

Experiment:

Build the calorimeter:

1. Measure 100 mL of water in the graduated cylinder and carefully pour it into one can.
2. Carefully cut a window (approximately 3.5 inches tall by 2 inches wide) out of the side of the second can (close to the bottom), if your teacher has not already done this for you.
3. On the side opposite the window, use a thumbtack to poke a small hole approximately 1-2 inches from the bottom. Insert a paper fastener into the hole and spread the arms slightly. This will be the platform for the nuts to sit on.
4. Place the can with the water on top of the can with the window. Be sure to place your calorimeter on the hot pad in a safe place where it will not be bumped or knocked over.

Test the nuts:

5. Determine the mass of the first nut with the digital scale. Record the type of nut and its mass in the data table.
6. Use the thermometer to take the start temperature of the water in the top can. Record it in the data table.
7. Place the square of aluminum foil over the hole in the top soda can (to act as a lid).
8. Carefully place the nut on the paper fastener in the lower can.
9. As directed by your teacher, you or your teacher will light the nut. Allow it to burn.
10. Do not touch the calorimeter as the nut is burning! It will be hot. If the nut falls off the fastener, use the tweezers to carefully put it back on.
11. When the nut has been consumed (and the fire goes out) take the end temperature. Record it in the data table. CAUTION: The bottom can will be hot!
12. Calculate the temperature change in ° Celsius. If necessary, convert both the start and end temperature to Celsius before calculating the temperature change. (Do not simply convert the temperature change!) Round to the nearest whole number.
13. Use the formula provided to calculate the calories released. Record in the data table.
14. Divide the calories released by the original mass of the nut to get the calories released per gram. Record in the data table.
15. Repeat the process for each nut

Graph your results:

16. Create a bar graph of your results:
 - Put the type of nut on the x-axis. Label the axis.
 - Put the calories per gram on the y-axis. Label the axis and be sure to include the units in your label.
 - Give your graph a title on the line provided.

Data

Type of Nut	Mass of Nut (g)	Volume of Water (mL)	Mass of Water (g)	Start Temp. (°C)	End Temp. (°C)	Temp. Change (°C)	Calories (cal)	Calories per Gram (cal/g)

Use the following formulas in your calculations:

- The formula for converting temperatures from Fahrenheit to Celsius is:

$$^{\circ}\text{Celsius} = \frac{5}{9} \times (^{\circ}\text{Fahrenheit} - 32)$$

- The formula for converting volume of water to mass is:

$$1 \text{ milliliter (mL) water} = 1 \text{ gram (g) of water.}$$

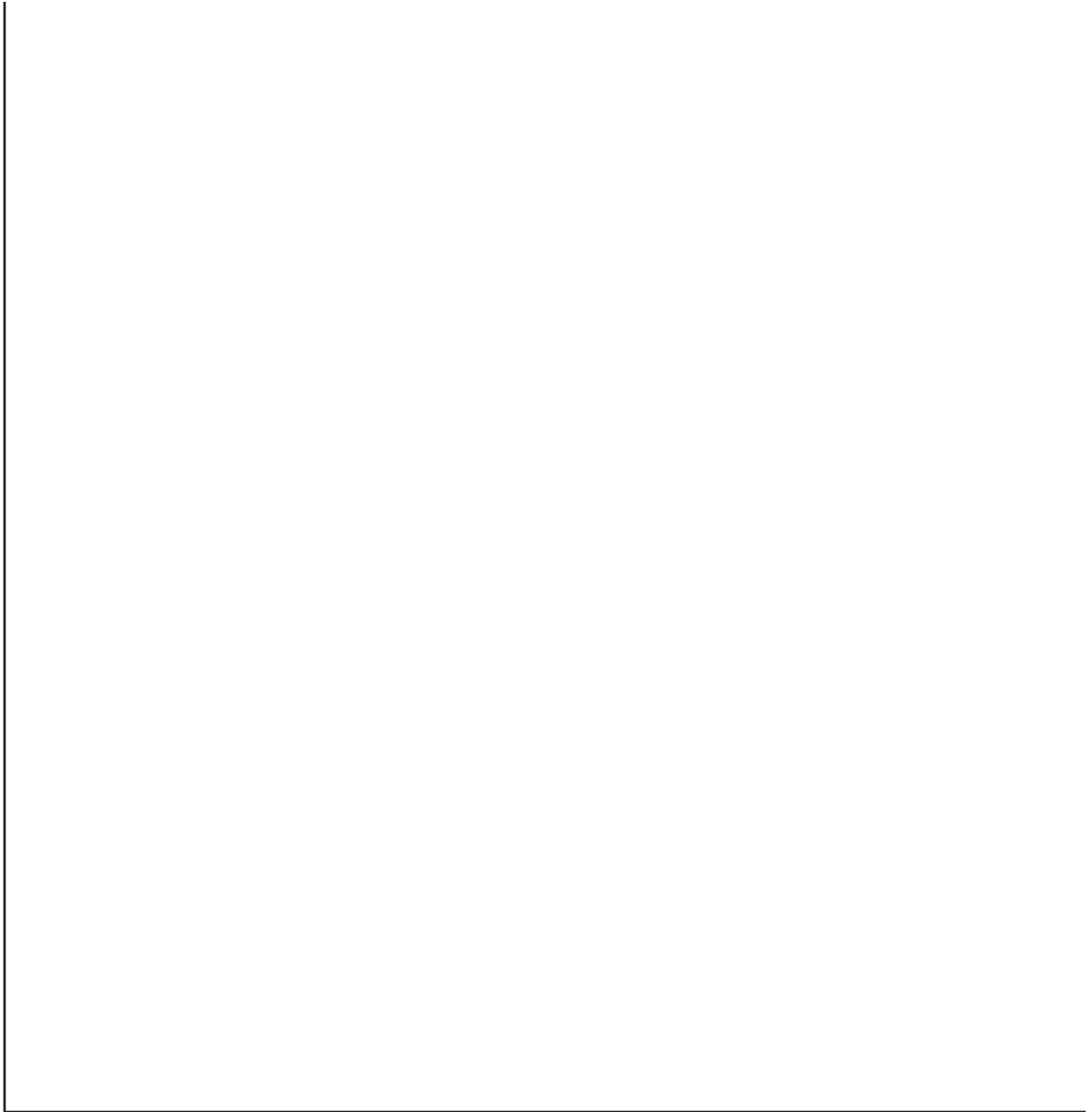
- A calorie is the amount of heat required to raise one gram of water by 1° Celsius, so:

$$\text{calories} = \text{mass of water (g)} \times \text{temperature change (}^{\circ}\text{C)}.$$

- The formula for calculating calories per gram is:

$$\text{calories per gram} = \text{calories} / \text{mass of nut}$$

BIOMASS ENERGY



Data Analysis:

1. According to your results, which type of nut contained the most stored energy (measured in calories)?

2. According to your results, which type of nut contained the least stored energy (measured in calories)?

3. What factors do you think contributed to the nut that produced the most heat?

Conclusion:

4. What types of biomass energy sources are available in your community? Explain what evidence supports your conclusion. Use complete sentences.

BIOMASS ENERGY

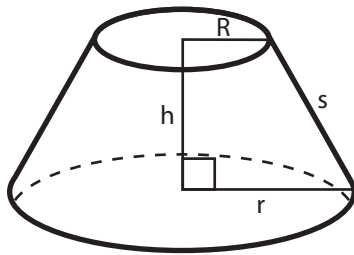
Biomass and Alaska Native Culture:

Alaska Native people have used biomass as a source of heat and light for thousands of years. Athabascan people built sod shelters with a central fire pit. The houses were usually constructed of spruce poles fastened with willow. The willow also provided a place to insert moss for insulation. The structure was covered with birch bark for weatherproofing. Finally, they added about two feet of dirt around the base of the structure to keep out drafts and covered the doorway with a bear hide with full fur.

Families maintained the fire in the center of the sod house to provide heat, light and a means of cooking food. Wood and small animal bones were burned. Smoke escaped through the vent in the top.

—Information provided by Chief Robert Charlie.

Directions: Use the formulas provided to complete the following word problems. Round to the nearest hundredth and show your work.



$$\text{base diameter} = 2 \times r$$

$$s = \sqrt{[h^2 + (r - R)^2]}$$

$$\text{surface area of a cone} = \pi \cdot r \cdot s$$

$$\text{volume of a truncated cone} = (\frac{1}{3} \times \pi \times h) \times [r^2 + R^2 + (r \times R)]$$

$$\pi = 3.14$$

- You would like to build an Athabascan sod house that is 30 feet in diameter at the base with a vent at least 4 feet in diameter. The house should be 9 feet tall at the center. What size spruce poles do you need to cut?
- How much birch bark would you need to collect in order to weatherproof your sod house? (Ignore the space lost to the vent.)
- What is the total volume of the space you will be heating with your fire?

BIOMATH

NAME: _____

1. Most scientists today use joules instead of calories to measure energy. Transfer the calories produced by each nut from the data table in your lab, then calculate the number of joules produced by each nut. Show your work. Use the back of your paper for more space.

1 calorie = 4.19 joules

SAMPLE (pecan): 2,800 calories x 4.19 joules/calorie = 11,732 joules

2. Watts are a unit of work used to express the rate of energy transfer. They are equivalent to joules per second. Most appliances and electrical devices are rated in watts. For example, a 60 watt light bulb uses 60 watts per hour. Calculate the watt hours produced by each nut. Show your work. Use the back of your paper for more space.

1 Wh = 3,600 joules

SAMPLE (pecan): 11,732 joules ÷ 3,600 joules/Wh = 3.26 Wh

Type of Nut	Calories (cal)	Joules (j)	Watt Hours (Wh)
<i>pecan</i>	<i>2,800</i>	<i>11,732</i>	<i>3.26</i>

BIOMATH

NAME: _____

3. Which nut released the most energy (Wh) when burned? Calculate how many of these nuts you would need to burn to run all of the appliances in the chart below for one hour. Show your work.

Type of Nut _____

Appliance	Watts per hour (Wh)
electric blanket	200
laptop computer	50
television	150
clock radio	1

Electric Blanket _____ nuts

Laptop Computer _____ nuts

Television _____ nuts

Clock Radio _____ nuts

4. Using the same nut as above, how many nuts would you need to burn to use each type of light bulb for one hour? Show your work.

Type of Light Bulb	Watts per hour (Wh)
incandescent light bulb	60
compact florescent light bulb	18
LED light bulb	5

Incandescent light bulb _____ nuts

Compact florescent light bulb _____ nuts

LED light bulb _____ nuts

BIOMASS: THREE ALASKA CASE STUDIES

CASE STUDY ONE: The Tanana Washeteria

Adapted from the Alaska Center for Energy & Power



The washeteria in Tanana is more than a place where local residents can do laundry and take a shower. It is an example of using local, sustainable resources to save energy and money.

In 2007, the Interior Alaska community installed two wood-fired Garn® Boilers to heat the washeteria and other buildings nearby. [A wood-fired Garn® Boiler is a wood stove located inside a water tank. The water absorbs and then stores the heat. This type of system can be used to heat multiple buildings by piping the heated water through a system of pipes in the floor.]

By stoking each boiler with wood just a few times during the day, the system produces enough BTUs to heat the buildings and the 280,000-gallon water storage tank. Use of heating oil has dropped by 30%, saving the community tens of thousands of dollars each year. Solar panels were also installed on the roof of the washeteria to help reduce electricity costs.

The city obtains wood for the boilers by paying local woodcutters \$250 per cord. The community used to buy diesel fuel and that money would leave the village. Now it has now created an economic opportunity for residents that keeps the money local. There are plans to expand the system with three larger wood-fired boilers to heat tribal buildings and the senior citizen center.

CASE STUDY TWO: The Craig Schools & Swimming Pool

Adapted from the Alaska Center for Energy & Power



Craig is a fishing village of 1,400 people located in southeast Alaska. In 2004 they looked at the heating bills for the local schools and swimming pool, and knew they needed to make a change. The boilers used 20,000 gallons of diesel and 40,000 gallons of propane annually. The monthly fuel bill for the three buildings was over \$10,000.

Craig is located in a forested area, so woody biomass is a plentiful resource and a local sawmill is able to supply tons of wood chips. In 2008, with support from the U.S. Department of Agriculture and Alaska Energy Authority, Craig installed a wood-fired heating system they hoped would save them money and reduce the amount of fossil fuels they needed.

It is too early to know the exact economic impact of the wood-fired system, but so far it has displaced 85% of the diesel and propane. With a price tag of \$1.5 million, the system will pay for itself in twelve years by using a resource that grows in the town's backyard.

A BTU (British Thermal Unit) is a unit of measure used to describe the amount of energy a fuel contains (similar to how an inch or a mile is used to express distance). BTUs are also used to rate heat-generating devices like wood stoves. One BTU is equal to the heat energy needed to raise the temperature of one pound of water by one degree Fahrenheit. One pound of dry wood contains about 7,000 BTUs. Propane contains about 15,000 BTUs per pound, while charcoal contains about 9,000 BTUs per pound.

BIOMASS: THREE ALASKA CASE STUDIES

CASE STUDY THREE: The Tok School

Excerpt from an article by Molly Rettig for the Fairbanks Daily News-Miner, December 6, 2010



A new wood energy project in Tok has turned surrounding forests from a fire hazard into renewable fuel. The Tok School lit a new wood chip-fired boiler for the first time several weeks ago.

The 5.5-million-BTU steam boiler produces the school's heat, saving the school district thousands of dollars in heating fuel and saving forest managers untold costs fighting fires and eliminating waste wood. The school district plans to add a steam turbine generator to the system in May to produce 75 percent of its electricity.

"We're the first school in the state to be heated entirely by wood," said project manager and assistant superintendent Scott MacManus, who has been trying to spur wood energy in Tok for 10 years. "As far as I know, we'd be the first public school in the country to produce heat and power from biomass."

At the school's new biomass facility, trees and slash are fed into a Rotochopper grinder, processed into chips that resemble wood shavings, spit into a bin and carried by conveyor belt into the boiler, which is 17 feet tall, 6 feet wide and 12 feet long. Fuel comes from forest thinning projects, scraps and nearby sawmills.

The forest around the school has yielded enough biomass for the first year, according to Alaska Division of Forestry spokeswoman Maggie Rogers. Project leaders hope the system will be used as a model of energy independence for other school districts, communities and utilities.

The project was a partnership between the Division of Forestry, the Tok community, the Alaska Gateway School District and the Alaska Energy Authority and used research from University of Alaska Fairbanks and elsewhere. Funding came from a \$3.2 million state renewable-energy grant as well as about \$750,000 in grants from the Alaska Legislature. A long-term fuel contract is in the works between the state and the school district.

Turning hazardous fuel into energy

The project started nearly four years ago as a way to get rid of wood from forest-thinning projects and lessen fire danger. In the past 25 years, nearly 2 million acres in the area have burned, costing more than \$60 million for fire suppression and causing six evacuations, according to the state.

"The fire history in Tok has basically demonstrated that Tok is going to burn unless we take action," said Jeff Hermanns, Tok area forester and a spearhead of the boiler project.

A recent wildfire protection plan recommended that 3,000 acres of black and white spruce forest in Tok be removed to make the community safer, including an area around the school, Hermanns said. Foresters usually try to sell or repurpose good wood, but the trees were junk wood, he said.

"Most of them aren't any bigger than three inches. Most people won't cut that tree for firewood. It's too small. You can't sell board out of it," Hermanns said.

Foresters thinned 100 acres of trees around the school and stacked them into decks. Then they set them on fire, a pricey and smoky last resort.

"All of those BTUs, all of that energy, just went up in smoke," Hermanns said. "By the school using this material, it's saving me a minimum of \$1,000 an acre." Sending timber to the grinder is cheaper because foresters don't have to hand-limb every 3-inch tree, as with other treatments. It's also cleaner than burning the decks because the boiler emits no smoke and little pollution. The carbon emitted by the boiler is offset by the carbon absorbed during the life of the tree.

BIOMASS: THREE ALASKA CASE STUDIES

"The beauty of it all is that it grows back. It's carbon neutral and our foresters can finally manage our forest," said Dave Stancliff, vice president of the Tok Chamber of Commerce and partner in the project. It's also cheaper than wildfires, which cost between \$10,000 and \$20,000 per acre to fight near urban areas.

The boiler should burn 40 acres worth of wood per year, using only one-third of the area foresters want to clear in the boiler's 30-year life span.

Form follows fuel

Hermanns and MacManus decided on a wood chip model because it best fit the fuel source. "You have to go out and determine what your fuel is, and then design your project around it," said Hermanns.

The grinder was key. "It effectively turns a large volume of these non-merchantable, scrawny little spruce trees, these hazardous fuels, into usable fuels," he said. The grinder processes up to 40 trees at once. You don't need to dry, trim or treat the wood before burning it.

"It's what we call gut, feathers and all. You put the whole bird in the soup," Hermanns said.

The boiler is supposed to be as clean as burning heating fuel, and the school district will monitor its emissions. It burns at 2,000 degrees Fahrenheit and generates very little smoke, thanks to air that moves up through the wood chips and fans the flame.

"You're getting a super-efficient burn," Hermanns said. Any smoke is removed by an electrostatic precipitator, which electronically charges smoke particles out of the exhaust. "If you look at the stack today, all you would see is steam," Hermanns said.

School savings

Tok School spends more than \$300,000 annually on heating fuel and electricity, said school district superintendent Todd Poage. The boiler will save an estimated \$125,000 per year on fuel, and the generator will further erode their bill.

The savings will go toward music and counseling programs, student activity funding, teacher training and other programs throughout the district, Poage said.

Students have been learning about fire science through the forest thinning and boiler projects and will visit the biomass facility when it is completed.

Administrators hope the project will inspire other communities in the district and the state to take advantage of local resources.

"This is a model I think that could be used in a lot of different villages," said assistant superintendent MacManus, who grew up in Ambler, a village outside of Kotzebue, where heating fuel runs \$9 per gallon. "A lot of villages, Fort Yukon, McGrath, Galena, have access to biomass. Those communities should be able to heat themselves."

Villages without forests can consider other resources, like fish waste, peat, stream or wave power, project leaders said.

"That's the beauty of this. This system utilized a product that there is no use for in the Interior," Hermanns said.

BIOMASS: THREE ALASKA CASE STUDIES

NAME: _____

Questions:

1. Describe the Garn® Boiler used at the Tanana Washeteria.

2. The Craig boiler has displaced _____% of the diesel and propane used by the local schools and swimming pool.

3. The Tok School boiler should burn _____ acres of wood per year, using only _____ of the area foresters want to clear in the boiler's 30-year life span. How many acres do Tok-area foresters want to clear in the next 30 years? Show your work below.

4. The Tok School will save an estimated _____ dollars per year on fuel. This represents a _____% savings on their annual heating fuel and electricity bill. Round your answer to the nearest whole percent and show your work below.

Thinking Deeper:

5. Based on these stories, identify at least three benefits of using biomass energy.

BIOMASS: THREE ALASKA CASE STUDIES

6. Based on these stories, identify at least three drawbacks of using biomass energy.

7. Think about the biomass energy resources available in your area and describe at least one way that your community could use this energy. Why did you choose this resource and where/how would you use it? Explain the challenges and potential drawbacks to using this energy resource in the way you described.
