Video: Renewable Power – Earth's Clean Energy Destiny

Student Objectives
The student:
- will be able to explain how renewable energy sources are currently being used
- will be able to explain the currnet limiting factors in the use of wind, solar, hydropower and hydrogen
- will be able to explain the link between renewable energy and hydrogen
- will be able to explain several different visions of the future use of energy.

Key Words:
biomass
distributed generation
hydroelectric
photon
photovoltaic

Time: 1 hour

Materials
- Renewable Power - Earth's Clean Energy Destiny video
- Laboratory manual

Background

An energy source is a supply of energy that is available for use. *Primary energy sources* are sources that are naturally available on the earth. They can be renewable, meaning that they are recurring or continuous, or they can be non-renewable. Examples of renewable primary energy sources include geothermal, hydropower and solar. Non-renewable primary energy sources include natural gas, oil, coal and uranium. *Secondary energy sources* are products of human technology, the most common of these energy sources is electricity.

Our current energy consumption in the United States (from 1998 statistics) is:

	Renewable	Non-renewable	Used for	Percent of total
Biomass	X		heating, electricity, transportation	3.2%
Coal		X	electricity, manufacturing	22.4%
Geothermal	X		heating, electricity	0.15%
Hydrogen	X		electricity, transportation	0.05%
Hydropower	X		electricity	3 . 7 %
Natural Gas		X	heating, industrial production, transportation	22.8%

Petroleum		X	transportation, manufacturing	38.1%
Propane		X	heating, transportation	1.8%
Solar	X		heating, electricity	0.1%
Uranium		X	electricity	7.6%
Wind	X		electricity	0.1%

Biomass - Biomass energy comes from agricultural or forestry waste, animal waste, trash, or similar organic materials. Since the biomass materials are organic, they originally received their energy from sunlight. Biomass materials release their energy in one of four ways--by burning, bacterial decay, fermentation or conversion. In *bacterial decay*, as the plant and animal materials decay, the bacteria produces an odorless, colorless gas–*methane*, which is the main ingredient in natural gas. In some landfills, wells have been drilled to capture the methane produced from the decaying waste. The methane is then purified and used like natural gas. *Fermentation* occurs when yeast (another bacteria) is added to biomass materials with a high sugar or starch content, to produce *ethanol*. Ethanol may be used as a transportation fuel instead of gasoline with some engine modifications. Biomass materials undergo *conversion* when heat or chemicals are added to change the biomass into gas or liquid fuels. These fuels can then be used for heating, electricity production, or transportation fuels. In India, cow manure is made into methane gas via conversion to provide heat and electricity. *Biodiesel*, is derived from vegetable oils by a process called *esterification*, in which the vegetable oil reacts with ethanol or methanol in the presence of a catalyst to produce a fuel that has physical properties similar to diesel. Many vegetable oils may be used to produce biodiesel, including waste oils from food production as well as those that are not suitable for human consumption. Soybean oil is currently the main source of biodiesel, however there has been an increased use of rapeseed oil because it has a high oil yield, and its by-products can be used as livestock feed. *Burning* is by far the most common way to release the energy from biomass. In *waste-to-energy* plants, garbage is burned to produce steam and electricity

People have used biomass longer than any other energy source. In the mid-1800s, wood gave Americans 90 percent of the energy they used, compared to 3 percent for all forms of biomass today. At the present time, only a very small amount of the electricity we use in this country is produced by biomass.

Biomass is renewable since we can grow more in a short amount of time. Biomass can pollute the air when it is burned; however, burning biomass does not produce certain pollutants like sulfur that can cause acid rain. It has been theorized that growing plants for biomass may actually reduce greenhouse gases since plants use carbon dioxide and produce oxygen as they grow.

Biomass is not generally cost competitive, but could become so with advances in technology and increases in the cost of oil. Biofuels produced from biomass could potentially replace one-third of our country's consumption of fossil fuels; however, some authorities wonder if we should encourage the production of energy producing crops over the production of food crops.

Hydropower - Hydropower refers to the conversion of the kinetic energy of moving water into electricity. Hydropower most commonly is produced by the movement of the water in a river or that released by a dam, but it can also refer to power created by wave or tidal

movement. Hydropower plants use modern turbine generators to produce electricity. The water is typically allowed to flow downwards, where the fast moving water spins the blades of a turbine which is attached to a generator where the motion is converted into electricity. When the moving water comes from tidal or wave action, barriers are usually erected to channel and speed up the flow of water. Currently, for tidal hydropower to be practical, the difference between high and low tides must be at least 15 feet. There are only two locations in the United States that meet this requirement. Tidal hydropower also requires barriers to channel and concentrate the flow into a small area. The water then moves into an elevated reservoir and ultimately passes through hydro-electric turbines. Wave action hydropower can be produced using an oscillating water column. When waves hit an oscillating water column, the air inside is compressed and forced through air turbines. Another method uses "Salter Ducks". These are floats that are connected in a chain of about 25. When they bob up and down in the water, a pump is driven. This can create a lot of energy, but it is still being studied to make it more reliable.

Hydropower has been used as a source of energy for centuries. Water wheels have been used to grind grain into flour for over 2,000 years, and American and European factories began using water wheels to power machines during the early 1800s. In 1882, moving water was first used to generate electricity at Fox River in Wisconsin. Today, hydropower is the world's largest renewable source of electricity, producing approximately 9.5 percent of the world's electricity. The United States presently has over 2,000 dams that are used to generate electric power; however, since this represents only about three percent of our country's dams, we have the ability in the future to increase the amount of power generated from this energy source.

Hydropower is a renewable, clean source of energy, but it can change the environment when damming rivers and creating reservoirs is necessary. Hydropower plants produce almost no emissions, because they do not need to burn any fuel for the energy that they produce. They also are located at the source of their energy supply, so there is negligible emissions from transporting this energy.

Solar - Solar energy is using the energy radiated by the chemical reactions of our sun for heat and electricity. During the nuclear fusion process in our sun, four hydrogen atoms combine to form one helium atom with a release of matter that is emitted and travels outward from the sun as radiant energy. The unit of measure for this energy is the *photon*. It takes these photons of energy a little over eight minutes to travel to earth. There is so much energy radiating from our sun that it produces more energy in one second than the earth has used since time began.

There are two types of solar energy currently being commercially used–**solar thermal** and **photovoltaic**. Solar thermal uses the energy of the sun to make heat; photovoltaic refers to the process of turning the energy of the sun directly into electricity. Solar thermal is mainly used to heat water for domestic and industrial use or for heating a building interior; however, it has also been used experimentally to create steam from a liquid that can then be turned into electricity with a turbine. Photovoltaic cells (commonly called solar cells) are made from silicon that undergoes a chemical process to add electrons and increase its instability, then the silicon mixture is allowed to form crystals from which the photovoltaic cells are made. Electricity is produced when a photon of light energy strikes the solar cell, causing the electrons to flow. The action of the electrons starts an electric current. This conversion of sunlight to electricity happens silently and instantly with no moving parts to wear out and no depletion of resources.

The first use of solar thermal dates back at least to the Greek and Roman times. Recent

research indicates that they used glass as a passive solar thermal collector. However, photovoltaic technology is relatively new; as a viable energy source, it is less than 50 years old.

Solar energy has great potential for the future. As a source of energy, sunlight is free, its supplies are unlimited and it is available in the majority of areas of the world. However, at this time the relatively high cost of photovoltaic cells and systems is limiting its use. This is expected to change as our supplies of fossil fuels diminish, new methods of producing photovoltaic cells are discovered, and the increase in demand for the technology brings the price down.

Wind - Wind energy uses the movement of air to turn the blades of a wind machine. These blades, ideally about 60 feet long, are connected to a drive shaft that turns an electric generator to make electricity. There are two types of wind machines commonly used today. The *horizontal-axis* wind machines have blades that go crosswise and look like an airplane propeller. They are typically as tall as a 10 story building, and have 2 or 3 blades. The *vertical-axis* wind machines have blades that go from top to bottom and look like giant egg beaters. They typically stand about 100 feet tall and are about 50 feet wide. Wind machines are commonly grouped together in a *wind farm* of sometimes several hundred machines.

At the present time, wind energy produces only a small fraction of the energy this country uses. One reason for this is that wind machines can only operate when the wind is blowing 14 mph or more. In most places in the United States, this wind speed is reached only about 25 percent of the time.

People have harnessed the power of the wind since the dawn of history to sail ships and grind grain. Today, most modern wind farms are privately owned by companies that sell the power generated to the utility companies.

Wind energy is a renewable, clean source of energy, burning no fuel to generate electricity.

Procedure

1. Show the 29 minute video.
2. Allow 5 - 10 minutes for the students to complete the questions in their Laboratory Manual.
3. Take a few minutes to discuss the video and discuss any questions that arise. If the students ask a question and you don't know the answer, ask if anyone in the class would like to research the question for the class (possibly for extra credit) and report back with the answer next class period.
4. Lead a discussion on what the students perceive as their energy future. Things they may want to discuss:
    - What kind of car do they think they will be driving in 15 - 20 years? What kind of fuel will it use? How will they refuel it?
    - How will the use of alternative energy sources impact portable power in personal devices–i.e. communications, computing, entertainment, etc. What do the students envision for the future in mobile devices?
    - In the future will electricity be carried through power lines to every residence and building, or will there be another system of distribution? Will we even plug our appliances into the wall?

- Which of the emerging energy technologies do they see as the most promising?
- What is the future of petroleum products--how long will they be affordable for general consumption? How will we transition to another energy source?
- Can conservation alone provide enough energy for our growing population? Should we restrict either population or energy consumption, and if not, how do we cope with the shortages? How bad do they think it will get?
- Should every country and every person in the world have the same conveniences and luxuries that we have? If so, how do we create energy equality and energy wealth for the whole world?
- What kind of careers in energy are going to be opening up?

Further Research

1. What is the current state of photovoltaics research? In what areas do scientists see the research heading?
2. What are the drawbacks to greater use of photovoltaics as an energy source? How can the industry overcome these obstacles?
3. What is the current state of wind power as a energy source? What are the drawbacks to greater use of wind power? Why is wind power not a viable option in Florida–and could this change in the future?
4. What new methods are being used in biomass technology? What are the drawbacks of using biomass on a large scale? How could these be overcome?
5. What other alternative energy sources could have potential in Florida? What is the current state of research in these areas?

Related Reading

- ***The Hydrogen Economy*** by Jeremy Rifkin (Tarcher, 2003)
  The road to global security," writes Jeremy Rifkin, "lies in lessening our dependence on Middle East oil and making sure that all people on Earth have access to the energy they need to sustain life. Weaning the world off oil and turning it toward hydrogen is a promissory note for a safer world." Rifkin's book presents the clearest, most comprehensive case for moving ourselves away from the destructive and waning years of the oil era toward a new kind of energy regime.
- ***Powering Our Future: An Energy Sourcebook for Sustainable Living*** by Alternative Energy Institute (iUniverse, Inc, 2005)
  The four biggest energy sources—oil, natural gas, coal, and uranium—currently power our earth. What would happen to our society if we experienced severe shortages of one or more of these resources? This book explores: how our world has become dependent on four nonrenewable resources; how each resource impacts us politically, economically, and environmentally; how renewable resources such as hydrogen, fuel cells, wind power, solar energy, hydropower, and more are waiting in the wings; and how the transition to renewable resources will take place, offering economically stable and environmentally safe choices.

Internet Sites

http://www.energyaction.net/main/index.php

Energy Action, a coalition of organizations working together to build and support the youth energy movement in North America.

http://www.dep.state.fl.us/energy/fla_energy/

Florida Energy Office. Site includes Florida state information and policies on renewable energies, conservation and alternative fueled vehicles.

http://www.fsec.ucf.edu/Executive_Summary.pdf

Florida Solar Energy Center. Summary of Florida's Energy Future, a report to the Florida Department of Environmental Protection. The full report may be found here: **http://www.fsec.ucf.edu/Energy_Future_final.pdf**

http://www.ucsusa.org/clean_energy/renewable_energy_basics/

Union of Concerned Scientists' Renewable Energy page. Includes information on the different renewable energy technologies, including costs, environmental impacts and benefits, safety, policies and testimonials.

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1. Biomass. You may also accept the answer 'fire' at your discretion. The key word in this question in 'harnessed'. Solar thermal was probably used first, but it is a passive technology, and not actually 'harnessed'.
2. Petroleum products or oil
3. Electricity
4. Accept any of the following: air pollution, climate change/global warming, military cost, oil spills/water pollution, health effects (asthma, lung disease, cancer), and environmental impacts of drilling.
5. Electricity
6. Wind power
7. Both wind power and solar are subject to times when they cannot be used–i.e. nightime and times with less than 14 mph wimd.
8. Amount of land and waste produced
9. Amount of suitable waterways
10. Battery
11. NASA (or the space program)
12. Never
13. Accept any of the following: production, storage, transportation, infrastructure, cost, safety concerns, public perception
14. Answers will vary, but the student should show knowledge of the concept of using photovoltaics to make electricity and hydrogen where the hydrogen is used when the Sun is not available.
15. Answers will vary, but the student should show knowledge of the public desire to have future transportation have the conveniences and luxuries that they current perceive that they have.
16. Answers will vary, but the student should show knowledge that hydrogen is not available in a 'natural' state and must be produced (or extracted) from another molecule or compound.

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			.1	.2	.3	.4	.5	.6	.7	.8
Energy	**Standard 1**	**SC.B.1.4-**	**X**				**X**			
	Standard 2	**SC.B.2.4-**								
Processes that Shape the Earth	**Standard 1**	**SC.D.1.4-**								
	Standard 2	**SC.D.2.4-**	**X**							
How Living Things Interact With Their Environment	**Standard 1**	**SC.G.1.4-**								
	Standard 2	**SC.G.2.4-**	**X**				**X**	**X**		
The Nature of Science	**Standard 1**	**SC.H.1.4-**								
	Standard 2	**SC.H.2.4-**								
	Standard 3	**SC.H.3.4**		**X**	**X**			**X**		
Social Studies benchmarks: SS.B.2.4.4, SS.B.2.4.7										

Benchmark SC.B.1.4.1 - The student understands how knowledge of energy is fundamental to all the scientific disciplines.

Benchmark SC.B.1.4.5 - The students knows that each source of energy presents advantages and disadvantages to its use in society.

Benchmark SC.D.2.4.1 - The student understands the interconnectedness of the systems on Earth and the quality of life.

Benchmark SC.G.2.4.1 - The student knows that layers of energy-rich organic materials have been gradually turned into great coal beds and oil pool by the pressure of the overlying earth and that humans burn fossil fuels to release the stored energy as heat and carbon dioxide.

Benchmark SC.G.2.4.5 - The student understands that the amount of life any environment can support is limited and that human activities can change the flow of energy and reduce the fertility of the Earth.

Benchmark SC.G.2.4.6 - The student knows the ways in which humban today are placing their environmental support systems at risk.

Benchmark SC.H.3.4.2 - The student knows that technological problems often create a demand for new scientific knowledge and that new technologies make it possible for scientists to extend their research in a way that advances science.

Benchmark SC.H.3.4.3 - The student knows that scientists can bring information, insights, and analytical skills to matters of public concern and help people understand the possible causes and effects of events.

Benchmark SC.H.3.4.6 - The student knows that scientific knowledge is used by those who engage in design and technology to solve practical problems, taking human values and limitations into account.

Benchmark SS.B.2.4.4 - The student understands the global impact of human changes in the physical environment.

Benchmark SS.B.2.4.7 - The student understands the concept of sustainable development.

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biomass - energy from agricultural or forestry waste, animal waste, trash, or similar materials

distributed generation - refers to the generation of power from smaller individualized sites rather than large central power plants

hydroelectric - the conversion of the kinetic energy of moving water into electricity

photon - a tiny particle or bundle of radiant energy that emanates from the Sun

photovoltaic - the effect of producing electric current using light

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After watching the video, answer the following questions:

1. The first form of energy harnessed by humans was _____

2. In the 1890s, what 'new' energy began to be used? _____

3. Almost overnight, what secondary energy source became a household necessity?

   _____

4. List at least three world-wide problems caused by our large scale use of petroleum products.

5. Photovoltaic cells create a flow of electrons which we commonly call _____

6. Currently, the fastest growing energy source is _____

7. A major problem with the availability of both with wind and solar power is _____

   _____

8. Biomass as a form of large scale energy production is limited by _____

   _____

9. Greatly increasing our country's use of hydroelectricity is limited by _____

   _____

10. Currently, the most common way to store electricity is the _____

11. _____ has been using large quantities of hydrogen since the 1960s.

12. When will we run out of hydrogen? _____

13. List at least four problems that need to be resolved before hydrogen can be our primary energy source

14. Explain how solar energy can be combined with hydrogen technology to power your house.

15. What did the video mean when it said that ‘what people want in cars is what they already have’?

16. Explain what is meant by saying that hydrogen is a ‘manufactured fuel’.