Wind Turbine Technology – Teacher Notes

Aims

- The aim of the following lesson is to provide an inspiring and entertaining science lecture, which includes interactive demonstrations showing how wind turbine technology works. The lesson will also explore the materials used and the forces involved with generating wind energy at sea, and will allow the class to build a miniature wind turbine thus encouraging learning through participation and interaction.

Objectives:

- What are renewable and non renewable energy sources, and what do these terms mean?
- How are wind turbines built and how do they generate electricity?
- What are the forces associated with building a turbine in the sea and generating wind energy?
- What materials are used for building turbines and what are their properties?

LEARNING OUTCOMES

After the lesson the class should be able to:

- Identify and use key vocabulary associated with wind turbine technology and associated forces and materials.
- Label the basic parts of a wind turbine.
- Build a model load-bearing wind turbine.
- Describe the forces associated with generating energy from the wind.
- Describe the properties required of the materials used to build a wind turbine in the sea.
- Explain how wind turbines are built in the sea and the challenges associated with this process.

Curricular Links:

This is a cross curricular session using elements from the Science and Design and Technology sections of the National Curriculum. The first part of the session can be used to cover the concepts of renewable energy, electricity and forces. After this, the students will be able to apply the knowledge learned from the first part of the workshop to work as a team to conduct a simple scientific experiment which will help to demonstrate the concept of variables.

Science

Sc1 Scientific enquiry

Ideas and Evidence in Science	1. a,b
Investigative Skills	2. a, b,c,d,e,i,j,k,l,m

Sc3 Materials and their properties

Grouping and Classifying materials:	1. a,e

Sc4 Physical Processes

Electricity	1. a
Forces and Motion	2. b,c,d,e

Design and Technology

Developing planning and communicating ideas	1. c,d
Working with tools, equipment, materials and components to make quality products	2. b,d
Evaluating process	3. a

Lesson Plan

This session is designed to run for approximately 45 minutes and involves interactive activities and discussions with the class.

Begin by Introducing renewable energy and then specifically talk about wind energy and electricity. Use the PowerPoint presentation (available late 2008) if desired. Explain that renewable energy is better for the environment as it is energy from a source that will never run out e.g. hydroelectric, solar, wind. Conversely, non-renewable – power stations burn coal oil or gas to make electricity. Non-renewable energy sources take millions of years to be made and they will run out one day. Non-renewable energy can be bad for the environment. Explain why we need electricity.

Using the supplied image of a wind turbine, encourage the class to label parts of a wind turbine and describe to them how electricity is generated by the various parts and how they work. Label parts of turbine including:

- Rotor and rotor blades
- Generator
- Tower
- Transformer

Demonstrate how strong a tower needs to by asking a student to hold a broom handle vertically. Ask another student to push on the handle just above his/hand. Then ask them to push the handle right at the top. Ask the student holding the handle to describe to the class how different it felt. You can then talk about how much pressure is put on the tower by the rotor being at the top. Explain that towers are firmly fixed into the seabed and are normally slightly conical in shape and made out of materials which are strong and can flex slightly so that they do not fail.

Show electricity being generated by miniature wind turbine. You can buy a model wind turbine to demonstrate the generation of electricity (www.philipharris.co.uk). The turbine can be attached to an ammeter light bulb or buzzer to show the output. If you don't have the resources to buy a wind turbine, you can use the video on the COWRIE website, which shows the wind turbine in action.

Explain the benefits of offshore wind turbine development – such as the high wind levels and large amount of space, and discuss the physical conditions which may benefit or pose challenges to this process.

Begin the Build your own turbine activity. Get the students into small groups ask them to make their own weight-bearing turbine, following the instructions on http://www.windpower.org/en/kids/choose/rotor/smturb.htm Give each group the same object to raise. This could be a small plastic toy, or a small piece of stationery, such as a pencil sharpener. The variable that the students will be testing is the size of the rotor blades, so supply each group with different blades.

When the turbines are assembled, ask if they can predict which group's will work the best and why. Blow each of the turbines with a fan/hairdryer (as long as the force is equal and fixed) and time how long it takes to raise the object to the turbine with a stop watch. Discuss with the class which model worked best and why.

Background Information

Wind Power

Wind Power is the conversion of wind energy into a useful form, such as electricity, using wind turbines. The potential energy created by wind power is plentiful, renewable, widely distributed, clean, and reduces greenhouse gas emissions when it displaces fossil-fuel-derived electricity. Wind energy is one of the cheapest of the renewable energy technologies. It is competitive with new clean coal fired power stations and cheaper than new nuclear power. Globally, wind power generation increased more than fivefold between 2000 and 2007 and produces about 1% of the electricity used world-wide.

How do wind turbines work?

The technology is fairly basic. The turbines are basically big windmills that use the energy of moving air to generate electricity. The kinetic energy in wind can be captured, just like the energy in moving water can be captured by the turbine in a hydroelectric dam. In the case of a **wind-electric turbine**, the turbine blades are designed to capture the kinetic energy in the wind. Sensors on the turbine detect the wind direction and turn the blades into the wind. When the turbine blades capture wind energy and start moving, they spin a shaft that leads from the hub of the rotor to a generator. The generator turns that rotational energy into electricity. Simple wind turbines that create electricity consist of five main parts:

- **Rotor blades** – There are a variety of designs of rotor blades, but they all act on the same principal. The rotor blades are shaped to give lift and spin the rotor e.g. birds wings/aeroplane wings. If they are too small they won't produce enough power, if they are too big they will not turn with small amounts of wind.
- **Shaft** - The wind-turbine shaft is connected to the center of the rotor. When the rotor spins, the shaft spins as well. In this way, the rotor transfers its mechanical, rotational energy to the shaft, which enters an electrical generator on the other end.
- **Generator** –A simple generator consists of magnets and a conductor. The conductor is typically a coiled wire. Inside the generator, the shaft connects to an assembly of permanent magnets that surrounds the coil of wire. When the rotor spins the shaft, the shaft spins the assembly of magnets, generating voltage in the coil of wire. That voltage drives an electrical current out through power lines for distribution.
- **Tower** – The tower is rigid and typically conical shaped. The generator and rotor blades sit at the top of the tower nearer to faster wind speeds.
- **Transformer** – The transformer transfers the energy created by the turbine into the power grid for public consumption.

A modern wind turbine produces electricity 70-85% of the time, but it generates different outputs dependent on wind speed. Over the course of a year, it will generate about 30% of the theoretical maximum output.

Offshore Wind Power:

Offshore wind farms are increasingly used as a way to combat the complaints raised by local communities at the change in the landscape created by adding large wind turbines to farm land.
The new technologies mean that offshore turbines can be erected far out to sea where they have little effect visual impact for people living on the coastline. Undersea cables then carry the electricity to land where it goes into the national grid.

How is an offshore wind turbine constructed?

Offshore wind turbines are generally built in relatively shallow water, less than 30 metres in depth. It is possible to build structures in water deeper than this, e.g. North Sea oil platforms, but it is expensive.

There are no technical barriers to installing wind turbines offshore, but the construction, delivery to site and assembly of such large machines requires specialist equipment, facilities at ports and careful timetabling to make sure that the possibilities of using calm weather windows are maximised.

Most developments will be installed on either gravity foundations or steel monopiles. Gravity foundations are structures, normally concrete, which settle and are stabilised by sand or water, with the turbine tower fitted onto them. Monopiles are long steel tubes which are hammered, drilled or vibrated into the seabed until secure, and then platforms and towers are installed on top. Most developments in UK waters will use monopile foundations for the foreseeable future.

The structural components of offshore turbines are designed and coated to protect them from corrosion by the salt in sea water.
(http://www.telegraph.co.uk/earth/main.jhtml?xml=/earth/2007/10/04/eawind204.xml)

Offshore Wind Turbines in the UK:

The UK has nearly 8,000 miles of coastline so is an ideal location for offshore power generation. The first developments in UK offshore wind power came about through the now discontinued Non-Fossil Fuel Obligation (NFFO).

Recently a huge expansion of offshore wind-power was announced by the government as part of the UK Energy Policy. They plan to construct thousands of turbines in the North Sea, Irish Sea and around the coast of Scotland. They plan to open up the whole of Britain's continental shelf to development, apart from areas vital for shipping and fishing and ultimately want up to a third of Britain's electricity to be generated from offshore wind power. This expansion could see turbines so large that they would reach 850ft into the sky, nearly 100ft taller than Canary Wharf. Each would be capable of powering up to 8,000 homes.

This current programme would expect to generate about eight gigawatts (GW = 1 billion watts) by 2016. The United Kingdom passed the milestone of 2 GW installed capacity on 9 February 2007 with the opening of the Braes O'Doune wind farm, near Stirling. The UK became the 7th country in the world to reach this capacity. The world leader in wind power is Germany with 20.6 GW installed.

The British Wind Energy Association (BWEA) says offshore wind could potentially generate close to 1,000 terawatt hours per year. That is equivalent to several times the UK's current total electricity consumption. They also predict that a substantial proportion of the total European offshore wind resource will one day be located in Britain's waters.

ADDITIONAL USEFUL RESOURCES

http://www.telegraph.co.uk/earth/main.jhtml?xml=/earth/2007/10/04/eawind204.xml
www.kidwind.org
http://www.berr.gov.uk/whatwedo/energy/index.html
http://www.bwea.com/offshore/
www.windpower.org
http://news.bbc.co.uk/1/hi/uk/7136178.stm
http://www.offshorewindfarms.co.uk/Pages/COWRIE/
http://science.howstuffworks.com/electromagnet.htm

http://en.wikipedia.org/wiki/Energy_policy_of_the_United_Kingdom