To our teachers:

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Name: *_____

Date: *____ / ____ / ____ Class Hour: *____

Center for Renewable Energy Advanced Technological Education

SOLAR LOCATION ANALYSIS: THE PV WATTS CALCULATOR

Student Activity Guide

INTRODUCTION:

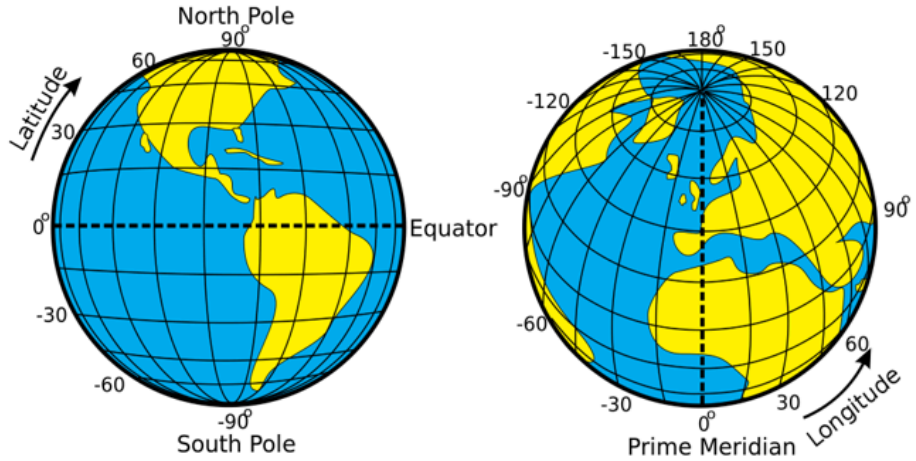
Until recently, it was difficult to make a good estimate of how much energy a solar PV system might be able to produce at a given location unless you had specialized training in solar PV technologies. However, an interactive web application developed by the National Renewable Energy Laboratory (NREL) called the PVWatts® Calculator has solved this problem. The PVWatts Calculator enables anyone with internet access and a little education to produce location-specific preliminary performance estimates for potential solar PV installations.* With PVWatts, solar installers, solar manufacturers, investors, homeowners, people who are curious, and students like you can now estimate the electricity production of a grid-connected solar PV system for many places across the globe with a few simple input prompts.

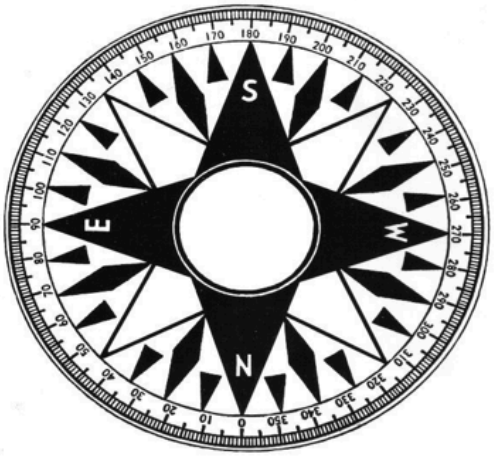
In this lesson you'll be introduced to, and then learn how to use the PVWatts Calculator. Along the way you'll become acquainted with important solar system terminology, information, economics, and production data. Using PVWatts you'll record solar PV production data from several locations and graph that data. Finally, you'll close the activity by using the graphs you made to draw important conclusions and summarize what you've learned about the science of locating a solar PV array.

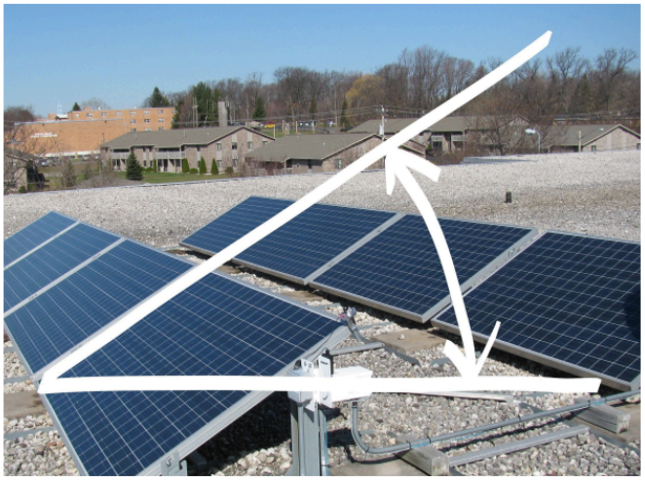
*** Important Note i**ncluded here from NREL's PVWatts Calculator website: "PVWatts® is suitable for very preliminary studies of a potential location for a photovoltaic system that uses crystalline silicon or thin film photovoltaic modules. The production estimates that PVWatts® calculates do not account for many factors that are important in the design of a photovoltaic system. If you are using PVWatts® to help design a system, you should work with a qualified professional to make final design decisions based on an assessment of the system location and using more detailed engineering design and financial analysis tools."

Part 1: Critical Definitions

Develop definitions for the following terms according to your teacher's directions. Word-process your definitions into the **Student Response Guide** for this lesson.

Definitions for:	
Latitude **Longitude** Figure 1.	

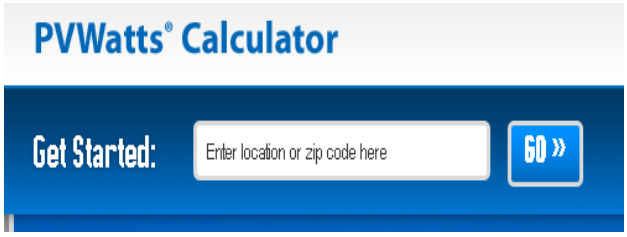
Definitions for:	
Solar azimuth **Solar altitude or solar elevation** Figure 2.	

Definition for: **Solar tilt angle** Figure 3.	

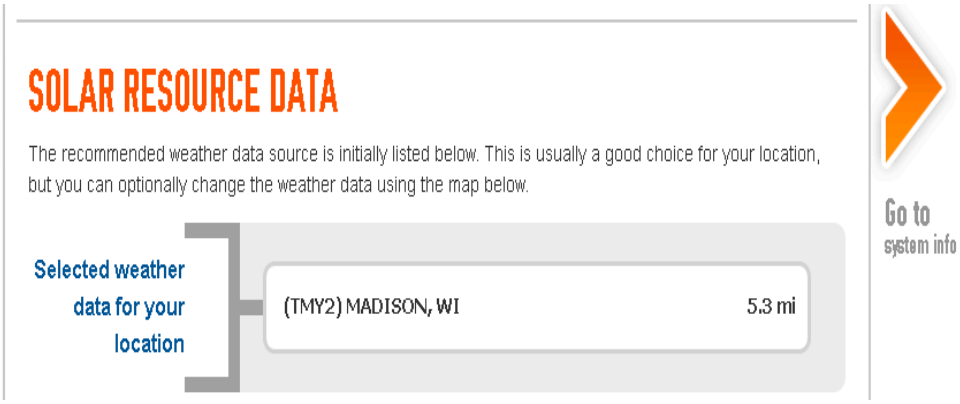
Part 2: Working With The PV Watts Calculator

1. Navigate to NREL's PVWatts Calculator: http://pvwatts.nrel.gov/

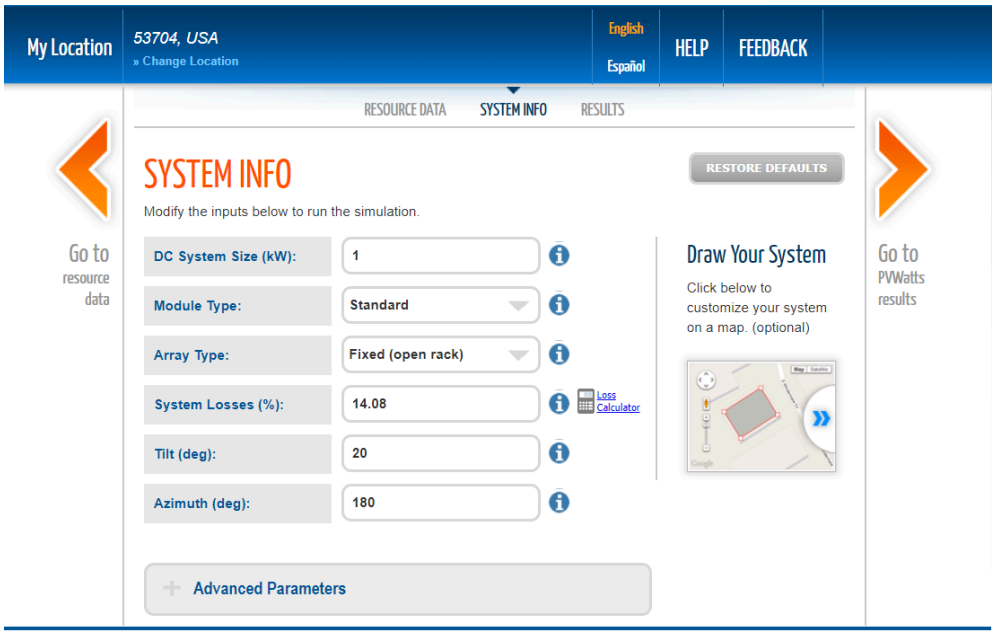
2. Enter your school's zip code in the menu bar labeled **Get Started.** Your school will be the first of three locations you'll survey. Click on **Go**.



3. Clicking on **Go** will access the solar database and weather station(s) nearest to your location. This customizes the inquiry you're making for your location. Click on the Orange Arrow on the right of the screen to **Go to system info**.

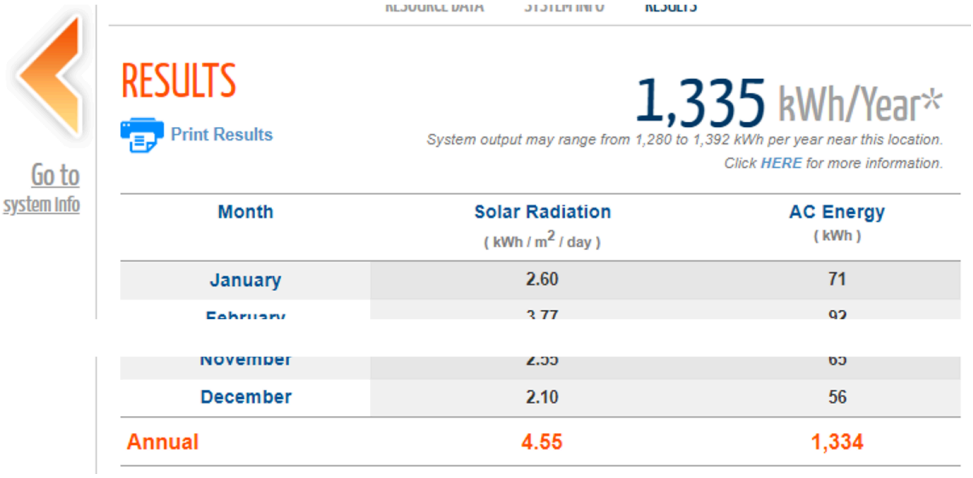


4. Input solar PV system information for your location using this data:
   - System size = 1 kW
   - Module Type = Standard
   - Array Type = Fixed (Open Rack)
   - System Losses = Retain the default value, usually around 14%
   - Tilt = 20 degrees (the default value for a 4:12 pitch roof)
   - Array Azimuth = 180 degrees (this is due south, the default value for a solar array in the northern hemisphere)



5. Click the orange arrow to the upper right of your screen to **Go to PVWatts results**.

6. Examine your **Results** and how this page is organized. You'll soon be recording Annual **AC Energy (kWh)** or **kWh/Year** information (same information) from the **Results** page into data tables provided by your teacher for this lesson.



RESULTS

Print Results

1,335 kWh/Year*

System output may range from 1,280 to 1,392 kWh per year near this location.

Click HERE for more information.

Go to system info

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	2.60	71
February	3.77	92
November	2.55	65
December	2.10	56
Annual	4.55	1,334

7. Open the **PV Watts Student Spreadsheet** for this lesson now to access the data tables available to you. You'll produce several meaningful graphs from the data you collect.

8. Click back to the **SOLAR RESOURCE DATA** page in **PV Watts**. At the top of the first table (**Location 1**) in your **PV Watts Student Spreadsheet,** enter your location, and its latitude and longitude. Next, add the Cost/kWh to your table for **Location 1**. Use the following link to connect with the United States Energy Information Administration (US eia) **US Electricity Profile** web page for the current year.

http://www.eia.gov/electricity/state/

Locate the Average retail price for electricity for your state (cents/kWh)*. Divide that number by 100 to convert it from cents/kWh to $/kWh. Enter the quotient in dollars/kWh to the table for **Location1** as your Cost/kWh.

Your **PV Watts Student Spreadsheet** is now ready to automatically generate information and graphs from data you input.

***Note:** It's important to recognize this number represents a statewide average. It will probably not be the same as your local rate. For greater accuracy, your teacher may have you use your local rate instead.

9. Click on the Orange Arrow to return to the **System Info** input page in the **PV Watts** Calculator. In the **System Info** section, you'll vary the Tilt Angle for the solar PV system at your location. Determine annual AC energy data for tilt angles of 0, 10, 20, 30, 40, 50, 60, 70, 80, and 90 degrees at a constant Azimuth of 180° (note this information in the data table for **Location 1** in your **PV Watts Student Spreadsheet**). Record the annual **AC Energy (kWh)** produced for each tilt angle in the data table for **Location 1**.

Use the orange arrows on the **System Info** and **Results** pages to systematically change the tilt angle and view the results you need to post each time to your data table.

10. After entering all of the data into your table from step 8, return to the **System Info** input page for the **PV Watts** Calculator. Set the solar array Tilt Angle back to a constant 20° for your location. You will now explore the effect of changing the solar array Azimuth on system performance. Determine annual energy data for azimuth angles of 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, and 330 degrees (note this information in the data table for **Location 1** in your **PV Watts Student Spreadsheet**). Record the annual **AC Energy (kWh)** for each azimuth. Enter data into the **Location 1** data table as before.

11. Now you'll compare a same size system in Quito, Ecuador with your location. Change the location in PVWatts to Quito, Ecuador. Use the same **System Info** as before. However, you'll have to do some internet research to find your entry for the **Average Cost of Electricity Purchased from Utility ($/kWh)**. This may require you to use an international exchange rate currency converter.

12. Collect data for Quito the same way you collected data for **Location 1** (your location) but post it in the data table for **Location 2**. Enter the necessary identifying information at the top of the table. Vary the Tilt Angle as before at a Constant Azimuth of 180°. Then vary the Azimuth as before at a Constant Tilt Angle of 20°.

13. Finally, choose another location from an area of the globe that interests you. Explore other continents, regions, climates, and countries. In the end, choose a latitude that is quite different from your location and Quito. Enter this location into PVWatts and collect solar energy data for it just as you did for your location and Quito. Record your data into the table for **Location 3**.

14. Evaluate the data you've collected to **Show What You Know!** Return to your **Student Response Guide** to answer the questions now that you are an expert with **Solar Site Analysis: The PVWatts Calculator**.