

Solar as a Cost-Effective Energy Source

Environmental Study of the Sun - Mathematics

Essential Question	*Is solar energy a cost-effective energy source?*
Outcomes	Students will be able to: • match solar vocabulary words to their definitions. • graph data and find averages of kWh and costs. • calculate the amount of solar energy available at a given location and time of day on Earth. • explain how solar energy is used in sustainable applications. • determine if solar is a cost-effective energy source.
Standards Benchmarks identified in RED are priority benchmarks.	**Science Assessment Targets** **P.a.4** Sources of energy (e.g. sun, fossil fuels, nuclear) and the relationship between different sources (e.g. levels of pollution, amount of energy produced). **Content Standards** **N.3.28**. Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation. (6.NS.3) **N.4.11.** Recognize and represent proportional relationships between quantities. (7.RP.2) a. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin. (7.RP.2a) **N.6.1**. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.* (N.Q.1) **N.4.2**. Understand a rational number as a point on the number line. Extend number line diagrams and coordinate axes familiar from previous levels to represent points on the line and in the plane with negative number coordinates. (6.NS.6) **A.4.9**. Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways. For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed. (8.EE.5) [Also see 7.RP.2b] **R.3.14.** Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and

	explain how the information contributes to an understanding of the text in which it appears. (RI.4.7) **R.4.10.** Integrate information presented in different media or formats (e.g., in charts, graphs, photographs, videos, or maps) as well as in words to develop a coherent understanding of a topic or issue. (RI.6.7) **R.3.5.** Determine the main idea of a text and explain how it is supported by key details; summarize the text. (RI.4.2) **R.4.2**. Determine a theme or central idea of a text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgments. (RI/RL.6.2) **R.5.2.** Determine a theme or central idea of a text and analyze in detail its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text. (RI/RL.9-10.2) **R.3.8.** Determine the meaning of general academic and domain specific words and phrases in a text relevant to a topic or subject area. (RI.5.4) **W.3.6.** Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (W.5.7) pace. (SL.5.4) **W.3.7.** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (W.5.8) **W.4.7.** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (W/WHST.6-8.8) **W.6.3.** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (W/WHST.11-12.7)
STEM Focus	☐ **Science** ☐ **Technology** ☐ **Engineering** **X Mathematics**

TEACHERS: this content was designed for ABE/ASE students. Instructional scaffolding used in this lesson can be beneficial for multilingual students.

Because adult classrooms are multi-level, teachers will want to differentiate this HyperDoc by accommodating the different ways that students learn by using scaffolding strategies and appropriate leveled materials. Teachers will want to vary the instructional activities based on their student's needed skills.

For more information about collaborating and sharing on Google Drive, check out videos 36-45: Google Junior Training series - YouTube.

STUDENTS: Before you begin this lesson



- Go to File > Make a copy
- Change the name to: <your name> Solar Math
- Begin working in your document
- When completing an activity, make a copy of the document and save with your name and the title of the activity

Be sure to read carefully. The green text is a prompt for reflection or activity.

Engage

You may be wondering about the rising cost of your electric bill. But have you considered solar energy as a possible solution to these increasing costs? Let's find out more about solar as a cost-effective energy source.

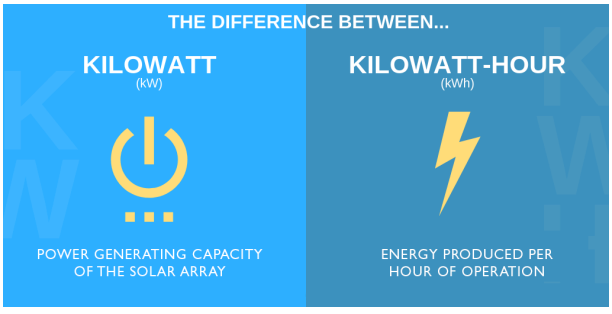
Read: ***Why Is My Electric Bill So High?***

Watch: ***Cut Your Electricity Bills by More Than Half with SOLAR*** *(15:40 min)*



Complete the vocabulary terms as you learn more about solar energy: **Math HyperDoc Vocabulary. Write out the definitions as you find them in the information you are learning. Be sure to make a copy of the document before filling in your answers.** Later in the lesson you will be matching terms and definitions.

Before looking into solar, it's helpful to understand what a kilowatt (KW) and a kilowatt-hour (kWh) are. This can be confusing and easy to mix up. The difference between KW and kWh can be explained using this analogy:
A mile is a unit of distance, mph is the measurement of distance covered over time. A kilowatt is a unit of energy, and a kWh is a measurement of energy consumed over a period of time.



Read: ***kW and kWh Explained***

Solve the Problem:

The Franks Family has provided their energy usage and costs for 2019-2021 in the **Utility Usage Costs Activity** worksheet (open and print a copy for your calculations).

1. **Find the average kWh usage per month and the average cost per month.**
2. **Find the total per year, putting each of your calculations in the yellow highlighted boxes.**
3. **Finally, create line graphs for monthly kWh and monthly costs using the data from above. Use the legend colors to represent each year.**

What observations can you make from your graphs?

Write observations in the box below:

Compare your results with the **ANSWER KEY**.



Explore

Do the benefits of solar outweigh the costs?

What are you most interested in learning? Select two questions from the list below:

- What are the initial cost considerations?
- What are the factors that affect the cost of using solar power?
- What savings can the homeowner expect to have?
- Can your house run on solar power alone?
- What should you look out for when considering solar?
- What is the long-term value of installing solar panels?

Use the Internet Resources below to search for the information to answer the three questions on your Solar Research Questions graphic organizer.

Internet Resources:

Top four benefits of installing solar panels on your home

The Cost of Solar Panels – and Are They Worth It?

The Cost of Solar Panels: Is It Worth It?

Are Solar Panels worth it in 2022?

What Do Solar Panels Cost and Are They Worth It?

Why Solar Is the Way of The Future?

Identify two additional sources from the list and write the answers you find in these sources. The spaces on the graphic organizer are particularly small, encouraging you to write notes (key phrases and words) rather than entire sentences. Later, you will use your notes to write a report using your own words or paraphrasing.

NOTE Depending on which articles you choose, you may not necessarily be able to address each of the questions



Which of the following is currently a hindrance to more widespread use of solar power?

1. Sunlight is intermittent and solar batteries are not as advanced as we would like.
2. Solar panels are expensive, partly because they are made with silicon, which is costly to produce.
3. All of the above

Both the current state of solar battery technology, and the cost of solar panels, are hindrances to more thorough harnessing of this vast, renewable source of energy.

	Source: Graphic Organizer: Research Note-Taking Made Easy https://www.educationworld.com/a_lesson/03/lp322-04.shtml	

Explain

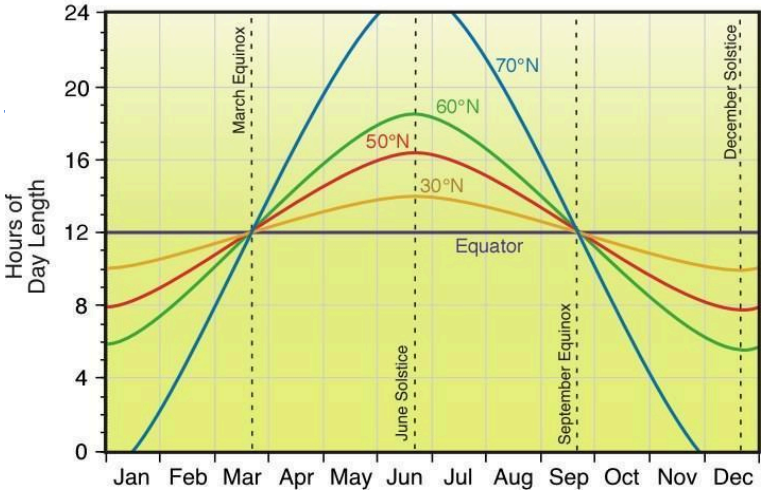
How much energy can we capture from the sun? What do you think it depends on?

Many communities have decided to use renewable energies such as solar power instead of coal, natural gas, oil, or wood.

Read the Solar Math Storyboard as you learn more about how to calculate the amount of solar energy available at a given location and time of day on Earth.

Complete the Solar Energy Estimation Worksheet. There will be an example using Boulder, CO for you to work through. Next, it will be your turn to complete the calculations for Columbus, OH. For Solar Energy Estimation Worksheet answer explanations, **refer to the ANSWER KEY.**

Review the Monthly Solar Maps, they will give you an opportunity to see the annual and each month's photovoltaic solar resources.



the NOAA Solar to calculate sunrise, solar noon, and solar any place on Earth.

Figure

Figure 1 Annual variations in day length for locations at the equator, 30, 50, 60, 70, and 70° North latitude.

The yearly changes in the position of the Earth's axis relative to the **plane of the ecliptic** also causes seasonal variations in day length to all locations outside of the

equator. Longest days occur during the **June solstice** for locations north of the equator and on the **December solstice** for locations in the Southern Hemisphere. The equator experiences day and night on every day of the year. Day and night is also of equal length for all Earth locations on the **September** and **March equinoxes**.

Source: Earth-Sun Relationships and Insolation http://www.physicalgeography.net/fundamentals/6i.html

In the box below, explain what Figure 1 is telling you about the relationship of day length throughout the year and how latitude affects these characteristics.

Check the ANSWER KEY to compare your interpretation.



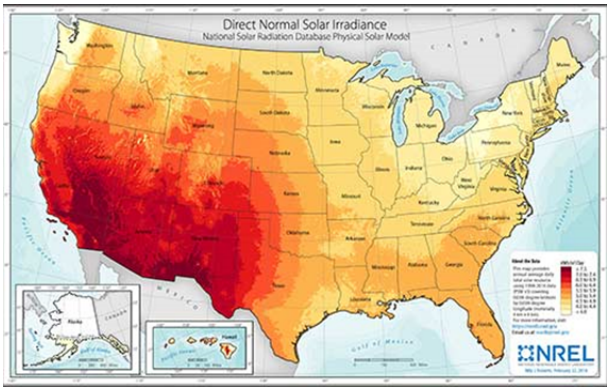
Elaborate

You choose the activity!

Choose only ONE of the three activities below to complete:

Activity 1

Click on the map to enlarge:



Sengupta, M., Y. Xie, A. Lopez, A. Habte, G. Maclaurin, and J. Shelby. 2018. "The National Solar Radiation Data Base (NSRDB)." *Renewable and Sustainable Energy Reviews* 89 (June): 51-60.

Using the Peak Sun Hours Legend, calculate the following locations:

Ohio	***hours***
Georgia	***hours***
Arizona	***hours***
New York	***hours***

Based on peak sun hours, which state would best support solar power?

Compare the four maps for each of the states listed below.
Use the infographic *How Much Does Solar Energy Cost?*

	Cost by state	Monthly savings	Savings over time	Payback period
Ohio				
Georgia				
Arizona				
New York				

Based on information from these four maps, which state would best support solar power?
Explain your reasoning in the box below:

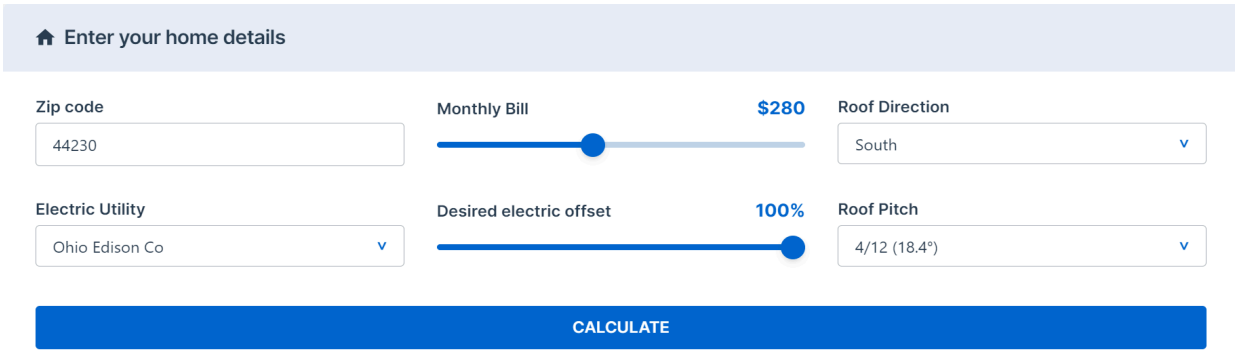
Activity 2

Solar Energy Key Takeaways:

- The average home in the U.S needs between 16 and 20 solar panels to cover its electric bills.
- Three main factors impact how many solar panels you need: your energy usage, the sunlight in your area, and the solar panels you choose.
- An average solar energy system will require between 280 and 351 square feet of roof space.
- If you have limited roof space, high-efficiency solar panels let you install fewer modules while still covering your energy needs.

Try out the Solar Panel Cost and Savings Calculator to provide you with an accurate solar savings analysis.

Here's an example:



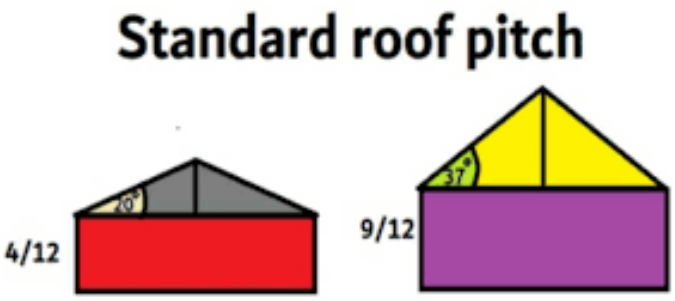
Some things to know before you get started, complete at least TWO cities for your comparison.

1. **Pick a zip code for the Toledo, Cleveland, Columbus, and Cincinnati areas using US Zip Codes**

City	Zip Code	System & Savings Details	Solar Generation & Usage
Toledo			
Cleveland			
Columbus			
Cincinnati			
<your city>			

2. **Choose an Electric Utility (Ohio Edison), Monthly Bill (use your current bill amount), Desired Electric Offset (100%), and Roof Direction (south optimal)**

3. **If you are unfamiliar with roof pitch, see the graphic below as an example; 4/12 is the most common pitch but consider your home and the steepness of the roof.**



4. **Calculate at least two cities, jot down results for the System & Savings Details section and the Solar Generation & Usage section.**

5. **Write a summary of your comparison:**

Activity 3

1. **Choose two articles about Ohio to read:**
   How Much Do Solar Panels Cost?

   Ohio Solar Panels [Cost & Installation Pricing Guide 2022]

   As Electricity Prices Increase In Ohio, Solar Energy Is A Solution

2. **Download the Quick Write**

3. **Based on your exploration of these resources, answer the question:**
   "Solar power generation is how we get energy from the Sun. Do you think that Ohio would be a good place to generate solar power? Why or why not?"
   Spend 3-5 minutes responding to the question. Share your Quick Write with one of your peers.

Collaborate



You will be working in pairs or triads to complete this activity.

Find your partners and get started using real-world data to evaluate whether solar power is a viable energy source for several cities in different parts of the U.S.

Download the Smart Solar Worksheet to examine maps and make your calculations in the fillable form. You will be asked to analyze cost and availability for solar power and then come to a conclusion about whether solar power is a good solution for these four different locations.

Make sure to have a master copy with your final answers so you can discuss your results with another group. Once you have shared your conclusions, check out the ANSWER KEY to compare findings.

The source of this material is the *TeachEngineering* digital library collection at *www.TeachEngineering.org*. All rights reserved.

Evaluate

Go to the Solar Math Terms on Quizlet.

Using your definitions from the Math HyperDoc Vocabulary, practice the terms by completing the self-study activities of Flashcards, Learn and/or **Match** options. **When you are ready, take the Test and report your score here:**

Math Vocabulary Results: _____/10

Or print the Test, answer the questions, and submit it to your teacher.

Writing Summaries

Use your completed graphic organizer Solar Research Questions from the Explore section above.

Write a summary report that includes a summary paragraph or two about each of the questions you researched. Each paragraph should include a topic sentence and at least three sentences with highlights from the graphic organizer.

Evaluation Challenge (your teacher will decide if this will be assigned)

Solve This Problem:
A small home in a temperate climate might use something like 200 kWh per month, and a larger home in the south where air conditioners account for the largest portion of home energy usage might use 2,000 kWh or more. The average U.S. home uses about 900 kWh per month. Calculate daily usage. Set up the problem and answer the question.

$\frac{900 \text{ kWh}}{30 \text{ days}}$ = 30 kWh per day

$\frac{30 \text{ kWh}}{24 \text{ hrs}}$ = 1.25 kWh

Daily usage __30__ kWh per day or __1.25__ kWh

Create a Math Problem about Solar Energy:
Using all the information you've learned about solar energy in this lesson, write a possible story problem you might find on the GED test. Remember to include the correct answer. Your teacher will collect everyone's questions and give the class a practice test.

Extend

How does solar energy measure up to other renewable energies?

The Cost of Solar Panels – and Are They Worth It?

Renewables were the world's cheapest source of energy in 2020, new report shows

Inside Clean Energy: The US's New Record in Renewables, Explained in Three Charts

100% Renewable Energy?

The Future of Renewable Energies

What Ohio technologies are effectively using solar energy?

Choosing Clean Energy in Ohio

Green Energy Ohio

City of Cleveland Going Solar

JP Morgan Chase is Betting Big on Solar

Ohio Solar Energy & Wind Power Supply Chain Businesses *see pages 14 & 15

After researching either *renewable energies* or *Ohio technologies*, choose one topic and thoroughly answer the question. Remember to introduce your writing with a topic sentence (thesis) and include at least three ideas to support your thinking in a couple paragraphs

