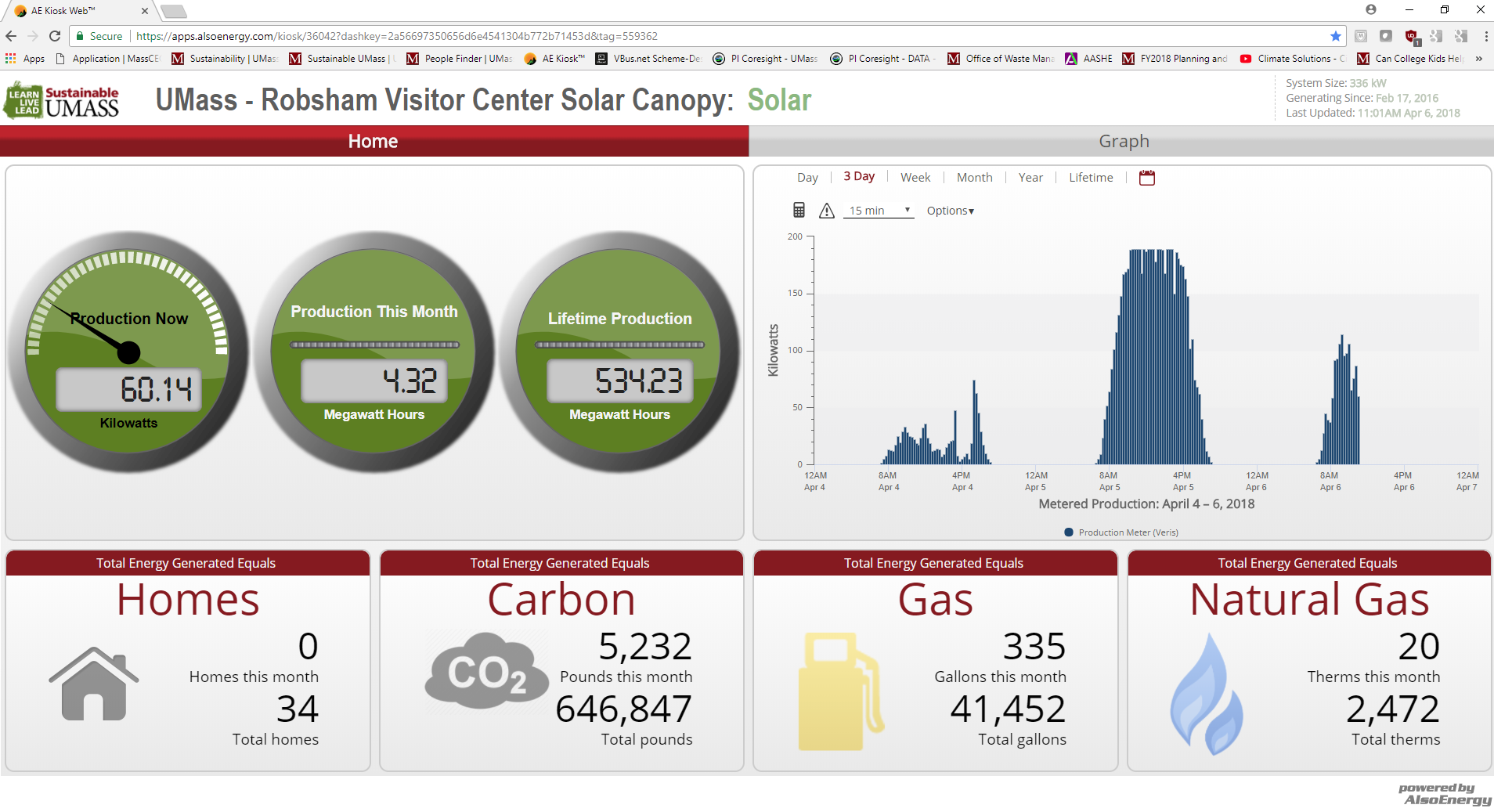
Solar Data Activity (Intended for lesson given in Computer Lab) E. Small, UMASS, 4/7/18

This activity utilizes actual solar data from UMass Amherst solar parking canopy systems as a learning tool for teaching and exploring earth systems, engineering problem solving and design, mathematical skills and patterns. Optional steps allow for the lesson to include Microsoft excel skill building which is heavily used in many STEM professions and heavily under-taught in grades 6-12 and even in college.

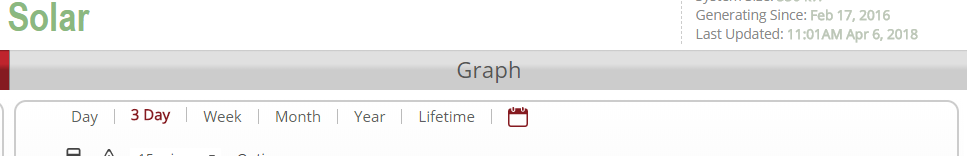
Resources Used:

1. UMass Amherst Robsham Visitor Center Solar Canopy Dashboard: <https://apps.alsoenergy.com/kiosk/36042?dashkey=2a56697350656d6e4541304b772b71453d&tag=559362>
2. U.S. Office of Energy Efficiency & Renewable Energy – Solar Radiation Basics Website: <https://www.energy.gov/eere/solar/articles/solar-radiation-basics>
3. Civic Solar Website – How Does Heat Affect Solar Panel Efficiencies?: <https://www.civicsolar.com/support/installer/articles/how-does-heat-affect-solar-panel-efficiencies>

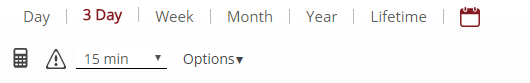
STEP 1: Use a web browser to navigate to: <https://apps.alsoenergy.com/kiosk/36042?dashkey=2a56697350656d6e4541304b772b71453d&tag=559362>.



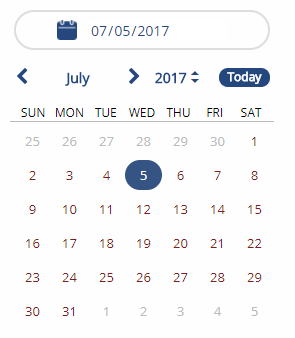
STEP 2: Click on the “graph” bar at the top right corner.



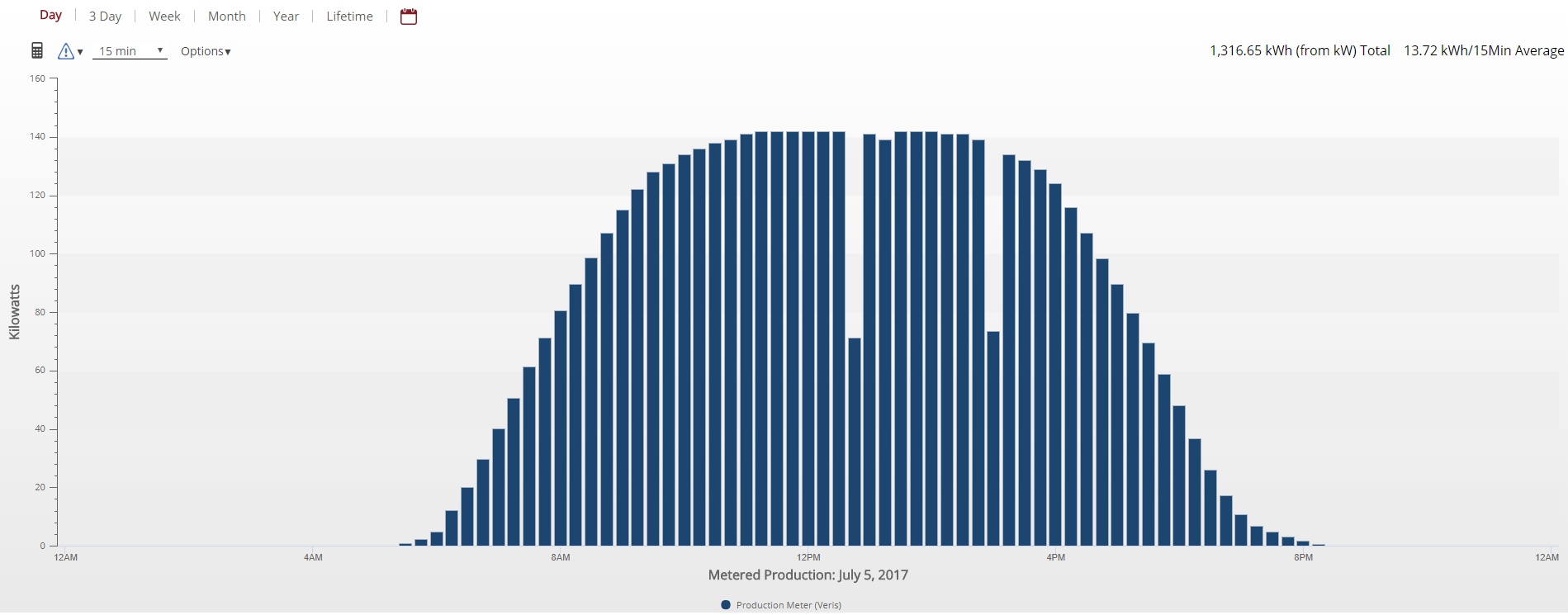
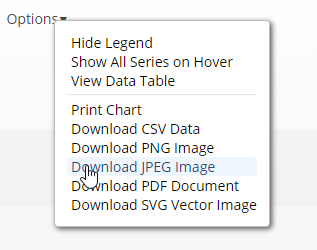
STEP 3: Use the data download tools that look like this:



STEP 4: Click on “Day”, then click on the Calendar icon and use the up/down arrow buttons to navigate to year “2017”, then use the left/right arrows to navigate the month to July and then click on the 5th of July day in the calendar…



STEP 5: You will now see the solar production meter data displayed on a 15 minute interval for Wednesday, July 5, 2017 on your screen. Click on “Options” and click “Download JPEG Image” or “Download PDF Document”

STEP 6: Open up the image or PDF file and let’s examine this…

QUESTION 1A: What mathematical concept/shape does this graph resemble?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_[[1]](#footnote-1)

QUESTION 1B: Look at the X and Y axis. What are they measuring and in what units?

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QUESTION 1C: What time interval does each blue bar represent?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

QUESTION 2: At around what time of the day do you see the “Mean” of the curve or the PEAK of the solar production?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_[[2]](#footnote-2)

QUESTION 3: Why do you think the solar production is peaking at this time?

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QUESTION 4: There are a two obvious 5 min. data points on the curve that are lower from the rest of the other points next to them. What do you think is happening here?

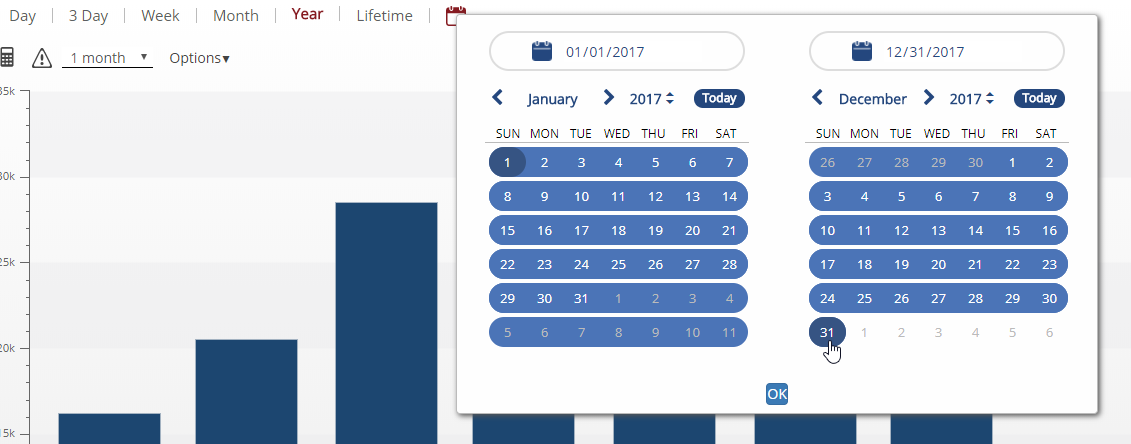
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_[[4]](#footnote-4)

QUESTION 5: On the sunniest day of the year, this system can generate almost 200 kW. Do you think this day (July 5, 2017) in Amherst, MA was good weather (sunny) or bad weather (cloudy or rainy)? What do you think think the graph would look like on a heavily clouded, overcast day?

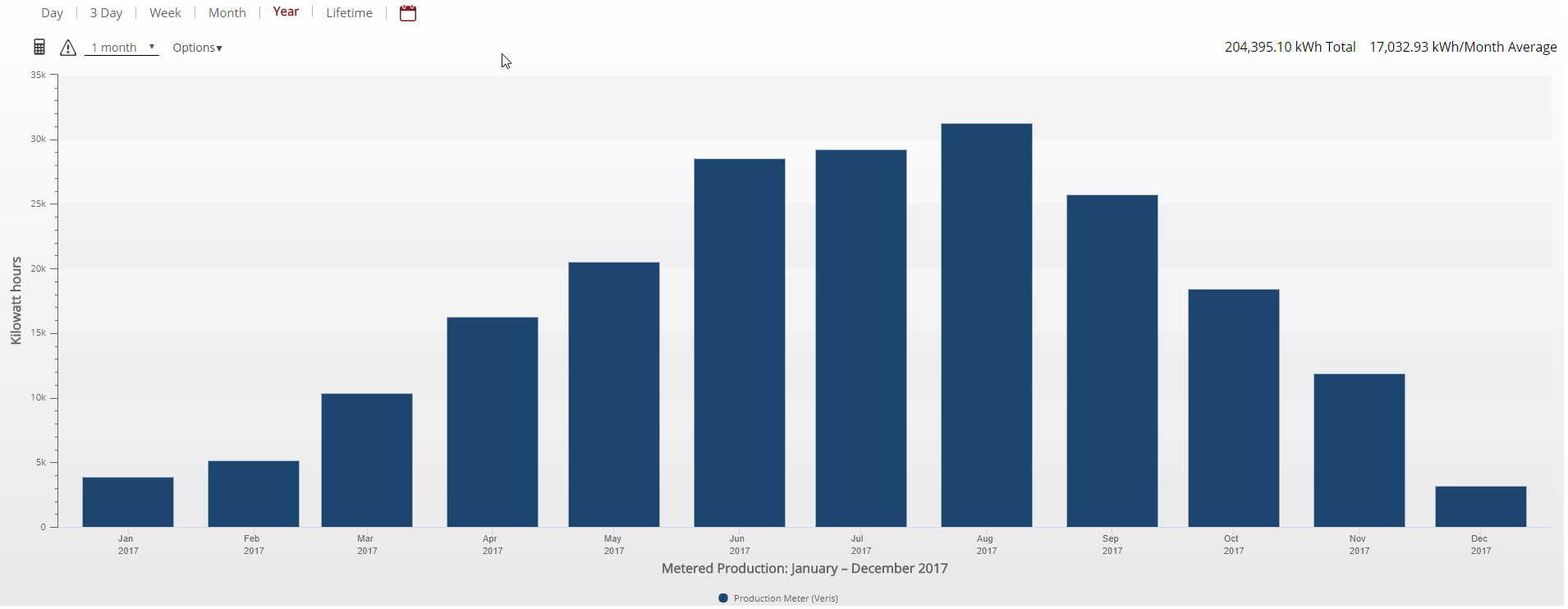
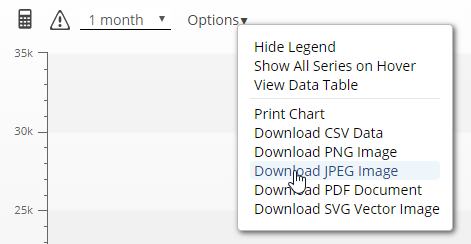
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_[[5]](#footnote-5)

Let’s go back to the dashboard in the browser and look at this data on a larger time scale!

STEP 7: Click on “Year” and then use the calendar icon to select a customized date range starting with 1/1/17 and ending with 12/31/17, click the “OK” button at the bottom of the calendar.



**STEP 8:** You will now see the solar production meter data displayed on a monthly scale for the entire calendar year of 2017 on your screen. Again, just as we did in STEP 5, select “Options” and click “Download JPEG Image” or “Download PDF Document”

STEP 9: Open up the image or PDF file and let’s examine this…

QUESTION 6: Which month in 2017 had the highest total solar production?

\_\_\_\_\_\_\_\_\_\_\_\_[[6]](#footnote-6)

QUESTION 7: Why do you think that is?

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QUESTION 8: Every location on Earth receives sunlight at least part of the year. The amount of solar radiation that reaches any one spot on the Earth’s surface varies according to:

1. Geographic location
2. Time of day
3. Season
4. Local landscape
5. Local weather[[8]](#footnote-8)

Circle all that apply?

QUESTION 9: As sunlight passes through the atmosphere, some of it is absorbed, scattered, and reflected by :

1. Air molecules
2. Water vapor and clouds
3. Dust and pollutants
4. Forest fires and volcanoes [[9]](#footnote-9)

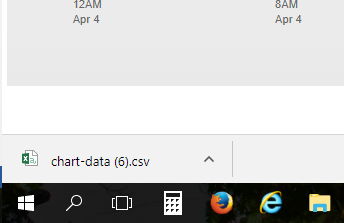
Circle all that apply?

QUESTION 10: But wait, the summer solstice was on June 21, 2017. Then why do you think June or July were not the highest solar producing months. What’s your hypothesis for why August was the highest?

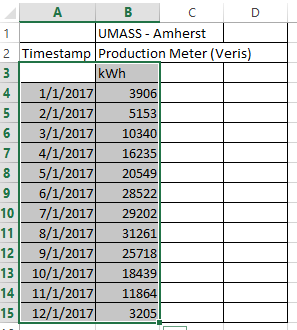
footnote-10)

**OPTIONAL ACTIVITY ADD-ONS:**

STEP 10: In the “Options” tab, rather than clicking on “Download JPEG Image” or “Download PDF Document” click on “Download CSV Data”



STEP 11: Your browser should save the data into a Microsoft Excel spreadsheet. Open up that file and have your students create their own chart by highlighting the data in the table and inserting a bar, X/Y Scatter Chart, etc..



1. QUESTION 1 ANSWER: A) Bell Curve or Normal Distribution or Normal Curve. B) Time, Solar Generation, kW. C) 15min [↑](#footnote-ref-1)
2. QUESTION 2 ANSWER: About 12 -12:15 pm (noon) [↑](#footnote-ref-2)
3. QUESTION 3 ANSWER: The Earth is round and therefore the sun strikes the surface at different angles, ranging from 0 degrees (just above the horizon) to 90 degrees (directly overhead). When the sun's rays are vertical, the Earth's surface gets all the energy possible. The more slanted the sun's rays are, the longer they travel through the atmosphere, becoming more scattered and diffuse. On a clear day, the greatest amount of solar energy reaches a solar collector around solar noon. [↑](#footnote-ref-3)
4. QUESTION 4 ANSWER: Cloud banks have rolled through in the sky and covered up the sun. [↑](#footnote-ref-4)
5. QUESTION 5 ANSWER: Very nice, sunny!!!! On a cloudy overcast day the bell curve would most likely still exist but the scale of the Y axis would be a lower number. [↑](#footnote-ref-5)
6. QUESTION 6 ANSWER: August [↑](#footnote-ref-6)
7. QUESTION 7 ANSWER: The Earth revolves around the sun in an elliptical orbit and is closer to the sun during part of the year. When the sun is nearer the Earth, the Earth's surface receives a little more solar energy. The Earth is nearer the sun when it is summer in the southern hemisphere and winter in the northern hemisphere. The 23.5° tilt in the Earth's axis of rotation is a more significant factor in determining the amount of sunlight striking the Earth at a particular location. Tilting results in longer days in the northern hemisphere from the spring (vernal) equinox to the fall (autumnal) equinox and longer days in the southern hemisphere during the other 6 months. Countries such as the United States, which lie in the middle latitudes, receive more solar energy in the summer not only because days are longer, but also because the sun is nearly overhead. *LEARNING STANDARD: 8.MS-ESS1-1b. Develop and use a model of the Earth-Sun system to explain the cyclical pattern of seasons, which includes Earth’s tilt and differential intensity of sunlight on different areas of Earth across the year.* [↑](#footnote-ref-7)
8. QUESTION 8 ANSWER: All of the Above [↑](#footnote-ref-8)
9. QUESTION 9 ANSWER: All of the Above. This is called diffuse solar radiation. The solar radiation that reaches the Earth's surface without being diffused is called direct beam solar radiation. The sum of the diffuse and direct solar radiation is called global solar radiation. Atmospheric conditions can reduce direct beam radiation by 10% on clear, dry days and by 100% during thick, cloudy days. *LEARNING STANDARD: 6.MS-PS4-1. Waves and Their Applications in Technologies for Information Transfer* [↑](#footnote-ref-9)
10. QUESTION 10 ANSWER: There could be multiple explanations for this. One could be that August is a longer month than June but not July. One could be hot temperatures in July. Excessive heat can significantly reduce the output of a PV system. It may seem counter-intuitive, but solar panel efficiency is affected negatively by temperature increases. Photovoltaic modules are tested at a temperature of 25 degrees C (STC) – about 77 degrees F., and depending on their installed location, heat can reduce output efficiency by 10-25%. As the temperature of the solar panel increases, its output current increases exponentially, while the voltage output is reduced linearly. In fact, the voltage reduction is so predictable, that it can be used to accurately measure temperature. Every PV panel has a “maximum power temperature coefficient (Pmax.)” It tells you how much power the panel will lose when the temperature rises by 1°C above 25°C. @ STC (STC is the Standard Test Condition temperature where the module’s nameplate power is determined). For example, the temperature coefficient of a Panasonic VBHN330SA16 solar panel is -.258% per 1 degree Celsius. So, for every degree above 25°C, the maximum power of the Panasonic solar panel falls by .258%, for every degree below, it increases by .258%. What this means no matter where you are, your panel may be affected by seasonal variations. *LEARNING STANDARD: 7.MS-PS3-3. Apply scientific principles of energy and heat transfer to design, construct, and test a device to minimize or maximize thermal energy transfer.*  [↑](#footnote-ref-10)