Renewable Energy Technologies

Summary

This project focuses on the new curriculum requirements of the grade 9 Exploring Technologies (TIJ 1O) course. The goal of this project is to develop an awareness of current renewable energy sources such as wind, solar, geothermal, and biomass. Students will learn how various energy sources are harnessed and converted to electricity and the resulting environmental and societal implications of these processes. Finally, students will use their knowledge to design and build an energy production project.

Specific Expectations met from the TIJ 10 Curriculum

A Technology Fundamentals:

A1.1, A1.3, A1.4, A1.5, A1.6
A 2.1, A2.2, A2.3, A2.4
A3.1, A3.2

B Technological Skills:

B1.1, B1.2, B1.3, B1.4, B1.5, B1.6
B2.1, B2.2, B2.3, B2.4

C Environmental and Societal Implications

C1.1, C1.2
C2.1, C2.2, C2.3, C2.5

D Professional Practice and Career Opportunities:

D1.1, D1.2, D1.3, D1.4

RATIONALE

Alternate energy sources are very important to our society for environmental and economic reasons. As the price of energy increases, consumers and our government search for efficient sources of energy with the least environmental impact possible. One possible solution is the harnessing of wind energy. Wind farm proposals have been submitted to our local government representatives and environmental impact studies are in the process. It is important that students are aware of the problems and the benefits of various energy sources and their impact on our society and our environment.

This project has several parts.

Part 1
The first part involves an investigation of energy sources, the technology used to convert them to electricity, and the advantages and disadvantages of each energy source.

Part 2
Using the differentiated instruction technique R.A.F.T.S. students will explain and communicate their findings in part 1 to their peers.

Part 3
Using demonstrations and visual aids, the instructor will show how rotational (kinetic) energy is converted to electrical energy. This demonstration helps the student understand how renewable energy sources are harnessed and converted to electricity which we can use.

Part 4
Students will modify various factors to produce the greatest amount of energy on a model wind generator.

MATERIALS

We purchased the following materials to accomplish our goals:

DESCRIPTION	CATALOGUE NUMBER	UNIT PRICE	SOURCE
Mysterious magnet tube	46213 M00	$18.70	Boreal Northwest [1]
Permanent chrome magnet	62325 M00	$30.70	Boreal Northwest
World's simplest motor	45691 M00	$7.19	Boreal Northwest
Hand driven AC/DC generator	47503 M00	$53.75	Boreal Northwest
Single turbine kit with loads	80-5438-SK	$165.00	Kidder [2]

[1]- Boreal Northwest: 399 Vansickle Rd., St. Catherines, ON L2S 3T4 1-800-387-9393 www.boreal.com

[2]- Kidder Design Technology and Science Education, 39 Glen Cameron Rd., Unit #3, Thornhill, ON L3T 1P1 1-800-263-3556 www.kidder.ca

PART 1: INVESTIGATION OF RENEWABLE ENERGY SOURCES

A) Web Site Investigation
Students log into the web site www.seedsenergy.ca. The author of this site, The Society, Environment and Energy development Studies (SEEDS) Foundation is a not-for-profit, federally chartered, organization that develops and implements educational programs in energy and environment for Canadian schools. Students should select the spot titled "Investigating Energy". Here they can read at their own pace an introduction to energy and energy sources. They will learn about renewable and non renewable energy sources, how they are harnessed, converted and used. They can summarize their findings on the suggested worksheets found in the "Learning Tools" section called "Energy Sources Chart" and "Renewable Energies" Additional information is available in the section "Energy Flow Charts"[3]

[3]- Adapted from the Energy Literacy Series, courtesy of the SEEDS Foundation www.seedsenergy.ca

B) Video Investigation
Have students watch the video "Earth Energy" which is one of the episodes in the television series "The Nature of Things with David Suzuki". It was produced by the Canadian Broadcast Corporation in 2005 and is 45 minutes in length. Students can answer the following questions while watching: (answers)

1. Where is energy found? (soil, air, sun, everywhere)
2. Which country produces 25% of their energy needs from the wind? (Denmark)
3. What percentage of our electricity is derived from
   a. hydro (25)
   b. cheap fossil fuels (40)

c. nuclear (30)

4. Which country derives almost 100% of it's energy from the ground? (Iceland)
5. What type of energy harnessing activity occurs in the Mojave desert? (solar)
6. How are solar panels designed so they capture maximum light energy all day? (they continuously rotate towards the sun)
7. Which factor is most important in order to maximize energy production through wind energy? (location)
8. Wood chips can be used for (biomass) energy.

PART 2: SHARING THEIR DISCOVERIES WITH OTHERS

Using the differentiated instruction technique "Role, Audience, Format, Topic, Strong Verb, (R.A.F.T.S.), students will explain and communicate their findings in part 1 to their peers. They must select one item from each of the titles (1 role, 1 topic etc) and prepare a presentation for their peers. Ensure that all energy sources are covered by at least one group. A rubric for evaluation is included.

R.A.F.T.S.
Course: Gr 9 Technology

Curriculum/Expectation: to explore how different sources of energy are harnessed and converted AND to identify the environmental and societal implications of……(see topic)

ROLE	AUDIENCE	FORMAT	TOPIC	STRONG VERB
Government Employee	Secondary Students	Newsletter	Wind Energy	Inform
Owner of _____ Energy company	General Public	Brochure	Biomass Energy	Persuade
	Home builders	Poster - including diagrams with captions	Solar Energy	Explain
		Letter	Geothermal Energy	
		Public Service Announcement (video)…must hand in script	Hydro Energy	

**Students should pick the TOPIC first, then select the remaining options.

RAFT Writing Rubric – TIJ 10 – Technology
Curriculum Expectation: to explore how different sources of energy are harnessed and converted AND to identify the environmental and societal implications of various sources of renewable energy

WRITING CATEGORIES	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Knowledge and Understanding Knowledge of Content (e.g. facts, terms and definitions). Understanding of Content (e.g. concepts and ideas).	Demonstrates limited knowledge of the relevant facts, terms and definitions relating to how the source of energy is harnessed and converted. Students have a limited understanding of the environmental and societal implications of the renewable energy source.	Demonstrates some knowledge of the relevant facts, terms and definitions relating to how the source of energy is harnessed and converted. Students have some understanding of the environmental and societal implications of the renewable energy source.	Demonstrates considerable knowledge of the relevant facts, terms and definitions relating to how the source of energy is harnessed and converted. Demonstrates considerable understanding of the environmental and societal implications of the renewable energy source.	Demonstrates thorough knowledge of the relevant facts, terms and definitions relating to how the source of energy is harnessed and converted. Demonstrates a thorough understanding of the concepts and ideas relating to the environmental and societal implications of the renewable energy source.
Communication	Ideas are not clear and concise and students are able to describe how the source of energy is harnessed and converted with limited consistency. Students can communicate that understanding for a specific purpose or audience with limited effectiveness.	Ideas are somewhat clear and concise and students are able to describe how the source of energy is harnessed and converted with some consistency. Students can communicate that understanding for a specific purpose or audience with some effectiveness.	Ideas are clear and concise and students are able to describe how the source of energy is harnessed and converted with consistency. Students can communicate that understanding for a specific purpose or audience with effectiveness.	Ideas are very clear and concise and students are able to describe how the source of energy is harnessed and converted with consistency. Students can communicate that understanding for a specific purpose or audience with a high degree of effectiveness.
Application	Students can demonstrate an understanding of 1) how the source of energy is harnessed and converted and 2) the environmental and societal implications of the renewable energy source with limited effectiveness.	Students can demonstrate an understanding of 1) how the source of energy is harnessed and converted and 2) the environmental and societal implications of the renewable energy source with some effectiveness.	Students can demonstrate an understanding of 1) how the source of energy is harnessed and converted and 2) the environmental and societal implications of the renewable energy source with effectiveness.	Students can demonstrate an understanding of 1) how the source of energy is harnessed and converted and 2) the environmental and societal implications of the renewable energy source with a high degree of effectiveness.

PART 3

Using demonstrations and visual aids, the instructor will show how rotational (kinetic) energy is converted to electrical energy. This demonstration helps the student understand how renewable energy sources are harnessed and converted to electricity which we can use.

Overview (for teacher preparedness)
The purpose of this overview is to provide a basic background into energy production theory and technique as well provide ideas for extension into possible student projects based on energy production.

Energy Theory and Production
Energy is defined as the ability to do work. To do work, energy MUST be converted from one form to another, or from one object to another. Some energy is always lost in every conversion so the most efficient systems are often the simplest, involving fewer conversion steps to obtain the desired outcome.

Energy is present in many forms. The most familiar to us are the forms we encounter everyday:

- gravitational potential energy is present whenever the force of gravity is able to make an object fall thereby creating motion
- kinetic energy is present in any moving object, including substances that are fluid like air and water
- electrical energy is present whenever we allow electrons to flow through conductors
- chemical potential energy is present in all matter and can be released in chemical reactions e.g. fire, chemical respiration in the body (burning food), explosions, etc.
- radiant energy is energy present in light and other forms of radiation
- heat energy is present in all objects due to the motion of the atoms in matter. Hot objects, e.g. steam can be harnessed to do work. Heat energy is the final form of all waste energy.

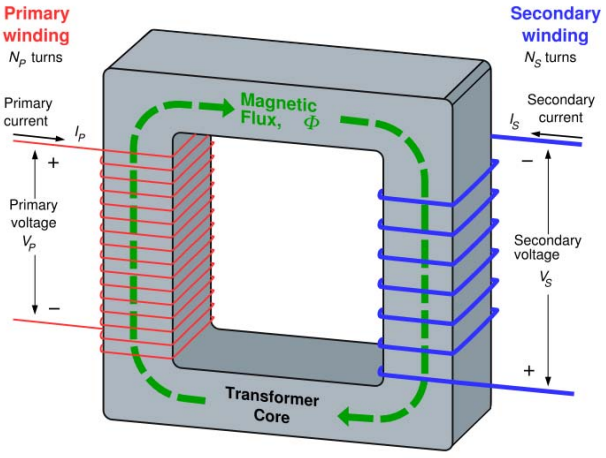
Different areas of science and technology focus on one or more of these and in varied ways. For the purpose of this discussion we will focus on the production of electrical energy.

Direct Current (DC) sources of electrical energy (DC) can be created by the conversion of chemical potential energy such as seen in any dry or wet cell (batteries), but this cannot provide an endless supply of energy and requires raw materials that cannot be reused and are bad for the environment.

For continuous supply of Alternating Current (AC, as used in homes) electricity a generator is used. A generator is simply a machine that converts kinetic energy, usually in the form of rotational motion, into electrical energy. Some external force must be used to provide the rotational motion of the generator's armature. Most often this motion is created with a steam driven turbine. The steam is usually created by burning fossil fuels or using nuclear reactors both of which are bad for the environment.

Alternative energy sources can be classified in several ways: 1) a focus on better ways to create steam (such as geothermal, biomass, or solar heaters), 2) utilizes new technologies that are not based on the standard generator at all (such as solar cells, hydrogen fuel cells, piezoelectrics, and thermoelectric), or 3) using other means of fluid motion other than steam (such as hydrodynamics/ waterfalls, wind, tides and waves).

Generators (and Electromagnetic Theory)
An electrical generator is a machine that converts mechanical/kinetic energy into electrical energy through electromagnetic induction. Faraday's Law of induction states that when a conductor is in a changing magnetic field a voltage (ElectroMotive Force/potential) is produced. If this conductor is part of a closed circuit then current will flow.

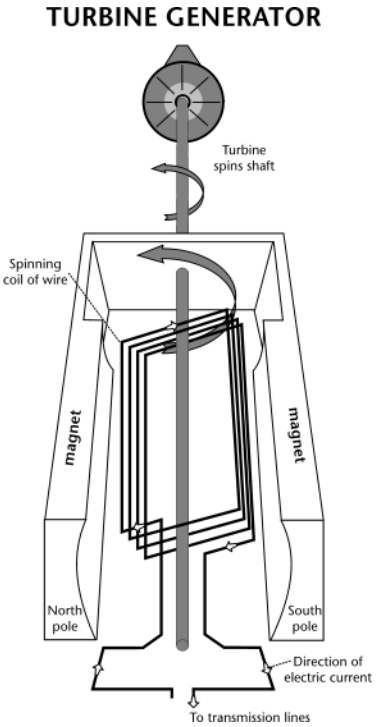


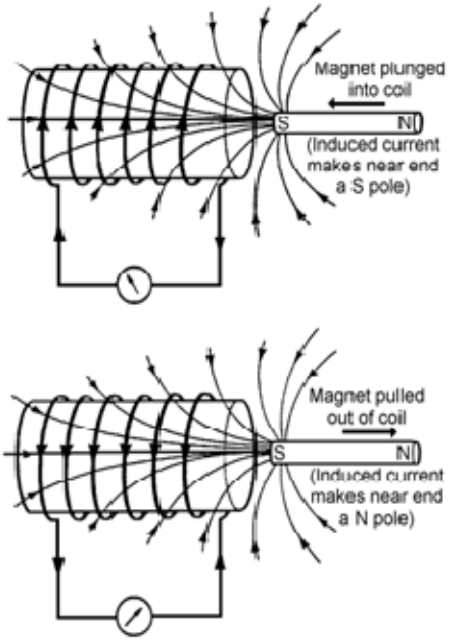
There are two primary physical scenarios in which a conductor can be influenced by a changing magnetic field:

1. A transformer uses two coils of wire wound around one piece of soft metal. As one coil is powered by AC it creates a changing magnetic field (alternates polarity as the current alternates) in the coil which passes through the metal core, thereby affecting the second coil. This creates a voltage in the second coil which depends upon the number of windings in the coil. Transformers can be either

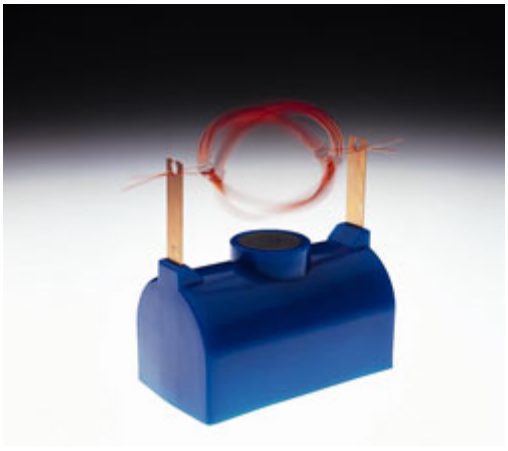
step down (e.g. adapters for small appliances) or step up.

2. A coil can be moved through a stationary magnetic field or vise versa. As the conductor cuts through the field lines EMF is produced. Maximum voltage is obtained when the movement is perpendicular to the magnetic field lines which run from the North pole to the South pole.





Conversely, the Motor Principal can be demonstrated to students by using an apparatus such as “The World’s Simplest Motor” shown below. A 1.5v D cell (concealed in the base) turns the coil (shown spinning) into an electromagnet which causes it to spin, in the presence of the small permanent magnet, due to the Law of Magnetic Poles (like poles repel, opposite poles attract).



A generator has essentially the same physical makeup as a motor but an outside energy source provides the turning movement and subsequently creates electrical energy (EMF) in the coils, as displayed in the schematic of the wind turbine above. Making an electrical generator can be good project for students (http://www.discoverthis.com/project-simple-electric-generator.html), however if the coil is to be rotated (on the rotor of the generator) then complications arise with creating effective commutators (electric connections). It is much easier, and more related to the topic of renewable energy resources, to use a commercially available generator (or a DC motor) and to have the students design wind mill design to better harness the energy available in the wind.

Below is one site that provides several power point presentations on wind energy, including discussion of the overall topic and need for renewable energy, technical aspects, and student projects.

http://www.kidwind.org/lessons/PPoint.html

PART 4 STUDENT PROJECT

We purchased the Adaptable Learning Turbine from Kidder. It comes complete with a base, tower, DC motor, multimeter and variable gears.

The design challenge is to create the greatest amount of energy possible (measured in voltage) using a floor fan as a wind source. After a brief lesson on aerodynamics and blade design, students will be given a list of materials which they can modify to make blades that produce the most energy output possible.

Notes For Teacher

Set up for testing: The Kidder guide suggests using a floor fan for testing as this provides a consistent wind speed. They suggest ensuring that the center of the turbine matches up with the center of the fan. Some limitations of a floor fan include variability in wind speed from the middle of the fan to the outside edges, and the limitation on the size of the turbine blades. Longer blades than the size of the fan will not be as efficient. The length extending beyond the fan will only cause drag and slow down the turbine.

Students will need to have a basic understanding of aerodynamics to maximize their learning process.

Aerodynamics is the study of the motion (dynamics) of air but usually is considered to be the study of the principles of flight. The basic shape in aerodynamics is the airfoil. It is this shape that creates the lift that allows airplanes to fly even though they are heavier than the air. It also creates another force called drag. An important factor which affects lift and drag is the angle of attack which is the angle between the airflow and the center of the airfoil.

Airfoil:

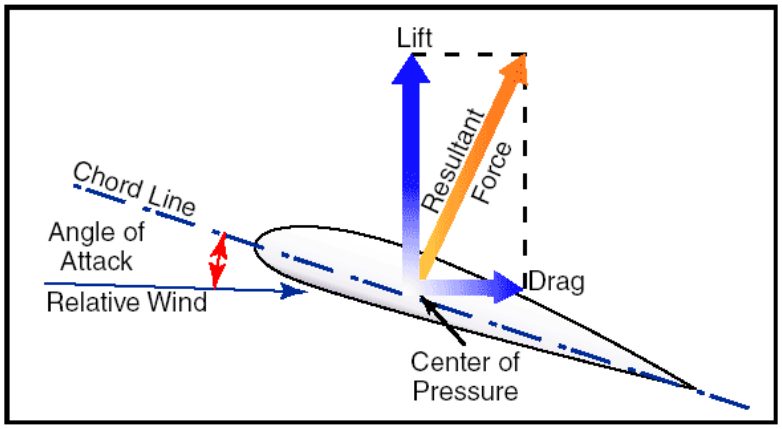


Image from: http://www.free-online-private-pilot-ground-school.com/aerodynamics.html

Lift is created by this shape because air flowing over the upper surface of the airfoil travels faster than the air traveling over the lower surface. It travels faster because it has further to go in the same amount of time. This results in lower air pressure on the upper surface of the wing than on the lower surface. This difference in pressure produces a force upwards known as lift.

Drag is the force created by the wind pushing against a surface. When you lean into the wind on a very windy day, you are acting against drag which is pulling you backwards. It usually works in the same direction as the airflow.

Most wind powered machines use aerodynamics in their design. If the blades you construct are airfoils, they will produce lift and spin much more quickly. The blades can be angled to increase the angle of attack and therefore produce more lift.

SOURCES

1. Energy Literacy Series, the SEEDS Foundation www.seedsenergy.ca
2. Technological Education, Grades 9-12, Draft document for training, December 2008.
3. video “Earth Energy” from the television series “The Nature of Things with David Suzuki”. produced by the Canadian Broadcast Corporation. 2005. 45 minutes.
4. Adaptable Learning Turbine Guide, Kidder Design Technology and Science Education, 39 Glen Cameron Rd., Unit #3, Thornhill, ON L3T 1P1 1-800-263-3556 www.kidder.ca