Designing a Biofuel Trailer

Objectives

- Students will need to design a mock flatbed truck that will hold wood chips.

Skill Level: High School	**Class time:** 50 minutes

Materials (per group)

- Blank printer paper
- Biofuel Trailer Design Worksheet
- Sawdust
- A scale
- Additional supplies can include: cardstock, tape, popsicle sticks, glue, paper clips, erasers, cardboard, etc. Anything the students may want to use to modify their trailer.

Next Generation Science Standards

Disciplinary Core Idea:
ETS1.C: Developing Possible Solutions

Performance Expectations:
HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

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	☐ Stability and change
☐ Obtaining / evaluate / communicate	

Background Information

Biofuels are a type of bioproduct made from a renewable source called a bioresource. This can include the sun, plants, and natural gas. When engineering a fuel that includes plant life, like trees, there is a substantial amount of waste that is converted into a more useful product. This can become wood chips and sometimes even sawdust. Transporting this waste can be a costly and difficult process. Engineers are currently developing a way to combat the many problems associated with transporting the waste from biofuels.

The biggest problem that engineers face is the amount of airspace between the sawdust. Currently there is no compaction method to combat this air space, which leaves trailers only 40% full. The reason why trucks are often not compacted is because the trailer is designed to be very lightweight so that they can fit as many wood chips as possible and be under the weight limit that most roads are restricted by. This becomes a problem when applying pressure or vibration for compaction. Even the a small vibration can destroy a trailer.

Figure 1. This image shows the traditional conveyor belt distribution method. Reference

In this activity, students must find a way to combat these issues. Students may want to think about the best way to distribute the sawdust into the trailer. There are currently two methods of distribution: a conveyor belt and a bark dust blower. The conveyor belt is hooked up to a wood grinder that directly distributes to the trailer depending on the trailer's position. With a bark dust blower a human strategically points a hose in the direction they desire, which can yield more controlled results. Students may want to choose one of these methods. Next, students may decide that it is beneficial to create a sturdier trailer to be able to compact the sawdust. However, the cost of this redesign may mean that there is less money for fuel to transport the waste. Finally, students can choose the method of compaction they think will work and still keep the trailer in tact. Students should keep in mind the cost of the materials needed for compaction. Details of this cost as well as the materials that should be provided are detailed in the procedure and worksheet. Again, the cost of compaction and delivery should not be more than the cost of gasoline to transport the waste. For this activity we suggest that the cost of combating the mentioned issues and gasoline should not cost more than $3,000 and should have a weight limit of 400 grams (these restrictions can be adjusted given the materials chosen).

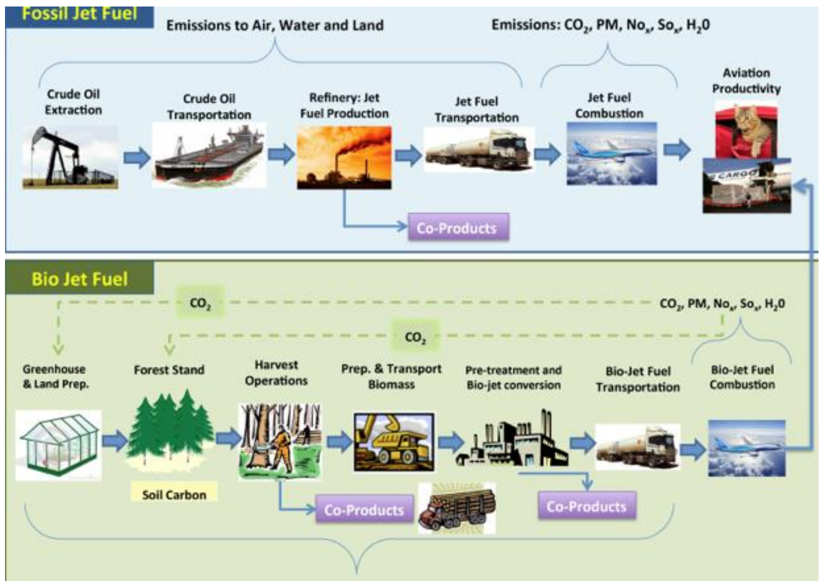

Figure 2. This shows a typical fuel process of fossil fuel as compared to biofuel. Reference

Engage

In this activity students get to be engineers and help solve a real world problem. This topic is one of current research with no real solution to date. This activity accurately simulates the problems engineers are trying to tackle when transporting bioresource waste like a fragile trailers and trailers not reaching capacity. They have to do this while balancing budget and weight restrictions.

Explore

Experiment Questions:

- What design provides the best balance between cost of materials and strength of trailer?

Procedure:

1. Make your trailer out of paper according to the instructions.
2. Have students experiment with the trailer. Brainstorm ways to adjust the trailer or why the

trailer should not be adjusted and share with the class.

3. Students may choose to add things to make the trailer sturdier but it comes with a cost. Remember all rates in this procedure are suggestions and can be adjusted to the materials that are provided to the class.
    a. Leaving the trailer as is: $30
    b. Adding cardboard, popsicle sticks, or additional support to the existing paper trailer: $40
    c. Making a completely new trailer out of different material: $60
4. Have students choose a method of loading their trailer.
    a. Conveyor belt method: $60
    b. A wood chip hose: $80
5. Once satisfied with the condition of their trailer have students try compaction methods. Remember anything they try must also translate to the real world.
    a. Vibration compactor: $ 800
    b. Pressure compaction methods: $900
6. Gasoline is an important factor in this as well. The amount of money spent on methods of alternative solutions will use up some of the gasoline funds. Let's say that the goal is to go 500 miles in a truck will cost $2,000 in gasoline. However, if students cannot reach the 500-mile goal make sure they still calculate how far their trailer would go with the money they have left over.
7. Remember, if the walls of the trailer begin bulging the trailer would collapse. Encourage students to try a different method when this happens. Allow student to adjust their worksheet to the method that works best for them.
8. Have students fill out the worksheet to determine the cost of their final product as well as how far their trailer can travel with their remaining budget as well as writing down what worked and what has not worked. The blanks in the cost column are up to the teacher to decipher. Students may use different materials to make their own solutions. Prices should be adjusted depending on number of materials used. An example sheet is provided (additional document).
9. Have the class do a final test of their trailer and present their final model. Have each group weigh their trailer and all the sawdust that they can fit in their trailer. They are not allowed to be over the weight of 400 grams. When weighing the trailer, any compaction or vibration

method designed to stay on the trailer while driving will also have to be part of the weight component. Ask the groups to share what they thought worked and did not work for their method of distribution, compaction, and trailer design. How much did the final design cost? Did you have to compromise on the amount of sawdust that your trailer could fit?

Explain

- Which design will have the best chance of success if actually built?
- What do you think would happen if you build a solution that was over the weight limit?
- Do you think the challenge of moving sawdust from the cut site to the plant can be solved economically?
- What are some of the differences between getting sawdust to the plant compared to getting oil from the well to the plant?

Elaborate

- How would your design change if you had a different role? What would the solutions look like for: An industrial engineer, a biofuels plant engineer, a forest engineer, an environmental engineer, a transportation engineer?
- How does each of the above-mentioned profit from this process?
- Why are their weight limits on roads? What happens if you exceed that limit? Why is this important to engineers?
- If you had an unlimited budget, what "Out-of-the-Box" ideas could you use to change the design?

Resources

Additional Resources:

- Engineering is Elementary

Resources Used:

- Carbon Cycle
- The Encyclopedia of the Earth
- Northwest Advanced Renewables Alliance

Name ________________________________

Designing a Biofuel Trailer Worksheet Example

After choosing the methods of distribution and compaction, as well as designing a trailer it is your turn to make sure the weight goal is met. Make sure these methods add up to be less than $3,000 and then the remaining money will be used to calculate how much money is left for gas. If a cost is left blank it is up to the teacher to set a price.

Step one: Trailer construction (choose one)

Method:	**Cost:**	**Remaining money:**
Keeping the paper trailer	$30	
Adding materials	$50	
Making a new trailer out of new materials	$70	$3,000 - $70 = $2,930

Why was this method chosen?

This method was chosen because I believe that the cost and weight of a studier trailer was worth it. It means I will have less sawdust in my trailer and less money for gas.

Step two: Distribution (choose one)

Method:	**Cost:**	**Remaining money:**
Conveyor belt	$60	
Wood chip hose	$80	$2,930 - $80 = $2,850
Alternative method		

What are the trade offs with choosing this method?

This method could allow for better and more compact distribution method, but it costs more again leaving less money for gas.

Step three: Compaction (choose one)

Materials:	**Cost:**	**Remaining money:**
Vibration maker	$800	
Pressure compaction method	$900	
Alternative method	Estimated $900	$2,850 - $900 = $1,950

How does this translate to the real world?

My method is neither compaction nor vibration; instead my trailer sits on springs, which in the real world would be a hydraulic system. Springs slowly shift the sawdust back and forth making a slight compaction and makes it easier for distribution by hose.

Step four: Weight goal

Weight goal	Actual Weight	Weight difference
400 grams	330 grams	70 grams

Besides sawdust, what added to the weight of your trailer?

The new trailer material and the hydraulic springs added weight to my trailer, but still met the weight goal.

Step five: Gas mileage

500 miles = $2,000	**Remaining money**	**Miles the trailer can travel**
0.25 miles = $1.00	$1,950	487.5 miles

Was the goal met? If not how would you redistribute cost?

I missed the goal by 12.5 miles. To save money I maybe should have gone with the conveyor belt method to save the extra $20.

What did you learn from this?

I learned that engineering is a process of trade-offs. You may have to spend more money to reach a goal and if you reach one goal you may no reach another.

Name ________________________________

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0.25 miles = $1.00		

Was the goal met? If not how would you redistribute cost?

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