Get to Know YOUR PV System

OVERVIEW

Students visit the PV array at their school and make observations about its physical characteristics and placement. Students work in teams of 2 or 4 to collect observations and create a set of "blueprints" for the school's PV system. Blueprints will detail the physical characteristics of the PV array as well as its location on the school campus. *Note: Some schools may have PV arrays that are not accessible to students (e.g., mounted on the building roof or attached to side of building).*

PRIOR KNOWLEDGE

Students will be most successful with this activity if they have read "The Path to Solar Energy" on pgs. 3-6 and are familiar with the terms and concepts introduced in that reading. A basic knowledge of circuits, series and parallel, and batteries will also be useful.

TIME

One to two 45-minute class periods

MATERIALS

- Observation Sheets or Researcher's Journal Question for students
- Blueprint Specifications
- Access to the PV array at your school
- Map of the school
- Compasses
- Protractor for measuring angles
- Rulers or measuring tapes (preferably metric)
- Clipboards for recording observations (optional)

PREPARATION

Note: There are two different sets of student worksheets for collecting information about the PV array. The "Observation Sheets" are intended to facilitate student-generated observations and

questions. The "Researchers Journal Version" provides a more directed question and answer format. Either will help students create blueprints.

- Review procedures and determine how you will do activity. Decide if students will work individually, in groups, using a jigsaw method, etc.
- Make copies of Observation Sheets or "Researchers Journal Questions" for students.
- Familiarize yourself with your PV array. Determine its location, direction it faces (also called *azimuth* - it should be facing south), angle of the array (also called *orientation*), number and size of panels, location of inverter, data logger and connecting wires.
- Make arrangements for students to visit the PV array.

PROCEDURES

- Explain to students that their task is to observe their school's PV system and create documents that would describe the system to someone who is in another state or country and cannot visit the school themselves.
- If using "Observation Sheets" method:

    1. Ask students to brainstorm what information would they need to make these documents (How big the panel is, where it is located, what it is made of, etc.). After a few suggestions, tell students they will continue their brainstorming in smaller groups and distribute the Observation Sheets.
    2. Divide students into groups of 2-4 and distribute observation sheets.
    3. Have students brainstorm questions in small groups for 5-10 minutes, circulate and help groups as needed.
    4. Bring class together and compile questions on overhead or blackboard.
    5. Now that students know what they are going to look for, have them think of supplies they may need for making their measurements (pencil, paper, clipboard, rulers/measuring tapes, compasses, etc.). Collect supplies and prepare to visit panel.

- If using "Researcher's Journal Questions" method:

    1. Distribute sheets
    2. Divide students into groups to work on questions
    3. Visit panel, have students work on their worksheet to answer questions. If needed, use the teacher "observation prompts" to help groups collect all necessary information.
    4. Return to class, distribute "Blueprint Specifications," have class start to work on creating documents.

PV Panel Observation Sheet

Directions:

1. In class – brainstorm and record questions you will want to collect answers to as you visit your schools solar panel. Make a note if you will need any special materials to make the observation (i.e. a ruler, a compass, a calculator).
2. While visiting the panel, record the answers to each question as you make observations.
3. Make a sketch of the Solar Array. Label the cells, the modules, and the array.
4. Record other observations and or questions you may have

PV Panel Observation Sheet

The Solar Array – Physical Characteristics

Questions To Consider	Tools needed?	Answers/Observations Made

Make a sketch of the Solar Array or an aspect of it. Label the cells, the modules, and the array.

Other Observations:

The Solar Array – Placement and Location

Questions To Consider	Tools needed?	Answers/Observations Made

Other Observations:

PV Panel Observation Sheet – Teacher Sheet

Directions:

1. In class – brainstorm and record questions you will want to collect answers to as you visit your schools solar panel. Make a note if you will need any special materials to make the observation (i.e. a ruler, a compass, a calculator).
2. While visiting the panel, record the answers to each question as you make observations.
3. Record other observations and or questions you may have at the bottom or on a separate sheet of paper.

Note to teachers: The goal of these sheets is to give the students a place to start with their observations. They will likely also make observations that they didn't think of beforehand. This is a sign of active thinking! You may want to prompt them / point out a few of the observations noted in the far right hand column. They may not think of them, but these are important aspects of the PV system.

The Solar Array – Physical Characteristics

Questions To Consider	Tools needed?	Answers/Observations Made
How big is it?	Ruler, measuring tape	
How many cells are there on each module?		36 cells per module
How many modules?		20 modules
How many panels?		Modules may be grouped into what looks like 5 groups of 4 modules or 2 groups of 10 modules.
What color is the array?		Dark blue with silver stripes.
What is it made of?		Silicon
What shape does it have?		Rectangular set up.
		Point out the + and – terminals on the back of the modules. Have students note the voltages and the wiring (series or parallel)

Other Observations:

Point out the voltages and wiring on the back of the array. Each module is like a 12V DC battery. Have students determine if they are connected in series, parallel, or a combination of both.

Example: Many of the Ohio Solar Schools have the arrays wired in one of the following ways:

- 5 sets of modules wired in series, and then the 5 sets in parallel, OR
- 2 sets of 10 modules wired in series, and then the 2 sets in parallel

The Solar Array – Placement and Location (Teacher Sheet)

Questions To Consider	Tools needed?	Answers/Observations Made
Where is it located?		
What direction does it face?	Compass	(should be southerly)
Does it face straight up to the sky or does it make an angle?	Protractor	(should be around 40 degrees – the latitude of Ohio)
Where is the inverter?		Usually on the side of the building near panels, just before the wires go into the school.
Where are the safety disconnects?		There may be 2 separate boxes on either side of the inverter (Sunny Boy systems). Or, they may be contained in the inverter box (GC-1000) systems.
Where does the electricity enter the school?		School's electric grid
Where is the data logger?		May be located inside or outside

Other Observations:

Researcher's Journal Version

You are on an information-collecting trip to learn as much as possible about the PV system at your school by making observations. The questions below are a guide to your researcher's journal entry.

Physical Characteristics

Make a sketch of the PV of Solar Array. Label the cells, the modules, and the array.

Using a measuring tape or meter stick, determine its dimensions in meters.

Length _____
Width _____.
Area = Length x Width = _____ m^2

How many modules are there? _____

How many cells are in each module? _____

How many cells are there in the whole array? Explain how you calculate this.

If each cell can produce approximately 1.5 Watts of power, how much power can the PV array produce under peak operating conditions?

Make a sketch of a single solar cell.

What color is the cell? Why might this be a useful color?
Make a guess at the function of the thin silver wires running along the cell.

Look at the back of the array. Make a sketch.

What value of voltage is labeled on each module?

Can you determine if the modules are wired together in series, parallel, or a combination of both?

Is the panel at a tilt? If so, measure and record the angle of the tilt (*orientation*).

Location and System Components

Where in the school is the PV array located?

Using a compass, determine what direction (*azimuth*) the PV array faces _____

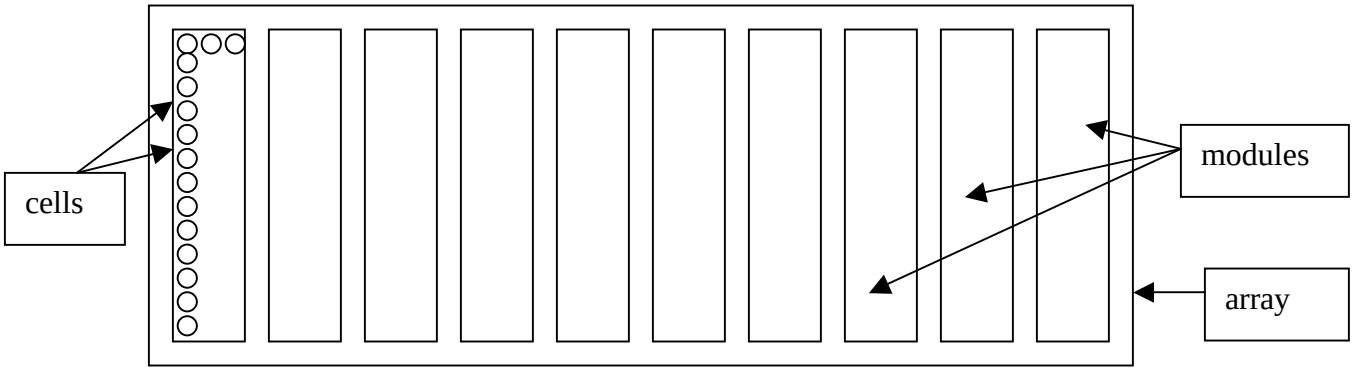
Find the inverter, record its brand (e.g., Advanced Energy Systems GC-1000)?

Make a sketch showing the array and all the equipment the electricity goes through from the array into the school.

Researcher's Journal Version – Teacher's Notes

Physical Characteristics

Make a sketch of the Solar Array. Label the cells, the modules, and the array.



Note: this just depicts 10 modules. Most arrays have 20. Student sketches should reflect the arrangement of the total number of modules, but not be overly detailed. Their labels should indicate an understanding of the relationship between cells, modules, and the array.

Using a measuring tape or meter stick, determine its dimensions in meters.

Length _____
Width _____.
Area = Length x Width = _____ m^2

How many modules are there? __*20 (for majority of schools*____

How many cells are in each module? __*36 (for majority of schools)*____

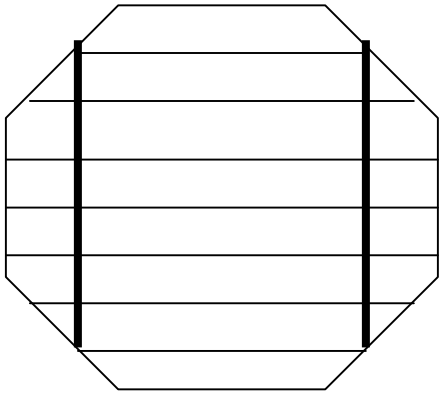
How many cells are there in the whole array? Explain how you calculate this.

720 – multiply the number of modules by the number of cells in each module.

If each cell can produce approximately 1.5 Watts of power, how much power can the PV array produce under peak operating conditions?

720 x 1.5 = 1080 watts ≅ 1000 Watts = 1 kW. This makes sense, since this is a 1 kW array.

Make a sketch of a single solar cell.



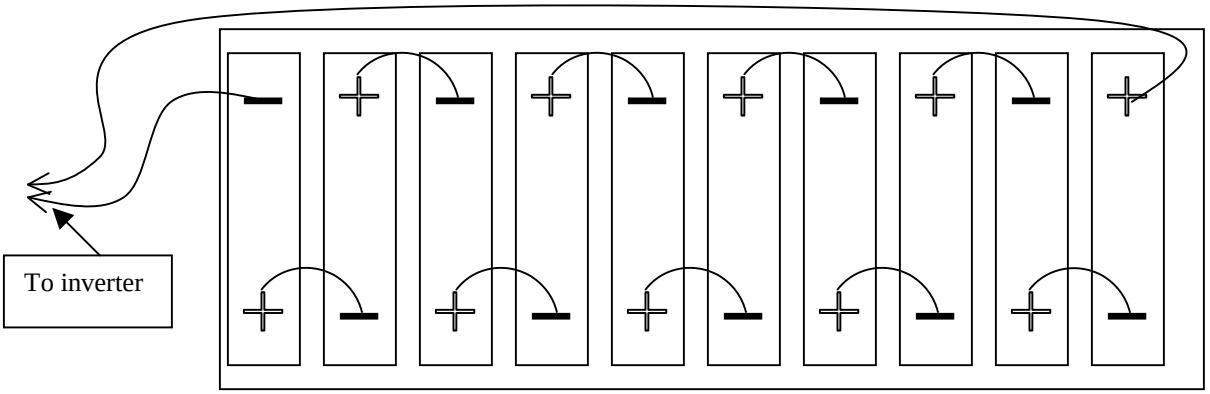
What color is the cell? *Dark blue*

How might this color affect the functioning of the cell? *It will absorb heat and the temperature of the cell may be higher than the actual air temperature.*

Make a guess at the function of the thin silver wires running along the cell.

They are conducting wires and provide a path for the electricity that is created from the sunlight shining on the solar cell.

Look at the back of the array, make a sketch showing the wiring connections.



What value of voltage is labeled on each module? *12 V*

Can you determine if the modules are wired together in series, parallel, or a combination of both? *Configurations will vary. Two possible combinations are 5 sets of 4 modules wired in series or 2 sets of 10 modules wired in series. The sketch above shows 10 modules wired in series to create a total of 120 V.*

Is the panel at a tilt? If so, measure and record the angle of the tilt.
Yes. The angle should be about 40 degrees. It should match the latitude of the location of the building. For optimal performance, the panel would be able to tilt +15° in the summer and -15° in the winter. See "Solar Panel Simulation" lesson for an interactive web applet that lets students explore the relationship between panel angle and seasons.

Location and System Components

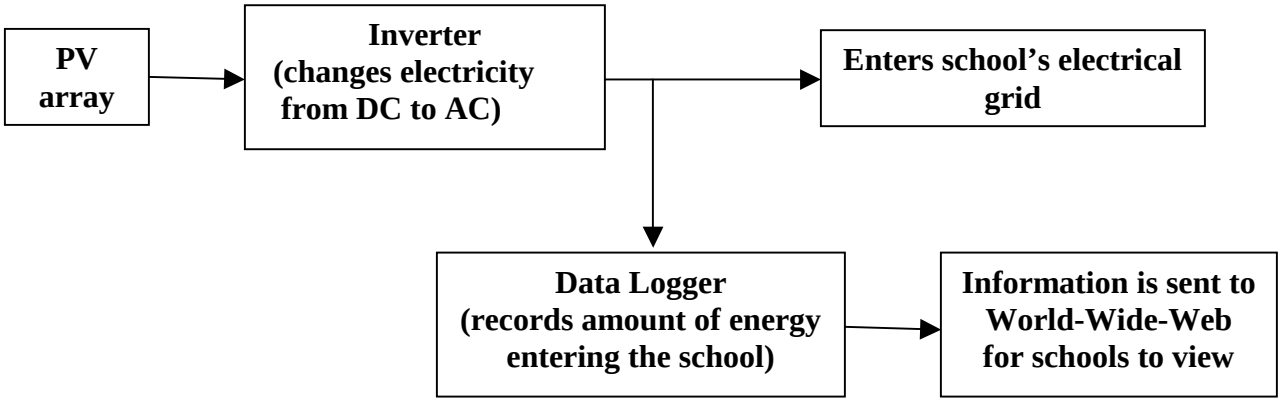
Where in the school is the PV array located?

Various locations: roof, mounted on the side of the building (awning style), free-standing.

Using a compass, determine what direction the PV array faces ___*SOUTH*___

Find the inverter, record its brand (e.g., Advanced Energy Systems GC-1000).

Make a sketch showing the array and all the equipment the electricity goes through from the array into the school.



Blueprint Specifications

Congratulations! You have completed the first information-collecting round. You should now have enough information to construct blueprints of your school's PV system that will help someone else imagine it.

Your task: Construct blueprints that describe your school's PV system using the information and observations you made as you visited it. Your completed blueprints will have 3 parts:

- They should show the physical characteristics of the PV array itself. Its size, number of modules, potential peak wattage, wiring arrangement.
- They should include a diagram showing all the parts of a PV system, indicating where they are and they must be properly labeled. The parts to include: PV array, safety disconnects, inverter, transformer, data collector and wiring connecting all these.
- A map of the school indicating where the array is, the direction it faces, the angle of its tilt, and any other physical features in the landscape you feel should be noted.