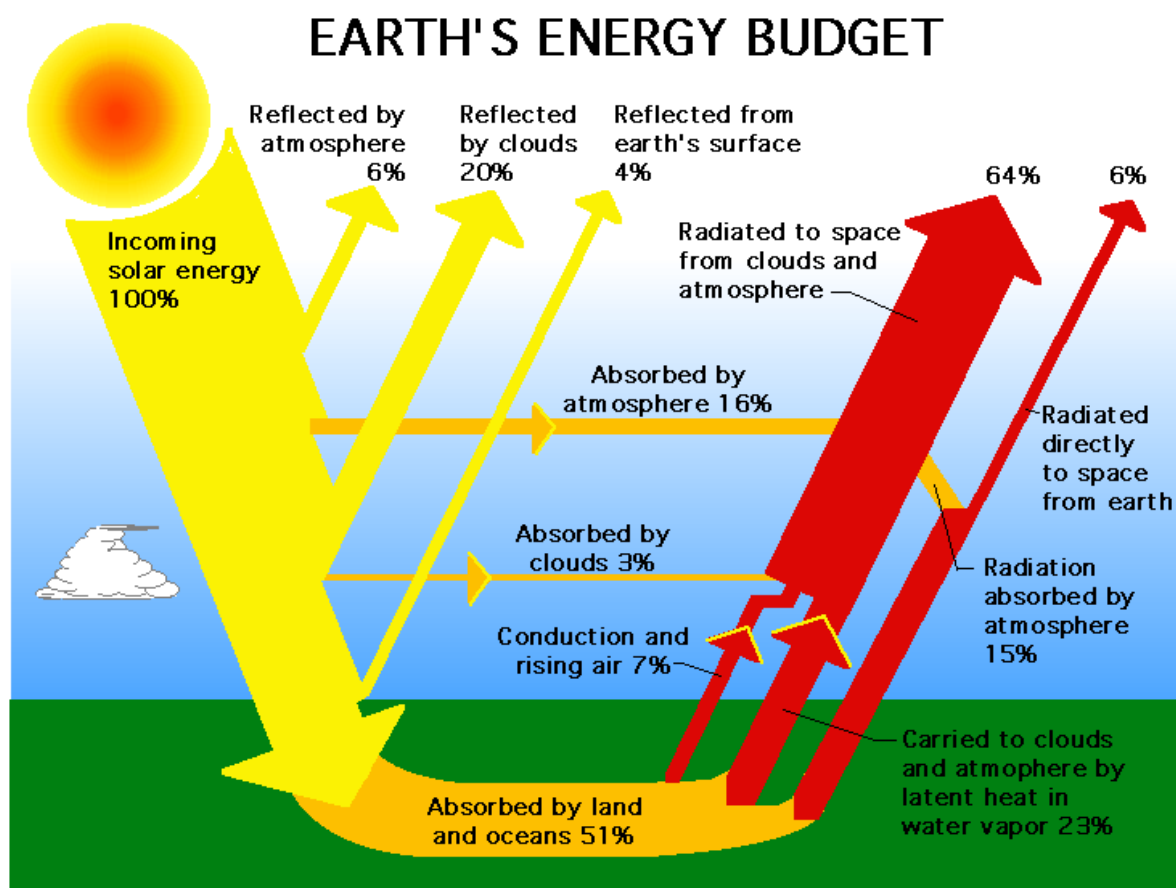


SOLAR ENERGY EXPERIMENTS

The sun is a star, made of mainly hydrogen and helium. It sends out huge amounts of energy every day in every direction. Most of the energy goes off into space. Even though a tiny fraction of the sun's energy reaches the Earth, it is still more energy than we can use. The energy in sunlight striking the earth for 40 minutes is equivalent to global energy consumption for a year. Imagine that! We could provide all the energy needed in the entire planet with the light energy provided by the sun in just 40 minutes. The potential of solar energy is off the charts. Besides generating electricity, solar energy can be used for heating, lighting, drying, etc. Although sunlight is free, the equipment needed to capture the light, convert it to electricity and store the energy, can be expensive. Scientists and engineers are continuously working on creating more efficient technologies.



The following experiments will help you understand the use of solar energy:

Experiment 1: Converting Light (Photo) into Voltage (Voltaic). You will use photo-voltaic (PV) panels to capture light energy and convert it to electrical energy (electricity).

Experiment 2: Powering electrical loads with the generated energy. You will use the generated electricity to power up electrical loads (lights and motors).

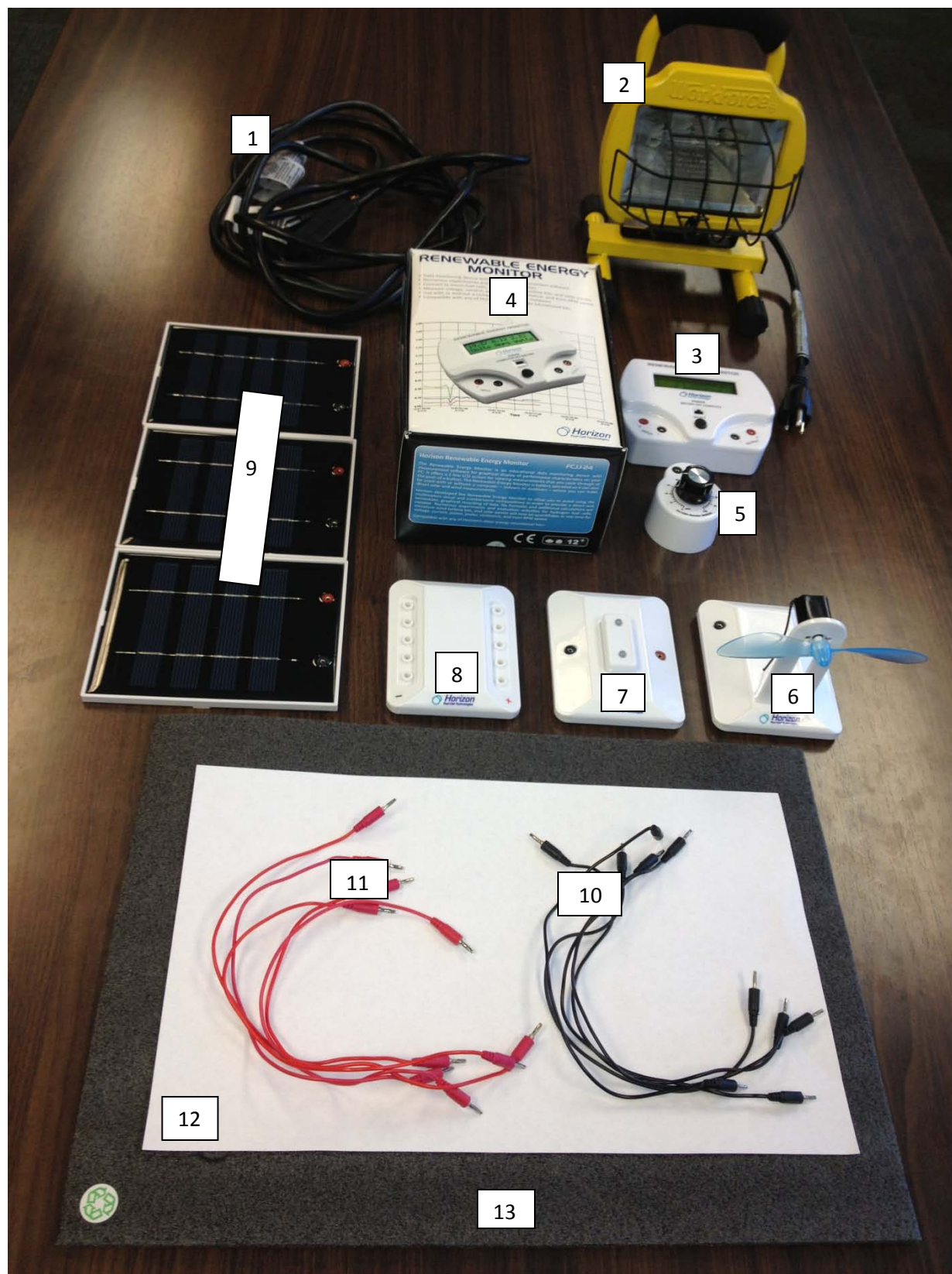
Experiment 3: The effect of tilt angle on photo-voltaic (PV) panels. You will discover how to optimize the capture of light energy with PV panels.

Experiment 4: The effect of shade on photo-voltaic (PV) panels. You will discover how the capture of light energy by PV panels, can be affected by the elements and its surroundings.

DIRECTIONS: Make sure you read the instructions thoroughly as well as refer to the photos provided to ensure that your experiments are successful.

MATERIALS: Gather all the necessary materials onto a working table (refer to photo on the next page, and compare to the list below).

1. (1) extension cord
2. (1) portable halogen work light
3. (1) renewable energy monitor (REM)
4. (1) renewable energy monitor (REM) packaging box
5. (1) variable resistor module (VRM)
6. (1) small fan motor module
7. (1) light emitting diode (LED) module
8. (1) circuit board module
9. (3) photo-voltaic panels (PV panels)
10. (5) black hook-up wires
11. (5) red hook-up wires
12. (1) sheet of white 8.5 x 14 paper, or 2 sheets of white 8 x 11 paper taped together to form a 8.5 x 22 sheet
13. (1) dark thin foam sheet (top inside cover of the kit box)

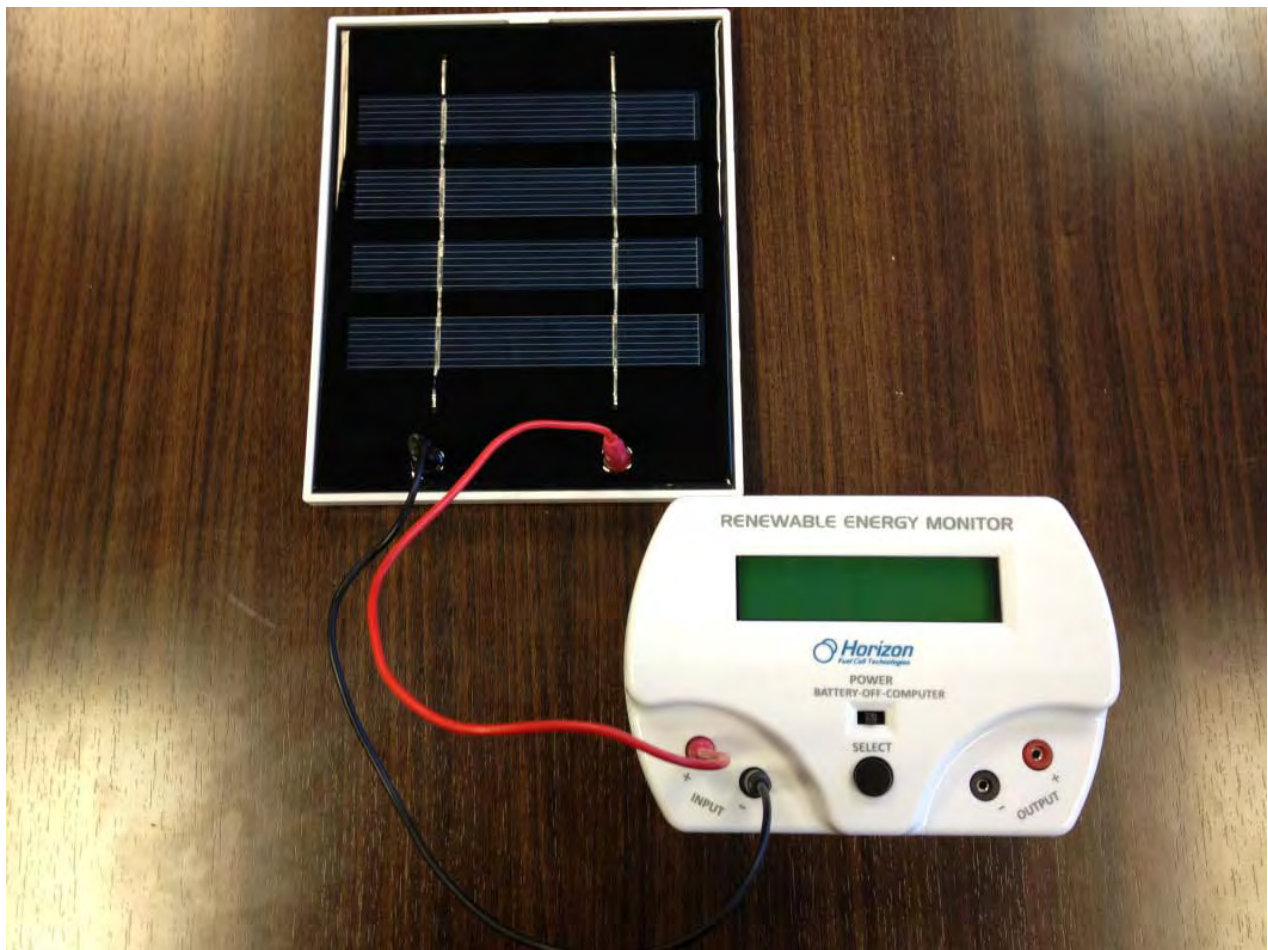


Set-up: Take the renewable energy monitor (REM), one of the three photo-voltaic (PV) panels, one red wire, and one black wire. Set them on a separate area of your working table. Place the REM next to the PV panel. From this point on, always work with care and avoid the wire ends touching each other. Always hold the wires with one hand on each end as illustrated in the photo below. This will help to ensure that the wire ends make contact only where you intend them to.

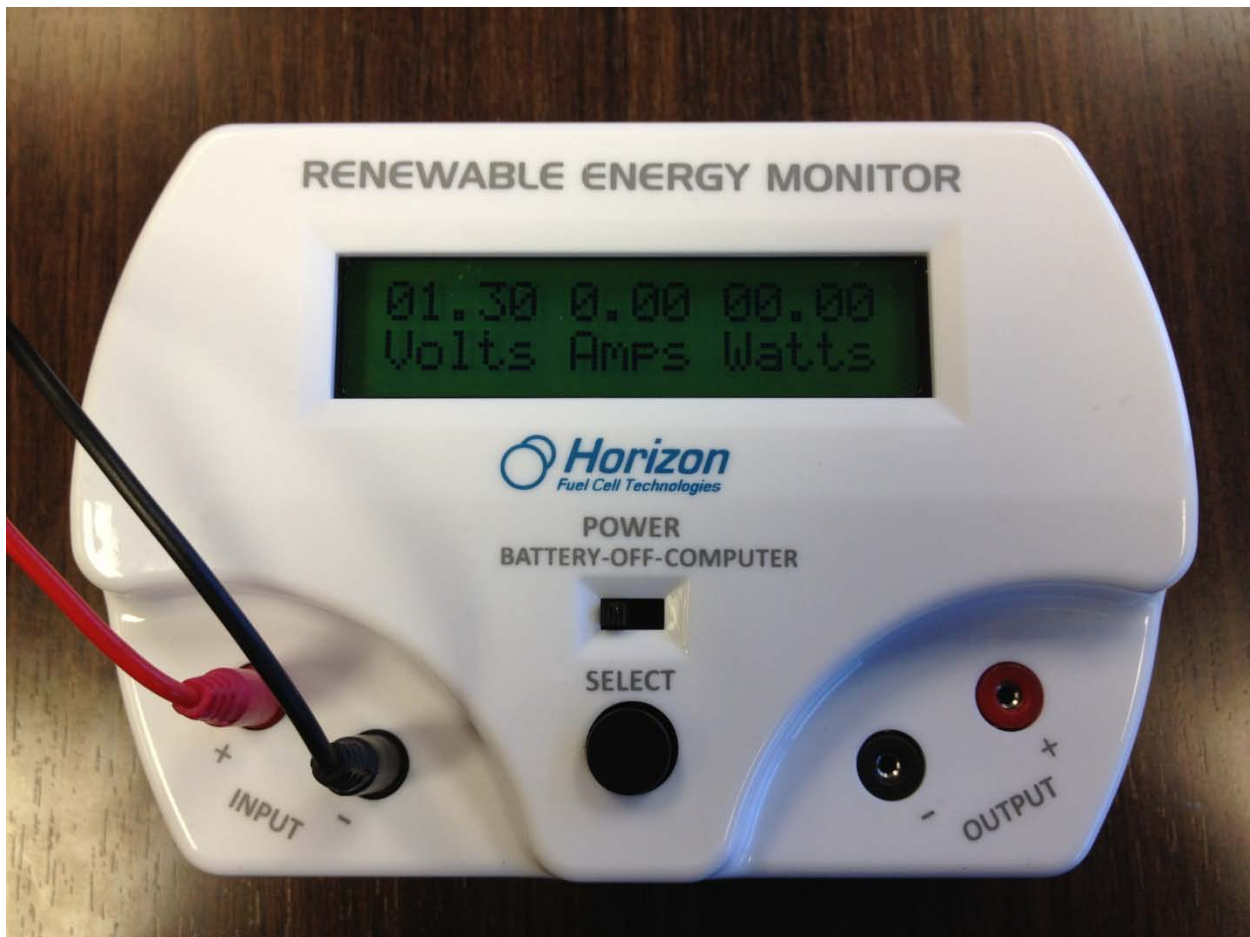


1. Insert a red wire end into the red (+) terminal on the PV panel, then insert the other end of the red wire into the red (+) REM INPUT terminal (left side).
2. Insert a black wire end into the black (-) terminal on the PV panel, then insert the other end of the black wire into the black (-) REM INPUT terminal (left side).

Your materials should look like the photo below:

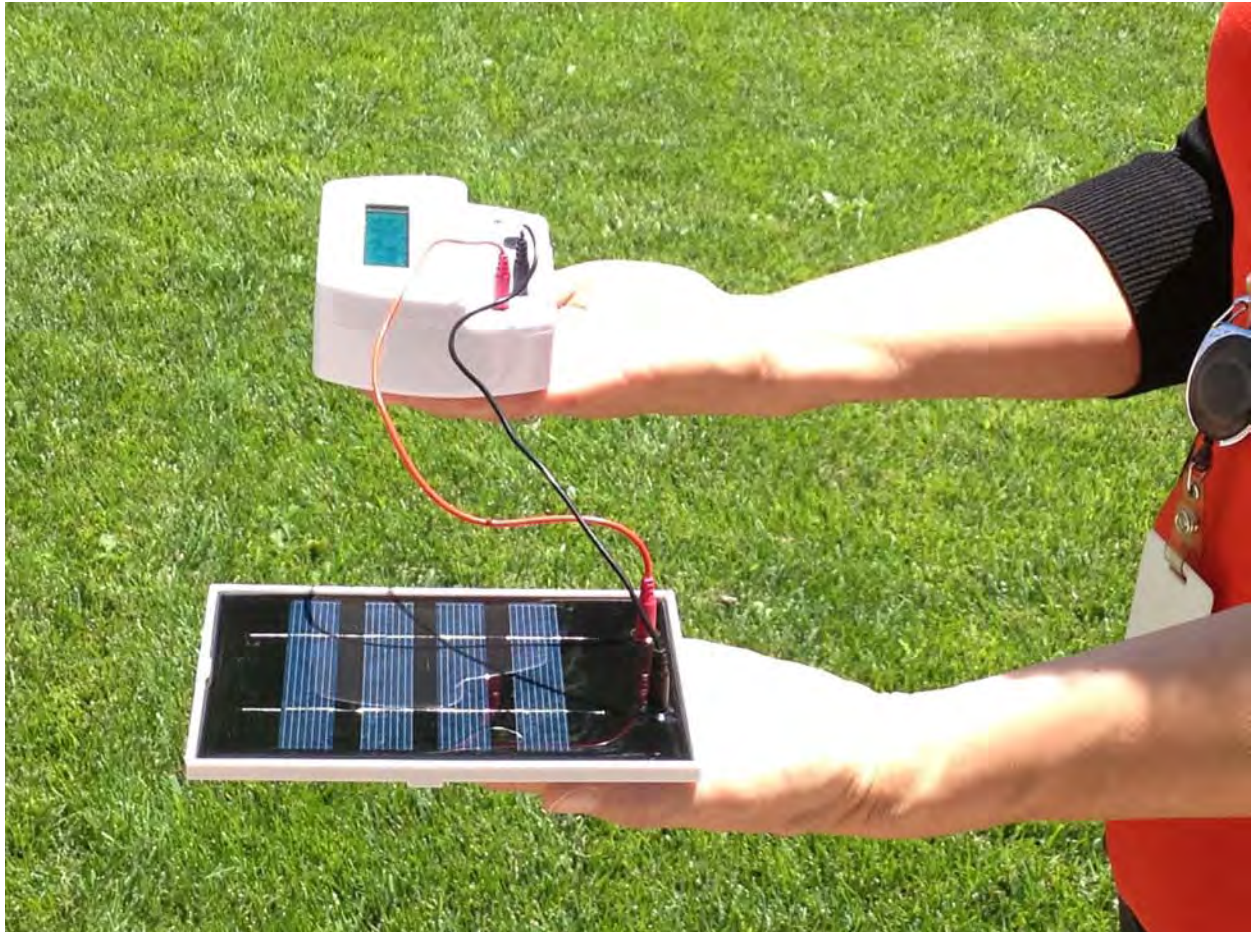


Slide the REM POWER switch from OFF to BATTERY. The REM display screen will show: **Volts-Amps-Watts** as illustrated in the photo below. If it doesn't, you can use the REM SELECT button to bring up that display screen. By pressing the button once, the REM switches to the next display screen. If you pass the display screen you want, keep pressing the button until you return to it, as there are only 4 display screens.



Experiment 1: Converting Light (Photo) into Voltage (Voltaic)

Take the two components you just connected (PV panel and REM) outdoors to a sunny spot. Hold the PV panel so that the black face points directly toward the sun as illustrated in the photo below:



Look at the REM display screen and observe how many Volts are being generated. Now slowly tilt the black face of the PV panel away from the sun, and observe the change in the Volts reading. Seems like the less light captured by the panel, the less electricity it generates. Keep this experiment in mind, as we will revisit this concept later. Now, go back indoors. Since the rest of the experiment takes place indoors, you will be simulating the light from the sun with an artificial light source (the halogen light).

Set-up: Place the connected PV panel and REM on the working table. Slide the REM POWER switch from BATTERY to OFF. Disconnect the red and black wires in no particular order from both the PV panel and the REM. Leave the PV panel and wires there as you will need them for the next experiment and then set the REM back with the other materials you are currently not utilizing.

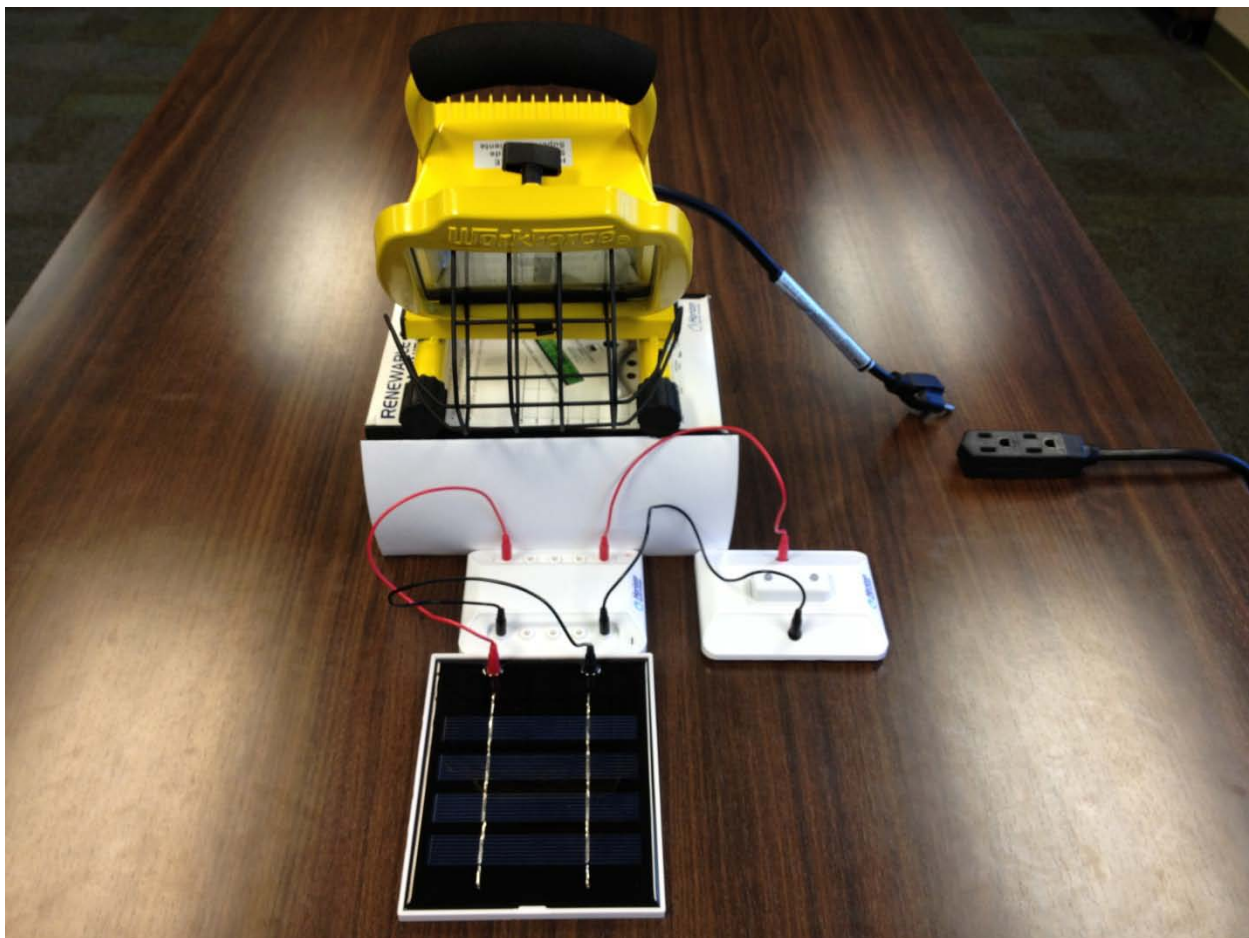
Now, from the materials area gather the halogen light, extension cord, REM packaging box, circuit board module, light emitting diode (LED) module, one red wire and one black wire. Set these materials next to the PV panel and wires you used previously.

1. Take the halogen light; make sure the top is tilted forward in relation to the base. If it is not, hold the top black handle with one hand and the base with the other and tilt the top forward. Set the light on top of the REM packaging box so that it is pointing down toward the table. The box should be positioned with its longest sides matching the front and back of the light. Make sure a portion of the black rubber feet on the light base is hanging off the end of the box (refer to photos on page 12).
2. Place the circuit board module directly in front of the REM packaging box so that the 5 terminals on the side labeled with the red (+) sign are closest to the box (refer to photo on page 9).
3. Place the PV panel directly in front of the circuit board module with the red (+) and black (-) terminals closest to the circuit board module (refer to photo on page 9).
4. Place the LED module base next to the circuit board module (refer to photo on page 9).
5. Take the extension cord to a wall AC outlet and plug it in the wall socket. Set the other end of the extension cord on the table next to the halogen light (refer to photo on page 9).
6. Insert a red wire end into the red positive (+) terminal on the PV panel, then insert the other end of the red wire into the furthest left of the 5 terminals on the side labeled with the red (+) sign on the circuit board module. Insert a black wire end into the black negative (-) terminal on the PV panel, then insert the other end of the black wire into the furthest left

of the 5 terminals on the side labeled with the black (-) sign on the circuit board module (refer to photo below).

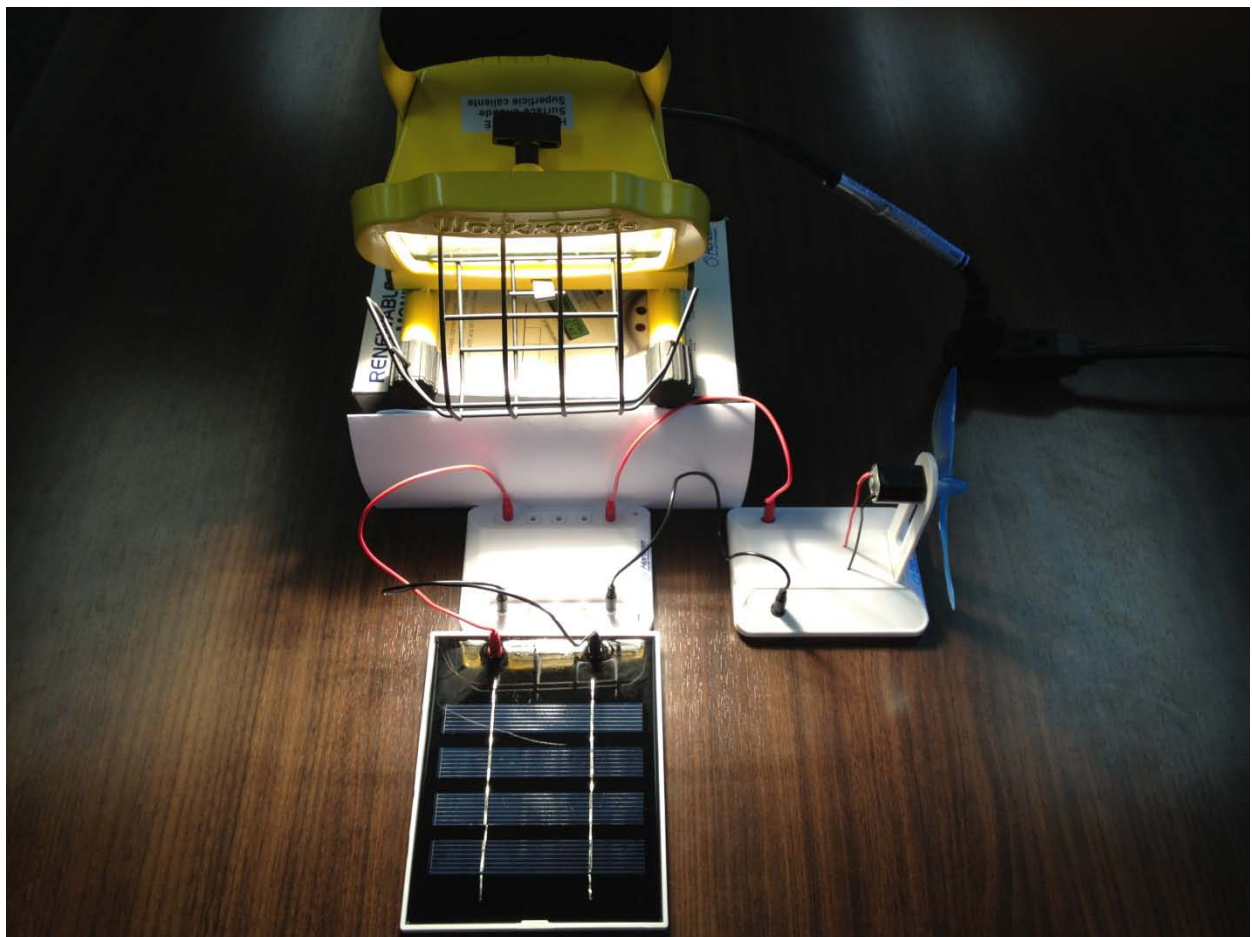
7. Insert a red wire end into the red positive (+) terminal on the LED module, then insert the other end of the red wire into the furthest right of the 5 terminals on the side labeled with the red (+) sign on the circuit board module. Insert a black wire end into the black negative (-) terminal on the LED module, then insert the other end of the black wire into the furthest right of the 5 terminals on the side labeled with the black (-) sign on the circuit board module (refer to photo below).

Your materials should now be assembled as in the photo below:



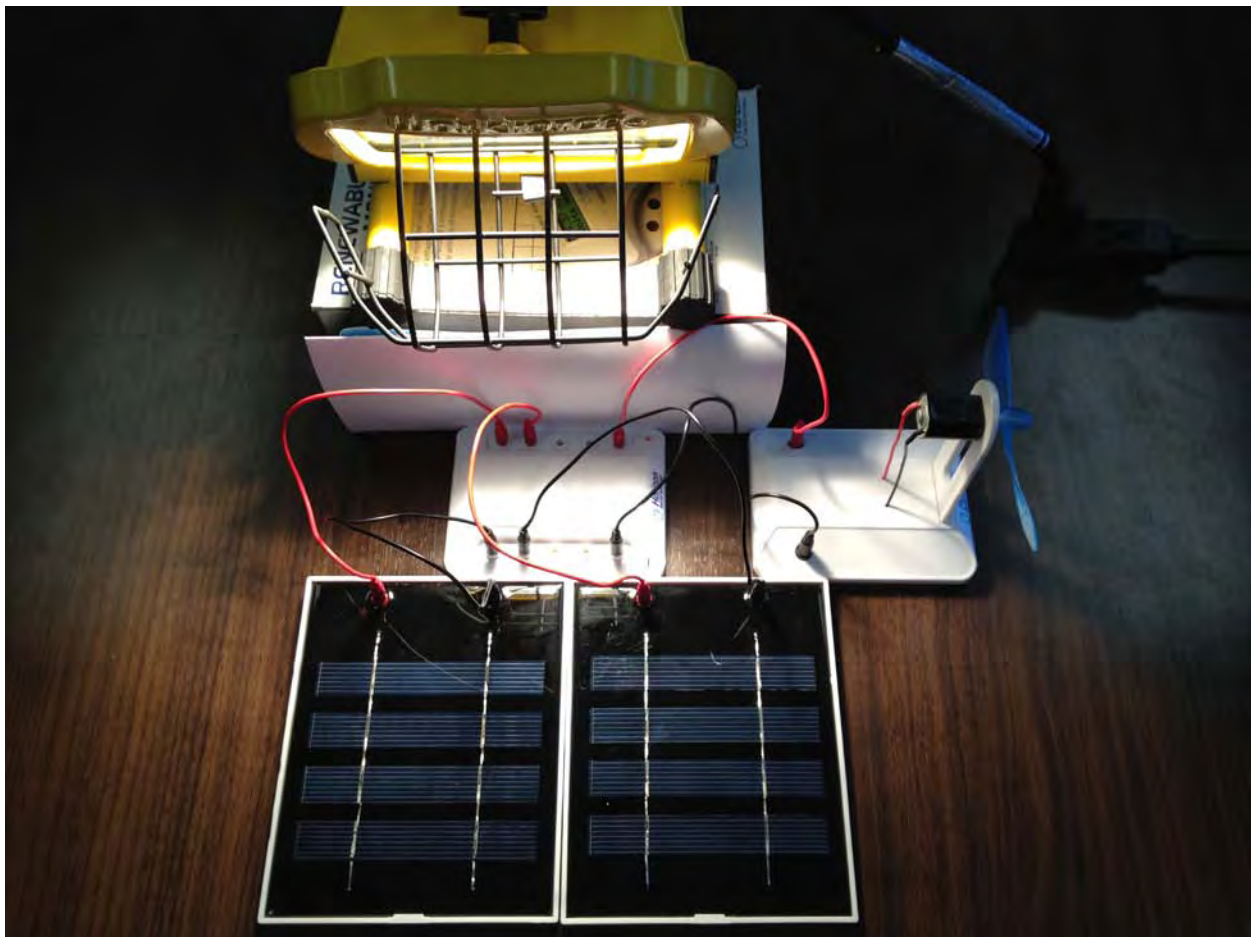
Experiment 2: Powering electrical loads with the generated energy

Now plug in the halogen light to the extension cord. **NOTE:** The light gets hot, so be careful not to touch the yellow surfaces, and always use the top black handle to hold the light. The tilted light should be shining down at an angle toward the PV panel on the table. Observe that the two LED lights on the module started flashing. The PV panel is generating enough electricity to power the LED module. Take the small fan motor module from the materials area and set it next to the LED module. Next, remembering not to let the wire ends touch one another, disconnect the red and black wires on the LED module and connect them to the small fan motor module instead. Set the LED module back with the rest of the materials you are not currently utilizing. Your materials should now be assembled as in the photo below:



Observe that the fan does not spin. Not enough electricity is being generated by one PV panel to run the small fan motor.

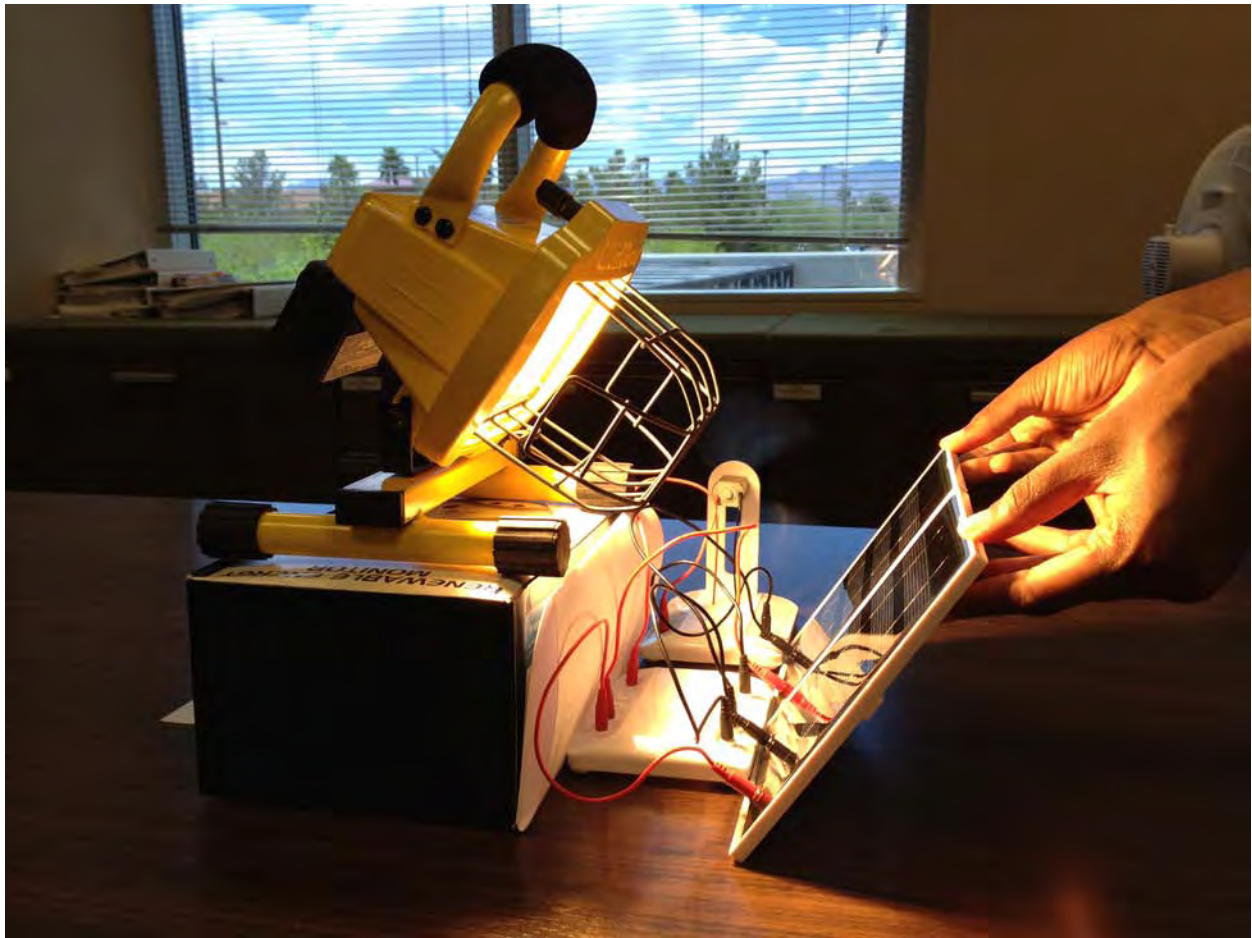
Set-up: From the materials area take a second PV panel, a red wire and a black wire. Following the same wiring procedure as before connect the additional panel to the circuit board module in order to build a 2-panel array which will allow for more energy generation. Use the available terminals furthest to the left on the circuit board module as illustrated in the photo below:



Observe that the small fan still does not spin. Even two PV panels do not seem to produce enough electricity to power the small fan motor. Remember when you were outside and held the black face of the PV panel so that it faced the sun directly? The PV panel generated more Volts in that position than when you tilted it away. So, let's use that concept next.

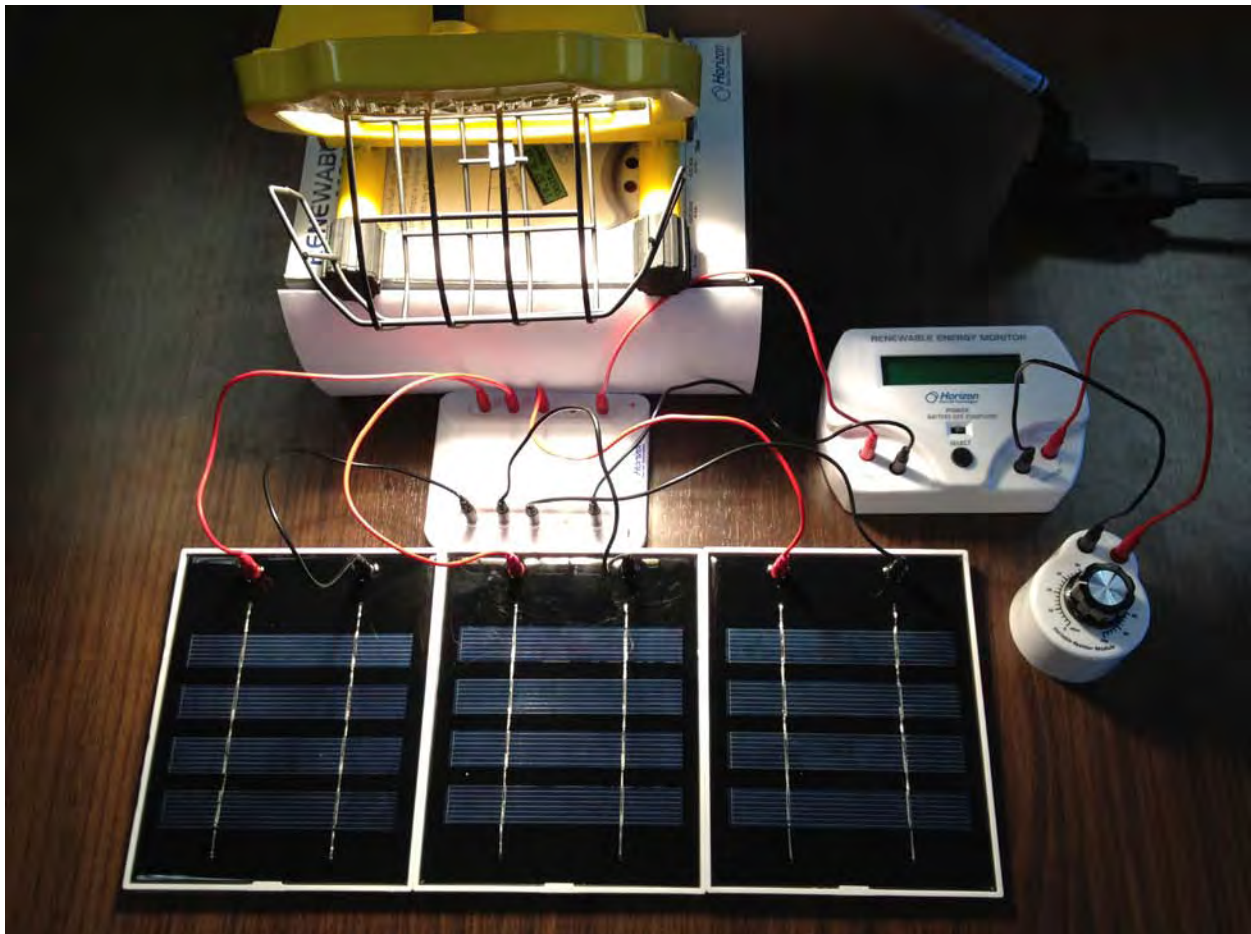
Experiment 3: The effect of tilt angle on photo-voltaic (PV) panels

Make sure the circuit board module is snug against the REM packaging box and the 2-panel array is snug against the circuit board module. Slowly tilt the two PV panels together toward the light until the fan starts spinning. Stop tilting the panels when they are directly facing the light as illustrated in the photo below:



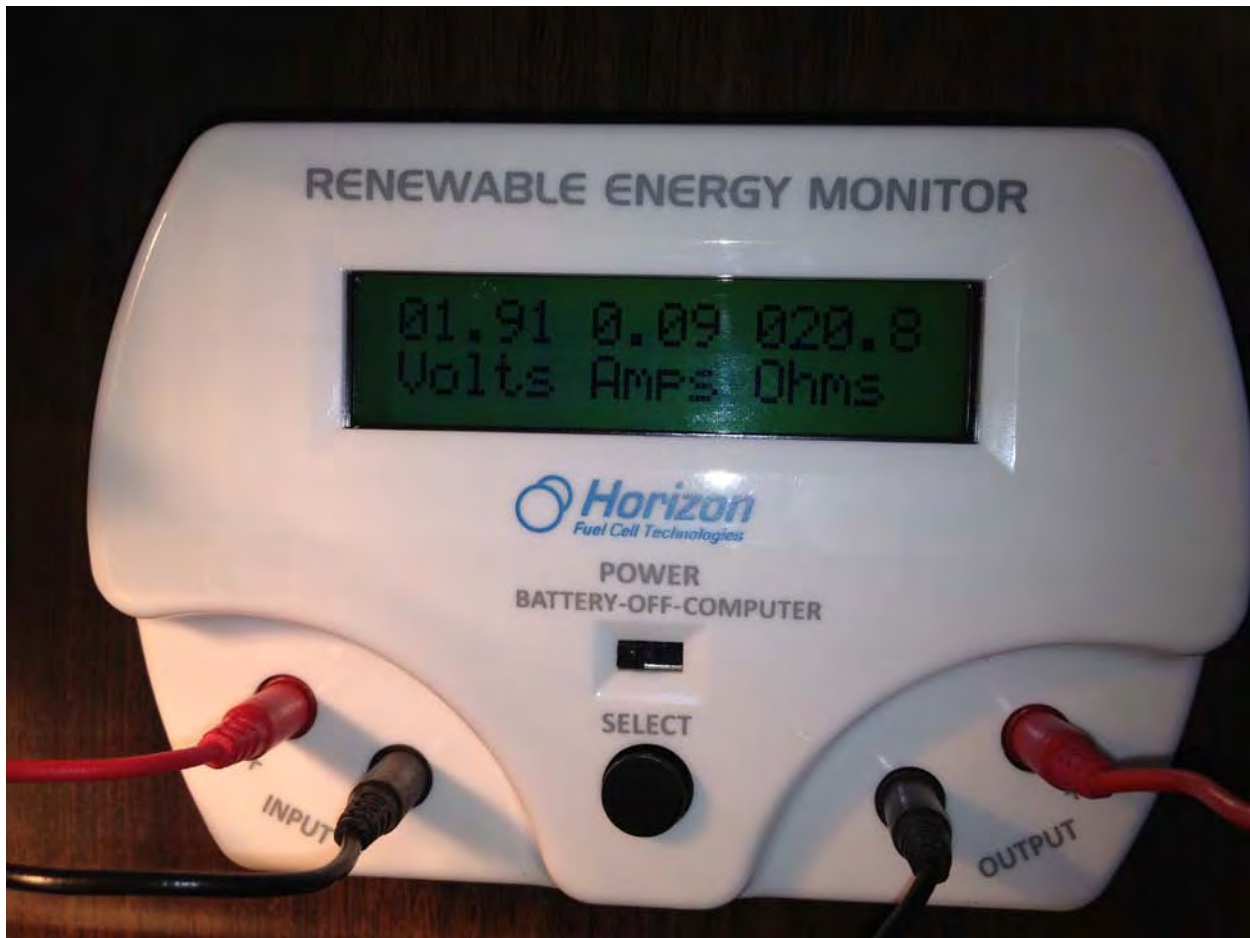
Observe that when you tilted the PV panels to face the light directly they were able to capture more light energy and convert it to electrical energy. Now they are generating enough electricity to power the small fan motor. Just as was observed outside, directly facing a PV panel toward the light source allows for optimal light capture and electricity generation. Carefully and slowly tilt the PV panels towards the table while observing the small fan motor module. The fan should eventually stop spinning after the PV panels are back horizontal on the table.

Set-up: From the materials area take the third PV panel, the REM, the variable resistor module (VRM), the remaining red and black wires, and place them in the working area of the table. Using the same wiring procedure as before, connect the third PV panel to the circuit board module to build a 3-panel array. Next, remembering not to let the wire ends touch one another, disconnect the red and black wires from the small fan motor module and connect them to the REM INPUT terminals (left side) as illustrated in the photo below. Then, remembering to observe red positive (+) and black negative (-) terminals, connect the variable resistor module (VRM) to the REM OUTPUT terminals (right side), as illustrated in the photo below.



Return the small fan motor module to the materials area of your table.

Slide the REM POWER switch to BATTERY. The display will read: **Volts-Amps-Watts**. This time you need to switch to the next display screen so, press the REM SELECT button once and the screen will switch to display: **Volts-Amps-Ohms**, as illustrated in the photo below.



If you pass this display screen, keep pressing the REM SELECT button until you return to the one you need, as there are only 4 display screens.

Adjust the knob on the variable resistor module (VRM) until the Ohm value reading on the REM display screen is as close to 20 as possible. Now use the REM SELECT button to go back to the: **Volts-Amps-Watts** display screen.

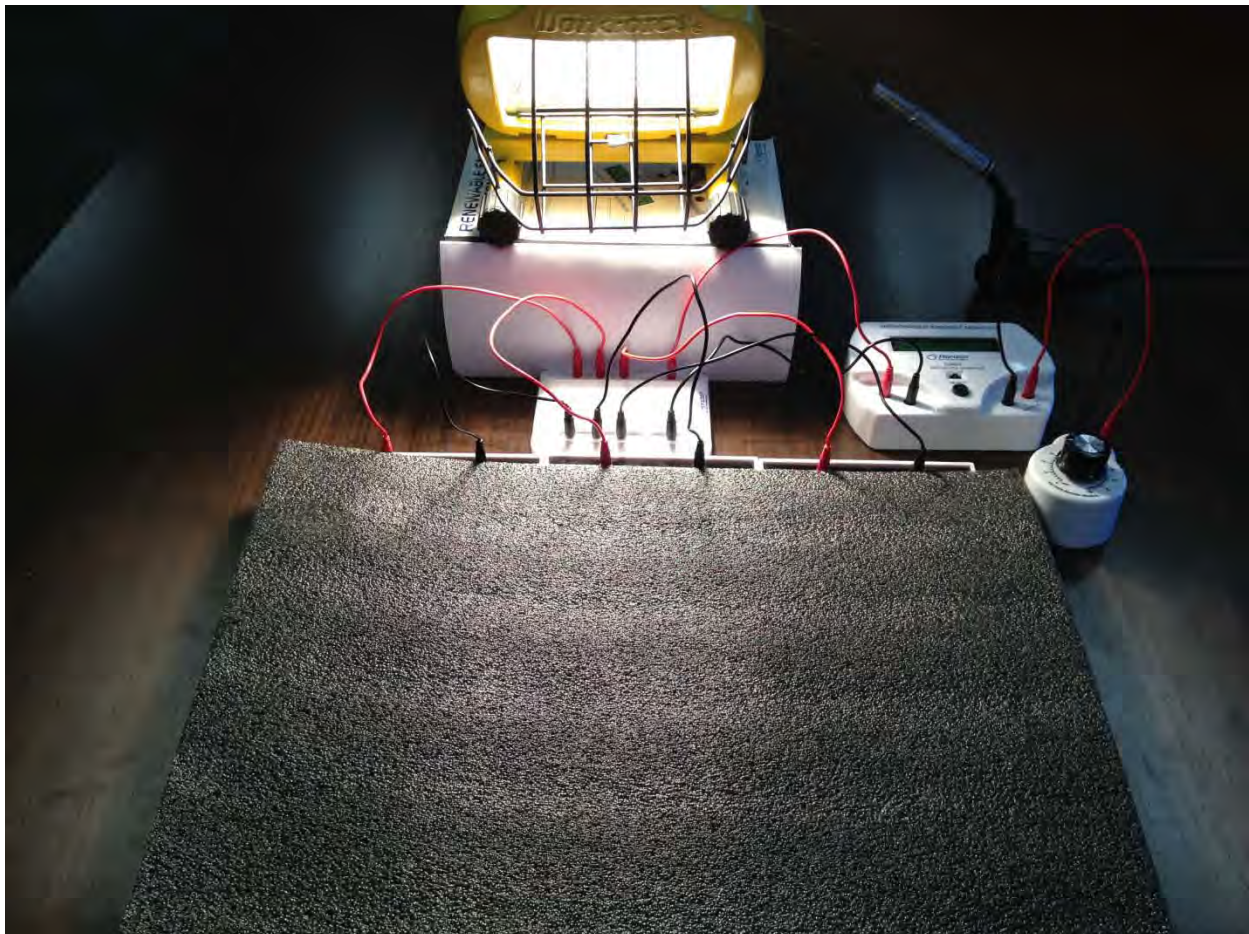
Experiment 4: The effect of shade on photo-voltaic (PV) panels

Next, take the white sheet of paper from the materials area. You will use it to simulate the effects of shade (buildings, clouds, trees, etc.) on PV panels. Observe on the REM display screen how many Volts are being generated with no shading. Set the white paper sheet down directly on the top of the first of the three panels furthest to the left, as illustrated in the photo below. Now, one third of the 3-panel array is being shaded. Observe that the Volts reading diminished. Next, slide the paper over to cover the second panel as well. Now, two thirds of the 3-panel array is being shaded. Observe the Volts reading diminished again. Lastly, slide the paper over to cover the third panel, shading 100% of the 3-panel array. Observe that the Volts Reading diminished again, but even when the white paper sheet is completely covering the array, the panels continue to generate electricity because some of the light is still getting through the white paper and being captured by the PV panel.



Similarly, sunlight can also get through clouds, tree foliage, etc. but as you have just seen, shade affects how well PV panels operate. There are other factors that can keep PV panels from operating efficiently like: dust, dirt, debris, etc. Now, return the white paper sheet to the materials area and take the dark thin foam sheet to your working area.

While observing the Volts reading on the REM, use the dark thin foam sheet to cover 100% of the 3-panel array as illustrated in the photo below. Observe that no electricity is being generated now. By using the dark thin foam sheet you have simulated nighttime conditions in which there is no light energy for the PV panel to capture and convert into electrical energy.



Slide the REM POWER switch from BATTERY to OFF. The display will go blank. Unplug the light from the extension cord. Carefully disconnect all the red and black wires, and return all materials.