How Many Ways to a Kilowatt Hour? Scavenger Hunt

Directions: Traditionally a scavenger hunt is a game in which the participants (individuals or teams) work to gather – or perform tasks involving – the items on the list. While typically the goal of a scavenger hunt is to be the first to complete the list, the goal here includes not only "finding" everything on the list, but doing so in the most creative manner. Most clues require calculations – to receive full credit you must show and label your work. An example solution has been given for number 1.

———

1000 watts (W) = 1 kilowatts (kW)
1 kilowatt hour (1 kWh) = 1 kW or 1000 W used over the period of an hour

———

Looking for a few more clues to get started? Remember, information about how many Watts different appliances use can be found on an appliance's nameplate, in its owner's manual, or by using a Kill A Watt meter. You may have also recorded Wattage information on your Appliance Cards. The *PowerSleuth* website (www.powersleuth.org) also has helpful resources.

1 A way to use incandescent light bulb(s) equal to 1 kWh

Example solutions: 100 watt bulb used for 10 hours = 1000 watts/hr or 1 kWh
OR 10 100 watt bulbs used for 1 hour = 1000 watts/hr or 1 kWh

Your solution:

2 A way to use one kitchen appliance equal to 1 kWh

Your solution:

3 **A way to use a different kitchen appliance equal to 1 kWh**

Your solution:

4 **A way to use two kitchen appliances at the same time equal to 1 kWh**

Your solution:

5 **An appliance that could use 1 kWh of electricity in less than 10 minutes**

Your solution:

6 **A way to hear your favorite songs using 0.5 kWh**

Your solution:

7 **The most efficient way (the method that uses the smallest number of kWh) to heat up pizza**

Your solution:

8 **A way to watch the most movies (average length of 1.5 hrs) equal to 1 kWh**

Your solution:

Going Graphic! Teacher Notes

About this activity: The May 16, 2011 raw data set was created by downloading the measurements taken from a home electricity monitoring device (a TED: The Energy Detective) using the device's Footprints software (www. http://ted5000/Footprints.html). The Google PowerMeter display of this data set is included here for comparison as well as tips for preparing data for students to use from a different TED home energy monitor.

When students create a graphical representation of a data set, it provides them with first-hand experience in considering how best to represent the data that conveys a clear picture of the pattern of electricity use in this household for a particular time period. Having students examine and work with the raw data also helps them develop a sense of how the home monitor reports the data. It allows them to consider how to represent the data so that it is clear and useful to the end user, just as the developers of the monitors (e.g. Google PowerMeter, TED) had to consider. As students compare and critique the different ways this data is displayed graphically, take this opportunity to discuss with them the idea that decisions made about what and how to display data are dependent on numerous factors. Step 5, Option B of the Investigation Guide outlines additional facilitation tips and discussion points for this activity.

Downloading and preparing data for student use from a TED

The most straightforward way to prepare a raw data set for student use from a TED home energy monitor is to use the Footprints software that resides online at http://ted5000/Footprints.html. This is the same software homeowners with a TED uses to set up and calibrate their devices. A TED's raw data can also be downloaded from the Google PowerMeter site, but since data points are recorded over 10-minute increments, they are reported as 10/60ths of a kWh.

Under the Export tab of the Footprints dashboard (see screen shot on next page) there are several time period options for downloading the raw data: second, minute, hourly, daily and monthly. For the purpose of this exercise, downloading the minute time period is recommended because from this file sample data points can be selected to mirror the

10-minute intervals displayed by Google PowerMeter. The file downloads as .historyexport.csv.

80

Notice the resulting file contains the power measurement for each minute over the last 48 hours in reverse chronological order (see table, right).

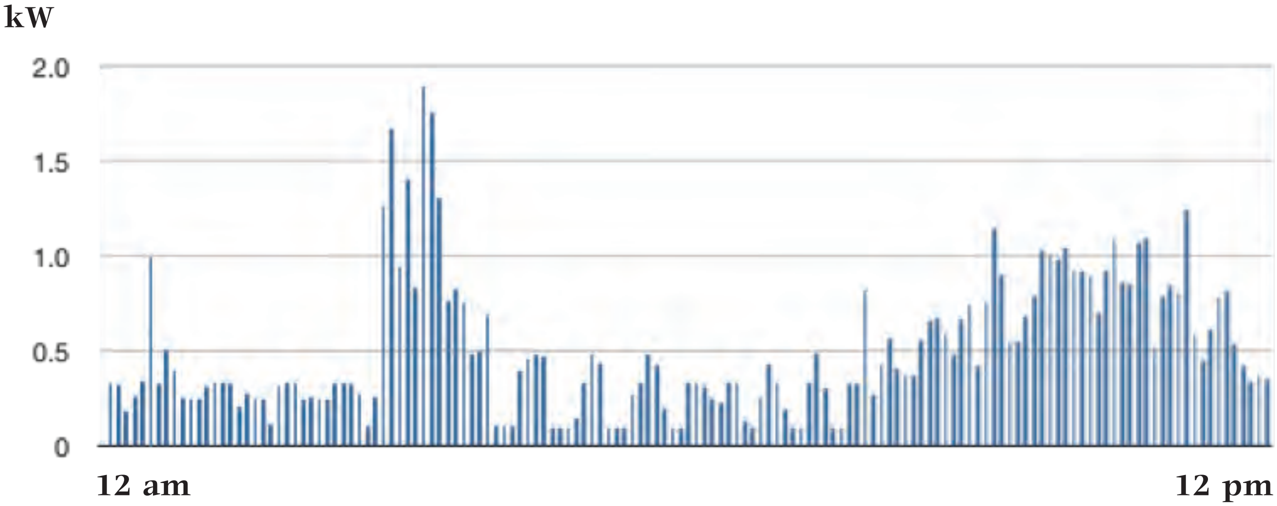
To make the raw data set more manageable and similar to the 10-minute samples reported by Google PowerMeter, create a table listing the time in chronological order and kWh used at each 10 minute mark. For example, the data in the table at the right would be simplified to:

Time	Usage in kW
7:30 PM	1.004
7:40 PM	0.985
and so on...	

Snapshot of Exported Minute Data from TED

mtu	date	power	cost	volts
0	5/16/11 19:43	1.204	0.08	123.1
0	5/16/11 19:42	1.08	0.07	122.9
0	5/16/11 19:41	0.979	0.06	123
0	5/16/11 19:40	0.985	0.06	123
0	5/16/11 19:39	0.986	0.06	123.1
0	5/16/11 19:38	1.078	0.07	123
0	5/16/11 19:37	1.225	0.08	123.1
0	5/16/11 19:36	1.223	0.08	123
0	5/16/11 19:35	1.212	0.08	122.9
0	5/16/11 19:34	1.217	0.08	123.2
0	5/16/11 19:33	1.001	0.06	123.1
0	5/16/11 19:32	1.004	0.06	123.2
0	5/16/11 19:31	1.003	0.06	123.4
0	5/16/11 19:30	1.004	0.06	123.7

While these sample points will not match exactly the data points displayed by Google PowerMeter, if graphed they will generate an electricity use pattern that is quite similar. Below is a graph generated using the raw data set that was prepared for student use following the process outlined above. Compare this graph of May 16, 2011 electricity use to the one generated by Google PowerMeter (refer to handout Real-Time Electricity Use Display for Addison Fox Household May 16, 2011) for this same day:



Going Graphic!

Directions: Create a visual representation (e.g. a graph) of this raw data that answers the question: What is the pattern of electricity use for this home on May 16, 2011? This data was collected from a home electricity-monitoring device. Each data point represents a sampling of the power being used in the home every 10 minutes and is reported in kW.

Time	Usage in kW
12:00 AM	0.332
12:10 AM	0.325
12:20 AM	0.188
12:30 AM	0.264
12:40 AM	0.345
12:50 AM	0.993
1:00 AM	0.331
1:10 AM	0.507
1:20 AM	0.400
1:30 AM	0.256
1:40 AM	0.251
1:50 AM	0.251
2:00 AM	0.371
2:10 AM	0.336
2:20 AM	0.335
2:30 AM	0.332
2:40 AM	0.210
2:50 AM	0.278
3:00 AM	0.254
3:10 AM	0.249
3:20 AM	0.116
3:30 AM	0.320
3:40 AM	0.337
3:50 AM	0.334

Time	Usage in kW
4:00 AM	0.246
4:10 AM	0.259
4:20 AM	0.252
4:30 AM	0.247
4:40 AM	0.333
4:50 AM	0.333
5:00 AM	0.328
5:10 AM	0.279
5:20 AM	0.107
5:30 AM	0.260
5:40 AM	1.264
5:50 AM	1.672
6:00 AM	0.947
6:10 AM	1.406
6:20 AM	0.838
6:30 AM	1.896
6:40 AM	1.756
6:50 AM	1.306
7:00 AM	0.766
7:10 AM	0.829
7:20 AM	0.756
7:30 AM	0.488
7:40 AM	0.500
7:50 AM	0.694

Time	Usage in kW
8:00 AM	0.108
8:10 AM	0.107
8:20 AM	0.107
8:30 AM	0.399
8:40 AM	0.460
8:50 AM	0.485
9:00 AM	0.472
9:10 AM	0.101
9:20 AM	0.100
9:30 AM	0.101
9:40 AM	0.149
9:50 AM	0.334
10:00 AM	0.487
10:10 AM	0.439
10:20 AM	0.100
10:30 AM	0.101
10:40 AM	0.101
10:50 AM	0.275
11:00 AM	0.333
11:10 AM	0.485
11:20 AM	0.428
11:30 AM	0.202
11:40 AM	0.100
11:50 AM	0.100

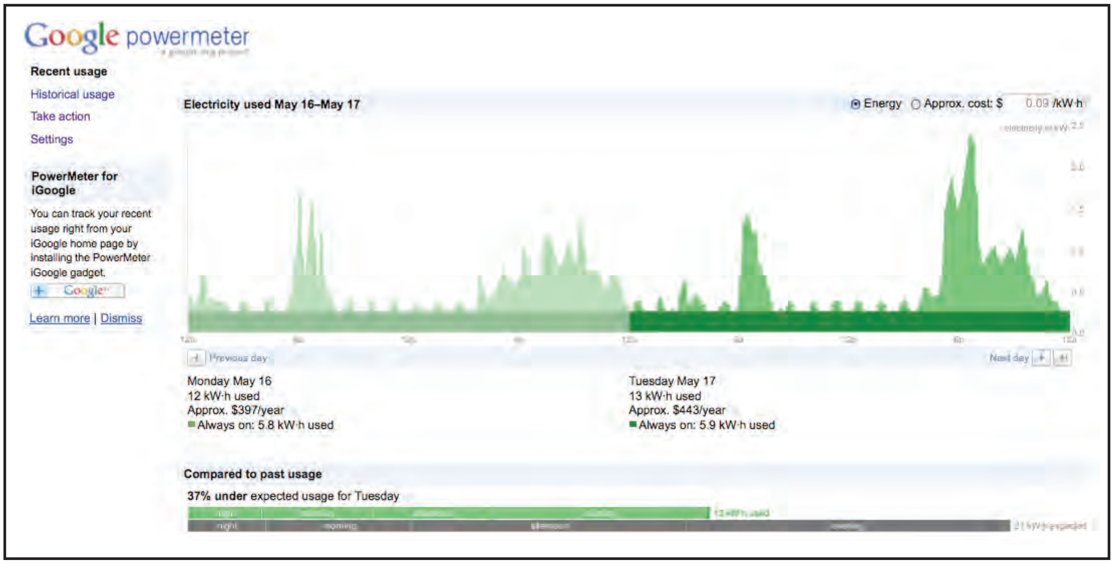
Time	Usage in kW
12:00 PM	0.336
12:10 PM	0.337
12:20 PM	0.315
12:30 PM	0.252
12:40 PM	0.231
12:50 PM	0.337
1:00 PM	0.338
1:10 PM	0.134
1:20 PM	0.102
1:30 PM	0.255
1:40 PM	0.436
1:50 PM	0.338
2:00 PM	0.196
2:10 PM	0.101
2:20 PM	0.101
2:30 PM	0.337
2:40 PM	0.491
2:50 PM	0.308
3:00 PM	0.100
3:10 PM	0.100
3:20 PM	0.330
3:30 PM	0.332
3:40 PM	0.822
3:50 PM	0.273

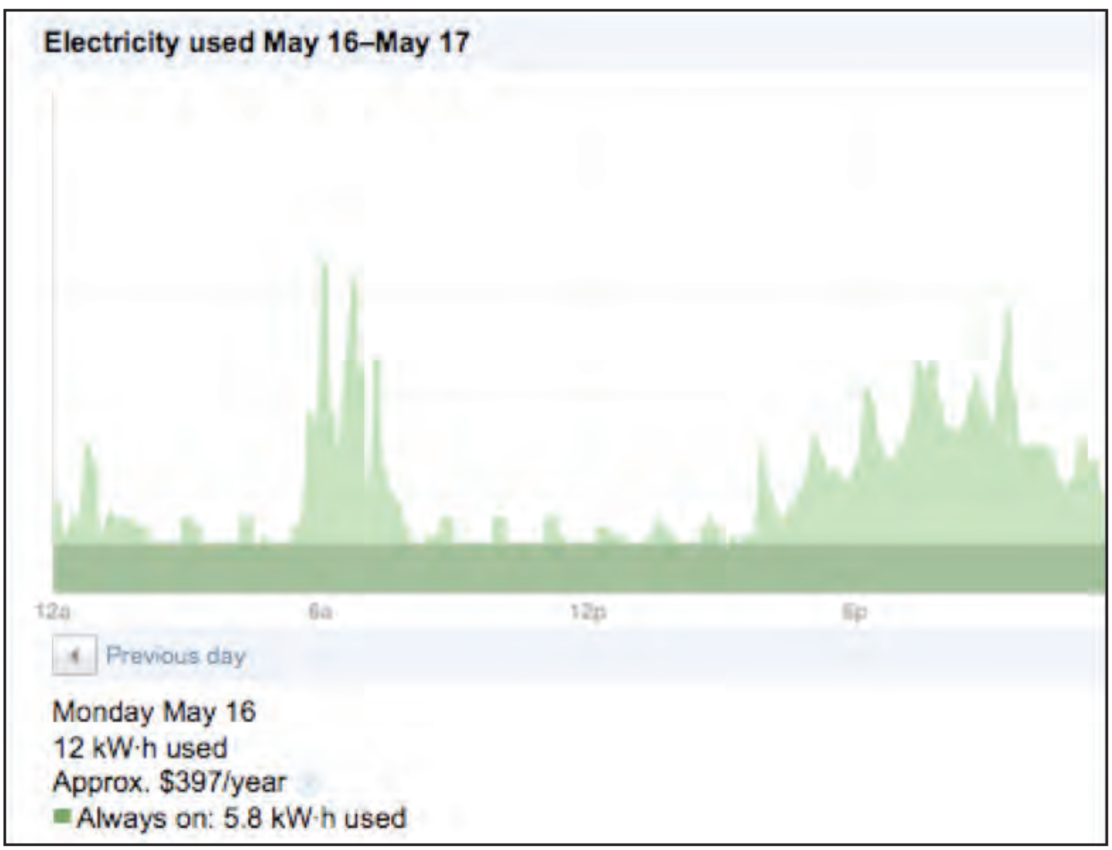
Time	Usage in kW
4:00 PM	0.432
4:10 PM	0.569
4:20 PM	0.41
4:30 PM	0.378
4:40 PM	0.376
4:50 PM	0.562
5:00 PM	0.664
5:10 PM	0.678
5:20 PM	0.594
5:30 PM	0.485
5:40 PM	0.669
5:50 PM	0.744
6:00 PM	0.425
6:10 PM	0.763
6:20 PM	1.152
6:30 PM	0.905
6:40 PM	0.553
6:50 PM	0.555
7:00 PM	0.689
7:10 PM	0.792
7:20 PM	1.031
7:30 PM	1.004
7:40 PM	0.985
7:50 PM	1.046

Time	Usage in kW
8:00 PM	0.925
8:10 PM	0.922
8:20 PM	0.897
8:30 PM	0.703
8:40 PM	0.926
8:50 PM	1.09
9:00 PM	0.865
9:10 PM	0.854
9:20 PM	1.073
9:30 PM	1.094
9:40 PM	0.522
9:50 PM	0.792
10:00 PM	0.846
10:10 PM	0.808
10:20 PM	1.244
10:30 PM	0.591
10:40 PM	0.453
10:50 PM	0.618
11:00 PM	0.786
11:10 PM	0.817
11:20 PM	0.540
11:30 PM	0.424
11:40 PM	0.345
11:50 PM	0.379

Power Meter Display

Real-Time Electricity Use Display for Addison Fox Household May 16, 2011





Graph Match Answer Key

About this activity: The "stories" require students to make some inferences and provide experiences observing and comparing what patterns are formed on the graphs when certain types of electrical devices are used. This activity is difficult for students if they do not have a sense of what types of appliances are relatively large electricity users and if they have not had experiences with cause and effect. When facilitating this activity, the focus should be on discussing the reasoning for the choices students have made. This activity can also be used as an opportunity to generate additional questions for further investigation and research about what causes different patterns of electricity use.

Notes:

____**F**__ 1. All four members of this family take turns showering. During this time a pot of coffee is brewed and a quick check of the TV news takes place before the family members dash out the door to work and school.

Why? Electricity use in this description is occurring primarily during morning hours. Graphs C, D and F are the only graphs that cover a typical morning time period. Graph D can be eliminated because the description says that the family leaves for work and school, and this graph shows that electricity is being used for a variety of things throughout the day. Even though Graph F does not show electricity use for the entire time period, the multiple spikes right around the 6 am time period would fit the coffee pot and 4 showers.

____**C**__ 2. It's another typical morning — all four family members shower, coffee is brewed, the TV news is checked, but today in addition, eggs are fried on the stove and toast is made in the toaster.

Yum!

Why? Much of the same reasoning listed in the first example can be used to narrow the possible graph choices. What makes Graph C the most likely match for this scenario is the fact that the large spike in the morning reaches almost 3 kW whereas the morning spike in Graph F reaches just past 1.5 kW. Appliances used to heat things up – in this example a toaster and stove – use a relatively large amount of electricity.

__A___ 3. After school kids watch a little TV and play video games. They start the dishwasher and hear the bread machine beginning to prepare pizza crust for tonight's dinner. After work, pizza is prepared and cooked in the oven. Even though the oven temperature is significantly lowered, it remains on to slowly cook "planets" made from salt dough for tomorrow's science class.

Why? Since the description includes activities that happened in the afternoon/evening hours, Graph F can be eliminated. One can infer that the parents and kids have been gone during the day ("After school..", "After work..) which eliminates Graphs B and D since these show electricity use throughout the day and leaves Graphs A, C and E. Graph C can be eliminated since the description says that the oven was left on throughout the evening. Although tough to distinguish differences between A and E, Graph A is a slightly better answer since a large spike, reaching over 4 kW appeared just after "after school" time, and another spike around 6 pm over 2 kW could be the oven coming on to cook the pizza.

___E__ 4. It's a typical weekday – kids are off to school, parents are at work. Dinner together at home tonight!

Why? Based on this brief description, many of the graphs are a possibility. Graphs B and D can likely be eliminated since they show use throughout the day, and Graph F doesn't show use in the evening. Graph A is missing electricity use details for the early part of the day so, though a possible choice, is probably not the best match. One could infer that "dinner together at home" means that dinner is cooked at home, making Graph E a better choice than Graph C, which shows very little electricity being used around the typical dinner hour.

__ B ___ 5. Midday house cleaning commences! The floors in the living room, dining room/kitchen, den, bathrooms, and bedrooms are all vacuumed and dusted, bathrooms cleaned, and floors washed. By early afternoon, kids are home from school and catch up on their favorite shows. No cooking tonight as there is a birthday being celebrated – the family enjoys takeout food together at home. Two loads of laundry are washed – one is dried in the dryer.

Why? Graphs B and D are reasonable matches since they both show electricity use throughout the day. While there are many electricity using activities described in both B and D, appliances such as vacuums and TVs use much less electricity than things like ovens and stovetops. The scale of Graph B ranges from 0-3 kW with the largest spike being just over 2 kW. The scale of Graph D ranges from 0-12 kW and shows spikes at times over 4, 6, 8, 10+ kW.

__ D ___ 6. There's no time to waste! The family is having guests for dinner. There are lots of preparations that need to occur. There are pies to make, homemade stuffing to prepare, vegetables and potatoes to wash and peel, casseroles to assemble, and a turkey to get ready for the roasting oven. Even though the guests aren't arriving until 5 pm, the turkey must start roasting around 2 pm. By mid morning there are enough dirty dishes to run the dishwasher, and some late risers take showers.

Why? Again, both Graph B and D are reasonable since they show electricity use throughout the day. Several clues in this description help make Graph D a better fit for the activities described here. First, a turkey roasting in the oven around 2 pm. This matches with a spike around 2 pm that reaches almost 6 kW. Dinner is scheduled to be served at just after 5 pm. Heavy electricity use indicated by large spikes (ranging from 6 kW to almost 12 kW) occur around and just before the scheduled dinner time. Spikes reaching almost 4 kW that occur around 8:30 – 9:00 am would also explain the "late risers taking showers."

Graph Match

Directions: Examine the following graphs. With a partner, talk about the story each graph tells. Discuss which graph you think matches each situation. Provide reasoning for each of your choices. What change is happening in each case?

______ **1.** All four members of this family take turns showering. During this time a pot of coffee is brewed and a quick check of the TV news takes place before the family members dash out the door to work and school.

______ **2.** It's another typical morning – all four family members shower, coffee is brewed, the TV news is checked, but today, in addition, eggs are fried on the stove and toast is made in the toaster. Yum!

______ **3.** After school kids watch a little TV and play video games. They start the dishwasher and hear the bread machine beginning to prepare pizza crust for tonight's dinner. After work, pizza is prepared and cooked in the oven. Even though the oven temperature is significantly lowered, it remains on to slowly cook "planets" made from salt dough for tomorrow's science class.

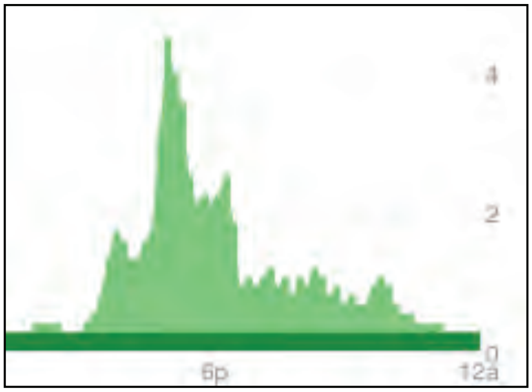
______ **4.** It's a typical weekday – kids are off to school, parents are at work. Dinner together at home tonight!

______ **5.** Midday house cleaning commences! The floors in the living room, dining room/kitchen, den, bathrooms, and bedrooms are all vacuumed and dusted, bathrooms cleaned, and floors washed. By early afternoon, kids are home from school and catch up on their favorite shows. No cooking tonight as there is a birthday being celebrated – the family enjoys takeout food together at home. Two loads of laundry are washed – one is dried in the dryer.

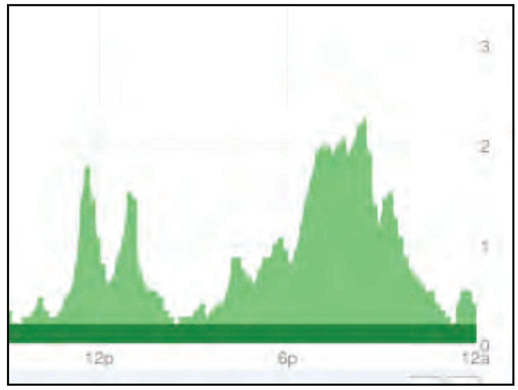
______ **6.** There's no time to waste! The family is having guests for dinner. There are lots of preparations that need to occur. There are pies to make, homemade stuffing to prepare, vegetables and potatoes to wash and peel, casseroles to assemble, and a turkey to get ready for the roasting oven. Even though the guests aren't arriving until 5 pm, the turkey must start roasting around 2 pm. By mid morning there are enough dirty dishes to run the dishwasher and some late risers take showers.

Graph Match

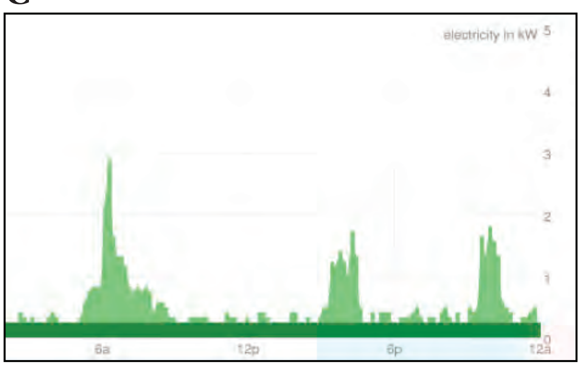
A



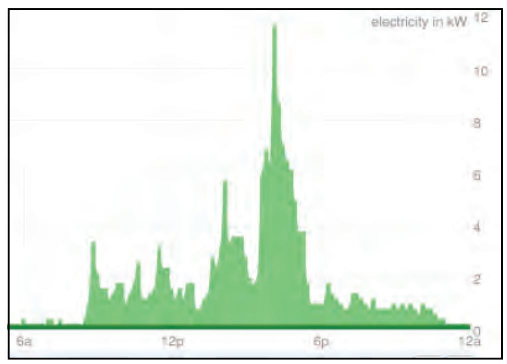
B



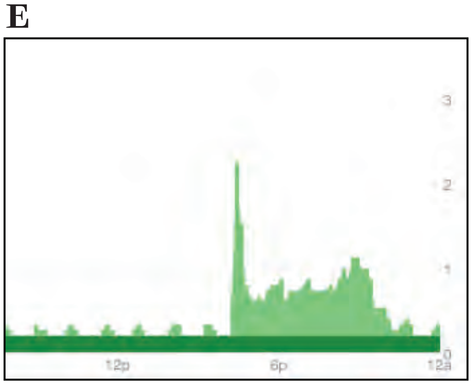
C



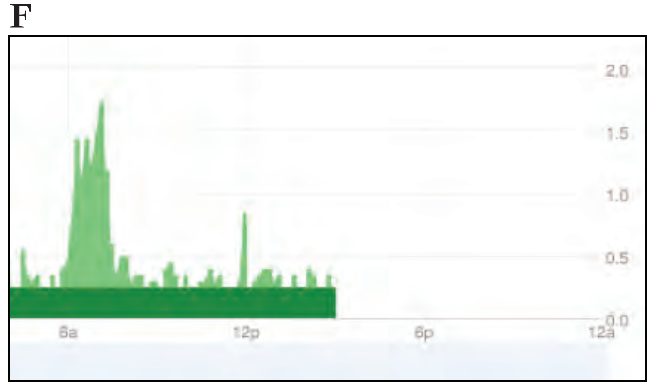
D



E



F



Developing a Graph from a Narrative *and* Developing a Narrative from a Graph Teacher Notes

About this activity set: The idea behind Developing a Graph from a Narrative is to have students read a narrative description of electricity use and sketch a graph that they think would result from the activities outlined in the narrative. Instruct students to focus on the shape of the graph and not graphing conventions.

Once students have constructed their graphs, engage them in partner and/or whole class discussions around their thinking as they developed their graphs. Ask students how they showed relatively high amounts of electricity use vs. low amounts of electricity use, constant electricity use, sharp changes in electricity use, etc.

In Developing a Narrative from a Graph, students are given a sample of a real-time electricity graph and are asked to write a scenario of electricity use that would match the display. As an alternative or as additional practice, students can trade their narratives with classmates and be asked to sketch a matching graph.

Either of these activities can be used as an assessment.

Maine Saves Energy

Developing a Graph from a Narrative

Directions: Read the narrative. Draw a graph showing electricity use throughout the day that you think would result based on the narrative. Focus on the shape of the graph, and do not be overly concerned with graphing conventions (numbers, scales, and other labels).

My mother wakes me up at 6:30 a.m. even though my alarm clock rang ten minutes earlier. The sun is already shining brightly and the temperature is quite mild already. I hop out of bed, click on my lizard's heat lamp, and toss in a few mealworms. After taking a shower, I get dressed, style my hair, and pack up my books and laptop for school. Before going downstairs to get some breakfast, I disconnect my iPod and cell phone from their chargers and tuck them into my school bag. Can't forget those!

Once downstairs in the kitchen, I toast an English muffin and pour a glass of juice. I sit down next to my mother who is drinking a cup of coffee while she catches up on the local morning news. She reminds me that I have a cross-country meet after school and asks if I've packed my uniform. After running back upstairs to my room, I remember that my jersey and shorts are probably still in the dryer, since that's where I put them last night! I hear my dad's voice calling to me from the other room; he's been sending off early morning emails to clients. "I'd better hurry up" he says "or I'll be late for the bus." As I dash out the door, my mother turns from putting her coffee mug in the dishwasher and says "Love you, have a good day, and I'll see you after work."

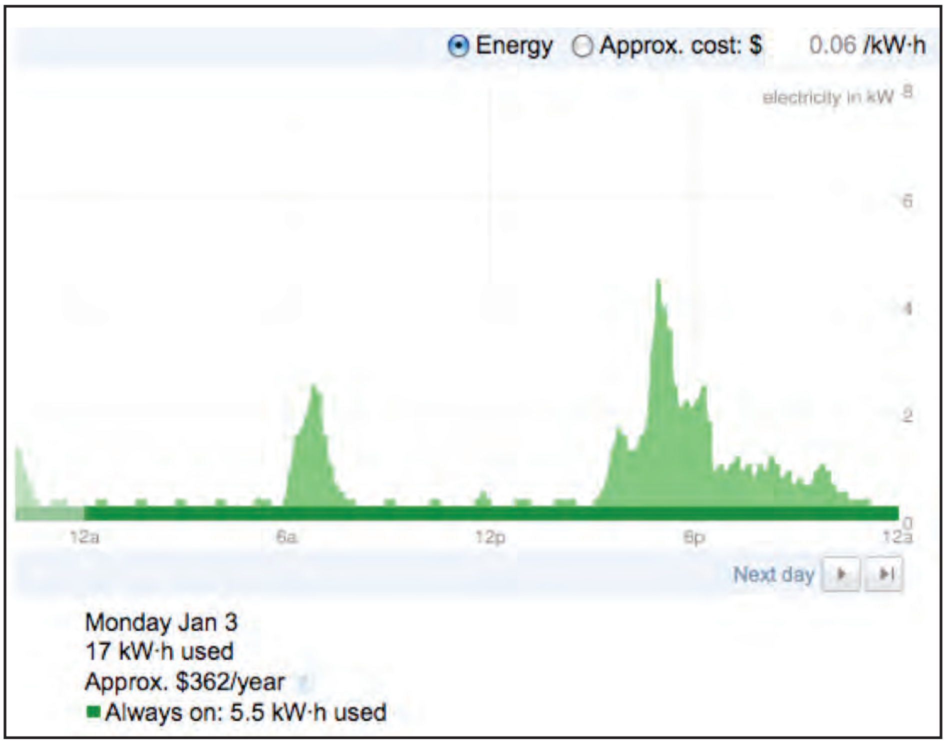
What a long day! It's 6:30 p.m. and I'm tired and hungry and I have a ton of homework! Thankfully, my parents suggest that I take my shower while they work on preparing dinner for us. As I grab a fresh towel out of the linen closet, I pass by my brother's room. I don't think he even notices I'm home! His radio is blasting, and the TV screen shows he's in the middle of a head to head race between Mario and Yoshi.

A nice long hot shower is just what this body needs after an intense and rather muddy run! The smell of garlic bread fresh out of the oven and a steamy plate of spaghetti and meatballs lures me to the dinner table. After gobbling down a satisfying meal, I place my dishes in the sink for my brother (it's his turn to load the dishwasher and wash the pots and pans) to clean up. My dad flips on the TV to take in a Red Sox game while my mother reads a book. I plop myself down at my desk, snap on the lamp, and open up my backpack. After a half hour of math homework, 20 minutes of Spanish, and 30 more minutes of reading, it is time to pack up my books for another day. Even though it is getting late, I can't help but log onto the computer to chat with friends for a while. I glance at the clock; it's 9:30 pm and definitely time to catch some z's! I head to the bathroom, brush my teeth, and wash my face. I snap off my lizard's lamp, set my alarm clock, and plug in my phone and iPod to charge.

Maine Saves Energy

Developing a Narrative from a Graph

Directions: Study the graph. Write a narrative description of what might be happening in this home with respect to electricity use. Alternatively, select a graph or a portion of a real-time electricity graph to describe.



Making a Statement Answer Key

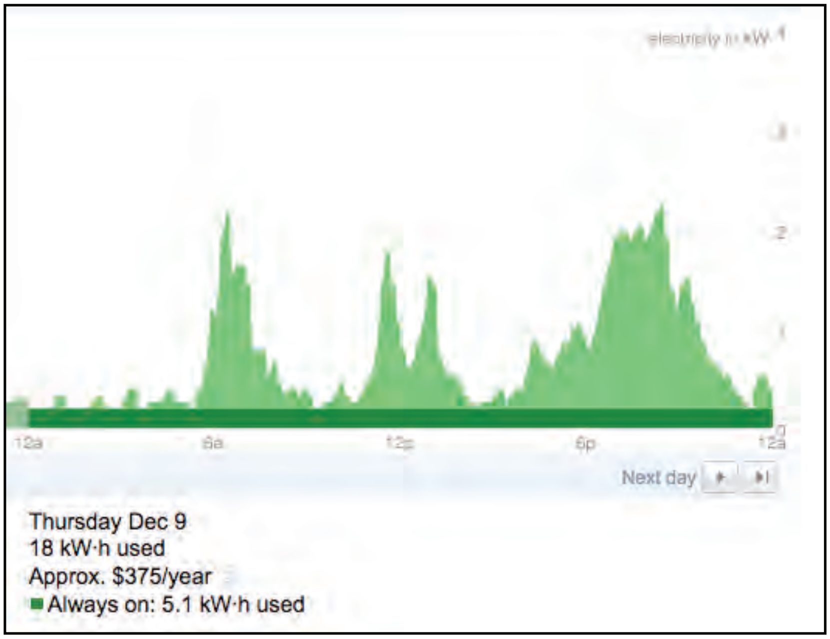
About this activity: In this activity, students are given two real-time electricity use graphs and several statements about the graph set. They are asked to discuss each statement with a partner, one at a time, to determine which statements are accurate. Students often find it challenging to differentiate between statements that can be made based on evidence found in data and statements that are made by making inferences from the data or from their own beliefs about the data. In addition to providing an opportunity for students to practice evaluating statements made about investigation data, this exercise allows students to practice linking the data to the claim made in the statement.

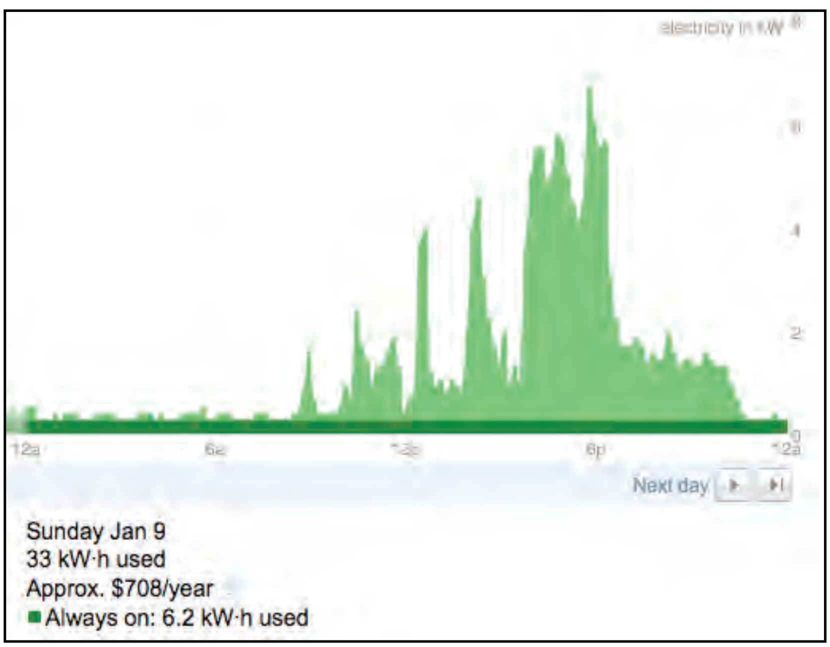
Statements 1, 4, 7, and 10 are accurate statements about the graphs. The remaining statements are ambiguous and/or would require one to make inferences or overgeneralizations.

This activity follows the Data Match strategy outlined in *Science Formative Assessment FACTS: 75 Practical Strategies for Linking Assessment, Instruction, and Learning* by Page Keeley.

Making a Statement

Directions: Examine the real-time electricity use graphs and the statements that follow. Discuss each statement with a partner. Which of these statements match the graph? Be prepared to justify your choices. The graphs are from the same household.





1. This household used 15 kWh more electricity on January 9 than on December 9.
2. More electricity is used on weekends than on weekdays.
3. More kWh were used on Sunday, January 9, because more people were at home.
4. The number of kWh used between 6 am – 9 am on December 9 is greater than on January 9 at this same time.
5. On January 9, people played video games and used computers for a longer period of time than on December 9.
6. Electricity peaks on December 9 were lower than on January 9.
7. The pattern of electricity use was more constant (had fewer peaks and sharp valleys) on December 9 than on January 9.
8. People took showers on December 9 around 11:30 a.m. and 1 p.m.
9. Electricity was not used in the home between 12 a.m. and 4 a.m. on either day.
10. Electricity usage peaked over 6 kW on January 9.

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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.

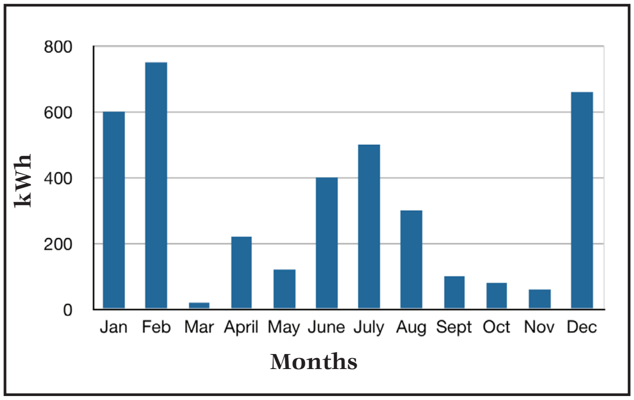
In the second activity, *Electricity Delivery Cost Rate of Change,* students calculate the rate of change using the Wishing's electricity use data. They compare the calculated change to the graph of this data (Graph B) constructed in the previous exercise. Students should recognize that the rate of change 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. 101

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?*

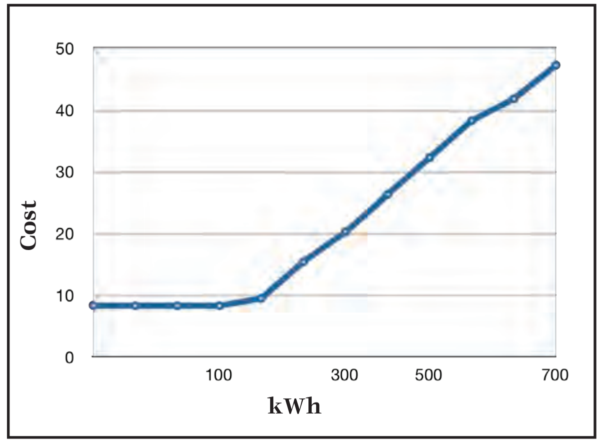
Graph A:

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.

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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.

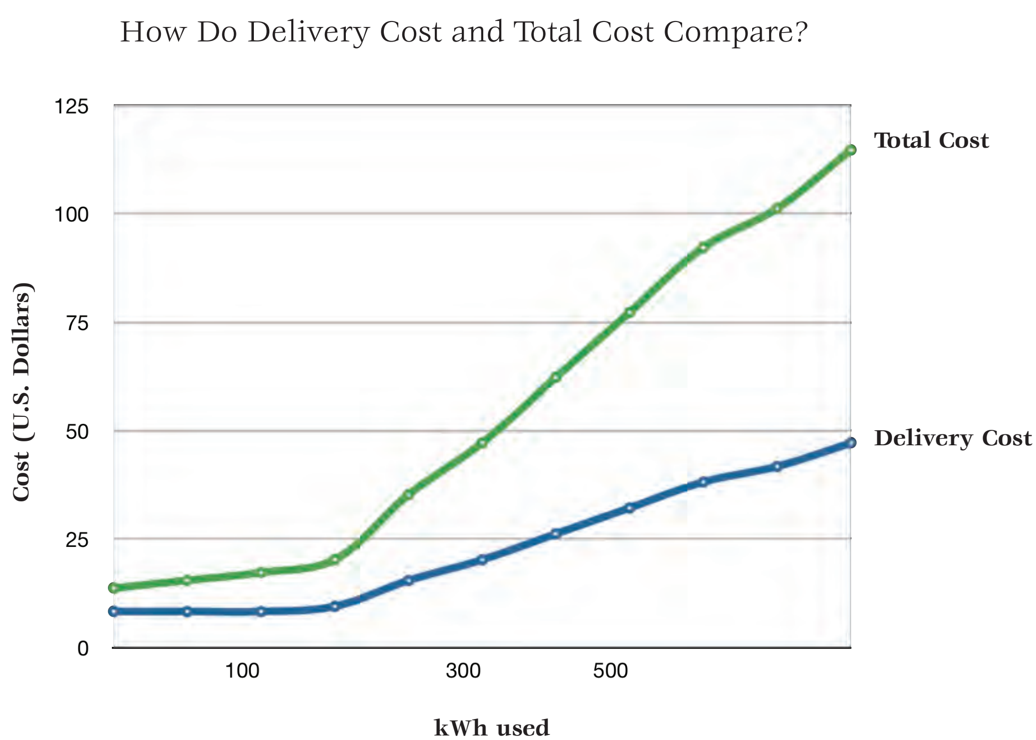
3. What does the Cost per kWh represent as far as what the family pays?
    - It represents how much the cost changes as the number of kilowatt hours the family uses increases.

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

The Wishings: Watt's a Graph Good For?

Directions: Work with a partner to complete this activity. One person will construct Graph A, the other person will construct Graph B. Discuss the questions about each graph that follow together and then individually record your responses.

Friends of the Addison Fox family, Mr. and Mrs. Wishing (they could live in Maine full-time) own a vacation house in Maine. They're interested in learning more about their electricity costs using graphs. Their electricity use and the amount they pay the electric company each month for a year for delivering their electricity is shown in the table below:

Month	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
kWh	600	750	20	220	120	400	500	300	100	80	60	660
Cost	$38.27	$47.24	$8.36	$15.54	$9.56	$26.31	$32.29	$20.32	$8.36	$8.36	$8.36	$41.86

Graph A

Using ¼ inch graph paper, construct a bar graph of ***kWh versus Month***.

1. Graph the ***Month*** on the horizontal axis.
Circle the correct adjective to complete the following sentence: We graphed ***Month*** on the horizontal axis because it is the (independent or dependent) variable.
2. Graph the ***kWh Used*** on the vertical axis.
3. Remember to scale and label each axis.
4. Remember to title the graph.
5. Construct a bar graph of the data ***kWh versus Month***.
Have your partner check your work and revise if necessary.

Graph B

Using ¼ inch graph paper, construct a line graph of ***Cost versus kWh.***

1. Graph the ***kWh Used*** on the horizontal axis.
Circle the correct adjective to complete the following sentence: We graphed ***kWh Used*** on the horizontal axis because it is the (independent or dependent) variable.
2. Graph the ***Cost*** on the vertical axis.
3. Remember to scale and label each axis.
4. Remember to title the graph.
5. Construct a line graph of the data ***Cost versus kWh***.
Have your partner check your work and revise if necessary.

Questions:
Remember; discuss each of the following questions with your partner.
Then, individually, write your own response.

1 Why were you asked to graph the kWh on the vertical axis for Graph A and on the horizontal axis for Graph B?

2 What kinds of questions can you answer using Graph A?

3 What kinds of questions can you not answer using Graph A?

4 Using Graph A, can you make a conjecture which months the Wishings were able to come to Maine?

Why do you think this?

5 Why do you think that a bar graph is a good choice of graph to display the data kWh versus Month?

6 What kinds of questions can you answer using Graph B?

7 What kinds of questions can you not answer using Graph B?

8 What can you say about the slope of the graph?
(Is it flat, increasing, decreasing, the same or changing, etc.)

9 What does this tell us about how this electric company charges its customers for delivering electricity? 111

10 Why do you think that a line graph is a good choice of graph to display the data Cost versus kWh?

The Wishings:
Electricity Delivery Cost Rate of Change

*Directions: The table below lists the **kWh Used** by the Wishings as well as the **Delivery Cost** of this electricity. Find the **Rate of Change** between each of the data points. Two have been done for you. After completing the table, answer the questions on the next page.*

kWh Used	Delivery Cost	<u>This Row's Cost – Previous Row's Cost</u> 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	<u>8.36 – 8.36</u> 60- 20	$0 per kWh	$0 per kWh
80	$8.36			
100	$8.36			
120	$9.56			
220	$15.54			
300	$20.32			
400	$26.31			
500	$32.29	<u>32.39 – 26.31</u> 500-400	$0.0598 per kWh	$0.06 per kWh
600	$38.27			
660	$41.86			
750	$47.24			

1 What can you say about the Rate of Change? (Is it always the same? Is it sometimes the same? When?)

2 How does the Rate of Change relate to the graph of this data? (Graph B)

3 What does the Cost per kWh represent as far as what the family pays?

The Wishings:
Total Cost of Electricity (Delivery + Supply)

Directions: Electricity bills typically include costs for the delivery of and costs for supplying electricity. Use the table below to calculate and record the total for the Wishings monthly electricity bills. One example is done for you.

kWh Used	Delivery Cost	Supply Cost Multiply number of kWh Used by $0.09	Total Cost Add the Delivery Cost to Supply Cost
20	$8.36	20 x .09 = $1.80	$8.36 + $1.80 = $10.16
60	$8.36		
80	$8.36		
100	$8.36		
120	$9.56		
220	$15.54		
300	$20.32		
400	$26.31		
500	$32.29		
600	$38.27		
660	$41.86		
750	$47.24		

The Wishings: Comparison of Delivery Cost and Total Cost Graphs

Directions: The table below gives the delivery cost and the total cost for electricity related to the kWh used.

1. On the same set of axes, graph the ***Delivery Cost versus kWh Used*** and the ***Total Cost versus kWh Used***. (There should be two different line graphs.)

2. Graph the ***kWh Used*** on the horizontal axis.

3. Graph the ***Cost*** on the vertical axis.

4. Remember to scale and label each axis.

5. Identify which graph is which.

kWh Used	Delivery Cost	Total Cost
20	$8.36	$10.16
60	$8.36	$13.76
80	$8.36	$15.56
100	$8.36	$17.36
120	$9.56	$20.36
220	$15.54	$35.34
300	$20.32	$47.32
400	$26.31	$62.31
500	$32.29	$77.29
600	$38.27	$92.27
660	$41.86	$101.26
750	$47.24	$114.74

Use your graphs to answer the following:

1. How are the two graphs similar?

2. How are the two graphs different?

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?

4. Even though they are called line graphs, are they really lines? Why or why not?

The Wishings:
Electricity Cost Rate versus Rate of Change

Directions: The Wishings were wondering: What is the difference between Cost per kWh Rate versus the Rate of Change in the Cost? Complete the following table to answer this question. The first two examples have already been done. After completing the table, please answer the questions on the following page.

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		
100	$17.36		
120	$20.36		
220	$35.34		
300	$47.32		
400	$62.31		
500	$77.29		
600	$92.27		
660	$101.26		
750	$114.74		

1 How does the Cost Rate (cost per kWh) change as the number of kWh increase?

2 What pattern do you see in the Rate of Change in Cost?

Why do you think this is so? (Hint: Remember how the Delivery Cost was distributed)