# LCA Mind Map

## Objectives

- Trace energy and carbon through a Life Cycle Analysis
- Describe what a Life Cycle Analysis is
- Describe steps in fuel processing where carbon dioxide is sequestered and released
- Create a LCA on a renewable fuel

| **Skill Level:** Middle School and High School | **Class time:** Two 45 minutes sessions |
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## Materials

- A mind map and LCA mind map worksheet (see attached)
- Scissors
- Glue sticks

## Next Generation Science Standards

**Disciplinary Core Idea:**

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

**Performance Expectations:**

MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem

HS-LS2-3: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions

| **Practices** | **Crosscutting Concepts** |
|---|---|
| ☐ Asking questions / defining problems | ☐ Patterns |
| ☒ Developing / using models | ☐ Cause and effect: Mechanism / explanation |
| ☐ Planning / carrying out investigations | ☐ Scale, proportion, and quantity |
| ☐ Analyzing / interpreting data | ☒ Systems and system models |
| ☐ Math / computational thinking | ☒ Energy / matter: Flows, cycles, conservation |
| ☒ Constructing explanations / design solutions | ☐ Structure and function |

| | |
|---|---|
| ☐ Engaging in argument from evidence<br>☐ Obtaining / evaluate / communicate | ☐ Stability and change |

## Background Information

When selecting alternative fuels, it is important to consider the relative advantages and disadvantages of each, especially in terms of environmental impact, carbon production and energy transfer. Many scientists link increased carbon dioxide in the environment to increases in global temperatures. Some alternative fuels also require large amounts of energy to be used to transport and process the biomaterials into fuel. Life cycle analysis (LCA) is a tool scientists use to realistically assess the overall impacts of alternative fuel processes and inputs on the environment. LCA can help by following the carbon footprints and energy efficiency for one process and comparing them to another process. For example, carbon can be traced from plants, through various unit operations and finally to the production of ethanol. Similar analysis can be done with energy inputs and outputs from a growing plant, transportation to a refinery, refinery energy requirements, and transportation to point-of-use. LCA considers one or many of the stages in the life of a product (from raw material acquisition to use of the product) and estimates the cumulative impact of processes and various inputs on the environment.

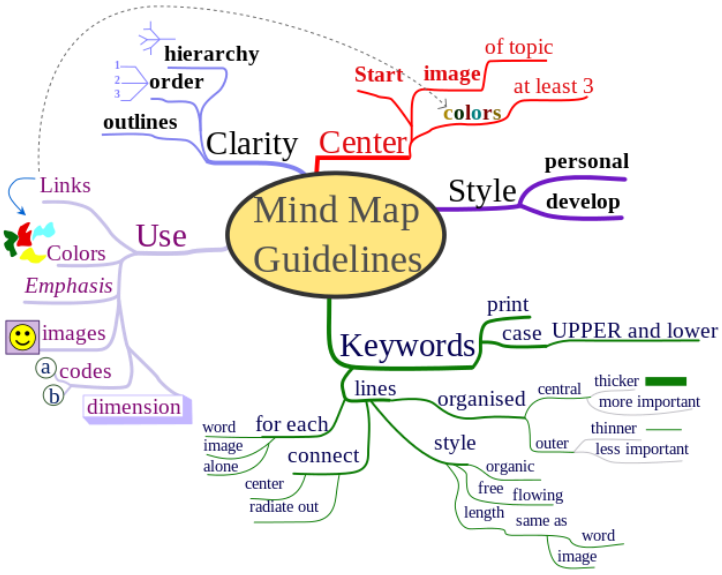


Figure 1. This shows potential guidelines to use when making a mind map. Reference

One way to organize thoughts for a life cycle analysis is to write them out in a mind map. A mind map usually starts with a central idea and then any words that relate to that idea are written down. Those ideas are then connected by explanation or by diagramming how they relate. In this activity students will use this concept to create what they think the steps of the carbon cycle are by creating a mind map.

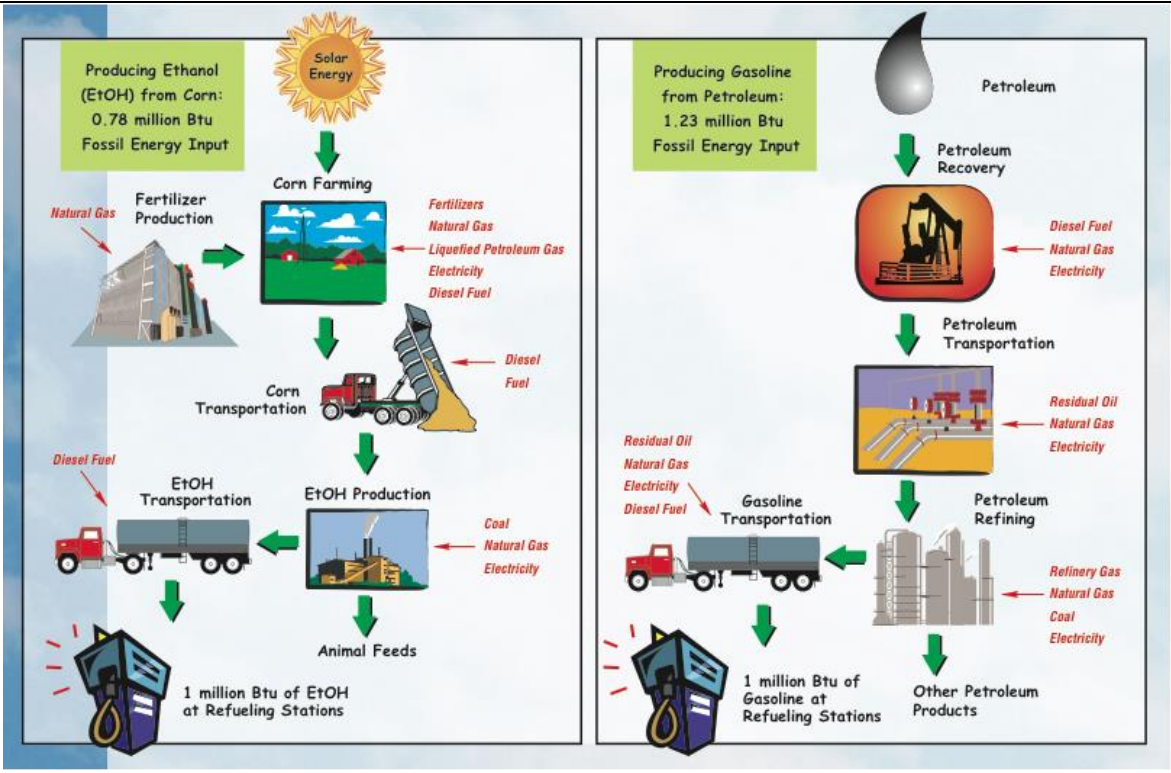


Figure 1. Life cycle of ethanol as compared to gasoline. Reference

Before completing this activity student should have some idea about biofuels, photosynthesis, and the refinery process. Biofuels are energy source that are mainly composed of renewable sources. These renewable sources can include plants, such as corn, that can be regrown (via photosynthesis) once processed into fuel. The process of turning plant into fuel includes the break down of glucose and cellulose. This fuel can then be used in cars, boats, and planes and because this process is renewable, it starts over again.

## Engage

Students should be excited to know that the Life Analysis Cycle is something that real scientists use. This is an important activity because it is not always obvious how much energy it takes to produce a biofuel or how much carbon dioxide it releases compared to petroleum fuels. Mind maps can be used whenever trying to figure out a process of an object. Mind maps have also been used for centuries as a way of problem solving, brainstorming, and learning. The processes seen in this activity (photosynthesis, fermentation and combustion) is something that the students experience everyday.

## Explore

**Experiment Questions**:

- Does all the energy put into the cycle make it to the final energy output stage? Why or why not? Remind students that energy can 'escape' in other forms other than gasoline or ethanol such as heat or steam.
- Transportation from the farm to the refinery and distribution of the final product were included in the basic LCA. Why would these be important to include in the LCA process? What gas are we trying to keep track of when doing this? How would we include this in the advanced LCA?
- First generation ethanol comes from feedstocks or corn crops that can also be used for food. What are the benefits or drawbacks from using these feedstocks?
- What are some ways that the Life Cycle could become more efficient?

**Procedure:**

**DIRECTIONS (DAY 1)**

1. In a large group, ask students to answer true or false to the following questions. Discuss any aspects of the questions or answers the students wish to discuss. (10 minutes):
    a. The original Model T Ford was designed to run on ethanol produced from corn. (**True**. The engine was capable of running on gasoline, kerosene, or ethanol, although the decreasing cost of gasoline and the later introduction of Prohibition made ethanol an impractical fuel.)
    b. You can use ethanol in your snowmobile, motorboat, chainsaw, and lawnmower, all without any special modifications. (**True**. It must be a fuel blend of 85% denatured ethanol fuel and 15% gasoline.)
    c. Much of US Gasoline is already blended with ethanol. (**True**, up to 10%.)
2. Hand out the mind map activity to the students. Guide them through the directions and answer any questions they may have about the process. Give students time to brainstorm and work on their maps before introducing the vocabulary in step 3.
3. Display the following 4 vocabulary words and their definitions. Have students add the 4 vocabulary words to their maps, encouraging them to group their concepts using those words.

**Vocabulary**

Feedstock—the plants or waste products used to create biofuels such as ethanol, or other industrial chemicals

Refining—the process of transforming the plant material into fuel. This may include physical and chemical changes to the plant material, fermentation and distillation

Sequester—to remove gases from the atmosphere (in our case carbon dioxide) and transform it via photosynthesis in the plant into carbohydrates, which can be stored

Transport—moving raw materials or finished products from point to point

4. Have the students share their mind maps with another student and make any desired amendments.
5. Have students share similarities and differences they found in their mind maps to the larger group. Project the basic LCA chart with students and see if any of them have these concepts in

their mind maps. Answer any questions they may have about the process.

**DIRECTIONS (DAY 2)**

1. Decide which format works best with your group. All formats are included in the attached worksheet.
    a. Individual Worksheets – students fill in the blanks of the LCA individually and then check their work with a large group review
    b. Small Group Cards – each small group receives a stack of cards which they must organize into the proper LCA format
    c. Large Group – students discuss the different inputs and outputs of the system in large group format
2. Provide students with their previous mind mapping activity. Explain that scientists use similar diagramming activities to trace the impacts of processes and inputs on the environment. Hand out one of the LCA activity sheets. Depending on which one you choose, you should have the students arranged individually, in small groups, or in a large group.
3. Project the Advanced LCA chart. Walk the students through each of the steps discussing the energy inputs, outputs, and processes needed to create the energy. Explain that this is a basic chart and that scientists also track carbon output. Ask students why scientists would want to do this.
4. Have the students look at feedstocks or other natural resources available in their community. Have them create a possible LCA for that resource. What are the benefits and drawbacks from using this resource?

## Explain

- What do feedstocks do?
- What are some of disadvantages you have identified of for using biofuels as an energy source?
- Why is it important to complete lifecycle analysis?
- What problems could occur if lifecycle analysis were not done on biofuels?
- What other ways do you think a Mind Map could be used?

## Elaborate

- Familiarize students with glucose by having them draw a glucose molecule. Afterwards, walk them through the process of the creation of two ethanol molecules and 2 carbon dioxide molecules. (See additional resources for more info.)
- Learn more about bioprospecting, which is the search for natural examples of microbial biomass degraders like the leaf-cutter ant. See below for more information.
- Make an LCA of a fossil fuel, and then create a chart comparing the similarities and differences between the LCA of a renewable fuel and the fossil fuel.

# Resources

**Additional Resources:**

- What is Bioprospecting?

**Resources Used:**

- Great Lakes Bioenergy Research
- Vimeo: How Does Cellulose Make Ethanol?
- Biofuel Basics
- Agriculture in the Classroom
- Mind Maps