# LIFE CYCLE ANALYSIS: EMBEDDED ENERGY

ONTARIO ecoschools écoécoles de l'ONTARIO

**Grade 8, Science and Technology**

*Source: Adapted from Life Cycle Analysis: Embedded Energy, Grade 7 Integrated Unit: Heat in the Environment, TDSB 2009*

## DESCRIPTION

This activity asks students to consider the environmental impacts of product manufacturing and the energy inputs that manufacturing entails. In three related tasks, students explore life cycles by studying three product life cycle posters and then research the life cycle of another product. They also make paper to get hands-on experience in the development of a product.

## CURRICULUM LINKS – SCIENCE AND TECHNOLOGY, GRADE 8

*Understanding Structures & Mechanisms– Systems in Action*
Overall Expectations: 1, 2, 3
Specific Expectations: 1.1, 1.2, 2.1, 2.6, 2.7, 3.1, 3.2, 3.3, 3.9

## PLANNING NOTES

### Materials

- Wood chips (enough for 4/5 bags)
- Recycled paper (enough for 4/5 bags)
- Hammer or mortar & pestle
- Safety goggles
- Paint rollers
- Blender
- *No Fish Story! – The Making of an Aluminum Can* (Appendix 1)
- *Lignin? Yeah, Lignin!* (Appendix 2)
- EPA life cycle posters from www.epa.gov/epawaste/education/mad.htm.

### Learning Skills & Work Habits

Responsibility, organization, independent work, initiative, self-regulation

### Prior Learning

Reviewing the 3Rs reinforces that when students save product materials (matter inputs) they are also saving energy inputs at every stage of the manufacturing process. The energy needed to make a product can be considered to be embedded in each stage of its making, hence the term "embedded energy." When you buy a product, you are not only buying the materials used to make the product, you are also buying all the energy that was used to make and assemble the parts of the product, as well as the energy used to transport all the parts and final product to the store. Automation has the potential to increase energy efficiency, but environmental impacts of the technology required must be considered.

### Recommended Class Time

- 4-5 periods (the activity does not have to be strictly linear and paper-making may occur over time)

## TEACHING/LEARNING STRATEGIES

### Part One: Product Inputs and Outputs

1. Introduce the terms "input" and "output." Focus on a product familiar to students such as bread or chocolate chip cookies. Ask students to list:
   - The inputs (ingredients)
   - The method of manufacturing (baking, which uses fuel and requires an oven, made mainly of metal)
   - The outputs (waste heat, waste water [from washing]), and the baked goods for consumption
2. Help students understand input-output diagrams, which allow them to compare an industrial process to a natural process. Use visuals and charts such the ones in *No Fish Story! – The Making of an Aluminum Can* (Appendix 1).

**Part Two: Learning about a Product's Life Cycle**

1. Display *No Fish Story!: The Making of an Aluminum Can* (Appendix 1) and use it to explain the basic process of making an aluminum can. Emphasize the fact that between each stage, there is consumption of fossil fuels for transportation, since each manufacturing stage occurs in a different place. Most of the damage to Earth is done during the first two stages: mining the bauxite and processing the ore. At each stage, energy, water, and chemicals are inputs. At each stage, waste water and waste heat are outputs.
2. Print 1 to 3 of the life cycle posters from www.epa.gov/epawaste/education/mad.htm. Invite students to scan the posters, moving in groups from poster to poster. Then assign pairs or small groups of students to study the poster more closely. One group could use the aluminum-can life cycle instead of a poster. As a way to focus their thinking about the energy embedded in these products, have them map out the stages of the product's life cycle on a piece of paper and identify the energy inputs (machines, transportation, storage, etc.) and the energy outputs (waste heat). With their partner or group have students answer the question: What is embedded energy? Have them compare their responses with another pair or group.

**Part Three: Making Paper Takes Energy!**

1. Tell students that they are going to learn first-hand about the energy involved in making paper.
2. Explain to students that you want them to think about how they can make their own paper from scrap material. In this section, explain that some groups will receive wood chips, and others will receive recycled paper. Treat their ideas seriously as they brainstorm how to achieve the end result. Let them carry out their plans as far as possible, ensuring their safety at the same time. This might be done over several days, or even weeks. Anticipate the kinds of materials and tools that students might need, for example, hammers for crushing, blenders and water for mixing, rollers, trays for drying. The point is for students to feel how much energy is required to mash up pieces of wood and usable paper will likely not be a product of students' efforts.
3. When students have finished their papermaking efforts, display and read aloud the story: *Lignin? Yeah, Lignin!* (Appendix 2). The information furthers their understanding of why paper production is so energy intensive. Then have students work in pairs to interview each other about the paper-making process and how successful they were. As part of the interview, students should ask whether the process has made them think differently about paper. As an alternative to the interviews, you could have students write about the experience in a paragraph, journal entry, or comic strip.

**Part Four: Researching the Life Cycle of a Product**

1. Have students work in partners or small groups to research a product of their choice. This activity will help solidify their understanding of matter and materials, how energy is part of the production process, and their own awareness of these processes.
2. Use the following guiding questions to help students organize their information for their research:
   a. What product (matter) have you chosen to learn more about?
   b. What natural resource or raw material is needed to make this product?
   c. Where is energy needed in the life cycle of this product?
   d. What is the effect of taking this raw material from the environment?
   e. Can this product be recycled? How is it done?
   f. What is the recycled product made into after recycling? What are benefits of recycling this product?

**Part Five: Review the 3Rs**

1. To conclude this series of activities, have a class discussion about the meaning of the 3Rs so that students understand the connection between each "R" and matter cycles and energy flows.

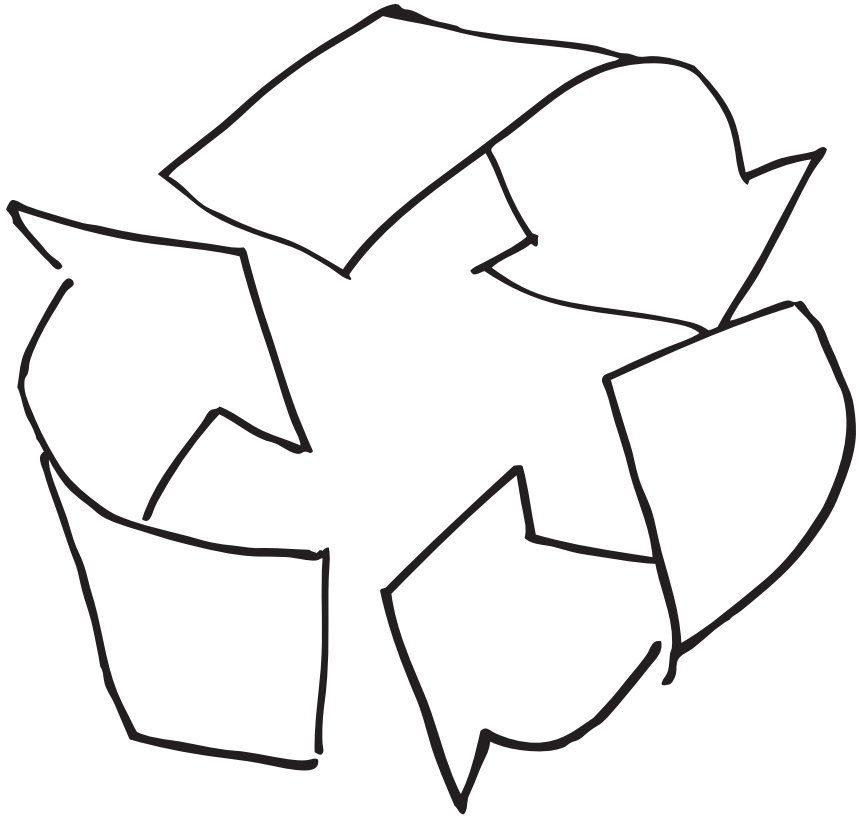
- **Reducing** the number of products that we purchase means we save not only materials (matter), but also the energy that is embedded in them. This reduces the energy and materials extracted from the Earth, and the fuel used to transport the energy and materials. Before purchasing an item, it is important to consider whether or not the item is really needed.

- **Reusing** items rather than buying new items also reduces the need for new items. Purchasing used items for yourself or donating your used items to organizations that will reuse them is a good way to reduce the need to produce new items, thus saving both materials and energy.
- **Recycling** is an industrial process that uses energy, so this "R" saves the least energy of the three. Making products using recycled instead of new materials conserves energy. It is important to be aware of the growing number of materials that are being collected for recycling in one's community.

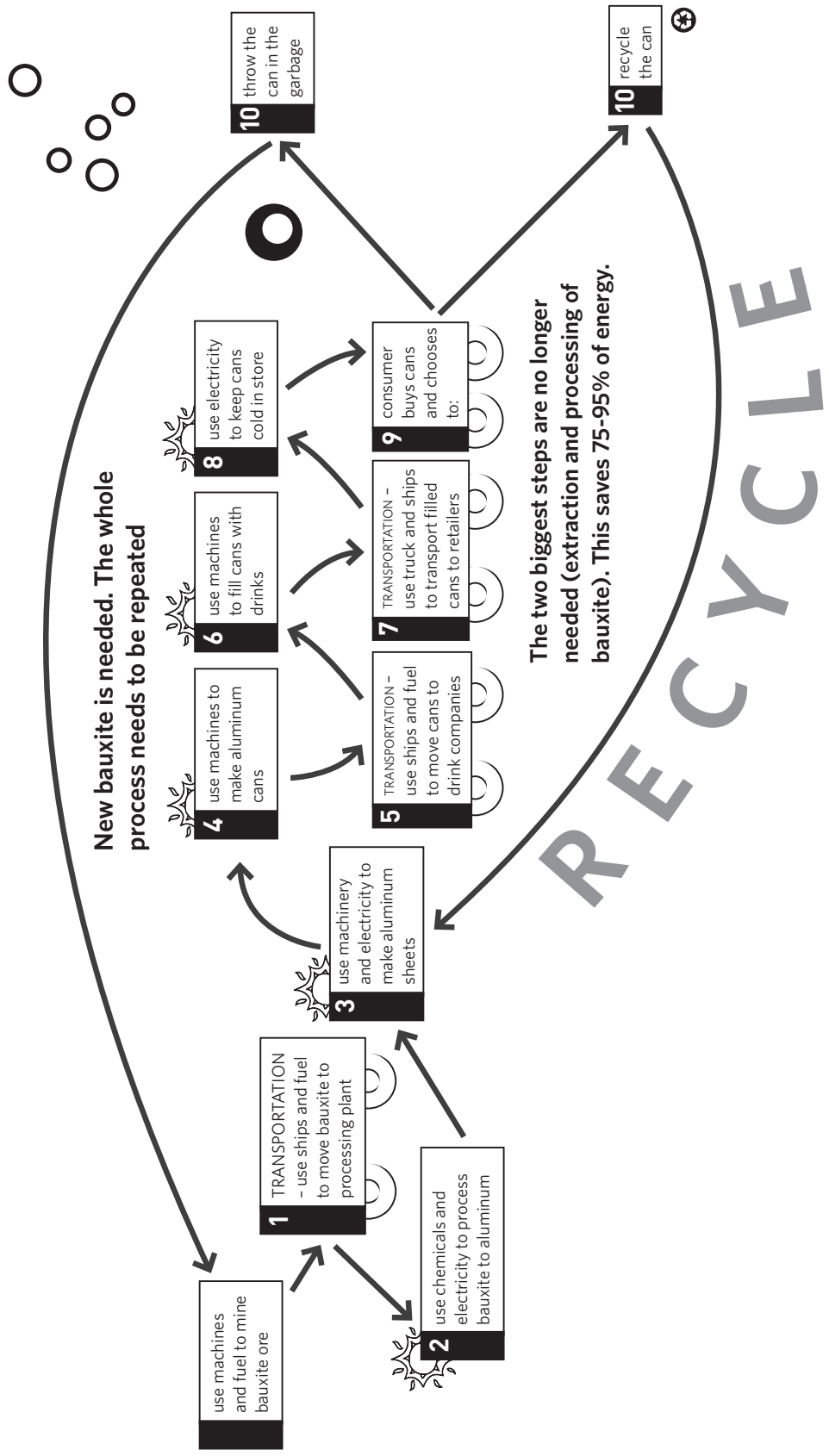
2. With the class, generate a list of questions related to the 3Rs for discussion and further research. For example:
   - Why do we need to reduce our energy consumption?
   - Who should recycle?
   - What kinds of products can be recycled?
   - Why do we need to reduce our use of paper?
   - What does 30% recycled paper mean?
   - What does 100% recycled paper mean?
   - What do we need to do to reduce our purchase of plastic products?
   - What are toner cartridges? What are they made of?
   - How can toner cartridges be reused?

**APPENDICES**

Appendix 1 – *No Fish Story! – The Making of an Aluminum Can*
Appendix 2 - *Lignin? Yeah, Lignin!*



# NO FISH STORY! – THE MAKING OF AN ALUMINUM CAN



# LIGNIN? YEAH, LIGNIN!

The building blocks of plants are plant cells. Plant cells are very different from animal cells. Plants don't have bones, but their structures are able to support a lot of weight – just think of a sunflower stem. What makes the stem so stiff? The answer is found by looking carefully at plant cells. Thet are surrounded by a thick cell wall. Two important fibres found in the cell wall are cellulose and lignin.

Lignin is the second-most abundant organic compound on Earth after cellulose. Lignin makes up about one-quarter to one-third of the dry mass of wood.

Lignin provides the cell wall with a lot of strength. It also plays an important role in forming vessels or tubes that allow water to reach the tops of trees through the trunk from roots in the ground. Lignin does not break down easily. It makes wood durable, and protects trees from fungus and bacteria. This is great news for trees, but bad news for some papers. When lignin is left in paper, the paper changes colour pretty quickly. Newsprint usually contains lignin, and newsprint changes colour when exposed to sunlight. In order to make many kinds of paper, the lignin must be removed. This requires a lot of energy and a lot of special chemicals.

Wood is mashed up into a pulp and chemically treated to remove the lignin. It is then washed away to leave paper-friendly fibres such as cellulose, from which the paper is made. Recycled fibres do not need to be treated for lignin – the lignin has already been removed, so a gentler (less energy-intensive) process is all that is needed to break the fibres apart. They can be broken apart about a dozen times before they are too short to be made into more recycled paper.