Unit 5: Consumption and Waste

Unit Objectives

At the end of this unit the students will be able to:

- Understand the concept of embodied energy and emissions
- Define lifecycle, upstream and downstream emissions
- Understand the hierarchy for reducing embodied emissions
- Identify ways in which various resources can be recycled and reused. **(Science Standard)**
- Clarify key aspects of an event, issue, or problem through inquiry and research. **(Social Studies Standard)**

Unit Background

Lesson 5A
Waste Audit (60 minutes)

Lesson 5B
Life Cycle Analysis (45 minutes)

Unit 5 Quiz
15 minutes

Unit 5 Appendix

Unit Background

Greenhouse gas emissions are associated with material goods at nearly every phase of their life cycle, from extraction to production to use (in some cases), and all the way through to the methane released from decomposition in the landfill. US residents generated an average of 4.6 pounds waste per person per day in 2006, for a grand total of 251.3 million tons before recycling. If we're tossing that much away, think of all we're consuming. Knowing that the production and disposal of a ream of nonrecycled content paper is responsible for 35.7 pounds of carbon dioxide emissions makes it easier to conceive of all the embodied energy and emissions associated with the goods we consume and throw away.

The US EPA estimates that residential waste makes up 55 to 65 percent of the nation's total waste stream, but even industrial and construction waste exist because of demand by individuals. According to the United Nations Systemwide Earthwatch initiative, those of us in industrialized countries account for only 20 percent of the world population, but consume 86% of aluminum, 81% of paper, 80% of iron and steel, and 76% of timber produced globally. In the average American's lifetime, he or she will consume 540 tons of construction materials, 18 tons of paper, 23 tons of wood, 16 tons of metals, and 32 tons of organic chemicals. Although we are recycling a higher percentage of our waste than in the past, we create more total waste per capita each year. In 1960, Americans averaged 2.68 pounds per person per day, but this jumped to 4.4 pounds of waste per person per day by 1997 (landfill + recycled). Today, it is very easy to find one-time use items created for convenience, which only increases the amount of waste produced.

How would a decrease in consumption and the resulting waste production relate to climate change? According to research by the EPA described in Reducing Waste Can Make A Difference, waste prevention is generally the best management option in terms of climate benefits. Recycling is the next best approach. The EPA found that by cutting the amount of waste we generate back to 1990 levels, we could reduce greenhouse gas emissions by 18 million metric tons of carbon equivalent (MMTCE is the basic unit of measure for greenhouse gases). This reduction in emissions was due to two main factors: 1) avoided methane released from landfills when organic matter decomposes anaerobically, and 2) avoided upstream emissions from energy used in resource extraction, production and transportation all along the way.

In terms of recycling, the EPA estimates that by increasing our national recycling rate from 2000 levels of 30 percent up to 35 percent, we would reduce greenhouse gas emissions by another 10 MMTCE, compared to landfilling the same material. Together, achieving these levels of waste prevention and recycling would be comparable to eliminating annual emissions from the electricity consumption of nearly 4.9 million households.

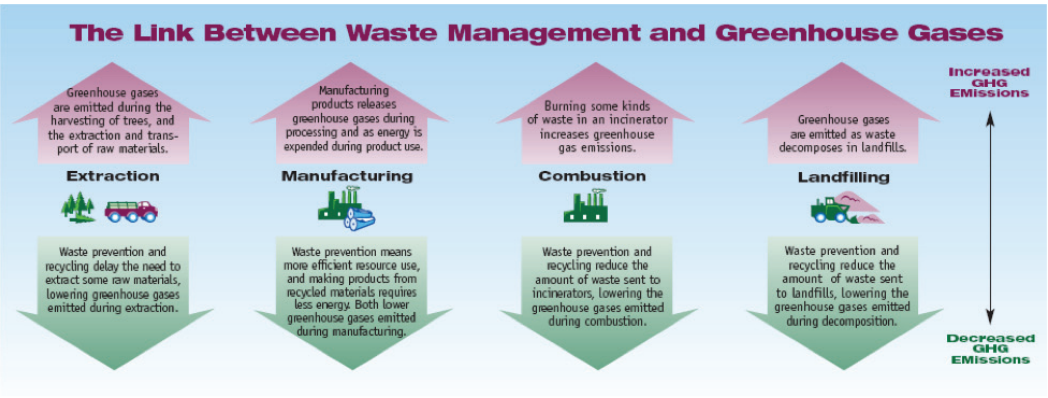
Every little bit helps! For example, by recycling all of its office paper waste for one year, an office building of 7,000 workers could reduce greenhouse gas emissions by 570 metric tons of carbon equivalent (MTCE), when compared to landfilling. This is the equivalent of taking about 370 cars off the road that year. If an average family of four were to recycle all of its mixed plastic waste, nearly 340 pounds of carbon equivalent emissions could be reduced each year.

Sources:

United States Environmental Protection Agency, "Municipal Solid Waste" www.epa.gov/msw/facts-text.htm

United States Environmental Protection Agency, "Municipal Solid Waste Charts." http://www.epa.gov/waste/facts-text.htm

United States Environmental Protection Agency, "Climate Change and Waste." http://www.epa.gov/waste/nonhaz/municipal/pubs/ghg/climfold.pdf



Source: *US EPA http://www.epa.gov/waste/nonhaz/municipal/pubs/ghg/climfold.pdf*

Lesson 5A—Waste Audit

This lesson has been adapted from the Oregon Green Schools *http://www.oregongreenschools.org/waste_audits.cfm*

Objectives

- Students will be introduced to the concepts of embodied energy and upstream and downstream emissions.
- Students will learn what exactly is being thrown away by their school and what alternatives there are to landfilling.

Suggested Timeframe

(65 minutes)

- 15 minutes—Discussion
- 30 minutes—Audit
- 20 minutes—Create a Plan

Materials

- Materials
- Rubber gloves
- Large tarp or plastic drop cloth
- Extra garbage bags
- Scale
- Several five-gallon buckets
- Waste category signs
- Waste audit forms

Teacher Information

A waste audit is a way to see what your school's garbage is made up of so that you can make a plan for reducing, reusing and recycling. It seems like a yucky, dirty task, but believe it or not, kids and adults usually have fun with it. The results of a waste audit can help your school determine what areas need work and how best to start your waste reduction program. (As a bonus, you can use the data you collect for real-world math lessons on weight and volume and creating graphs and charts.)

Discussion

This outline highlights the key points to be shared with students.

1. Consumerism and waste in America
   a. On average, Americans landfill approximately 4.6 pounds of waste daily.
   b. 55-65% of waste produced is from residential sources.
   c. Every year we recycle more but we also send more to the landfill.
   d. Despite representing a small percentage of the world's population, the US consumes a large percentage of the earth's natural resources.
2. Embodied Energy
   a. This includes the energy used throughout the product's entire life cycle, from production to disposal, including fuel for machinery used in production and transportation, energy required to make chemical pesticides and fertilizers, not to mention processing and packaging. You may want to bring in an example of a packaged, processed food.
   b. For every product purchased, embodied energy is a factor.
   c. The more embodied energy in a product, the greater the GHG emissions.
3. Emissions
   a. Upstream: emissions associated with resource extraction, production and transportation. Much of this is CO_2 from energy use.
   b. Point of use: emissions associated with use of the product, largely energy related.
   c. Downstream: emissions associated with the disposal of the product. These emissions are largely CO_2 from transportation to the landfill and methane from waste decomposing anaerobically in the landfill.

4. Reducing GHG emissions associated with consumption.
   a. Purchasing less new goods is the most important step.
   b. Buy only what you need.
   c. Create a strategy, like waiting a week before making major purchases, to decrease impulse buying.
   d. Reusing products is the second most important step.
   e. Choose goods with recycled content when buying new items.
   f. Finally, recycle and compost to avoid "downstream" emissions from landfills.
5. Waste in schools.
   a. Many items thrown away could be reused.
   b. Other items can be recycled or composted.

Preparation

- Obtain permission to conduct the audit in the cafeteria, gym, or in a covered area outdoors and work with your custodian to save or collect cafeteria and/or classroom and office garbage from previous day.
- Photocopy Waste Audit Form: *http://www.oregongreenschools.org/pdf/SchoolWasteSortForm.pdf*
- Print out signs for sorting: *http://www.oregongreenschools.org/pdf/WasteAuditSigns.pdf*
- Safety considerations:
  - Please do not sort bathroom or health room waste.
  - Ask students to wear closed-toe shoes and rubber gloves throughout activity.

Audit

1. Using the waste audit form, record where the waste was collected from (Classrooms, cafeteria, etc.).
2. Put on gloves and estimate the total volume and weight of the waste to be audited. Record on form.
   a. Weight: Weigh the unopened bags of garbage. (With a bathroom-type scale, have a student hold the bag while standing on the scale, and then subtract the student's weight).
   b. Volume: Compare volume to the 5-gallon buckets.
3. Empty the contents of the bag on tarp and sort into waste categories listed on the form.
4. Record the weight and estimate the volume for each of the categories.
   a. Weight: put in buckets and weigh, subtract weight of bucket.
   b. Volume: estimate volume by measuring how much of the bucket is full
5. Make notes about items that you find a lot of in the trash – types of food, pop cans, etc., or other interesting things you observe.
6. Clean up!
   a. Return non-recyclables to garbage cans and sort recyclables into recycling bins.
   b. Wash tarp and buckets, sweep floor.

Create a Plan

1. Complete calculations on the waste audit form. Use these numbers to chart or graph your school's waste by weight and volume.
2. Create a plan to reduce waste based on your findings. Questions to think about:
   a. What were the main components of the school's waste?
   b. Would the results be different if the sort was done at a different time in the school year?
   c. What were some of the items that could have been reused, composted, or recycled instead of thrown away?

Discussion Questions

- How could students reduce how much was thrown away some of the items?
- Discuss the connection between waste and greenhouse gases (GHGs). How can decreasing use, reusing, composting and recycling reduce GHGs?

Extension Activities (optional)

1. Share the results and the plan with the rest of the school.
2. Put your plan into action!

Lesson 5A Assessment

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Teamwork	Worked well as a team.	Worked well with some guidance.	Worked as a team with a great deal of guidance.	Did not work well together.	
Participation in Activity	Participates fully during activity	Participates somewhat during activity	Demonstrates minimal participation during activity	Does not participate in activity	
Waste Audit Sheet	Worksheet is complete with all entries showing thoughtfulness.	Worksheet is complete with most entries showing thoughtfulness.	Worksheet is incomplete and lacks thoughtfulness.	Worksheet is not attempted.	
Post Audit Discussion	Participates fully during class discussion.	Participates somewhat during class discussion.	Demonstrates minimal contribution during class discussion.	Does not participate in class discussion.	
				Total Score	**/16**

Objective Check

1. What does it mean to say that a product has embodied energy? (Embodied energy is the energy used throughout the product's entire life cycle, from production to disposal, including fuel for machinery used in production and transportation, energy required to make chemical pesticides and fertilizers, not to mention processing and packaging.
2. What are upstream emissions? (These are associated with resource extraction, production and transportation.)
3. What are three alternatives to throwing something away? (Sell or give away the object, reuse for another purpose and recycle.)

Lesson 5B—Life Cycle Analysis for a CD or DVD

Objectives

- Students will be introduced to the concept of life cycle analysis.
- Students will learn more about the embodied energy that is associated with consumption.

Suggested Timeframe

(45 minutes)

- 10 minutes—Discussion
- 20 minutes—Poster making
- 15 minutes—Poster presentations and discussion

Materials

- Easels with chart paper or butcher paper
- Markers

Teacher Information

The term "life cycle" refers to the major activities in the course of a product's life-span from resource extraction, manufacture, use, and maintenance, to the product's final disposal. Life cycle assessment (LCA) is a tool used to evaluate the potential environmental impact of a product, process or activity throughout its entire life cycle by quantifying the use of resources ("inputs" such as energy, raw materials, water, labor) and environmental emissions ("outputs" to air, water and soil) associated with the system that is being evaluated. There are two types of LCA: cradle to gate and cradle to grave. "To gate" refers to manufacturers getting the product to the store while "to grave" includes every step until disposal. A newer movement, called "cradle to cradle" goes one step further by aiming to create product systems that create zero waste. For example, all extra materials used during manufacturing could be used for another function or composted. The product itself would also be reusable or compostable, like greeting cards with seeds embedded in them that can be planted upon receipt. The US EPA hosts annual Cradle to Cradle contests for companies and individuals that can come up with an innovative design. This is how they define the movement:

- Cradle to Cradle Design is a system of thinking based on the belief that human design can approach the effectiveness and elegance of natural systems by learning from nature and incorporating its patterns. Industry can be transformed into a sustaining enterprise—one that creates economic, ecological, and social value—through thoughtful and intentional design that mirrors the safe, regenerative productivity of nature and eliminates the concept of waste.
- The application of cradle-to-cradle principles to industry creates cyclical material flows (cradle-to-cradle rather than cradle-to-grave) that, like the earth's nutrient cycles, eliminate the concept of waste. Each material in a product is designed to be safe and effective, and to provide high quality resources for subsequent generations of products. All materials are conceived as nutrients, circulating safely and productively in one of two "metabolisms"—the biological metabolism and the technical metabolism.

Graphic Source: *http://www.scienceinthebox.com/en_UK/programs/pic/lca.gif*

Concerns about increasing quantities of waste and the associated GHG emissions have become more serious due to the short life cycles and heavy packaging of more and more goods. For years there has been a push for Americans to develop policies that make manufacturers more responsible for their product from cradle to grave and now cradle to cradle. Many people feel that products should be made more durably (rather than "planned obsolescence"); made easier to dismantle for repair, reuse or recycling; and made with fewer toxic and landfill-bound materials. Not only would this reduce the amount of landfilled material, but it would also decrease the amount of GHGs that are released from manufacturing new products. Generally, the fewer products we

consume, particularly those made from virgin materials, the fewer GHGs are released into our atmosphere.

Waste issues can be better understood by examining the life cycle of the materials that compose it, from extraction to final disposal. On the surface many products seem to have a simple life cycle. However, as you begin to dig a little deeper and conduct a LCA on a product, you can find it is quite complicated.

In this lesson students will attempt to develop a map of the life cycle of a CD or DVD. Keep in mind that the primary steps that will be analyzed are materials acquisition, materials processing, manufacturing, packaging, distribution, use, reuse/recycling and disposal.

Sources:
United States Environmental Protection Agency, "Cradle to Cradle Design Award." http://www.mbdc.com/challenge/cradle-to-cradle.shtml

Discussion

1. Life cycle analysis (LCA)
   a. Definition— see above
   b. Cradle to gate—from materials acquisition to point of purchase
   c. Cradle to grave—from materials acquisition to disposal
   d. Cradle to cradle—life cycle with no waste products being produced
2. Steps in LCA
   a. Materials acquisition
   b. Materials processing
   c. Manufacturing
   d. Packaging
   e. Transportation/distribution
   f. Useful Life
   g. Reusing, recycling or disposal
3. Problems with consumerism
   a. Planned obsolescence—giving a product a certain life span
   b. Lack of durability – could make products easier to repair
4. Toxic and landfill bound materials

Preparation

Create a poster, slide or overhead of the following pdf: *http://www.epa.gov/osw/education/pdfs/finalposter.pdf* but do not show it to the class until they are finished with their life cycles.

Lesson

1. Break the class into small groups of 3-5 and distribute one piece of chart paper and marker to each group.
2. Tell the students to come up with a life cycle of a CD or DVD. Give them as much guidance as you feel necessary. You may want to tell them to try to think of all the steps that go into the process of manufacturing to disposal of a CD or give them the following information:
   a. CDs and DVDs are made from plastic and aluminum foil.
   b. The steps in a life cycle analysis are: materials acquisition, materials processing, manufacturing, packaging, transportation/distribution, useful life, and reuse/recycle/disposal. Keep in mind that the more guidance you give them, the more similar their LCA will be to the EPA's.
3. They can sketch their rough draft on a piece of scratch paper first if you like. When they are satisfied with their life cycle, have them transfer it to the chart paper so they can share it with the class.
4. Note that the students' and the EPA's LCAs could be very different, depending on the boundaries that the students use. If you would like the students' LCAs to match the EPA's more closely, you may want to start out with a class discussion of how far back they should go for each step of the process. For example, if you wanted to draw very broad boundaries when discussing resource extraction, you could include things like the fuel needed to transport workers to the oil fields.
5. Once every group is finished, display all of the posters in front of the room. Have each group stand by their posters, and go around the room having each group answer one or two questions from students in other groups.
6. Show the students the life cycle poster developed by the US EPA.

Discussion Questions

Lead a class discussion asking all or some of the following questions:

- How was your life cycle analysis (LCA) different from the EPA's?
- What did you forget to add?
- What did you choose not to add? Why did you make this choice?
- What did the EPA not have on their LCA that you had on your LCA? Why do you think the EPA chose not to include it?
- Did you include the energy that it took to make the trucks that transported the DVDs? Why not? (This is referred to as defining the "scope" of the product.)
- Which steps in your LCA produced GHGs?
- How does the change to digital downloads and MP3 players help in decreasing GHGs? How do they contribute to more GHGs? (For example, by disposing of CD players and buying new MP3 players, by using more energy in spending more time online.)

Lesson 5B Assessment (for group)

Aspect	Expert (4)	Practitioner (3)	Apprentice (2)	Novice (1)	Score
Chart Presentation: Content	Content shows thoughtfulness and creativity. Includes most of the lifecycle.	Content shows some thoughtfulness but lacks several parts of the lifecycle.	Content shows little thoughtfulness. Major parts of the lifecycle are missing.	Content does not relate to the assignment.	
Chart Presentation: Oral	Presentation is clear and is easy to understand. Tone is conversational or informational.	Presentation is good but sometimes difficult to follow.	Presentation is difficult to follow. Tone is not appropriate.	Presentation does not relate to the assignment.	
Chart Presentation: Written	Clearly readable text of the lifecycle and uses drawings to help communicate ideas.	Text is generally readable. Limited drawings are used.	Text is barely legible. No drawings are used.	Poster is not completed.	
Teamwork	Worked well as a team.	Worked well with some guidance.	Worked as a team with a great deal of guidance.	Did not work well together.	
Post Chart Presentation Discussion	Participates fully during class discussion.	Participates somewhat during class discussion.	Demonstrates minimal contribution during class discussion.	Does not participate in class discussion.	
				Total Score	**/20**

Objective Check

1. What is the difference between "cradle to gate" and "cradle to grave" life cycle analysis? ("To gate" refers to analyzing a product from its resource extraction to the store, whereas "to grave" refers to analyzing it until the object is disposed of or recycled.)
2. For which steps of a life cycle analysis is there no embodied energy added? (In every step there is energy added. From resource extraction to reuse every step requires some new energy to be inputted.)

Consumption and Waste Quiz

Name _____

Multiple Choice: Read all possible responses and select the best answer.

1. **What is the best approach to managing waste?**
   a. Recycling
   b. Prevention
   c. Incineration
   d. Landfilling

2. **What is the best way, in terms of GHGs, to dispose of food waste?**
   a. Recycling
   b. Composting
   c. Incinerating
   d. All of the above

3. **How much waste does the average American generate per day?**
   a. 7.8 pounds/day
   b. 4.6 pounds/day
   c. 3.4 pounds/day
   d. 2.5 pounds/day

4. **The amount of stuff we produce as a society affects how much GHG we emit because:**
   a. Carbon dioxide is released in the process of making each product.
   b. Carbon dioxide is emitted in packaging and transporting each item.
   c. Greenhouse gases are produced in the disposal of garbage.
   d. All of the above.

5. **Which of the following trash can be composted?**
   a. Glass bottle
   b. Plastic bottle
   c. Orange peel
   d. All of the above

6. **Which of the following items can be reused?**
   a. A glass jar
   b. A plastic jar
   c. A cardboard box
   d. All of the above

7. **Which production processes are included in a life cycle analysis?**
   a. Raw material collection
   b. Transportation
   c. Manufacturing
   d. All of the above

8. **What type of life cycle analysis includes every step until disposal?**
   a. Cradle to gate
   b. Cradle to grave
   c. Gate to grave
   d. None of the above

9. **Consumers who are concerned with life cycle analysis feel products should be made so they are**
   a. More durable
   b. Easier to dismantle and repair
   c. Have fewer toxic materials
   d. All of the above

10. **The largest component of our school's waste stream is:**
    a. Paper
    b. Food
    c. Bottles and cans
    d. Glass

Short Answer

11. **Distinguish between cradle to grave and cradle to cradle life cycle analysis.**

12. **What does embodied energy have to do with greenhouse gas emissions?**

13. **What is the difference between upstream and downstream emissions?**

Quiz Answer Key

1. b
2. b
3. b
4. d
5. c
6. d
7. d
8. b
9. d

1. Answer depends on your waste audit.
2. Cradle to grave refers to analysis to disposal/recycling whereas cradle to cradle refers to an analysis that includes reusing the product or materials used to make the product (zero environmental impact.)
3. Every step of a products life adds embodied energy; this energy must be produced, and therefore releases GHGs.
4. Upstream emissions occur before consumption of the product, downstream emissions occur from consumption onwards.

Consumption and Waste Appendix

Climate Change and Waste from the US EPA. An excellent overview of the waste/Climate Change relationship: *http://www.epa.gov/waste/nonhaz/municipal/pubs/ghg/climfold.pdf*

A Waste and Climate Change game from the EPA. It is aimed at "Junior High and Middle Schools." This could be done in one 45 minute period. The EPA will also mail you copies if you plan far enough ahead: *http://www.epa.gov/waste/education/pdfs/4-6.pdf*

The Story of Stuff online video chronicles the social and environmental impacts of our production and consumption patterns at: *http://www.storyofstuff.com/*