SECTION 3 ACTIVITIES

Activity 9: Solar-Electric System Puzzle

ACTIVITY TYPE: Worksheet

OVERVIEW: Introduces the basic components of the Solar 4R Schools (S4RS) solar-electric system and identifies the role each component plays in the generation of electricity.

GOAL: Students learn where the components of their school's solar-electric system are and gain an understanding of how the components work.

SUBJECTS: Science

TIME: 2-3 30-minute class periods

SETTING: Classroom and tour of the school's solar-electric components.

MATERIALS: Solar-Electric System Puzzle Worksheet. See the S4RS CD for images of the solar-electric system and Power Point sides to share with students.

KEY VOCABULARY: Alternating current (AC), communications gateway, direct current (DC), electric utility, electrical current, electromagnetic radiation, electrons, energy, inverter photon, solar module, and utility net meter.

CORRELATIONS TO STANDARDS	
NATIONAL	**Science as Inquiry – 1:** Abilities necessary to do scientific inquiry. **2:** Understandings about scientific inquiry and using tools to measure results. **Science and Technology – 1:** Understandings about science and technology.
IDAHO	**Science – Goal 1.1:** Understand systems, order, and organization.
OREGON	**Grade 5 Science – Energy:** Identify forms of various types of energy and their effects on matter. Describe energy transfer. **Grades 3-6 Math – Estimation:** Estimate solutions to problems and determine if the solutions are accurate and reasonable.
WASHINGTON	**Science – Inquiry 2.1 Investigating Systems:** Develop the knowledge and skills necessary to do scientific inquiry. **Math – 1.1:** Understand and apply concepts and procedures from number sense—number and numeration, computation, estimation.

ABOUT THE AUTHORS: Founded in 1998, Bonneville Environmental Foundation (BEF) is essentially a non-profit business. Through the sales and marketing of green power products (known as carbon offsets) BEF gives individuals and businesses a way to participate in solving our most pressing environmental issues. All of the net revenues, or "profits," that the organization makes are reinvested in projects that restore damaged watersheds and support the development and understanding of renewable energy technologies such as solar, wind, and biomass.

Solar-Electric System Puzzle

Teacher Instructions:

1. Begin by introducing the Key Concepts (see below) and explaining how a solar-electric system generates electricity. The vocabulary could be reviewed a number of times by creating a matching game, flash-card quiz, or group discussion.

2. Take students on a guided tour of the school's solar-electric components, point out the system components, and discuss how the components work.

3. Have students complete the Solar-Electric System Puzzle by drawing arrows between the components to show how energy from the sun becomes electricity we can use. This activity can be done individually with handouts or as a group with an overhead projector or Power Point presentation.

4. Review answers as a class.

Key Concepts

To understand how your solar-electric system works, let's begin with the photon. A **photon** is the smallest particle responsible for **electromagnetic radiation**. Electromagnetic radiation is energy derived from the sun in the form of waves. Some of these waves we see, and these are called visible light waves. The sun emits visible waves of light as well as waves that we can't see, like gamma rays, X-rays, ultraviolet light, infrared light, microwaves, and radio waves. All of these different wavelengths contain **energy**, which is carried by the photons. Your solar-electric system turns light energy into electrical energy.

When a photon from the light (or electromagnetic radiation) of the sun strikes a **PV module**, a portion of the photon's energy is absorbed within the material of the module. This absorbed energy knocks loose **electrons** within the solar module, allowing them to flow freely. These "excited" electrons are forced to start moving in a certain direction because of the way the solar module is wired. This flow of electrons in a particular direction is called an **electrical current**, and it is what provides power to things that use electricity like light bulbs, computers, and refrigerators.

The difference between the current made by the photons from the sun hitting the solar module and what comes out of our electrical outlets is the direction that the current flows. The current generated by a solar panel is called **direct current (DC)**, which means that the electrons flow directly from the source to the user in one direction. The type of current that comes out of electrical outlets is called **alternating current (AC)**, which means that electrons flow in both directions between the source and the user. The reason that the United States uses AC current is because it is more efficient than DC because fewer electrons are lost as they flow back and forth. Although the solar panel is generating an electric current, we can't simply plug our appliances into it because our appliances are made to only use AC current. In order to use this electric current to power appliances, we must change the DC current into AC. The part of the system that does this is called an **inverter**. The DC current from the solar panel flows to the inverter, which turns it into AC current, which then flows to a **utility net meter**.

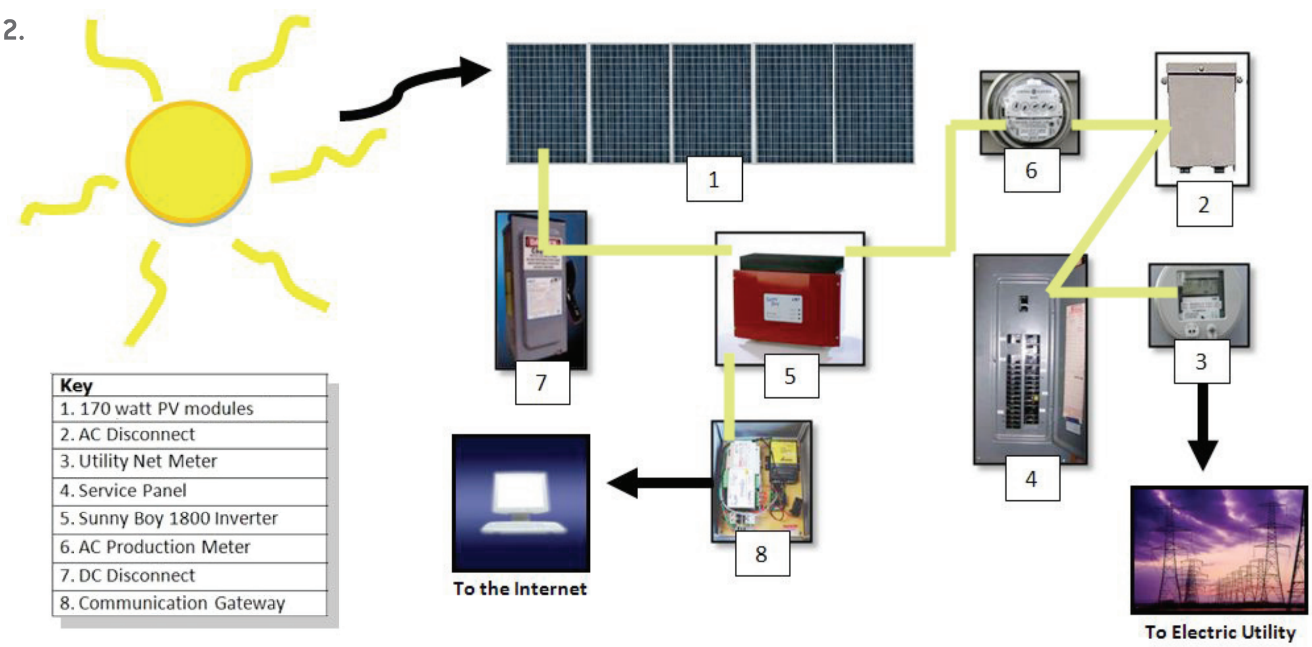
Every building that gets its electricity from an **electric utility** has a meter. This meter is what sends the power from the utility to the building. When your school's solar-electric system is connected to the utility meter, the meter sends the electricity produced directly to your school to power your lights, appliances, and other electronics. Any extra or leftover electricity that your school doesn't need right away is sent by the meter back to the utility, where it will then be sent out to some other building to be used. The **communications gateway** is another piece of equipment in your solar-electric system that keeps track of how much electricity the system is producing and sends that data to the internet, where you will be able to look at and use it.

Solar-Electric System Puzzle

ANSWER KEY

Components		Definition
1. 170 Watt PV Modules	3	Logs electricity sent to the grid from the photovoltaic system.
2. AC Disconnect	7	Cuts the flow of current from the solar panels to the inverter.
3. Utility Net Meter	4	Transfers power from the utility line to a house or from a house to the utility line.
4. Service Panel	5	Converts DC current into conventional AC electricity.
5. 1800 Inverter	8	Gathers system data and relays the information to the internet.
6. AC Production Meter	2	Cuts the flow of current from the inverter to the service panel.
7. DC Disconnect	6	Logs electricity produced by the photovoltaic system.
8. Communications Gateway	1	Photovoltaics used to capture sunlight and convert it into electricity.

2.



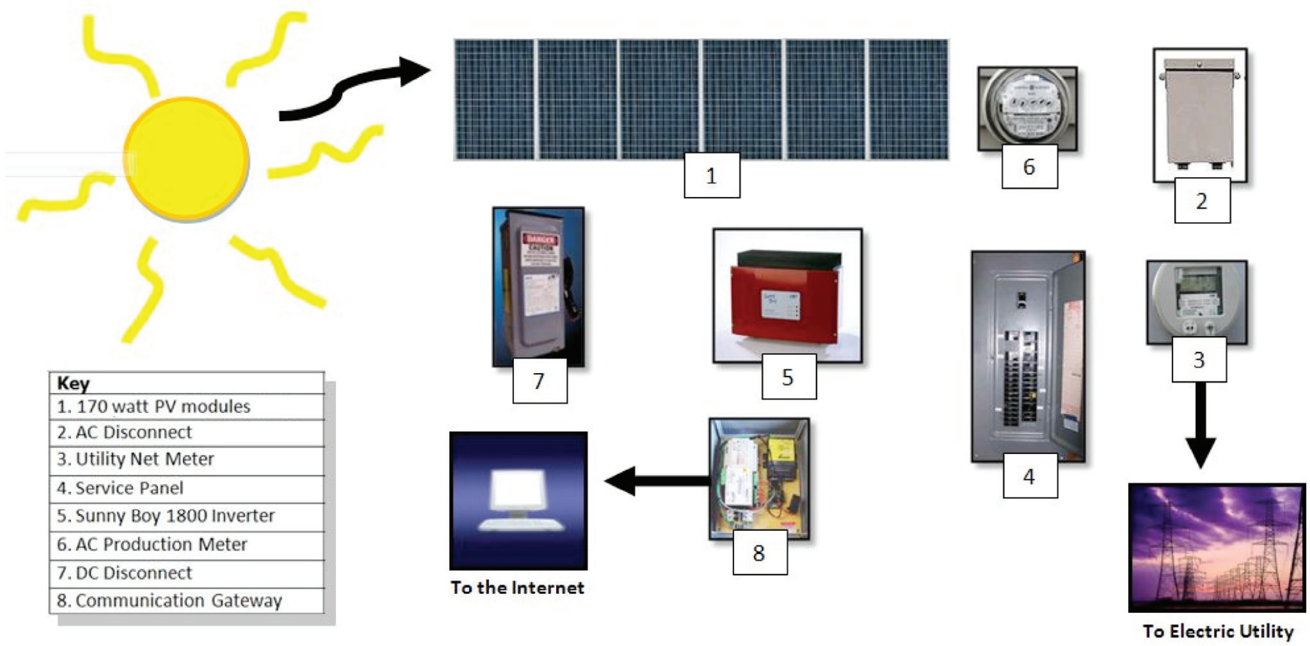
3. Sun energy is gathered by the solar panels. The solar panels turn sun energy into direct current (DC) electricity. The DC breaker cuts the flow of energy from the solar panels to the inverter. Direct current electricity is converted into alternating current (AC) electricity by the inverter. The communications gateway connects to the inverter. The communications gateway gathers system data and transfers it to the internet. The AC production meter logs the AC electricity generated by the PV system. The AC breaker cuts the flow of energy from the inverter to the service panel. The utility net meter logs the amount of energy transferred from the PV system to the grid. The service panel transfers power from the utility line to the grid.

Solar-Electric System Puzzle Worksheet

1. Match the components with the appropriate description. Write the number for the component in the empty space next to the correct definition.

Components		Definition
1. 170 Watt PV Modules		Logs electricity sent to the grid from the photovoltaic system.
2. AC Disconnect		Cuts the flow of current from the solar panels to the inverter.
3. Utility Net Meter		Transfers power from the utility line to a house or from a house to the utility line.
4. Service Panel		Converts DC current into conventional AC electricity.
5. 1800 Inverter		Gathers system data and relays the information to the internet.
6. AC Production Meter		Cuts the flow of current from the inverter to the service panel.
7. DC Disconnect		Logs electricity produced by the photovoltaic system.
8. Communications Gateway		Photovoltaics used to capture sunlight and convert it into electricity.

2. Create a flow from the sun's energy to your school and the electric utility. Make sense of the puzzle shown below by connecting the solar-electric system components in the correct order.



3. Briefly describe the flow of energy through the photovoltaic system.