as a class whether the plants they brought in are native to the area and whether they would make a good fuel source for Wisconsin.

Have students research what biomass fuels are suitable to be grown in Wisconsin and whether they are native. Give them a map of Wisconsin and ask them to draw or color the areas of the state where that particular biomass fuel source grows. Ask them to compare Wisconsin's biomass fuel sources to other states and other countries. Where do the most biomass fuel plants grow and why? Are countries taking full advantage of the use of biomass fuels? Do the students think this type of alternative fuel source will grow and become more widely used? Are they (or their families) willing to use it in their homes or in their cars?

Charts

Plant Growth and Development

		Germination					Average Height				
Seed Type	Date Planted	Day of 1st sprout	Date of 10th sprout	Date of 20th sprout	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
Wheat or Rye											
Corn											
Rye											

		Weight	
		Fresh Weight (oz.)	Dry Weight (oz.)
Test plants	Wheat or Rye		
	Corn		
	Rye		

Roadside Renewables

Summary:
Students build a model landfill, observe the decomposition process, and collect the gas that is emitted from the model.

Objectives

Students will be able to

- explain why we use landfills;
- identify materials that go into a landfill and what is recycled; and
- explain how methane is collected from a closed landfill.

Background

What is a Landfill?

A landfill is not simply a hole in the ground where we dispose of trash, but a thought out system of disposing of waste. Landfills are designed to protect the soil, groundwater, and air from being polluted by the items we throw away. Landfills have a liner of clay and a synthetic material that keeps the liquids in a landfill inside so they will not leach into the soil or groundwater. Landfills also get a layer of soil put on top of them at the end of the day, called a daily cover, to reduce problems with animals and smells and to keep debris from blowing away.

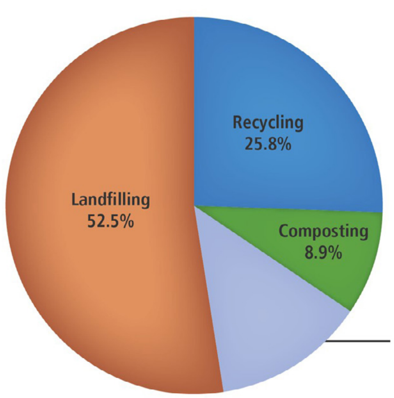
Why Do We Use Landfills?

Throughout the world, humans dispose of things they do not need anymore. In the United States, we also use landfills to hold the things we no longer want. Most households have a trash can and a recycling bin somewhere, and once a week the trash and recycling are picked up by a truck and taken away. What happens after it leaves the curb? It goes to two separate places. Approximately 26% of the waste is recyclable materials that go to a recycling plant where they are sorted and shipped to other places to be reused. Approximately 53% of our trash goes to a landfill where it is dumped, piled, and plowed, to be continued forever. Nearly 9% of waste is composted. The remaining 12.8% of trash is burned by incineration.

Life cycle of a Landfill

A landfill location must be approved before the building begins. This can be a long and complicated process because many people do not want to live next to a landfill. There is often a lot of public opinion on the location. Then an environmental impact study must be conducted in order to determine what effect, if any, the landfill will have on the environment. The impact study is reviewed by the Wisconsin Department of Natural Resources, and, if the environmental impact study is completed without raising concern then the local government or private company must submit forms to obtain permits and raise the money to build a landfill. A vote from the public is often needed to raise the money to build a landfill. After these first steps have been completed, the landfill is built.

Once the landfill is operating, our waste begins to be brought by truck and local citizens to be disposed of. A landfill has small



While nearly 30% of our trash is recycled or composted, there is still more than 50% that goes into landfills. This never-ending pile of waste can provide renewable energy for years to come.

Source: Environmental Protection Agency (2015) figures: www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials

Grade Level: 5–8 (9–12)

Subject Areas: Environmental Education, Family and Consumer Education, Science

Setting: Classroom

Time:
Preparation: 90 minutes
Activity: One 50-minute class period to construct models, plus several weeks to watch the process unfold

Vocabulary: Anaerobic digestion, Decomposition, Landfill, Leachate, Methane

Academic Standards:
NGSS: MS-ESS3-3
SEP: Constructing Explanations and Designing Solutions
DCI: ESS3.C: Human Impacts on Earth Systems
CCC: Influence of Science, Engineering, and Technology on Society and the Natural World

WI Env Literacy & Sustainability: C1.A.m, C1.B.e, EX2.A.i, EX2.A.m, EX2.B.i, EX2.B.m, EX2.C.e, EX3.A.m, EX3.B.m, EX4.A.i, EX4.A.m, EX5.C.i, EN6.A.i, EN6.A.m, EN6.B.m, EN6.C.m

Materials: Samples of commonly discarded waste materials, including recyclable materials (kitchen scraps, leaves, newspaper, plastic bottles etc.) NOTE: Natural materials and food waste will work best for this activity. Think about what items decompose quickly.

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Each group of students will need the following:

- Copies of ***Pre- and Post-Activity Worksheets, How to Build a Model Landfill–Student Activity Sheet,*** and ***Roadside Renewables–Data Sheet***
- Glass or plastic jars with tight covers
- Drill for drilling holes in jar covers.
- One foot of plastic or glass tubing
- Ceramic clay in slip (liquid) form
- Scissors
- Rubber bands
- Plastic bag or other lightweight bag/balloon
- Clear plastic wrap

Resources:

How Stuff Works
https://science.howstuffworks.com/environmental/green-science/landfill.htm

Related KEEP Activities:

"Community Design–It's a Gas"–*BioFutures.* "Biomass Gazette"–*BioFutures.*

Credits:

Adapted with permission from *The Infinite Power of Texas*. "Follow Up Activity 'A' - Making Landfill Gas" p. 13 in Clean Energy from Texas Landfills Activity Guide. Austin, Texas. Used with permission.

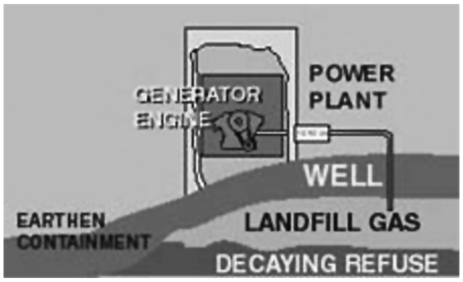
areas called cells where dumping takes place in during the day. This is done so it is easier to manage and easier to cover the smaller area with dirt at the end of the day (daily cover). Once a cell is closed, it is covered with a six-inch layer of soil and another section is used the next day. Once a cell is closed and permanently capped the methane generated from decomposition can be collected (see section on Energy from Landfills).

Once the landfill is closed and capped, it must be monitored. The landfill is monitored to look for leaks in the liner and several groundwater wells are also tested regularly in order to determine if any liquid/leachate from the landfill has leached into the groundwater.

Energy from Landfills

The material in a landfill decomposes because there are anaerobic bacteria that thrive in the oxygen-free (anaerobic) environment. As decomposition takes place, gases are given off. This process is called anaerobic digestion. Methane, carbon dioxide, and other landfill gases are pulled out of the landfill through well and vacuum systems that are piped into the landfill. 50–60% of the gas given off by a landfill is methane. Methane is a gas that can be used to generate electricity and can be used like natural gas for heating spaces, heating water, and cooking. Natural gas is a non-renewable fuel that is usually burned to produce heat and to generate electricity. Methane is a very harmful greenhouse gas and must therefore be burned, or flared, as it is released from the landfill.

While the United States has reduced the waste going into our landfills by recycling, there will always be landfills. Because landfills will remain the main place to dispose of our waste, this source of energy is considered renewable. Not only are we generating energy from the methane, but we are reducing the amount of climate changing gases that are released into the atmosphere. This reduces smog, pollution, and global climate change and generates energy.



This graphic shows a simple cross section of a landfill and how energy can be harnessed from it.

Source: Primary Power International. Ithica, Mich.

Procedure

Orientation

Ask students what happens to their trash after it is taken to the curb. They should reply that it is picked up by the garbage truck and then it is taken to the landfill. Make sure students know the difference between what happens to their recycling and their garbage.

Show students the collection of sample waste materials. Hold up each of the materials and ask students where each item should go (landfill or recycling). Separate them into two piles and have the landfill materials ready for the activity. NOTE: You can identify biomass materials as any organic matter, such as any plant material.

Ask students to share what they know about landfills and how they operate. Correct or supplement their answers with information found in the Background and other sources. Make sure students understand the following key points:

- Nearly 53% of our trash goes to a landfill
- It takes many years for the trash to decompose and the landfill will eventually be full and a new landfill will need to be built.
- Landfills need to be covered and monitored to protect the environment.
- The trash in the landfill decomposes even when the landfill is covered.
- The process of decomposition gives off gases that are harmful to the environment. Because the gas is considered a source of pollution, it must be burnt or collected. The gas being collected is composed of carbon dioxide, methane, and many other gases.
- One thing that can be done with the gas is to burn it to create electricity and/or heat.

Steps

1. Divide the class into groups of four and explain that each group will be building a model landfill.

2. Provide each group with a copy of the ***How to Build a Model Landfill*** handout. Review the steps and, after students understand the activity, provide each group with a bag of landfill materials (the bulk of the materials should be organic matter such as food waste and yard waste). Hand out or have one student from each group collect the other materials needed for the activity.

3. After students have completed building their model, tell them that their landfill has been closed by the city and that it is time to seal it up. Explain that when the material in the landfill breaks down, it generates gases and those gases need to be vented out of the landfill.

4. After students have completed sealing their landfill, ask why the landfill needs to be sealed tightly. NOTE: If students are not able to seal their landfills with the rubber bands, they might use extra clay. The landfill needs to be sealed so the gas will not escape.

5. Hand out the ***Pre-Activity Worksheet.*** Students should complete the form as a group.

6. If possible, place the models outside in the sun, in a sunny interior window, or another warm place. Hand out copies of ***Roadside Renewables–Data Sheet*** and have students monitor their landfills and complete the questions at the end. This activity may take an extended amount of time to produce enough gas to be viewed by the students. The more easily broken down the materials are and the more tightly the jar is sealed, the better off you will be.

7. Ask students what they think cities and municipalities do with the collected gas. Explain that in closed landfills which do not collect the methane for energy, the methane must be burned off. You can sometimes see this as you drive by a landfill at night. Inform them that because the city has decided to use the gas from the landfill for energy, they must burn the methane so it is not released into the atmosphere (see **Background**). Methane is burned and used much like natural gas. **Caution: Students should release the gas from their landfills outdoors in a well ventilated area; it is too risky to try to burn the gas their landfills might generate.**

Closure

Review the discussion in the **Orientation** about which materials are recycled and which items are not. Hold up a few items and ask students where they should go. Have students review the purpose of a landfill and how it works for communities. See if they list landfills as a potential energy source within their descriptions.

Have students complete the **Post-Activity Worksheet** and discuss the results.

Ask students why landfills need to be closed when they are full. Ask them to explain what happens inside the landfill. Why does the gas need to be collected and flared off? What is another option besides flaring or burning off?

Assessment

Formative

- Can students describe the purpose of a landfill and how it works for the community?
- Have students list materials that should go into a landfill and what should be recycled.
- Ask students to explain how landfills can be an energy source for the community.
- Can they identify the gas that is collected from landfills?
- How thoroughly did students complete their *Roadside Renewables–Data Sheet*?

Summative

Have students conduct additional research on landfills as an energy source, listing pros and cons of this resource. Do they think capturing and using gas from landfills is a good option? Why or why not?

Extension

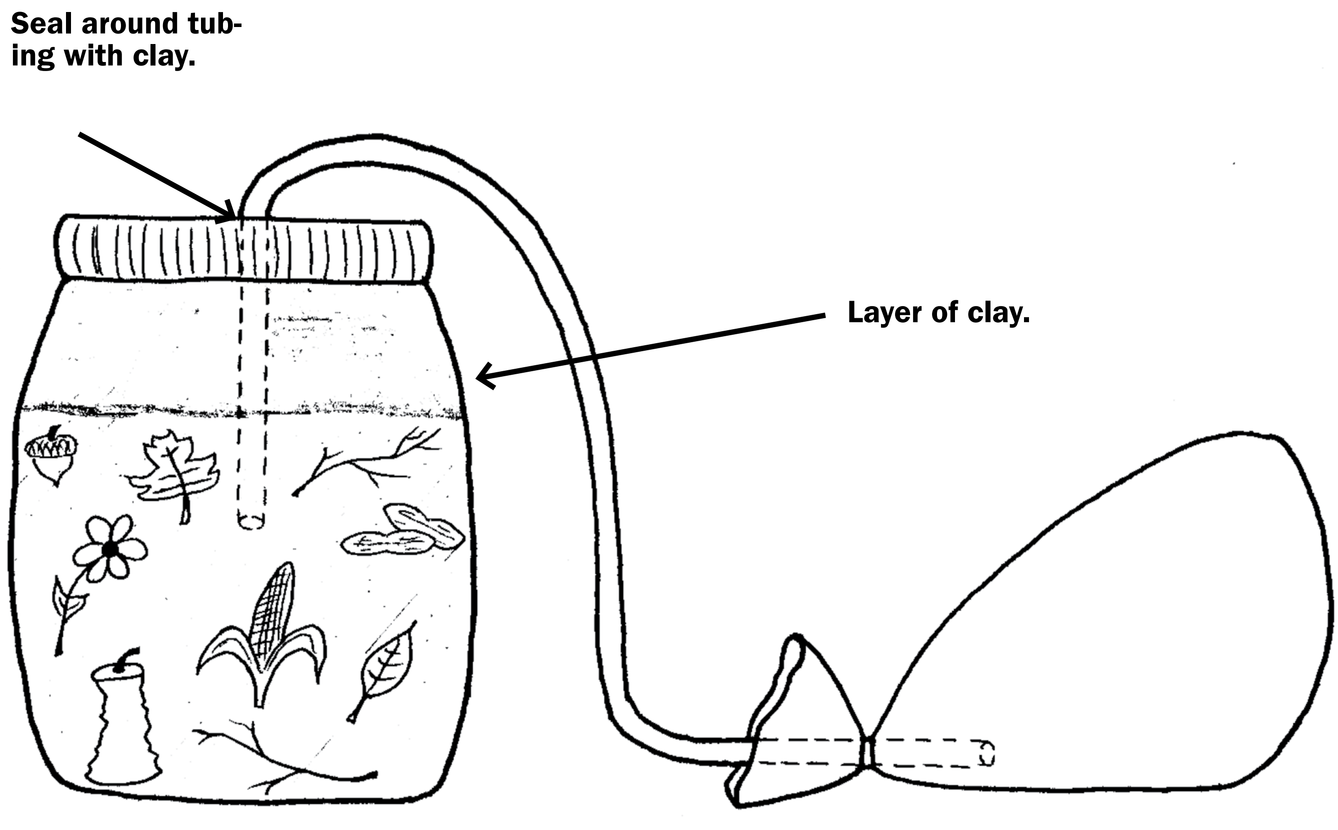
Have students work in groups to find out if there are any landfills in Wisconsin that use anaerobic digestion to generate energy. Put a state map on the board and have students mark them as they locate them. Have one student call the local landfill to find out the history of the landfill. How long will it last? Where was the last landfill and what is it being used for now? Are there any closed landfills nearby? What are those used for?

Take students on a field trip to a landfill so students can see how much waste is generated.

NOTE: This activity uses materials that can also be composted or put into a yard waste facility. These materials were used in the activity because they decompose much faster than the other materials we put into a landfill. Consider building a compost bin with your students to discuss this process as well.

How to build a model landfill

1. Drill a hole in the lid of your container the size of the plastic tubing.
2. Fill your landfill with materials from the landfill pile. Write down the materials you put in your landfill on the ***Roadside Renewables–Data Sheet.***
3. Add a couple drops of water.
4. Insert the plastic tubing into the landfill pile and then cover the top of the waste with a layer of clay.
5. Push the other end of the plastic tube through the lid of the container and carefully seal the container with clay.
6. Put a light-weight plastic bag (or balloon) on the end of the tubing and seal it tightly with a rubber band.
7. Make sure that the landfill is sealed against any leaks and pay special attention to the area surrounding the plastic tube.



Roadside Renewables
Pre-activity Worksheet

1. What did you put in your landfill?

2. How long do you think it will take the plastic bag to fill with gas?

3. Fill out the data sheet.

Post-activity Worksheet

1. How many days did it take for your landfill to produce gas?

2. Did your landfill produce gas before other students', at the same time as others', or not at all? Why?

3. What would you do differently next time you build a landfill in order to produce gas more quickly?

Roadside Renewables Data Sheet

Date	Observations

Biofuel Beliefs

Summary:
Students use research skills to investigate various viewpoints surrounding the issue of ethanol as a fuel in Wisconsin.

Grade Level: 9–12 (5–8)

Subject Areas: Agriculture, Environmental Education, Language Arts, Science, Social Studies

Setting: Classroom, Library, Computer lab

Time:
Preparation: 30 minutes
Activity: Up to one week

Vocabulary: Energy input, Energy output, Ethanol, Net energy value (NEV)

Getting Ready: It may be helpful to involve the school librarian with research.

Academic Standards:
Common Core ELA: RL.9-12.1, RI.9-12.1, W.9-12.1-2&4&7-8

NGSS: HS-ESS3-1, HS-ESS3-4
SEP: Engaging in Argument from Evidence
DCI: ESS3.A: Natural Resources, ESS3.C: Human Impacts on Earth Systems, ETS1.B: Developing Possible Solutions
CCC: Influence of Science, Engineering, and Technology on Society and the Natural World, Science is a Human Endeavor

WI Env Literacy & Sustainability: C1.A.h, C1.B.h, EX2.C.h, EX3.A.i, EX3.B.h, EX3.C.h, EX4.B.h, EX5.A.h, EN6.A.m, EN6.B.h, EN6.C.i, EN6.C.m, EN7.A.h, EN7.B.h

Materials

- Copies of ***Ethanol Viewpoint Form***
- Articles and Web sites on ethanol (see the *Resources* section of the KEEP Web site for *BioFutures* and the articles).

Continued Next Page

Objectives

Students will be able to

- provide an overview of ethanol production;
- identify at least two different viewpoints about ethanol; and
- write an objective paper about the opinions of different people involved in the ethanol debate.

Background

To better understand environmental issues, it is helpful to analyze the viewpoints surrounding the issue. Investigating the viewpoints involves research, observation, and critical thinking skills.

See background material from *"Corn in Your Car."*

Read the articles listed below (found on the KEEP Web site in the Curriculum< *BioFutures* section) to gain a better understanding of the debate about ethanol.

- History of Ethanol Production (websites)
- Why are there disparities in the net energy value of ethanol? Read the United States Department of Agriculture's article, "The Energy Balance of Corn Ethanol: an Update." A summary of the article is on page iii.
- Read David Pimentel's article "Biomass Utilization, Limits." Section C is specifically about ethanol production.

Procedure

Orientation

Write the word "ethanol" on the board and ask students what they have heard or know about the topic. Note their responses.

Survey students to get an idea of their opinions and knowledge on the topic. Ask students if they think there is agreement about the use of ethanol as fuel. Help students understand that there are disagreements about the benefits of ethanol and that they are going to learn about the varying viewpoints.

Provide students with a basic description of what ethanol is and how it is made. Make sure students understand all vocabulary words.

Steps

1. Tell students they are going to investigate different people's opinions about the positive and negative impacts of producing and using ethanol as a fuel.

2. Discuss sources where students can find articles and Web sites on ethanol. Students should mention the Internet, journal articles, news reports, and books. Invite the school librarian to speak to the class about researching information.

3. Have students work in pairs or groups of three to investigate the various viewpoints. The groups can designate responsibilities for each member. For example, one student can be responsible for looking at Web sites and newspapers. Another student can research journal articles and books. Students can use various strategies to research viewpoints. Following is one approach:

- Each group should find at least six sources of information on ethanol. Allow about a week for students to research the information. Out-of-class assignments may be necessary.
- Ask the group to select two sources to investigate further. At this time, students can share their choices with you to make sure a diversity of resources are being investigated.
- Have students use the ***Ethanol Viewpoint Form*** to summarize their findings. Review the different parts of the form. The "Viewpoint" is a one-sentence summary that succinctly states the author's opinion. Students should use the "Additional or supplementary information" section to explain the reasoning or background behind the viewpoint. Ideally, students should cite scientific facts that were referenced within the source. The "Source" section

- should include reference information to help the reader find the resource, but it also identifies who authored the resource. (Knowing if the author is a member of a certain organization or receives funding from a particular agency can provide insight into motivations or influences behind the viewpoint presented).
- Everyone in the group should read all the sources, but each group member can be responsible for drafting the ***Ethanol Viewpoint Form*** for one of the sources. They should then meet as a group and share their work and edit and revise the form together.

4. After the groups have investigated at least two different sources of viewpoints about ethanol, have each group present their findings to the class.

5. When the students finish their presentations, have them post the ***Ethanol Viewpoint Form*** on the wall. Challenge the class to group similar or related viewpoints together. They can create a diagram similar to the one on the next page, where ethanol is in the center and the viewpoints are grouped around the center.

Closure

Have students summarize the various opinions presented in the diagram (Step 5). Were they aware of these different viewpoints before they conducted this research? Why do students think there are varying opinions?

Ask students to present their own viewpoints (compare to the survey conducted in the orientation). Do they find themselves agreeing with one or more of these viewpoints? Generate a list of questions about what else they would like to know about ethanol before they form an opinion.

Have students examine their energy use in relation to transportation.

NOTE: You can also conclude the activity with a debate on the pros and cons of using ethanol. You can divide students into groups and assign them each a role to play (farmer, politician, feed company president, investor, etc.).

Assessment

Formative

- Did students use effective research strategies to identify a variety of different viewpoints about ethanol?
- By reading students' ***Ethanol Viewpoint Forms***, can the reader quickly understand the viewpoint of the source?
- Were students able to group similar viewpoints together?

Summative

Have students write an informative article about ethanol and the various viewpoints involved. Encourage students to be objective and not to favor any viewpoint. Discuss the challenges with developing a paper of this format and the strategies they use to remain impartial. They can submit the article to the school newspaper or their local paper.

Extensions

Have students each pick a viewpoint and stage a debate.

Take students on a field trip to an ethanol production facility or invite staff from the facility to come be a guest speaker in the classroom.

Resources:

Ethanol Across America
www.ethanolacrossamerica.net/education.html

All About Ethanol
www.ethanol.org/

Renewable Fuels Association
https://ethanolrfa.org/

Growth Energy (America's Ethanol Supporters)
https://growthenergy.org/

Opposition to Ethanol
www.energyjustice.net/ethanol/

Viewpoints

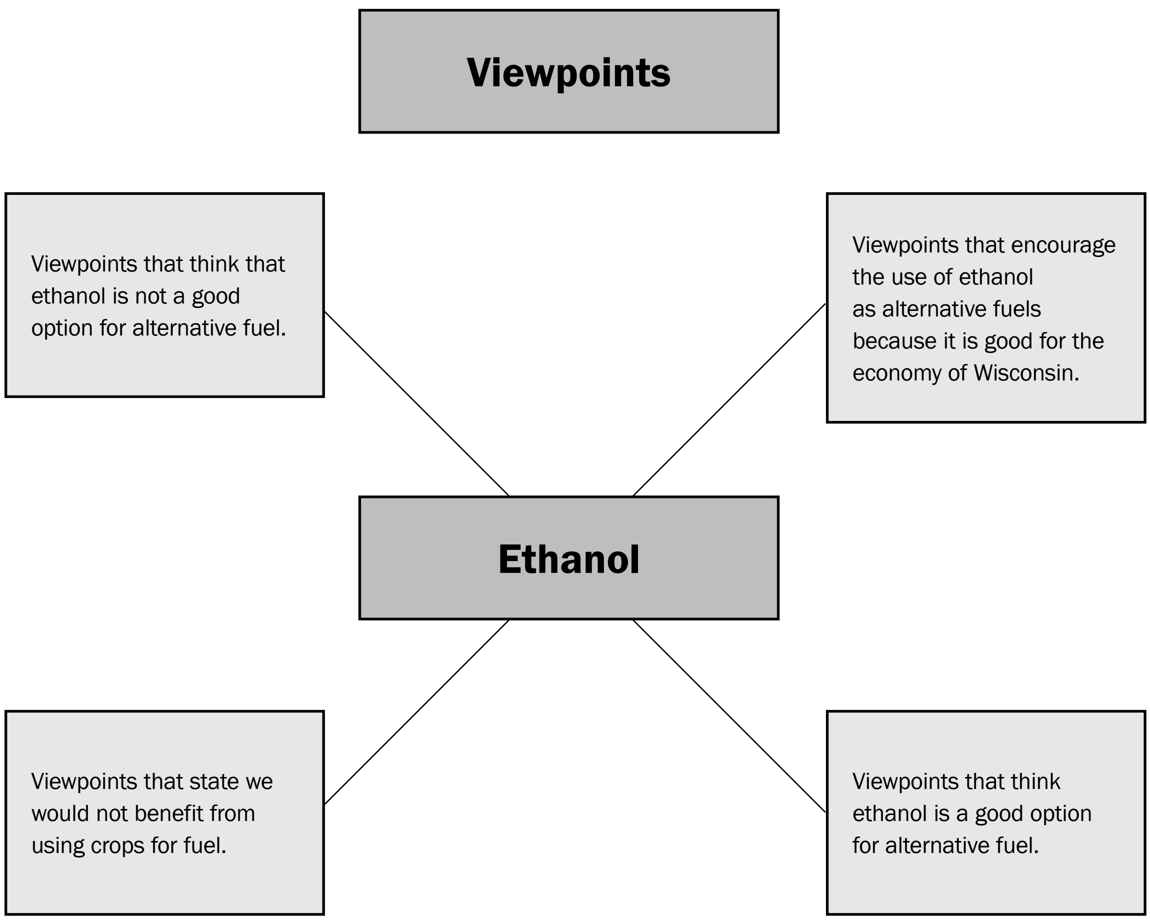
Pro-Ethanol Viewpoint

- Net Energy Value (NEV) is positive
- Good for Wisconsin's faming economy
- Low air pollutant emissions

Anti-Ethanol Viewpoint

- Net Energy Balance (NEV) is negative
- Not enough corn for food and/or feed
- More research needed

Ethanol–(Issues) Viewpoints that think there is not enough corn for food or feed. Viewpoints that think the Net Energy Balance is negative. Viewpoints that think the net energy balance is positive. Viewpoints that think there should be more research.



Ethanol Viewpoint Form

Viewpoint

Write a one or two sentence summary for the information in this source.

Additional or supplementary information

Source

Author or organization:

Title (of article or Web site):

Title of book or journal:

Date:

Other reference information (Web site address or volume number):

Summary:
Students will act as reporters assembling a newspaper on biomass energy.

Biomass Gazette

Grade Level: 9–12 (7–8)

Subject Areas: Environmental Education, Language Arts, Science, Social Studies

Setting: Classroom, Computer lab, Library

Time:
Preparation: One hour
Activity: One–two weeks

Vocabulary: Bioenergy, Biomass

Academic Standards:
Common Core ELA: RL.9-12.1, RI.9-12.1, W.9-12.2&4-8

NGSS: HS-ESS3-4
DCI: ESS3.A: Natural Resources, ESS3.C: Human Impacts on Earth Systems, ETS1.B: Developing Possible Solutions
CCC: Influence of Engineering, Technology, and Science on Society and the Natural World

WI Env Literacy & Sustainability:
C1.B.m, EX2.C.i, EX4.B.i, EX4.B.m, EN6.C.i

Materials

- Resources and reference materials about bioenergy resources
- Computer lab with Internet access

Resources:

National Corn Growers Association
www.ncga.com/home

Wisconsin Biofuels Association
http://wibiofuels.org/associate-members/

EPA Alternative Fuels
www.epa.gov/renewable-fuel-standard-program/alternative-fuels

Objectives

Students will be able to

- describe how bioenergy works;
- provide examples of biomass energy use in Wisconsin; and
- describe how a news article is different than an essay.

Background

Points of Journalism:

Writing a news article is different from writing an essay. In a news article, there is no conclusion. The reader should be able to stop reading the story at any time and still know what the story is about. The headline of a story is usually short and should send a message about the article. The headline can be clever, as long as the cleverness does not interfere with the message. The lead is the first sentence of a story and is one of the most important parts of the article. If the reader likes the lead, then he/she will continue to read the story. The lead usually contains six elements: the who, what, why, when, where, and how of the story. The most important information of the article should be at the beginning and the least important at the end. Paragraphs should be short and concise; two to three sentences are usually enough.

When writing a news article, every good journalist must keep journalism ethics in mind. Ethics deal with what is good/bad and moral/immoral. Journalists have four basic rules to follow, according to the Society of Professional Journalists:

1. **Seek truth and report it**–"Journalists should be honest, fair, and courageous in gathering, reporting, and interpreting information."
2. **Minimize harm**–"Ethical journalists treat sources, subjects, and colleagues as human beings deserving of respect."
3. **Act independently**–"Journalists should be free of obligation to any interest other than the public's right to know."
4. **Be accountable**–"Journalists are accountable to their readers, listeners, viewers, and each other."

Biomass

Biomass is any plant-derived organic matter available on a renewable basis, including dedicated energy crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, animal wastes, municipal wastes, and other waste materials. These sources can provide energy in the form of electricity, heat, steam, and fuels.

Some biomass topics include:
(* indicates a more difficult topic.)

Direct burning–Burning biomass only for energy. *Examples: Wood burner, pellet stove.*

Co-firing–Burning biomass along with a fossil fuel. *Example: Combining coal and biomass to generate energy.*

Anaerobic digestion–Bacteria decomposes biomass in liquid to produce biogas in an airtight vessel or enclosure. Biogas is then used to generate energy. *Example: Anaerobic digesters are being used on farms to generate biogas from animal waste.*

Bio-fuels–Alternative fuels made from biomass; used for transportation. *Examples: Biodiesel and ethanol.*

***Gasification**–The solid form of biomass is heated up and it changes into a gas. The gas is then changed into other fuels or burned in a boiler. The gas can be used as a substitute for natural gas.

***Pyrolysis**–Pyrolysis uses a process similar to gasification except it eliminates the presence of oxygen altogether.

Biomass is a controversial topic. When writing their articles, it is important for students to understand what makes a good article (see ***Points of Journalism*** in B***ackground***). Before reporting, they should verify that their information is from a reputable source and make sure they address both sides of the story. See **Resources** for more information on biomass.

NOTE: For examples of newspaper articles on biomass, see the following newspapers: *The Country Today, Agri-View, Wisconsin Farmer*, or *The Agriculturist.*

Procedure

Orientation

Ask students where people get news (TV, newspapers, radio, etc.). Ask them what makes a good story. List this on the board. Ask students what rules they think a reporter must follow in order to do a good job reporting a story (see *Points of Journalism*). List these on the board.

Ask students if they think renewable energy is a newsworthy topic. What might make renewable energy headline news? Have students look through newspapers and see if renewable energy is mentioned.

Tell students they are going to be assembling a newspaper about bioenergy, or energy made from biomass. Make sure students understand the components of a good article and the ethics of journalism. Have students explore newspapers (or on-line papers) looking for information on energy use in Wisconsin and throughout the world. Have them analyze their articles utilizing the Points of Journalism. Have students identify the ways in which information is given to the reader. Is it always text, or are charts, graphs, and pictures used to tell a story as well? When discussing new, innovative, or advanced topics (including biomass energy in Wisconsin), journalists are challenged to help the public understand technical concepts in a clear manner. Remember, a picture speaks a thousand words. Use diagrams and illustrations to help explain. Think of other strategies journalists use to educate the public in an interesting manner.

Steps

1. Provide students with a brief background on biomass energy (see **Background**). Discuss the differences between the different types of bioenergy.

2. Have students break into groups and select a topic to write about. See list of “Selected Topics” for suggestions. (*indicates a more difficult topic.)

Selected Topics:

- basic bioenergy facts
- alternative fuel–ethanol
- alternative fuel–biodiesel
- *positive and negative aspects of bioenergy use
- energy from landfill gases
- energy from cow/pig/poultry waste
- energy from wood
- *how businesses use their waste
- wood for energy (paper mills and other businesses that use wood)
- biomass energy use worldwide

3. Encourage the groups to assign tasks to each group member (e.g., researcher, writer, editor), making sure that one member acts as the graphic designer. The editors and graphic designers should meet to establish guidelines for font style and size, length of each article, etc. They may need to research this topic by visiting the local newspaper or talking to the school newspaper advisor.

4. Provide the groups with time to research their topic in the library and computer lab.

5. Have students hand in their articles in one week. Edit their reports and have students make recommended changes.

Closure

Discuss the results of their research and publication. What do students know about biomass energy use in Wisconsin as well as the rest of the world? What is their opinion of its use? Have the class discuss how to distribute their production. How might they use this publication to educate others in the community about renewable energy?

Assessment

Formative

Did students find and write up information on their selected topic?

Summative

Have students perform Internet searches for other articles on biomass energy. Then have them analyze the article for parts, ethics, and intrigue within the story.

Extensions

This can be repeated in other classes with different renewable topics (solar, wind, hydro, and geothermal). The newspapers can be shared and discussed in other classes.

Ask students to identify whether any biomass resources are being used in their community. What government agencies or utilities could they contact to find out? What makes biomass energy a good or poor choice for their community?

Biomass Gazette

STUDENT PAGES

For this project you will be researching different types of biomass energy and will be putting together a newspaper that includes articles from each member in your group. You will be responsible for your own article and for the final layout of the newspaper.

In your article you should: (see grading rubric)

- Define your topic
- Describe how it works
- Explain where/how it is produced
- Provide examples of uses in Wisconsin
- Include graphs/charts/pictures
- Include an interview (extra credit)
- Include a headline, lead, and short paragraphs
- Use correct spelling and grammar
- Keep the reader's attention

Writing a news article is different from writing an essay. In a news article there is no conclusion. The reader should be able to stop reading the story at any time and still know what the story is about.

The headline of a story is usually short and sends a message about the article. The headline can be clever, as long as the cleverness does not interfere with the message.

The lead is the first sentence of a story. It is one of the most important parts of the article. If the reader likes the lead, then he/she will continue to read the story. The lead usually contains six elements: the who, what, why, when, where, and how of the story.

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Biomass is defined as any plant-derived organic matter available on a renewable basis, including dedicated energy crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, animal wastes, municipal wastes, and other waste materials. These sources can provide energy in the form of electricity, heat, steam, and fuels.

Some biomass topics include: (* indicates a more difficult topic.)

Direct burning–Burning biomass only for energy.
Examples: Wood burner, pellet stove.

Co-firing–Burning biomass along with a fossil fuel.
Example: Combining coal and biomass to generate energy.

Anaerobic digestion –Bacteria decomposes biomass in liquid to produce biogas in an airtight vessel or enclosure; biogas is then used to generate energy.
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Bio-fuels–alternative fuels made from biomass; used for transportation. *Examples: Biodiesel and ethanol.*

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***Pyrolysis–**Pyrolysis uses a process similar to gasification except it eliminates the presence of oxygen altogether.

Biomass Grading Rubric

		Easily understood by reader	Hard to understand for some readers	Most readers won't understand	Too difficult to understand
Research	Definition of topic	**15**	**10**	**5**	**0**
	Describes how it works	**15**	**10**	**5**	**0**
	Explains where/ how it is pro-duced	**15**	**10**	**5**	**0**
	Examples of uses in Wisconsin	**15** More than one good example	**10** One example	**5** One example, but not in Wisconsin	**0** No examples given
Extra Credit ☺	Interview	**10–9** Excellent	**8–7** Good	**6–1** Poor	
Graphs Charts Images	**10–9** Easily understood and related to the topic	**8–7** Not easy to understand and/or not quite related to the topic	**6–5** Takes too much time to understand and/or not quite related to the topic	**4–3** Too difficult to make sense or and/or not related to the topic	**2–0** Doesn't make sense at all, or not related to the topic
Headline	**10–9** Captured attention, catchy	**8–7** Somewhat catchy	**6–5** Average	**4–3** Could be better	**2–0** Poor
Lead	**10–9** All info; gets attention	**8–7** All info; loses attention	**6–5** Missing some info; loses attention	**4–3** Missing a lot of info loses attention	**2–0** Missing most info; reader gets bored and stops reading
Layout Spelling Grammar	**10–9** Article form; good spelling and grammar	**8–7** Loses article form; some spelling and grammar mistakes	**6–5** Not in article form; a lot of spelling/ grammar mistakes	**4–3** Reads like an essay; many spell-ing/grammar mis-takes	**2–0** Format is wrong; spelling and gram-mar are poor
Paragraphs	**20–18** Short, concise, easy to understand; reader remains interested	**17–16** Short, not very concise, easy to understand; reader loses some interest	**15–14** Too long, not con-cise, not easy to understand; reader gets bored	**13–12** Run-on para-graphs, not con-cise, hard to under-stand; reader stops before finish	**11–0** Sentence/para-graph structure very poor, reader stops reading immediately
Keeps Attention	**20–18**	**17–16**	**15–14**	**13–12**	**11–0**

Participation: **25 Points**

Total Individual Grade

Corn in Your Car

Summary: Through mapping and research, students measure the availability of ethanol-based fuels in their community, and the environmental benefits of using these fuels.

Objectives

Students will be able to

- identify the plant resources used to produce ethanol;
- describe the process of converting corn to ethanol;
- map the distribution of ethanol-blended fuel stations in their community; and
- explain the pros and cons of ethanol fuels.

Background

The term bioenergy, or biomass energy, means any plant-derived organic matter available on a renewable basis, including dedicated energy crops and trees, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, animal wastes, municipal wastes, and other waste materials. These sources can provide energy in the form of electricity, heat, steam, and fuels.

Biomass is a renewable resource—it can be replaced fairly quickly without permanently depleting Earth's natural resources. By comparison, fossil fuels, such as petroleum and coal, require millions of years of natural processes to be produced. Drilling for petroleum is considered a nonrenewable process since it depletes Earth's resources for thousands of generations.

More than 60% of petroleum resources in America are imported, and a majority of this petroleum is used as gasoline for automobiles. The burning of fossil fuels, such as gasoline, is a major contributor to air pollution and increased greenhouse gas. Ethanol represents an option for vehicle fuel that burns cleaner than gasoline, can be produced in the United States, and could reduce U.S. dependence on foreign oil.

Ethanol is ethyl alcohol. It is made via an advanced distillation process from crops and vegetable matter, such as corn (see Experimentation in Fermentation for more information). With many of Wisconsin's farmers growing corn, ethanol fuel production could benefit the state's economy. There are already a number of ethanol plants in Wisconsin, with others being proposed and planned.

Liquid ethanol can be used as a fuel when blended with gasoline or in its original state. There are three primary ways that ethanol can be used as a transportation fuel:

- As a blend of 10% ethanol with 90% gasoline (known as E-10)
- As a component of reformulated gasoline, directly and/or as ethyl tertiary butyl ether (ETBE)
- As a mixture called E-85 that consists of 85% denatured ethanol blended with 15% gasoline: E-85 does not burn well in conventional vehicles, but flexible-fuel vehicles (FFV) are designed to run on all blends up to 85%.

Ethanol can be used to increase octane levels, decrease engine emissions, and extend the supply of gasoline. According to the United States Department of Agriculture, 3.9 billion gallons of ethanol were produced in the United States in 2005. Each bushel of processed corn yields 2.5 gallons of ethanol, along with several valuable by-products. The first blends in the 1970s were 10% by volume (E-10), and a blend of 85% by volume (E-85) was introduced in the mid 1990s.

Methanol, which is similar to ethanol, is a racing fuel for major sporting events such as the Indianapolis 500. Aside from being a component of fuel, ethanol is also widely used as a solvent, in industrial applications, and as the intoxicating ingredient in alcoholic beverages.

Procedure

Getting Ready

For this activity, the number and size of student groups will depend on the size of your community. In a larger community, divide the community into regions and assign a group of students to each region. In a small community, you may want to assign individual streets to student groups.

Grade Level: 9–12

Subject Areas: Agriculture, Environmental Education, Language Arts, Mathematics, Science, Technology Education

Setting: Classroom, Community

Time:

Preparation: One hour

Activity: One–two weeks

Vocabulary: Bioenergy, Biomass, Ethanol, Fermentation, Flexible-fuel vehicle (FFV)

Academic Standards:

Common Core ELA: RI.9-12.1, RST.9-12.3&7, SL.9-10.1, W.9-12.2&7-8, WHST.9-12.10

Common Core Math: MP1, MP6, N-Q.1

NGSS: MS-PS1-2, MS-PS1-3, MS-PS1-4, MS-PS1-5, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3
SEP: Planning and Carrying Out Investigations, Analyzing and Interpreting Data, Constructing Explanations and Designing Solutions
DCI: PS1B: Chemical Reactions, PS2B: Types of Interactions, PS3.A: Definitions of Energy
CCC: Cause and Effect

WI Env Literacy & Sustainability: C1.A.m, C1.C.h, EX2.B.m, EX3.B.m, EX4.A.m, EX4.B.i, EX4.B.m, EN6.A.i, EN6.C.i, EN6.C.m, EN7.A.m, EN7.A.h, EN7.B.m

Materials

- Street maps of your community
- Copies of ***Experimentation in Fermentation worksheet*** (optional)
- Small colored stars or circles
- Materials for posters/displays

Resources:

Alternative Fuel Data Center
www.afdc.energy.gov/fuels/ethanol.html

Orientation

Ask students what they know about ethanol. Some students may know of farmers who grow corn for ethanol production or they may know of ethanol plants in Wisconsin. Describe some of the uses of ethanol in the United States (see **Background**).

Do students think that ethanol-blended products are already available in their community? Explain to students that through this activity, they will find out what resources are available.

Steps

1. Divide the class into working groups (see **Getting Ready**).

2. Each group will receive a street map of the community that shows their assigned study region. Encourage students to share responsibilities and come up with innovative ways to complete their research.

3. Allow students one to two weeks to conduct the following research:

- Develop a one-page fact sheet about ethanol, summarizing how it is produced, how it is used, and its economic and environmental costs and benefits.
  –Students can conduct Internet research to learn more about ethanol.
  –Make sure students explore E-10 and E-85 blends and understand the costs and benefits of each.
  –See **Experimentation in Fermentation** for a hands-on activity that illustrates some aspects of ethanol production.
- Map stations in their region that do and do not sell ethanol fuel (students can visit or call the stations).
- Classify stations that sell ethanol based on fuel blend:
  –Fuel stations that sell E-10 fuel (10% ethanol, 90% gasoline)
  –Fuel stations that sell E-85 fuel (85% ethanol, 15% gasoline)

4. Have the groups transfer their researched information to a class map. The class can create a key, using colored stars or dots to represent fuel stations of different classifications. NOTE: This step may not be necessary in small communities.

5. Challenge student groups to create a one-page informational flier (or some other public service announcement) that provides an overview of ethanol and identifies fuel stations that sell ethanol-blended fuels. Encourage students to be creative! These fliers can be posted around the school or students can contact community planners about displaying the fliers around the community.

Closure

As a class, review the presence (or absence) of ethanol and ethanol blends in your community. Based on students' research and perceptions, discuss pros and cons of ethanol use in your community.

Assessment

Formative

- Did the students properly identify the major sources of ethanol production?
- How well did the students explore and map the fuel stations in the community?
- Are students able to identify the environmental benefits of using ethanol fuels?
- How extensively and thoughtfully did students develop their marketing strategy?
- Did students create plans that appropriately addressed the availability of ethanol-blended fuels in the community and reasons to use these fuels?

Summative

How has this activity increased students' knowledge of ethanol and their attitudes toward ethanol use? Have each student write a reflective essay to summarize their views.

Extensions

There are many resources available that describe how to produce ethanol or how to transform a gasoline vehicle into a FFV. Depending on the level and curriculum of your classroom, investigate these avenues for a possible student project. In urban areas such as Milwaukee, residents are required to purchase "reformulated gasoline" year round, but the formulation of the gas changes with the season. Have students explore this concept and survey community residents on their knowledge and perceptions of ethanol and reformulated gasoline. Integrate this data into a marketing strategy for promoting ethanol use.

Although methanol is the main component of superior racing fuels, other fuels utilized for racing contain varying amounts of ethanol. If students are interested in racing, have them research and analyze racing fuels and octane ratings. How do racing vehicles differ from FFVs? What effect would using an ethanol-blended fuel have on a non-racing car?

Math skills can be put to the test by having students calculate the miles an automobile can be driven using ethanol derived from a certain crop of corn. For example, have students compute the miles from 750 acres of corn in an automobile using E-10 (10% ethanol blend) that gets 26 miles per gallon. Consider that an acre of corn produces an average 127 bushels and each bushel produces about 2.5 gallons of ethanol.

Experimentation in Fermentation

Ethanol is made from a variety of plant substances including corn, sugar cane, and wood. The process used to make ethanol is called fermentation. Fermentation was discovered many years ago when bubbles or foam formed while making wine and beer. Studies by Louis Pasteur described fermentation as changes caused by yeasts growing in the absence of air. Fermentation is an energy-yielding process in which fuel molecules such as glucose (sugar) are broken down in the absence of oxygen.

Changing corn to ethanol by fermentation takes many steps. Starch in corn must be broken down into simple sugars before fermentation can occur. In earlier times, this was done by chewing the corn. This allowed the salivary enzymes to naturally break down the starch. Today, this is achieved by cooking the corn and adding the enzymes alpha amylase and gluco amylase. These enzymes function as catalysts to speed up the chemical changes. Once a simple sugar is obtained, yeast is added.

Yeast is a single-celled fungus that feeds on the sugar and causes fermentation. As the fungi feed on the sugar, they produce alcohol (ethanol) and carbon dioxide. In fermentation, the ethanol retains much of the energy that was originally in the sugar, which is why ethanol is an excellent fuel.

This experiment can be modeled by the teacher or used as a laboratory exercise.

Materials:

- 8 or more pkgs of yeast
- ice
- measuring spoons
- 4 clear half-liter glass containers
- stirrers
- heating element
- flour, salt, sugar, vinegar

Steps:

1. Empty a package of yeast into each half-liter (1 pint) beaker of warm water. Stir for 1 minute.

2. Add 10 ml (2 tsp.) of flour to each beaker and stir again.

3. Add 5 ml (1 tsp.) of salt to the first beaker, 5 ml of sugar to the second beaker, 5 ml of vinegar to the third, and do nothing to the fourth. Stir again.

4. Wait 5 minutes and record your observations.

Beaker 1

Beaker 2

Beaker 3

Beaker 4

5. Wait 15 minutes and record your observations.

Beaker 1

Beaker 2

Beaker 3

Beaker 4

6. Let the solutions sit overnight and record your observations.

Beaker 1

Beaker 2

Beaker 3

Beaker 4

On a separate piece of paper, describe the fermentation that is taking place, or have students answer the following questions:

1. What is the evidence that reactions are going on in the containers?

2. How are these observations related to fermentation?

3. State any conclusions about which of the substances tested was most helpful to yeast fermentation.

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Cross Reference Charts
Grade Levels

Activity	K–4	5–8	9–12
Photosynthesis Promenade	X		
Would You Heat With Wood?	X		
Advertising Biodiesel		X	
Community Design - It's a Gas		X	
Don't Waste Waste		X	
Grasses for the Masses		X	
Roadside Renewables		X	
Biofuel Beliefs			X
Biomass Gazette			X
Corn in Your Car			X

Subject Areas

Arts: Art, Drama, Dance, and Music
English: English and Language Arts
Living: Family Living and Consumer Education, Technology Education, and Agriculture
Math: Mathematics
Phy Ed: Physical Education
Science: Environmental, Life, Earth, and Physical Sciences
Soc St: Geography, History, Global Studies, Economics, and Government
EL&S: Environmental Literacy & Sustainability - Connect, Explore and Engage

Activity	Arts	English	Living	Math	Phy Ed	Science	Soc St	EL&S
Photosynthesis Promenade	X	X		X	X	X		X
Would You Heat With Wood?	X			X		X		X
Advertising Biodiesel	X	X	X					X
Community Design–It's a Gas		X				X	X	X
Don't Waste Waste		X		X		X		X
Grasses for the Masses			X			X		X
Roadside Renewables		X	X			X		X
Biofuel Beliefs		X	X			X	X	X
Biomass Gazette		X				X	X	X
Corn in Your Car		X	X	X		X		X

Teaching Methods

Read: Reading
Write: Writing
Calcul: Calculating
Discuss: Discussing
Debate: Debating
Demo: Demonstrating

Design: Designing, creating
Hands: Working hands-on, including playing card game
Body: Using whole body
Invest: Investigating, researching, experimenting
Map: Mapping, graphing

Activity	Read	Write	Calcul	Discuss	Debate	Demo	Design	Hands	Body	Invest	Map
Photosynthesis Promenade				X		X			X		
Would You Heat With Wood?	X	X		X				X			
Advertising Biodiesel	X	X		X			X			X	
Community Design–It's a Gas				X			X			X	X
Don't Waste Waste			X	X				X		X	
Grasses for the Masses			X	X	X			X		X	X
Roadside Renewables				X			X	X		X	
Biofuel Beliefs	X	X		X	X					X	
Biomass Gazette	X	X		X			X			X	
Corn in Your Car	X	X		X				X		X	X

Assessment Strategies

Oral: Student-generated oral work including debates, dramatizations, reports, simulations/role-playing, and speeches
Write: Student-generated written work including essays, reports, journals and logs, letters, worksheets, and survey results
Prod: Student products including models, artwork, exhibits, and portfolios
Graph: Graphic organizers including concept maps, collages, computer logs, and Venn diagrams
Prob: Problem solving process
Discuss: Discussion including open-ended and guided response

Activity	Arts	English	Living	Math	Phy Ed	Science	Soc St
Photosynthesis Promenade	X				X	X	
Would You Heat With Wood?	X	X				X	
Advertising Biodiesel	X	X	X			X	
Community Design–It's a Gas						X	X
Don't Waste Waste				X		X	
Grasses for the Masses			X			X	
Roadside Renewables			X			X	
Biofuel Beliefs		X	X			X	
Biomass Gazette		X				X	
Corn in Your Car			X			X	