# IV. Window into Energy

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## 4.1 Introduction

Maintaining a sufficient level of energy to power the needs of a robust economy requires a thorough understanding of the costs and benefits of current production methods, as well as a desire to develop newer methods that cause less environmental impact. Students will learn about common sources of energy and also be encouraged to look for possible energy sources in less common materials.

### *Objectives*

***In this lesson students will***:

- Identify common sources of energy
- Locate the presence of various energy producers in Virginia
- Demonstrate the processes behind creating power from various methods
- Discuss the importance of developing newer, more efficient means of energy in order to limit the use of non-renewable resources

### *SOLs*

Science 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.9, English 6.2

### *Key Terms/ Concepts*

- Renewable Resources
- Fossil Fuels
- Biofuels
- Cogeneration
- Generator
- Greenhouse Gases
- Methane
- Passive Solar Homes
- Radioactive Elements
- Retrofitting
- Non-Renewable Resources
- Biodiesel
- Carbon cycle
- Electricity
- Geothermal Reservoirs
- Green Roofs
- Organic Matter
- PV Cells
- Renewable Energy
- Turbine

***Fundamental Learnings Related to Energy Resources***

- Virginian's use a mixture of nonrenewable and renewable energy for mobility and electricity production.
- Nonrenewable and renewable energy resources are managed based on cost/benefit tradeoffs between conservation and society.

# IV. Window into Energy

## 4.2 Student Information

### *Energy*

Have you ever been sitting at the bus stop on a cold winter day and wished you were somewhere a lot warmer? Believe it or not your body is using a form of energy to stay warm. This energy is thermogenic and is created by processes within your body. The friction created by your shivering creates heat and also causes the "burning" of fat to keep you warm. Hopefully your body is kept warm enough until the bus arrives and several new forms of energy are available. The bus (just like the car your parents drive) requires a fossil fuel, underground deposits of organic materials, to run. Once you arrive at school, the main form of energy used to heat the building, light your classroom, and run the computers you use is electricity.

Energy involves your everyday life. No matter what the source of energy, a chemical process is necessary to convert it to a usable form. No chemical reaction is 100% efficient, so there is always waste. This waste may come in the form of excess heat formation or air emissions. These emissions may have adverse effects on the environment in which we live. In addition, a majority of the resources we use (petroleum, coal, natural gas) to create energy are non-renewable. Opinions vary, but some people fear that we will soon run out of these non-renewable resources. Thus, newer and "cleaner" forms of energy are being researched. In this Window we will discuss different forms of energy production. Think of the forms of energy you use. What new methods might work well in your area?

### *Corporate Conservation Case Studies*

***Covanta Alexandria/Arlington, Inc., Alexandria, VA***

The Alexandria/Arlington Resource Recovery Facility began commercial operation in February 1988 and serves about 300,000 residents of the County of Arlington and the City of Alexandria, which jointly own the site. The facility's three 325 ton-per-day furnaces process 975 tons of solid waste, generating up to 23 megawatts of renewable energy that is sold to Dominion Virginia Power Company. The Facility is located on the smallest site of any of the waste-to-energy plants operated by Covanta.

http://www.covantaholding.com/

***Crown Cork & Seal Company Inc., Winchester, VA***

Crown Winchester produces ends for aluminum beverage cans along with coating operations on steel sheet stock that is used for the production of steel food cans. Crown's program has eliminated landfilling of over 9 tons of packaging material through a supplier return program, recycled over 12 million pounds of scrap aluminum per year, reduced the usage of aluminum by 20 million pounds per year through the metal lightweighting program, reduced compound usage by 34,000 gallons per year and VOC emissions by 114 tons/year, reduced solvent purchase by 40,000 gallons/year through in-line filters and on-site recycling, reduced water consumption by 130,000 gallons/year through improved systems, and reduced landfill waste by 75 tons/year through solid waste management and recycling.

http://www.crowncork.com/about/about_environment.php

***Virginia Port Authority – Port of Virginia***
***Flag Winner Gold Level***

In recent years, regulatory officials have increased their focus on air emissions generated from port operations throughout the United States. In 2005, regulatory officials were surprised to learn that The Port of Virginia had voluntarily implemented an Air Emissions Reduction Program in 1999. Though a change in equipment purchasing policies, air emissions from The Port of Virginia have decreased by 30% over the last six years despite the fact that containerized cargo throughput has increased by approximately 55% during that same time period.

http://www.portofvirginia.com/corporate/environment/air--water-quality.aspx

***Philip Morris USA – Park 500: Environmental Management System***
***Gold Medal Winner***

By following the plan-do-check-act environmental management system (EMS) process, the Philip Morris USA – Park 500 facility, located in Chester, has been able to significantly reduce its environmental impact. The EMS has been certified as meeting the ISO 14001 Standard, recognized by the Virginia Environmental Excellence Program at the E4 level, and accepted into EPA's Performance Track program. Results to date: solid waste reduction of one million pounds per month; 50% reduction in monthly steam use; 40% reduction in electricity use; and, reduction of monthly water use by 10 million gallons or 20%.

http://www.philipmorrisusa.com/en/cms/Responsibility/Reducing/Reducing_Our_Environmental_Impact/

***EarthCraft Virginia***
***Silver Medal Winner***

EarthCraft Virginia, a voluntary green building program based in Richmond, provides a green building certification process for single family and multifamily projects and serves as a blueprint for healthy, comfortable homes that reduce utility bills and protect the environment. The organization works with builders to educate them on more advanced building science practices that result in less waste and greater efficiency, all with the goal of creating high performance homes. To date, EarthCraft has certified 200 single family houses and 13 multifamily projects.

http://www.ecvirginia.org/

***Better Living Building Supply: Better Living Phase II***
***Silver Medal Winner***

The 24,000 square foot Better Living Building Supply facility is the first LEED for new construction registered project in Fluvanna County. The facility uses a standard metal building technology typically used in industrial facilities, but with the added innovative technology of a solar wall. The southern wall of the building collects heat from the sun for use inside the facility; the traditional heating and cooling system is used only for supplemental heat. The facility, which has water efficient fixtures, also collects rainwater in an 80,000 gallon storage tank under the parking lot for use in the sprinkler system and for site irrigation. Other features include no or low volatile organic chemical materials inside the building, the use of a large percentage of recycled materials, and the recycling of more than 75% of construction materials.

http://www.btrlvg.com/

***Southeastern Public Service Authority – SPSA Refuse Derived Fuel Plant, SPSA Power Plant***
***Flag Winner Gold Level***

The Southeastern Public Service Authority (SPSA) operates an integrated solid waste management system that includes waste-to-energy facilities. SPSA diverts more than 50% of waste received to beneficial reuse. Steam and electricity manufactured by the Waste-to-Energy division is sold to the Norfolk Naval Shipyard for green energy. This division has diverted a score of wastes to Waste-to-Energy and Recycling, installed pollution prevention controls, and developed a wastewater reuse project. These projects have demonstrated annual savings of $434,660; produced annual revenues of $14,725,665; reduced dioxin emissions by 99%; and has diverted at least 520 tons and 280,000 cubic feet from landfilling annually.

http://www.spsa.com/

***Green Roofs –***
***City of Charlottesville City Hall/Police Station***
***Eventide Restaurant – Clarendon, VA***
***Halstead Tower Apartments – Alexandria, VA***

Government, commercial, hospitality and health care buildings are all selecting green roofs as a means to reduce heating and cooling expenses, reduce stormwater run-off, and reduce the urban island heat effect in densely populated areas.

Green roofs have a lot of diversity in design from 3-inch-deep grassy plugs to 30-inch-deep planters which can support shrubs and small trees.

http://www.capitolgreenroofs.com/

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## 4.3 Teacher Content

Before presenting the topic, have students participate in *Activity One*. Alone, or in a small group, students are to create a list of all of the various ways they use energy in their daily lives. Once the lists have been compiled, a short discussion of the uses of energy should follow.

Energy is part of our daily lives; from the alarm that wakes us up, the heated water for a shower, the car we drive to work, to the lights that brighten our temperature-controlled buildings.

We receive and use most of our energy in the form of **electricity**, in our homes, at school, and at work. Generating electricity is one of the world's largest industries (Flavin). Electricity is generated when a wire moves in a magnetic field. Many sources can cause the wire, or armature, to move, including: steam, water, and wind. In a steam power plant, fuel (oil, coal, gas, wood, etc.) is burned to heat water into steam, which spins a **turbine** connected to a **generator.** Electricity is the same, regardless of the source, and flows from the generator into the power lines and into your home, school or office (EIA). No matter the source, chemical reactions are an important factor for converting fuel into usable energy. Since energy conversion is never 100% efficient, there is always waste. Such inefficiencies can include heat waste or air emissions from the burning of fuels.

In Virginia, we get our energy from both **non-renewable** and **renewable resources.** Examples of non-renewable resources include coal, petroleum, natural gas, and nuclear. Most non-renewable resources are called **fossil fuels** because they are found in ancient underground deposits of **organic matter** (plants and animals). Fossil fuels are slowly and continuously renewed in the earth's crust, but we are consuming them faster than they are being replenished. For this reason, fossil fuels are a non-renewable resource. Eventually we will run out of them or we won't be able to drill fast enough to keep up with the demand.

Fossil fuels are often used over renewable resources because they can be less expensive to produce and are found in great abundance. When burned to produce energy, the fossil fuels (coal, oil, natural gas) create pollution from sulfur and nitrous oxides. Consumer interest in low cost energy with minimal impact on the environment is driving a search for new sources of energy and making better use of the energy we use from existing fuels through conservation.

### *Coal*

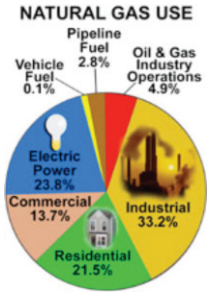
***Coal*** is the most prevalent source of energy in Virginia and the state's most valuable mineral resource. (USDOE and DMME). The Commonwealth ranks as one of the nation's top 10 producers with production valued at more than $1.7 billion annually. Much of Virginia's coal is low in sulfur and is used for electrical power generation and residential heating. Most of Virginia's coal is mined in Southwest Virginia. Sometimes whole mountain tops have been removed to get coal. Some estimates predict that, at current usage rates, the known amount of coal reserves might last less than 100-200 years (van der Leeden).

### *Petroleum*

***Petroleum*** products provide 40% of the energy Virginian's use each year. Transportation consumes three-quarters of this petroleum per year with 55% being used for motor vehicles. Nearly all of the petroleum used in Virginia is imported and transported through pipelines and waterways. Virginia has one oil refinery in Yorktown which has about a 53,000 barrel per day capacity (van der Leeden).

## Natural Gas

Another commonly used form of non-renewable energy is natural gas. ***Natural gas*** is colorless, odorless, and shapeless in its pure form. It is composed primarily of the gas **methane** (USDOE).




Natural gas was first discovered when observers saw flames caused by gas escaping from the Earth combining with heat, such as lightning. Today, the gas is harvested from large wells beneath the Earth's surface and is used for a variety of activities.

One of the byproducts of natural gas is propane. At rather high pressure, propane exists in the liquid state. It remains in this liquid form when consumers purchase it for use in heating homes, cooking on the gas grill, fueling vehicles, and even floating a hot air balloon. Of the 230 million motor vehicles on the road in 2000, 276,000 were propane fueled cars or trucks (USDOE).

Natural gas and propane are cleaner burning than the other fossil fuels, coal and petroleum. One potential problem with natural gas is the characteristic of being colorless and tasteless. In order to prevent leaks from going undetected, an unpleasant smelling chemical is added to the gas during production (USDOE).

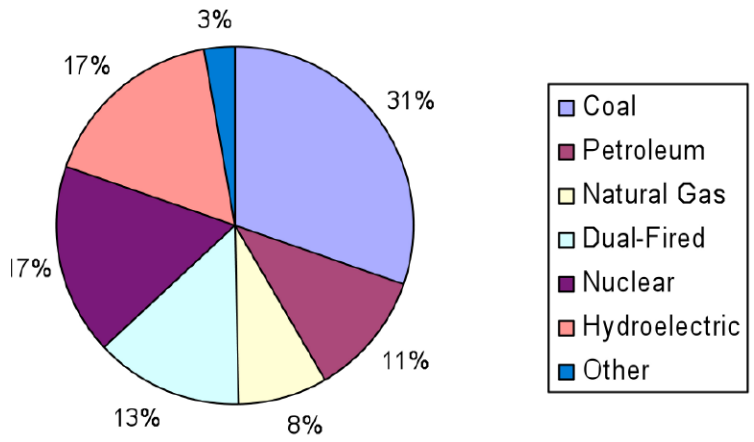
## Nuclear Power

***Nuclear power*** uses the heat from the splitting of atoms in certain radioactive materials (usually a type of uranium) to boil water to make steam that is then used to turn a turbine to make electricity. One hundred and four commercial nuclear power plants produce about 20% of the United States' electricity. In Virginia, four reactors at two power stations, at Surry and North Anna, produce about 38% of the electricity generated in the Commonwealth. Globally, about 16% of electricity generated is from nuclear plants. The United States and several other countries' navies also power submarines and aircraft carriers with nuclear energy.

Confidence in nuclear energy declined following the 1979 accident at the Three Mile Island plant in Pennsylvania and the 1986 Chernobyl disaster in Ukraine (although no reactors in the United States use the flawed design of the Chernobyl facility). U.S. interest in nuclear energy has revived as concerns about fossil fuel use and climate change have grown. Nuclear reactors do not emit carbon dioxide (CO2), the major greenhouse gas associated with global warming, or the other air pollutants associated with burning coal, oil, and natural gas. Further, the nuclear industry has advanced the safety of power plant design.

Since nuclear power plants don't emit CO2 and other air pollutants they are viewed by some as clean power and vital to reducing global warming emissions, especially as U.S. and world demand for electricity increase. But others remain concerned about the safety of nuclear power plants as well as risks of radioactive material releases from mining and processing uranium and managing wastes. (Student research question: Does burning coal release radiation? Answer is yes.) The United States has not yet implemented a long term approach to manage used nuclear fuel and high-level wastes, which remain dangerously radioactive for many thousands of years. Some European countries, Russia, and Japan reprocess spent nuclear fuel to recycle plutonium into new nuclear fuel. However, nuclear fuel processing and spent fuel recycling raises concerns that certain materials can be diverted for purposes of making nuclear weapons.

**Virginia Electricity – Industry Generating Capability by Primary Energy Source, 2002**




Energy Information Administration, U.S. Department of Energy
http://www.eia.doe.gov/cneaf/electricity/st_profiles/virginia.pdf

Cost is also a challenge for nuclear power. It takes a long time to site and permit nuclear plants. Construction is expensive because of the need for very specialized equipment and labor and the need to build plants to very high safety standards.

Nuclear power may be able to provide large and growing amounts of reliable electricity in an energy-hungry world without adding the greenhouse gases that would come from using fossil fuels. But there remain technical and economic challenges for nuclear power.

Have students recall the advantages and disadvantages of each source of energy in *Activity Eight*.

## *Alternative Sources of Energy*

**Renewable energy** comes from a source that is continually replenished — the wind keeps blowing, the sun keeps shining, and plants keep growing. This energy will be around for as long as the Earth and Sun. There is a wide variety of renewable sources of energy in use today, plus more being researched and developed (USDOE). These sources include: Solar, Photovoltaic Systems, Thermal Electric, Wind, Geothermal, BioMass, and Hydro.

## *Solar Energy and Photovoltaic Systems*

Our sun is about 93 million miles away from the Earth. Yet, were it not for its energy, all of the organisms on Earth could not survive. Even the fossil fuels we use were produced millions of years ago by the heat of the sun breaking down plant and animal matter. The plants we eat and those eaten by the animals we eat are dependent on the sun for their production of energy through photosynthesis. When solar power is listed as an alternative power source, we are referring to the sun's ability to produce heat and our ability to convert the sun's power into electricity.

The sun's rays produce heat in addition to visible light. Over hundreds of years, people have learned ways to use this heat to their advantage. Solar water heaters are an easy and popular way to use solar heat. Many times the solar panels on the top of a house are for this purpose. Panels on the roof of a building contain dark colored water pipes. When the sun hits the panels, the water in the pipes warms up and can then be pumped for household use. A typical system will reduce the need for conventional water heating by about two-thirds.

An easy way to observe this heat is by wearing a white shirt and sitting in the sun for ten minutes. After you've done this, change into a black shirt. The added heat you're feeling that is absorbed by the darker color is the same heat that warms the house water in a solar water heater.

***Did you know . . . ???***

No matter what the form, almost all energy on Earth is derived from the sun. Fossil fuels are created by processes "fueled by the sun." It drives the water cycle, winds, air currents, and process of photosynthesis (without which animals would have no food).

***Consider these facts:***

- Stored solar energy provides well over 90 percent of the fuel used in human agriculture, industrial buildings, and transportation;
- The average American household uses 60 kilowatt-hours of electricity per month;
- Energy radiated from the sun in just 43 minutes equals the amount of solar radiation that is consumed worldwide in a year;
- It takes hundreds of thousands of years for the energy created by fusion reactions in the center of the sun to reach the sun's surfaces and then just eight minutes as light energy to travel the 93 million miles to Earth;
- The sun produces nearly all the heat on the planet and without it, the Earth would be freezing cold, just like in outer space.

http://projectsol.aps.com/energy/energy_life.asp

http://web.stclair.k12.il.us/splashd/solarexp.htm

Sunlight can be changed directly to electricity using solar cells. Solar cells are also called **photovoltaic (PV) cells** and can be found on anything from small appliances, like calculators, to equipment on spacecraft. They were first developed in the 1950s for use on U.S. space satellites. Each cell, usually made from a silicon base mixed with other elements such as phosphorus or boron, creates an electrical current when light hits its surface. When sunlight strikes the solar cell, electrons are knocked loose. They move toward the treated front surface. An electron imbalance is created between the front and back of the cell. When the two surfaces are joined by a connector, a current of electricity occurs between the negative and positive sides. A typical cell is about 4" x 4" although they can range in size depending on the type of cell.

Another way to take advantage of the sun's energy is to heat our homes through passive or active solar heating systems. Today, over 200,000 homes in the United States have been designed to use solar heating. **Passive solar homes** are designed so that large, south-facing windows naturally collect the sun's heat. Once the heat is inside the house, thermal mass holds the heat. In solar buildings, sunspaces are used on south sides of buildings and the floors of these sunspaces, usually made of tile or brick, act as thermal mass to absorb the heat. The sun heats these sunspaces and when the air is colder than the floor, the tiles or bricks release heat into the air. A downside to solar heating is that it heats the house even during the warm months. One way to get around this is to plant deciduous trees in front of your

windows. Their leaves will block the sun's heat during the warm months and during the colder months their leaves will be off, allowing the sun to heat your home.

**Active solar homes** are designed so that the thermal mass is heated by either air through convection or a liquid through conduction. This thermal mass is then used as heat storage and is circulated with either a fan or a pump through the homes existing heating system.

To demonstrate the use of solar energy, have students participate in *Activity Two*.

### *Thermal Electric Energy*

Solar thermal systems can also change the sun's energy into electricity, but function in a different way. In most systems, sunlight is concentrated to produce heat, which is used to boil water to make steam or to expand a gas. The steam is then used to turn the wheel of a turbine connected to a generator while the expanding gas operates a Sterling Engine which makes the electricity. Solar thermal systems can best be used in places around the world that have intense sunlight. Also, like the photovoltaic systems, solar thermal systems are intermittent. However, systems making steam have a backup that uses natural gas to heat the water.

### *Wind Power*

We have wind because the sun does not heat the earth evenly, and hot air rises. As hot air rises it produces a wind current. This basic principle explains how windmills work. As the arms of a windmill, often called turbines, spin, energy is created. Our wind turbines today look very different from windmills built long ago. Wind turbines today only have two to three blades, as long as 82-feet long, and they work like the turbine of the solar thermal system. As the wind blows, the blades move, helping drive the generator that produces electricity. Special machines called inverters convert the energy produced by the turbines to usable power that can be distributed through the grid (Renewable).

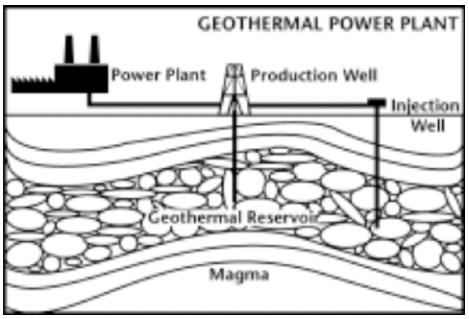
Large groups of turbines, called wind farms, are connected to utility lines distributing electricity for many people.

Windmills don't take up much land; in fact, crops can be grown on the same field. Windmills can produce modest amounts of electricity, especially if positioned in windy areas. The windiest areas of Virginia are Appalachia and the Tidewater area (van der Leeden). Another advantage to wind energy is that it can produce energy day or night as long as the wind is blowing.

Wind power is controversial. Though wind is a renewable resource, there are some problems with depending on it for power. Wind does not blow all the time, even in the windiest places, so windmills do not generate a constant stream of energy. Wind also does not stop blowing everywhere at the same time. Through use of the national electrical grid, distributed wind power spaced over a wide geographic area can provide a more stable base load of energy (Sobin). Some people regard windmills as an eyesore that mars the natural landscape, and some people complain about the noise created by the rotating blades and generator. Finally, the number of birds or bats killed by windmills is uncertain. www.dgif.virginia.gov/

## Geothermal Electric Energy

Geothermal energy involves taking heat from the Earth's crust and using it as energy. Heat from the Earth's crust heats underground pools of water called geothermal reservoirs. These **geothermal reservoirs** form hot springs or even geysers if they boil up through a crack in the crust to the surface. We can now drill deep into the Earth's crust for the direct use of these geothermal reservoirs. One method of producing geothermal energy is by digging two holes fairly close together. These holes, or wells, dive 2,000 to 3,000 feet below the earth's surface. Once these holes are drilled, an explosive is dropped into the well, destroying the rock between the two holes. Water is then forced down one hole with such force that it drives back up the other hole, but not until after it has traveled through the hot rock. Some geothermal plants direct the steam produced by this water into a reservoir to power a turbine/generator, while others use the hot water to boil a working fluid that vaporizes and then turns a turbine. Hot water near the surface of the Earth can be used directly for heat.




At the end of 2002, there were 43 power plants producing electricity from geothermal energy in the United States. Most of these are located in California and Nevada. Utah has two geothermal plants and Hawaii has one, formed by volcanic eruptions. Generation from geothermal sources is therefore "site specific," meaning it's only possible in a few places under unique geologic conditions. The Geysers Geothermal Field in northern California is the largest source of geothermal energy and produces as much energy as two large coal or nuclear power plants.

Geothermal energy has a major environmental benefit because it offsets air pollution that would have been produced if fossil fuels were the energy source. It also has a minor impact on the soil – the few acres used look like a small light-industry building complex. Although geothermal energy is an excellent source of energy, it too can be thought of as a non-renewable resource because we could draw out more energy from the reservoir than is replenished. Another problem is that geothermal reservoirs contain minerals that can be corrosive and polluting.

Make a geothermal power plant in *Activity Three*.

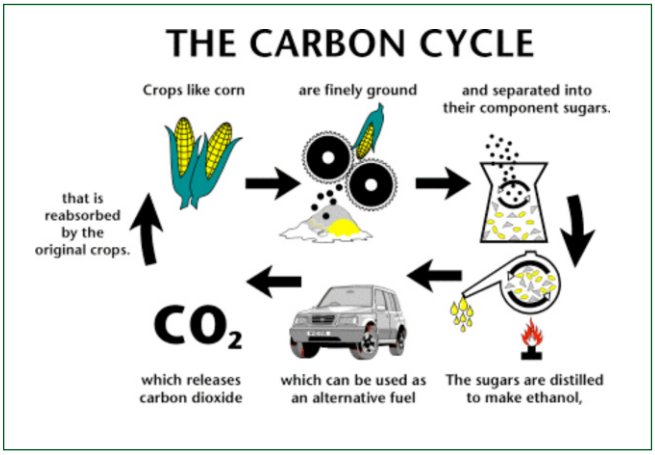
## Geothermal Heating and Cooling Energy

***Geothermal heat*** is not exclusive to these power plants though, because the temperature below ground remains fairly constant (between 45 and 75 degrees Fahrenheit) which make it easy to tap. Pipes flow under a house, harness the heat when it's cold to warm the house, and harness the cold when it's hot to cool the house. These systems utilize the constant temperature of groundwater by means of a geothermal heat pump. While they require ample water reserves, utility bills can be reduced by 20-70%. In Virginia, there are some new environmentally friendly communities in Fountain Head and Loudoun County that use this technology to heat and cool their homes (Virginia Tech). EcoVillage in Loudoun County has a very informative site about their homes located at: http://www.ecovil.com/index.html.

## BioMass and Refuse Derived Fuel

***Biomass energy generation*** is a multi-stage process that converts non-fossil-fuel derived organic material into energy we can use directly in our everyday lives. Examples of this organic material include residues from harvests and trees; marine crops, such as algae and seaweed; animal wastes; even municipal garbage. Recycling biomass for fuel and other uses reduces the need for "landfills" to hold garbage. Some might even have a place for unused table scraps and other wastes in a compost pile in

their backyard for use as an environmentally safe fertilizer. Biomass can be used in other ways as well. Waste wood, tree branches, and other scraps from farms and factories are gathered together and transported to a biomass power plant. Here the biomass is dumped into huge hoppers and fed into a furnace where it is burned. The heat is used to boil water in the boiler, and the energy in the steam is used to turn turbines and generators.




Biomass can be burned to create energy at the landfill. When garbage decomposes it releases methane. Gas pipelines are put into the landfills and the methane gas can be collected. It is then used in power plants to make electricity. This type of biomass is called landfill gas. The newest biomass gas is called ethanol and is produced from corn. In recent years, it has been blended with gasoline in cars so that less fossil fuel is burned. Today, over one-third of our nation's energy use is for transportation. **Biofuels** could help reduce the need for fossil fuels. Vegetable oil can also be used for **biodiesel** to supplement our diesel fuels. Any seed that produces oil – corn, soybean, cottonseed, peanut, canola, and sunflower – can be used to make biodiesel.

When burned, biomass releases carbon dioxide, a greenhouse gas, but when biomass crops are grown, an equivalent amount of carbon dioxide is consumed through photosynthesis, closing the **carbon cycle** as shown on the next page (EIA). The convenience of being able to grow fuel locally also offsets the issue of carbon dioxide production.

Virginia has Waste-to Energy plants in Alexandria, Hampton, Harrisonburg, Lorton and Portsmouth.

In Virginia, a covered anaerobic lagoon digests swine wastes to produce methane gas. The gas is then used to fire a generator which produces over 80 percent of the electricity and some hot water on the farm. Other projects being pursued in the state include research on wood waste and also on the benefits of using chicken litter (waste) to safely produce fuel. For more information on these, visit: http://www.dmme.virginia.gov or http://www.deq.virginia.gov/p2/vise/biomass.html

*Activity Four* illustrates the energy created by waste products.

Energy formed from trash is a special form of energy called RDF, which stands for Refuse Derived Fuel. A leading adopter of RDF is the SPSA (Southeastern Public Service Authority) plant in Portsmouth, Virginia, located in southeastern Virginia. Built in 1988, this center allows businesses to safely and completely dispose of items such as confidential files, off-specification consumer products, pharmaceuticals, and out-of-date products. Also at the plant, aluminum and ferrous metals are removed for recycling (Southern). The RDF plant is designed to process 2,000 tons of waste per day. Using equipment to screen, size, separate, and shred burnable waste into a uniform four-inch particle size, the RDF plant is able to produce a superior fuel which burns more efficiently in completing SPSA's Waste-to-Energy cycle (Southern).

Waste delivered to the Portsmouth-based plant is unloaded on a 1.3-acre tipping floor, where it is pushed onto conveyors to begin processing. Employees on the tipping floor and cameras located in the control room screen the waste for hazardous materials or bulky items, which could endanger or impede the processing of the waste. In addition to Refuse Derived Fuel production, non-processable waste and reject materials are removed from the RDF Plant's waste stream, and ferrous metals and aluminum cans are separated for recycling.

A system of belt magnets extracts over 1,000 tons of ferrous metals monthly for recycling. Contract employees hand-pick approximately 75 tons of aluminum each month (Southern). Employees get whatever they want out of the aluminum and can cash it in for themselves. Also at the RDF Plant, used motor oil is collected from area residents for recycling and a household hazardous waste collection facility is open on designated days to offer residents a place to dispose of hazardous products safely.

The SPSA helps companies that are in need of large amounts of energy. Many companies like DuPont and Northern States Power use RDF energy to power their machinery. Shipyards in Southeastern Virginia depend on RDF energy. SPSA assumed operational and maintenance responsibility for the power plant in May 1990. The plant is designed to burn 1,500 tons of RDF daily. It produces all of the process and heating steam, as well as the majority of the electrical power required by the Navy's largest shipyard, the Norfolk Naval Shipyard. Electrical power in excess of the shipyard's needs is then sold to Dominion Power (Southern). Fuel produced at the SPSA power plant is transported 2,000 feet underground to the power plant via conveyor belts. The power plant operates its boilers and turbine generators 24 hours per day.

The Norfolk Naval Shipyard uses RDF to provide process and heating systems throughout the plant. Seventy-five percent of its electricity is also from RDF (Waste News). In 2000, 466,000 tons of refuse-derived fuel to create steam and electricity was used in the shipyard (Waste News).

SPSA also helps solve landfill problems. Instead of dumping all the trash, SPSA is burning and using most of the trash for other purposes. This helps conserve more space in our areas, and taxpayers will not have to spend their money on a future landfill.

*SPSA FACT:* Here's a bouquet. SPSA makes enough Nature's Blend compost (from recycled leaves and grass clippings) to grow 85 football fields full of roses.

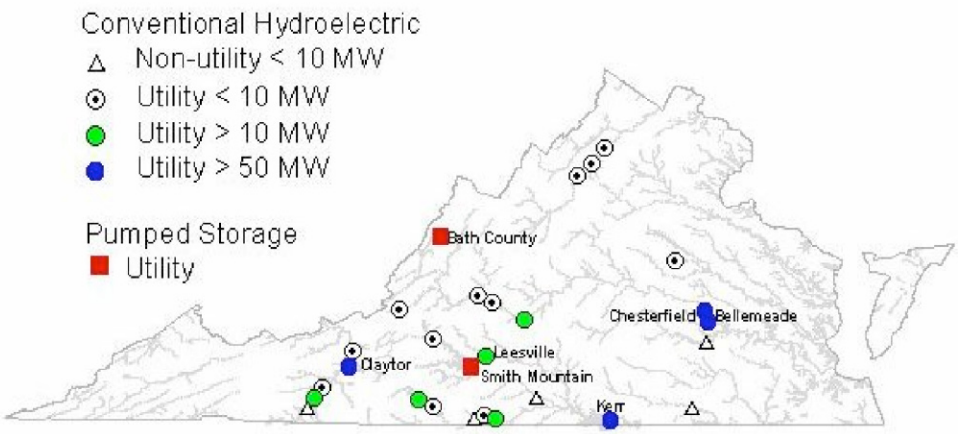
*SPSA FACT:* Flying higher! SPSA recycled 57 million beverage cans in 2000-2001 for enough aluminum to make a dozen jumbo jets.

*Activity Five* will help students appreciate everyday items and trash that can be recycled or used for refuse derived fuels.

## Hydropower

***Hydroelectric power,*** also called hydropower, is a very old concept. You've probably seen a mill next to an old cabin that used hydropower to grind grain, power textile mills, and support other early industrial processes. Today, we use hydropower to create electricity in two ways: conventional and pumped storage facilities.

Conventional facilities are located on rivers and harness energy by placing a dam across the river, channeling the water flowing around the dam to flow through electricity-generating turbines. The flow of water can be controlled in the facility to increase/decrease the power generated during high/low times of demand. Many of these dams provide another use as well: recreation. For instance, Claytor Lake was formed when Appalachian Power Company built a dam on the New River, just south of Radford, Virginia, in 1939 (DCR). In 1946, local governments raised money to buy this area from Appalachian Power, turning it into a state park. Not only did the dam make this large recreational area possible, but when water is released from the dam, the New River runs higher than normal, providing rapids for the area's large community of rafters, canoers, and kayakers. Virginia is also home to two very large pumped-storage hydro facilities, both in western Virginia: Dominion Generation Company's Bath County pumped storage unit, and American Electric Power's Smith Mountain Lake facility. Below is a map showing where a variety of hydroelectric plants are located around the state (California Energy Commission).




Students can reproduce a water powered turbine in *Activity Six*.

An additional process that takes advantage of water is tidal energy. The world's bodies of water move in tides about every 12 hours. Tidal energy systems use this predictable and relentless process to produce energy by powering turbines as the high tide water flows back out and through large propellers that spin axles. Two main technologies include underwater turbines and semi-submerged barrages, like the famous one in the headwaters of the Bay of Fundy in Canada.

## 4.4 Conservation Strategies

*"Though we make up just six percent of the world's population, we, the citizens of the United States, consume 25-30 percent of the energy produced in the world today. The average American consumes twice as much energy as the average British citizen, two and-a-half times as much as the average Japanese citizen, and 106 times that of the average Bangladeshi. Consequently, we Americans produce, per capita, the most greenhouse gases on the planet. As of 1996, each of us here in the U.S. produced, on average, almost twice the greenhouse gases of the average German, and 80 times that of the average Indian"* (Solar).

The Virginia Energy Plan (http://www.dmme.virginia.gov/DE/ConsumerInfo/energysaverhandbook.shtml) sets forth goals for energy conservation and independence, and provides additional information about home energy conservation.

### *Consumer Choices*

Individuals can collectively make a big difference with the choices they make about energy use. There are many ways individuals can conserve energy. Recycling is one way to save energy by reusing already extracted materials rather than using virgin materials. Since the material has already been made, less manufacturing is required. Examples include melting down glass, shredding paper, and melting aluminum to make products instead of starting from scratch.

To reduce energy use in your house, conserve the amount of hot water and lighting you use. To conserve hot water, water heaters can be adjusted to make the water a few degrees cooler. Also, try to take shorter showers, and use low-flow showerheads. Lighting accounts for 1/5 of the energy used in the U.S. To reduce that amount, turn lights off when they are not being used, and purchase more energy-efficient light bulbs. Compact fluorescent light bulbs are usually the most energy efficient (USDOE).

*ENERGY STAR* is a seal given to products that are energy efficient. To be given this seal, a light bulb must last between 10,000 - 20,000 hours. This means, with regular use (about 3.5 hours per day), you won't need to change the bulb for at least seven years (USDOE). Appliances can also be designated with the *ENERGY STAR*. When an appliance has this seal, it means that it meets government standards for low energy use.

The American Electric Power company's online tool Watt, Why & How provides home energy calculators to estimate energy use as well as energy conservation tips. Watt, Why & How can be found at http://www.wattwhyandhow.com/.

Consumers can also choose to incorporate energy conservation into the design of their houses. Orientations of the house and surrounding landscape have large effects on energy consumption. A well-oriented, well-designed home admits low-angle winter sun to reduce heating bills; rejects overhead summer sun to reduce cooling bills; and minimizes the chill effect of winter winds. Fences, walls, nearby buildings, and rows of trees or shrubs block or channel the wind (Fleishman).

## Thermally Efficient Buildings

Another way to conserve electricity is to make existing structures more efficient. This is sometimes called **retrofitting**, because it involves taking an old structure and updating the technology. One method of retrofitting a building is to provide better insulation. Insulation keeps buildings cool in hot weather and warm in cold weather so less energy is used in cooling or heating. Some simple ways to better insulate are to install better windows and to caulk the windows (USDOE).

Some buildings are retrofitted with Green Roofs. A Green Roof (www.capitolgreenroofs.com) is a relatively flat roof that has living plants growing on it. Electricity is conserved when a Green Roof is put on a building because the soil and plant materials provide insulation. The soil stays at a more even temperature than a regular roof, so less electricity is needed for heating and cooling. The green in the plants reflects the sun's rays, instead of absorbing them like a regular roof (Greenroofs).

Another way to retrofit a building is to replace old devices. Newer machines are usually more energy efficient than older ones. In addition, wind breaks can be installed with trees and walls to decrease the amount of wind that hits a building. Wind can make the heat dissipate out of a building. Light colored roofs can also decrease the amount of sun absorbed, compared to a dark colored roof. This also reduces the electricity needed to cool the building.

These principles can also be applied to homes. Having a light-colored roof absorbs less of the sun's heat and keeps the home cooler in the summer. Homes are most efficient when faced in a southerly direction. Facing south, a home can take advantage of the sun's warmth in living spaces in the winter and be cooler in the summer (Fleishman).

*Activities Nine and Ten* reiterate the production of more efficient buildings.

## Cogeneration

**Cogeneration** refers to a variety of methods for capturing energy lost during manufacturing processes; for example, using the heat generated by a factory's machinery to power the hot water heater for the restrooms. "Waste to Energy" or "Combined Heat and Power" are both terms used to describe cogeneration. This method is a logical way to conserve electricity because it involves collecting and making productive use of heat that would otherwise be lost.

During conventional U.S. power production, about one-third of the primary energy source is converted into electricity. That means about two-thirds is potentially lost as waste heat! Combined Heat and Power, or CHP, captures much of that lost heat. Using CHP can result in nearly 70 percent of the primary energy source being converted into electricity (USDOE).

Cogeneration has many levels of application. Utility power plants can be designed so that cogenerated steam is channeled to nearby users. Such CHP systems are already in practice. In Harrisonburg, Virginia, for example, steam that is cogenerated from a Waste-to-Energy plant is used for James Madison University, while the rest is used to cogenerate electricity for the Harrisonburg Electric Commission. This system can drastically reduce annual energy needs and polluting emissions (van der Leeden).

On a smaller scale, single buildings can use CHP systems to generate their own electricity while providing thermal energy for internal uses. The best time to consider the application of a CHP system is during the initial planning of new buildings, or during the replacement of old machinery.

Cogeneration is also widely used in wood products companies and petroleum refineries. These facilities already have sources of fuel on site and can increase efficiency by using heat created in manufacturing. Heat can be captured on the site by burning tires, or wooden pallets. When manufacturers generate their own energy, less energy is lost than in the transmission of energy from the power plant. This can also reduce costs to the manufacturers (USDOE).

### *Additional Resources*

- Virginia Energy Plan (http://www.dmme.virginia.gov/vaenergyplan.shtml)
  Ten-year comprehensive energy plan geared to implement the Commonwealth's energy policy providing a clear path to protect the public health, safety, and welfare for all Virginians.

- Virginia Energy Savers Handbook
  (http://www.dmme.virginia.gov/DE/ConsumerInfo/energysaverhandbook.shtml)
  Guidebook for improving home energy efficiency which is available online or through local city or county Cooperative Extension Offices

- Energy Hog (http://www.energyhog.org)
  Energy Hog is an energy efficiency campaign developed by the Ad Council and run by the Alliance to Save Energy that engages children and raises awareness of the benefits of energy efficiency. He is a villainous character who wastes energy in the home. The campaign is a non-profit effort with more than twenty sponsors, including The Home Depot, the U.S. Department of Energy, and several state energy offices.

- Get Smart About Energy (http://www1.eere.energy.gov/education/lessonplans/)
  On this site you'll find links to more than 350 lesson plans and activities on energy efficiency and renewable energy for grades K-12. Each includes a short summary that identifies curriculum integration, time, materials, and national standards.

- Another home energy calculator and conservation tips are provided by American Electric Power company's online tool Watt, Why & How (http://www.wattwhyandhow.com/)

- Specific information about Virginia's mineral resources and energy use can be found in the Virginia Natural Resources Education Guide – http://www.vanaturally.com/vanaturally/guide/mineralsandenergy.html as well as a lesson plan comparing energy types.

## 4.5 Materials List

### *4 – 1 Energy Use*

- Paper,
- Pencil

### *4 – 2 Make a Solar Oven*

- One pizza box from a local pizza delivery store
- Newspapers
- Tape
- Scissors
- Black construction paper
- Clear plastic wrap
- Aluminum foil
- A piece of notebook paper
- A pencil or pen
- A ruler or a wooden dowel or a stick

### *4 – 3 Make a Geothermal Power Plant*

- Child's pinwheel
- Aluminum foil
- Empty soup can or similar sized tin can with one end cut off
- A wooden ruler
- Small cooking pot
- Hot plate
- Hammer
- 10p nail
- Tape or rubber bands
- Mitten type of pot holder

### *4 – 4 Simulate the Production of Energy from Garbage*

- Packet of dried peas or beans
- Six airtight clear plastic bags
- Water

### *4 – 5 Products that can be Recycled or Used for RDF*

- Cardboard
- 50 pieces of garbage per group (twigs, old toys, plastic bags, aluminum cans, etc.)

### *4 – 6 Construct a Turbine*

- A quart or half gallon milk carton
- String
- A nail
- Water in another larger container
- Tape

### *4 – 7 Tour a Nuclear Power Plant*

### *4 – 8 Advantages and Disadvantages of Various Energy Sources*

- Paper
- Pencil

### *4 – 9 Effective Use of Building Management to Reduce Heating and Cooling Costs at Your School*

- Attached worksheet

### *4 – 10 Demonstrate Efficiency of Positioning Buildings to Face Southward*

- Two cups (same size)
- Cardboard
- Water
- Thermometer

### *4 – 11 Hybrid Cars: A Cost-Benefit Analysis*

- Cardboard
- 50 pieces of garbage per group (twigs, old toys, plastic bags, aluminum cans, etc.)

# IV. Window into Energy

## 4.6 Activities

### *4 – 1 Energy Use*

Students will spend time brainstorming all of the ways in which they have used "energy" in the past 24 hours. This activity will gain students interest in the topic and impress upon students the importance of a continuous supply of power.

### *4 – 2 Make a Solar Oven*

Using a pizza box and various other supplies, a solar oven will be made. Observing the warming of a snack from the solar oven models the efficiency of heating a home by taking advantage of natural sunlight

### *4 – 3 Make a Geothermal Power Plant*

Geothermal power plants take advantage of steam from the Earth's crust to turn turbines, thus producing energy. This activity uses steam from a can and a pinwheel to illustrate this same process.

### *4 – 4 Simulate the Production of Energy from Garbage*

An increasing trend in fuel production is the use of biofuels. Students will create an environment where they can observe the production of gases from biomass.

### *4 – 5 Products that can be Recycled or Used for RDF*

With the increased production of waste by humans, one solution is creating an additional fuel called Refuse Derived Fuels. This activity allows students to become aware of additional uses of our "trash" even after it is thrown out.

### *4 – 6 Construct a Turbine*

Much like activity 4 – 3, this activity provides an example of a turbine, using water as the driving force rather than steam.

### *4 – 7 Tour a Nuclear Power Plant*

Provides resources for supplemental information regarding nuclear power plants. Information on videos, contact information for Virginia plants, and interactive websites are included.

### 4 – 8 *Advantages and Disadvantages of Various Energy Sources*

This activity provides an opportunity for students to review all of the different sources of energy available and share their thoughts on the positive and negative aspects of each.

### 4 – 9 *Effective Use of Building Management to Reduce Heating and Cooling Costs at Your School*

Creating new sources of energy is not the only way in which the threat of using up all our resources may be curbed. Well thought out building design and renovation can make homes and offices more energy efficient. Students can use the worksheet provided to see what practices are being done in the school or at home to help.

### 4 – 10 *Demonstrate Efficiency of Positioning Buildings to Face Southward*

Passive solar heating is another way to make use of natural warmth from the sun, as can be observed from this activity.

### 4 – 11 *Hybrid Cars: A Cost-Benefit Analysis*

Cost/Benefit Analysis – Hybrid Cars vs. Fossil Fuels

## 4 – 1 *Energy Use*

***Purpose***

Students will gain an appreciation for all the ways they depend upon energy.

***Materials Needed***

- Paper
- Pencil

***Procedure***

- Take a few minutes to brainstorm all of the possible ways you have depended upon energy in the past 24 hours.

- When you are ready, create your list independently and prepare to share your thoughts with the class.

## 4 – 2 Make a Solar Oven

### Purpose

This activity allows students to build a solar oven that gets hot enough to warm up cookies and other treats, like s'mores.

### Materials Needed

- One pizza box from a local pizza delivery store
- Tape
- Black construction paper
- Aluminum foil
- A pencil or pen
- Newspapers
- Scissors
- Clear plastic wrap
- A piece of notebook paper
- A ruler or a wooden dowel or a stick

### Procedure

- Make sure the cardboard is folded into its box shape and closed.
- Place the piece of notebook paper in the center of the lid of the box and trace its outline on the lid. Put the piece of paper aside.
- Carefully cut the two long edges and one of the short edges of the rectangle that you just traced on the lid of the box, forming a flap of cardboard.
- Gently fold the flap back along the uncut edge to form a crease.
- Wrap the underside (inside) face of this flap with aluminum foil. Tape it on the other side so that the foil is held firmly. Try to keep the tape from showing on the foil side of the flap. The foil will help to reflect the sunlight into the box.
- Open the box and place a piece of black construction paper in so it fits the bottom of the box. This will help to absorb the sun's heat.
- Close the box, roll up some newspaper, and fit it around the inside edges of the box. This is the insulation that helps hold in the sun's heat. It should be about 1 to 1 1/2 inches thick. Use tape to hold the newspaper in place, but only tape it to the bottom of the box, not the lid.
- Cut two pieces of plastic wrap an inch larger than the flap opening on the box top. Open the box again and tape one piece of plastic wrap to the underside of the flap opening. After taping one side, ***be sure to pull the plastic wrap tight,*** and tape down all four sides so the plastic is sealed against the cardboard.
- Then close the box and tape the other piece of plastic wrap to the top of the flap opening. Again, be sure the plastic wrap is tight and tape down all four edges to form a seal. This creates a layer of air as insulation that helps keep the sun's heat in the box.
- Finished building—Let's give it a try!
- On a sunny day, pick a treat to warm up and carry it and the box outside to a sunny spot. If it's cold outside, put a towel or blanket under the box so the bottom doesn't get cold.
- Open the box, put the treat in the center, and close the box. Now open the flap and turn the box so the foil is facing the sun. The shadow of the flap should go straight back to the back of the box. Move the flap up and down and note how it reflects the sunlight. Use a dowel, ruler, or stick to prop up the flap so that it bounces the sunlight into the box.
- Wait about a half hour for the box to warm up in the sun. Then enjoy your warmed-up treat!

## 4 – 3 Make a Geothermal Power Plant

*Provided by the Energy Information Administration*

### Purpose

Make your Own Geothermal Power Plant (Renewable)
California Energy Commission

### Materials Needed

- Empty soup can or similar sized tin can with one end cut off
- Child's pinwheel
- A wooden ruler
- Hot plate
- 10p nail
- Mitten type of pot holder
- Aluminum foil
- Small cooking pot
- Hammer
- Tape or rubber bands

### Procedure

- Take hammer and nail and carefully punch a hole in the end of the tin can near the edge. Punch another whole directly across the top from it. The two holes should not be bigger than 1/8 inch across.
- Tape or attach the ruler to can with rubber bands.
- Put water into the pot and cover the top of the pot with two layers of tin foil. Tightly crimp the tin foil around the edges so it seals the top tightly.
- Using the nail, punch a hole in the top of the tin foil cover in the very center about 1/16 inch across. Put covered pot to side.
- Put the pot onto the hot plate and bring to a boil.
- Put on the mitten pot holder, and when steam starts coming out of the top, carefully hold the pinwheel over the one hole. Notice how fast the wheel spins.
- Take the can on the ruler and place it on the top of the pot so that the hole is in the center of the open end of the can. Steam should now be coming out of the top of the can through the two holes.
- Carefully hold the pinwheel. Turn the pinwheel so that the holes are on opposite sides of the pinwheel. Notice how fast the pinwheel turns
- Take pot off the hot plate and let cool. Carefully take off the tin foil, add more water to the pot and put tin foil top back on. Take the nail and poke lots of holes all over the tin foil. Punch 5 holes close to the edge away from the center hole, repeat the experiment with ten holes around the edge, 20 holes around the edge.
- Bring the pot back up to boiling. Hold the pinwheel over only the one center hole.

## Reflection

How much steam do you see?

How fast is the pinwheel turning?

With one hole in the pinwheel, how fast did the pinwheel turn?

With the can making the steam hit the wheel equally on either side, what happened?

When you punched more holes in the tin foil, what happened?

In a geothermal power plant, steam is used to turn a turbine. The turbine is attached to a generator to make electricity. There are two places in the world where natural steam is found under ground and is used to make electricity. One is in Italy. The other is north of San Francisco in an area called The Geysers. The Geysers produces enough energy to power a city of about one million people, but in recent years, the amount of steam produced by the area has decreased. Some people think that it's because there are too many "holes" in the ground like the pot cover with 20 holes. It's like having a soda with 20 straws in it and all of your friends and you sipping at the same time. The soda glass will be drained ***very*** fast. That's what some people think is happening to the Geysers…that it's running out of steam.

## 4 – 4 *Simulate the Production of Energy from Garbage*

*http://www.need.org/needpdf/IntGarbageEnergy.pdf*

**Purpose**

Illustrate a small scale example of biomass fuel production.

**Materials Needed**

- Packet of dried peas or beans
- Six airtight clear plastic bags
- Water

**Procedure**

- Soak the peas or beans overnight.
- Place 10 peas or beans into each bag and squeeze out all the air before you seal them.
- Put two bags in a warm sunny place, two bags in a warm shady place, and two bags in a totally dark place for a week and observe what happens.

**Reflection**

What do the bags look like?

_____

_____

_____

What is being produced by these beans/peas?

_____

_____

_____

What's actually happening?

_____

_____

_____

The peas/beans have produced gas that is being trapped in the bags. This is a small-scale example of biomass fuel production.

## 4 – 5 *Simulate the Production of Energy from Garbage*

***Purpose***

This activity has students determine further uses of "trash."

***Materials Needed***

- Cardboard
- 50 pieces of garbage per group (twigs, old toys, plastic bags, aluminum cans, etc.)

***Procedure***

- Students can make a "trash pizza."
- First put students in teams of 4 or 5.
- Get big pieces of cardboard and cut them into circles like a pizza for each group.
- Label three sections of the pizza: Trash, Recycle, or RDF.
- Next the teacher should have harmless things the students would not mind touching in the bags for each group, around 50 pieces of garbage per bag, with items that can be recycled and things that are just trash.
- Put in funny things to stimulate students' curiosity about what it is made of, like balloons, or little green army soldiers. Put in items like twigs and leaves to illustrate that they could be used in paper products or mulch.
- Instruct students to dig through their garbage and sort through the trash and then glue or tape the pieces of trash to the cardboard under the right section.
- The team with the most correct items in the right sections gets to eat all the pizzas!

## 4 – 6 *Construct a Turbine*

*www.energy.vt.edu/vept/electric/maps/majorpowerplants.html*

**Purpose**

Make A Turbine (Flavin) – California Energy Commission

**Materials Needed**

- A quart or half gallon milk carton
- String
- A nail
- Water in another larger container
- Tape

**Procedure**

- Using the nail, punch a hole in the bottom right corner of each side of the milk carton.
- Punch another hole exactly in the middle of the top section of the carton
- Push the string through the top hole of the carton and tie securely so the carton will hang from the string.
- Tape up each hole with masking tape.
- Go outside and hang the carton from a low tree branch or another place when the carton can hang freely and you won't mind if the ground gets wet underneath.
- Fill the carton with water.
- Pull off the tape on one corner. Watch what happens.
- Pull off the tape on two corners opposite each other. Watch what happens.
- Pull off the tape on all corners and watch what happens.

**Reflection**

What happened as you took each piece of tape off?

_____

_____

Why do you think this happened?

_____

_____

What's actually happening?

_____

_____

Sir Isaac Newton discovered the principle that for every action there is an equal and opposite reaction. This is called his Third Law, as the water pours out of the small hole and its force pushes the carton in the opposite direction. This is what makes it turn. The more holes there are the faster the carton turns.

This is similar to some turbines. Some turbines use water or steam that is forced at high speed through many small holes to turn a turbine around. The turbine is connected by a shaft to an electrical generator, which makes electricity when it is turned.

## *4 – 7 Tour a Nuclear Power Plant*

***Purpose***

Visit a working nuclear power plant.

***North Anna Power Station***
Information Center
540-894-2029 or 540-894-2028
Open Monday-Friday, 9:00 a.m.-4:00 p.m.

***Surry Power Station***
Information Center
757-357-5410
Open Monday-Friday, 9:00 a.m.-4:00 p.m.

Interactive Website – Tour of a nuclear power plant:
http://www.dom.com/about/stations/nuclear/nuctour.html

***Reflection***

How would you feel about living near a nuclear power plant?

Is it important to you to preserve the Earth for future generations?

Do you think past generations (your ancestors) thought about you when making decisions? If not, do you wish they had? What could they have done differently?

## 4 – 8 *Advantages and Disadvantages of Various Energy Sources*

***Purpose***

Students will become more familiar with a particular energy source in order to present further information to the class.

***Materials Needed***

- Paper
- Pencil

***Procedure***

- Divide students into groups and have each individual group contemplate advantages and disadvantages of their source of energy.

- Once sufficient discussion time has been given, have each group present their thoughts to the class.

## 4 – 9 *Effective Use of Building Management to Reduce Heating and Cooling Costs at Your School*

***Purpose***

This activity helps students discover ways in which their school is managing the efficient heating of the building by answer the following questions.

***Materials Needed***

- Copies of the attached checklists

# 4 – 9 *Effective Use of Building Management to Reduce Heating and Cooling Costs at Your School*

## *Interior of Building Checklist*

| Energy Item | Yes | No | Comment |
|---|---|---|---|
| 1. Are the ceilings insulated? | | | |
| 2. How thick is the insulation? (in inches in the last column) | | | |
| 3. Is there a vapor barrier on the indoor side of the insulation (plastic, aluminum, or heavy brown paper)? | | | |
| 4. If the building is on a slab or has an unheated basement, does the first floor have insulation under the floors? | | | |
| 5. If the basement is heated, are the basement walls insulated? | | | |
| 6. About how much of the floor is covered with rugs, carpeting, etc. (in percent or fraction)? | | | |
| 7. Are heating and cooling equipment blocked by furniture, rugs, and drapes? | | | |
| 8. Are walls and ceiling light enough in color to reflect light well? | | | |
| 9. Are hot water faucets free from drips? | | | |
| 10. Have flow-restrictors been placed in pipes connected to shower heads? | | | |
| 11. Is there a clock thermostat? | | | |
| 12. Is the exhaust hose from the clothes dryer detached from its vent and run through a filter to keep warm, damp air inside the house? | | | |
| 13. Has the furnace been cleaned and serviced in the last year? | | | |

# 4 – 9 *Effective Use of Building Management to Reduce Heating and Cooling Costs at Your School*

## *Exterior of Building Checklist*

| Energy Item | Yes | No | Comment |
|---|---|---|---|
| 1. Are there fewer windows on the north side of the building? | | | |
| 2. Are the north windows smaller than those on the other sides? | | | |
| 3. Does the roof on the south side extend out from the house far enough to block summer sun from walls and windows? | | | |
| 4. Will the roof block the lower winter sun from the walls and windows? | | | |
| 5. Are the storm windows in place and tightly sealed? | | | |
| 6. If there are no storm windows, are there temporary barriers installed? | | | |
| 7. Are evergreen shrubs and trees planted as windbreaks around the north and west sides of the building? | | | |
| 8. Are deciduous (leaf shedding) trees planted on the south side for summer shade and winter sun? | | | |
| 9. Are cellar doors insulated and tight-sealing? | | | |
| 10. Are cracks and joints around windows, doors, stairways, pipes, and electrical wires caulked? | | | |
| 11. Is there weather stripping around the inner and outer doors? Windows? | | | |
| 12. Are cracks in walls and foundations sealed and holes plugged in? | | | |
| 13. Is there an air lock entry hall, double door, or insulated storm door at each outside entrance? | | | |

## 4 – 10 *Demonstrate Efficiency of Positioning Buildings to Face Southward*

### *Purpose*

The sun shines most on the south side of buildings. If you have windows on the south side, they can let in the sun's heat and warm up the building. When it gets cold in the winter, south facing windows help buildings stay warm. This activity emphasizes the benefits of proper positioning of a building for effective solar heating.

### *Materials Needed*

- Two cups (same size)
- Cardboard
- Water
- Thermometer

### *Procedure*

- On a nice sunny day, you can see for yourself how much the sun can heat things up. Get two cups that are the same size and color. It's best if they are a dark color. Also get two pieces of cardboard that are a dark color, or use crayons to color them black.

- In the morning, fill both cups with water. Put one by a window on the south side of your house and one by a window on the north side. Make sure the shades are up on the windows.

- Cover each cup with a piece of cardboard.

- Wait until the end of the day, when the sun is starting to set, and get both cups of water and put a thermometer in them to measure their temperature.

- The water that was on the south should be warmer, because it was heated by the sun. Do you want the sun to warm up your house? If it's usually warm outside where you live, you probably want to keep the sun out. But if it's usually cold outside, the sun can help keep you warm.

## 4 – 11 *Hybrid Cars: A Cost-Benefit Analysis*

### Background

A hybrid car couples an electric engine with an internal combustion engine, combining the best aspects of both types of engines. At low speeds, the hybrid car uses the electric engine, but at high speeds, it switches to the internal combustion engine, which also acts to recharge the battery in the electric engine, eliminating the need to plug in the car. Because of the engine type, hybrid cars are small and lightweight. A large hybrid car could seat five people. This size might not be suitable for large families or people who need room to transport things. Hybrid cars produce fewer emissions and have a better fuel efficiency. In a country dependent on foreign oil, hybrid cars could be of great value since they reduce the amount of gasoline consumed. There is no doubt that hybrid cars save their owners money on gas, but are they worth it? Hybrid cars are more expensive than regular cars. In order to explore this, let's take a look at the Honda Civic and the Honda Civic Hybrid. Comparison of these two vehicles can help us determine if the hybrid model will be worth the cost.

As we go along, keep a running tab of the cost of each vehicle. The initial cost of the vehicles reveals that the hybrid is significantly more expensive than the regular Civic. The hybrid model can be purchased for about $21,000, while a comparably equipped regular Civic can be bought for about $17,000 after dealer incentives, which hybrids rarely have (Incantalupo). The initial costs of the hybrid could be lower in the future if they are produced in greater number. The higher cost of the hybrid also results in a higher sales tax. If sales tax is 5 percent, then the Civic Hybrid would result in a tax of $1,050, and the Civic would have a tax of $850. As an incentive for people to purchase the more environmentally friendly hybrid model, the government offers a tax deduction of $1,500, which results in an actual amount of $150 - $579, depending on the buyer's tax bracket (Incantalupo). Assuming that the buyer is somewhere in between, that would result in a tax break of about $350. So, for the initial cost of the vehicles, we are at $21,700 for the Civic Hybrid and $17,850 for the Civic. Assuming equal maintenance and repair costs, this means that the buyer needs to save $3,850 in fuel costs in order for the Civic Hybrid to be equal in cost to the Civic.

The Environmental Protection Agency (EPA) gives fuel economy ratings for all vehicles, however, the vehicles tend to get lower fuel economies than the ratings indicate. The EPA rating for the Hybrid Civic is 48 mpg (miles per gallon) and 34 mpg for the Civic. Consumer Reports tested the two cars and found the Hybrid Civic to get 36 mpg and the Civic to get 29 mpg (Incantalupo). For these calculations, an average of the two ratings will be used. The average car is driven 15,000 miles per year. Using a fuel cost of $1.75/gallon, it can be calculated that the Hybrid Civic would cost about $625 each year and the Civic would cost about $835 per year. Since the value of money changes over the years with inflation, the present value of the future gasoline costs needs to be calculated. Allowing for the discounted rate of 3% over the course of the vehicle's lifetime (approximately 12 years), the present value of the fuel used over the lifetime of the Hybrid Civic would be about $6,565 and the Civic would be about $8,560. This gives a savings of $1,995 in fuel costs for the Hybrid Civic. Since the consumer needed to save $3,850 in fuel costs in order for the Civic Hybrid to be equal in cost to the Civic, the buyer has ended up paying an additional $1,855 for the hybrid car. In fact, the owner would have to drive the hybrid car for more than 220,000 miles to break even (Incantalupo). Most cars don't last that long. In addition to operating costs, it should be noted that the resale value of hybrid cars are lower than regular automobiles. A hybrid car depreciates about $4,200 in the first few years, but a regular car depreciates about $2,800 (Ahmed, 6). Although the hybrid car is more

expensive, there are other benefits for the owner that cannot be as easily measured in terms of money. Some buyers enjoy driving a car that is better for the environment. What value should be put on that?

| | *Honda Civic* | *Honda Civic Hybrid* |
|---|---|---|
| *Cost of car* | $17,000 | $ 21,000 |
| *Sales tax* | $ 850 | $ 1,050 |
| *Tax incentive* | $ 0 | –$ 350 |
| *Fuel costs (12 years)* | $ 8,560 | $ 6,565 |
| **Total cost** | **$26,410** | **$28,265** |

It is important to keep in mind that these costs only apply to the owner. What about social costs? The hybrid car produces less pollution. Pollution costs society money. Researchers at Carnegie Mellon determined that a hybrid car (the Toyota Prius) cost society $3,393, which includes future costs of greenhouse gases in the atmosphere, but the Toyota Corolla cost society $4,167 in pollution costs, a difference of $774 (Ahmed, 8). In addition to the costs of dealing with pollution, one must consider the healthcare costs associated with pollution-related illnesses in the future. This would be difficult to determine, especially since there could be loss of life involved. Also, there are indirect costs to society due to people getting sick or dying, and therefore, not being able to contribute to society.

## Reflection

Which car do you feel is the overall best value? Why?

How do you feel about putting a price on pollution or human illness?

What does your family need to get out of your vehicle? (Driving the family around? Carpooling to soccer practice? Taking the trash to the dump?) Would the smaller hybrid car be suitable?

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