Allocating Energy from a Photovoltaic System

SPN LESSON #27

TEACHER INFORMATION

LEARNING OUTCOME

Students look up and analyze power ratings for the appliances they use, and make decisions on allocation of the photovoltaic electric energy, as it is generated, to appliance use on an hourly basis. Students then are able to cite examples of compromises that could be made to conserve energy while experiencing minimum effects on lifestyle.

LESSON OVERVIEW: This lesson helps students distinguish between power and the amounts of electric energy generated or used. The purpose of the lesson is twofold: students are to inventory their use of electric energy for home appliances and compare this with the typical total of 6.5 kilowatt-hours (kWh) produced in New York State by a 2 kilowatt (kW) photovoltaic system. Then students are to allocate the photovoltaic electric energy, as it is generated, to appliance use on an hourly basis.

GRADE-LEVEL APPROPRIATENESS

This Level III Physical Setting lesson is intended for use in high school physical science or physics classrooms.

MATERIALS: Student handout

SAFETY: No special precautions are necessary.

TEACHING THE LESSON: This lesson provides an excellent opportunity to distinguish between power (the rate at which electric energy is generated by the photovoltaic system or used by electric appliances) and the amounts of electric energy generated or used. Students are to look up the power ratings for the appliances they use, and then multiply these ratings (in kilowatts, converted from watts) by the time used (in hours) to find the amount of electric energy used (in kilowatt-hours). As a culmination of the lesson, you might want to contrast the net-metered approach in place for your school's PV system to systems that attempt to store excess energy that is produced.

ACCEPTABLE RESPONSES FOR DEVELOP YOUR UNDERSTANDING SECTION:

These responses will vary considerably. Some students may have difficulty cutting their electric energy usage back to 6.5 kWh per day and will have to draw the remainder of their electric energy usage from their local utility. Other students might end up with a stored surplus. These students, however, should be helped to realize that building up an indefinite amount of energy storage into their system is expensive and that since a new supply of solar energy is received every day, there is little point in trying to store more than a day's usage (in the case of extremely overcast weather).

ADDITIONAL SUPPORT FOR TEACHERS

SOURCE FOR THIS ADAPTED ACTIVITY: Data used is provided by Clayton Handleman, Heliotronics Inc.

BACKGROUND INFORMATION: Power is the rate at which energy is produced or used. Its basic unit is the watt. The amount of energy produced or used is determined by multiplying the power by the time. If the power is given in kilowatts and the time in hours, the energy is given in kilowatt-hours. If the power is given in watts and the time in seconds, the energy is given in joules.

REFERENCES FOR BACKGROUND INFORMATION: any physics text

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www.nyserda.ny.gov

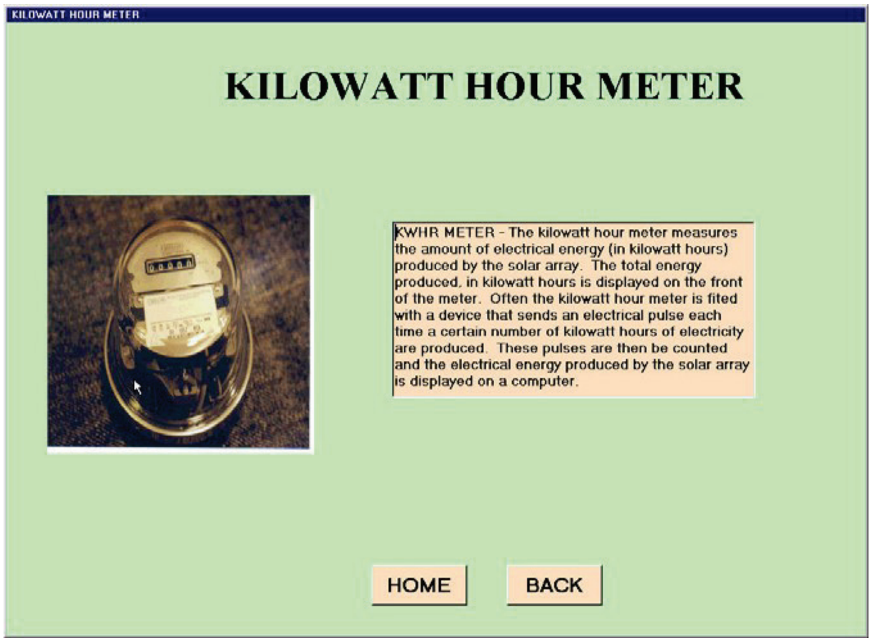
(STUDENT HANDOUT SECTION FOLLOWS)

Name___________________________________

Date ___________________________________

Allocating Energy from a Photovoltaic System

A 2 kW photovoltaic system produces 2 kW only at maximum insolation— when the Sun's rays are shining most intensely on its panels. The number of watts produced at any given time tells us the power, or rate at which energy is produced. The amount of energy produced in any given time interval is found by multiplying this rate by the interval of time. If the rate of energy production is given in kilowatts and the time interval in hours, the amount of energy is given in units of kilowatt-hours. A 2 kW photovoltaic system in New York State can be expected to produce an average of 6.5–7 kWh of electric energy per day.



DEVELOP YOUR UNDERSTANDING

How many kilowatt-hours of electric energy do you use per day? To find out, list the electric appliances you use, the number of hours per day that you use them, and the rate at which they use electric energy in watts, according to the table "Number of Watts for Some Typical Home Appliances" below. If you list this information in a spreadsheet like the one below, you can facilitate your calculations. To determine the number of kilowatts in the fourth column, divide the number of watts in the third column by 1000. To determine the number of kilowatt-hours per day, multiply the number of kilowatts in the fourth column by the number of hours per day in the fifth column.

Number of Watts for Some Typical Home Appliances

Appliance	Number of appliances	Power (W)	Power (kW)	Number of hours/day	Number of kWh/day

1. What is the total number of kilowatt-hours used in a day?

When it comes to the generation and use of electric energy, it is also important that it is generated when it is wanted. Otherwise, it must be stored. Even if you use less than 6.5 kWh per day, it is unlikely that the amount of electric energy produced in every given hour of the day will match the amount you want to use. Therefore, some electric energy will need to be stored for future use. If you use more than 6.5 kWh per day, you will need to get the rest of what you use from your local electric utility. In column two of the table below, list the number of kilowatt-hours generated in each hour of a typical day by a 2 kW system. In column three, list how you will allocate this electric energy (identify what appliances are to be used for what amount of time, and then total up and record the number of kilowatt-hours). In column four, indicate how many kilowatt-hours are to be stored for future use. If you use stored energy, this number is to be reduced. If you draw energy from the utility, indicate this in column five. Add columns four and five to determine your total electric energy storage and total reliance on your local utility.

Hour of day	#kWh generated	Allocation of kWh	Number of kWh stored	Number of kWh drawn from local utility
12 m – 1 a.m.	0			
1 a.m. – 2 a.m.	0			
2 a.m. – 3 a.m.	0			
3 a.m. – 4 a.m.	0			
4 a.m. – 5 a.m.	0			
5 a.m. – 6 a.m.	0			
6 a.m. – 7 a.m.	0			
7 a.m. – 8 a.m.	0.1			
8 a.m. – 9 a.m.	0.25			
9 a.m. – 10 a.m.	0.5			
10 a.m. – 11 a.m.	0.9			
11 a.m. – 12 n	1.5			
12 n – 1 p.m.	1.5			
1 p.m. – 2 p.m.	0.9			
2 p.m. – 3 p.m.	0.5			
3 p.m. – 4 p.m.	0.25			
4 p.m. – 5 p.m.	0.1			
5 p.m. – 6 p.m.	0			
6 p.m. – 7 p.m.	0			
7 p.m. – 8 p.m.	0			
8 p.m. – 9 p.m.	0			
9 p.m. – 10 p.m.	0			
10 p.m. – 11 p.m.	0			
11 p.m. – 12 m	0			

2. How many kilowatt-hours did you cumulatively store in your system?

3. How many kilowatt-hours did you draw from your local utility?

4. What changes could you make to eliminate reliance on your local utility?

Number of Watts for Some Typical Home Appliances

(from *Energy: How Does It Impact Our Lives?* ♥1994 by the Research Foundation of the State University of New York on behalf of the New York Science, Technology and Society Education Project)

Electric Appliance	Power (W)	Electric Appliance	Power (W)
Air cleaner	50	Hot plate	1200
Air conditioner, large window	1300	Hot water circulating pump	200
Blender	390	Humidifier	177
Broiler	1200	Iron	1100
Can opener	100	Light bulb	60
Carving knife	100	Light bulb	75
Clock	2	Light bulb	100
Clothes dryer	5000	Lighted mirror, fluorescent	20
Coffeemaker, drip	1100	Lighted mirror, incandescent	50
Coffeemaker, percolator	600	Microwave oven	1450
Coffeemaker, urn	1200	Mixer	150
Computer	300	Oil burner motor	260
Computer monitor	600	Portable electric heater	1350
Computer printer	200	Radio	70
Corn popper, hot air	1400	Range	12000
Corn popper, oil	575	Refrigerator/freezer, frost free, 17.5 cu.ft.	450
Curling iron	40	Sewing machine	75
Deep fryer, mini	600	Shaver	15
Deep fryer, regular	1500	Skill saw	1000
Dehumidifier	625	Slow cooker, Crock-Pot™	200
Dishwasher	1200	Stereo	80
Drill, ¼”	250	Sunlamp	300
Electric blanket	170	Television, solid state (B & W)	160
Fan, attic	375	Television, solid state (color)	300
Fan, table	100	Toaster	100
Fan, window	200	Toaster oven	1500
Food grinder	200	Toothbrush	10
Freezer, frost free 16 cu.ft.	400	Trash compactor	400
Freezer, manual defrost 16 cu.ft.	340	Typewriter	30
Frying pan	1200	Vacuum cleaner	650
Garbage disposer	445	Waffle iron	1200
Grill, sandwich	1200	Warm air furnace motor	375
Hair dryer, hand held	1200	Washing machine	375
Hair setter	350	Water bed heater	375
Heat lamp	250	Water heater	4000
Heating pad	60	Well or water pump	335