

# Captain Biomass and the Pooper Scooper Problem

## TEACHER INFORMATION

### Background

In this lesson, students will use a variety of language arts skills and artistic skills to learn, and teach, about biomass as a source of energy. In addition to reading and performing a play about biomass, students will teach younger buddies, make art projects, think about world energy issues (social studies connection), explore STEM careers, and answer assessment questions. Some skills practiced in this lesson include reading, reader's theater, drama performance, making costumes, scenery, and props, small group discussion, drawing and coloring, creating an original piece of art from natural and recyclable materials, critical thinking, online research, and using a graphic organizer.

This play and similar plays on other topics can be found in NEED's *Energy on Stage* at [shop.NEED.org](http://shop.NEED.org).

### Grade Levels

- Elementary, grades 3-5
- Intermediate, grades 6-8
- Secondary, grades 9-12

### Time

- 1-7 class periods, depending on which activities you choose to complete

### Objectives

- Students will be able to describe the flow of energy through a biomass system.
- Students will be able to describe processes that release energy stored in biomass and how we use that energy.
- Students will be able to assess the social and economic value of a biomass technology.
- Students will be able to describe biomass-related STEM careers.

### ★ Concepts

- Biomass is a renewable source of energy.
- Biomass is organic material made from plants and animals that were once alive. Wood, crops, food and yard waste in garbage, animal manure, and human waste are biomass.
- The energy in biomass comes from the sun. During photosynthesis, plants absorb the sun's radiant energy and convert it into chemical energy.
- Biomass can be burned directly or converted to liquid biofuels or biogas that can be burned as fuels. When biomass burns, its chemical energy is released as heat. The heat is used to make steam to heat buildings, for industrial use, or to make electricity.
- Combustion directly burns solid forms of biomass like wood, crops, and garbage. A waste-to-energy plant burns garbage to produce heat.
- Fermentation changes biomass into ethanol, a liquid biofuel made from corn.
- Biomass can be converted into biodiesel, a liquid biofuel made from soybean oil.
- Bacterial decay changes biomass in a landfill into landfill gas. Bacterial decay changes biomass in an anaerobic digester into biogas.

### Vocabulary

- anaerobic
- chaos
- combustion
- decompose
- exaggerate
- hypnotize
- manure
- organic
- sewage

### Materials

- Miscellaneous art supplies to make props and costumes, glue for art sculptures
- Captain Biomass and the Pooper Scooper Problem*, pages 9-13
- My Biomass Superhero* template, page 14
- Exploring STEM Careers* graphic organizer, page 15
- Biomass Assessment* sheet, page 16
- Biomass Assessment Answer Key*, page 17

### ✓ Preparation

- Make copies of the reader's theater, *Captain Biomass and the Pooper Scooper Problem*, for each student.
- Make copies of *My Biomass Superhero* template for students/buddies.
- Make copies of the *Exploring STEM Careers* graphic organizer for each student.
- Make copies of the Biomass Assessment sheet for each student.

## Step One: Read and Learn

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- Assign roles and read *Captain Biomass and the Pooper Scooper Problem* as a reader's theater.
- For additional background, read the "Energy" and "Biomass" sections of your *Energy Infobook*.
- Discuss concepts and vocabulary as needed.

## Step Two: Get Creative

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- Assign character parts and have actors rehearse their lines. Assign a stage manager and director to run the show. Assign students to the art department to brainstorm ideas, collect materials, and make costumes, scenes, and props. Practice, practice, practice.

### SCENERY IDEAS

- Scene II - Backyard Treehouse – two chairs, table holding science lab equipment, paper leaves for a backdrop

### COSTUME IDEAS

- Robot – wears a grey sweat suit, hat made of foil, walks/moves with jerky robot-like motion
- Lunch Ladies – wear hair nets, aprons, rubber gloves
- Captain Biomass – wears a garbage bag cape

### PROP IDEAS

- Smellvin's handheld robot controller – rectangular tissue box covered in foil with antennas sticking out
- Cafeteria "landfill" – cut a piece of cardboard into a mound shape, glue on lunch items such as a paper napkin, plastic container, plastic fork, drawing of a sandwich and apple core, milk carton, straw, chip bag, candy wrapper, etc.
- Trash can
- Georgia and Hannah's invention – garbage bag filled with air, tape on a sign that says "biogas digester," paper towel tube connecting bag to a drawing of a Bunsen Burner with a flame
- Rope to wrap around Robot
- Large posters or drawings – show how photosynthesis works, how a landfill makes landfill gas, how a biodigester makes biogas, etc. (hold posters up during the play to reinforce what the audience is learning)
- Signs with vocabulary words or key words like biodiesel and ethanol (hold signs up during the play to reinforce what the audience is learning)
- Cue cards or funny signs like "The Next Day" or "EWWW Gross!" (hold signs up during the play to make them laugh)

## Step Three: Kids Teaching Kids

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- Perform the play for your classroom buddies or another class at school.
- Break into small groups. Have students lead a discussion with their buddies about biomass.
  - What is biomass? (*Biomass is made from plants and animals that were once alive.*)
  - Is biomass a nonrenewable or renewable source of energy? (*Biomass is a renewable source of energy.*)
  - Name some examples of biomass found in a forest? (*wood, logs, bark, branches, leaves, pine needles*)
  - Name some examples of biomass found on a farm? (*corn, corn cobs, corn stalks, wheat stalks, hay, soybeans, cow manure*)
  - Name some examples of biomass found around your yard? (*grass clippings, leaves, branches, yard waste, fruit that fell off a tree, dog poop*)
  - How is biomass used for energy? (*burn biomass to make heat, turn biomass into ethanol or biodiesel, bury biomass in a landfill to make landfill gas, burn biomass in a waste-to-energy plant, put biomass in an anaerobic digester to make biogas*)
- Create a biomass superhero. Give each buddy the superhero template to decorate. Allow time for small buddy groups to share their superheroes with each other.
- Create biomass art. Send buddy groups out around the school to collect biomass materials. Search outside, in the lunchroom, classroom, office, etc. Once they have collected materials, have each group create a piece of art, perhaps a sculpture or a collage. Allow time to share their art piece with the class and point out their favorite biomass item and where they found it.

## Step Four: Connections & Careers

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- Explain to students that biomass can be a great resource in other cultures and geographical areas with limited resources. Explain that biogas is created by decaying matter.
- Show a video clip or describe to students that in some areas of the world, families rely on burning charcoal or wood for cooking. They may live without access to electricity, running water, or even a place to use the bathroom. Discuss the difficulties these families face every day accessing sources of energy, the environmental drawbacks of their use, and health problems related to this lifestyle. (*constant need to collect firewood, deforestation, expense of charcoal, lack of safe/private bathrooms, human waste contaminates the water supply and leads to spread of diseases, emissions, and pollution*)
- Show students a video clip or describe to students that an off-grid biodigester system may help a family generate free, clean-burning biogas from their waste. A biodigester produces biogas for cooking and fertilizer that helps crops grow. There are many digesters on the market today. One company making a positive impact is HomeBiogas. As a class, check out their website, [www.homebiogas.com](http://www.homebiogas.com), to:
  - Learn how the system works.
  - Check out the bio-toilet.
  - Figure out how much a complete system costs to buy. What is the payback period? Does this system seem like a wise investment for a family living in Africa?
  - Would a biodigester work at your house?
  - What are some benefits of using a home-sized biogas digester system?
  - What are some drawbacks to using a home-sized biogas digester system?
- Have students use the "Characters" list from the Captain Biomass play to find each character's future career. Students should choose one career to learn about. Use online resources such as Science Buddies (<https://www.sciencebuddies.org/science-engineering-careers>) or the Bureau of Labor Statistics Occupational Outlook Handbook (<https://www.bls.gov/ooh/>) to research the career. Complete the graphic organizer.
- Assign students to small groups. Each group member will represent a different career. Allow time for each student to share his/her career graphic organizer within the group.
- As a class, have a closing discussion about biomass related STEM Careers. Suggested questions:
  - Were any of the careers new to you?
  - Share the most surprising, interesting, or awful job duty you learned about.
  - Which jobs have the highest pay per hour?
  - Do any of the jobs require a college degree or technical training?
  - Do any of the jobs allow you to work outside instead of sitting at a desk?
  - What is the difference between a Chemist, a Chemical Engineer, and a Chemical Technician?
  - Do people in your community work in these careers?

## Step Five: Assessment

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- Distribute the assessment to students. Discuss answers in small group format or as a class.
- Organize an Energy in the Arts night to show off student work in this sampler.

# Captain Biomass and the Pooper Scooper Problem

## Characters

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**NARRATOR 1:** Dramatic voice, introduces and closes the story, future *Water & Liquid Waste Treatment Plant & System Operator*

**NARRATOR 2:** Dramatic voice, introduces and closes the story, future *Methane Gas Generation System Technician*

**GEORGIA:** Hannah's best friend, loves science and a bit of mischief, future *Environmental Engineer*

**HANNAH:** Georgia's best friend, loves science and a bit of mischief, future *Chemical Engineer*

**WOODY:** One of the Forester twins, loves camping and roasting marshmallows, future *Plant Scientist*

**TWIGGY:** One of the Forester twins, loves camping and roasting marshmallows, future *Chemical Technician*

**DAISY:** One of the Flower sisters, loves to ride go carts, future *Biodiesel Engine Specialist*

**ROSE:** One of the Flower sisters, loves to ride go carts, future *Biofuel Technology & Product Development Manager*

**LILY:** One of the Flower sisters, loves to ride go carts, future *Chemist*

**MR. GRUMP/CAPTAIN BIOMASS:** Cranky science teacher, turns into a superhero when fingers snap, future *dog walker and pooper scooper*

**SMELLVIN:** Inventor of contraptions, loves homework, future *Robotics Engineer*

**ROBOT:** Smellvin's high tech invention, the non-verbal Pooper Scooper 2000, future *Power Plant Distributor and Dispatcher*

**LUNCH LADY 1:** Lazy cafeteria worker, future *co-author* of Meatloaf Surprise, a Lunch Lady Cookbook

**LUNCH LADY 2:** Lazy cafeteria worker, future *co-author* of Meatloaf Surprise, a Lunch Lady Cookbook

**SCIENTISTS:** Class or Cast

## Scene I - Introduction

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**NARRATOR 1:** Unless you live under a rock, you know the epic tales of famous superhero Captain Underpants.

**NARRATOR 2:** He was created by George Beard and Harold Hutchins, two young friends who love to pull pranks at school and write comic books in their backyard treehouse. These hilarious stories are usually stinky and rude.

**NARRATOR 1:** What you probably don't know, is that Captain Underpants isn't the only school superhero in town. Let's meet Georgia and Hannah, two young friends who love to behave at school and do science experiments in their backyard treehouse.

**NARRATOR 2:** One of their science experiments accidentally...

**NARRATOR 1:** sort of on purpose...

**NARRATOR 2:** hypnotized their cranky old science teacher, Mr. Grump. Now, whenever they snap their fingers, Mr. Grump transforms into a superhero science teacher, Captain Biomass.

**NARRATOR 1:** Science is fun again. That is, until Captain Biomass gets sprinkled with water, then he turns back into Mr. Grump.

**NARRATOR 2:** So, sit back and enjoy this epic tale of superhero Captain Biomass. And don't worry, this story gets stinky, too.

## Scene II – Backyard Treehouse

**GEORGIA:** Are you excited about the Invention Convention tomorrow at school?

**HANNAH:** It's so cool that we're focusing on bioenergy this year. But, I'm a little nervous. I heard Smellvin Smeedly invented a robot pooper scooper to clean up after his dog.

**GEORGIA:** Oh, boy! Somehow his inventions always lead to chaos.

**HANNAH:** Hopefully the robot is just a display because nobody wants to smell dog poop at school.

**GEORGIA:** Well... we do need poop for our biogas digester. *(Hannah and Georgia giggle together.)*

**HANNAH:** Okay, let's practice our presentation.

*(Georgia and Hannah stand up. They use loud, confident voices, as they are giving an important speech.)*

**GEORGIA:** Biomass is a renewable source of energy. It is an organic material, made from plants and animals that were once alive.

**HANNAH:** The energy in biomass comes from the sun. During photosynthesis, plants absorb the sun's radiant energy and convert it into chemical energy.

**GEORGIA:** Wood, crops, food, and yard waste in garbage, animal manure, and human waste are all biomass. We can use their stored chemical energy as sources of fuel.

**HANNAH:** To release the chemical energy in biomass, it needs to be burned. The process of burning something is called combustion. Some biomass is burned in its solid state. Some biomass needs to be converted into a liquid or a gas fuel before it's burned. Whenever biomass burns, its chemical energy is released as heat.

**WOODY and TWIGGY:** *(Voices call from off stage, in unison)* Georgia! Hannah! Are you up in the treehouse?

**GEORGIA:** It's Woody and Twiggy, the Forester twins. We're in here.

*(Woody and Twiggy enter.)*

**TWIGGY:** Could you help us with our project for the Invention Convention?

**HANNAH:** Sure, tell us about your invention.

**WOODY:** Our Mom is a lumberjack. We invented a laser beam that splits logs so she won't have to chop wood with an axe. Our invention works great.

**TWIGGY:** The problem is, after it's cut, our pile of wood just sits there. It doesn't give off any energy.

**GEORGIA:** Have you ever sat near a campfire?

**WOODY:** Sure, we love to roast marshmallows over the heat of a fire.

**TWIGGY:** Oh! To get the energy out of the wood we need to burn it!

**HANNAH:** That's right. People have burned wood to heat homes and cook food for thousands of years. Until the mid-1800s, wood was the main source of energy for the world.

**GEORGIA:** These days, most homes use natural gas and electricity for heating and cooking.

**HANNAH:** But in developing countries, families still depend on wood as a main source of fuel.

**GEORGIA:** In the United States, it's mostly industry and electric power producers who burn wood and wood waste as fuel.

**WOODY:** What's wood waste?

**HANNAH:** It's the material leftover after paper mills make paper or manufacturers make products from wood. Tree bark, sawdust, wood chips, and scrap lumber are wood wastes.

**GEORGIA:** When burned, they give off heat. The heat is used to produce steam and electricity, or it's used to heat buildings.

**HANNAH:** Remember that burning biomass can pollute the air, so you probably shouldn't burn your wood pile inside the school.

**TWIGGY:** Too bad, it would have been fun to roast marshmallows during the Invention Convention.

**WOODY:** Thanks for your help, we'll see you tomorrow!

*(Woody and Twiggy exit.)*

**SCIENTISTS:** Burning wood, gives off heat. Biomass energy, can't be beat!

**HANNAH:** Alright, back to our presentation.

**GEORGIA:** *(Stands and speaks using her "giving a speech" voice.)* Industry uses biomass to make products. The transportation sector uses biomass by consuming ethanol and other biofuels. Power companies use biomass to generate electricity.

**DAISY:** *(off stage)* Georgia! Hannah! Are you up in the treehouse?

**HANNAH:** It looks like the Flower sisters are here. Come on in.

*(Daisy, Rose, and Lily enter.)*

**ROSE:** We made two go-carts for the Invention Convention. They run on biofuels. Would you like to take them out for a spin?

**GEORGIA:** Definitely! But tell us about the biofuels first.

**LILY:** Agricultural crops are biomass. They can be burned as fuel. Or, crops can be converted into a liquid biofuel, like ethanol or biodiesel.

**DAISY:** In the United States, most ethanol is made from corn. The starch in corn is broken down into sugar. Then, in a process called fermentation, the sugar is changed into alcohol.

**ROSE:** In other parts of the world, sugar cane, switch grass, and sugar beets are used to make ethanol.

**LILY:** Scientists are studying how to make ethanol from fast growing grasses and trees, from agricultural waste such as corn cobs, and from wood wastes like sawdust, and wood chips.

**DAISY:** We have a fireplace that hangs on the wall. We pour ethanol into it. When we light the fireplace, the ethanol burns making light and heat.

**ROSE:** Ethanol is mixed into gasoline. It is burned in the engines of most cars and trucks on the road.

**LILY:** And it powers one of our go-carts. The other runs on biodiesel.

**DAISY:** Biodiesel is produced from vegetable oils, animal fats, and even used cooking oils and grease.

**ROSE:** In the United States, most biodiesel is made from soybean oil.

**LILY:** Biodiesel is blended with diesel fuel. It can be burned as a heating oil or burned in the diesel engines of buses, trucks, and tractors.

**HANNAH:** Or that go cart! Should we go take a ride?

**DAISY:** Let's go!

*(Everyone exits.)*

**SCIENTISTS:** Burning biofuels, gives off heat. Biomass energy, can't be beat!

### **Scene III – At the Invention Convention**

*(Mr. Grump stands in the center of the stage. Georgia, Hannah, Smellvin and the Robot stand to one side, Lunch Lady 1 and 2 stand on the other.)*

**MR. GRUMP:** *(speaks in a very grumpy voice)* I guess I have to welcome everyone to Biome Compostowitz Elementary School's annual Invention Convention. I'm not sure why you bothered to be here... Our theme this year is bioenergy. As if any cares about dead plants or animal poop...

**GEORGIA:** Mr. Grump seems extra grumpy today.

**MR. GRUMP:** The children worked very hard on these inventions. Copied them off the internet probably... Thank you for coming. Don't let the door hit you on the way out... *(Mr. Grump stomps off the stage.)*



**HANNAH:** Hey, Smellvin. How did your robot turn out?

**SMELLVIN:** I invented the Pooper Scooper 2000. It does a lot more than just scooping poop. I'll show you. *(Smellvin turns to the Robot, pushes a button on the hand-held control device, and uses a commanding voice.)* Robot, throw a baseball.

*(Robot pretends to wind up a pitch and throw a baseball. Then stands back at attention.)*

**GEORGIA:** Wow! That's so cool. Does it do anything you tell it to do?

**SMELLVIN:** He isn't very good at eating my vegetables at dinner, but we're working on it.

**LUNCH LADY 1:** *(in a loud voice, to catch everyone's attention)* The students of Biome Compostowitz Elementary School make a lot of trash. We're tired of carrying garbage bags to the curb.

**LUNCH LADY 2:** Our invention is the Lunch Lady Landfill. It holds the garbage in the middle of the cafeteria.

**HANNAH:** I think we better check this out.

**WOODY and TWIGGY:** *(run across the stage holding their noses)* Ewww – it smells so gross in here!

*(Georgia, Hannah, Smellvin and Robot walk over to Lunch Lady 1 and 2 and hold their noses.)*

**SMELLVIN:** Ladies, what you have here is MSW. Municipal Solid Waste. Also known as garbage. And it stinks!

**LUNCH LADY 1:** Even though it's stinky, garbage can be a good thing.

**LUNCH LADY 2:** At a waste-to-energy plant, garbage is burned as fuel. Heat from the fire makes steam to heat buildings, for industrial uses, or to make electricity.

**SCIENTISTS:** Burning garbage, gives off heat. Biomass energy, can't be beat!

**LUNCH LADY 1:** Garbage in a landfill makes energy, too, during a process called bacterial decay.

**GEORGIA:** Bacteria that stay alive without any oxygen are called anaerobic bacteria. They live naturally in landfills.

**HANNAH:** The bacteria feed on plant and animal materials, decomposing them. As food waste, leaves, grass clippings, wood, and materials like paper and cardboard decompose, it produces a biogas rich with methane.

**SMELLVIN:** It's called landfill gas. It is collected, cleaned, and burned to generate electricity.

**LUNCH LADY 2:** Just think, yesterday's meatloaf surprise could be lighting our kitchen someday.

**GEORGIA:** Unfortunately, there's no anaerobic bacteria here. This is just a stinky pile of garbage.

**HANNAH:** Smellvin, can your robot scoop this up?

**SMELLVIN:** Of course! The Pooper Scooper 2000 is the greatest invention of all time. *(Smellvin turns to Robot, pushes a button on the hand-held control device, and uses a commanding voice.)* Robot, take out the trash.

*(Robot pantomimes scooping up garbage and putting it into a trash can while the conversation continues.)*

**GEORGIA:** Let's show everyone our invention. It's an anaerobic digester for our treehouse.

**LUNCH LADY 1:** How does it work?

**HANNAH:** Anaerobic bacteria don't need oxygen to survive. These bacteria live inside the digester. They feed on dead plant and animal material - including animal manure and human waste!

**LUNCH LADY 2:** That's so gross!

**GEORGIA:** Human waste is a biomass resource. Some cities have sewage treatment plants that use anaerobic digesters during the waste treatment process. The biogas produced is burned to heat the digesters or to make electricity to use at the facility.

**HANNAH:** Some dairy farms use anaerobic digesters to make biogas from their cows' manure. Livestock farms can also collect biogas from cow manure decaying in holding ponds. They burn the biogas to heat water and buildings, or to generate electricity to use on the farm.

*(Robot moves about the room, pantomimes picking up a ball, winding up, and throwing it across the room.)*

**GEORGIA:** We're going to put dog poop and food waste in our digester. The biogas it makes will fuel our Bunsen burner in the treehouse science lab.

**SCIENTISTS:** Burning biogas, gives off heat. Biomass energy, can't be beat!

**HANNAH:** On no! Look what the robot is doing. It's scooping up garbage and throwing it at the parents!

**GEORGIA:** Smellvin! Do something!

**SMELLVIN:** *(Pushes the button on the hand-held controller, voice sounds frantic)* I can't get it to shut off! It has a life of its own!

**HANNAH:** I think we need some help here. Let's get Captain Biomass.

*(Georgia and Hannah do an exaggerated SNAP! with their fingers. Captain Biomass rushes onto the stage.)*

**CAPTAIN BIOMASS:** Fa La Laaa!!!! Your robot wrangler to the rescue!

*(Captain Biomass wraps a rope around Robot pinning its arms to its side.)*

**CAPTAIN BIOMASS:** *(while walking Robot off stage)* I've got a recycling bin with your name on it!

**SMELLVIN:** Whew, that was a close one. Good thing Captain Biomass was here to save the day.

**GEORGIA:** I guess we should turn him back into Mr. Grump again.

**HANNAH:** Or..., we could just wait until the Invention Convention is over.

*(Everyone giggles and nods in agreement and walks off stage together – except Smellvin. Smellvin sneaks off the stage after his robot.)*

## Scene IV – Conclusion

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**NARRATOR 1:** You may be wondering, "What happened to our superhero after the Invention Convention?"

**NARRATOR 2:** Captain Biomass smelled so bad after wrangling the robot that he went home and took a shower. That turned him back into cranky old Mr. Grump.

**NARRATOR 1:** Smellvin secretly gathered the pieces from the Pooper Scooper 2000 out of the recycling bin. He is busy working on his next great invention, the Veggie Eater 2000.

**NARRATOR 2:** But before we can tell you that story, we have to tell you this story.

**NARRATOR 1:** Woody and Twiggy got sick to their stomachs eating too many roasted marshmallows. The Flower sisters got a speeding ticket for zooming around the neighborhood on their biofuel go-carts. And, the lunch ladies earned an award for their meatloaf surprise. They are thinking about writing a cookbook.

**NARRATOR 2:** Up in the backyard treehouse, Georgia and Hannah are using biogas for their Bunsen burner. Science experiments are underway. They may...

**NARRATOR 1:** or may not...

**NARRATOR 2:** be working on a long-lasting, super-duper, water-proof, science teacher hypnotizing potion.