

## Good Day Sunshine!

### Student Objective

The student:

- will explain the relationship between the amount of sunlight and the power produced by a photovoltaic device
- given a graph of solar irradiance will be able to predict the performance of a photovoltaic system
- given a graph of a photovoltaic system's power output will be able to deduce what the weather was for the given days
- will be able to infer from a table of irradiation data the relative amount of sunlight in different locations at different times of the year.

### Key Words:

hypothesis  
irradiance  
irradiation  
pyronometer

### Time:

1 class period

### Materials:

- computer with internet access
- Science Journal pages

### Background Information

The performance of the school's solar photovoltaic system at any given time depends primarily on the amount of sunlight available to it. On bright, sunny days, the system gradually produces more and more energy throughout the day until the sun is directly overhead. A graph showing the energy production of the PV system over time on a sunny day will resemble a smooth, tall, bell shaped curve.

On consistently overcast days, the curve will have the same width but will be much lower, and on partly cloudy days with patched of clouds intermingled with bright sun, the curve will tend to be spiky, showing that the system produces more energy during sunny periods and less energy during cloudy periods.

### Procedure

1. If necessary, divide the students into groups according to how many computers are available to them.
2. Lead a review discussion on their findings during the *Solar Powered System* activity as it related to sun and shade.

3. Students should complete their Laboratory Manual.

### **Related Research**

1. Look up irradiation data from:
  - different latitudes worldwide
  - different climatic regions
  - different altitudes

Compare the data and determine how each parameter would affect the output of a photovoltaic array.

### **Internet Sites**

**[http://rredc.nrel.gov/solar/old\\_data/nsrdb/](http://rredc.nrel.gov/solar/old_data/nsrdb/)**

National Solar Radiation Database contains 30 years (1961-1990) of solar radiation and supplementary meteorological data from 237 NWS sites, plus a user manual to help in reading the tabular information.

**<http://sol.crest.org/solrad/data/index.html>**

Center for Renewable Energy and Sustainable Technology (CREST), solar radiation and climate data for the United States for flat plate, tracking and concentrating collectors.

**<http://wrdc-mgo.nrel.gov/>**

World Radiation Data Centre. Worldwide solar radiation site.

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**Benchmark MA.B.2.4.2** - The student solves real-world problems involving rated measures.

**Benchmark MA.B.4.4.2** - The student selects and uses appropriate instruments, technology and techniques to measure quantities in order to achieve specified degrees of accuracy in a problem situation.

**Benchmark MA.D.1.4.1** - The student describes, analyzes, and generalizes relationships, patterns, and functions using words, symbols, variables, tables, and graphs.

**Benchmark MA.E.1.4.1** - The student interprets data that has been collected, organized and displayed in charts, tables, and plots.

**Benchmark SC.B.1.4.4** - The student knows that as electrical charges oscillate, they create time-varying electric and magnetic fields that propagate away from the source as an electromagnetic wave.

**Benchmark SC.B.1.4.5** - The student knows that each source of energy presents advantages and disadvantages to its use in society.

## Good Day Sunshine!

**hypothesis** – an explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation.

**irradiance** - the measure of the power density of sunlight. Expressed in watts per square meter.

**irradiation** - the measure of the energy density of sunlight reaching an area summed over time. Usually expressed in kilowatts per square meter per day.

**pyronometer** – a device to measure the amount of solar irradiance



The irradiance data for Orlando, Florida is shown below.

**Insolation (irradiance) – kWh/m<sup>2</sup>-day – for Orlando, FL (28.55° North Latitude)**

Tilt	Jan	Feb	Mar	Apr	Ma	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
0°	3.14	3.92	4.99	5.99	6.27	5.78	5.68	5.28	4.72	4.11	3.46	2.92	4.69
15°	3.75	4.43	5.30	6.05	6.10	5.54	5.49	5.24	4.89	4.53	4.06	3.56	4.91
20°	3.92	4.56	5.36	6.01	5.99	5.41	5.37	5.18	4.90	4.63	4.23	3.74	4.94
25°	4.07	4.67	5.39	5.95	5.85	5.26	5.23	5.10	4.89	4.70	4.37	3.90	4.95
30°	4.19	4.75	5.39	5.85	5.67	5.07	5.06	4.99	4.86	4.75	4.49	4.04	4.93
35°	4.29	4.80	5.36	5.72	5.47	4.87	4.87	4.85	4.79	4.77	4.58	4.15	4.88
40°	4.37	4.82	5.31	5.56	5.24	4.63	4.66	4.69	4.71	4.76	4.64	4.24	4.80

Use the tilt angle in the table above, that is closest to your system’s tilt angle to answer questions 4 - 8..

4. According to the chart above, which month has the greatest amount of sunlight, March or August?
5. We usually think of the summer months as being the sunniest and therefore the best for photovoltaic systems. Is this a correct assumption?
6. Which month out of the year has greatest amount of sun hours?
7. Which month of the year has the least amount of sun hours?
8. Draw a line graph to show the average amount of sun hours (y-axis) for the months of the year (x-axis).

The irradiance data for Orlando and Spokane, Washington are below.

**Insolation (irradiance) – kWh/m<sup>2</sup>-day – for Orlando, FL (28.55° North Latitude)**

Tilt	Jan	Feb	Mar	Apr	Ma	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
0°	3.14	3.92	4.99	5.99	6.27	5.78	5.68	5.28	4.72	4.11	3.46	2.92	4.69
15°	3.75	4.43	5.30	6.05	6.10	5.54	5.49	5.24	4.89	4.53	4.06	3.56	4.91
20°	3.92	4.56	5.36	6.01	5.99	5.41	5.37	5.18	4.90	4.63	4.23	3.74	4.94
25°	4.07	4.67	5.39	5.95	5.85	5.26	5.23	5.10	4.89	4.70	4.37	3.90	4.95
30°	4.19	4.75	5.39	5.85	5.67	5.07	5.06	4.99	4.86	4.75	4.49	4.04	4.93
35°	4.29	4.80	5.36	5.72	5.47	4.87	4.87	4.85	4.79	4.77	4.58	4.15	4.88
40°	4.37	4.82	5.31	5.56	5.24	4.63	4.66	4.69	4.71	4.76	4.64	4.24	4.80

**Insolation – kWh/m<sup>2</sup>-day – for Spokane, WA (47.63° North Latitude)**

Tilt	Jan	Feb	Mar	Apr	Ma	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
0°	0.99	1.91	3.28	4.72	6.05	6.57	7.44	6.13	4.53	2.65	1.25	0.81	3.86
35°	1.84	2.93	4.13	5.10	5.91	6.14	7.12	6.41	5.45	3.84	2.18	1.63	4.40
40°	1.92	3.01	4.16	5.04	5.76	5.95	6.92	6.31	5.46	3.93	2.27	1.71	4.38
45°	1.99	3.08	4.17	4.97	5.59	5.73	6.69	6.18	5.44	3.99	2.34	1.78	4.34
50°	2.05	3.13	4.16	4.86	5.39	5.49	6.42	6.01	5.39	4.03	2.40	1.84	4.27
55°	2.09	3.15	4.12	4.73	5.17	5.22	6.13	5.81	5.31	4.05	2.44	1.89	4.18
60°	2.12	3.16	4.06	4.58	4.92	4.93	5.80	5.59	5.20	4.04	2.46	1.92	4.07

9. On the average, which location has the greatest amount of sun hours in July?
10. Is this what you would have expected? Why or why not?
11. What factors do you think contribute to this effect?
12. Which location has the greatest yearly average irradiance?