PV In Schools

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PV Lesson Plan 3 – PV Array Generating Electricity

Prepared for the Oregon Million Solar Roofs Coalition

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Photovoltaics in Arrays: Solar Cells Generating Electricity Lesson Plan

Content: In this lesson, students will learn about the effects of some of the variables related to the effectiveness of Photovoltaic (PV) arrays in generating electricity.

Objectives: Students will learn to use a tool called PV WATTS to calculate the output of PV arrays as a function of local conditions. They will answer questions about the effect of various variables on electrical production and be caused to think about energy use.

Student background: It is assumed that students have completed the lesson "Solar Cells" so they have some idea about how PV's work, but a complete mastery of that lesson is not necessary. They will also need to know basic power/energy vocabulary, terms like kWh and kW, and be familiar with the ideas of angles (latitude, longitude, etc.). They should be able to plot a graph and interpret it. They will need Internet access to perform the activities.

Methodology: Have the students read the following paragraph and indicate which of the questions/activities you want them to deal with.

Activity:
So...now you understand that PV's (photovoltaics) can be arranged in various ways to make the voltage you need. How many solar cells do you need to run, say, a house: Obviously the answer will depend on how much electricity you use, your location, your latitude, local weather, the angle of tilt of your PV array (is it horizontal on a flat roof, tilted toward the average sun elevation, tracking the sun, ... ?) An interesting tool, called a PV performance calculator or **PV WATTS** has been developed which you can access via the Internet by going to http://solardat.uoregon.edu and selecting "PV performance calculator" from the menu. The PV performance calculator will help you calculate the effectiveness of a solar array. The program is easy to use; on its main page you can select “more about PV WATTS” for an explanation of which variables can be changed and “"system parameters” for detailed explanations of what the terms mean. Also on that screen “How Photovoltaics Work” are many references you can pursue for more information of that type. (The site also lists other solar data sources and contains links to related sites and lots of other cool stuff.)

Suggested Procedure:

1. Access the PV Calculator and its screens (above) to see how it works.

2. Go to the map and click on your state to run the calculator. Click on "help" for explanation of options. You can, for example, plug in your own electric rate from your electric company (EWEB, SUB, EPUD, ?) bill, your latitude, etc.... if your town isn't one of the choices.

3. Print a copy of the table of results.

Questions/Suggested Follow-up:

1. Look at the month-by-month energy column.
   (a) Plot the energy each month versus month to help you see the patterns, if any.
   (b) Do the results make sense? (For example: What month is the best for solar energy production? What would you have predicted? Why? What do you think is more important, hours of sunlight or angle of sun in the sky?)

2. Re-run the PV Calculator using a variable tilt. Do you expect the pattern to change? Did it? In what way?

3. PV arrays currently (Summer 2000) cost about $10,000 per kiloWatt (installed). The array used for the calculation above was a 4 kW array (unless you changed the default setting).
   a. How much would a 4 kW array cost?

   b. Look at the energy value you calculated for a year. How long would it take you to generate enough electricity to pay for the array?

c. Now look at the “cost of electricity” figure used in the calculation. In some parts of the U.S., in the summer of 2000, electricity costs approached 20¢/kWh. How much would the electricity you generated be worth at that rate?

d. At 20¢/kWh, how low would the cost of installing PV systems need to go to generate electricity to pay off the system in 30 years? In 20 years?

4. How much electricity does your family use in a year at home? (Or in a typical month?)
Obtain an electrical bill or copy the relevant information off your bill. Obtain the following:
Month_____
Cost/kWh_____
kWh used_____ kWh used (year)(estimate)_____

(a) Can you think of any major reasons why you can't just multiply the kWh used by 12 to estimate your yearly use figure? (That is, are some months going to show much larger /smaller than average use? Why?)

Use the figure for your home in the PV Calculator to answer the previous questions instead of using the "default' data.

(b) If you wanted to install a system that generates as much electricity as you use in your house in a year, how many kW's would you have to install? What would it cost?

(c) Your answer to (b) above is probably a pretty big number. What could you change to make it affordable? (Think about all the variables you've encountered so far.)

Further resources and follow-up:

The site used above ("PV WATTS") (http://rredc.nrel.gov/solarcodes_algs/PVWATTS/) has links to several other sites that students can use to learn more about PV arrays. Also, one could go more deeply into environmental costs of generating electricity by all means, patterns of usage by people in various countries, capital costs, etc.

Useful Web Sites:

http://www.eren.doe.gov/millionroofs/whatispv.html

http://www.sandia.gov/pv/training.htm

http://www.nrel.gov/ncpv/

http://www.fsec.ucf.edu/Ed/index.htm

http://www.nrel.gov/data/pix/searchpix.html

http://www.ascensiontech.com/RTD/ashlandrtd.html

http://www.ascensiontech.com/RTD/pge.html

http://www.ases.org/

http://www.seia.org/main.htm

For further reading:

The Solar Electric House by Steven J. Strong with William G. Scheller, Sustainability Press, Still River, Massachusetts 01467-0143, 1987.

From Space to Earth – The Story of Solar Electricity, John Perlin, aatec publications, Ann Arbor, MI 48107, 1999.