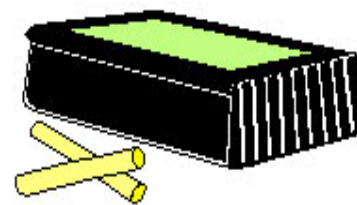




## Teacher Information

### Lesson Title: CO<sub>2</sub> Closure Loop Cycle Lab series



**Lesson Description:** This series of activities helps the students understand a closed loop system by using an interactive model. They will complete a lab exercise and explain the cycle of CO<sub>2</sub> in the willow biomass energy production cycle. The students will be asked to synthesize the information from this activity with their knowledge of global warming. They will also compare and contrast data between willow biomass and other fossil fuel sources and make conclusions based on the data. Mathematically students will be using concepts of percentages and ratios to help assess the data.

### Learning Outcomes:

Students will be able to:

- Explain the CO<sub>2</sub> closure loop cycle in the willow biomass system
- Use a basic ratio to help understand the CO<sub>2</sub> cycle in the willow biomass system
- Explain the benefits of using willow biomass as a source of energy
- Explain how using willow biomass as an energy source benefits the atmosphere
- Explain how the use of willow biomass affects the global warming concerns
- Compare and contrast using a venn diagram, the use of willow biomass vs. fossil fuels

### Materials Needed:

CO<sub>2</sub> closed loop cycle student worksheets (1 per student)

CO<sub>2</sub> close loop cycle sheet (1 per student)

Graph paper (1 per student)

One-dollar bill or a representation of a dollar bill (1 per lab team) and 10 pennies

17 chips or markers (per lab team)

Calculator (1 per lab team)

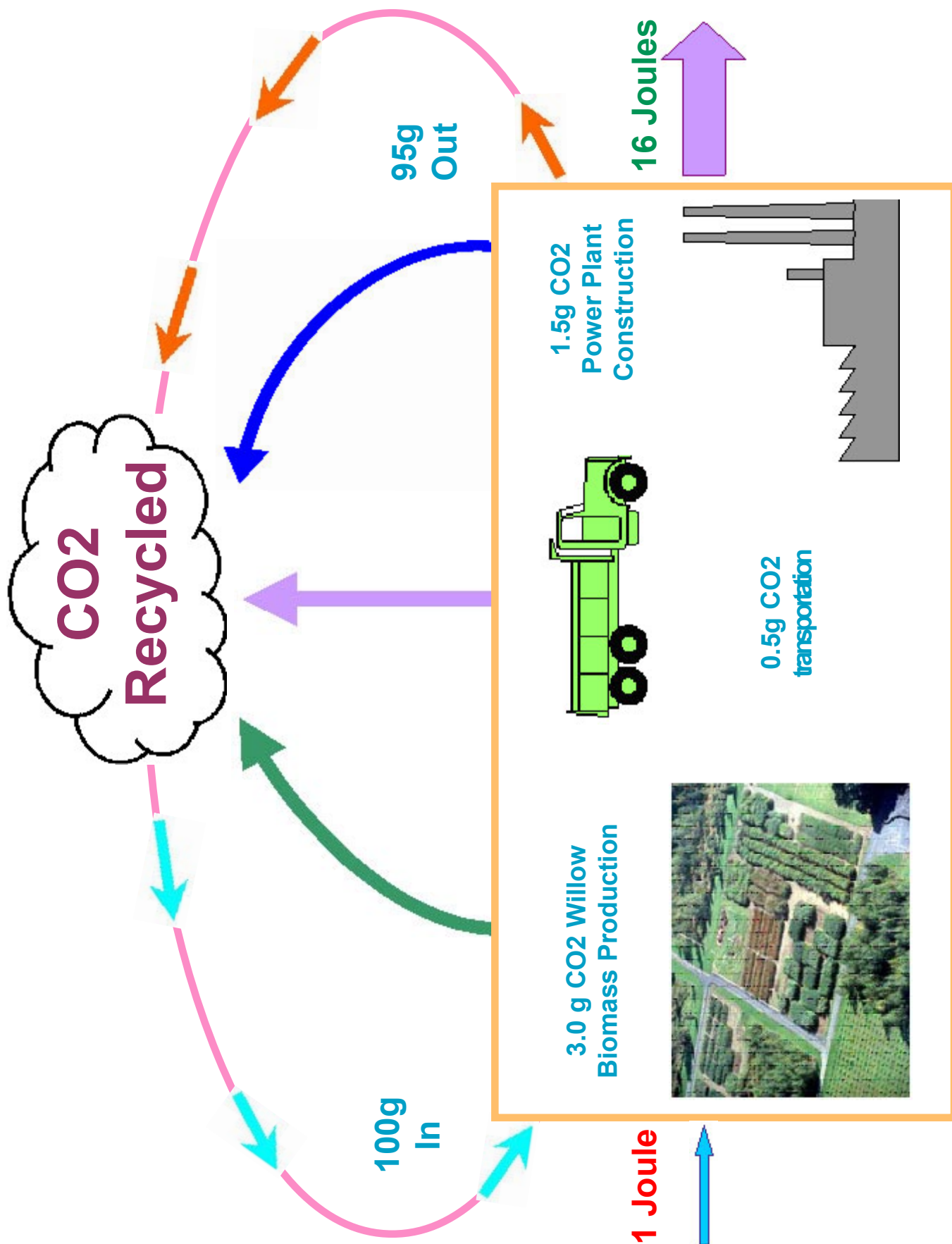
**Method:** Set up lab teams (2-4 students per team) and ask them to work through the lab activity. Provide support as needed. If the students are not familiar with ratios then work through the activity as a guided instructor exercise instead of a lab activity.

Time Requirements: 90 minutes

Non-blocked classrooms: Recommend two class periods, pages 1-4 in the first lesson and pages 5-6 for the second lesson

Blocked or double period: Use one full block lesson or the double period to complete the full exercise.

**MST standards:** See overview chart for the MST standard correlation





**Willow Biomass Module**  
**Lab exercise**

**CO<sub>2</sub> Closed Loop Cycle**

Name \_\_\_\_\_

Partner's initials \_\_\_\_\_

Date \_\_\_\_\_

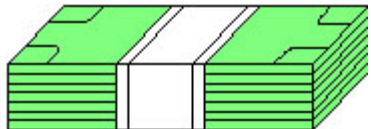
**Materials:** \_\_\_\_\_ CO<sub>2</sub> closure loop diagram for willow

\_\_\_\_\_ One dollar bill and 10 pennies

\_\_\_\_\_ 16 bingo chips or markers

**Directions:** Look at the “CO<sub>2</sub> Closure Loop Cycle”. The diagram shows what happens to 100g of CO<sub>2</sub> in the cycle of growing and using Willow as a biomass fuel source. This diagram or model will be used to explain the closed loop cycle for willow biomass.

Every penny will equal 1 gram of CO<sub>2</sub>



What ratio will be used in this model? 1 penny =

$$\frac{\text{_____}}{\$1.00} = 100 \text{ g of CO}_2$$

1) On your diagram place the dollar bill to the left side. This represents the starting point of 100 g of CO<sub>2</sub> taken in by the plants to be used for their growth.

2) Place the number of pennies that equals the amount of CO<sub>2</sub> released to the atmosphere through the willow biomass production stage of the cycle on the tree. How many did you place on the tree? \_\_\_\_\_



3) Place the number of pennies that equal the amount of CO<sub>2</sub> released into the atmosphere by the transportation stage on the truck. How many pennies did you place on the truck? \_\_\_\_\_

Could you place one whole penny on the truck? \_\_\_\_\_ Notice the circle below the truck. Color in the amount of the circle to represent the portion of the circle that would represent 0.5g of CO<sub>2</sub> released into the atmosphere.

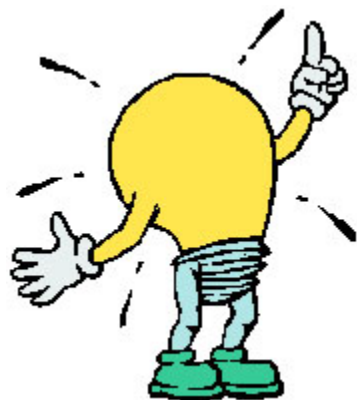


4) Place the number of pennies that equals the amount of CO<sub>2</sub> released into the atmosphere due to the power plant construction and maintenance stage of the process. Again note that there is a fractional portion. Color in the amount of the circle that would equal the fractional portion of CO<sub>2</sub> released into the atmosphere.

5) When the willow biomass is burned for fuel, 95g of CO<sub>2</sub> that was originally taken up by the willow is released into the atmosphere. This represents \_\_\_\_\_ percent of the original 100g?

6) How much total CO<sub>2</sub> is released into the atmosphere in the production, transportation, power plant construction, and the burning of the willow biomass for fuel? (use a percentage) \_\_\_\_\_? Using this number, fill in the box at the top of your diagram in the cloud picture.

7) Scatter pencil or pen dots around the top of the diagram to indicate carbon being released into the atmosphere in the form of CO<sub>2</sub> from the burning of the willow biomass for fuel.



**Thought questions:**

a) How much of the CO<sub>2</sub> that is released to the atmosphere through the burning of the willow for fuel, is taken up by the growing of the shrub trees?



b) In the process from growing to using willow as a fuel source, which is the biggest source of CO<sub>2</sub> to the atmosphere? (willow biomass production, transportation, or power plant construction and maintenance) Why do you think this is the case?

c) Explain why willow biomass crops are referred to as a closed loop cycle fuel?

d) How does growing willow to be used as an energy source effect the CO<sub>2</sub> levels in the atmosphere?



e) How will using willow biomass as a fuel affect the global warming issues?

## Part II Fossil Fuel Comparison

1) Substitute fossil fuels (oil, coal, or natural gas) into the CO<sub>2</sub> closed loop cycle diagram or sketch your own diagram. Think about the following factors.



2) In the process of harvesting/extracting fossil fuels would any CO<sub>2</sub> be produced? Would it be more or less than that for the willow biomass production stage? \_\_\_\_\_  
\_\_\_\_\_

3) Do you think transportation emissions of CO<sub>2</sub> would go up, down, or remain the same for the fossil fuels? \_\_\_\_\_  
\_\_\_\_\_

4) How about at the power plant construction and maintenance stage of the cycle? Would CO<sub>2</sub> emissions of fossil fuels be more, less, or about the same for Willow emissions? \_\_\_\_\_  
\_\_\_\_\_

5) Would fossil fuels have a large CO<sub>2</sub> output when they are burned for fuel?  
\_\_\_\_\_

6) Would there be any CO<sub>2</sub> going back into the fossil fuel system?  
\_\_\_\_\_

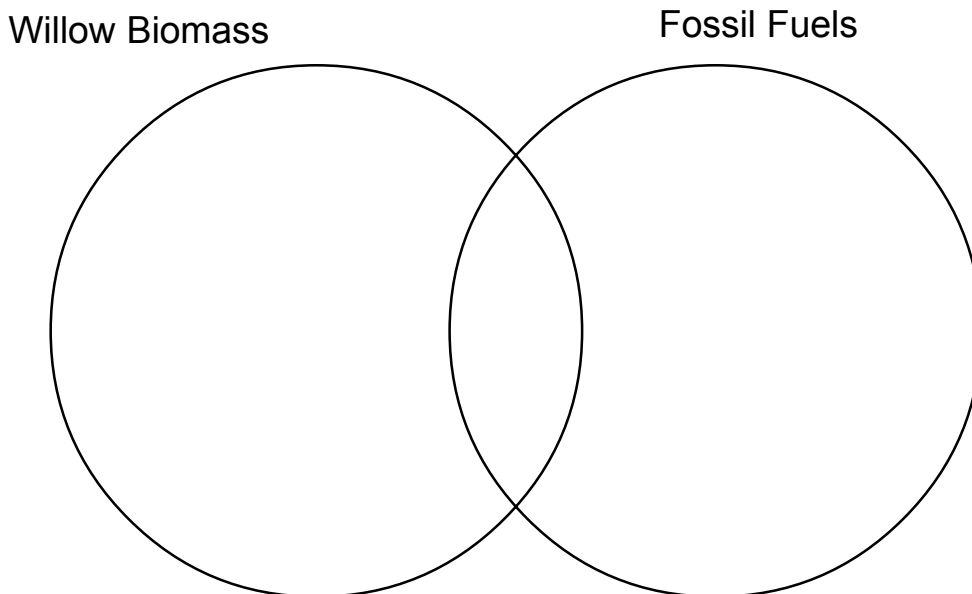
7) Would you consider the use of fossil fuels for energy to have a closed loop cycle? Explain your response.  
\_\_\_\_\_  
\_\_\_\_\_

8) How does the use of fossil fuels affect the global warming concerns?  
\_\_\_\_\_  
\_\_\_\_\_





9) Complete the Venn diagram below:



### Part 3: ENERGY EFFICIENCY

**Energy Balance Exercise Directions:** 1 joule of energy will be represented by one bingo chip. Place 1 chip at the beginning of the cycle on the diagram. How many chips will be placed at the end of the diagram where the willow is used to produce energy?

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1) Interpret the meaning of the bingo chips on the diagram.

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#### Thought Questions:

1) Energy is neither created nor destroyed but changes form, so where is the energy coming from in the willow biomass energy ratio?

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**Extra credit work:** How does the energy ratio for willow, 1Joule in = 16 joules of energy out compare to any of the fossil fuels? How about other alternative energy sources? (Find these through the internet, the library or ask your instructor for guidance)



**Alternative:**

Use the chart below and have the students complete the table and summarize the data.

**Complete the chart below and answer the questions:**

Energy In to Energy Out Ratios for Fossil Fuels vs. Willow Biomass

Type of Fuel source	Energy in MJ	Energy out MJ	Ratio
Willow Biomass	1		.064
Coal	1	0.30	
Fuel Oil	1		1.128
Natural Gas	1	0.40	

1) Summarize the data presented in the graph above in three to five sentences. \_\_\_\_\_

\_\_\_\_\_

2) Graph the data above for energy in vs. energy out, with clear labels, units listed and a title for the graph. \_\_\_\_\_

\_\_\_\_\_

3) Observe the slide presentation available from the website \_\_\_\_\_. Write a summary of the information provided in the slide presentation (5 to 10 clear sentences). \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_