

Renewables Workshop

Last updated: July 22, 2013

Background:

The term renewable energy is used to describe energy sources that are naturally replenished (EPA Glossary). The primary types of renewable energy sources are: solar energy, wind energy, hydropower, biomass burning, geothermal energy, and wave energy. Note, while there is considerable discussion as to whether hydropower is technically a renewable energy source, for simplicity we will include it in this discussion.

Solar energy is a prominent type of renewable energy. Solar rays from the sun are converted into heat or electricity. There are three major types of solar energy technology: passive solar design, active solar thermal systems, and photovoltaics. **Passive solar design** is used to generate heat. For instance, passive solar design buildings are constructed to maximize exposure to sunlight by placing windows on the south side of house, having the front of the house face the south, and using dark materials to effectively store sunlight and heat. **Active solar thermal systems** use the sun's rays to heat air and water. For instance, many hot water heaters in developing countries use mirrors to bounce light onto a water tank to heat the liquid. **Photovoltaics, or solar cells**, contain semiconductor materials that convert solar radiation to electricity. If the solar cells absorb more energy than needed, that energy can be credited to the grid, where it can be used later when the sun isn't shining. Harvesting solar energy through photovoltaics is quiet, relatively pollution free, and does not increase greenhouse emissions. While photovoltaics are quite expensive to install and maintain (even in comparison to other solar energy technologies), the technology is decreasing in price (About Solar Power). In addition, solar panels are bulky, and the technology is not as efficient as other technologies (Whitburn, Greg).

Wind energy is a second prominent type of renewable energy. Kinetic energy from the wind is harnessed by a wind turbine. The wind moves the blades on the turbine, which creates mechanical energy by spinning a shaft inside of the turbine. The shaft connects to a generator, and the energy is converted into electricity by a generator (Wind Program: How Do Wind Turbines Work?). Like solar energy, there are both advantages and disadvantages to implementing wind energy technology. Wind energy doesn't require the burning of fossil fuels, the technology doesn't take up a lot of space, and the turbines are easily implementable in remote locations. However, wind power can be unreliable if the wind strength in an area isn't strong enough. In addition, wind power doesn't produce as much electricity as a traditional power station, noise pollution can be similar to that of a jet engine, and many people think that the turbines are eyesores (Advantages and Disadvantages of Wind Energy).

In addition to wind and solar power, hydroelectric energy, biomass, geothermal energy, and wave energy are also sources of renewable energy. Hydroelectric energy is generated by forcing water – often at a dam – through a hydraulic turbine connected to a generator. While there are no “harmful” air emissions associated with hydropower, studies vary on its release of

greenhouse gases, and the technology can significantly affect river systems and ecosystems (Hydroelectricity). Biomass energy is energy from plants and plant-derived materials used as fuels, for power production, and for products that would otherwise use fossil fuels (NREL: Learning – Biomass Energy Basics). Biomass energy is clean-burning energy, is abundant, and would reduce both dependency and the number of landfills. However, it's also expensive, inefficient, and increases carbon emissions (Advantages and Disadvantages of Biomass Energy). Geothermal energy uses the heat from the earth – either from hot water reservoirs or shallow ground near the Earth's surface. The heat is used directly, used to produce electricity, or used in a heat pump (NREL: Learning – Geothermal Energy Basics). While geothermal energy reduces reliance on fossil fuel, is a source of cheap energy, and doesn't cause any pollution, it's expensive to install and not a widespread source of energy (Advantages of Geothermal Energy). Finally, the most experimental of the listed technologies is wave energy. Wave energy is produced when generators are placed near or at the surface of the ocean in an offshore location. While wave power has an enormous potential to generate energy, they are only beginning to be developed and tested (Ocean Wave Energy).

Objectives:

1. Identify pros and cons of different types of renewable energy (land use, intermittency, different types of renewables)
2. Explain why renewable energy works in some places better than others
3. Explain the relationship between wind speed and wind power output
4. Explain the physics of wind and solar generation
5. List renewable energy policies and which ones are in place (RPS, carbon tax, subsidies)

Materials:

- Wind kits (1 per group)
 - Suggested Source: http://www.amazon.com/Green-Science-Windmill-Generator-Toysmith/dp/B0016PBH9Q/ref=sr_1_3?ie=UTF8&qid=1340722953&sr=8-3&keywords=wind+turbine+kit
- Voltmeters (1 per group)
- Electric fan (the more the better; a window fan works well)
- Plastic Bottles (1 per group)
- Manila Folders (2 per group)
- Scissors (1 per group)
- Tape (1 per group)
- Laptop and projector (for powerpoint presentation)
- Blackboard and Chalk

Safety Concerns:

- Depending on the type of fan used, goggles and/or oral warnings not to touch the fan blades may be appropriate.

Vocabulary:

- Solar energy: energy from the sun's rays
- Photovoltaics: cells that contain semiconductor materials to convert solar energy into electricity
- Wind energy: kinetic energy from the wind moves a turbine, generating mechanical energy that can be converted into electricity
- Hydroelectricity: energy generated by forcing water through a turbine connected to a generator
- Biomass: plants and plant-derived material
- Biomass energy: using biomass as a fuel, for power production, or to replace fossil fuels
- Geothermal energy: energy derived from the heat of the earth
- Wave energy: energy produced from ocean waves offshore

Procedure:

Time	Activity	Description	Supplies
15	1. Introduction	<ol style="list-style-type: none"> Figure out what the students already know about renewable energy. Ask questions such as the ones below, while taking notes on the blackboard. Don't give too much feedback. <ol style="list-style-type: none"> What is renewable energy? What kinds of renewable energy technology do you know about? Why do people want more of it? How do you think renewable energy technologies work? Ask which state produces the most renewable energy. Show the NREL resource map of wind and solar energy. <ol style="list-style-type: none"> NREL Wind Resource Map - http://www.nrel.gov/gis/images/80m_wind/USwind300dpe4-11.jpg NREL Solar Resource Map - http://www.nrel.gov/gis/images/eere_csp/national_concentrating_solar_2012-01.jpg Briefly introduce specific renewable energy technologies. <ol style="list-style-type: none"> Solar Wind Hydro Biomass Geothermal Wave 	Chalkboard and chalk, computer, projector
15	2. Group Discussion	<ol style="list-style-type: none"> Divide the class into groups of about 3 students each. Have them brainstorm advantages and disadvantages of each 	Worksheet, Chalkboard

		<p>technology and record their findings on the given worksheet.</p> <ol style="list-style-type: none"> Have each group focus primarily on two topics Have them discuss the technologies in terms of land use, intermittency, expense, resource base, how developed the technology is, and wildlife Have the instructor(s) walk around, listen to conversations, and offer suggestions <p>3. Bring everyone back together and go over each group's list of advantages and disadvantages. Talk about each technology in more detail while adding to the lists.</p>	and chalk (to write down list)
10	3. Introduction to solar / wind	1. Introduce the students to how solar power and wind power work.	Computer, projector,
20-25	4. Wind Kits Activity	<ol style="list-style-type: none"> Break the students into groups such that there are four or five groups. Give each group of students a wind kit, an electric fan (or access to a window fan if electric fans aren't possible), 2 manila folders, a voltmeter, scissors, and tape. Challenge the students to increase the performance of the wind kit by improving the blades. Have them measure the power output of each different trial. 	Per group: one wind kit, an electric fan or window fan, 2 manila folders, scissors, tape, a voltmeter
10	5. Policy Discussion	<ol style="list-style-type: none"> Begin a discussion on renewable energy policy with the students. Ask questions such as: <ol style="list-style-type: none"> Should we subsidize these technologies? Why or why not? Why might we need subsidies to get these technologies off the ground? 	
10	6. Extra – Obscure Technologies	<ol style="list-style-type: none"> If time, introduce more obscure renewable energy technology examples. <ol style="list-style-type: none"> Piezoelectric dance floors Kite power Space solar farms Ask the students if they can think of any other ideas for strange types of renewable energy. 	Computer, projector

Additional Resources:

Reputable

Ocean Wave Energy

Bureau of Ocean Energy Management "Ocean Wave Energy." *Bureau of Ocean Energy Management*. Web. 11 Jul 2013. <<http://www.boem.gov/Renewable-Energy-Program/Renewable-Energy-Guide/Ocean-Wave-Energy.aspx>>

The BOEM page on ocean wave energy gives a brief introduction to what the technology is, the amount of energy it can generate, and the different forms of wave energy being tested. Teachers who simply want an introduction to the topic could look here.

CMU Renewable Energy Pamphlet

Carnegie Mellon University. "Managing Variable Energy Resources to Increase Renewable Energy's Contribution to the Grid." *Scott Institute for Energy Innovation*. Web. 10 Jul 2013. <<http://www.cmu.edu/energy/public-policy/renewable-energy-guide.pdf>>.

CMU's Renewable Energy PDF from the Scott Institute gives a succinct, well-diagramed look at what renewable energy is and how it's being used. The future of renewable energy and the challenge of implementing renewable energy technologies are also discussed. Teachers looking for a reliable source for an outline of renewable energy topics could look here.

EPA Glossary.

Environmental Protection Agency. "Glossary." *Environmental Protection Agency*. Mar 2013. Web. 5 Jul 2013. <<http://www.epa.gov/greenpower/pubs/glossary.htm>>
The EPA glossary contains an alphabetized list of all terms relevant to green power. Teachers looking to define a term using a reputable source should look here.

EPA Hydroelectricity

Environmental Protection Agency. "Hydroelectricity." *Environmental Protection Agency*. 30 Apr 2013. Web. 11 Jul 2013. <<http://www.epa.gov/cleanenergy/energy-and-you/affect/hydro.html>>

The EPA page on hydroelectric power gives a brief description on how hydropower works, and then goes into detail about its effects on the environment around it. Teachers looking for a good background summary on hydroelectric power could look here to start.

Environmental Protection Agency – Renewable Energy

Environmental Protection Agency "Renewable Energy." *Environmental Protection Agency*. Environmental Protection Agency, 20 Jun 2013. Web. 10 Jul 2013. <<http://www.epa.gov/statelocalclimate/state/topics/renewable.html>>

The EPA page on renewable energy gives a brief description about what renewable energy is, the benefits, the barriers, and the different policies in support of renewable energy. Teachers looking for an introduction to the topic from a reputable source might want to start here.

Mass.Gov Energy and Environmental Affairs

Mass.Gov. "About Solar Energy." *Energy and Environmental Affairs*. Web. 5 Jul

2013. <<http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/about-solar-energy.html>>.

Mass.Gov's page on solar power describes what solar power is, and the three primary technologies that use solar power. Teachers looking to give a complete overview on solar power technology and uses should look here.

National Renewable Energy Lab

National Renewable Energy Laboratory. "National Renewable Energy Laboratory Homepage." *National Renewable Energy Laboratory*. 5 Jul 2013. Web. 11 Jul 2013. <<http://www.nrel.gov/>>.

The National Renewable Energy Laboratory page highlights the work that they've been doing both with renewable energy technology (such as solar power) and federal policy. Teachers who want to give examples about current progress being made with renewable energy resources could look here.

Natural Resources Defense Council – Renewable Energy

Natural Resources Defense Council. "NRDC: Renewable Energy in Pennsylvania." *Natural Resources Defense Council*. Web. 10 Jul 2013. <<http://www.nrdc.org/energy/renewables/penn.asp>>.

The NRDC page on renewable energy lists brief updates on how Pennsylvania is introducing different types of renewable energy technologies (such as wind energy and solar energy), as well as providing about 20 other sources. Teachers looking for more resources, or to talk about renewable energy in Pennsylvania specifically, could look here.

National Renewable Energy Laboratory - Biomass

National Renewable Energy Laboratory. "NREL: Learning - Biomass Energy Basics." *National Renewable Energy Laboratory*. National Renewable Energy Laboratory, 30 May 2013. Web. 11 Jul 2013. <http://www.nrel.gov/learning/re_biomass.html>.

The National Renewable Energy Laboratory page on biomass energy talks briefly of both the basics behind biomass energy and some of the benefits of using biomass energy. Teachers looking for a short, but positively skewed introduction to the topic could look here.

National Renewable Energy Laboratory – Geothermal

National Renewable Energy Laboratory. "NREL: Learning – Geothermal Energy Basics." *National Renewable Energy Laboratory*. 30 May 2013. Web. 11 Jul 2013. <http://www.nrel.gov/learning/re_geothermal.html>

The NREL page on geothermal energy gives a brief description about the core concept behind geothermal energy, and offers three additional links to more specific applications of the technology. Teachers looking for background information and examples of geothermal energy use could look here.

National Renewable Energy Laboratory – Renewable Energy Activities

National Renewable Energy Labtory. "Renewable Energy Activities - Choices for Tomorrow." *National Renewable Energy Laboratory Education Programs*. Web. 11 Jul 2013. <<http://www.nrel.gov/docs/gen/fy01/30927.pdf>>.

The NREL prepared a middle school curriculum for teaching renewable energy. An extensive background summary on energy is given, followed by a series of different activities. Teachers looking for perhaps a more extensive renewable energy lesson plan could look here.

Union of Concerned Scientists – Renewables are Ready

Union of Concerned Scientists "Renewables Are Ready." *Union of Concerned Scientists*. Web. 11 Jul 2013. <http://www.ucsusa.org/assets/documents/clean_energy/renewablesready_fullreport.pdf>.

The Union of Concerned Scientists created a series of curricula designed to teach renewable energy to junior high and high school students. Games and labs are also included. Teachers looking for other ways to teach renewable energy, or perhaps other examples of activities to complete, could look here.

DOE Energy Efficiency and Renewable Energy – Wind Turbines

United States Department of Energy. "How Do Wind Turbines Work?" *United States Department of Energy: Energy Efficiency and Renewable Energy*. . 17 Jan 2013. Web. 11 Jul 2013. <https://www1.eere.energy.gov/wind/wind_how.html>

The DOE page on wind turbines gives a brief yet educational description of how wind turbines work, as well as offers a number of diagrams and animations to illustrate the process. Teachers looking to explain the technology behind wind energy could look here.

Department of Energy – Energy Efficiency and Renewable Energy

United States Department of Energy "US DOE Energy Efficiency and Renewable Energy (EERE)." *United States Department of Energy: Energy Efficiency and Renewable Energy*. 3 Jul 2013. Web. 10 Jul 2013. <<http://www.eere.energy.gov/>>.

The Department of Energy's page on Energy Efficiency and Renewable Energy links to information about the renewable energy work that they're doing, the applications of different renewable energy technologies, and current news articles. Teachers looking for

practical examples of the work being done with renewable energy technology could look here.

Opinion / Newspaper

Advantages and Disadvantages of Wind Energy

Clean Energy Ideas. "Advantages and Disadvantages of Wind Energy." *Clean Energy Ideas*. Web. 11 Jul 2013. <<http://www.clean-energy-ideas.com/wind/wind-energy/advantages-and-disadvantages-of-wind-energy>>

The page from Clean Energy Ideas gives a succinct, bulleted list of the arguments for and against wind energy. Teachers looking to familiarize themselves with both sides of a debate about wind energy could look here.

Advantages and Disadvantages of Biomass Energy

Conserve Energy Future. "Advantages and Disadvantages of Biomass Energy." *Biomass Energy*. Web. 11 Jul 2013. <http://www.conserve-energy-future.com/Advantages_Disadvantages_BiomassEnergy.php>

This page on biomass energy gives a brief introduction to what biomass energy is consists of, and then gives a list – complete with explanations – about the pros and cons of biomass energy. Teachers looking to open a debate on the topic, or introduce the topic in the first place, could look here.

Advantages of Geothermal Energy

Conserve Energy Future. "Advantages of Geothermal Energy." *Conserve Energy Future*. Web. 11 Jul 2013. <http://www.conserve-energy-future.com/Advantages_GeothermalEnergy.php>

The NREL page on geothermal energy lists a number of advantages to the technology, and links to a page listing a similar number of disadvantages. Teachers looking to learn about both positives and negatives associated with geothermal energy could look here.

Kite Power Generation

Martinelli, Nicole. "Generating Power from Kites." *Wired*. Wired, 10 Oct 2006. Web. 12 Jul 2013. <<http://www.wired.com/science/discoveries/news/2006/10/71908>>.

Martinelli's article on generating power from kites discusses the technology behind generating wind power with a series of kites. The benefits of the budding project are also discussed.

Solar Powered Satellite

Solar Energy. "Solar Powered Satellites." *Solar Energy*. Web. 12 Jul 2013. <<http://www.gstriatum.com/solarenergy/2012/04/solar-powered-satellites/>>.

This page on solar powered satellites briefly discusses the technology, the ways it can work, the benefits over traditional solar power. It also mentions the steps being taken to begin research.

Why is renewable energy important?

RenewableEnergyWorld.com "Why is renewable energy important?" *RenewableEnergyWorld.com*.

Web. 11 Jul 2013. <<http://www.renewableenergyworld.com/rea/tech/home>>.

RenewableEnergyWorld gives a succinct, clear description of numerous types of renewable energy technology. Their home page features news articles, blogs, and opinion pieces on renewable energy and its different technologies. Teachers looking for resources about a specific technology could look here for examples.

The Guardian – Renewable Energy News

The Guardian – US. "Renewable energy: Solar, wind, wave, tidal, and hydropower." *The Guardian - US*. 8 Jul 2013. Web. 11 Jul 2013. <<http://www.guardian.co.uk/environment/renewableenergy>>.

The Guardian's Renewable Energy page offers the latest news stories on topics related to renewable energy. Teachers who want to introduce an example of current events in relation to renewable energy could look here for constant updates.

Piezoelectric Dancefloor

Trotter, Cate. "Dancefloor generates electricity at London's first eco-disco!" *Inhabit*.

Inhabit, 16 Jul 2008. Web. 12 Jul 2013. <<http://inhabitat.com/green-a-go-go-at-londons-first-eco-disco/>>.

Trotter wrote an article about how a power-generating dancefloor in London works. A diagram walking readers through the power generation process is also included.

13 Advantages and Disadvantages to Solar Power

Whitburn, Greg. "13 Advantages and Disadvantages of Solar Energy."

Exploringgreentechnology.com. Exploringgreentechnology.com. Web. 11 Jul 2013. <<http://exploringgreentechnology.com/solar-energy/advantages-and-disadvantages-of-solar-energy/>>

Greg Whitburn offers a comprehensive summary of solar energy advantages and disadvantages. Teachers looking to spark a debate about the effectiveness of solar energy, and its potential for widespread use, may want to look here to introduce a few points to either argument.

Wikipedia – Renewable Energy

Wikipedia – The Free Encyclopedia. "Renewable Energy." *Wikipedia*. Web. 11 Jul 2013.

<http://en.wikipedia.org/wiki/Renewable_energy>.

The Wikipedia page on renewable energy summarizes the different sources of renewable energy, the different technologies using renewable energy sources, and talks about emerging renewable energy technologies. Teachers looking for a brief outline of renewable energy – as well as an abundance of additional sources – could look here.

Other:

NREL Map of Wind Resources - http://www.nrel.gov/gis/images/80m_wind/USwind300dpe4-11.jpg

NREL Map of Solar Resources - http://www.nrel.gov/gis/images/eere_csp/national_concentrating_solar_2012-01.jpg

Author(s):

Lesson idea from Brandon Mauch, Allison Weiss, Emily Fertig, and Christian Blanco; final product compiled by Sabrina Larkin on behalf of the Leonard Gelfand Center for Service Learning and Outreach.

Funding Sources:

Portions of this work were supported by a) the Leonard Gelfand Center for Service Learning Outreach, and b) the Center for Climate and Energy Decision Making (SES-0949710) through a cooperative agreement between the National Science Foundation and Carnegie Mellon University.

Next Generation Science Standards Alignment

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Crosscutting Concept: Influence of Science, Engineering, and Technology on Society and the Natural World

Connections to other DCIs: HS.ESS3.A

HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Crosscutting Concept: Stability and Change

Connections to other DCIs: HS.LS2.C, HS.LS4.D