Examining Energy Resources

Background

The race is on to find "new" sources of energy. Over the last 200 years, nonrenewable energy resources such as coal and oil have provided most of the world's energy. In the mid-20th century, nuclear fission opened new possibilities and introduced a new set of concerns. One undeniable issue with all these fuels is that they will eventually run out. Even before they are completely exhausted, fossil fuels will become more expensive to extract. Accessibility and quality of coal deposits have been important factors in siting the coal mines already in operation, and as they become exhausted, people look to deposits that are in less desirable locations or are of poorer quality. A new emphasis has turned to renewable energies.

Solar, wind, biofuels, and even wave energy are potential sources. Not only are these sources renewable, but they produce either no pollution or less pollution. However, there are still some environmental concerns to be addressed with each of these technologies.

Coal Gas

The United States has a tremendous supply of coal. Some forecast the supply to last another 100 to 200 years. Coal has been a main energy source for the U.S., first for heating, transportation, and manufacturing, and then for large-scale generation of electricity. Burning coal releases nitrogen and sulfur gases, along with carbon dioxide. These gases mix with water vapor in the air and produce weak acids. Over widespread areas in the eastern U.S., acid deposition has become a real concern, damaging swaths of forest and reaching streams and lakes, where it kills many aquatic organisms. The acid also deteriorates limestone, a component in buildings and bridges. Carbon dioxide, a major greenhouse gas, is a player in global warming.

One alternative to burning coal is to gasify it. Coal gasification technology, which produces coal gas or syngas, has existed for more than 100 years but has not been used much. Heating coal and injecting steam into it causes the coal to break apart into smaller molecules, including carbon monoxide and hydrogen gas. Both of these gases can be used as fuel. The remaining components, which normally cause most of the pollution associated with coal, are captured during gasification and can be sold for other uses. Engineers continue to refine the technology, and several coal gasification plants are now in operation.

Coal gasification may help reduce the threat of pollution, but it does not address the fact that coal will run out. One promising point is that the gasification technology seems to work also with organic feedstocks other than coal, such as cellulose from plants, and people are experimenting along those lines.

Hydrogen

Another promising fuel that is gaining interest, especially in the auto market, is hydrogen. Automakers are developing cars that run on hydrogen fuel cells. This technology could end people's reliance on gas and oil. Hydrogen is the most abundant element in the universe, and there is no shortage of it on earth. One conspicuous source is water; separating the oxygen from the two hydrogens in a water molecule yields hydrogen gas. Hydrogen is combustible, and the product from burning it is water. The exhaust from a car that runs on hydrogen gas is water vapor.

The main catch with this technology is that energy is required to break the bonds in water molecules, and something must supply that energy. Currently, most of the energy needed for large-scale production of hydrogen fuel would probably come from a coal- or nuclear-powered electric-generating plant.

Although hydrogen might help reduce dependence on oil, there is still the issue of the pollution and the use of nonrenewable fuels associated with its manufacture.

Another problem with hydrogen is that cars do not presently run on hydrogen fuel, and people would need to purchase new ones. A large-scale move toward hydrogen would also require a different sort of infrastructure for fuel distribution.

Solar

Most of the sun's energy that hits the earth is reflected back into space. By capturing less than one percent of the sun's energy that reaches earth, plants and algae create the basis of the entire planet's food chain. Solar energy is abundant, renewable, and clean, and its use has gained momentum in recent decades. There are many different ways to harness the energy from the sun. On some homes, plastic water pipes are run along the roof and are covered with black tarps to absorb sunlight and heat the water during the day. This reduces the need for a water heater, an appliance that is normally a big energy user. In some parts of the world, people make solar cookers, which have mirrors to concentrate the sun's rays onto a small area to produce enough heat to cook food.

On a larger scale, solar power-generating plants are being built all around the world. Some plants use a field of mirrors to direct the sun's rays to a central boiler to produce steam, which rotates turbines and generates electricity. Photovoltaic (PV) cells are also used in solar plants as well as in homes. These cells are designed to capture the sun's energy and convert it directly to electricity. These cells are widely used to power many devices, including calculators, clocks, and landscaping lights.

Currently, a problem with solar power is the cost to create the photovoltaic cells. Some of the materials, such as silicon, are in high demand, causing the cells to be expensive. A variety of new types of cells are being developed to overcome the price obstacles. Since coal is readily available and cheaper than solar cells, though, it is still difficult to change over to this renewable and clean energy. Another problem with the use of solar energy alone is that some areas may not have enough sunlight, especially during the winter.

Wind

Wind power has been harnessed for centuries. The mechanical energy of windmills has been used to grind grain and to pump water. The addition of a generator enables a windmill to produce electricity through a process called electromagnetic induction. Like solar energy, wind is clean, renewable, and abundant. After the initial costs of building and erecting the turbines and the power transmission lines, wind energy is virtually free.

Some of the controversial issues surrounding wind power are noise, lights, and the threat to wildlife. The problem of noise produced by wind turbines is hard to evaluate. The turbines are often located in rural areas, where residents are unaccustomed to background noise and often report interrupted sleep and nervousness due to the turbines. As with any noise, the sound bothers some people more than others. In some cases, the sound of the wind itself helps mask the sound of the turbines. Still, complaints and concerns about turbine noise have occurred frequently enough to make noise reduction an important aspect of the ongoing improvement in the design and siting of wind turbines. Because sound energy is wasted energy, noise reduction efforts often lead to greater efficiency. In some cases, light pollution is an irritating side effect of wind turbines. Any structure in the U.S. that is higher than 200 feet must have warning lights for aircraft. On a large wind turbine farm, this requires many flashing red and white lights

Conservationists are concerned with the effects of wind turbines on wild bird and bat populations. Many of the migratory routes of birds and of tree bats follow coastal areas or mountain ridges with sustained high winds-the same areas that are best for wind farms. There have been reports of significant numbers of birds and bats killed by the towers and turbines. Wildlife biologists monitor the extent of this problem. It appears that in some areas, the mortality rate is troubling, but in comparison with the numbers of migratory birds killed by power line accidents or vehicles, the numbers seem less significant. As with the noise problem, wildlife protection has become one of the issues taken into account in the location and design of wind farms.

The Future

Many new technologies are being developed today to create energy for the future as people realize that fossil fuels are not going to last forever, that energy demand will increase, and that existing technologies cause too much pollution. It is estimated that the world population will surpass 9 billion people by 2050. No single technology can effectively supply enough energy for the world, and each has good and bad points. The likely scenario for the future is that a multitude of energy sources will be used in conjunction.

PART I: Coal Gas

In this activity, your group will explore an indirect way coal can be used as a fuel. This process has been known for more than 100 years, but scientists are now reexamining some advantages of coal gas.

Materials: coal, test tube, metal file, ring stand, buret clamp, Bunsen burner, toothpicks, rubber stopper w/hole, medicine dropper, weigh boat, striker

Procedure:

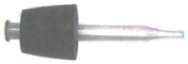

Figure 1

1. Set up the support stand, buret clamp, and Bunsen burner.
2. Using the metal file, shave off a small pile of coal into a weigh boat. There should be just enough to cover the bottom of a test tube.
3. Carefully dump the coal shavings into a test tube.
4. Remove the bulb from the medicine dropper. Insert the glass dropper tube through the hole of the rubber stopper, upside-down. Make sure the small end of the dropper is protruding through the larger end of the stopper. Be careful not to break the dropper by forcing it through the stopper too hard. (see *Figure 1*)
5. Cap the test tube with the stopper and place it in the buret clamp. The tube should be positioned horizontally, with the coal shavings directly over the burner. (see *Figure 2*)
6. Light the burner and, if necessary, carefully lower the test tube until the flame is touching the glass at the coal shavings.
7. As the gas fills the test tube and begins to funnel out the end of the dropper tube, light a toothpick. Hold the lit toothpick to the end of the dropper tube until it lights the gas coming out. This may take several tries; try holding the toothpick just below the tip so that the flame can rise to meet the gas.
8. Observe what happens not only to the gas coming out of the test tube, but also to the gas inside the tube. Extinguish the burner and toothpick.
9. Allow the test tube to cool completely before removing it from the buret clamp. Once cooled, dispose of the test tube with the coal shavings as directed by your teacher.
10. Answer the questions in the Results & Analysis section.

Figure 2

Results & Analysis:

On a separate sheet of paper, answer the following questions thoroughly using complete sentences. You may complete your work on the computer. Staple your work, including any graph(s) to the back of this packet.

1. What was formed when the coal was heated?
2. What happened when the lit toothpick was held up to the tip of the glass tube?
3. Why is gas produced when the coal is heated?
4. What are some of the drawbacks with using this type of fuel?
5. What are some of the environmental concerns with using coal gas?

PART II: Hydrogen Fuel

Hydrogen fuel is becoming more frequently discussed as an alternative to burning gas or diesel in cars. Some hydrogen cars are on the market. In this activity, your group will generate hydrogen gas and witness the energy it contains.

Materials: micro electrolysis apparatus, small test tubes (x2), trough, 150 mL beaker, 10 mL graduated cylinder, 1 M sodium sulfate, 9V battery, toothpicks, Bunsen burner, striker

Procedure:

1. Measure 10 mL of sodium sulfate with a graduated cylinder and place it in the rectangular trough.
2. Add 140 mL of water to the trough.
3. Lay the two test tubes on their sides in the solution in the trough and let them fill completely with the solution.
4. Place the micro electrolysis apparatus on its side in the solution so that the electrodes are facing the mouths of the submerged test tubes. Slide a test tube onto each electrode while keeping the tubes submerged and full of solution. Once they are in position, carefully turn the apparatus upright with the test tubes pointing vertically. The tubes should remain filled with solution and have no air trapped inside. If needed, repeat this step to eliminate the air. (see *Figure 3*)
5. Connect the red wire to the positive (+) terminal of the battery and the black wire to the negative (-) terminal of the battery. (see *Figure 3*)
6. Observe the bubbles of gas being generated at each electrode.
7. After the tube at the black wire is half to three-quarters filled with gas, disconnect the battery.
8. Remove the tube with the most gas (at the black wire) from the water, keeping it inverted (mouth down).
9. Gently shake the tube to remove any water at the bottom, or use a paper towel to dab the end. Be sure to keep the tube inverted so the gas does not escape.
10. Have someone in your group use a match or burner to light a toothpick.
11. While holding the test tube at a 45° angle with the mouth down, insert the burning toothpick into the mouth of the tube and observe what happens.
12. Discard the solution down the drain and rinse everything with water.
13. Answer the questions in the Results & Analysis section.

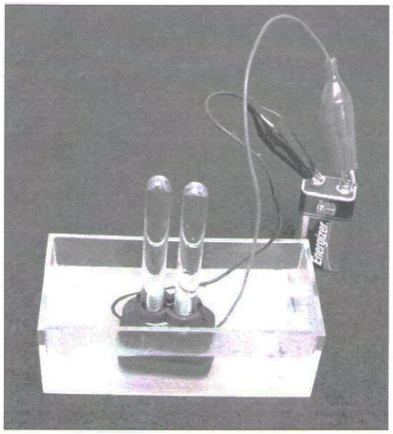

Figure 3

Results & Analysis:

On a separate sheet of paper, answer the following questions thoroughly using complete sentences. You may complete your work on the computer. Staple your work, including any graph(s) to the back of this packet.

6. Since sodium sulfate does not form any gas, what were the two gases that formed in the tubes?
7. By observing the gas that is produced in the tubes, how could you tell which gas is which?
8. What happened when the lit toothpick was placed in the test tube?
9. In what ways is using hydrogen as a fuel source environmentally friendly?
10. What are some drawbacks with using this type of fuel?

PART III: Solar

Materials: photovoltaic (PV) cell, battery, multimeter, alligator clip leads, meter stick

Procedure:

1. Set up the multimeter. Plug the black cable into the COM port and the red cable into the DC port.
2. Clip the red alligator lead to the probe on the red cable. Do the same for the black alligator lead and probe.
3. Using the AA battery, touch the red alligator clip to the positive (+) end of the battery and the black alligator clip to the negative (-) end.
4. Adjust the dial as instructed until you have a reading in DC volts.
5. Using the same setting, place the red alligator clip on the red lead of the solar PV cell and the black alligator clip on the black wire.
6. Using this technique, place the PV cell under different light sources, *keeping the distance between the source and solar panel the same,* and record the voltage. Be sure to deduct any voltage generated due to the ambient lighting in the room.
7. Answer the questions in the Results & Analysis section.

Results & Analysis:

On a separate sheet of paper, answer the following questions thoroughly using complete sentences. You may complete your work on the computer. Staple your work, including any graph(s) to the back of this packet.

11. How many volts of electricity does a battery have?
12. List the different sources of light that you tried with the PV cell, and the corresponding readings.
13. Not counting direct sunlight, which light source produced the highest voltage?
14. In what ways is using solar PV cells environmentally friendly?
15. What are some of the drawbacks with using this type of technology?