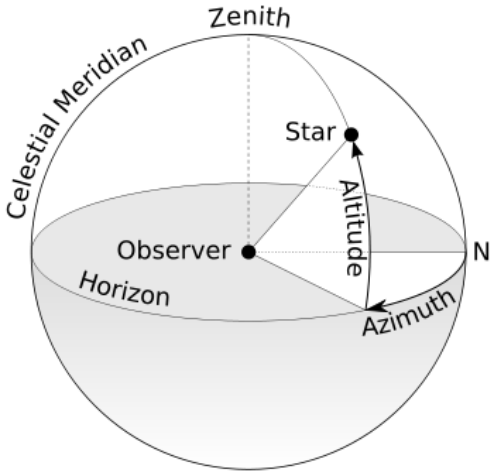
OAR NORTHWEST: EDUCATION

CWF Africa to the Americas Expedition 2013

Lesson 1.2: Rowing with the Sun



http://en.wikipedia.org/wiki/Azimuth

Introduction

The sun is a constant force and companion during the CWF Africa to the Americas Expedition. This lesson will explore the question: How much sun is available for solar powered energy production? The *James Robert Hanssen* (JRH) is outfitted with solar panels that capture solar radiation for the purpose of powering boat systems and scientific instrumentation (Go here for a list of instruments on the JRH: http://bit.ly/VxmGDd). The following activity will give students a sense of the available solar energy, both at their location and on the JRH. At the end of the lesson students should be able to explain what an azimuth is and be able to compare the solar energy available at their location to the current location of the JRH.

Background

The path of the sun across the sky changes with the time of year. At the two equinoxes, the sun rises due east and sets due west. At solar noon on the equinoxes, the altitude of the sun is 90 minus the local latitude. For example, if you live in Denver with a latitude of 40 degrees, the altitude of the sun at noon on the equinoxes will be 90 - 40 = 50 deg. The length of the day on the equinox everywhere on the earth is 12 hours. The spring equinox occurs on Mar 21, and the fall equinox on Sept 21.

The winter solstice is the shortest day of the year and occurs on Dec 21 in the northern hemisphere. On this day the sun will rise well to the south of east, and will set well to the south of west. The altitude of the sun at solar noon will be 23.5 degrees less than it was on

the equinox -- or, 50 -23.5 = 26.5 degrees in our Denver example. This will be the lowest that the noon sun will be in the sky all year.

The summer solstice is the longest day of the year and occurs on June 21 in the northern hemisphere. On this day the sun will rise well to the north of east, and will set well to the north of west. The altitude of the sun at solar noon will be 23.5 degrees more than it was on the equinox -- or, 50 + 23.5 = 73.5 degrees in our Denver example. This will be the highest that the noon sun will be in the sky all year.

The 23.5 degrees referred to above is the tilt of the earth axis of rotation relative to the plane of the earths orbit. The summer solstice in the northern hemisphere occurs when the North Pole is tilted toward the sun, and the winter solstice when the North Pole is tilted away from the sun.

For more information about azimuth see here: http://en.wikipedia.org/wiki/Azimuth and watch this video on the topic: http://www.youtube.com/watch?v=OR8EQ0DWpPw

Activity

Solar Energy Survey

By following the directions in this activity, student will be able to conduct a solar energy survey of both their school location and of the location of the JRH. When conducting a survey for the JRH, use the latitude and longitude of the boat's current location by clicking on the yellow balloon found on the www.oarnorthwest.com website:

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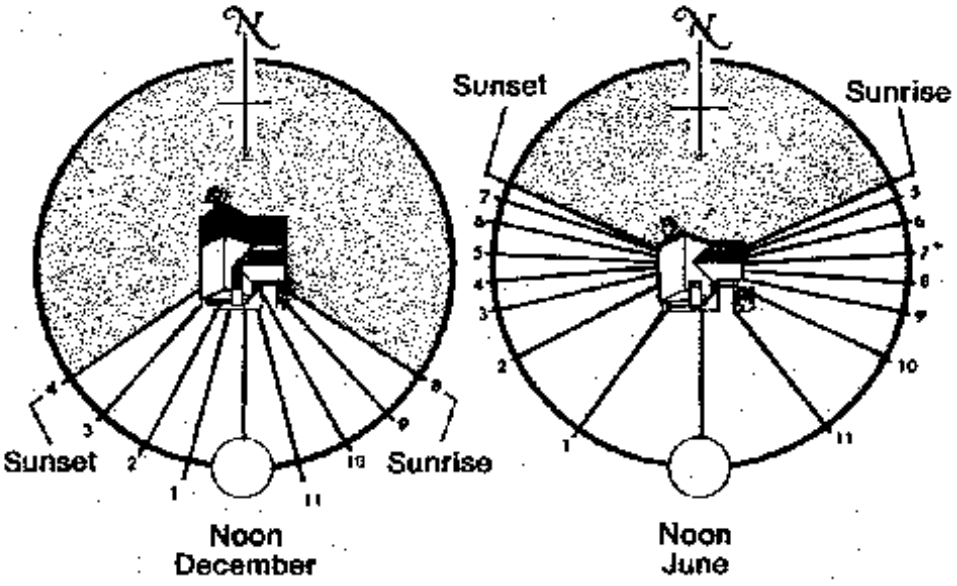
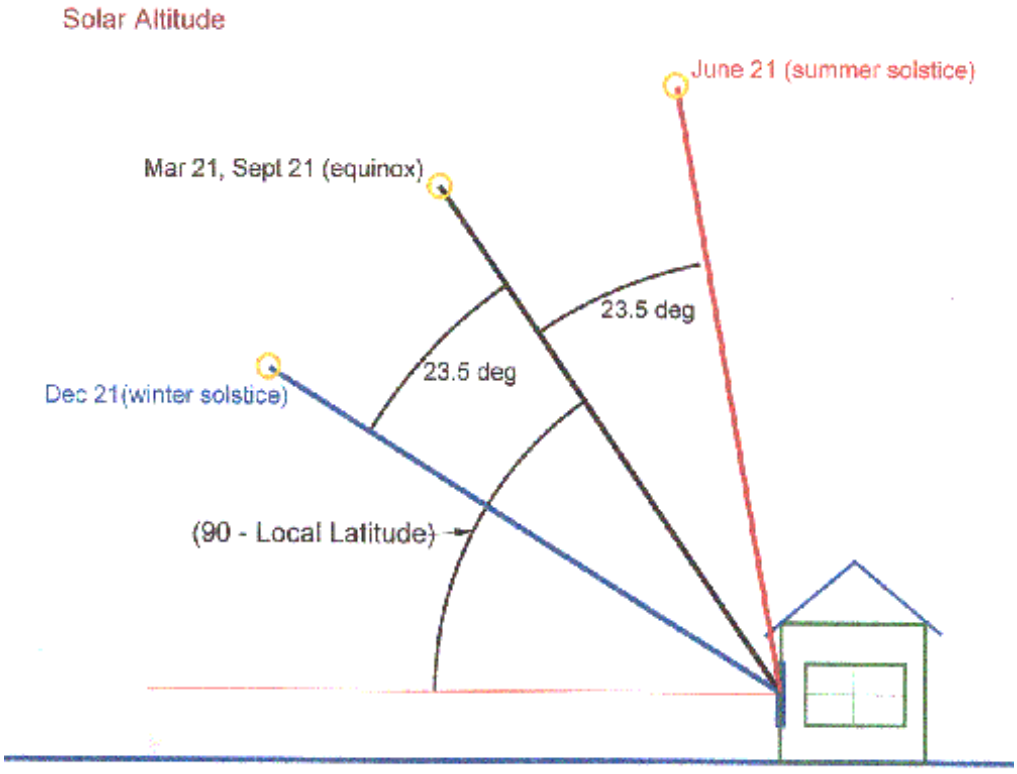




Diagrams showing sunrise/sunset positions for the summer and winter solstices, and the suns altitude at the solstices and equinoxes.

Materials

You will need the following

- A Sun Chart for your area (see below)
- A device to measure elevation and azimuth angles (see below)

Sun Charts are available here: http://solardat.uoregon.edu/SunChartProgram.html. Just enter your zip code, download the .pdf version of the Sun Chart, and print it out. The Sun Chart shows the position (azimuth and elevation) of the sun for every minute of the year -- all on one piece of paper! It is worth spending a few minutes studying the Sun Chart, and understanding how it works. It's a great way to check your understanding of the movement of the sun in the sky throughout the day and the year.

You will also need to make gages to measure the sun azimuth and elevation angles.

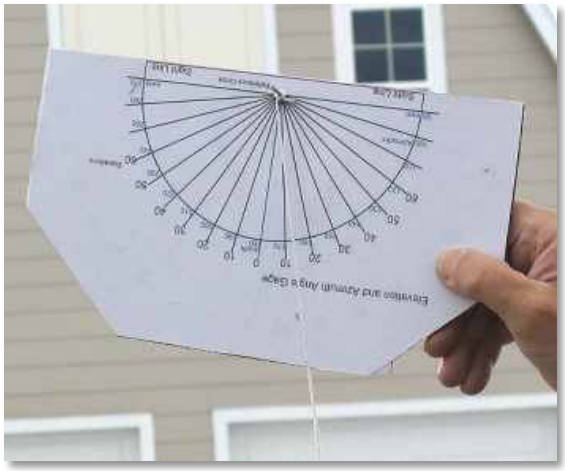
- Download this Solar Elevation and Azimuth Gage, and print out two copies of it: http://www.builditsolar.com/SiteSurvey/ElevAzGage.pdf

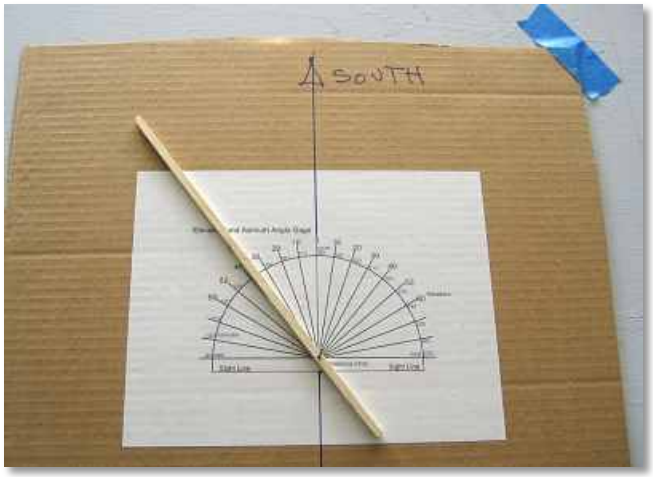
Make the Elevation gage

- Paste one copy onto a piece of cardboard.
- Trim the cardboard along the Site Line (you will site along this edge for elevation measurements)
- Put a small nail through the center of the Reference Circle where all the lines meet
- Tie one end of a light string to the nail, and the other end to any small weight (e.g. a bolt or nut)

Make the Azimuth angle gage

- Paste the other copy onto another piece of cardboard.
- Find a thin, straight piece of wood (e.g. a wood pencil) and drill a small hole near one end. You will site along this pointer to measure azimuth angles.
- Put a small nail through the drilled hole, and then through the center of the reference circle.





Elevation and azimuth gages in use.

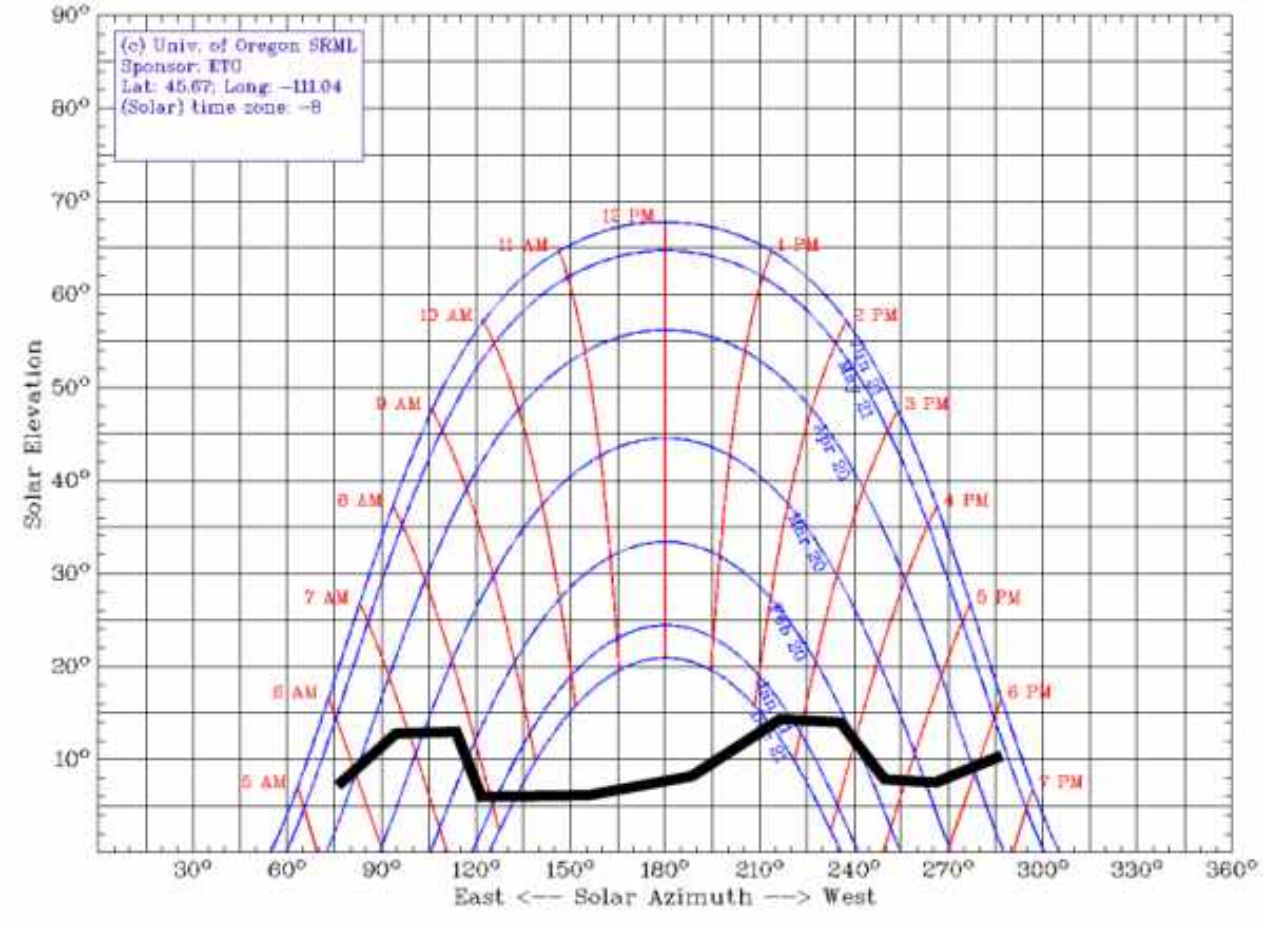
Procedures

Doing the Site Survey

Set up a reasonably level surface (e.g. a card table) about where your solar energy collector would be.

Tape the Azimuth angle gage to the table such that 180 on the blue azimuth scale faces true south. Here are some ways to determine where true south is:
http://www.builditsolar.com/SiteSurvey/FindingSouth.htm

Measure the azimuth and elevation angles for each of the high points along your horizon. Start from northeast and work your way around through south to the northwest. To measure the azimuth angle of a object, site along the pointer that you attached to the azimuth gage, and move it until it is lined up with the object. Then read the azimuth angle off the azimuth gage where the pointer passes the azimuth angle number scale. Measure the elevation angle for the same object by sighting along the Sight Line on the Elevation Gage. Read the elevation angle where the string crosses the elevation angle scale. Make sure that the string is not binding on the gage when you make the reading. Mark the azimuth and elevation angles of each high point on the Sun Chart as you go with a dot. Mark the position of the horizon on your sun chart by drawing lines between the elevation points you marked on the chart.



Sun chart with obstacle horizon marked.

Reading the Results

Ask students:

How many hours of unblocked sun do we have at our location?

How many hours of unblocked sun does the JRH have?

If you want a quantitative look at how much a particular obstacle might hurt, run the Radiation On Collector tool:
http://www.builditsolar.com/Tools/RadOnCol/radoncol.htm

Look at the hourly solar energy inputs, and see what percentage of the total solar input for the day that the obstacle blocks.

Photovoltaic panels can be particularly sensitive to partial shading. Shading even a small part of a panel can significantly cut the panels output.

Lesson Wrap-up
Ask students:

Which location has the best potential for powering solar panels, our school location or the JRH?

What are the similarities between our school location and the location of the JRH for solar energy?

What is an azimuth?

What is the solstice?

What is an equinox?

Send education@oarnorthwest.com photos, videos, and/or stories from doing this activity with students. What question do you and your students have for the JRH crew?

Citations
http://www.builditsolar.com/SiteSurvey/site_survey.htm

http://solardat.uoregon.edu/SunChartProgram.html