Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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Energy in a Clean Environment

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Unit Objectives

The unit “Energy in a Clean Environment” is designed for a ninth grade integrated science class. The topics of energy, work and power will be covered in this unit. The class will begin by covering what energy is and its various forms. The relationship of work and energy will then be discussed. We continue by correlating the units calories, joules and watts used to describe energy, work and power. The first two activities “Heat Energy Calculation Lab” and “Personal Power Lab” are inquiry-based labs used to help the student created an understanding of what the joule and the watt are. The student will be able to take these ideas out of the classroom into real life applications such as reading their energy bill and understanding wattage in home appliances. A discussion will follow on our current energy use and acquisition and conclude with the issues of alternative and sustainable energy sources while looking at each sources advantages and disadvantages. At this point in the unit a field trip to a local power company is used to justify what the class has been learning. It will help to create relevance to the subject of energy. The final unit activity consists of a group research project and presentation on renewable energy sources. In this presentation the students pay particular attention to the efficiency of each alternative energy source as well as what limitations exist in terms of extracting the useable energy. The student will be able to determine which energy source will be most effective to the economy and the environment in the future. It is suggested that the teacher prepare their own model presentation of fossil fuels following the guide lines of the presentation prior to the field trip to enhance the understanding of how heavily we rely on fossil fuels and their role in electrical energy production.

After completing this unit students will:

1. Distinguish between potential and kinetic energy
2. Identify and describe different forms of energy
3. Explain how heat is a form of energy in transfer
4. Define units for describing energy, such as the calorie and joules.
5. Explain how power is used to describe work done over time.
6. Recognize that some energy is wasted in energy conversion.
7. Demonstrate and understanding of renewable and nonrenewable sources of energy

8. Explain why the supply of fossil fuels is finite and discuss the deleterious environmental effects of fossil fuel use.

I. Discussion on Energy and its Various Form

A. Introduction

The survival of human beings has been predicated on our artful manipulation of energy. When fire was first used to radiate heat this harnessing of energy began. The use of energy has been important to food supplies, industrialization and in the improvement of the quality of life. The use of energy relies on the availability of resources and the technological skills in converting the resources to useful heat and work.1

The U.S. industrial society is based on energy and its ability to do work. The success of an industrial society, its economical growth, the quality of life of its people and its impact on other societies depends largely on the quantities and kinds of energy resources it exploits and on the efficiency of its systems for converting potential energy into work and heat.1 Therefore our industrialized society is characterized by its consumption of energy. This consumption is currently based on its dependence of fossil fuels; solar energy stored potentially as coal, oil and natural gas rather than renewable sources such as wind, hydro, nuclear, solar, geothermal and biomass.

During the 1970's and early 1980's there was an increase in the price of oil. This was largely due to the global reductions in oil supplies as a result of the OPEC oil embargo in 1973 and the Iranian hostage crisis in 1979. As a result there was an increasing interest in energy policy and energy conservation nationwide. As the price of oil increased during this period both government and private sectors scurried for the development of renewable energy sources such as solar, wind, geothermal and biomass. When the oil prices fell back to reasonable levels toward the late 1980's national commitment to renewable energies subsided. The prices of these alternative sources were too high for government and consumers to invest in and the inexpensive fossil fuels were again the primary source of energy.1

In recent years there has been a growing interest in renewable energy due to environmental health and political concerns. Fossil fuel use correlates to air pollution especially in urban areas, which is a growing health concern while acid rain and global warming continues to evoke debate. Another growing concern is the current Middle Eastern situation due to the U.S. dependence on foreign oil.

The youth are the future that is why it is crucial for the education of our future engineers and policy makers in the laws of thermodynamics and alternative energy sources. Public policy issues concerning energy have direct correlations with the economy. To solidify wise public policy citizens and legislators must have an understanding about energy sources and be able to apply this knowledge to economic concepts in their analysis of energy issues.

What are energy, work and power?

Energy cannot be created or destroyed but it is converted from one form to another. Everything that occurs in the universe revolves around energy. Heat, light, sound, and electricity are all forms of energy. There are two major categories of energy: kinetic and potential energy. Potential energy is stored energy, energy waiting to be used. Kinetic energy is energy in motion. The energy of a moving object or the movements of light energy are both examples of kinetic energy. Heat energy, the motion of rapidly moving and colliding molecules is also an example. The most important potential energy used by our developing societies is chemical energy, which is found in our foods and fuels.

There are limiting laws of energy which describe what can and cannot happen during interactions of energy. The laws of thermodynamics are stated as:

1. Energy can neither be created nor destroyed.
2. No device can be constructed which operating in a cycle accomplishes only the extraction of heat energy from a reservoir and its complete conversion to mechanical energy (work).

Energy can be defined as the capacity to do work. Work is defined as any interaction between a system and its surrounding that has or could have as a sole effect in either the system or the surroundings the raising of a weight.2 Work is a measurable amount of energy which is converted from one form to another. Therefore work represents a change in energy from one form to another.

An example of how the concept of energy can be used to do work is the Hero engine described in 150 B.C. by a Greek, Hero of Alexandria. Water is placed into a sphere and heated until it boils. When the steam escapes through nozzles it results in forces that cause it to spin. This was the first example of a properly designed steam engine and jet engine and shows that heat can be transformed into work. Another example is rubbing your hands together. Mechanical work, that is force applied through a distance, is transferred to your hands and you feel the result as a rise in temperature. Therefore heat is produced by work and that heat can be used to cause a force to move through a distance. Heat and work are just different forms of the same thing and can be converted into one another.

Light can cause an object to heat up and the hot object can be made to do work. Therefore light can be converted into work. Electricity flowing through a wire causes it to heat up and that heat can be made to do work. We can also spin a magnet in a coil of wire (by applying a force through a distance) and cause electricity to flow through the wire. We can use that electricity to light a light bulb or heat up wires or boil water in our Hero engine so that it spins around.

In all of these examples we are converting the quantity that we call energy from one form into another. When one part of the universe loses energy another part gains energy in the same amount. Therefore **Energy** is anything that can do **Work** or cause a change.

In comparing the amount of energy stored in foods and fuels the unit called a calorie is used. One calorie is the amount of energy needed to raise the temperature of 1 g of water by 1ºC. One thousand calories equals a kilocalorie or the more standard food Calorie. This is the amount of heat energy, which will raise the temperature of 1 kg of water 1ºC.

The unit of measurement of work combines the unit of force, Newton, with the unit of distance, meter, and the resulting unit of work is the Newton-meter. One joule of work is done when a force of 1 N is exerted over a distance of 1 m. In James Joule's original experiments of a paddle wheel he was able to show that 1 joule is equal to 4186 Calories. 4

The rate at which work is done is called **Power** and can be calculated by dividing work by time. The SI unit for power are (N)?(m)/s or J/s. The units of power are given the name Watt (W) after the inventor of the first practical steam engine James Watt.

Watt calculated the power of his machines in terms of how fast horses could do work so that people of his time during the 1700's could understand them. Watt's observations showed that a horse could lift 550 pounds to a height of 1 foot in one second. That rate of doing work is called a horsepower (HP) and is still used as a standard today in the United States. One HP is equal to about 746 W.

A 100 Watt light bulb uses energy at a rate that could lift 100 N of weight to a height of 1 m each second. That's about 13 pounds raised to a height of a little more than 3 feet each second. If you run a 60 W bulb for an hour it brings an awful lot of energy into your house. If we look at work as energy then the calculation looks like this.

The amount of electrical energy used over a given time is measured in a unit called the watt. We can use the watt to compare the rates at which different electrical devices use energy. Electricity companies provide us with a lot of energy for a pretty low price. These companies are often called power companies however they are really energy companies. They convert chemical energy in coal, oil, gas, or nuclear energy from the nuclei of uranium atoms into electrical energy for us to consume as light, heat, or some sort of electromagnetic energy.

Energy Sources: Renewable and Non Renewable

The U.S. uses a variety of primary energy sources including petroleum, coal, natural gas, nuclear, hydropower, geothermal, wind, solar and biomass. These energy sources can be classified as renewable and nonrenewable. Renewable energy sources are sources that have the inability to be depleted. Solar, hydropower, wind, geothermal and biomass are all examples. Nonrenewable energy sources will eventually run dry. These sources include the fossil fuels; oil, coal and natural gas.

Fossil Fuels and Our Dependence.

Fossil fuels are found in deposits in rock formations. The formation began 350 million years ago. It is theorized that decayed remains of ancient plants and animals were buried by sediments. Over millions of years increased pressure and heat caused this biological decay to change chemically to form coal, oil and natural gas.

After food, fossil fuel is humanity's most important source of energy. There are three major fuels coal, oil and natural gas. Coal is used primarily to produce electricity. It therefore provides us with light, motive power from electric motors, and our many electronic devices. Oil gives us our mobility, our cars, planes, trains, trucks and boats. Natural gas is used primarily to produce heat, for our buildings, hot water, and industrial processes..

Most electricity in the US, about 70%, is generated using fossil fuels, especially coal. There are several thousand power generating and supply organizations including investor owned utilities, government - especially municipal - utilities, rural electric cooperatives and independent power producers. Utilities and cooperatives sell the electricity to consumers, so do power marketers in some states, where consumers can now choose their supplier. The electric power industry is changing in a big way, called deregulation. Competition is being added at many levels. The future, including the role of fossil fuel, is hard to predict.

Although there is an enormous amount of inexpensive fossil fuels that are still untapped the continued exploitation of these nonrenewable resources will deplete as time elapses. In the future, after the last sequestered drop of oil or inhalation of coal fly ash, big business will be in renewable energies. Today there is a considerable interest in this topic. This is due to the growing concerns of environmental degradation due to the burning of fossil fuels. Acid rain and global warming are two major concerns.

One of the most potentially threatening problems is global warming. Naturally the earth is surrounded by an atmosphere made of predominately CO_2 and H_2O. This atmosphere allows solar radiation in and traps some of the outgoing radiative heat causing and average surface temperature of 21ºC.

When fossil fuels are combusted the products are CO_2 and H_2O. Excess H_2O in the atmosphere has no environmental effects. However, increased CO_2 levels cause more heat to be trapped in and result in increased surface temperature and hence global warming. This increasing CO_2 concentration has shown a rise in temperatures averaging between 0.5-1.0 ºC a year. This increase in surface temperature may cause several ancillary effects on global climate and hydrology affecting human habitat, welfare and ecology.

Prevention of global warming will require changes in technology of energy production. Fossil fuel use should be decreased. On the surface, a conversion to renewable green energy sources would make sense, however investing in renewable energy can be quite controversial. Scientifically not all scientists feel that this environmental decline is due to fossil fuel use. Economically, fossil fuels are currently abundant and obtainable at a minimal cost. They are important contributors to economic development and a conversion to a more environmentally friendly energy source may cause economic problems.

Solar Energy

Solar energy is the primary source of energy on the earth. This energy is derived from the thermonuclear reaction of fusing hydrogen atoms to form helium, a reaction responsible for driving the suns existence. During this reaction a very small amount of mass is lost. It travels to the earth as pure, radiant energy. Less than 1% of this energy reaches the earth and is enough to provide all of our energy needs. This energy travels as waves of photons, which are easily absorbed or reflected. Heating is important at the earth's surface. When heat is absorbed by land it provides the major heat input into the lower atmosphere. This solar energy fuels the kinetic energy for wind generation of the great trade winds. The combination of solar energy, gravity and the rotation of the earth are responsible for oceanic movement relating to ocean energy. Heat absorbed by the ocean gives surface water molecules enough energy for evaporation to occur. The water vapor is then lifted by rising heated air and is carried by the winds until it falls as rain. By this lifting of great masses of water away from the earth the surface of the earth this solar energy is converted to gravitational potential energy. Some of this gravitational potential energy is then converted to mechanical energy when the water returns to the earth in the form of rain or snow, which move to rivers and streams. The flowing water is used to turn a turbine. 1

Radiant energy from the sun is absorbed by plants and used to break up the molecules CO_2 and H_2O and rearrange them to form carbohydrates. The carbohydrate formed with the help of the suns energy is either food or fuel. Eating or burning the carbohydrates form CO_2 and H_2O while releasing energy in the process.5

Humans have found ways to use the sun's energy directly to provide heat and hot water for homes, offices and factories. In an active system solar energy is collected in a special device used to store and distribute the energy. This solar collector absorbs solar energy and converts it into heat energy. Water circulating through the collector increases in temperature and is used to run a home heating system. In a passive system solar architecture converts a building structure such as a home into a solar energy collector. The home is designed to allow large amounts of heat in while trapping the energy and heating the home.

Solar energy is also used to produce electricity. Photovoltaic (PV) cells originally used for space applications are now use to power solar calculators, toys and roadside telephone boxes. This is accomplished by transforming light directly into electricity with the use of a crystal emitting electrons into a system. Solar electricity production also occurs in solar thermal-electric systems. In these systems collectors concentrate the sunlight into a receiver to superheat a liquid used to produce steam to power electrical generators.6

The potential for solar energy is enormous and should represent a major percentage of our future energy throughout the U.S. It is an unlimited supply of energy and causes no air or water pollution. However the amount of energy received by a solar collector is affected by geographic location, time of the day, seasonal variations and atmospheric conditions. This may cause unreliability and a necessity for storage or backup sources due to the sporadic availability of sunlight.

Wind Energy

Wind is created by the uneven heating of the earth creating temperature, density and pressure differences. In tropical regions there is a net gain of solar radiant energy resulting in heat. In the polar region solar radiation is minimal and we see a net loss of heat. Air at the equator is heated and is raised into the atmosphere. Cooler air from the north replaces the rising warm air. As the warm air loses heat energy it falls back to the earth's surface at the 30º N and 30ºS latitude. This air is very dry and moves east due to the rotation of the earth. Due to this cycle wind is generated.

Wind turbines have been used for thousands of years to convert the kinetic energy to mechanical energy to allow simple machines to grind grain and pump water. During the 19th century wind turbines contributed greatly to economic development of the U.S. but during the 20th century declined due to the exploitation of fossil fuels. During the energy crisis of 1973 the development of wind turbines to generate electricity resumed. Today wind turbines are used to produce electricity. Only about 0.10 % of the U.S. electrical production comes from wind turbines.6

Modern wind turbines operate with a rotor, transmission, generator, and a control panel. Wind drives the rotor creating a rotation speed of 40-100 rpm's. The transmission transfers the low revolution to a high speed shaft for electricity production. The control panel monitors wind speed and direction and regulates turbine operation. Turbines are classified as horizontal axis and vertical axis. Horizontal axis machines contain blade resembling an airplane propeller. 6 This type can attain energy conversions efficiencies as high as 45% of the wind energy. Vertical-axis turbines have two to three fixed pitched blades with both ends attached to a rotating vertical tower. They are easier to maintain, accept wind from any direction and do not require protective features to guard against high winds. However, the efficiency is about 10% less than a horizontal unit. 7

Most of the electricity production from wind occurs on large wind farms. These wind farms are predominately owned by independent producers who operate the farms and sell electricity to the utility company for distribution. The Public Utility Regulatory Act (PURPA) requires these producers to sell the electricity at reasonable rate.

Wind energy is a free source of energy. In the use of electricity generation turbines produce no water or air pollution. Wind farms can be inexpensive to build with the right engineering and the land around the farm can be used for other uses (how about crops for biomass energy). Due to the fluctuation of wind patterns wind power can be variable. For optimal electrical production these systems require constant and significant amounts of wind. Planning issue also revolve around wind farms. A common concern is the visual impacts to the landscape.6

Hydropower

Hydropower is the energy that comes from moving water. Water runs downhill in a path of least resistance due to the gravitational pull of the earth. This constant supply is replenished by the continuous solar evaporation of water from our oceans and lakes and the inevitable return to earth in the form of snow and rain. From the moment it touches ground water trickles, creeps, flows and rushes downhill and downstream eventually finding its way back to the sea. The suns energy is therefore in the flowing water.

Turbines are the mode of energy collection. As water flows through a turbine the kinetic energy of flowing water is converted to mechanical energy which can be used to grind grain, drive a sawmill, pump water and produce electricity. There are several types of turbines used to capture this kinetic energy. Run-of-the-river turbines are submerged in a stream or river and are rotated by the waters flow. The spinning turbine turns a magnet through coils of wire generating a current of electricity. These turbines do not need a dam and have low environmental impact.

The more commonly used hydropower system collects the energy from falling water. A dam is used to capture water. The captured water is released down a pipe with a turbine positioned at the bottom. The vertical distance of the falling water determines how much energy can be captured. The larger the drop the more energy harnessed. The turbine is then used to collect the kinetic energy. Some rivers have the potential to have several of these dams and hydropower stations. The Columbia River which flows through Washington and Oregon supports seven of theses stations.9

Rivers currently contribute over 12 percent of the U.S. electrical supply. Over the past 100 years dams and hydropower plants have been used in the U.S. Because of this long history of development most of the highly marketable river sources have been developed. However there is still room for expansion of hydropower while opportunities exist in the development of small hydropower plants which can supply local electrical needs. This has recently been seen in a renovated plant at Cornell University. This hydropower system provides 5 percent of the electrical needs for the university and generates $250,000 worth of electrical sales to the local utility companies.

Waterpower represents a clean source of electricity. The cost of a power station is relatively low once the station is built. The energy is relatively free once the equipment costs needed to harness it have been paid back. Reservoirs of water offer recreational benefits like boating and fishing, or can be used as companions to solar and wind power.

However, hydropower has environmental impacts. Dams flood large areas covering much more area than solar facilities producing the same amount of energy. Ecosystems have been disrupted by turning narrow stretches of moving water into a wide still pond or lake, disrupting long established plant and animal communities. Local, state and federal regulations cause difficulties in the production of a new power station. These productions require patience, close work with local citizens and environmental groups and constant interactions with government agencies.9

Geothermal Energy

All of the energy we could ever use sits deep below our feet. Geothermal energy is the only renewable resource that is not derived by the sun. Radioactive decay of unstable elements such as thorium and uranium in the earth’s core releases heat, which remain trapped deep below the earths surface. In areas of deep faults and fissures groundwater is able to seep down to heated rocks. The contact causes the water to heat up and rise back to the surface where it can be captured for use.

Greeks and Romans built public baths over hot springs. Native Americans use hot springs for cooking. Early settlers in Oregon and Idaho captured the hot ground water and heated their homes with it. Since 1960 large reservoirs of Geothermal steam and other hot water reservoirs in the U.S. west have been tapped to generate 3,000 megawatts of electricity.9

There are four types of geothermal resources. Hot dry rocks, magma and geopressured brines are still untapped and un-researched areas which could prove quite beneficial in the future, while hydrothermal reservoirs are more commonly utilized. Hydrothermal reservoirs have two basic ingredients water and steam. Pressurized steam that is emitted from drilled wells has the ability to turn a turbine to generate electricity. Hot water from geothermal reservoirs can be used for heating homes, drying food and paper, pasteurizing milk and generating electricity. In Elko, Nevada geothermal hot water is pumped into homes and is used to provide clean and reliable heat.9

Geothermal energy provides an unlimited supply of clean energy. It provides no air or water pollution and any salts or minerals which are waste products can be pumped deep into the ground where they will cause no harm.

Geothermal resources have the potential to be overexploited when heat is removed faster than natural reactions replace it. If this is the case output of energy may fall if the number of wells increases for a given area. Start up and development costs can be expensive as well as maintenance costs due to corrosion. In some rare cases ground settlement has taken place over some reserves.9

Biomass Energy

Biomass is a term defined to describe a variety of energy derived products from photosynthesis. This technology includes all plant material such as trees, crops, seaweed, and animal wastes. All forms of biomass contain sunlight energy stored in chemical bonds. By the process of photosynthesis plants use solar energy to transfer CO2 and H20 into glucose (carbohydrates). The strong covalent bonds between the carbons, oxygen and hydrogen of the glucose molecule are stored as potential energy. The breaking of the bonds by digestion, burning or decomposition releases the stored energy. 9

Biomass in the form of wood has been traditionally man’s oldest form of energy. Sequestering of this energy has been by the process of burning to produce heat and cooking. Historically, as industrialization and energy needs increased biomass reserves were depleted.

Large wood burning stoves are used to heat a large area or generate electricity. Techniques include burning chips of wood or sometimes the tree itself in a mammoth sized boiler. Other systems heat biomass in the absences of oxygen extracting flammable gasses which can be used as an alternative renewable fuel replacing fossil fuels.

Another common form of biomass energy is the burning of municipal solid wastes. Waste-to-energy power plants operate like a traditional coal plant except garbage is burned to produce steam to turn a turbine to generate electricity. Some of these plants burn raw trash, others convert it into dried pellets called *refuse derived fuel* . Sludge from treatment plants can also be incinerated from energy in the same way.

Garbage sites may not be appealing to humans but are feeding grounds to bacteria. These bacterial species slowly digest the organic matter found in the wastes while emitting their own waste products. Their methane gas product is colleted. The burning of this gas can be used similar to fossil fuel use. 9

Major crops such as corn and wheat can be used to generate liquid fuels such as methanol and ethanol. These are relatively high cost fuels to produce but when combining 10 % of ethanol to 90% gasoline Gashol is produced. Gashol is much more cost competitive and can be used in a traditional gasoline engine. It has a higher octane rating than gasoline and is also cleaner burning.

Biomass is a versatile local energy source. Those that live in wooded areas can tap a constant supply of wood while high urban areas can relish in the constant waste production. High yielding quick growing crops can be used to make fuels while providing new jobs for farmers, foresters and loggers around the country. However, burning of wood, alcohol or dried sewage creates the same set of air pollutants as fossil fuels. Over harvesting of wood causes erosion, and silting to our steams and destruction of habitats for plants and animals. Most of these problems can be manage requiring appropriate regulation, which are not yet in place.8

Activity 1

Heat Energy Calculation Lab

Introduction

Heat is a form of energy. Heat energy is used to heat buildings (our school) and run motors (cars). In this lab you will be calculating the amount of solar energy (heat) used to raise the temperature of water.

Objective

The student will:

1. determine how much energy is used to raise the temperature of the water.

2. use the unit of joules to measure energy

3. correlate differences in joules used to heat the water at various temperatures

4. correlate differences in joules used to heat various amounts of water

Materials

250 ml beakers. Thermometers, graduated cylinders, watch

Procedure

1. Obtain a group number from your teacher.
2. Fill your beaker to the desired amount of water and temperature according to your assigned

group number below.
3. Answer the Pre-lab questions on the following page.
4. Place the filled beaker with water in direct sun for 30 minutes.
5. After 30 minutes take the beaker of water out of the sun and answer the post-lab questions.
6. Calculate the amount of heat energy added to raise the temperature of the water with the formula below.
7. Fill in the class table with your information under your group number. The other groups will fill in their information under their group number and we will compare our results with the completed class table.
8. Answer the Conclusion questions.

Group 1 100ml H_2O cold water
Group 2 100 ml H_2O at room temp water
Group 3 100ml H_2O in hot water
Group 4 100ml H_2O at room temp

Group 5 200ml H_2O at room temp

Group 6 300ml H_2O at room temp

Formula: Q = mc /_\ t

Heat *(Joules)* = mass x specific heat x change in temp.

Q = heat in Joules added

c = specific heat = 4.184 J/g °K = specific heat of water

m = mass of water

/_\ t = final temperature – initial temperature

Variables to be studied

1. Same Mass Different Temperature
2. Different Mass Same Temperature

Pre-Laboratory Questions

1. Before we go outside

1. Measure initial volume_________________
2. Measure initial temperature_____________

2. What is the variable for groups 1-3 ______________________________.

Group 1 100ml H_2O cold water

Group 2 100 ml H_2O at room temp water

Group 3 100ml H_2O in hot water

3. What is the variable for groups 4-6________________________________.

Group 4 100ml H_2O at room temp

Group 5 200ml H_2O at room temp

Group 6 300ml H_2O at room temp

Data Tables

Variable 1____

Title:

Group Mass Specific Heat /_\ temp Joules

1.

2.

3.

Variable 2____

Title:

Group Mass Specific Heat /_\ temp Joules

4.

5.

6.

Post-Laboratory Questions

After we return

1. measure final volume___________________
2. measure final temperature_______________
3. Calculate the amount of heat energy used to raise the temperature of the water for your group.

Formula: Q = mc /_\ t

Conclusions

1. Discuss your differences in volume. What caused this difference
2. What is the phase change which is occurring for this difference to take place?
3. Discuss the idea of heat in relation to its formula
4. Draw a conclusion on the correlation between mass, temperature and heat from the class results.

Activity 2

Personal Power Lab

Introduction

A person is a machine which has a *power rating* . Some people are more powerful than others; that is, they are capable of doing the same amount of work in less time or more work in the same amount of time. In the Personal Power lab, students determined their own personal power by doing work on their bodies to elevate it up a flight of stairs. By measuring the force, displacement and time, we are able to measure our personal power rating. Suppose that a student elevates her 60-kg body up the 2.0 meter stairwell in 2.1 seconds. If this were the case, then we could calculate the student's *power rating* . It can be assumed that the student must apply a 588-Newton upward force upon the stairs to elevate her body.

Force = mass x gravity

Work = Force x displacement

1 watt = 1 Joule / sec

Power = Work / time = 588 N x 2.0 m / 2.1 seconds

Power = 560 watts

Objectives

The student will

1. Use the measurements of mass, distance and time to calculate energy, work and power.
2. Correlate how much power is needed by the student to elevate themselves with how much is needed to run house hold utilities.

Materials

Stop watch, meter stick, calculator

Procedure

1. Measure and record your body mass (in kilograms).
2. Measure and record the height of the steps that will be used.
3. Run the stairs, two steps at a time, at three different speeds (slow, medium, maximum effort). Make sure you maintain a constant speed throughout each run. Also, make sure you run consistently (check the time for each trial - for a given speed [slow, medium, maximum], the times should be within 0.05 s of each other).
4. Record the time for each run. Repeat each speed three times. Allow a one minute rest between the maximum effort trials.
5. Enter all data into the spreadsheet with appropriate formulas to calculateenergy, work, and power.
6. Graph Average Work and Power vs. Speed for each group member. Also make a composite graph (average of each member’s averages) of work and power vs speed

Mass Displacement

Speed Trial Time Work Power Energy

Slow 1

2

3

Average

Medium 1

2

3

Average

Fast 1

2

3

Average

Activity 3

WATT Did You Say?

As a homework assignment, instruct students to locate all the light bulbs in their homes, adding up and recording the total wattage. Have them list all the electronic appliances, including refrigerators and air-conditioning units, examining each item when it is turned off to find and record the wattage rating. Then students should add up the total number of watts required to power all the items in their homes. In class, have students estimate the amount of time each item is in use during a month and determine the total power consumption in kilowatt hours for one month. Have them work together to develop a plan to conserve energy in their homes.

Activity 4

Once the concept of energy is understood the unit will introduce how our society

cultivates, harnesses and uses energy. It will begin with our reliance on fossil fuels. It would be advantageous to set up a tour of the Connecticut Light and Power (CL&P) facility or Yale's power plant to create an understanding of energy production and its reliance on fossil fuels.

As the teacher I will model a presentation on fossil fuels. I will take a role as a Historian who discusses this energy source in other places and times, a Local Expert who discusses the use of this energy in the local area and an Environmentalist who discusses the impact of this energy source on the environment, the group will then work together to come up with ways to build structure to capture the natural renewable energy.

The next few classes will be used to break up into groups of three. The class will be provided with a problem to be solved. The problem will be to persuade the members of CL&P to convert their facility to the group's alternative energy source. Each group will have the responsibility to give a persuasive presentation to the members of CL&P. Each group will select an alternative energy source and a role as the historian, local expert or the environmentalist. Group topics will include Hydroelectric, Ocean-Based, Nuclear, Wind, Solar and Bio Fuels. Students will research their topic via the media center incorporating literature, and the internet to create a three-part presentation, which will be given using Power Point. A model of the techniques used to collect the energy will be designed and displayed during the presentation.

Researching Renewable Energy Presentation

Introduction

Although there is an enormous amount of inexpensive fossil fuels that are still untapped the continued exploitation of these nonrenewable resources will deplete as time elapses. In the future, after the last sequestered drop of oil or inhalation of coal fly ash, big business will be in renewable energies. Today there is a considerable interest in the topic of renewable energy. This is due to the growing concerns of environmental degradation due to the burning of fossil fuels. Acid rain and global warming are two major concerns. On the surface a conversion to renewable green energy sources would make sense however investing in renewable energy can be quite controversial. Scientifically not all scientists feel that this environmental decline is due to fossil fuel use. Economically fossil fuels are currently abundant and obtainable at a minimal cost. They are important contributors to economic development and a conversion to a more environmentally friendly energy source may cause economic problems such as unemployment increases.

Procedure:

1. Your group will be assigned a renewable energy resource to research.

2. There will be one of three roles taken by each member of the group;

   a. a **Historian** who discusses this energy source in other places and times
   b. a **Local Expert** who discusses the use of this energy in the local area
   c. an **Environmentalist** who discusses the impact of this energy source on the environment

3. The group will then work together to come up with ways to build structure to capture the natural renewable energy.

Topics to be discussed in you presentations

A discussion on what your renewable energy is.
What are some examples of your renewable energy.
What are the advantages and disadvantages of you renewable energy.
How much energy does the assigned energy source currently produce in the U.S.

How important is this source likely to become in the future?
Is this resource affordable?
How does this energy affect the environment?
A diagram of how energy is sequester from your energy source.
1 Table (at least)
1 Graph (at least)

4. Your presentation will be conducted with Power Point

5. These presentations will be a product of your research including tables and graphs you feel are appropriate to you topic.

Group 1 = Solar energy
Group 2 = Wind energy

Group 3 = Hydropower energy

Group 4 = Geothermal energy

Group 5 = Biomass energy

Group 6 = Tidal energy (Ocean energy)

Activity 5

(To be filled in during the presentations)

Name ______________________________

Renewable Energy Worksheet

1. Complete the table below after listening to your colleges presentations

TYPE DEFINITION EXAMPLES ADVANTAGES/DISADVANTAGES

Solar

Hydropower

Wind

Geothermal

Biomass

Tidal energy (ocean energy)

2. What main **advantage** do the fossil fuels have over the renewable energy resources?

3. What are two **disadvantages** of fossil fuels compared to renewable energy?

National Science Standards

STRUCTURE OF ATOMS

- The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars.

CONSERVATION OF ENERGY AND THE INCREASE IN DISORDER

- All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained by a field, such as electromagnetic waves.

- Heat consists of random motion and the vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion.

MOTIONS AND FORCES

- Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship $F = ma$, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

Bibliography

1. Scientific American. *Energy and Power* . Freeman and Co., 1971.

2. Fenn. J.B. *Engines, Energy, and Entropy* . W.H. Freedman and Co. New York, New York, 1982.

3. Fowler, J.M. *Energy and the Environment* . McGraw-Hill Book Co. New York, New York, 1975.

4. Hewitt, P.J., *Conceptual Physics* , 3rd Edition, Addison-Wesley Publishing Co., San Francisco, California, 1997.

5. Brown, J., and Brutoco, R. *Profiles in Power The Antinuclear Movement and the Dawn of the Solar Age* . Prentice Hall International, London England, 1997.

6. World Energy Council. *New Renewable Energy Resources, A Guide to the Future* . Kogan Page, London 1988.

7. Eiser R.J., Pligt J., Spears, R. *Nuclear Neighbourhoods* . University of Exeter Press, 1995.

8. Sheahan, R.T. *Alternative Energy Sources, A Strategy Planning Guide* . Aspen Publication. Rockville Maryland, 1981.

9. Cole N., and Skerrett, P.J. *Renewables Are Ready People Creating Renewable Energy Solutions* . Chelsea Green Publishing Co. White River Junction, VT, 1995.

Reading List for Teachers

Scientific American. *Energy and Power* . Freeman and Co., 1971.

Freese, Barbara. *Coal: A Human History* . Penguin USA, 2004.

Boyle, G. *Energy Systems and Sustainability* . Oxford University Press. January 2004.

Berger, J. and Thurow, L. *Charging Ahead: The Business of Renewable Energy and What It Means for America* . University of California Press; Reprint edition, September 1998.

Hoffman, P. *Tomorrow's Energy: Hydrogen, Fuel Cells, and the Prospects for a Cleaner Planet* . MIT Press; Reprint edition, 2002.

WEC. *New Renewable Energy Resources : A guide to the Future, World Energy Council* . Kogan Page Ltd. London, UK; 1994.

Fenn, J.B. *Engines, Energy, and Entropy* . W.H. Freedman and Co. New York, New York, 1982.

Fowler, J.M. *Energy and the Environment* . McGraw-Hill Book Co. New York, New York, 1975.

Hewitt, P.J. *Conceptual Physics, 3rd Edition* Addison-Wesley Publishing Co. San Francisco, California, 1997.

Brown, J. and Brutoco, R. *Profiles in Power The Antinuclear Movement and the Dawn of the Solar Age* . Prentice Hall International. London, England, 1997.

World Energy Council. *New Renewable Energy Resources, A Guide to the Future* . Kogan Page. London, England, 1988.

Eiser, R.J., Pligt, J. and Spears, R. *Nuclear Neighbourhoods* . University of Exeter Press, 1995.

Sheahan, R.T. *Alternative Energy Sources, A Strategy Planning Guide* . Aspen Publication. Rockville, Maryland, 1981.

Cole, N. and Skerrett, P.J. *Renewables Are Ready People Creating Renewable Energy Solutions* . Chelsea Green Publishing Co. White River Junction, VT, 1995.

Reading List for Students

Energy

Energy Shortage, Glut of Enough? Information Plus. Wylie, Texas, 1999. Solar Energy

Hoke, J., *Solar Energy* . Franklin Watts Inc. New York, New York, 1978.

Buckley, S., *Sun Up Sun Down Understanding Solar Energy* . McGraw-Hill. New York, New York, 1979.

Brown, J. and Brutoco, R. *Profiles in Power The Antinuclear Movement and the Dawn of the Solar Age* . Prentice Hall International. London, England, 1997.

Nuclear power

Morgan, N. *20th Century Inventions Nuclear Power* . Steck-Vaughn Co. Austin, Texas, 1998.

Graham, Ian. *Energy Forever? Nuclear Power* . Steck-Vaughn Co. Austin, Texas, 1999.

Eiser, R.J., Pligt J. and Spears, R. *Nuclear Neighbourhoods* . University of Exeter Press, 1995.

Renewable Energy

Cole, N. and Skerrett, P.J. *Renewables Are Ready People Creating Renewable Energy Solutions* . Chelsea Green Publishing Co. White River Junction, VT, 1995.

Cozic, C. P., Polesetsky, M. *Energy Alternatives* . Greenhaven Press, Inc. San Diego, CA, 1991.

Morgan, S. *Alternative Energy Sources (Science at the Edge)* . Heinemann Library, September 2002.

Peterson, C. *Alternative Energy (True Books)* . Children’s Press, March 2004.

Fossil Fuels

Rock, M. *The Automobile and the Environment* . Chelsea House. U.S., 1992.

Nardo, D. *Oil Spills* . Lucent Books. San Diego, CA, 1991.

Global Warming, Greenhouse Effect

Kraljic, M.A. *The Greenhouse Effect* . H.W. Wilson Co. New York, NY, 1992.

Bilger. *Global Warming* . Chelsea House. U.S., 1992.

Leggett, J. *Global Warming The Greenpeace Report* . Oxford University Press. Oxford, 1990.

Bender, D. and Bruno. L. *Global Warming Opposing Viewpoints* . Greenhaven Press, Inc. San Diego, CA, 1997.

Fisher, M. *The Ozone Layer* . Chelsea House. New York, 1992.

Gay, K. *Air Pollution* . Library of Congress, 1990.