Solar Panels, Energy and Area Under the Curve Lesson

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Goal: Determine the total energy produced by a solar panel array over the course of a day by using the graph of power vs time (see Figure 4).

Figure 1. Solar Panels.

1. What do you know about solar power?
2. Looking at the accompanying utilities bill for electric residential service, how much electricity was used during the current month? What units are used to describe the amount of electrical energy? How much was the electrical bill for the month?
3. What are the units for power and for energy and how are they related?
4. a. If a household is using 3 kW (kilowatt) of power continuously from 1pm to 5 pm (see Figure 2), how much energy is used?
   b. What is the area = height x width under the power curve for $1 \leq t \leq 5$? Give the units for this area that you get by multiplying the units for the height by the units for the width.

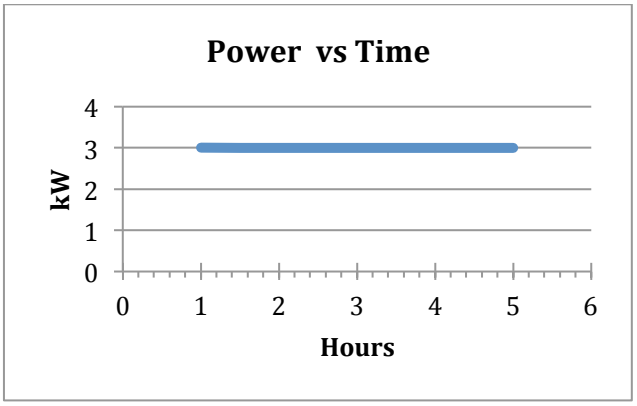

Figure 2. Energy usage with constant power.

5. a. If the household uses 2 kW of power from 1pm to 3pm, then 4 kW from 3pm to 7pm and 1 kW from 7 pm to 9 pm (see Figure 3), how much energy does it use?
   b. What is the area = height x width under the power curve for $1 \leq t \leq 9$? Give the units for this area that you get by multiplying the units for height by the units for the width.

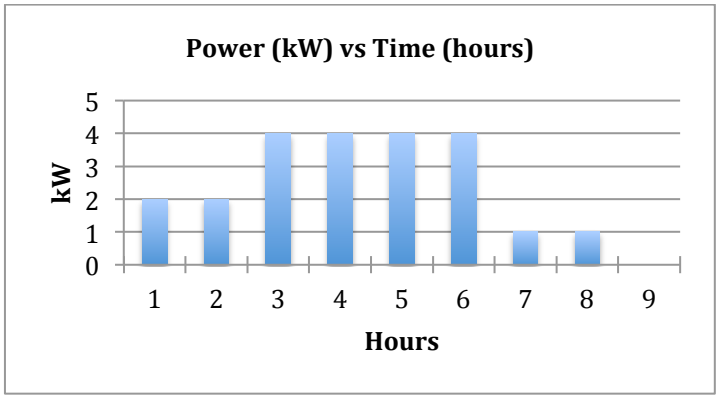

Figure 3a. Energy usage with piecewise constant power.

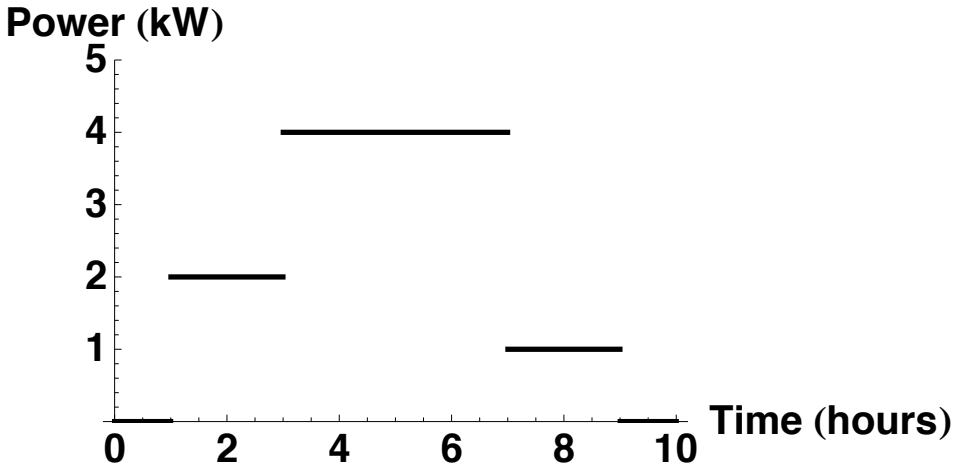

Figure 3b. Energy usage with piecewise constant power.

In Figure 4, we plot the power (kW) produced by a solar panel installation at Bryn Mawr College on January 27, 2013 as a function of time. The value of the power was recorded every 5 minutes so we have a plot of a discrete set of points rather than of a continous curve. We have plotted the data starting at 5 am and continuing until 7 pm (19 hundred hours).

6. At 9 am, how much power is being produced by the solar panels?
7. Estimate the time of sunrise and sunset on January 27, 2013 in Bryn Mawr, Pa.
8. The graph consists of values plotted at 5 minute intervals. On Figure 4, draw a continuous curve that fits the data.

9. Examine the power vs time graph generated by the solar panels (Figure 4).
   a. What is the maximum power that the solar panels generated during the day? At what time of day did that maximum occur?
   b. If the panels had been able to produce that maximum amount of power from sunup to sunset, how much energy would they have produced?
   c. Estimate how much energy the solar panels actually produced.
   d. Why are there some dips and wiggles in the graph?

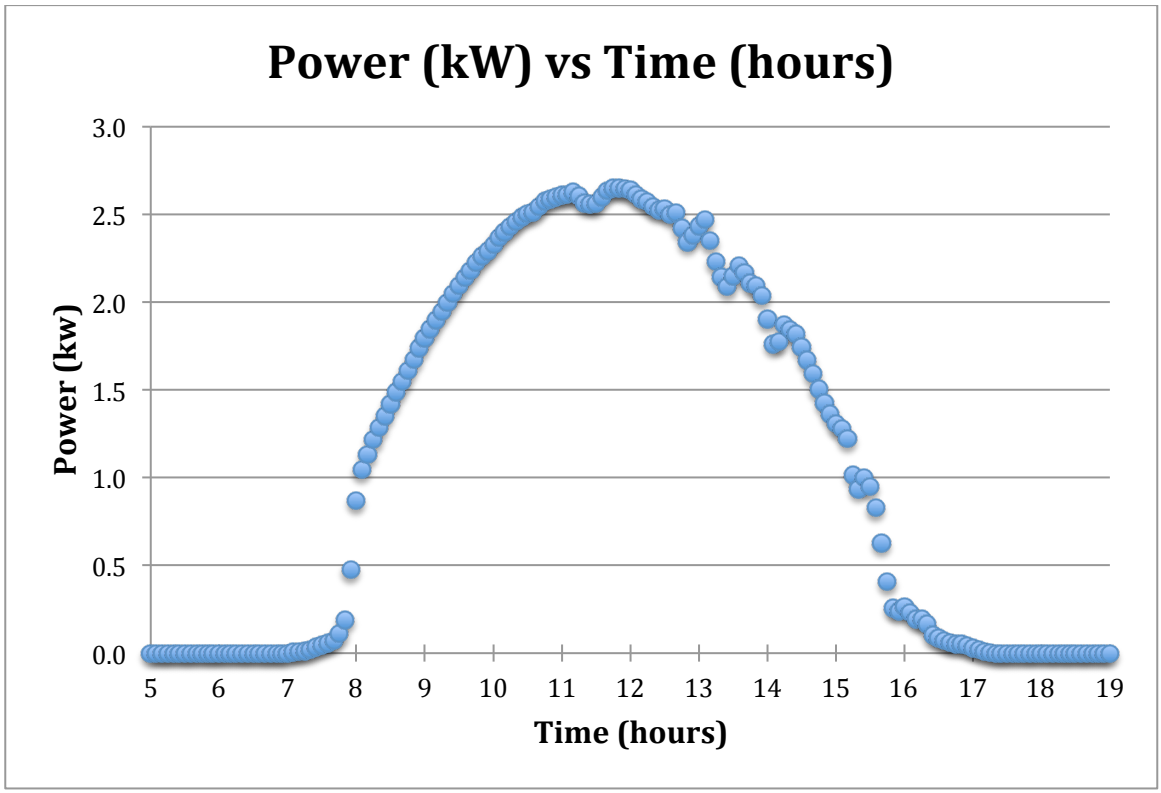

Figure 4. The power (kW) produced by a solar panel installation at Bryn Mawr College on January 27, 2013. http://sustainability.blogs.brynmawr.edu/2012/11/13/first-solar-panels/.

10. Do you think it would be "worth it" home to install solar panels at your school (or home)? What information would you need to be able to answer this question? Present your findings to the school board (or college administration).