

*Power and Energy Lesson Guides*

# *Power and Energy in the Home*

*TCIP Educational Development*

*TCIP: Trustworthy Cyber Infrastructure for the Power Grid*



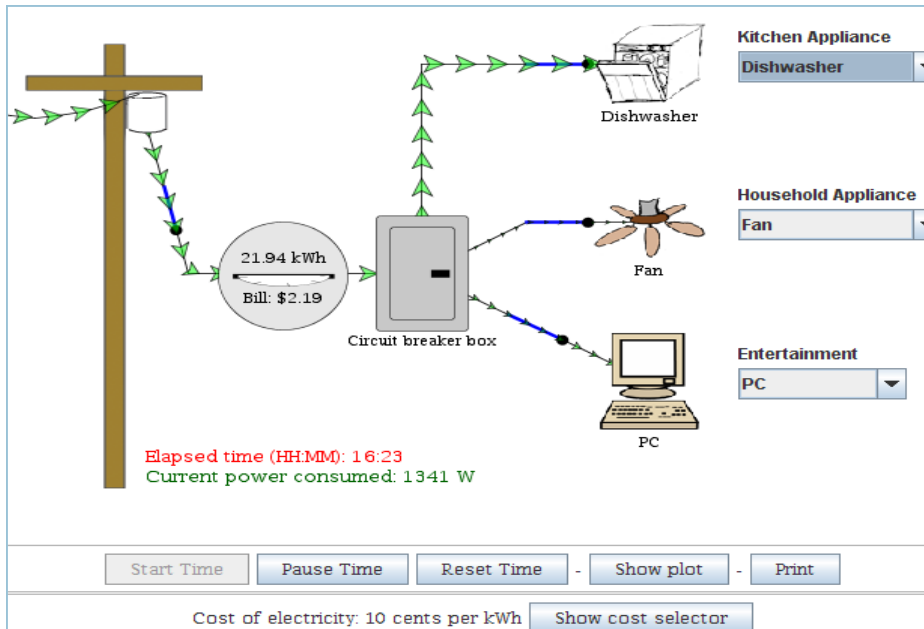
# Power and Energy in the Home

Lesson 1

Comments for  
Teachers

This lesson uses the applet at

<http://tcip.mste.uiuc.edu/applet1.html>



The applet shows power flowing through the transformer drum, the kilowatt-hour meter and into the circuit breaker panel. From the panel it powers various appliances including video game consoles, kitchen appliances, and light bulbs.

When the applet opens time is passing and the kWh meter is running. The meter shows the energy used since time started and the cost of that energy at \$.10 per kWh.

**Elapsed time** (hours and minutes) and **Current power consumed** are displayed near the bottom of the pole. Remind students that energy use and cost are determined by the amount of power used and the amount of time it's used.

The applet window can be scrolled and resized or it can be opened in its own window for better viewing.

Encourage students to explore the applet. There are blue switches to click with the mouse. Choose appliances from the drop down menus and see the flow of power increase and decrease. Use the mouse to click the blue switches near the appliances. These switches act like the circuit breaker switches in the circuit breaker panel. In your home, however, one circuit breaker switch may control the flow of electricity to an entire room of appliances. When you click open the blue switch nearest the transformer all of the power stops flowing. Students can explore various combinations of appliances with opened and closed switches and view the changes in **Current power consumed**, the meter readings and in the arrow sizes.

## More Resources

- Home Energy Saver <http://hes.lbl.gov/>
- A Consumer's Guide to Energy Efficiency and Renewable Energy [http://www.eere.energy.gov/consumer/your\\_home/appliances/index.cfm/mytopic=10040](http://www.eere.energy.gov/consumer/your_home/appliances/index.cfm/mytopic=10040)
- Energy Savers Website <http://www.eere.energy.gov/redirects/consumerinfo.html>
- Energy Information Administration's Energy Kid's Page <http://www.eia.doe.gov/kids/>



# Power and Energy in the Home

## Lesson 1

Use the applet at <http://tcip.mste.uiuc.edu/applet1.html> to explore power usage in the home. Open and close the blue switches and use the drop down menus to change the appliances. Watch how the flow of power changes. What do you see?

Electricity comes from a power plant to your home through a system of power lines, power substations, and transformers that make up the power grid.

Read about the power grid here.



Power flows through a transformer drum on a power pole into a kilowatt-hour meter. The meter measures the amount of energy going into

the home so the power company knows how much to bill the people who live there. An apartment building may have a meter for each apartment.

1. List three of these appliances that you might use for an hour or more. (1 \_\_\_\_\_ (2 \_\_\_\_\_ (3 \_\_\_\_\_
2. Set the blue switches so only the Energy Star refrigerator (E-Star Fridge) is on. What is the **Current power consumed**? (It's the green number near the bottom of the pole.) \_\_\_\_\_
3. Compare the Energy Star refrigerator with the standard refrigerator. About how much more power does the standard refrigerator use? \_\_\_\_\_
4. How much power does the plasma television use? \_\_\_\_\_
5. Which of the three video game systems uses the least power? \_\_\_\_\_
6. Energy is sold by the kilowatt hour. A kilowatt is one thousand watts. If you use the 1000 watt hair dryer for one hour, you use 1 kWh (one kilowatt hour) of energy. How much energy is used if you dry your hair for 15 minutes? \_\_\_\_\_
7. Using a 100 watt light bulb for one hour uses 0.1kWh of energy. How many kilowatt hours do you use when you leave a standard light bulb on for two hours? \_\_\_\_\_ for six hours? \_\_\_\_\_
8. If your XBOX 360 and 40" LCD TV are on for ten hours, how much energy is used? \_\_\_\_\_





# Power and Energy in the Home

Lesson 2

This lesson uses the applet at

<http://tcip.mste.uiuc.edu/applet1.html>

The applet shows power flowing through the transformer drum, the kilowatt-hour meter, the circuit breaker panel, and into various appliances. If you keep the blue switch to only one of the appliances closed, the **Current power consumed display** shows the power needed for that one appliance. If you **reset** and **start time** the meter shows the energy used and the bill. Energy use and cost depend on both the amount of power needed and the time it is used.

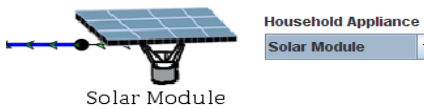
There is a solar module in the list of **household appliances**. A homeowner would typically have several (10-20 can provide a significant portion of the needed power for most

homes) modules of this size, probably on the roof of the house. In this applet the solar module is **grid-connected**. This means that the solar module is a contributor to the power needs of the household when it is needed, but if the household needs more than the solar module is producing, additional electricity is delivered

from the power utility, and if the solar module is producing more power than is needed, the excess flows into the power grid to be used by others.

Federal law requires utilities to allow this connection to the grid and also requires utilities to purchase the

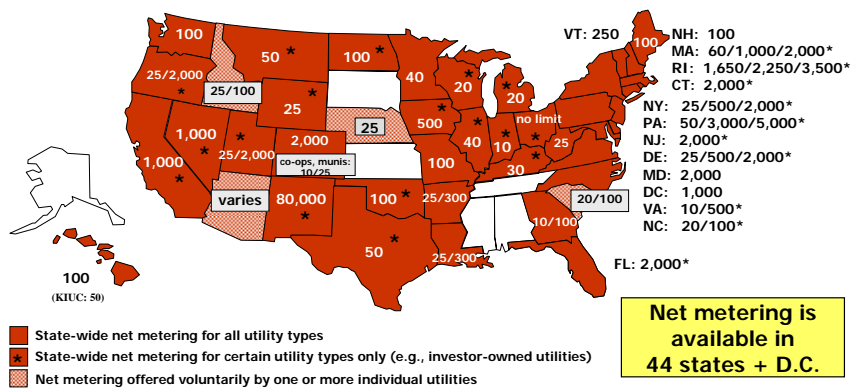
excess power. Most states have **net metering** programs that allow the meters of power customers to turn backward when the solar module (or wind turbine) is producing excess energy. The details of these arrangements vary by state and by utility company.



DSIRE: [www.dsireusa.org](http://www.dsireusa.org)

October 2008

## Net Metering



### More Resources

Information from the U.S. Department of Energy, Energy Efficiency and Renewable Energy Office

- Solar Energy <http://www1.eere.energy.gov/solar/>
- Green Power Marketing and Net Metering <http://apps3.eere.energy.gov/greenpower/markets/netmetering.shtml>
- PV Systems and Net Metering [http://www1.eere.energy.gov/solar/net\\_metering.html](http://www1.eere.energy.gov/solar/net_metering.html)



# Power and Energy in the Home

## Lesson 2

Use the applet at <http://tcip.mste.uiuc.edu/applet1.html> to explore power usage in the home. Open and close the blue switches and use the drop down menus to change the appliances. Which appliances need a lot of power?

Some appliances need a lot of power, but we don't often use them for a very long time so they don't use much energy. Other appliances may not need as much power, but they are used for more time. Energy use and cost depend on both the amount of power needed and time it's used.

1. Set the blue switches so only the toaster is on. What is the **Current power consumed**? (It's the green number near the bottom of the pole.) \_\_\_\_\_
2. Click on the **Pause Time**, **Reset Time** and then **Start Time** buttons. You should see the energy use and energy cost change on the kWh meter. You should also see the **Elapsed time** total changing at the bottom of the applet. If you use the toaster for ten minutes how much energy do you use? \_\_\_\_\_ When the cost per kWh is 10 cents per kWh, how much do you pay to use the toaster for ten minutes? \_\_\_\_\_

3. Use the applet to fill in the table.

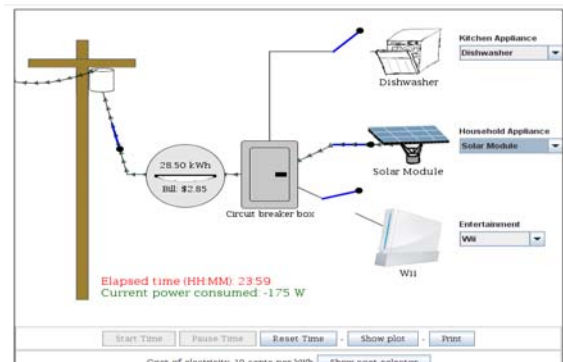
Appliance	Power needed	Time	Energy used	Bill
Microwave		15 minutes		
40" LCD TV		3 hours		
Vacuum		30 minutes		
Iron		2 hours		

4. Set the switches so only the solar module is connected. What happens?

5. Switch on the LCD TV. Now what happens?

6. Which appliances need less power than the solar module can supply?

7. If there were twenty of these solar modules producing electricity, how much power could they supply?



# Power and Energy in the Home

Lesson 3

Comments for  
Teachers

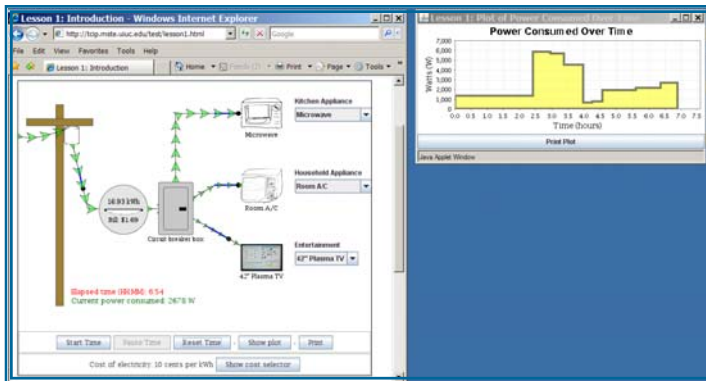
This lesson uses the applet at  
<http://tcip.mste.uiuc.edu/applet1.html>

In the applet the meter between the power pole and the circuit breaker box measures the energy being used as time passes. **Elapsed time** and **Current power consumed** are shown near the bottom of the power pole. When the applet opens, the dishwasher, ceiling fan and the personal computer are demanding a total of 1341 watts of power. After one hour the meter shows 1.35 kWh's of energy used and the bill is \$.13. The meter continues to run for 99 hours, 59 minutes unless the **Pause Time** button is clicked. When you change the appliances or open and close the blue switches, the demand for power changes and is shown in the **Current power consumed** tabulator.

If you change the appliances, the power demand will increase or decrease and the meter will adjust and spin faster or slower just like the wheel that spins in the meter at your home. The meter shows the cost of the energy at a rate of ten cents per kilowatt hour. If the only appliance you are using is a 100 watt light bulb, the cost of the energy is one cent per hour. Disconnecting the power pole stops energy usage and power demand. The meter stops but doesn't reset to zero. Time is still passing.

There are buttons at the bottom of the applet.

- Clicking **Pause Time** pauses the **Elapsed time** clock. The meter stops measuring kWh and cost because energy is only consumed as time passes.
- Clicking **Start Time** starts the meter and the **Elapsed time** clock to begin tabulating again from where they were paused.



**Power and Energy units**  
Watt—basic unit of power

Watt hour—a unit of energy; one watt of power delivered over one hour

Kilowatt—1000 watts

Kilowatt hour—one kilowatt of power delivered over one hour

Megawatt—1,000,000 watts

- Clicking **Reset Time** sets the meter and **Elapsed time** back to zero.
- The **Print** button allows you to print the applet.
- Clicking **Show plot** opens a new window showing a graph. The window can be resized or moved to a convenient place on the screen. It also has a button for printing the plot.

## More Resources

- Energy Star Products [http://www.energystar.gov/index.cfm?fuseaction=find\\_a\\_product](http://www.energystar.gov/index.cfm?fuseaction=find_a_product).
- Wisconsin Public Service Electric Appliance Calculator <http://www.wisconsinpublicservice.com/home/appcalc.asp>
- U.S. Department of Energy's educator's page <http://www.energy.gov/foreducators.htm>



# Power and Energy in the Home

Lesson 3

Use the applet at <http://tcip.mste.uiuc.edu/applet1.html> to explore power usage in the home.

Much of the electricity that we use is produced by

steam-powered turbines.

Coal or natural

gas is burned to make the steam. When we conserve energy in our homes, schools and businesses, less fuel is burned so fewer greenhouse gases are released into the air and the power company charges us for fewer kilowatt hours so we save money too.



Close some or all of the switches and then click on the **Pause Time**, **Reset Time** and then **Start Time** buttons. You should see the energy use and energy cost change on the kWh meter. You should also see the **Elapsed time** total changing at the bottom of the applet. (Click the **Pause Time**, **Reset Time** and **Start Time** buttons to start over.)

1. How does the bill change as you change appliances and open and close the various switches?

When the applet opens, the cost of the electricity is ten cents per kilowatt hour. Use the questions below to explore the applet more.

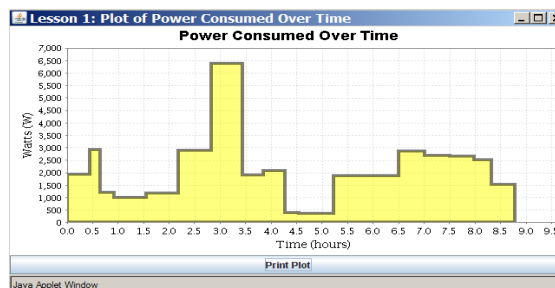
2. Turn on the incandescent light, the room A/C and the XBOX 360. What is the **Current power consumed** by these three appliances? **Reset** and **Start Time** and then keep them all on for six hours. Read the meter to find the total energy usage.

\_\_\_\_\_ What is the cost of that energy? \_\_\_\_\_

The energy calculator at <http://wattsonschoools.com/calculator.htm> shows kWh's as a variety of energy equivalents.

3. Turn on the incandescent light bulb, the Energy Star ceiling fan and the 40" LCD television. **Reset** and **Start Time** and then **Pause** the time at one hour. What is the total energy consumed? \_\_\_\_\_

4. Click on the **Show plot** button. You should see the graph of Power Consumed Over Time. Since you **Paused** time in the previous exercise, you should see a graph for 341 watts used for one hour. Change the appliances and **Start Time**. (Click **Reset Time** to start over.) How does the graph change as you change appliances and open and close the



You can move or re-size the plot window

various switches?





# Power and Energy in the Home

Lesson 3 page 2

This lesson uses the applet at <http://tcip.mste.uiuc.edu/applet1.html>

At the very bottom of the applet is the **Show cost selector** button. Clicking on this button shows a slider that allows you to change the cost of a kilowatt of electricity. The average price of electricity in the U.S. is around \$.10 per kWh. Electricity in the Midwest and Plains states is less expensive than on the coasts. The New England area has the highest rates. It's possible to open the applet portion in its own window. If you do this, you should close the original window. The windows can be moved and resized to make them easier to use on your computer.



[about CFLs >](#)

## Information about Using Compact Fluorescent Light bulbs (CFL bulbs)

- The average U. S. household spends 15% to 20% of its energy dollars on lighting.
- Incandescent bulbs produce as much as nine times more heat than light.
- CFL's produce almost no heat. They won't burn you if you touch them and they also reduce cooling costs.
- The purchase price of a CFL bulb is more, but it lasts about ten times as long as an incandescent bulb.
- CFL bulbs contain a small amount of mercury. Get the Mercury Fact Sheet from [Energy Star](http://www.energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Mercury.pdf) [http://www.energystar.gov/ia/partners/promotions/change\\_light/downloads/Fact\\_Sheet\\_Mercury.pdf](http://www.energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Mercury.pdf)
- Saving energy saves money and also reduces carbon dioxide produced by fossil fuel powered power plants.
- National Geographic has produced a video, [This Bulb](#), promoting CFL bulbs. You can see it on You Tube at <http://www.youtube.com/watch?v=dvUVXwJQcco>

## More Resources

- One billion bulbs: Changing the World one bulb at a time <http://onebillionbulbs.com/>  
This site contains a calculator that gives the energy saved by replacing incandescent bulbs with CFL's
- U. S. Department of Energy: Energy Efficiency and Renewable Energy <http://www.eere.energy.gov/>
- ENERGYSTAR@home allows the user to click on areas of the home and learn about saving energy <http://www.energystar.gov/index.cfm?fuseaction=popuptool.atHome>
- Energy Star products pages [http://www.energystar.gov/index.cfm?c=cfls.pr\\_cfls](http://www.energystar.gov/index.cfm?c=cfls.pr_cfls)
- Change a Bulb. Change Everything. [18seconds.org](http://18seconds.org)

This site tracks the number of CFL bulbs purchased in the United States since January 1, 2007. It also gives information for individual states and specific zip codes.



# Power and Energy in the Home

Use the applet at <http://www.tcip.mste.uiuc.edu/lesson1.html> to explore power usage. Click on the **Show cost selector** button. When the applet opens the cost of electricity is \$.10 per kilowatt hour. The average cost of electricity in your state may be higher or lower. Use the slider to change the cost to \$0.14 per kWh and then do the exercises.

Energy Star is a joint program of the U. S. Department of Energy and the U. S. Environmental Protection Agency. A product with an Energy Star label has met strict energy-efficiency criteria set by EPA and DOE. Energy Star promotes using energy wisely, and offers information for using less energy in every area of your home at [ENERGY STAR @ home](http://www.energystar.gov).

1. Turn on only the LCD TV and the Wii. **Reset and Start Time.** After 40 minutes turn on the standard fridge. How much energy is used when the elapsed time is one hour? \_\_\_\_\_ What is the cost of that energy? \_\_\_\_\_
2. Compare the incandescent light bulb with the fluorescent bulb. If a lamp is on for six hours, how much energy is saved by using the CFL bulb? \_\_\_\_\_ How much money? \_\_\_\_\_
3. How many light bulbs do you think there are in your home? \_\_\_\_\_ How many hours are light bulbs on per day? \_\_\_\_\_ per month? \_\_\_\_\_ How much energy could you save per month if you replaced them all with CFL bulbs? \_\_\_\_\_ How much money? \_\_\_\_\_

The U. S. Department of Energy and Disney's Ratatouille are promoting a nationwide campaign to encourage the use of CFL bulbs. <http://www.eere.energy.gov/features/>



The website [18seconds.org](http://18seconds.org) tracks the number of CFL light bulbs purchased since January 1, 2007.

4. One household can save energy and money by changing incandescent bulbs for CFL bulbs, and if many households change their light bulbs, the energy savings per month or per year is more dramatic.

A chart can help us organize the information for large numbers. Complete the chart.

"If every American home replaced just one light bulb with an ENERGY STAR qualified bulb, we would save enough energy to light more than 3 million homes for a year, more than \$600 million in annual energy costs, and prevent greenhouse gases equivalent to the emissions of more than 800,000 cars." - [www.energystar.gov](http://www.energystar.gov)

Hours of Use	Energy Consumed by One incandescent bulb (kWh)	Energy Consumed by One comparable CFL (kWh)	Energy Saved by replacing one bulb (kWh)	Energy Saved by replacing 1,000,000 bulbs (kWh)	Cost of the energy at \$0.10 per kWh (1,000,000 bulbs)	Cost of this energy at \$0.18 per kWh (1,000,000 bulbs)
1	0.1	0.033	0.067	67,000	\$6700	\$12,060
2	0.2	0.066	0.134	134,000	\$13,400	\$24,120
3	0.3	0.099				
10						
300						
3600						

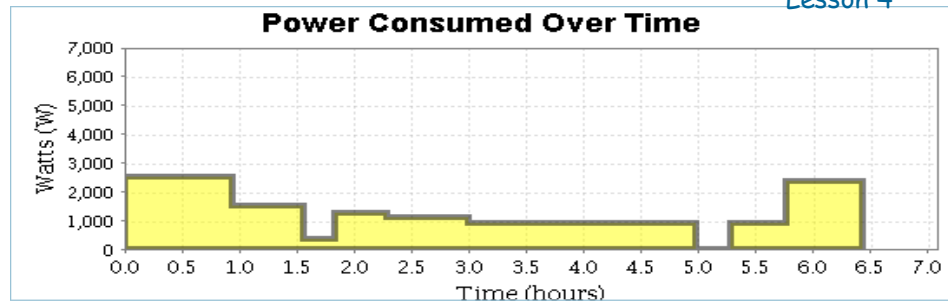


# Power and Energy in the Home

Lesson 4



Clicking the **Show plot** button at the bottom of the applet opens a graph in a new window.



The graph shows time in hours on the horizontal axis and power demand on the vertical axis. As energy is used in the applet, the amount of energy being used appears as a yellow area. As the energy use changes the area changes.

After six hours the graph resizes the horizontal axis. You can also resize the window with your mouse. Click on **Print Plot** to print just the graph.

## One possible story for the graph

At the beginning of the time, the hair dryer, the dishwasher and the plasma tv were all on. They all remained on for a little less than one hour. Then the hair dryer was turned off, but the dishwasher and the tv remained on for about a half hour. Next the dishwasher was off, leaving only the television on for approximately the next fifteen minutes. Then the standard fridge came on. About a half hour later the tv was turned off and the personal computer and the CFL were turned on for about forty-five minutes. After that only the refrigerator was on for the next two hours. Then the fridge turned off for about fifteen minutes and then came back on again. Thirty minutes later the vacuum was turned on and stayed on for about forty minutes.

The yellow area in the Power Consumed Over Time graph is the amount of energy consumed. A rectangle 1 hour wide and 1000 watts tall indicates one kilowatt hour. Find the number of kWh consumed by finding the total yellow area.

## More Resources

- Safe Electricity <http://www.safeelectricity.org/>
- This site has useful information about home energy usage. Check out the Bill Estimator with Online Usage Calculator and the Home Energy Use Guide. [http://cpi.coop/home\\_energy/](http://cpi.coop/home_energy/)
- General Electric Energy Cost Calculator - This site has a variety of calculators. <http://www.csgnetwork.com/elecenergycalcs.html>
- Official Energy Statistics from the U. S. Government <http://www.eia.doe.gov/>



# Power and Energy in the Home



After the power goes through the meter it goes through a circuit breaker panel. Inside the circuit breaker panel at the top are wires bringing power in from the transformer. There is a main circuit breaker here that can switch off all the power to the house. There are also more circuit breaker switches for each of the separate circuits for various parts of the house. The circuit breaker is a safety device. The circuit breakers can be switched off manually, but if too much current is flowing through because there is a dangerous wiring or equipment problem the breaker switches off automatically.

The graph below was produced by clicking **Show plot** and opening and closing the switches for the various appliances in the applet at

<http://tcip.mste.uiuc.edu/applet1.html>

Complete the story describing which appliances are on and for how long.

At the beginning of the time, the hair dryer, the dishwasher and the plasma tv were all on. They all remained on for a little less than one hour. Then the hair dryer was turned off

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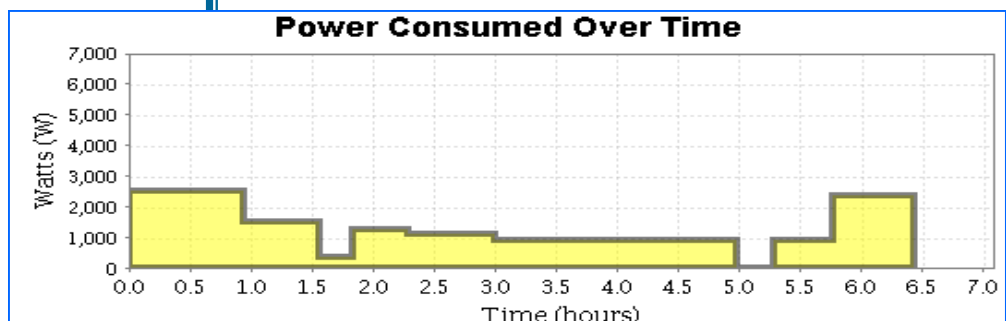
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Write your own power use story and use the applet to make a graph to illustrate it.





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These materials were developed by Jana Sebestik and Zeb Tate in consultation with George Reese and Molly Tracy

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