People for Energy and Environmental Literacy (PEEL)

Lesson Plan 9

Biomass Energy

Basic Level
Intermediate Level
Advanced Level

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Version 1.0

PEEL is supported by the Community Environment Action Program. This project is offered in partnership with GreenLearning Canada Foundation, provider of free online education programs about energy, climate change and green economy.

Summary of Activity

Grade: 3 – 12 Subject: Science, Social Studies

Time: 1.5 - 2 Hr Theme: Biomass Energy

Description: This lesson discusses all thing biomass from what constitutes as biomass to the many ways that biomass is used. Three presentations are available:
Basic level – Grades 3-5
Intermediate level – Grades 6-8
Advanced level – Grades 9-12

What's included: PowerPoint file – Biomass Energy – Basic Level (Grades 3-5)
PowerPoint file – Biomass Energy – Intermediate Level (Grades 6-8)
PowerPoint file – Biomass Energy – Advanced Level (Grades 9-12)
Each PowerPoint file has notes on each slide with questions and advice for the instructor.

The lesson can be completed over one to two class periods. There are activities at the end of the presentation that students can complete to solidify and test their understanding of the material.

Overview

This lesson begins with an introduction to photosynthesis. This concept is key to understanding how biomass obtains its energy from the sun. Students then learn about sources of biomass and the main biomass conversion processes (combustion, gasification, pyrolysis, anaerobic digestion/biodigestion, and fermentation – the number of biomass conversion processes are modified in each Lesson Plan Level. The basic level lesson plan includes one kind of biomass conversion (combustion). Students will gain an understanding of how each biomass technology and source differ from one another, and the main uses. The use of each biomass energy is also described such as transportation, electricity and, heat.

Curriculum Links

The table below provides a guide to some of the curriculum links between this lesson plan, grades, and subjects.

Table 1: Curriculum links to this lesson plan

	SUBJECT			
Grade Level	**Science**	**Social Studies**	**Career & Technology Studies**	**Environment and Outdoor Education**
3		Global Citizenship	• Environmental Stewardship Occupational Area, • Primary Resources Occupational area,	• Part of a complex global environment • Human life and life styles are dependent on environmental resources • Humans influence environment through direct and indirect means. • Principles of conservation
4	Waste and Our World	Alberta: A Sense of the Land		
4		Alberta: Celebrations and Challenges		
5	Mechanisms Using Electricity			
6		Citizens Participating in Decision Making		
7	Interactions and Ecosystems			
7	Heat and Temperature			
9	Biological Diversity	Issues for Canadians: Economic System in Canada and the United States		
9	Environmental Chemistry			
10	Energy and Matter in Chemical Change			
10	Energy Flow in Technological Systems			
10	Energy Flow in Global System			
10	Stewardship			
11	Science Technology and Society			
12	Chemistry and the Environment			
12	Energy and the Environment			

In addition to curriculum links, there are also direct links to the Alberta 21st Century Learner competencies.

Figure 1: Alberta 21st Century Learner Competencies

This lesson focuses on the following learner competencies:

- Critical Thinking
- Managing Information
- Cultural and Global Citizenship
- Creativity and Innovation

Energy and Environmental Learning Outcomes

By the end of the lesson, students should be able to:

- Identify the most common biomass source in Alberta
- List the biomass conversion processes and provide a brief description of each
- Define the term feedstock
- Identify the different types of biomass feedstock
- Identify the products that come from biomass

Planning Notes

Materials

- Biomass Energy PowerPoint presentation (different versions available as applicable)

Prior Learning

This lesson builds on the concepts established in Lesson 4 – Renewable Energy 101. Students should have a basic understanding of what biomass and where the energy source comes from (i.e., the sun's energy is stored in the form of chemical energy in a plant through a process call photosynthesis).

Teaching/Learning Strategies

This lesson can be taught with the slide presentation, or with alternative research and analysis completed on own. The slide presentation provides in-class activities that can be done during the presentation. There are also short quizzes to test knowledge during the class.

Instructions

Pre-activity discussion

It is beneficial for teachers to review the concepts taught in Lesson 4 – Renewable Energy 101. Ask the students if they have any questions they wish to be addressed in this lesson. If the students still have questions, have them do a mini research project and present their findings to the class.

Activity

Teachers are to present the presentation to the class. There is a short quiz at the end of the presentation to test the student's understanding of the topic. Additionally, there is a short experiment that students can complete in small groups or as a class at the end of the lesson. See the experiment section below in this lesson plan.

Post-Activity questions (Follow up questions)

1. What interested you the most about biomass?
2. Name one of the biomass facilities mentioned in the presentation? What feedstock do they use?
3. Do you think biomass is a viable source of renewable energy in Alberta? Why or why not?
4. How does biomass compare to the other renewable energy technologies we learned about? Do you think it is more or less efficient in Alberta?
5. Do you know of any biomass facilities not mentioned in the presentation? Is there one close to where you live?

Resources

All resources are identified in the PowerPoint presentation in the notes section.

Websites

- This website describes the common feedstock types. The site also goes into detail about the emissions associated with biomass energy production.
    - https://corporate.vattenfall.com/about-energy/renewable-energy-sources/biomass/how-it-works/

Videos

- This video by Acciona (an energy company) illustrates the process biomass goes through to heat a building and generate electricity. (All levels)
    - https://www.youtube.com/watch?v=slQRWbRE8VI
- This video discusses how the life cycle of biomass has net zero emissions and is a sustainable source, whereas fossil fuels are not. It shows how biomass also has the potential to reduce atmospheric carbon concentrations, however, could also contribute to an increase in carbon and deforestation if not properly managed. (All levels)

- https://www.youtube.com/watch?v=-jln6yi7LF0

Publications

- This article discusses the different conversion processes in biomass and explains how each work. (Intermediate and Advanced Levels)
  - http://www.globalproblems-globalsolutions-files.org/gpgs_files/pdf/UNF_Bioenergy/UNF_Bioenergy_5.pdf
- This source is all about how the combustion conversion process works. There are also some details on how some of the other processes work. (Intermediate and Advanced Levels)
  - http://www.invent.hs-bremen.de/e-learning_Dateien/Presentations/Biomass%20Combustion%20Processes.pdf
- This 2014 CanBio report discusses the state of Bioenergy in Canada. Go to page 15 for policy information in Alberta. (Advanced Level)
  - http://www.fpac.ca/wp-content/uploads/2014_CanBio_Report.pdf

GreenLearning.ca

The following resources are GreenLearning activities that are related to this PEEL topic.

- Re-Energy: http://www.greenlearning.ca/programs/re-energy/

Data References

References are available in the Biomass Energy presentation in the notes section of the PowerPoint Document.

Feedback

We are continuously interested in improving and updating this lesson plan. Please send your feedback to info@teachpeel.ca.

EXPERIMENT – INFLATE A BALLOON WITH BIOMASS

Big Idea: One of the conversion processes, anaerobic digestion, involves the breakdown of biomass feedstock in the absence of air. Microorganisms break down the matter and biogas, such as methane, is released. The methane gas produced can then be combusted to generate electricity.
In this experiment, we will observe how organic matter breaks down in the absence of oxygen. We will use yeast, a microorganism, to break down the glucose in sugar. The process we will observe is called fermentation. There are three important conditions required for fermentation to occur: there must be food (sugar), moisture (water), and a warm environment (warm water). When these three conditions are met, the process can proceed. The process is evident from the presence of gas. In this experiment, we will observe yeast fermentation in a controlled environment, and measure the amount of gas produced. We will also test how this process reacts to different temperatures and amounts of light. When fermentation (anaerobic digestion) is done on a larger scale, the highly pressurized gas produced can be used to generate electricity.

Materials:

- Clear plastic bottle
- Balloon
- 1 teaspoon of sugar
- 2 teaspoons of yeast
- Warm water (enough to fill the water bottle 1 inch from the bottom)

Activity:

1. Fill the water bottle with warm water (~ 1 inch)
2. Add the yeast, and gently swirl
3. Add the sugar, swirl again
4. Stretch out the balloon so that it can inflate easily
5. Place the balloon over the opening of the bottle
6. Let the bottle sit for 20 minutes (try changing a variable of this experiment such as the surrounding temperature)
7. Conclude what happened.

Post-Activity Questions:

1. What did you notice throughout this experiment?
2. What happened to the balloon?
3. What environmental conditions yielded the most change?
4. What is the role of the yeast, sugar, and water in the experiment?
5. How much gas was formed (volume)? *Hint: what is the circumference for the inflated balloon.* $V = \frac{4}{3}\pi r^3$ (Intermediate and Advanced)

6. Can you explain how the gas produced could go on to generate electricity as seen in an anaerobic digester? (Advanced)

Expected Outcomes & Conclusions:

- Students should observe the balloon fill with gas throughout the experiment
- Students should be able to conclude that this is due to the stored energy found in the yeast (organic matter)
- Students should understand that yeast is the microorganism, and the sugar is the feedstock that breaks down and releases gas, which is captured in the balloon.
- Students should conclude that this emitted gas can be used to generate electricity if made in a large quantity.

INFLATE A BALLOON OBSERVATION SHEET

Fill out this table with your observations. In the first row, measure the temperature of the water, and identify if the bottle is left to ferment in an area with natural light, artificial light, or no light.

	Environment 1: Water temperature: Type of light:	Environment 2: Water temperature: Type of light:	Environment 3: Water temperature: Type of light:
Observations			
Circumference of balloon			
Volume of balloon (show calculation)			

Conclusions:

What can you conclude about this experiment? How did changing the environmental conditions impact your results? What other variables would you change? What do you think will happen? Relate this experiment to biomass energy generation, and identify the similarities.