# WASTE TO WATTS

## Overview:

In this lesson, students build a calorimeter, test the energy content in various edible nuts and investigate biomass as an alternative energy source for Alaskan communities through three case studies.

## Objectives:

The student will:
- build a simple calorimeter and test the energy content of various edible nuts;
- extrapolate to consider the feasibility of using biomass energy in their school; and
- examine three case studies featuring Alaska communities using biomass energy.

## Alaska High School Graduation Qualifying Exam Performance Standards Addressed:

R4.1 Apply knowledge of syntax, roots, and word origins, and use context clues and reference materials to determine the meaning of new words and to comprehend text.

R4.2 Summarize information or ideas from a text and make connections between summarized information or sets of ideas and related topics or information.

R4.4 Read and follow multi-step directions to complete complex tasks.

M2.3.1 Estimate and measure various dimensions to a specified degree of accuracy.

M2.4.2 Estimate and convert measurements between different systems.

M10.3.1 Apply mathematical skills and processes to science and humanities.

M10.3.2 Apply mathematical skills and processes to situations with peers and community

## Vocabulary:

**biomass –** all living and recently living things

**calorie –** the amount of heat required to raise the temperature of one gram of water by 1°C

**calorimeter –** a device used to measure energy content by calculating the heat required for a chemical reaction

**joule –** a unit of energy equal to 1/3,600 watt hour (equal to burning a 1 watt light bulb for one second)

**nonrenewable energy source –** a mineral energy source that is in limited supply, such as fossil fuels (gas, oil, and coal) and nuclear fuel

**renewable energy source –** an energy source that can be replenished in a short period of time (solar, wind, geothermal, tidal)

**specific heat –** the quantity of heat needed to change the temperature of a given mass of a material by one degree Celsius; the specific heat of water is 1 calorie/gram °C or 4.186 joule/gram °C.

**watt –** a unit of power; equivalent to one joule per second

**watt hour –** a measure of electrical energy equivalent to consuming one watt for one hour

## Whole Picture:

Biomass is a renewable energy source that includes all living and recently living things. Biomass energy is created by the combustion of carbon-based matter. The energy in biomass comes from the sun. Plants convert radiant energy into chemical energy through photosynthesis and store this energy as glucose. When we burn biomass, we use this stored energy to produce heat.

Alaska Native people have been using biomass fuels for heat and light for thousands of years; the most common source is wood. Other forms of biomass energy include biofuels made from fermented plant material (such as ethanol made from corn), solid waste (garbage and animal waste), and landfill gas (capturing the methane released during decomposition).

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Interior Alaska has extensive biomass resources including wood, sawmill waste, fish byproducts and municipal waste (garbage, especially paper and wood products). Conventional timber as well as fast growing shrubs like willows and alders can be cultivated and harvested for power generation and/or heating. On average, 1.5 million acres of forested land in Alaska is adversely affected by wildfires and beetles each year. Some of this wood is salvageable as biomass fuel.

Biomass is currently being used in Alaska communities to generate electricity and heat. It may become a more feasible energy option as the cost of oil and gas continue to rise, especially in rural communities.

We use a variety of units for power and energy such as calories, joules, watts and BTUs. Many people are familiar with calories as a unit of food energy. A calorie is actually a unit of heat. It approximates the energy needed to increase the temperature of one gram of water by 1°C. Its use is largely archaic, having been replaced by the joule. However, it remains in use as a unit of food energy. The calories seen on food labels are actually "large calories", "kilogram calories" or simply "food calories." On large calorie is 1,000 calories. It approximates the energy needed to raise the temperature of one kilogram of water by 1°C.

A joule is a unit of power in the International System of Units. It is equivalent to the work required to produce one watt of power for one second. Watts are a unit of power that is equivalent to one joule/second. A calorie is equal to 4.19 joules.

Watts are a unit of power per unit time. One watt equals one joule per second. Power output and consumption (of engines, motors, heaters, etc.) is often expressed in kilowatts (1,000 watts). Electric companies often bill consumers in kilowatt hours. One kilowatt hour is equivalent to 1,000 watt hours or 3,600 joules. Using a 60 watt light bulb for one hour uses 60 watt hours or 0.06 kilowatt hours of electricity.

BTUs (British Thermal Units) are often used to rate heating and cooling systems like wood stoves, grills and air conditioners. Like the calorie, the BTU is a traditional unit of measure that is largely archaic in scientific contexts. One BTU is approximately 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.

## Materials:

- 12-ounce soda pop cans (two per group)
- Safety glasses (one pair per student)
- Digital scale (one per group)
- Oven mitt (one per group)
- Scissors (one per group)
- Shelled pecans, almonds, cashews, walnuts, peanuts or other nuts (enough for each group to have a variety of types)
- Paper fasteners (at least 1.5 inches long, 5-10 per group)
- Thermometer (with probes or small enough to fit in the opening of a soda can, one per group)
- 100 mL graduated cylinder (one per group)
- Thumbtack (one per group)
- Water (room temperature, 100 mL per group)
- Long tweezers (at least 6 inches, one per group)
- Aluminum foil (3-inch square, per group)
- Hot pad to protect desk/table (one per group)
- Grill lighter
- Needle-nose pliers (for optional class demonstration)
- STUDENT LAB SHEET: "Biomass Energy"
- STUDENT WORKSHEET: "BioMATH"
- STUDENT WORKSHEET: "Biomass: Three Alaska Case Studies"

# WASTE TO WATTS

## Activity Preparation:

1. Carefully review procedure.

   Note that this experiment involves cutting up an aluminum can and burning nuts. The nuts will produce a significant amount of heat and some smoke. Use discretion to determine if it is better to conduct the lab as a class demonstration or in small groups.

   Teachers may want to choose a location with some ventilation (at least a window that can be opened.) Each nut will take approximately five minutes to burn. Larger nuts like Brazil nuts may take up to 10-15 minutes to burn. If time is limited, each group could test one kind of nut and then the class can share data.

2. Be prepared to clearly review safety precautions. Calorimeters need to be placed on a stable surface. While in use, the bottom will become hot. Use your own discretion to determine whether students are allowed to use the lighter, or whether you will light the nuts for them. Consider safety and the time available and decide if you will precut the holes in the soda cans. Do not discard the squares of aluminum!

3. Review *Biomass and Native Alaskan Culture*. Determine if you will need to use examples to lead students through the math exercises. If so, prepare examples.

4. Decide if/how you will use STUDENT WORKSHEET: "BioMATH" and STUDENT WORKSHEET: "Biomass: Three Alaska Case Studies." You may choose to use them along with the student lab, as homework or as a follow-up later on.

## Activity Procedure:

1. Ask students how they think their ancestors stayed warm during long Alaska winters. (People have been burning organic fuels like wood and animal fat for thousands of years.)

2. Introduce students to the terms "biomass" and "biofuels." What does the prefix "bio" mean? (The root word bio means "life," and so biomass means a total mass of living or once living material; biofuel refers to a fuel made directly from living matter.) Although wood is still the most common biomass resource in Alaska, we have many other resources. Ask students to brainstorm Alaska's biomass resources. Keep a list on the white board and provide hints as needed. (Students may mention fish oil, burning garbage, wood scraps and sawdust, fast-growing shrubs, capturing landfill gases, biodiesel made from used vegetable oil, etc.)

3. Explain more Alaska communities are again looking to biomass as an energy source. Ask students why they think this is? (The cost of oil and gas continue to rise making energy costs in rural Alaska among the highest in the nation.)

4. Explain today's lab will focus on biomass as an energy source. Students will measure the energy available through combustion of a plant product (nuts). Remind students that energy comes in many forms and can change form. Ask students where the energy in the nuts came from. (It is originally from the sun. This radiant energy was captured via photosynthesis by the plants that grew the nuts and is stored as potential chemical energy in the cells of the plant. This energy is released as light (radiant) and heat (thermal) energy when we burn the nut.)

   OPTIONAL CLASS DEMONSTRATION (to accompany this discussion): Hold a cracker, potato chip or other available snack food with the needle nose pliers. Light with the grill lighter and allow to burn as you discuss the energy available through the combustion of plant products. If time allows, compare various snack foods. Be aware that oily foods like potato chips will produce smoke. Choose a location with appropriate ventilation.

5. Distribute STUDENT LAB SHEET: "Biomass Energy" and provide instructions for completing the lab in small groups or as a class demonstration. Allow time to carefully review the safety considerations mentioned in the Activity Preparation section.

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6. When all groups are finished, share data on the white board (if necessary), review results and answers to questions.
7. If applicable, distribute STUDENT WORKSHEET: "BioMath" and/or STUDENT WORSHEET: "Biomass: Three Alaska Case Studies."

## Extension Ideas:

1. Try burning other food items in the calorimeter (including snack foods and leftovers from student lunches!) Oily foods work particularly well. How do these compare to nuts? Graph results.
2. Contact one of the communities featured in STUDENT WORKSHEET: "Biomass: Three Alaska Case Studies." Find out more about the project's successes and challenges.

## Answers to STUDENT LAB SHEET: Biomass Energy

Data Analysis:

1. Answers will vary but it should be the nut that produced the most calories per gram.
2. Answers will vary but it should be the nut that produced the least calories per gram.

Conclusion:

3. The nut that produced the most heat would be the one that produced the most calories (not per gram). Factors contributing to this would be the size of the nut, and the stored energy contained in the nut.
4. Answers will vary but may include: wood, sawmill waste, fish byproducts, municipal waste (garbage, especially paper and wood products), and fast growing shrubs like willows and alders.

Biomass and Alaska Native Culture:

5. You would need spruce poles measuring 15.81 feet in length.

| | | | |
|---|---|---|---|
| diameter = $2r$ | 30 feet = $2r$ | $r$ = 15 feet | |
| $s = \sqrt{[h^2 + (r - R)^2]}$ | $s = \sqrt{[9^2 + (15 - 2)^2)}$ | $s = \sqrt{(81 + 169)}$ | $s$ = 15.81 feet |

6. You would need 744.65 $ft^2$ of birch bark to cover the structure.

$$\text{surface area} = \pi \cdot r \cdot s$$
$$= 3.14 \cdot 15 \text{ feet} \cdot 15.81 \text{ feet} = 744.65 \text{ ft}^2$$

7. You will be heating 2,439.78 ft3.

$$\text{volume of a truncated cone} = (⅓ \times \pi \times h) \times [r^2 + R^2 + (r \times R)]$$
$$\text{volume} = (⅓ \times 3.14 \times 9) \times [15^2 + 2^2 + (15 \times 2)]$$
$$= 9.42 \text{ x } (225 + 4 + 30)$$
$$= 2,439.78 \text{ ft}^3$$

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## Answers to STUDENT WORKSHEET: BioMATH

1. Answers will vary based on lab calculations.
2. Answers will vary based on lab calculations.
3. Answers will vary based on lab calculations.
4. Answers will vary based on lab calculations, but the most nuts should be required to light the incandescent bulb and the least nuts should be required to light the LED bulb.

## Answers to STUDENT WORKSHEET: Biomass: Three Alaska Case Studies

1. The Tanana Washeteria Garn® Boiler is a wood stove located inside a 280,000 gallon water tank. The water absorbs and then stores the heat. It heats the buildings by piping the heated water through a system of pipes in the floor.
2. 85%
3. 40, ⅓, 3,600 acres
4. 125,000, 42%
5. Answers will vary but may include: creating local jobs, reducing the risk of wildfire close to the community, using a renewable energy source, reducing the cost of fuel used, decreasing carbon emissions and reducing dependence on imported fuel.
6. Answers will vary but may include: high initial investment (very expensive to buy), may require special expertise to maintain equipment, could deplete nearby forests.
7. Answers will vary.

# BIOMASS ENERGY

**NAME:** ______________________________

## Directions:

A calorimeter is a device used to measure energy content by calculating the heat required for a chemical reaction. Follow the directions below to build a calorimeter and use it to measure the biomass energy available through the combustion of different nuts. (Do not eat the nuts!) Read through the lab, then write your hypothesis below.

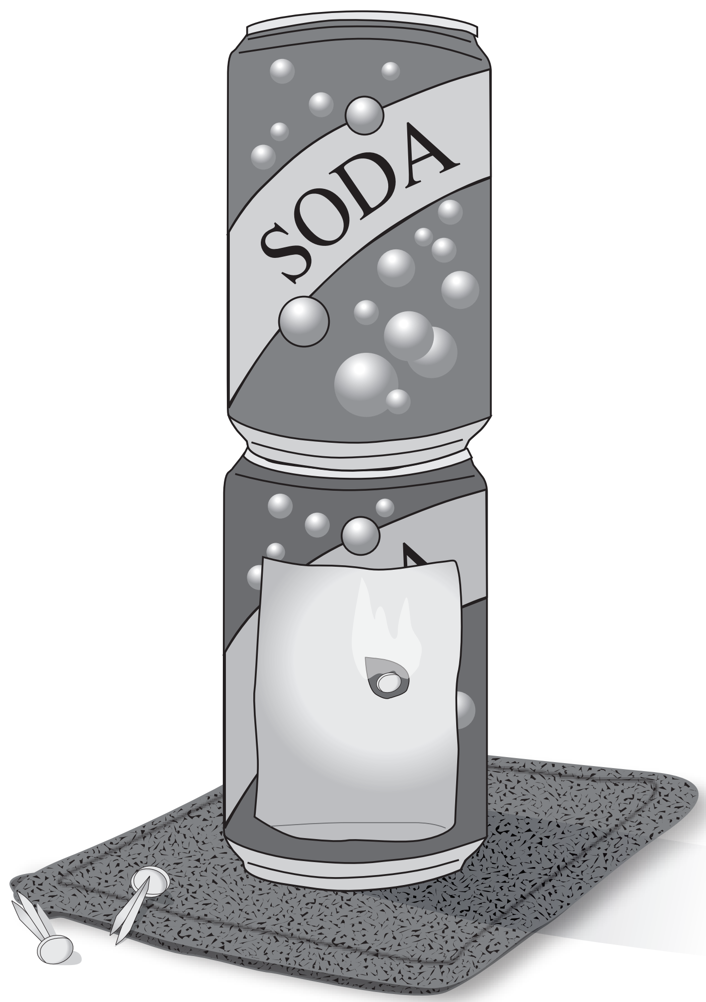
## Hypothesis:

______________________________________________________________________

______________________________________________________________________

## Materials:

- 12-ounce soda pop can (2)
- Digital scale
- Safety glasses
- Scissors
- A variety of shelled nuts
- Paper fasteners (5-10)
- Thermometer
- 100 mL graduated cylinder
- Thumbtack
- Water (room temperature)
- Oven mitt
- Tweezers
- Aluminum foil (3-inch square)
- Hot pad



## 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:

  **° Celsius = $\frac{5}{9}$ × (° Fahrenheit – 32)**

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

  **1 milliliter (mL) water = 1 gram (g) of water**.

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

  **calories = mass of water (g) × temperature change (°C)**.

- The formula for calculating calories per gram is:

  **calories per gram = calories / 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

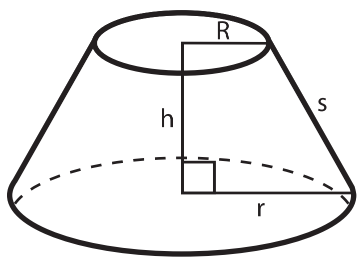
## Biomass and Alaska Native Culture:

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.




**base diameter = $2 \times r$**

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

**surface area of a cone = $\pi \cdot r \cdot s$**

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

**$\pi = 3.14$**

5. 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?

6. How much birch bark would you need to collect in order to weatherproof your sod house? (Ignore the space lost to the vent.)

7. 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) |
|---|---|---|---|
| *pecan* | *2,800* | *11,732* | *3.26* |
| | | | |
| | | | |
| | | | |
| | | | |

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.

## 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.

"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 $300,0000 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.

_______________________________________________________________________

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_______________________________________________________________________

_______________________________________________________________________

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.