Good Day Sunshine!

Irradiance is the scientific term for the amount of sunshine that strikes an object. To investigate how the amount of irradiation affect the amount of electricity that your school's photovoltaic system produces, print a copy of your school's data graphs from the Energy Whiz website.

1. From the *Plane of Array Irradiance* graph, what can you say about the available sunlight on each of the three days? Describe each day below and include the advantages and disadvantages of using solar energy to provide electric energy.

2. Study the *Plane of Array Irradiance* and the *PV System DC Current* graphs. Are they similar or different? Describe below how they are similar and how they are different.

3. Use your comparison above to mathematically describe the relationship between the *Plane of Array Irradiance* and *PV System DC Current*.

Scientists have been collecting irradiance data from places all over the world since 1960. This data has been used to calculate the average amount of sunlight at these places for different times of the year. In order to make the data comparable from place to place and even out the effects of daily weather, the data is converted into an equivalent number of peak sun hours. "Peak sun hours" is defined as the number of hours that the given sun would equal when converted to 1000 watts per square meter. A very sunny day would have a value of 4 - 6 sun hours while a cloudy

day may only have the equivalence of 1 sun hour.

The irradiance data for Orlando, Florida is shown below.

Insolation (irradiance) – kWh/m^2-day – for Orlando, FL (28.55^o North Latitude)

Tilt	Jan	Feb	Mar	Apr	Ma	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
0^o	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^o	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^o	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^o	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^o	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^o	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^o	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 best matches the tilt angle of your school's PV system to answer questions 4 - 8.

4. According to the chart above, which of these two months, March or August, has the greatest amount of available or irradiated sunlight when considering all the listed tilt angles?

   How did you obtain this answer?

5. We usually think of the summer months as being the sunniest and therefore the best for photovoltaic systems. Is this a correct assumption?

   Why or why not?

6. Which month out of the year has the greatest amount of sun hours? To justify your answer, briefly explain the procedure you followed to obtain this answer.

7. Which month of the year has the least amount of sun hours?

What contributing astronomical event can be used to justify your answer?

Would someone in the southern hemisphere share this same answer? Why or why not?

8. Draw a line graph on a separate sheet of paper to show the average amount of sun hours (y-axis) for each month of the year (x-axis).

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

Insolation (irradiance) – kWh/m^2-day – for Orlando, FL (28.55^o North Latitude)

Tilt	Jan	Feb	Mar	Apr	Ma	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
0^o	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^o	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^o	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^o	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^o	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^o	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^o	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^2-day – for Spokane, WA (47.63^o North Latitude)

Tilt	Jan	Feb	Mar	Apr	Ma	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
0^o	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^o	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^o	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^o	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^o	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^o	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^o	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. Based on the data above, which city 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? How did you obtain this answer?

13. Why are the tilt angles different for the two cities listed in the data tables?

14. Looking at the big picture, supplying electricity to the U.S. using photovoltaic power plants, during what months would the Spokane plant contribute the most solar energy to the grid?

15. During what months would the Orlando plant contribute the most solar energy to the grid?

16. What tilt angle would you recommend for the Spokane solar array? Why?

Good Day Sunshine!

1. Using the output power from your school's array at 1000 w/m^2, and the insolation data from the NREL chart closest to your location, calculate how many lbs of CO_2 were not released into the atmosphere by using the electricity your SunSmart photovoltaic array produced versus the average coal fired power plant.
(Note: to calculate CO_2 emissions, use 2.3 lb CO_2 per kWh of electricity)

2. Your school decides to design a rack system for your SunSmart array that can be set at two different tilt angles to maximize the output of the system for both winter and summer conditions. For the largest increase in power, what two angles should the array be set at, and what months should the array tilt be changed?

3. What would be the average daily increase in sun hours over the course of a year for the array with the new racking system?

4. If the new racking system cost $1000. to fabricate, how long would it take for the additional savings in electricity cost to pay for the new rack? (Assume electricity at 12 cents per kWh)