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Student Objective

The student:

- given the size of their school's photovoltaic array, the amount of available sunlight and a fixed rate for electricity, will calculate the monetary savings to the school daily, monthly and yearly
- given their family's electricity usage, will be able to calculate the array size needed for their home to be a 'zero energy' home

Key Words:

conservation
energy efficiency
kilowatt hours
zero energy home

Time:

2 class periods

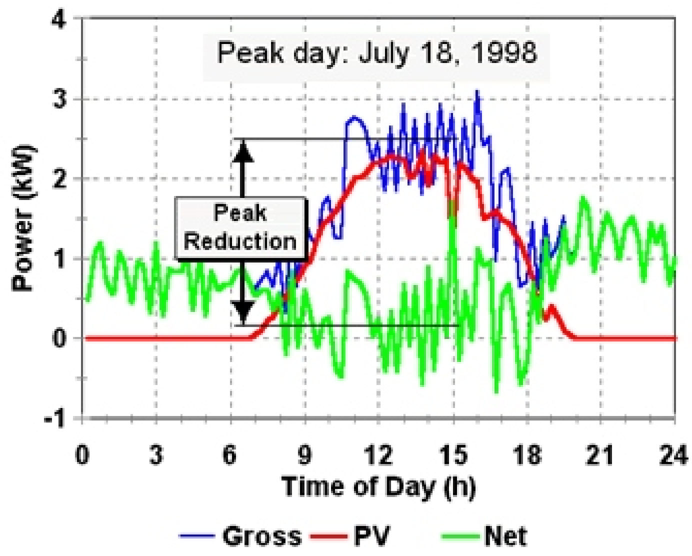
Materials:

- computer with internet access
- Insolation (iradiance) charts for your latitude/climate pattern (or Insolation charts from the *Good Day Sunshine!* activity)
- electricity bill and online access to family's electricity usage

Background

A '**net zero energy**' building or home is one that produces as much electricity as it uses over the course of a year. Most zero energy homes are also connected to the utility grid. When this is the case, it is not important that the energy produced equals the energy used in a minute-to-minute situation, or even on a daily basis. Electricity is purchased from the utility when the system isn't producing enough for the home's demand (nighttime for example), and then sold back to the utility when the system is producing more than the building needs (when the sunlight is intense, when no one is home, or on very sunny days). This averages out the production and the usage to equal zero or near zero. The graph below from the first 'zero energy' home research in the United States, done by the Florida Solar Energy Center in Lakeland Florida, demonstrates this fact.

In the graph below you can see that when the sun isn't shining in the morning and evening, the homeowners are buying their power from the power company (green line). But during the day when the sun is bright and the photovoltaics are producing power (red line), the homeowners are actually 'selling' power back to the utility (green line dips below zero).



The interesting thing for Florida homeowners is the near match that the output from a photovoltaic array (red line) makes with the energy consumption of the house (blue line). When our houses are needing the most electricity for air conditioning, the systems are also producing the most power. If you're interested in more information about this study, the link to the zero home research and this particular one in Lakeland Florida is located in the Internet Sites section.

Because of the size and cost of photovoltaic systems, it is advantageous to improve the **energy efficiency** of a building before buying and installing enough photovoltaics to make the building 'zero energy'. Research has shown that doing the energy **retrofits** listed below will reduce energy usage in a home by 56%. In the order from the easiest and most cost effective to the larger retrofits are:

- Install a programmable thermostat
- Fix leaky ductwork
- Replace incandescent lightbulbs with compact florescent or LED lighting
- Insulate hot water storage tank
- Upgrade ceiling insulation
- Replace old refrigerator with an Energy Star model (and get rid of the old refrigerator in the garage!)
- Install a solar thermal hot water system
- Install a energy efficient air conditioner

In Florida, 51% of our electricity is used by our homes. By reducing the amount of conventionally produced electricity needed to power our homes we can dramatically decrease the amount of pollution, and other harmful environmental effects.

Procedure (prior to class)

1. Send a note home advising the parents that the students will be learning how to calculate their family's electrical use with the goal of energy conservation and saving money.

Request that a copy of the family electric bill (or a printout of energy use from the utility website) be brought to school by the student.

2. For students that are unable to obtain their family's bill, have copies of an anonymous bill available for them to use.

Procedure (during class)

1. If necessary, divide the students into groups according to how many computers are available to them.
2. Lead a review discussion on their findings during the Good Day Sunshine! activity. Tell the students that now they have all the tools they need to be able to predict how much electricity their school's system will produce next month, and also how much money the system will save the school in electricity that will not have to be bought from the power company.
3. Students should complete Problems 1 - 3 in their Science Journals using insolation charts from the same latitude and climate pattern as your school's location. If local charts aren't available, the insolation chart from the *Good Day Sunshine!* activity for Orlando may be substituted.
4. Assist the students as needed.
5. Note–there are two different ways to attack the calculation in question 3. Students can either figure each month's savings separately and then add them together, or they could figure each months total Peak Sun Hours and add them together to get a yearly total Peak Sun Hours and then multiply this times the system size and the cost of electricity.
6. Have the students share how they calculated the total, encouraging them to see that because multiplication is cumulative, there are at least two different ways the problem could be approached.

Internet sites

http://www.fsec.ucf.edu/en/consumer/buildings/homes/priorities.htm

Florida Solar Energy Center list of Priorities to reducing energy usage in new and existing buildings

http://www.fsec.ucf.edu/en/research/buildings/zero_energy/index.htm

Florida Solar Energy Center's Zero Energy Homes research. The Lakeland house has graphs and photos that students can use to understand how a photovoltaic system can be effectively used to power a family home.

http://energy.gov/energysaver/articles/estimating-appliance-and-home-electronic-energy-use

U.S. Department of Energy site to estimate and home electronic use. Includes typical wattages of various appliances

https://www.energystar.gov/index.cfm?fuseaction=HOME_ENERGY_YARDSTICK.showGetStarted

U.S. Environmental Protection Agency's Energy Star Home Energy Yardstick. The site assesses the energy efficiency of your home through a question answer format.

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conservation - the preservation and careful management of natural resources

energy efficiency - the process of doing more with less

kilowatt hours (kWh) - the standard unit used to describe electricity usage over time

zero energy home - a home that produces as much energy as it uses when averaged over a year

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1. How much electricity will your school's photovoltaic system produce this month (assuming that this month is an 'average' month)? To figure this out:
   - Multiply the size of your school's system in kilowatts by the number of Peak Sun Hours per day for this month. That will give you the kilowatt hours per day your system produces. (If you have not calculated the size of your system in a previous lesson, it can be found on your school page on the Energy Whiz website. The Peak Sun Hours can be found in an insolation table for your area using the tilt angle closest to your schools tilt angle. If you don't have a table for your area, use the Orlando table from the *Good Day Sunshine!* activity.)

     For the month of ________, the average kilowatt hours per day: __________ kWh

   - Multiply the daily total by the number of days in the month to get the total kilowatt hours of electricity that it is expected will be produced this month.

     For the month of ____________ it is expected that our school's system will

     produce ____________kWh of electricity.

2. How much money is the school saving this month by producing some of the electricity being used by photovoltaics rather than buying it from the electric company? (Use 12¢ per kilowatt hour for electricity cost)

3. How much money will the school save each year? (Remember–each month has a different number of Peak Sun Hours). Show your work below and on the next page.

4. If you could move the photovoltaic system at your school to your home and hook it up there, would it produce all the electricity that your family currently uses? (Use your family's electricity bill/statement or one supplied by your teacher to calculate this)

- If the photovoltaic system produces more than your family uses, approximately how many panels (or what %) could be removed and still have the array be big enough to supply your family with electricity? (Either show your work or describe below how you calculated your answer)