Lesson 9: The Right Site

Adopted/ Revised From
Build It Solar, Teach Engineering

Grade Level
6-12

Objectives
- Apply knowledge of elevation, azimuth and sun charts
- Determine the suitability of a site for solar energy production

Overview
Students will use simple tools to estimate how much sunlight will fall on a solar collector at a given site over a period of time. They will use this information to decide if a site is an appropriate location for solar energy production.

Materials
- Small (0.5 V – 1 V) solar panels
- Multimeters
- Sun Path chart – available for your location online at: http://solardat.uoregon.edu/SunChartProgram.html (Print charts using the Average Solar Radiation data and do both June to December and December to June.)
- Solar Elevation and Azimuth Gauge – 2 per group available at http://builditsolar.com/SiteSurvey/ElevAzGage.pdf
- Compasses for finding true south

For each set of gauges:
- 2 pieces of cardboard
- Glue
- 2 small nails or paperclips
- Small weight
- String
- Thin straight piece of material for pointer: pencil, chopstick, small dowel, or a sturdy straw. The pointer will need a hole made at one end.

Estimated Cost of Materials
$5

Computer Required
Only to download sun path charts and gauge templates

Duration
1-2 class periods

Primer References
3.1 Solar

Related Articles
N/A

Engagement

- We know it is very sunny in Colorado. Does that mean that we can efficiently generate solar electricity anywhere in the state?
- If we wanted to put solar collectors (panels) on our school grounds or in our town somewhere, how would we decide the best place to put them?
- What kinds of things do we have to know about the sun to make the best use of its energy?
- What obstacles could interfere with the sun's light reaching a solar collector?

Investigation

1. Have students look at the overhead map labeled Solar Photovoltaic Resources in the United States in Appendix B to see how much sunlight falls on Colorado. The map can also be found at http://www.nrel.gov/gis/images/map_pv_national_lo-res.jpg. Does the class feel that Colorado is an appropriate place for solar energy production?
2. In "Watt's Your Angle", students may have learned that knowing the appropriate tilt and azimuth is important to the efficiency of solar panels. Challenge students to come up with other things that must be considered when placing solar panels. Either brainstorm a list, or if time, give each group of students a multimeter and solar panel. Have them go outdoors and measure the voltage produced in different areas around the school yard. What conditions decrease the voltage produced?
3. Have each group build an azimuth gauge and an elevation gauge:

   To make the Elevation gauge:
   a. Paste one copy of the gauge template on a piece of cardboard.
   b. Trim the cardboard along the Sight Line (you will sight along this edge for elevation measurements).
   c. Put a small nail or a paperclip with one end bent up through the center of the Reference Circle where all the lines meet.
   d. Tie one end of a light string to the nail or paperclip and the other end to a small weight like a nut or bolt.

   To make the Azimuth angle gauge:
   a. Paste the other template on another piece of cardboard.
   b. Find a thin, straight piece of wood, like a pencil, chopstick or even a sturdy straw and make a small hole near one end. The pointer should be long enough to extend beyond the edge of the gauge. You will site along this pointer to measure azimuth angles.
   c. Attach the pointer to the center of the reference circle using a small nail or bent paperclip.

To see photos of the tools, go to http://builditsolar.com/SiteSurvey/site_survey.htm

4. Outside, have each group set up a fairly level workspace where they think they would like to put their collector. In actuality this may be on the roof, but for now, have them work on the ground.
5. Tape the Azimuth angle gauge to a flat surface so that 180˚ faces true south.
6. Have each group find the azimuth angle and elevation angle of each of the high points along the horizon as seen from their location, starting from the northeast (about 55˚) and working around to the northwest (about 305˚).
7. To find out the azimuth angle of each object, line up the pointer on the Azimuth gauge with the object and read the angle where the point crosses the number scale.
8. To find the elevation angle, place the gauge right at eye level and look along the sight line. Without moving the gauge, read the number that is crossed by the string.
9. Record both values for each object that is a high point as you move along the horizon.
10. Plot the data for each obstacle on the sun path chart. Connect the dots and fill out the activity sheet.

Class Review

1. Have each group report on their findings.
2. Overall, are any of the locations suitable for placing solar collectors?
3. If there are obstacles, how can those be overcome?

Elaboration

1. Where are the best places in Colorado for solar energy production?
2. What factors are important to consider when looking for a location for solar collectors?
3. What kinds of things do we have to know about the sun to make the best use of its energy?
4. What obstacles interfere with the amount of sunlight reaching a solar collector? What are some ways to mitigate each? Do some research on the effects of trees on solar collectors.
5. What other strategies could you use to improve the amount of sun the collectors receive?

Instructor Notes:

- The sun path charts cover June to December or December to June. Give one of each to each group or to make the activity a bit shorter, have two groups work at each location, one charting the data for Dec to June and the other doing June to December.
- When you make the sun path chart for this activity, use the Average Solar Radiation button.
- Students should learn strategies for finding true south before they start this activity. Learn to find true south at http://www.builditsolar.com/SiteSurvey/FindingSouth.htm
- A small thin piece of wood like a chopstick or a very thin piece of balsa wood, or even a sturdy straw makes a good pointer for the Azimuth gauge. You can make a hole through these materials easily with a nail or paperclip.
- One good way to fasten the string and pointer so they lay flat during use is to unbend one part of a paperclip and stick it up through the string or straw. Then fold it back down snugly.

- Cereal boxes are an inexpensive source of cardboard; however it is sometimes a bit floppy so gluing a double layer together may be helpful.
- When using the azimuth gauge, tape it to the flat surface once it is facing true south so that it does not move when the pointer is moved.

Extensions and Variations:

- Another tool from Popular Science for assessing obstacles can be found at http://ncsc.ncsu.edu/wp-content/uploads/SitingActive.pdf
- For a computer based method of seeing how obstacles impact available sunlight, students can go to Google sketchup, draw their building, add obstacles and use tools to show shadows on any day of the year. Go to http://www.builditsolar.com/References/SketchUp/SketchUpEx.htm for more information.

References/For More Information:

Build It Solar - http://builditsolar.com/ - look especially at "Getting Started" and "Projects"

North Carolina Solar Center - http://ncsc.ncsu.edu/wp-content/uploads/SitingActive.pdf
(Siting of Active Solar Collectors and Photovoltaic Modules)

The Right Site

Date:
Time:
Location:
Latitiude:
Longitude:

Obstacle	Elevation	Azimuth	Hours (solar time) when sunlight hits

Questions

1. Plot the elevation and azimuth for each obstacle on the sun path chart.

2. For excellent solar energy output, about 6 hours of uninterrupted sunlight between 9 am and 3 pm solar time are needed year-round. Does your site receive this amount of sunlight?

3. What blockages occur during the 6 hour window? What time of the year do they occur? How long do they last?

4. Based on your answers to the questions above and the data you collected, rate your site "excellent", "good", "fair", or "poor" for solar electricity generation and justify your rating.