

# Life Cycle Assessment:

## The Life of a Biofuel and Its Effects on The Earth

**Overview:** This lesson explores the life cycle of a biofuel, and how its production affects the environment.

**Keywords:** *Biofuel: a fuel derived from organic material*

*Biomass: biological material derived from living or recently deceased organisms*

*Carbon Cycle: the exchange of carbon between the biosphere, pedosphere, geosphere, hydrosphere, and atmosphere.*

*Conversion: the process of converting biomass into isobutanol through pretreatment, enzymatic hydrolysis, and fermentation.*

*Co-Product: a product manufactured along with another product. In the context of fuels, common products include plastic water bottles and Gor-Tex*

*Diameter at Breast Height (DBH): the diameter of a tree at approximately 4.5 feet*

*Ozone: is an inorganic molecule, O<sub>3</sub>, that makes up .06ppm of the atmosphere. The Ozone Layer of the Earth contains 2-8ppm of O<sub>3</sub> and helps prevent too much UV Light from hitting the Earth's surface.*

*Transportation- the process of moving woody biomass to a processing facility, via tractor trailers*

**Age / Grade Range:** 9<sup>th</sup>-12<sup>th</sup>

**Background:** To determine the environmental health impacts of the producing biofuels, a life cycle assessment (LCA) can be used. In 2014, Pierobon et al, writes that a LCA “is a popular tool for the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product throughout its life cycle.” A life cycle assessment generally includes nine impact categories; global warming, ozone depletion, eutrophication, acidification, smog formation, eco-toxicity, human health criteria, human health cancer and human health non-cancer (Pierobon et al, 2014). When analyzing biofuel production and use, there is an enhanced focus on its impact on global warming (Pierobon et al, 2014).

In 2014, Pierobon et al, also determines that “The emissions generated through feedstock collection, biomass burning and the decay of forest residuals left in the forest were compared with the carbon sequestration achieved through biomass growth within the forest. The results show that the potential impact on global warming in regards to biomass collection and burning from industrial forests in the Pacific Northwest region is fully offset within 18 years of forest growth and carbon sequestration (Pierobon et al, 2014). Upon completion of a full lifecycle assessment, NARA will be able to determine the environmental impact and feasibility of their biofuels project, including every step from the cutting of the tree, to the Alaska Airlines flight in the Spring of 2016.

## **Next Generation**

### **Science Standards**

**and Common Core: HS-LS2: ETS1.B Developing Possible Solutions**

**HS-ESS3.A Natural Resources**

**HS-ESS3.C Human Impacts on Earth Systems**

## **HS-ESS3.D Global Climate Change**

### **HS-ESS3. ETS1.B Developing Possible Solutions**

#### **Goals:**

What are all of the steps in the life of bio fuel?

How much carbon do you release into the atmosphere every year?

How much Carbon Dioxide and Ozone is released from the production of a biofuel?

What are some methods than can be used to reduce your carbon footprint?

#### **Objectives:**

Students will understand:

The life of a biofuel

The environmental impacts of biofuel production

Their carbon footprint and impact on the earth

The effects that Carbon Dioxide and Ozone have on the atmosphere

#### **Materials:**

Computer

Markers/Colored Pencils

Paper

Pencil/Pen

Global Footprint Calculator Quiz

LCA Excel Spreadsheet

Calculator

LCA Scenario Guide (Attached)

**Set Up:** XXXXXXXXXXXXXXXXXXXXXXXX

**Classroom Time:** 90 Minutes

**Introduction:**

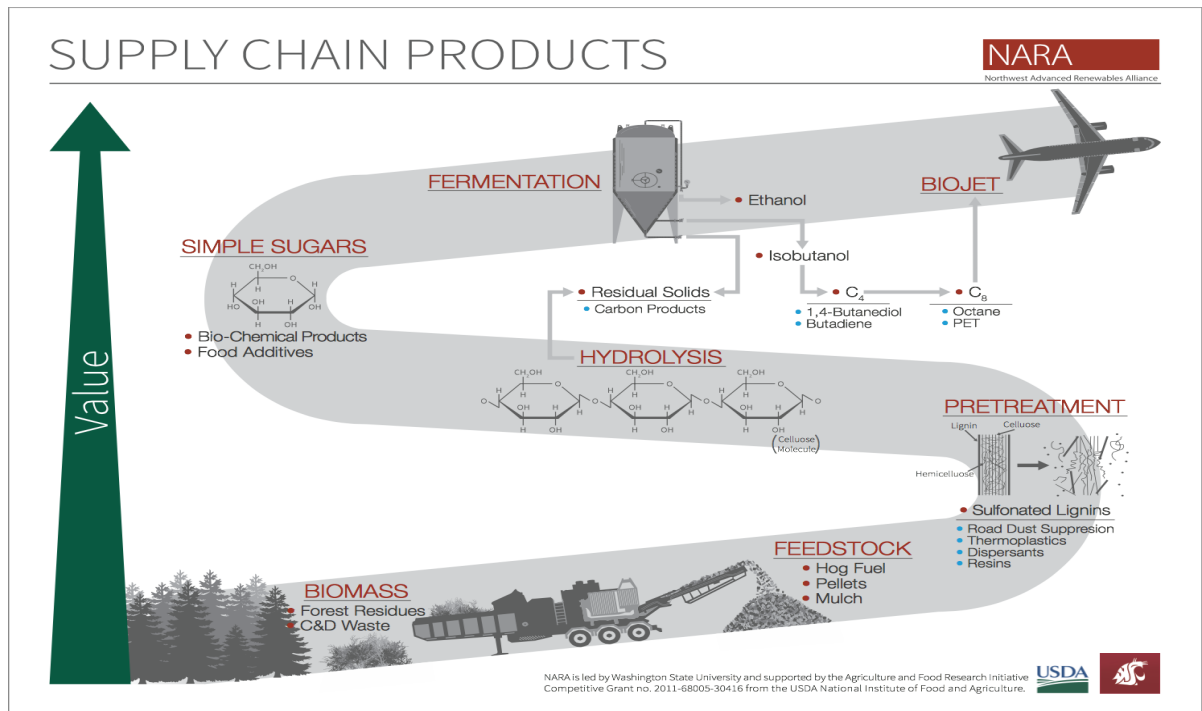
Review with the class all the steps of biofuel process

**(Engage)**



Have students draw a supply chain and all the products and materials at each step (See example below)

Have them share and compare drawings with a partner.



Ask the class about the impacts that they think each step may have on the environment?


Discuss the effects that increased amounts of O<sub>3</sub> and CO<sub>2</sub> have on the atmosphere.

**Activity:** How many tons of Carbon do you think you produce every year?

**(Explore)**

“Take the Quiz” to determine your impact on the environment/carbon footprint

[http://www.footprintnetwork.org/en/index.php/GFN/page/personal\\_footprint](http://www.footprintnetwork.org/en/index.php/GFN/page/personal_footprint)



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Frequently Asked Questions

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### Personal Footprint

How much land area does it take to support your lifestyle? Complete our online personal Footprint calculator to find out your Ecological Footprint, discover your biggest areas of resource consumption and learn what you can do to tread more lightly on the earth.

**Take the Quiz**


RELATED LINKS

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Have students discuss with a partner, or small group, ways that they think that can reduce their impact.

\*Use attached worksheet

Spreadsheet (volume of trees/how many/scenarios)



\*Use Attached Spreadsheet and LCA Scenario Guide

	A	B	C	D	E	F
1	Whole Trees	Tree Volume (cubic feet per tree)	Forest Residues Preparation Bone Dry Woody Bio Mass (Pounds)	Amount of Bio Jet Fuel (Gallons)		Lignin (Pounds)
2						
3	500	30	840	18.90189019		252.2522523
4						
5						
6						
7						
8						
9						
10						
11						
12	Gallons of Biofuel	Feedstock Production Lbs/CO2 Emissions	Feedstock Production Lbs/O3 Emmisions			
13	18.90189019	64.764	30.114			
14						
15						
16						
17						
18						
19						
20	Gallons of Biofuel	Number of Dumptrucks needed for transport	Distance Traveled to Processing Plant	Amount of Diesel Fuel Used for Transport (Gallons)		Amount of Carbon released into the atmosphere (Pounds)
21	18.90189019	15.13333333	10	24.39493333		545.958608
22						
23						
24						

**Explanation:**

Have students research the LCA of fossil fuels and compare to the LCA of biofuel

\*Use attached LCA Scenario Guide

**Evaluation:**

XXXXXXXXXXXXXXXXXXXX

**Bibliography:**

XXXXXXXXXXXXXXXXXXXX



# Life Cycle Assessment: Scenario Guide

## Carbon Footprint Results:

1. How many earths do you need?

• \_\_\_\_\_

2. How much carbon do you release per year (tons), based on your lifestyle?

• \_\_\_\_\_

3. How much carbon have you potentially released over the course of your life so far (tons)?

• \_\_\_\_\_

4. What are 3 steps you can take every day that will aid in reducing your carbon footprint?

• \_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_

• \_\_\_\_\_

\_\_\_\_\_

• \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

5. Describe 1 lifestyle change you could make that could significantly reduce your carbon footprint, and how you would go about making/implementing this change.

• \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

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### LCA Background Information:

Now that you all have looked at an assessment of your own lives, and how much carbon dioxide you released based on different actions you take, let's investigate the Life Cycle Assessment of a biofuel.

A supply chain coalition has been developed to evaluate the feasibility of creating biofuel from woody biomass. Since they are approaching this challenge from a business perspective they are interested in understanding if it will be economically viable. But this group is also interested in the social and environmental impact of this process. To look at environmental impacts specifically they are using a process called LCA. They are hoping that this process will lead to a 60% reduction in greenhouse gas emissions when this process is compared to conventional jet fuels. But they are also interested in other local emissions on this process. Using the information below, figure out what the balance CO<sub>2</sub> emissions and other gases based on different scenarios. Then, you'll figure out if this process is "good" overall — does it reduce greenhouse gas emissions on balance? Are the local emissions socially acceptable? How would you go about making this evaluation of "good"?

How to find the volume\* of a tree:

$$V = \pi r^2 \times h$$

\*this volume equation is conceptual for the purposes of this exercise, and is not an intended to be a precise caution of tree volume.

## LCA Interactive Spreadsheet Scenarios:

Using the LCA Spreadsheet, determine the following:

### *Jet Fuel and Co-Products*

Scenario: You have a logging site containing 450 trees; they have a DBH of ~2.5ft and a height of ~65ft

1. What is the potential weight of the bone dry woody biomass that can be produced from the 453 tree?
  - \_\_\_\_\_ LBS
2. What is the the potential amount of bio jetfuel that can be produced?
  - \_\_\_\_\_ GALS
3. What is the potential amount of Lignin that can be produced?
  - \_\_\_\_\_ LBS
4. What is the potential amount of Isobutanol that can be produced?
  - \_\_\_\_\_ LBS

### *Feedstock Production*

Scenario: You have a logging site containing 450 trees; they have a DBH of ~2.5ft and a height of ~65ft

1. From the Feedstock Production, how much CO<sub>2</sub> is emitted?
  - \_\_\_\_\_ LBS
2. From the Feedstock Production, how much O<sub>3</sub> is emitted?
  - \_\_\_\_\_ LBS

### *Transportation*

Scenario: You have a logging site containing 450 trees; they have a DBH of ~2.5ft and a height of ~65ft

1. If you need to travel 47 miles to the processing station, how much CO<sub>2</sub> will be emitted throughout the transportation of the biomass?
  - \_\_\_\_\_LBS
2. If you need to travel 47 miles to the processing station, how much diesel fuel will be needed to transport of the biomass?
  - \_\_\_\_\_GALS
3. If you need to travel 100 miles to the processing station, how much CO<sub>2</sub> will be emitted throughout the transportation of the biomass?
  - \_\_\_\_\_LBS
4. If you need to travel 100 miles to the processing station, how much diesel fuel will be needed to transport of the biomass?
  - \_\_\_\_\_GALS
5. If you need to travel 13 miles to the processing station, how much CO<sub>2</sub> will be emitted throughout the transportation of the biomass?
  - \_\_\_\_\_LBS
6. If you need to travel 13 miles to the processing station, how much diesel fuel will be needed to transport of the biomass?
  - \_\_\_\_\_GALS

### **LCA Fossil Fuel Information:**

Research the LCA of petroleum, with a focus on jet fuel. Try to find out the carbon and ozone emissions through the extraction, transportation, and production phases. Compare

[illegible]