Alternative Energy Workshop

QUT Extreme Engineering

Introduction

This workshop is designed for grades 6-7, to give them an introduction to the different types of alternative energy, and some hands-on experience in seeing solar panels in action. The activities are preceded by a PowerPoint presentation to introduce the topic, in preparation for the activities.

In this booklet, some background information on alternative energy is provided, followed by the content of the QUT Extreme Engineering school workshop.

Glossary

Alternative energy	Energy fuelled in ways that do not use up the earth's natural resources or otherwise harm the environment, especially by avoiding the use of fossil fuels or nuclear power
Energy	Power derived from the utilization of physical or chemical resources, especially to provide light and heat or to work machines
Fuel	Material such as coal, gas or oil that is burned to produce heat or power
Kinetic energy	The energy of motion
Potential energy	Energy that is stored
Solar energy	Radiant energy emitted by the sun
Solar power	Power obtained by harnessing the energy of the sun's rays
Turbine	A machine for producing continuous power in which a wheel or rotor, typically fitted with vanes, is made to revolve by a fast-moving flow of water, steam, gas, air, or other fluid

Background information on alternative energies

Wind power

Societies have taken advantage of wind power for thousands of years. The first known use was in 5000 BC when people used sails to navigate the Nile River. Persians had already been using windmills for 400 years by 900 AD in order to pump water and grind grain. Windmills may have even been developed in China before 1 AD, but the earliest written documentation comes from 1219. Cretans were using "literally hundreds of sail-rotor windmills [to] pump water for crops and livestock."

The Dutch were responsible for many refinements of the windmill, primarily for pumping excess water off land that was flooded. As early as 1390, they had connected the mill to "a multi-story tower, with separate floors devoted to grinding grain, removing chaff, storing grain, and (on the bottom) living quarters for the windsmith and his family." Its popularity spread to the point that there were 10,000 windmills in England. But perfecting the windmill's efficiency to the point that it "had all the major features recognized by modern designers as being crucial to the performance of modern wind turbine blades" took almost 500 years. By then, applications ranged from saw-milling timber to processing spices, tobacco, cocoa, paints, and dyes.

The windmill was further refined in the late 19th century in the US; some designs from that period are still in use today. Heavy, inefficient wooden blades were replaced by lighter, faster steel blades around 1870. Over the next century, more than six million small windmills were erected in the US in order to aid in watering livestock and supplying homes with water during the development of the West. The first large windmill to produce electricity was the "American multi-blade design," built in 1888. Its 12-kilowatt capabilities were later superceded by modern 70-100 kilowatt wind turbines.

Water power (Hydropower)

Hydropower is one of the oldest sources of energy. It was used thousands of years ago to turn a paddle wheel for purposes such as grinding grain. Our Nation's first industrial use of hydropower to generate electricity occurred in 1880, when 16 brush-arc lamps were powered using a water turbine at the Wolverine Chair Factory in Grand Rapids, Michigan.

The first U.S. hydroelectric power plant opened on the Fox River near Appleton, Wisconsin, on September 30, 1882.

Because the source of hydroelectric power is water, hydroelectric power plants must be located on a water source. Therefore, it wasn't until the technology to transmit electricity over long distances was developed that hydropower became widely used.

Solar power

The first practical photovoltaic (PV) cell was developed in 1954 by Bell Telephone researchers examining the sensitivity of a properly prepared silicon wafer to sunlight. Beginning in the late 1950s, PV cells were used to power U.S. space satellites. PV cells were next widely used for small consumer electronics like calculators and watches and to provide electricity in remote or "off-grid" locations were there were no electric power lines. Technology advances and government financial incentives have helped to greatly expand PV use since the mid-1990s. Shipments of PV cells and panels by U.S. manufacturers in 2006 were the equivalent of about 337 Megawatts, about 25 times greater than the shipments of about 13 Megawatts in 1989. Since about 2004, most of the PV panels installed in the United States have been in "grid-connected" systems on homes, buildings, and central-station power facilities. There are now PV products available that can replace conventional roofing materials.

Geothermal Energy

The word geothermal comes from the Greek words *geo* (earth) and *therme* (heat). So, geothermal energy is heat from within the Earth. We can recover this heat as steam or hot water and use it to heat buildings or generate electricity. Geothermal energy is a renewable energy source because the heat is continuously produced inside the Earth.

Geothermal energy is generated in the Earth's core. Temperatures hotter than the sun's surface are continuously produced inside the Earth by the slow decay of radioactive particles, a process that happens in all rocks. The Earth has a number of different layers:

- The core itself has two layers: a solid iron core and an outer core made of very hot melted rock, called magma.
- The mantle surrounds the core and is about 2,900km thick. It is made up of magma and rock.
- The crust is the outermost layer of the Earth, the land that forms the continents and ocean floors. It can be 5 to 8km thick under the oceans and 25 to 55km thick on the continents.

The Earth's crust is broken into pieces called plates. Magma comes close to the Earth's surface near the edges of these plates. This is where volcanoes occur. The lava that erupts from volcanoes is partly magma. Deep underground, the rocks and water absorb the heat from this magma. The temperature of the rocks and water gets hotter and hotter as you go deeper underground.

People around the world use geothermal energy to heat their homes and to produce electricity by digging deep wells and pumping the heated underground water or steam to the surface. We can also make use of the stable temperatures near the surface of the Earth to heat and cool buildings.

Biomass

Biomass is organic material made from plants and animals (microorganisms). Biomass contains stored energy from the sun. Plants absorb the sun's energy in a process called photosynthesis. The chemical energy in plants gets passed on to animals and people that eat them.

Biomass is a renewable energy source because we can always grow more trees and crops, and waste will always exist. Some examples of biomass fuels are wood, crops, manure, and some garbage.

When burned, the chemical energy in biomass is released as heat. If you have a fireplace, the wood you burn in it is a biomass fuel. Wood waste or garbage can be burned to produce steam for making electricity, or to provide heat to industries and homes.

Burning biomass is not the only way to release its energy. Biomass can be converted to other useable forms of energy, such as methane gas or transportation fuels, such as ethanol and biodiesel. Methane gas is the main ingredient of natural gas. Smelly stuff, like rotting garbage, and agricultural and human waste, release methane gas — also called "landfill gas" or "biogas". Crops like corn and sugar cane can be fermented to produce ethanol. Biodiesel, another transportation fuel, can be produced from left-over food products like vegetable oils and animal fats.

The most common form of biomass is wood. For thousands of years people have burned wood for heating and cooking. Wood was the main source of energy in the United States and the rest of the world until the mid-1800s. Wood continues to be a major source of energy in much of the developing world.

QUT Extreme Engineering workshop activities

There are four activities in this workshop, to explore the basics of using a solar panel. The activities are run simultaneously, with students working in groups of 3. Each group has its own kit, which contains everything they need for all four activities. The activities are:

1. **Colours of the rainbow**
   - Students measure the energy output of the solar panel when exposed to light, then compare that to the energy output of the solar panel when it receives light of a particular colour (by placing cellophane over the panel)
2. **How much light do we need?**
   - Students measure the energy output of the solar panel when exposed to light, then compare that to the energy output of the solar panel on a cloudy day, using pieces of shadecloth to mimic clouds
3. **Fighting an uphill battle**
   - Students use a solar powered water pump and measure the volume of water that it can pump when exposed to light, then compare that to the volume of water that the solar panel can pump when it has to pump the water uphill and downhill
4. **Concentrate!**
   - Students measure the energy output of the solar panel when exposed to light, then compare that to the energy output of the solar panel when mirrors are used to concentrate light onto the solar panel

Students are provided with worksheets to fill out during the workshop. It is designed to reiterate what they have learnt, and to build a little further on that knowledge. The questions refer to the activities, requiring them to record their observations, and then to formulate possible explanations for these observations.

The activity instructions and worksheet are provided in the next section of this booklet.

Activity 1: Colours of the rainbow

Light from the sun is made up of a mixture of all the colours in the rainbow – this is known as the light spectrum. Different colours can give different amounts of energy. Solar panels are made to operate better for with some types of the colour spectrum, but they often differ. Today, you will investigate which colour of the rainbow (or spectrum) gives our solar panels the most energy, using different coloured cellophane to filter the light reaching the solar panel and measuring the power output of the solar panel.

For this activity you will need:

- A sunny spot or a halogen lamp
- A solar panel
- Pieces of cellophane – yellow, green and purple
- A multimeter

To carry out your experiment, follow these steps:

1. Set up the solar panel in a sunny spot, or under the halogen lamp
2. Take one probe of the multimeter and put it inside the plug output of the solar panel. Make sure the probe tip is touching the side of the plug
3. Place the other probe on the side of the plug (on the metal) and try to hold it steady or your reading will keep changing
4. Take your first reading without any cellophane, and record it in your table on the worksheet
5. Place the sheet of yellow cellophane over the solar panel, and record the reading on your worksheet
6. Repeat for the green and purple sheets of cellophane

Activity 2: How much light do we need?

The amount of energy we get from then sun will depend on how much sun we get! So on a sunny day, we get lots of energy, and the solar panels operate well. But what about cloudy days? How does the amount of light that reaches the solar panels affect how much energy they can give us? You will investigate this by using shade cloth to block light from the solar panels.

For this activity you will need:

- A sunny spot, or a halogen lamp
- A solar panel
- Pieces of shade cloth
- A multimeter

To carry out your experiment, follow these steps:

1. Set up the solar panel in a sunny spot, or under the halogen lamp
2. Take one probe of the multimeter and put it inside the plug output of the solar panel. Make sure the probe tip is touching the side of the plug
3. Place the other probe on the side of the plug (on the metal) and try to hold it steady or your reading will keep changing
4. Take your first reading without any shade cloth, and record it in your table on the worksheet
5. Place shade cloth A over the solar panel, and record the reading from the multimeter on your worksheet
6. Repeat for shade cloths B and C

Activity 3: Fighting an uphill battle

What happens if we want to use our solar panel to power a piece of equipment? What are some problems that may arise in day-to-day use of a solar panel, other than the amount of sun the panel is exposed to? In this activity you will investigate how some variables will affect the amount of power we can get from our solar panel. You'll be using the solar panel to power a water pump, and you will be pumping the water on an even level, uphill and downhill. What differences do you think you will see in these three situations?

For this activity you will need:

- A sunny spot or a halogen lamp
- A solar panel
- A multimeter
- A water pump
- A pump regulator
- A 500mL measuring cylinder
- A jug, filled with water

To carry out the experiment, follow these steps:

1. Set up the solar panel in the sunny spot, or under the halogen lamp
2. Put the water pump into the jug of water, leaving the cords outside of the jug
3. Take the pump hose and hold it above the jug (so any water that comes out goes back into the jug)
4. Connect the solar panel to the water pump to get the flow of water started
5. When the water starts flowing, pinch the hose, hold it up high (the pump should stay on the bottom of the jug) and have another person collect the water into the cylinder for 10 seconds
6. Pinch the hose and disconnect the pump from the solar panel to stop the flow of water, and record the volume of water on your worksheet in the uphill column
7. Repeat for the level measurement (on the table) and downhill (as low as you can get the hose)
8. Repeat the measurements with the mirrors on an angle facing the solar panels to concentrate the light

Activity 4: Concentrate!

What happens if we want to get even more energy from our solar panel, than we can get on a perfectly sunny day? How can we get the solar panel to provide more power? One way is to concentrate the amount of light that reaches the panel. This can be done a few different ways, one of which is using mirrors on angles to shine more light on the panel. You will investigate how much difference this makes to our solar panels and how much more power they can generate!

For this activity you will need:

- A sunny spot, or a halogen lamp
- A solar panel
- 2 mirrors
- A multimeter

To carry out the experiment, follow these steps:

1. Set up the solar panel in a sunny spot or under the halogen lamp
2. Take one probe of the multimeter and put it inside the plug output of the solar panel. Make sure the probe tip is touching the side of the plug
3. Place the other probe on the side of the plug (on the metal) and try to hold it steady or your reading will keep changing
4. Take your first reading without any shade cloth, and record it in your table on the worksheet
5. Repeat the measurements with the mirrors on an angle facing the solar panels to concentrate the light

Alternative energies worksheet

Activity 1: Colours of the rainbow

Use different coloured cellophane to test which parts of the rainbow give our solar panel the most energy. You can test purple, red and blue cellophane by placing the cellophane over the solar panel.

Solar panel covering	Voltage
None	
Purple	
Yellow	
Green	

Which colour allowed the solar panel to generate the **most** power? ___________________________

Which colour allowed the solar panel to generate the **least** power? ___________________________

Can you think of any real-life situations where you might find different coloured light affecting solar panels? __________ ____

Activity 2: How much light do we need?

Use different types of shade cloth to mimic different types of days – sunny, cloudy, and in between.

Solar panel covering	Voltage
No shade cloth	
Light 50%	
Medium 70%	
Heavy 90%	

Based on your results, what do you think happens to the power generated by a solar panel on a cloudy day? ____

What do you think we can change to generate more power using solar panels? _________________

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Activity 3: Fighting an uphill battle

Use the solar panels to pump water uphill, at level and downhill, and record the volume of water they can pump in 10 seconds, for each of these tests.

	Volume of water moved in 10 seconds
Uphill (on the box)	
Level (table)	
Downhill	

When do you think we would we have to use a solar powered pump? __________________________

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Would you recommend using a solar powered pump? ____

Activity 4: Concentrate!

Record the output of the solar panel without the mirrors, and then with them.

	Voltage
No mirrors	
Using mirrors	

Can you explain how the mirrors affect the amount of energy the solar panel can capture? ________

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Can you think of a situation where we might need to use the mirrors? __________________________

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Resources

http://www.altenergy.org/

http://www.eia.doe.gov/kids/energy.cfm?page=solar_home#top-container

http://www.eia.doe.gov/kids/energy.cfm?page=hydropower_home-basics