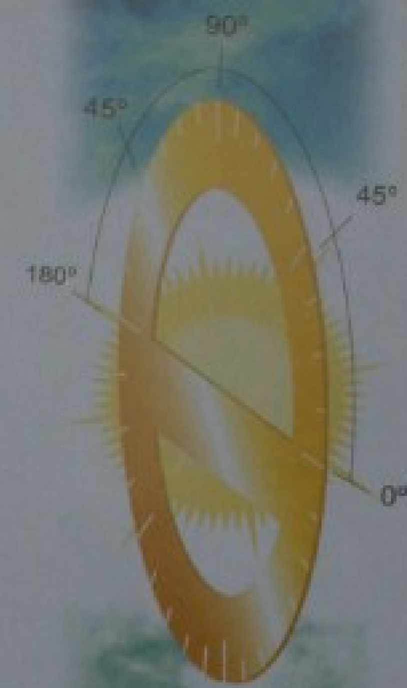


Experiment 06
Tracking and Fixed Solar Arrays

Objective

Students make periodic measurements of light intensity for two solar array configurations. Students calculate the area under two curves and express the results as the percentage difference. This shows how much more energy is available from a tracking array than a fixed array during a day.

Value

Lambert's Law in Experiment 01 demonstrates that the energy available from a solar module is maximised if the sunlight is normal to the surface of the array.

The Sun Compass in Experiment 05 illustrates a device that could be used to point an array directly at the sun. In two-axis tracking, two sun compasses would be used: one in an east-west configuration to track the movement of the sun throughout the day, and a second in a north-south configuration to adjust for the seasonal changes in the sun's position. In this way, the attached solar array would always have the maximum available sunlight striking it.

A fixed (non-moving) solar array has the advantage of having no moving parts. This increases the system's reliability, however, the solar array is not exposed to the maximum amount of sunshine available throughout a day.

In a two axis-tracking array, the maximum amount of sunshine available throughout a day is delivered, however, the system's moving parts are prone to breakdown and system reliability may be an issue.

In this experiment, students determine how much additional energy would be available from a two-axis tracking array than from a fixed array.

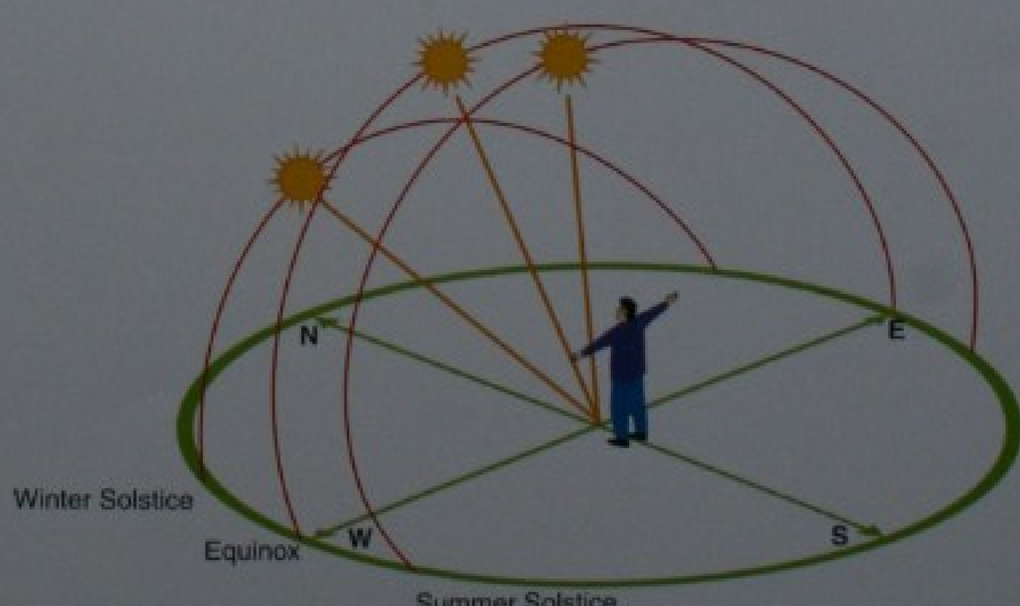
Equipment

Solar array, multimeter with clip-leads (in current mode), protractor, and a knowledge of the direction of true north.

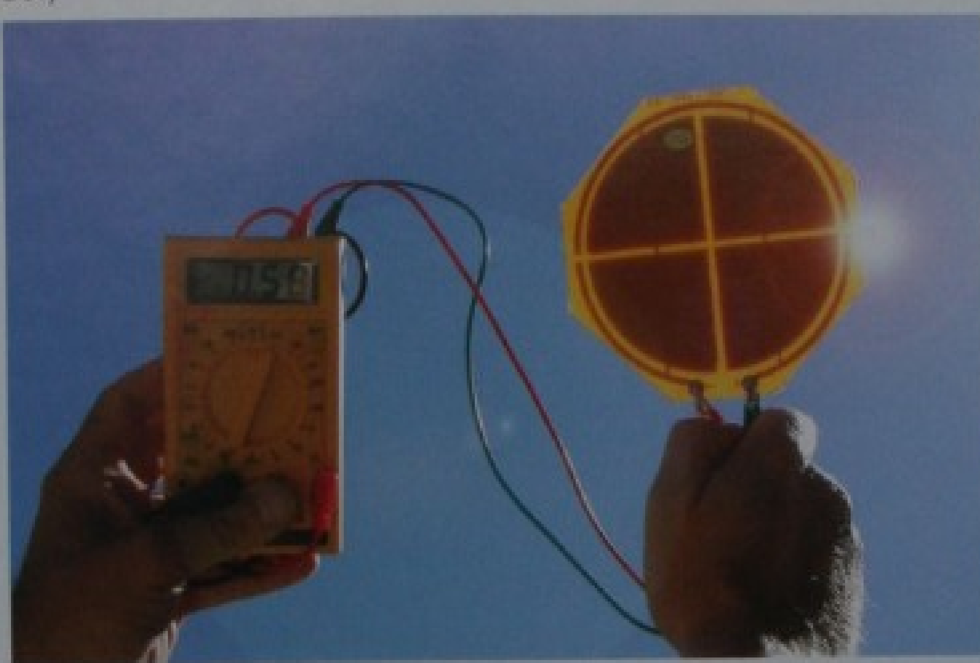
Method

Two short circuit measurements are made at 30-minute intervals throughout the day.

The fixed array measurement is with the solar array pointing due north and at a tilt angle equal to the latitude + 15 degrees. In stand-alone photovoltaic systems, this fixed angle of tilt is used to increase the electrical energy available from the system during



wintertime. (In grid-connected systems the optimum tilt angle is at the angle of the site's latitude.)



The solar array is adjusted to give the highest current reading.

The two-axis tracking measurement is made by having a student placing the solar module above their head and orienting it to give the maximum short circuit measurement. The time and current values are plotted either on graph paper or via a spreadsheet.

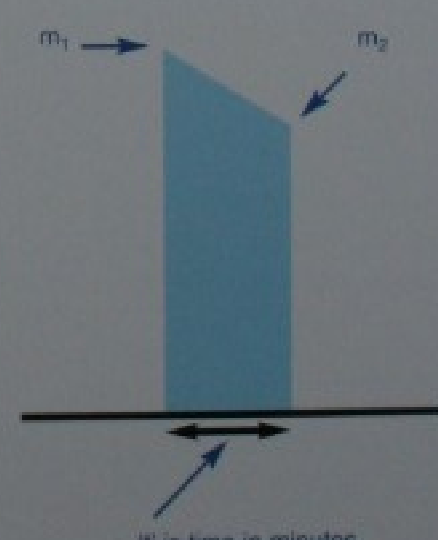
The area under each curve is a measure of the energy available throughout the day for the corresponding array.

By using the trapezoidal method, students sum the area under each curve and then determine the percentage difference in available energy between a fixed and a two-axis tracking system.

The area of the trapezoid is

$$(m_1+m_2)*t/2$$

where m_1 and m_2 are two values of current (taken approximately 30 minutes apart) and t is the time between the measurements in minutes. Because of symmetry, only the values from noon till late afternoon are required. The area of each adjacent trapezoid is calculated and summed with the others for each curve giving an area that corresponds to the energy available to the solar array.

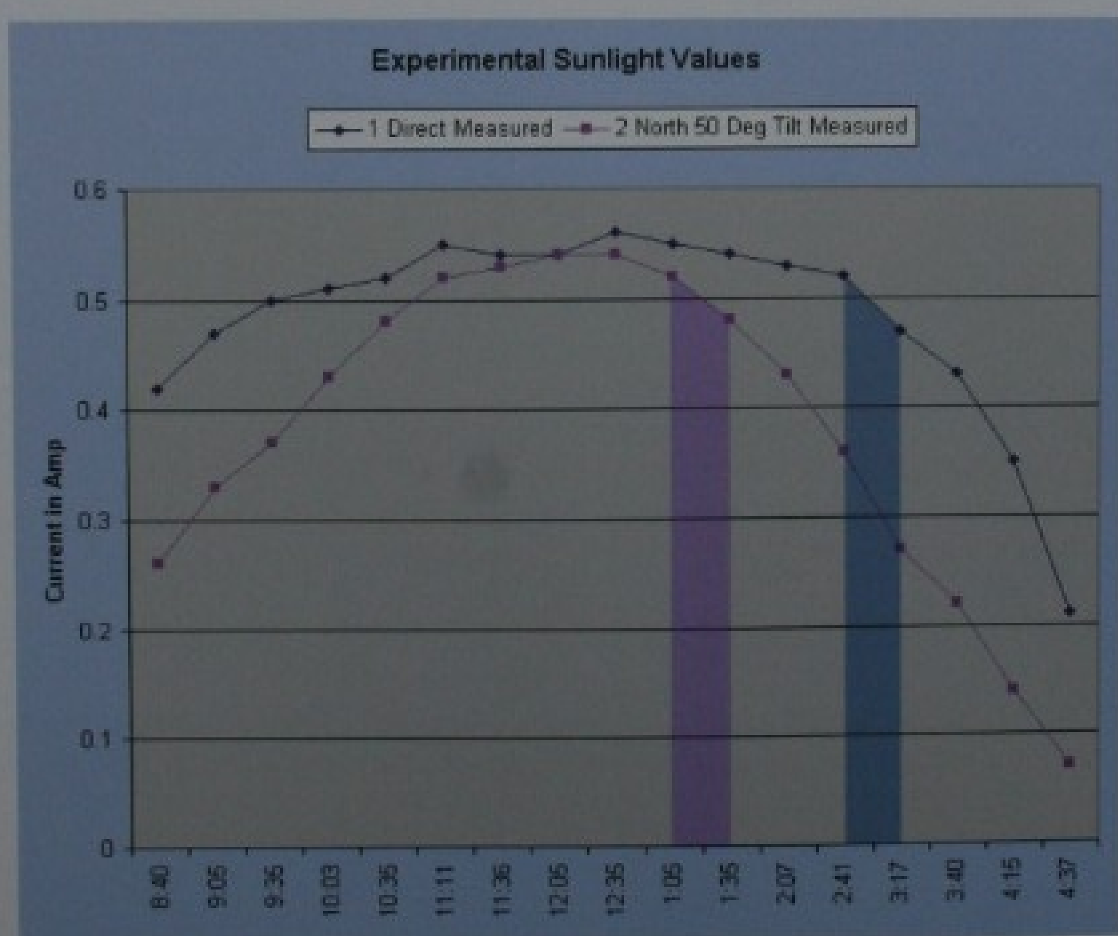


The area of a trapezoid is used as a measure of the energy available to the solar array.

The percentage difference in the energy of the day is

$$\text{Percentage Difference} = (\text{Area}_{tracking} - \text{Area}_{fixed}) / \text{Area}_{fixed} *100\%.$$

Date	9-Aug-02	UNSW	Sydney
Time	Direct Measured Current Amp	50 Degree North Tilt Current Amp	
8:40	0.42	0.26	
9:05	0.47	0.33	
9:35	0.5	0.37	
10:03	0.51	0.43	
10:35	0.52	0.48	
11:11	0.55	0.52	
11:36	0.54	0.53	mist over sun
12:05	0.54	0.54	
12:35	0.56	0.54	
1:05	0.55	0.52	
1:35	0.54	0.48	
2:07	0.53	0.43	
2:41	0.52	0.36	
3:17	0.47	0.27	
3:40	0.43	0.22	
4:15	0.35	0.14	
4:37	0.21	0.07	



Spreadsheet showing short circuit current for a "tracking" array and a "fixed" array.