The Wishings Teacher Notes and Answer Key

About this activity: This set of activities, developed by Mt. Ararat middle school mathematics teacher Mary Theberge, provides students with the opportunity to examine electricity use through mathematics and see real-world applications of slope and rate of change. The first activity, *Watt's a Graph Good For?* involves having students work with a partner to construct two graphs – one shows the number of kilowatt hours the Wishings, a couple who have a vacation home in Maine, use each month over the course of a year. The second graph shows the how the cost of electricity changes based on the number of kilowatt hours used. *Watt's a Graph Good For?* allows students to consider when it is appropriate to use a bar graph versus a line graph, examine how the questions that can be answered from each of the graphs differs, and make predictions about and identify patterns of electricity use using the graphs.

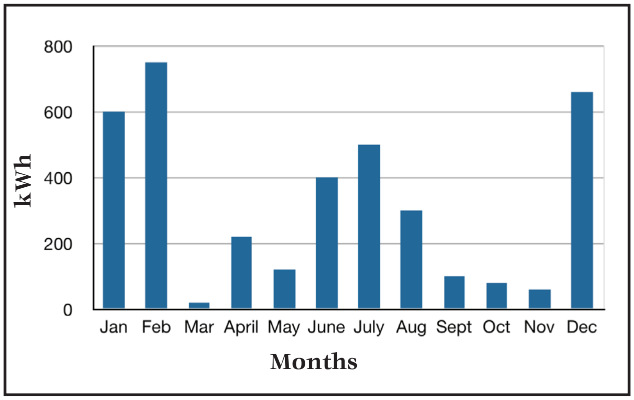
In the second activity, *Electricity Delivery Cost Rate of Change,* students calculate the rate of change using the Wishing's electricity use data. They compare the calculated change to the graph of this data (Graph B) constructed in the previous exercise. Students should recognize that the rate of change is the slope of the graph and that the family pays the rate of $0.0597 per kWh used after the first 100 kWh. In the third activity, *Total Cost of Electricity (Delivery + Supply)*, students calculate the total cost of the Wishing's monthly electricity bill. Typically electricity companies charge customers for both the delivery of electricity and for supplying electricity to a home. Delivery costs are for the infrastructure of the electricity system – in other words the electric company collects a fee for the equipment (e.g. wires, substations, poles, meters, maintenance) necessary for getting electricity to homes. The supply charge is the fee for the energy a customer uses.

In the activity *Comparison of Delivery Costs and Total Cost Graphs* students graphically compare delivery cost and total cost calculated earlier. They examine similarities and differences between the shapes of the graphs and articulate what the graphs tell us about electricity costs. In the *Electricity Cost Rate versus Rate of Change* activity, students examine patterns as they examine a real-world example of rate of change.

Answer Key for *Watt's a Graph Good For?*

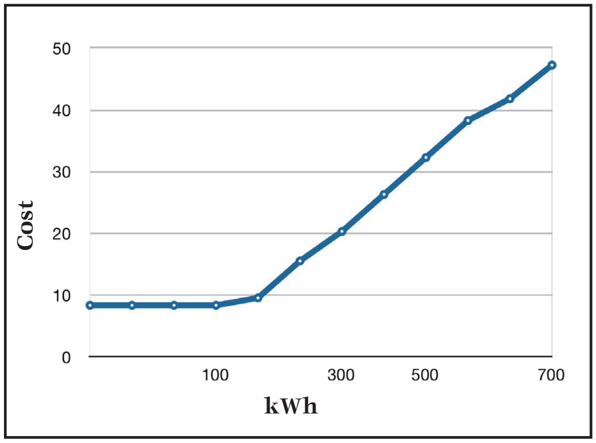
Graph A:

How Many kWh of Electricity do the Wishings Use Each Month?



Graph B:

What is the Cost of Electricity per kWh?



- For Graph A, month is graphed on the horizontal axis because it is the independent variable.
- For Graph B, kWh used is graphed on the horizontal axis because it is the independent variable.

Note: *Independent variables are those that stand-alone and do not change as a result of the other variable being measured. Dependent variables depend on or respond to the independent variable. Independent (manipulated) variables are graphed on the x-axis and dependent (responding) variables are graphed on the y-axis.*

Questions:

1. Why were you asked to graph the kWh on the vertical axis for Graph A and on the horizontal axis for Graph B?
    - Graph A relates kWh used to months while Graph B relates the total cost to number of kWh used. In Graph A, the number of kWh used is dependent on when electricity was used; in other words, which months the Wishings were in Maine. In Graph B, the cost depends on the number of kWh used.

2. What kinds of questions can you answer using Graph A?
    - Graph A can answer which months electricity was used at the Wishing home and which months the greatest number of kWh of electricity and the least number of kWh of electricity were used.

3. What kinds of questions can you not answer using Graph A?
    - Graph A cannot tell us specific things such as how many people were at the Wishing's home or which days or hours the Wishings used the most/least amount of electricity.

4. Using Graph A, can you make a conjecture which months the Wishings were able to come to Maine? Why do you think this? *Note: A conjecture is a statement believed to be true but not yet proven or disproven.*
    - Possible conjecture: The Wishings were in Maine in December, January, February, April and part of June, July, and August.
    - Why do you think this? Students will likely say that the Wishings were in Maine during these months due to the relatively large number of kWh used for those months. Students may also say that the Wishings were probably not in Maine at all in March and possibly November as these months show under 100 kWh of electricity used. Students may say that the Wishings were in Maine for part of the remaining months, but it is difficult to know for certain.

5. Why do you think that a bar graph is a good choice of graph to display the data kWh versus Month?
    - A bar graph is a good choice for showing data that falls into categories. Graph A shows the number of kWh used for each month (categorical, as opposed to numerical data).

6. What kinds of questions can you answer using Graph B?
    - Using Graph B, you can tell how much it will cost (approximately) for any number of kWh used.

7. What kinds of questions can you not answer using Graph B?
    - From Graph B, you cannot tell which months people used the most electricity.

8. What can you say about the slope of the graph? (Is it flat, increasing, decreasing, the same or changing, etc.)
    - The graph starts out fairly flat until the 100 kWh mark, then the line increases at a constant rate.

9. What does this tell us about how this electric company charges its customers for delivering electricity?
    - The graph tells us that the power company charges a flat rate for electricity use for the first 100 kWh of electricity used. After that, people are charged a certain amount for each kWh used.

10. Why do you think that a line graph is a good choice of graph to display the data Cost versus kWh?
    - Line graphs are a good choice for showing quantitative data that is ordered (have an x, y value). Line graphs are good for showing change and can also be used to make predictions about data not recorded (via interpolation and extrapolation of data).

Answer Key for *Electricity Delivery Cost Rate of Change*

1. What can you say about the rate of change ? (Is it always the same? Is it sometimes the same? When?)
    - The rate of change was zero initially, but after 100 kWh it remained a constant rate of about $0.06 per kWh.

2. How does the rate of change relate to the graph of this data? (Graph B)
    - The rate of change is the slope of the graph.

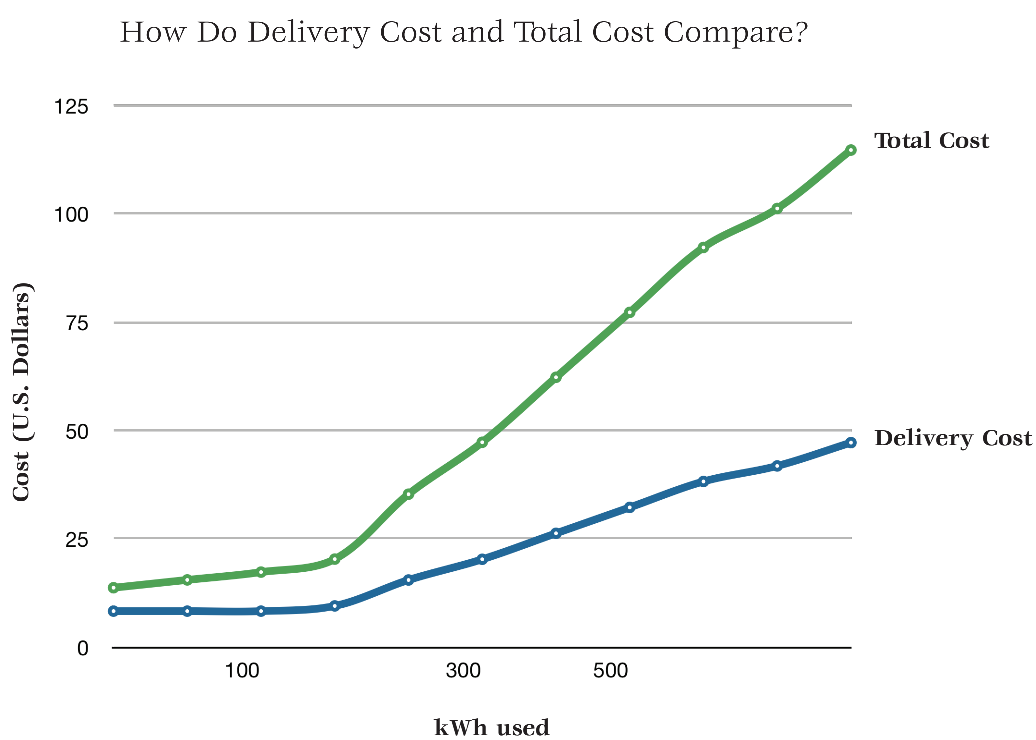
3. What does the Cost per kWh represent as far as what the family pays?
    - It represents how much the cost changes as the number of kilowatt hours the family uses increases.

kWh Used	Delivery Cost	*This Row's Cost – Previous Row's Cost* / *This Row's kWh – Previous Row's kWh*	Rate of Change of Cost per kWh	Rate of Change of Cost per kWh (Rounded to nearest hundredth)
20	$8.36	***********************************	*******	
60	$8.36	8.36 – 8.36 / 60- 20	$0 per kWh	$0 per kWh
80	$8.36	8.36 – 8.36 / 80-60	$0 per kWh	$0 per kWh
100	$8.36	8.36 – 8.36 / 100-80	$0 per kWh	$0 per kWh
120	$9.56	9.56 – 8.36 / 120-100	$0.06 per kWh	$0.06 per kWh
220	$15.54	15.54 - 9.56 / 220-120	$0.598 per kWh	$0.06 per kWh
300	$20.32	20.32 – 15.54 / 300-220	$0.05975 per kWh	$0.06 per kWh
400	$26.31	26.31 – 20.32 / 400 - 300	$0.0599 per kWh	$0.06 per kWh
500	$32.29	32.39 – 26.31 / 500-400	$0.0598 per kWh	$0.06 per kWh
600	$38.27	38.27 – 32.29 / 600 – 500	$0.0598 per kWh	$0.06 per kWh
660	$41.86	41.86 – 38.27 / 660 - 600	$0.0598 per kWh	$0.06 per kWh
750	$47.24	47.24 – 41.86 / 750 – 660	$0.0597 per kWh	$0.06 per kWh

Answer Key for *Total Cost of Electricity (Delivery + Supply)*

kWh Used	Delivery Cost	Supply Cost Multiply number of kWh Used by $0.09	Add the Delivery Cost to Supply Cost
20	$8.36	$8.36 + $1.80 = $10.16	$8.36 + $1.80 = $10.16
60	$8.36	$8.36 + $5.40 = $13.76	$8.36 + $5.40 = $13.76
80	$8.36	$8.36 + $7.20 = $15.56	$8.36 + $7.20 = $15.56
100	$8.36	$8.36 + $9.00 = $17.36	$8.36 + $9.00 = $17.36
120	$9.56	$9.56 + $10.80 = $20.36	$9.56 + $10.80 = $20.36
220	$15.54	$15.54 + $19.80 = $35.34	$15.54 + $19.80 = $35.34
300	$20.32	$20.32 + $27.00 = $47.32	$20.32 + $27.00 = $47.32
400	$26.31	$26.31 + $36.00 = $62.31	$26.31 + $36.00 = $62.31
500	$32.29	$32.29 + $45.00 = $77.29	$32.29 + $45.00 = $77.29
600	$38.27	$38.27 + $54.00 = $92.27	$38.27 + $54.00 = $92.27
660	$41.86	$41.86 + $59.40 = $101.26	$41.86 + $59.40 = $101.26
750	$47.24	$47.24 + $67.50 = $114.74	$47.24 + $67.50 = $114.74

Answer Key for *Comparison of Delivery Cost and Total Cost Graph*



1. How are the two graphs similar?
    - Students should describe the graphs as both steadily increasing after a flat start.

2. How are the two graphs different?
    - Students might say that the Total Cost graph has a steeper slope and reaches a higher point on the y-axis (cost).

3. What do the slopes of the graphs tell you about this situation? In other words, which graph has a steeper slope and what does this tell you?
    - Students should notice that the Total Cost graph has the steeper slope, which shows that the total cost increases more per kWh than the delivery cost does. Some may also note that the slopes of these graphs show rate of change and that the Total Cost graph has a higher rate of change.

4. Even though they are called line graphs, are they really lines? Why or why not?
    - The lines on line graphs help people see change between data points and overall trends in the data being displayed. The line segments connecting two points in these graphs express the slope.

Answer Key for *Electricity Cost Rate versus Rate of Change*

1. How does the cost rate (cost per kWh) change as the number of kWh increase?
    - The cost rate decreases as the number of kWh the Wishings use increases.

2. What pattern do you see in the rate of change in Cost?
    - The rate of change in cost is constant for two categories: 1) for use less than 100 kWh and 2) after the number of kWh used exceeds 100 kWh.

   Why do you think this is so? (Hint: Remember how the delivery cost was distributed)
    - In general terms, the more kWh used the lower the unit cost. When the number of kWh used exceeds 100, the delivery cost is proportionally spread across the total cost.

kWh Used	Total Cost	Cost per kWh (Round to the nearest hundredth.) *To calculate this, divide the Cost by kWh*	Rate of change in Cost This Cell's Cost – Previous Cell's Cost / This Cell's kWh – Previous Cell's kWh
20	$10.16	$10.16 ÷ 20 = $0.51 per kWh	NA
60	$13.76	$13.76 ÷ 60 = $0.23 per kWh	$13.76 ÷ 10.16 / 60 - 20 = $0.09
80	$15.56	$0.19	$0.09
100	$17.36	$0.17	$0.09
120	$20.36	$0.17	$0.15
220	$35.34	$0.16	$0.15
300	$47.32	$0.16	$0.15
400	$62.31	$0.16	$0.15
500	$77.29	$0.15	$0.15
600	$92.27	$0.15	$0.15
660	$101.26	$0.15	$0.15
750	$114.74	$0.15	$0.15