Lesson 13: Are Renewables Right for Me?

Adopted/Revised From
N/A

Grade Level
6-12

Objectives
- Determine the technical feasibility of wind and/or solar energy at your school
- Calculate the costs and savings associated with solar or wind at your school
- Use online tools to assist in this exercise
- Identify the factors that are considered when deciding if solar and/or wind energy is right for a school

Overview
Students assess the technical and economic feasibility of using wind and/or solar energy to generate electricity at their school using site-specific information from the internet.

Materials
- Computer with internet access
- Tape measure (optional)
- Compass (optional)

Estimated Cost of Materials
None

Computer Required?
Yes

Duration
1-2 class periods

Primer References
1.1 Forms of Energy
3.1 Solar
3.2 Wind

Related Articles
- "Wind Turbines Whip Up Excitement, School Pride" – National Renewable Energy Laboratory

Engagement
1. What energy source(s) currently provide electricity to the school?
2. What are some alternatives? (Use PV panels and/or model wind turbines as visual aids.)
3. What are the advantages and disadvantages of using wind and/or solar energy?

4. Make a hypothesis: which is the better resource for the school (wind or solar)? Why? (Although it may seem windy or sunny all the time, personal observations aren't sufficient to determine whether or not a site would be good for a solar panel or wind turbine.)

Investigation

Now we're going to conduct an assessment of our school and use research data to determine if solar and/or wind is a cost-effective option for our school:

1. Divide the students into groups that want to assess the feasibility of solar and groups that want to assess the feasibility of wind.
2. Based on their group's selection/assignment, students should use the appropriate activity sheet to complete the exercise.

For Solar:

1. Have students in the solar group go out and visually (or with a compass and tape measure) estimate tilt, azimuth, and usable square footage of the school's roof (all major sections) and enter the data into the activity sheet.
2. If the top of the roof cannot be seen, estimate that 65% of the roof square footage is available for solar PV (not interfered with by heating units, vents, etc.).
3. Students should then follow the instructions on the activity sheet to use the National Renewable Energy Lab's online PV Watts tool and deductive skills to analyze that data for electricity generation.
4. If the solar team determines that the school roof is capable of generating more electricity than the school consumes in a year, have the team determine the maximum system size for a solar PV array using information gathered on the activity sheet.

For Wind:

1. Following the activity sheet, students find their CSU Anemometer Loan Program site number (online), enter relevant data, and determine the direction the prevailing winds come from by using the site's wind rose.
2. Then have students in the wind group go out and identify a location on school property as far away from upwind obstructions as possible.
3. Once there, students visually (or with a tape measure) estimate the height and distance away of the most prominent upwind obstruction. (This may or may not be the school building.)
4. Students should then enter this data on the activity sheet and continue their exercise using this sheet.

Class Review

1. Ask the groups to share the results of their experiments by reviewing each of the questions on the activity sheets as a class.
2. Is a solar PV system technically feasible at the school? A wind system?
3. Based on payback periods calculated by the groups, which is the most cost-effective option for your school – wind or solar? Why?

Elaboration

Now we have to look deeper into how solar and wind energy systems transform solar or wind energy into electricity:

1. Have students read the Primer References.
2. How does each technology generate electricity?
3. As a class, list or "map" the energy forms associated with the transfer of energy from its source at the sun and/or wind to the light we see from a light bulb.
4. During which energy transfer does the most significant inefficiency take place?

Instructor Notes

Solar

- If the class has not already conducted the "Watt's Your Angle" lesson, be sure to transmit that the ideal tilt of a solar panel equals the latitude of a location and the ideal azimuth for anything in the northern hemisphere is true south (180 degrees).
- If an open space owned by the school is a better candidate for solar than the school's roof (i.e. because it needs to be replaced), ask the students to calculate the usable area, tilt, and azimuth of the open space instead.

Wind

- It may be worthwhile to investigate whether or not there is enough space at the school to even potentially put up a viable wind turbine before engaging students in this activity.
- The recommended hub height is 2H + the radius of the rotor where H = the highest point of the most prominent upwind object.
- If a turbine location meets the distance requirement (at least 20H away from obstruction), the ALP site-given hub height can be used.
- Students need to adjust the cost of their turbine and the net energy output of their turbine above $7.50/watt if the turbine hub height must be increased above the ALP site-given hub height as indicated in the activity sheet "Assumptions".

Extensions and Variations

- Have students conduct the Watt's Your Angle and/or Blade Design Competition lessons either before or after this lesson.
- Use Colorado State University Extension's Solar PV Feasibility Calculator to more accurately assess the economic feasibility of a school solar array (http://www.ext.colostate.edu/energy/solar.html).
- Conduct the school energy audit lesson plan to see what percent of the school's energy use would be offset using the same solar array/wind turbine after implementing energy efficiency measures. Would system costs for renewable energy decrease?
- Students can present their findings using graphs and or powerpoint to the class and/or school administrators.

References/For More Information

National Renewable Energy Lab's PV Watts (Version 1):
http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/
Colorado State University Anemometer Loan Program:
http://www.engr.colostate.edu/ALP/

Are Renewables Right for Me - Solar?

Roof section	Tilt	Azimuth	Roof square feet	Number of panels	Maximum watts	Maximum kW (DC)	Annual kWh (AC)*	Value of the electricity	Installed cost before incentives	Rebates and incentives	Total installed cost	Simple payback period (years)	CO2 emissions reduced (tons)
					Total								

Assumptions

Each panel has a 230 watt capacity
Each panel is 15 square feet
As a default, estimate that 65% of a school roof's area is usable for solar PV (not interfered with by air conditioning units, vents, etc.)
For a tilted roof, assume that panels can fill the entire usable area at the tilt and azimuth of the roof itself.
For a flat roof, assume that each panel has a footprint of 30 square feet of roof space that accounts for the panel mount and winter shading at the ideal tilt and azimuth.
For the value of electricity, use the data from an actual school electricity bill or use a default of $0.08/kWh
It costs $5.50 per installed watt of solar PV
A tax credit worth 30% of the installed cost is available as an incentive
Each kWh produced will save 1.4 lbs. of CO2 from being emitted

*Use the National Renewable Energy Lab's online "PV Watts" tool to determine annual kWh:
a. Go to http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/ and click on Colorado in the U.S. map.
b. Locate the nearest data site to your school and click on it.
c. Enter the size, tilt, and azimuth for a section of your school's roof, then click "Calculate" to get AC energy (kWh).
d. Repeat for all sections of your school's roof and enter the data in the worksheet.

Questions

1. Using either the sample school electricity bill (times twelve) or actual school electricity bills over a one-year period, determine what percentage of the school's electricity use can be generated by solar PV.

2. If more than 100%, determine the maximum size system your school would need and calculate the cost and simple payback period on that system.

3. If a solar PV system has a 25-year lifespan, would your school's system be economically feasible?

4. If electricity rates increased to an average of $0.15 over the 25-year life of the array, would your system be economically feasible?

5. How does tilt affect electrical generation? What is the ideal tilt of a solar PV system at your school?

6. How does azimuth affect electrical generation? What is the ideal azimuth of a solar PV system at your school?

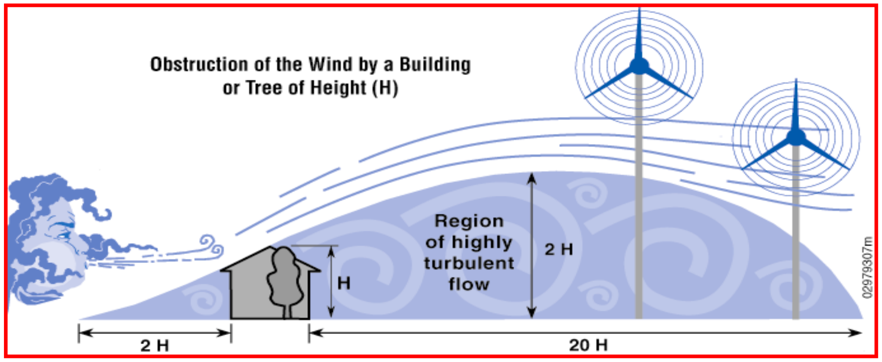
Are Renewables Right for Me - Wind?

Identify the best site for a wind turbine at your school:

Annual school kWh used*	ALP site number**	Turbine generating closest kWh under school use	Rotor diameter of turbine (convert to feet)	Hub Height (convert to feet)	Prevailing winds come from (direction)	Identify possible location for turbine	Highest point of most prominent upwind object in feet (H)	Distance away from possible turbine location in feet	20H	Meets horizontal distance requirement?	If no, minimum recommended height of rotor bottom	Minimum recommended hub height

Assumptions

A wind turbine should be at least 2H in height if within 20H of the nearest object per below:



Calculate the payback period for a turbine near your school:

	Annual school kWh used*	ALP site number**	Turbine generating closest kWh under school use	Rotor diameter of turbine (convert to feet)	Rotor power (kW)	Average annual net energy output of turbine (kWh)	Annual value of the electricity	Installed cost before incentives	Installed cost after incentives	Simple payback period (years)

Assumptions
1 meter = 3.28 feet
For the value of electricity, use the data from an actual school electricity bill or use a default of $0.08/kWh
It costs $7.50 per installed watt of wind
A tax credit worth 30% of the installed cost is available as an incentive
Each kWh produced will save 1.4 lbs. of CO_2 from being emitted

*From sample monthly bill times 12 or from actual school billing data

**Use the Colorado State University Anemometer Loan Program website as follows:
a. Go to http://www.engr.colostate.edu/ALP/ and click on "ALP Sites and Data" on the left navigation bar.
b. Locate the nearest data site to your school and click on it.

Questions

1. Based on the height of objects (i.e. trees and building) near your school, is a wind system practical?

2.Using data from your ALP site, graph the relationship between tower hub height and wind speed.

3. Based on the following formula, which factor is the most important in determining the power of wind: air density, the swept area of the blades, or the wind speed?

Power in the Wind = $\frac{1}{2}\rho A V^3$

ρ = air density

A = swept area of the blades

V - wind speed

4. Using either the sample school electricity bill (times twelve) or actual school electricity bills over a one-year period, determine what percentage of the school's electricity use can be generated by the selected wind turbine.

5. If a wind energy system has a 25-year lifespan, would a system near your school be economically feasible? What other factors would affect the economic feasibility of the wind system?