Evaluating a Site's Solar Potential   **May, 2003**

When evaluating a site's solar potential, there are several things to consider.

Major points:

1. Area large enough to support in which to mount a solar system
    a. The solar radiation only a 10 sq ft area is enough to produce between 100 and 150 watt hours per hour at peak sun. An area of roughly 100 sq ft is necessary to produce approximately 1500 kWatt hours per year.
2. A relatively clear field of view of the sun's path across the sky
    a. Trees, buildings, or a nearby chimney can significant reduce the performance of a system located to close to these objects.
    b. Consideration should be given to future construction or growth that will shade the modules.
    c. Use of sun path charts can help minimize potential shading problems.
3. Systems tilted 45° or less usually receive sufficient incident solar radiation to justify their installation as long as they are not facing too far east or west.
    a. Systems on south facing vertical surfaces typically produce about 2/3rd the power of a system optimally tilted. Tilting the surface at 75° instead of 90° will increase the power production by about 25%.
    b. Orienting a vertical surface east or west will provide only about ½ of the power of a system optimally oriented.

Other considerations:

-   The system should blend in with the architecture and/or the landscaping. This helps insure that the system will remain in place.
-   Select an area where the system could be maintained and inspected with minimal effort.
-   Choose an area that enables natural ventilation to cool the solar modules. This will improve system lifetime and performance.

Use of the sun path chart:

Once the potential locations for the solar electric system have been identified, it is important to optimize the system performance by choosing the best orientation and minimizing the degradation due to shading. The desire for optimum performance should be tempered with considerations of added costs, esthetics of the installation, and ease of maintenance.

Sun path charts are use to help optimize the system orientation while at the same time reducing shading of the modules.

The suitability of a location can be evaluated by drawing the horizon on a sun path chart. There are four steps to draw the horizon on the sun path chart.

1. First one needs to obtain a sun chart.
    a. There are two ways to obtain a sun path chart
        i. Get an Energy Trust Shade Evaluation Form
            1. From the web at: http://www.energytrust.org/
            2. Phone: (503) 493-888
        ii. From the UO Solar Radiation Monitoring Laboratory web site at: http://solardata.uoregon.edu/SunChartProgram.html

2. Next the orientation of true south must be determined
    a. With a compass find magnetic north and adjust for the difference between magnetic north and the north pole. In Oregon it is necessary to add approximately 17° to the reading on the compass to get the true azimuthal orientation.
    b. A more precise determination of the magnetic declination can be found at http://www.ngdc.noaa.gov/cgi-bin/seg/gmag/fldsnth1.pl
    c. Most maps contain information on the direction of true north and it is possible to approximately determine the alignment of a nearby street with north on the map and the orientation of the building to the street.

3. Next, stand in the middle of the potential location for the array.
    a. Use a Solar Path Finder™ or a Solar Site Selector™ to determine the horizon
    b. With a compass determine the azimuth of obstructions. Using a clinometer or a protractor, determine the angular height of the obstructions. Also note the width of the objects and the height of the horizon at the base of the obstruction.
        i. Obstructions can be buildings, trees, power poles, hill tops, or another other object that can potentially be in the path of the sun as it crosses the sky.

4. Draw the horizon in the sun path chart on the Energy Trust's shade evaluation form.

If there is significant shading, it is helpful to draw sun path charts at other potential locations for the array and determine which area offers a minimum in shading. It might be possible to move along the line of the roof to move to a area where the object cast as large a shadow on the array. Another alternative is to rotate the array away from the obstruction to minimize the shading.

Choosing the appropriate Energy Trust Shade Evaluation Form:

Currently the Energy Trust only has shade evaluation forms for Medford, Pendleton, Portland and Redmond. For areas outside these locations, Fig. 1 can help in choosing the appropriate form.

- In the areas around Portland, the Willamette Valley, or other areas shaded blue, select the form for Portland
- In northeastern Oregon, areas along the Columbia gorge from Hood River east, or the northern green shaded areas, select the Pendleton form
- For those in eastern Oregon in the pea green or yellow areas, select the Redmond form.
- For those in southwestern Oregon in the green shaded area, select the Medford form.
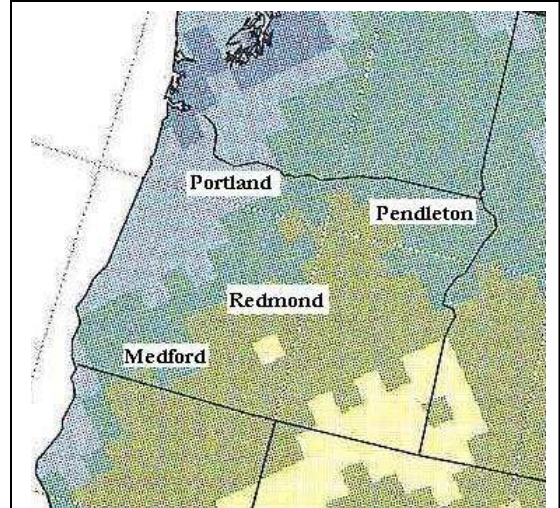

Fig. 1: Locations for which shade forms are available on top of a solar resource map of Oregon. Southeast Oregon has the highest resource while northwest has the least.

Once the form with similar solar resource is selected, it is important to select the form for the appropriate tilt and orientation.

The right column of Table 1 gives the range of tilts and the top row gives the range of orientations. If the collector is tilted 33° and has an orientation of 215° (south-west), the appropriate form would be 22.5°, 180° form.

A more appropriate estimate of the annual system performance for the given tilt and orientation can be obtain using PVWatt at http://rredc.nrel.gov/solar/codes_algs/PVWATTS/.

Table 1: Determining the right chart to use for analysis.

Tilt \ Orientation	75° - 105°	105° - 140°	140° - 220°	220° - 255°	255° - 285°
0° - 10°	0°, 90°	0°, 120°	0°, 180°	0°, 240°	0°, 270°
10° - 35°	22.5°, 90°	22.5°, 120°	22.5°, 180°	22.5°, 240°	22.5°, 270°
35° - 60°	45°, 90°	45°, 120°	45°, 180°	45°, 240°	45°, 270°
60° - 85°	75°, 90°	75°, 120°	75°, 180°	75°, 240°	75°, 270°
85° - 90°	90°, 90°	90°, 120°	90°, 180°	90°, 240°	90°, 270°

Select the tilt range in the first column that is most appropriate for the array and go across to the orientation range appropriate for the array. The values in the box identify the shading effect form to use for the analysis.

Filling out the shade evaluation form:

In the top right hand corner fill in:
- Job Name
- Contractor
- Array Tilt
- Array Orientation (the direction the array is facing)
- Zip Code of site:
  - This information can be used to obtain a sun path chart on the UO web page at http://solardata.uoregon.edu/SunChartProgram.html on the day of the evaluation.
    - Enter zip code
    - Enter year month and day of evaluation
    - Click local standard time
    - Then go to step 7 and click on the create chart button
  - On a clear period this chart can be used to check the orientation of the system if there are problems with a compass reading.
    - During daylight savings time subtract one hour to get local standard time
    - Estimate the fraction of the hour from the nearest hour and mark that on the sun path on the chart. Then go down to the Solar Azimuth axis and see where the azimuth of the sun at that time.
    - Have the compass point at the sun with that azimuth reading and then deter the direction of due south (180°). This is a quick check on a compass' determination of due south.

- Draw in Horizon line on the Sun Path Chart.
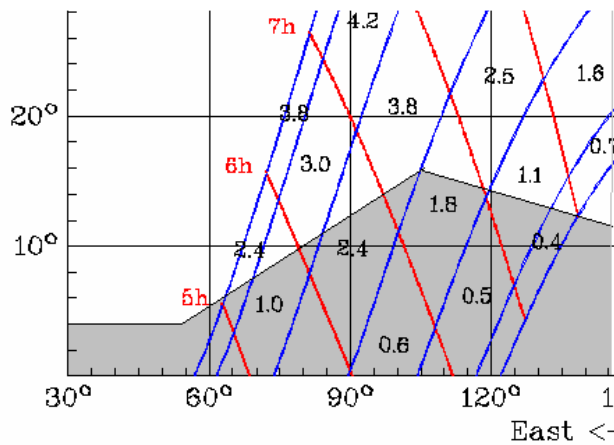 - Lightly shade area under horizon line (See Fig. 2.)

Fig. 2: Example of shading for an east facing vertical surface.

- Fill in table under sun path chart
  - Table 2 is an example using the shading in Fig. 2.

Table 2: Sample calculation of shading. Annual shading is 6.7%

Period\Hr	5-6	6-7	7-8	8-9	9-10	10-11
May-Jun	2.4*(1/4)=.6	0	0	0	0	0
Apr-May	1.0*(.7)=.7	3.0*(.1)= .3	0	0	0	0
Mar-Apr	0	2.4*(2/3)=1.6	3.8*(.1)=.4	0	0	0
Feb-Mar		.6*(1)=.6	1.8*(.7)=1.3	0	0	0
Jan-Feb		0	.5*(1)=.5	1.1*(1/3)=.4	0	0
Dec-Jan			0	.4*(.8)=.3	0	0
Sum of Hourly Shading	1.3	2.5	2.2	.7	0	0

- Sum up the hourly shading and put the percentage next to the Pct Annual Shading

Calculating the system performance

- To calculate the annual performance, multiply (<u>100 – Pct Annual Shading</u>) times the <u>estimate annual performance of the system under study</u> times the <u>kW_{peak} DC system rating</u>
  - The annual production of the system under study is given in the first paragraph to left of sun chart.
    - Alternatively, the annual production can be calculated using PVWatts at <u>http://rredc.nrel.gov/solar/codes_algs/PVWATTS/</u>. Note that the system size used by PVWatts is in kW_{peak} AC. One needs to convert the kW_{peak} DC to kW_{peak} AC for this calculation.
  - The production of the system was calculated assuming that the peak AC system output at standard operating temperature and solar radiation was 85% of the kW_{peak} DC system's output under similar conditions.
    - If the system performs better or worse than this assumption, multiply the result of above calculation by the <u>correct percent</u> divided by 85%.

- To see if the system qualifies for the ETO program, divide the system output obtained from the above calculation and divide by the optimum system output.
  - If the value is above 0.75 and the system meets other ETO specifications, the system qualifies for the ETO program.