$olar $avings

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
- will understand the concept of a 'zero energy' home or building
- given their family's electricity usage, will be able to explain whether or not their school's array produces enough power to supply their family's electrical power usage
- will develop a list of recommended conservation measures to help reduce electrical usage and watse

Key Words:
conservation
energy efficiency
kilowatt hours
zero energy home

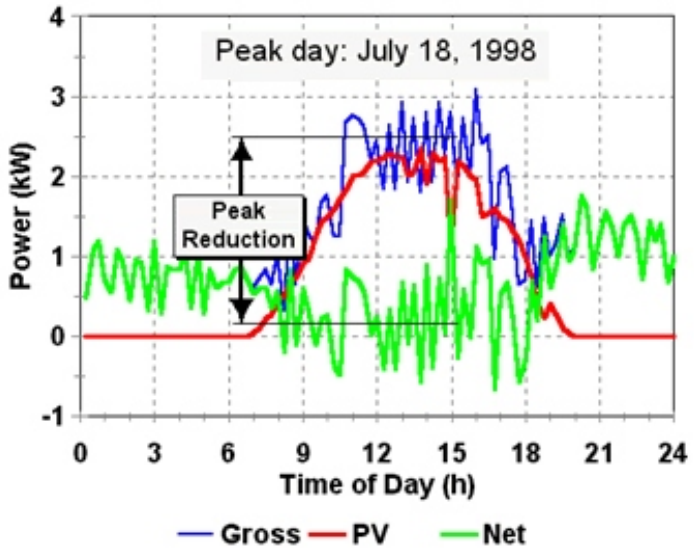
Time:
2 class periods

Materials:
- computer with internet access
- Insolation (iradiance) charts for your latitude/climate pattern (or Insolation charts from the *Good Day Sunshine!* activity)
- gallon gasoline jug (or gallon water jug with 'gasoline' printed on it)
- poster board (12 sheets)
- markers, paints and other art materials for making posters
- 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 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 12 groups, one for each month of the year.
2. Lead a review discussion on their findings during the Good Day Sunshine! activity. Tell the students that now they are talking about the amount of electricity production (and usage) over time. Make sure that they understand the difference between an instantaneous power reading (watts, kilowatts) and the measure of electricity over time (watt hours, kilowatt hours). An activity that can help with this discussion is below.
   - show the students a partially filled gallon gasoline container, or a partially filled gallon water jug with 'gasoline' printed on it
   - ask the students to tell you about it. Let the students free respond; the goal is to get them to speculate on what can be done with the fixed amount of energy (part of a gallon of gasoline)
   - ask the students how long a car would run on a the jug of gasoline. The goal is to have the students recognize that they don't have enough information to answer the question; they need to know how much gasoline is in the container and also how much gasoline their cars use.
   - ask the students what unit of measure we use when we talk about how far a car can go on a fixed amount of gasoline (mpg). Explain to the students that similarly there are units of measure for electricity production and usage of **power over time** – watt hours (number of watts an hour) and kilowatt hours (number of thousands of watts over an hour).
3. Tell the students that they will be working in groups to predict how much electricity their school's array will produce each 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.
4. Assign each group a month of the year. Tell them they will be calculating the power production for that month, and how much money the system will save the school that

month.

5. In their groups, they should complete the problems in their Science Journals. Provide the students with 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.
6. Assist the students as needed.
7. Write 'kWh Production and $ Savings' on the board with the months below in a column on the left with space to the right for the group's totals. After all the groups have finished their calculations have the groups write their totals on the board. Lead a discussion on how weather has affected the totals each month.
8. With the student's input, total the production for the year, and calculate the yearly savings for the school. Explain to the students that even though this seems like a lot of money, the school uses a lot more electricity than this.
9. Lead the class on a discussion of how the school could save (conserve) on its electricity usage. Encourage them to think of things that students and teachers could do as well as things that administrators and facility managers could implement. Make sure that the students understand that production of energy and conservation of energy are both important and both part of the solution to pollution and energy problems.
10. Explain to the students that each group will be creating a poster to represent their month. The poster should show both parts of energy–both production and use (conservation). The goal is for them to show others not only how much electricity is produced by their PV array and money saved by the school, but also energy efficiency and energy conservation ideas that could be put in place to make the electricity from the PV array go even further.
11. Write the student conservation internet sites on the board (below), and tell the students that if they need ideas for the conservation side of the poster that they can use these sites (and any books you may have in your classroom library).
12. Help the students as needed.
13. Posters could be hung in a common area of the school to provide information to all students about their photovolatic array and energy conservation.

Further Research

1. Use the student's posters to make a display or brochure on energy conservation for the school. Implement as many ideas as feasible.
2. Have the student's research ideas of conservation at home and draft a realistic action plan for their family.

Internet sites

http://www.aaps.k12.mi.us/aaps/ease/energy_saving_tips

Ann Arbor Michigan Public School site with student Energy Saving tips for home and school

http://www1.eere.energy.gov/education/pdfs/energyactionlist.pdf

U.S. Department of Energy, Energy Efficiency and Renewable Energy site. The Easy Energy Action Plan in handout, check-off format

http://www.energystar.gov/index.cfm?c=kids.kids_index

U.S. Department of Energy, Energy Star student site. Includes interactive 'You Can Make Big Changes' conservation idea page.

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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 PV system produce the month you have been assigned? Here is how to figure this out:

   - Month your group has been assigned: _____
   - Write the size of your system (in kW) here: _____kW (Hint: If you don't know its size, look on your school's page on the Energy Whiz website for the total 'system size'.
   - From the Irradiance chart (Good Day Sunshine lesson or one your teacher provides), write the number of Peak Sun Hours each day. _____Peak Sun Hours per day
   - Multiply the kW size of your school's PV system by the number of Peak Sun Hours per day for this month. That will give you the kilowatt hours per day your system produces. Label your total **kWh per day in** (your month).

     _____
   - Number of days in the month you were assigned _____

- Multiply the number of days in the month by the number of kWh per day to get the total kWh of electricity your array will produce in the assigned month. Label your total: **Total kWh for** (your month).

_____

2. How much money is your school saving during the month by producing the electricity by your PV array rather than buying it from the electric company? (Hint: Use 12¢ per kilowatt hour for electricity cost)

   - Multiply the total kWh produced for the month by 12¢. Label your answer: **Money saved by the school in** (your month)

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