Many homeowners now use solar panels to collect sunlight and convert it into electricity on their rooftops. This is a good idea when there are no clouds in the sky, but what happens on a cloudy day? To get some idea of whether you should consider installing a solar power system, you need to understand how much cloud cover your area typically gets during the year. Too much cloud cover and you will not be able to support your house hold electrical needs by going 'off-grid'.

For example, the plot above (courtesy Weatherspark.com) describes the cloud cover percentage over Two Harbors, Minnesota during the course of an average year. This region has a humid continental climate with warm summers and no dry season. During a typical year, we can see that the cloud cover varies from nearly 90% in the winter to below 40% during the summer. Together with the high latitude of this location, it may be difficult to operate a year-round solar power system on your roof-top. At least during the winter, you will need to go back 'on grid' to run the electrical needs of your home because only 10% of the usable sunlight is available for your electrical system.

You can investigate the cloud cover over your location and report what you see to other students and scientists by joining the S'COOL program (http://scool.larc.nasa.gov/). You can also use My NASA Data (http://mynasadata.larc.nasa.gov/live-access-server-introduction/) to download NASA cloud cover data and other Earth science resources.

There is a simple formula to predict how much sunlight reaches the ground for different amounts of cloud cover:

$$P = 990 \, (1 - 0.75F^3) \quad watts/m^2$$

where F is the fraction of sky cloud cover on a scale from 0.0 (0% no clouds) to 1.0 (100% complete coverage). Now let's see how to use this formula!

Problem 1 – For what percentage of the year are conditions considered cloudy in Two Harbors?

Problem 2 – Based upon the trend in the black line on the graph, what is the average cloud cover during the year?

Problem 3 – From the formula for solar power, for what percentage of sky cover will the homeowner get more than 50% of the maximum solar power from their electric system?

Problem 4 – On the cloud cover graph, shade in the region that represents the condition that the homeowner will get more than 50% of the available electrical power.

Problem 5 – About what percentage of the year will the homeowner be able to generate more than 50% of the available solar power?

Common Core Math Standards:

CCSS.Math.Content.6.RP.A.3c Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.

CCSS.Math.Content.8.EE.A.2 Use square root and cube root symbols to represent solutions to equations of the form $x^2 = p$ and $x^3 = p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that $\sqrt{2}$ is irrational.

More about the cloud cover formula can be found at:
http://www.shodor.org/os411/courses/_master/tools/calculators/solarrad/

The data from Two Harbors is from
http://weatherspark.com/averages/31818/Two-Harbors-Minnesota-United-States

Problem 1 – For what percentage of the year are conditions considered cloudy in Two Harbors? Answer: January, February, March and October, November and December so P = 100% x (6/12) = **50%**.

Problem 2 – Based upon the trend in the black line on the graph, what is the average cloud cover during the year? Answer: The highest is 90% and the lowest is 28% so the average of these two is **59%**. Students may also calculate the average monthly coverage (January=85%, February=75%, March=67%, April=60%, May=55% June=45% July=32% August=32% September=45% October=70% November=87% December=87%) and get **62%**.

Problem 3 – From the formula for solar power, for what percentage of sky cover will the homeowner only get 50% of the maximum solar power from their electric system? Answer: The maximum solar power occurs for F=0 and equals 990 watts/m^2. Half of this is 495 watts/m2 so we want 495 = 990(1-0.75F^3). This means that 0.50 = 0.75F^3 and so F^3 = 0.67 and so solving for F we get F = (0.67)$^{1/3}$ = 0.87. **So 87% cloud cover produces a reduction of 50% in electrical power.**

Problem 4 – On the cloud cover graph, shade in the region that represents the condition that the homeowner will get more than 50% of the available electrical power. Answer: Draw a horizontal line across the graph at '87%'. And shade in all the area below this line to indicate 'more than 50% of available power'.

Problem 5 – About what percentage of the year will the homeowner be able to generate more than 50% of the available solar power? Answer: Only three months have more than 87% cloud cover: January, November and December, so there are 9 months producing more than 50% : P = 100% (9/12) = **75%**.