

A drop in the bucket?

Summary: Ever wonder why your parents are always complaining about how long you spend in the shower? All those showers can add up to a significant chunk of change over time. Each drop of water has costs associated with the supply transport, treatment, and energy required to heat water to a comfortable temperature. In this activity you will figure out how much each shower you take costs, what that cost adds up to over the course of a year and investigate how much money could be saved by investing in water conservation.

Key words: unit conversion/cancellation, water conservation, energy conservation, practical knowledge

Materials:

- Bucket (that holds at least 1 gallon)
- Measuring cup or empty gallon milk jug
- Stopwatch
- Calculator, Abacus or Multiplication and Dividing Skills

Procedure:

1. **Calibrate your bucket:** To do this you will first need a bucket that will be used to measure how long it takes for 1 gallon of water to be collected by the showerhead. Use an old 1-gallon milk jug or a measuring cup to add 1-gallon of water to your bucket (1 gallon = 16 cups). Mark the water level in the bucket with a permanent marker.
2. **Determine the flow rate of your showerhead:** Flow rate is the amount of water released by the showerhead during a period of time. Flow rate is usually expressed as gallons per minute (gpm). Using your calibrated bucket, turn on your showerhead onto high like you would for a shower. A) Using a watch or stop watch, measure how many seconds it takes to fill your bucket to the 1 gallon mark. Repeat this procedure at least 3 times and calculate an average. B) The flow rate in gallons per minute can be calculated by dividing 60 seconds by the average number of seconds needed to collect 1 gallon of water.



A)

Trial 1		seconds
Trial 2		seconds
+ Trial 3		seconds
<div style="display: flex; justify-content: space-between; width: 100%;"> Total _____ seconds by 3 = _____ seconds </div>		

B)

1 gallon	60 seconds	=	_____ gallons per minute
→ _____ seconds	1 minute		

3. **Calculate the cost you are paying per gallon for water and sewer fees:** The majority of water that we use in our homes is not actually consumed but rather sent to a sewer where it is carried to a wastewater treatment plant and cleaned up before being released back into the environment. For each drop of water used to take a shower, there are two separate fees, one for the service of providing the water (this is the water fee) and two for the service of cleaning up the water (this is the sewage fee). Water and sewage fees vary by municipality but represent the costs associated with maintaining the infrastructure and operational costs of treating, transporting and cleaning up the water you use. These costs are expressed as a price charged for a particular volume of water. Most utilities choose to express these volumetric fees in terms of dollars per 100 cubic feet (CF) of water (Note: 100 CF = 748 gallons). Using the water and sewer fees for your municipality (provided by your teacher or parents) simply add the water and sewer fees together. This total volumetric charge represents the cost associated with using 748 gallons of water.

Water Fee - \$		per 748 gallons or 100 CF
+ Sewer Fee - \$		per 748 gallons or 100 CF
<div style="display: flex; justify-content: space-between; width: 100%;"> Total Volumetric Charge - \$ _____ per 748 gallons or 100 CF </div>		

4. **Calculate the water costs per shower:** To calculate the cost of water per shower, you will first need to determine how many gallons of water you use for each shower. The number of gallons used to take a shower can be determined by multiplying the amount of time you spend in the shower (in minutes) by the flow rate (gpm) of the showerhead. *You can either estimate the number of minutes you usually spend in the shower or use a watch to get an accurate measurement.*

A) Flow Rate (gpm) x Length of Shower (minutes) = gallons / shower

$$\frac{\text{_____ gallons}}{\text{minute}} \times \frac{\text{_____ minutes}}{\text{shower}} = \frac{\text{_____ gallons}}{\text{shower}}$$

B) Next, to obtain the cost per shower; divide the total volumetric charge by 748 gallons to give you cost per gallon and then multiply by the total number of gallons per shower to give you the cost per shower.

$$\frac{\text{_____ gallons}}{\text{shower}} \div \frac{748 \text{ gallons}}{\text{_____}} = \frac{\$ \text{_____}}{\text{shower}}$$

(from 3 b)

5. **Calculate the energy costs per shower:** Along with the water and sewer fees, you must also consider the cost of heating the water. Approximately 73% of the water used for showering is hot water. Multiply 0.73 by the total number of gallons used to take a shower (from 4 A.) to give you the gallons of hot water used during the course of the shower.

$$\frac{\text{_____ gallons}}{\text{shower}} \times \frac{0.73 \text{ gallons hot water}}{1.0 \text{ gallons}} = \frac{\text{_____ gallons hot water}}{\text{shower}}$$

Water coming into the house averages about 55° F. Most hot water heaters are set at 120° F. This represents a temperature increase of 65° F (120 – 55 = 65). A British Thermal Unit (BTU) is a unit of measurement that helps us understand the amount of energy needed to heat water. At 100% efficiency, 8.34 BTU are needed to heat 1 gallon of water 1° F. Using this information we can estimate how much energy is required to increase the temperature of the water by 65° F for the hot water used for the shower.

Perform either a or b depending on which type of water heater you use.

(from question 5)

a. If you have a **gas hot water heater**: Gas hot water heaters are approximately 62% (0.62) efficient. Natural gas costs are calculated per therm used. \$0.69 is the estimated cost per therm. (1 therm = 100,000 BTU). Using this information:

$$\frac{\cancel{\text{gallons hot water}}}{\text{shower}} \times \frac{65^\circ\text{F}}{0.62} \times \frac{8.34 \cancel{\text{ BTU}}}{1^\circ\text{F} * \cancel{\text{gallon}}} \times \frac{1 \cancel{\text{ therm}}}{100,000 \cancel{\text{ BTU}}} \times \$0.69 = \$ \underline{\hspace{2cm}} \text{ per shower}$$

b. If you are using an **electric hot water heater**: Electric hot water heaters are approximately 93% (0.93) efficient. Use \$0.12 as the estimated cost per kWh for the electricity. (1 kWh = 3,413 BTU)

$$\frac{\cancel{\text{gallons hot water}}}{\text{shower}} \times \frac{65^\circ\text{F}}{0.93} \times \frac{8.34 \cancel{\text{ BTU}}}{1^\circ\text{F} * \cancel{\text{gallon}}} \times \frac{1 \cancel{\text{ kWh}}}{3,413 \cancel{\text{ BTU}}} \times \$0.12 = \$ \underline{\hspace{2cm}} \text{ per shower}$$

6. **Calculate the total cost per shower (water + energy).** To calculate what it costs for both the water usage and energy costs per shower, simply add together the costs per shower from questions 4 and 5. Depending on what type of water heater you have you will use either 5 a or b.

Water Costs (from question 4)	- \$ <u> </u> per shower
+ Energy Costs (from question 5 a. or b.)	- \$ <u> </u> per shower
Total Cost per Shower	- \$ <u> </u> per shower

7. **If you shower once per day for an entire year, how much does that cost?** The cost per shower might not seem like a lot, but if you shower once per day for a year, it can add up to a significant amount of money.

$$\frac{\$ \underline{\hspace{2cm}}}{\cancel{\text{Shower}}} \times \frac{1 \cancel{\text{ shower}}}{\cancel{\text{day}}} \times \frac{365 \cancel{\text{ days}}}{\text{year}} = \$ \underline{\hspace{2cm}} \text{ per year * person}$$

8. **How much for your whole household to shower for the entire year?** Simply multiply the cost for 1 person to shower each day for a year and multiply by the number of people in your household.

$$\frac{\$ \underline{\hspace{2cm}}}{\cancel{\text{year * person}}} \times \underline{\hspace{2cm}} \cancel{\text{ persons}} = \$ \underline{\hspace{2cm}} \text{ per year * household}$$

9. **Could money be saved by installing a more water efficient showerhead?**

Modern showerheads generally have lower flow rates which can help save money. If the flow rate you calculated for your showerhead (from question 2 b.) is greater than 1.25 gpm, your family could save a lot of money by simply replacing it with a more efficient one.

- What was the flow rate of your shower head that you calculated for question 2.b?
_____ gallons per minute (gpm)
- Is the flow rate from your showerhead greater than 1.25 gpm? **Yes or No**
- **If you answered No** then proceed to question 10.
- **If you answered Yes**, calculate how much your family could save by installing a low flow showerhead (showerheads can have flow rates as low as 1.25 gpm).

First calculate the percent reduction in water use:

$$\left(\frac{\text{_____ gpm} - 1.25 \text{ gpm}}{\text{_____ gpm}} \right) \times 100 = \text{_____ \% Less water used}$$

Next calculate how much money could be saved:

To see how much money could be saved, simply multiply the total that your household spends on water and energy from showering (get this from question 8) and multiply by the percent less water used calculated above.

$$\frac{\$ \text{_____}}{\text{year} * \text{household}} \mid \frac{\text{_____ \%}}{100} = \frac{\$ \text{_____}}{\text{year} * \text{household}}$$

This is the amount of money that your family could save by installing a more efficient showerhead.

10. **Besides installing a more efficient showerhead what are some other ways that your family could conserve water/energy and save money?**
