



## Understanding the Energy Demand of Bottled Water

### INTRODUCTION

The production of bottled water uses huge amounts of energy compared to the production of tap water. Students will illustrate the steps required to produce bottled water and the relative amounts of energy used at each step. They will then debate the pros and cons of drinking bottled water and actions they can take at school to reduce their drinking water-related energy footprints. Finally, students will reflect upon what they have learned and write an “op ed” piece for their school newspaper.

### LESSON OVERVIEW

**Grade Level & Subject:** Grades 5-8; Science, Social Studies, Math and English

**Length:** 2-3 class periods

#### Objectives:

After completing this lesson, students will be able to:

- Illustrate each of the steps where energy is used in the process of making bottled water.
- Identify the steps in this process that use the most energy.
- Consider environmental impact of plastic bottles and the pros and cons of drinking bottled water.
- Write an editorial about one’s position on whether to ban bottled water from school.

#### National Standards Addressed:

This lesson addresses the following [National Science Education Standards](#) from the [National Academies of Science](#):

- **Content Standard: [NS.9-12.5 SCIENCE AND TECHNOLOGY](#)**  
As a result of their activities, students should develop an understanding of:
  - Abilities of technological design
  - Understandings about science and technology
- **Content Standard: [NS.9-12.6 PERSONAL AND SOCIAL PERSPECTIVES](#)**  
As a result of activities in grades 9-12, all students should develop understanding of
  - Personal and community health
  - Population growth
  - National Resources
  - Environmental quality

Earth Day Network

1616 P Street NW, Suite 340 • Washington, DC 20036

(P) 202-518-0044 • (F) 202-518-8794

[www.earthday.org/education](http://www.earthday.org/education) • [education@earthday.org](mailto:education@earthday.org)

- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

This lesson addresses the following [Standards & Position Statement](#) from the [National Council for the Social Studies](#):

- **Content Standard:** [NSS-G.K-12.5 ENVIRONMENT AND SOCIETY](#)

As a result of activities in grades K-12, all students should

- Understand how human actions modify the physical environment.
- Understand how physical systems affect human systems.
- Understand the changes that occur in the meaning, use, distribution, and importance of resources.

This lesson addresses the following [Standards for School Mathematics](#) from the [National Council of Teachers of Mathematics](#):

- **Content Standard:** [NM MEASUREMENT STANDARD FOR GRADES 9–12](#)

Instructional programs from prekindergarten through grade 12 should enable all students to—

- Understand measurable attributes of objects and the units, systems, and processes of measurement.

In grades 9–12 all students should—

- Make decisions about units and scales that are appropriate for problem situations involving measurement.

- **Content Standard:** [NM CONNECTIONS STANDARD FOR GRADES 9–12](#)

Instructional programs from prekindergarten through grade 12 should enable all students to—

- recognize and apply mathematics in contexts outside of mathematics.

This lesson addresses the following National Education Standards from the [National Council of Teachers of English](#):

- **Content Standard:** [NL-ENG.K-12.12 APPLYING LANGUAGE SKILLS](#)

Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

### Materials Needed:

- Plastic water bottle filled one-fourth of the way with “oil” (Cooking oil or a substance that looks like oil such as coffee would work well)
- Reproducible #1 – Steps in Getting Bottled Water to You
- Reproducible #2 – Record of Drink Bottles Used in a Week
- Butcher paper
- Colored markers
- Sample water utility bill (Extension – optional)
- Calculators (Extension – optional)
- Examples of various sized bottles – 355ml, 591ml, 1L and 2L (Extension – optional)

### Assessment:

Students will be assessed through the following activities:

Earth Day Network

1616 P Street NW, Suite 340 • Washington, DC 20036

(P) 202-518-0044 • (F) 202-518-8794

[www.earthday.org/education](http://www.earthday.org/education) • [education@earthday.org](mailto:education@earthday.org)

- Participation in making an illustration of the energy requirements of bottled water.
- Participation in a class debate.
- Completion of an op ed piece stating his/her position.

## LESSON BACKGROUND

### Conversion Information:

- 1 U.S. liquid gallon is equal to 3.785411784 litres/liters
- 1 U.S liquid gallon is equal to 128 fluid ounces
- 1 cubic meter is equal to 264.172052 US gallons
- 1 kilogram is equal to 2.20462262 pounds
- 1 gallon is equal to 1 meter cubed x 246
- 1 gallon is equal to 1 foot cubed x 7.48
- 1 gallon is equal to 1 liter x 0.264

### Relevant Vocabulary:

- **Embedded Energy:** also known as “Cumulative Energy Demand,” represents the sum of all the energy inputs into a product system, from all stages of the life cycle (for example, extraction of materials, processing, transportation, manufacture, etc).<sup>1</sup>
- **Energy Footprint:** the embedded energy in a product.
- **Fossil Fuels:** hydrocarbons such as coal, oil, and natural gas that formed from the remains of dead plants and animals.<sup>2</sup>
- **Micro-Filtration or Ultra-Filtration:** a purification process that helps to remove any suspended solids in water.<sup>3</sup>
- **Op Ed:** is a page of special features usually opposite the editorial page of a newspaper; *also:* a feature on such a page.<sup>4</sup>
- **Ozonation:** a purification process that helps to kill bacteria and other micro-organisms.<sup>5</sup>
- **PET:** short for polyethylene terephthalate, this is the petroleum-based plastic substance used to produce most plastic drinking bottles. It is categorized with a #1 plastic recycling code.<sup>6</sup>
- **Reverse Osmosis:** a purification process that helps to remove some chemicals and heavy metals from water.<sup>7</sup>

<sup>1</sup> *Embedded Energy*. Environment Australia: Department of the Environment and Heritage. Retrieved 14 March 2010 from [http://buildlca.rmit.edu.au/Embodied\\_energy\\_definition.html](http://buildlca.rmit.edu.au/Embodied_energy_definition.html).

<sup>2</sup> *Fossil Fuels*. Science Daily. Retrieved 12 March 2010 from <[http://www.sciencedaily.com/articles/f/fossil\\_fuel.htm](http://www.sciencedaily.com/articles/f/fossil_fuel.htm)>.

<sup>3</sup> *Micro- Filtration*. Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P.5.

<sup>4</sup> *Op Ed*. Merriam- Webster Online Dictionary. Retrieved 12 March 2010 from <<http://www.merriam-webster.com/dictionary/op%20ed>>.

<sup>5</sup> *Ozonation*. Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P.5.

<sup>6</sup> *PET*. Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P. 2.

<sup>7</sup> *Reverse Osmosis*. Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P.5.

Earth Day Network

1616 P Street NW, Suite 340 • Washington, DC 20036

(P) 202-518-0044 • (F) 202-518-8794

[www.earthday.org/education](http://www.earthday.org/education) • [education@earthday.org](mailto:education@earthday.org)

- **Ultraviolet Radiation:** a water purification process that helps to kill bacteria and other micro-organisms.<sup>8</sup>
- **Water Footprint:** equal to the water required to produce the goods and services an individual consumes.<sup>9</sup>

### Information:

Many people simply do not consider the energy used to make and transport the products they buy. Even something as seemingly commonplace as drinking bottled water requires many steps to produce, including extracting resources for plastic, processing the materials, manufacturing the bottles, treating the water, and transporting the product to market. Each of these steps uses energy. The total amount of energy used to create and distribute a product is known as the “energy footprint” or the “embedded energy” of that product. Thinking about products’ embedded energy is important to fully understand the full ecological impact of its lifecycle.

The energy footprint of bottled water is dominated by the energy to produce the plastic bottles and the energy to transport the bottles to market, especially if they are traveling a good distance – if the transportation is long-distance, those energy costs can be similar to or even larger than the energy to produce the bottle. One bottle of water can require as much as 2000 times the energy as producing the same amount of tap water.<sup>10</sup> When considering the consumption of bottled water in the United States (33 billion liters in 2007), the energy required to produce the bottled water is equivalent to 32-54 million barrels of oil or a third of one percent of total primary energy consumption in the United States.<sup>11</sup> Another way to think of this fact is to consider how much oil would need to be poured into each bottle to represent the energy that went into producing it. The Pacific Institute estimates that each bottle would need to be filled one-fourth full with oil.<sup>12</sup> Thinking about embedded energy in products can shift how we think as consumers and the decisions we make.

### Resources:

- “Bottled Water and Energy Fact Sheet,” Pacific Institute, [http://www.pacinst.org/topics/water\\_and\\_sustainability/bottled\\_water/bottled\\_water\\_and\\_energy.html](http://www.pacinst.org/topics/water_and_sustainability/bottled_water/bottled_water_and_energy.html).
- *Drinking and Groundwater Statistics*, U.S. Environmental Protection Agency, [http://www.epa.gov/safewater/databases/pdfs/data\\_factoids\\_2008.pdf](http://www.epa.gov/safewater/databases/pdfs/data_factoids_2008.pdf).
- “Energy Implications of Bottled Water,” Pacific Institute, [http://www.pacinst.org/reports/bottled\\_water/index.htm](http://www.pacinst.org/reports/bottled_water/index.htm).
- Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK.

---

<sup>8</sup> *Ultra Violet Radiation*. Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P.5.

<sup>9</sup> “Introduction,” Water Footprint. Retrieved 10 March 2010 from <http://www.waterfootprint.org>.

<sup>10</sup> Sohn, Emily, “Bottled Water Carries Hidden Cost to Earth,” *Discovery News*, Discovery Channel, April 6, 2009. <http://dsc.discovery.com/news/2009/04/06/bottled-water.html>.

<sup>11</sup> Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P.6.

<sup>12</sup> “Bottled Water and Energy Fact Sheet,” Pacific Institute [http://www.pacinst.org/topics/water\\_and\\_sustainability/bottled\\_water/bottled\\_water\\_and\\_energy.html](http://www.pacinst.org/topics/water_and_sustainability/bottled_water/bottled_water_and_energy.html).

- “Ground Water & Drinking Water FAQs,” U.S. Environmental Protection Agency, <http://www.epa.gov/ogwdw000/faq/faq.html#source>.
- “Local Drinking Water Information,” U.S. Environmental Protection Agency, <http://www.epa.gov/safewater/dwinfo/index.html>.
- Sohn, Emily, “Bottled Water Carries Hidden Cost to Earth,” *Discovery News*, Discovery Channel, April 6, 2009. <http://dsc.discovery.com/news/2009/04/06/bottled-water.html>.
- “Sources of Drinking Water,” Excel Water Technologies, [http://www.excelwater.com/eng/b2c/about\\_10.php](http://www.excelwater.com/eng/b2c/about_10.php).
- Singhal, Vikas, Manager of Budget and Finance at the Army Corps of Engineers Washington Aqueduct.

## LESSON STEPS

### Warm-up: *A Bottle of Oil*

1. Present students with a plastic water bottle filled one-fourth of the way with “oil.” (Cooking oil or a substance that looks like oil such as coffee would work well.)
  - a. Ask students if they are familiar with the concept of “embedded energy” or “energy footprint.” Embedded energy is also known as “Cumulative Energy Demand,” and represents the sum of all the energy inputs into a product system, from all stages of the life cycle (for example, extraction of materials, processing, transportation, manufacture, etc).<sup>13</sup>
  - b. Explain that you brought in this bottle to illustrate that drinking a bottle of water is like using this amount of fossil fuels. One-fourth of a bottle of oil or other energy source is embedded in the production costs of a bottle of water.
  - c. The point is that many products require the use of fossil fuels such as oil in order to be produced and transported to consumers, but we often are not aware of how much energy is used or in what ways. “The Pacific Institute estimates that the total amount of energy required for every plastic bottle is equivalent, on average, to filling each plastic bottle ¼ full with oil.”<sup>14</sup>
2. Let your students know that in this lesson they will be learning about the specific ways energy is used to bottle water and transport it to them. As consumers they have the power of choice, and their choices have impacts. Explain that you want them to consider the pros and cons of drinking bottled water versus tap water and they will be having a debate on this. Let them know that there is no right or wrong opinion, but that you want them to think carefully about the pros and cons of each type of water and the impact of the choices they make.

---

<sup>13</sup> *Embedded Energy*. Environment Australia: Department of the Environment and Heritage. Retrieved 14 March 2010 from [http://buildlca.rmit.edu.au/Embodied\\_energy\\_definition.html](http://buildlca.rmit.edu.au/Embodied_energy_definition.html).

<sup>14</sup> “Bottled Water and Energy Fact Sheet,” Pacific Institute [http://www.pacinst.org/topics/water\\_and\\_sustainability/bottled\\_water/bottled\\_water\\_and\\_energy.html](http://www.pacinst.org/topics/water_and_sustainability/bottled_water/bottled_water_and_energy.html).

### **Activity One: *Illustrating the Energy Used in Making Bottled Water***

1. Pass out copies of Reproducible #1 – Steps in Getting Bottled Water to You. This handout describes the steps where energy is used.
2. Put students in groups of 3-4 and explain that you would like them to illustrate the many steps in which energy is embedded in the process of obtaining bottled water and transporting it to consumers such as themselves. Explain that you would like them to illustrate these steps on a large piece of butcher paper. Your students can organize their poster the way they prefer; a web-like illustration with arrows connecting one step to the next might work best. Be sure they include all steps from source to hand. Encourage them to be creative. Remind them that they do not need to be masterful drawers – in fact a cartoon effect and a little humor are great! The point is for them to better understand all of the energy that is required to produce a plastic bottle of water.
3. You may want to share all or some of the facts on Reproducible #2 – Record of Drink Bottles Used in a Week for students to incorporate into their illustrations.
4. Provide enough class time for the completion of the illustrations. Circulate among groups as they work, asking students to explain their work to you. Urge them to add a little text to describe each step for other people who look at their drawings.
5. Have students share their group's work with the rest of the class. Discuss these with the class. Did they learn anything new? Did any groups think of something that others did not have?
6. Exhibit the large illustrations on classrooms walls or in the hallway so students can enjoy each other's work and share the information with other classes and teachers.

### **Activity Two: *Discussion – Your Choices***

1. Ask students how much they pay when they buy a liter of bottled water. *Average will likely be between \$.60 - \$2.00 per liter depending on location and brand.*
2. Then, tell them that the Army Corps of Engineer's Washington Aqueduct pays \$155 in energy for the collection, treatment, and transportation of one million gallons of drinking water to the Washington, DC metropolitan area.<sup>15</sup> This costs far less than one cent per liter of drinking water.
3. Discuss the economic benefits of tap water vs. bottled water. To explore this further, consider implementing the Extension at the end of this lesson – ***Calculate the Cost of Drinking Water in Your Municipality.***

---

<sup>15</sup> Data supplied by Vikas Singhal, Manager of Budget and Finance at the Army Corps of Engineers Washington Aqueduct. February 3, 2010.

4. Remind students that, in addition to economic costs, all products have environmental costs as well. One of these is included in a product's embedded energy – the energy used in all steps of extracting, processing, producing, and transporting the product. This energy is often “invisible” and we tend not to think about it, but the embedded energy has real impacts. Whether to buy or drink bottled water seems like a small decision, but there are significant ecological consequences that students are now more aware of.

### **Activity Three: *Reducing the Energy Footprint of Your Drinking Choices***

1. Revisit the idea of an energy footprint. Remind students that a product's energy footprint is the amount of that product's embedded energy. Students can have an energy footprint if they account for all of the energy they use and all of the embedded energy in every product they use or consume.
2. Explain that you would like your students to think about what they learned in the first activity and consider actions they can take to reduce their energy footprints when it comes to the water they drink. Depending on your school facility and policies, you may discuss ideas such as banning bottled water from your school campus and vending machines, providing reusable beverage containers to students, or allowing students to take more frequent water breaks to use drinking fountains. See if students can come up with any other creative but realistic solutions.
3. In class or as a homework assignment, ask students to make a list of reasons for and against these actions. These can be based on the embedded energy activity and/or students can conduct research or be creative to come up with additional ideas. Then, have them consider all of these arguments before writing a paragraph explaining their position and their reasons for it.
4. After choosing the drinking water solution that could be best implemented at your school, divide the class into two groups based on whether they agree with the proposed solution or not. Allow each group to share their reasoning and clarify their arguments. Feel free to make suggestions if either side has missed an important argument.
5. Hold an informal debate. Allow students from each side to explain their rationale. Give each side the opportunity to ask questions of those on the opposing side, and allow for discussion and debate in response to each question. Be sure students consider perspectives of multiple people, including students, teachers, faculty, administrators, facilities staff, etc. and arguments they may have in favor or against such action.
6. Have a final vote on whether or not to take action on implementing a new policy at your school. Let students know that they do NOT have to vote for the side they represented in the debate if the debate changed their mind.

7. If your students feel strongly about taking action, have a discussion about how to best express this to the school community or to school officials. The next activity invites students to write editorials for the school newspaper explaining their opinions.

### **Wrap-Up: Write an Op Ed for Your School Newspaper**

1. Explain that an 'op ed' is a page of special features usually opposite the editorial page of a newspaper. Op eds also refer to all of the features on that page.<sup>16</sup> 'Op ed' stands for "opposite the editorial page" because this is where it is located in a newspaper. This is a space for the readers and general public expresses opinions.
2. Explain that you would like each of them to write an op ed piece for the school newspaper expressing their opinion on reducing the energy footprint of water and beverages consumed at school. They can choose to represent a specific action or write about several. They may also choose to write against an action. In any case, they should be sure to include thoughtful and persuasive evidence considering all sides of the issues and the perspectives of others.
3. Exhibit the op ed pieces in a prominent hallway or on the school website for other members of the school community to read. Select several of the strongest samples for submission to your school newspaper (or local paper!). You might also consider having your students decide which ones should be submitted.

### **Extension: Calculate the Cost of Drinking Water in Your Municipality**

1. As a class or as an additional assignment for students, research the drinking water municipality for your area. Who provides, collects, treats, and transports the water in your area? You may want to use or refer to the *Where Does Your Drinking Water Come From?* lesson plan in this unit.
2. Bring in a typical water utility bill. Compare the cost of tap water at your home with an equal amount of bottled water. Estimates are fine.
3. Instead, or in addition, find data online or contact your municipality to find out how much your community spends on drinking water. Online resources include:
  - "Ground Water & Drinking Water FAQs," U.S. Environmental Protection Agency, <http://www.epa.gov/ogwdw000/faq/faq.html#source>.
    - This is a great place to start for answering Frequently Asked Questions on groundwater and drinking water. For more information on your drinking water you can also visit their [question and answer database](#) on this site or call the EPA's [Safe Drinking Water Hotline](#) at 1-800-426-4791.
  - *Water Science for Schools*, U.S. Geological Survey, <http://ga.water.usgs.gov/edu/wwvisit.html>.

---

<sup>16</sup> *Op Ed*. Merriam- Webster Online Dictionary. Retrieved 12 March 2010 from <<http://www.merriam-webster.com/dictionary/op%20ed>>.

- This site includes a step-by-step guide describing what happens at each stage of the water treatment process and how pollutants are removed to help keep our waterways clean.
  - “Local Drinking Water Information,” U.S. Environmental Protection Agency, <http://www.epa.gov/safewater/dwinfo/index.html>.
    - This site allows you to find data and contact information for your state drinking water program.
  - “Standards and Risk Management,” Office of Ground Water and Drinking Water, U.S. Environmental Protection Agency, <http://www.epa.gov/ogwdw000/standards.html>.
    - Here you can find information on contamination and regulation of drinking water.
  - *Watershed Assessment, Tracking & Environmental Results*, U.S. Environmental Protection Agency, <http://www.epa.gov/waters/>.
    - This site unites water quality information from several independent and unconnected databases.
4. Convert this amount to cost per liter and compare to the numbers discussed in Activity Two section of this lesson.
  5. How does your area compare to other communities in other regions? What factors might some of these differences in cost? How do these costs compare to general bottled water costs? What are some possible reasons for differences?

**Extension: *Calculate the Oil Consumed in Drink Bottles by Your Class in One Week***

1. Ask students to record how many drink bottles (of any kind) they use in a week and their sizes. Pass out copies of Reproducible #2 – Record of Drink Bottles Used in a Week, and explain how to complete the sheet. It may be helpful to present examples of various sized bottles for student reference (355ml, 591ml, 1L and 2L).
2. Compile the results of all students and calculate how much oil was consumed simply to provide the drink bottles that they used in a week. (Remember to divide the total number of milliliters by 1000 to get a total number of liters.)
3. Consider filling that number of liter bottles with “oil” and displaying them with a sign in a prominent location in your school for others to see.
4. Talk to students about what other products they use that have energy embedded in their lifecycle (nearly everything does). Have students choose an object, research its lifecycle, and give a report or presentation in class.

**Extension: *Calculate Your Water Footprint***

1. In addition to energy footprints, many products also have water footprints, using substantial amounts of water to produce and transport. Have students calculate their water footprints. The [Water Footprint Calculator](http://www.waterfootprint.org) (found under “Your Footprint Calculator” at [www.waterfootprint.org](http://www.waterfootprint.org)) is a great online tool that will allow your students to calculate their extended water footprints (equal to the water required to produce the goods and services they consume). They can also visit <http://www.h20conserve.org/home.php?pd=index> or [www.epa.gov/watersense/calculate\\_your\\_water\\_savings.html](http://www.epa.gov/watersense/calculate_your_water_savings.html).

## CONCLUSION

As a result of this lesson, students will understand that every product they buy has embedded energy in it. Specifically, they will have mapped out and illustrated each step in the process of making bottled water that requires energy and learned that bottled water can take up to 2000 times the energy required to produce tap water! Students used what they learned to discuss and debate options at school or actions they could take to reduce their drinking water’s energy footprint. They also wrote an op ed piece expressing their opinion on this topic.

## LESSON PLAN CREDITS

### **Margaret Pennock – Author**

Curricula Writer, Earth Day Network  
Middle School Science Teacher, Sidwell Friends School

### **David Wood – Author**

Curricula Writer, Earth Day Network  
8<sup>th</sup> Grade Science Teacher, Sidwell Friends School

### **Brenna Holzhauer – Author, Editor**

Education Manager, Earth Day Network

### **Mary Beall – Researcher**

Education Intern, Earth Day Network

## Steps in Getting Bottled Water to You

### A FEW FACTS ABOUT THE WATER IN BOTTLED WATER

The water in bottled water can come from municipal water (tap water) or from protected springs or groundwater. About 44% of bottled water comes from municipal water sources while the rest comes from springs or groundwater.<sup>17</sup> In the United States, bottled water labeled 'purified' is tap water that receives additional processing. First, the municipality must meet the national standards under the Safe Drinking Water Act. The bottling company commonly adds further processing; bottled tap water that does not receive further treatment must be labeled 'municipal water'.<sup>18</sup> Spring water is not supposed to go through treatment that significantly changes its chemical composition, although it usually undergoes some processing at the bottling plant.<sup>19</sup>

At the bottling plant, energy is used to process the water. The methods used to treat the water vary from one plant to another, but include some or all of the following methods: ultraviolet radiation, micro or ultra-filtration, reverse osmosis, and ozonation. (Ultraviolet radiation and ozonation help kill bacteria and other micro-organisms; reverse osmosis helps to remove some chemicals and heavy metals from water; and micro and ultra filtration help to remove any suspended solids in water.) These methods use different amounts of energy; ozonation uses the least amount while reverse osmosis uses the most.<sup>20</sup>

#### Tips for Your Illustration

- Choose a source for your water: tap water, a natural spring, or ground water. (Remember, the water from the spring or ground probably gets pumped into the bottling plant, and this uses energy.)
- Include a bottling plant. (You can give it a name!)
- Show that energy gets used, but you will see that the total amount of energy used in this step is very small (probably less than 1% of all of the energy used to produce bottled water) compared to the energy used to actually bottle the water! Think of a way to illustrate the energy used at each step.

### A FEW FACTS ABOUT THE PLASTIC BOTTLES USED FOR BOTTLED WATER

- Most single-use plastic bottles are made out of a petroleum-based substance called PET, which is short for polyethylene terephthalate. (PET can be identified by the recycling code '1' on the bottom of a bottle.) The production of PET requires many steps that include heating, stretching, and blowing the plastic into a bottle shape. Some energy is used in the production of PET and more energy is used to turn PET into bottles. (Remember, the energy is usually supplied by natural gas and other petroleum products as well as

---

<sup>17</sup> Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P. 2.

<sup>18</sup> Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P. 3.

<sup>19</sup> Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P. 3.

<sup>20</sup> Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P.5.

electricity.)<sup>21</sup> It's common for PET bottles to be produced in one plant before being transported to the bottling plant. This also requires energy. Some plastic bottles are harder than PET and can use 40% more energy to make!

### **Tips for Your Illustration**

- Include a manufacturing plant that makes PET bottles and show them being transported to the bottling plant.
- Typically, the step of making PET bottles and transporting them uses over half of the energy used in all of the steps of making bottled water. (Use 51% of energy depicted in your poster.)

## **CLEANING, FILLING, SEALING, AND LABELING BOTTLES**

Once bottles are produced and the water is treated, machines must rinse, fill, cap and label the bottles. The energy required to rinse, fill, cap and label the bottles is approximately 1% of all of the energy used in total.

## **TRANSPORTING THE BOTTLES TO STORES**

Now that the bottled water has been produced, it needs to be transported to stores to be sold. Water is quite heavy (1 gallon weighs 8.34 pounds) so the energy needed to transport it can be quite significant. The amount of energy used in this step depends on the distance from the bottling plant to the store as well as the mode of transportation; for example truck, train, boat, or plane.

### **Tips for Your Illustration**

- Show any form of transportation (or multiple forms!) The most energy intensive method is by air, while the least energy intensive is by train. Travel by truck falls in the middle, with heavy trucks being less energy-intensive than medium trucks.<sup>22</sup>
- 46% of all energy is a reasonable figure to use for this step. (This is based on the median range from three scenarios.<sup>23</sup>)

## **ARE THERE ANY OTHER STEPS THAT REQUIRE ENERGY?**

- Remember, if you drive to buy the bottled water—more energy is used! This will vary on the distance you drive.
- Can you think of any others? If you have space on your poster, add as many other steps as you can, such as further transportation or the energy used to refrigerate water bottles in a vending machine.
- Show an electric generating plant providing the electricity to each of the steps that requires electricity.

---

<sup>21</sup>Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P. 2.

<sup>22</sup> Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P.5.

<sup>23</sup> Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P.5.

## **HOW DOES THIS ENERGY COMPARE TO THE ENERGY USED IN PRODUCING TAP WATER?**

- Bottled water can require as much as 2000 times the energy that producing tap water requires.<sup>24</sup> See if you can find a way to note or illustrate this on your poster.

## **WHAT ARE THE SIDE EFFECTS OF MAKING BOTTLED WATER?**

- Think about the side effects of making bottled water and include them in a sidebar or with additional arrows on your poster. For example, what happens to the bottles when people are done with them? What about the emissions of trucks, trains, and planes when they transport bottles?

---

<sup>24</sup> Gleick, P.H. and Cooley, H.S. (2009). *Energy Implications of Bottled Water*. IOP Publishing Ltd. UK. P.6.

Name: \_\_\_\_\_

Date: \_\_\_\_\_

### Record of Drink Bottles Used in a Week

Record how many drink bottles you used each day of the week and the size of each one.

Beginning Day: \_\_\_\_\_ Ending Day: \_\_\_\_\_

	12 Fl Oz (355 ml)	20 Fl Oz (591 ml)	1 Liter	2 Liters
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Saturday				
Sunday				
	Total:	Total:	Total:	Total:

Remember, each drink bottle would be filled  $\frac{1}{4}$  (or 89 ml of a 355 ml bottle) with oil to indicate how much energy was used to produce and transport that bottle. Complete the table below to calculate how much oil you used. You may need a calculator!

Number of 355 ml bottles you used: →	Multiply this number by 89 ml (X 89 ml) →	How many ml in total?
Number of 591 ml bottles you used: →	Multiply this number by 148 ml (x 148 ml) →	How many ml in total?
Number of 1 Liter bottles you used: →	Multiply this number by 250 ml (x 250 ml) →	How many ml in total?
Number of 2 Liter bottles you used: →	Multiply this number by 500 ml (x 500 ml) →	How many ml in total?
		Total ml:

To determine the total number of liters of oil used by the class, add up the total number of ml used. Then, divide that by 1000 to determine the number of liters.