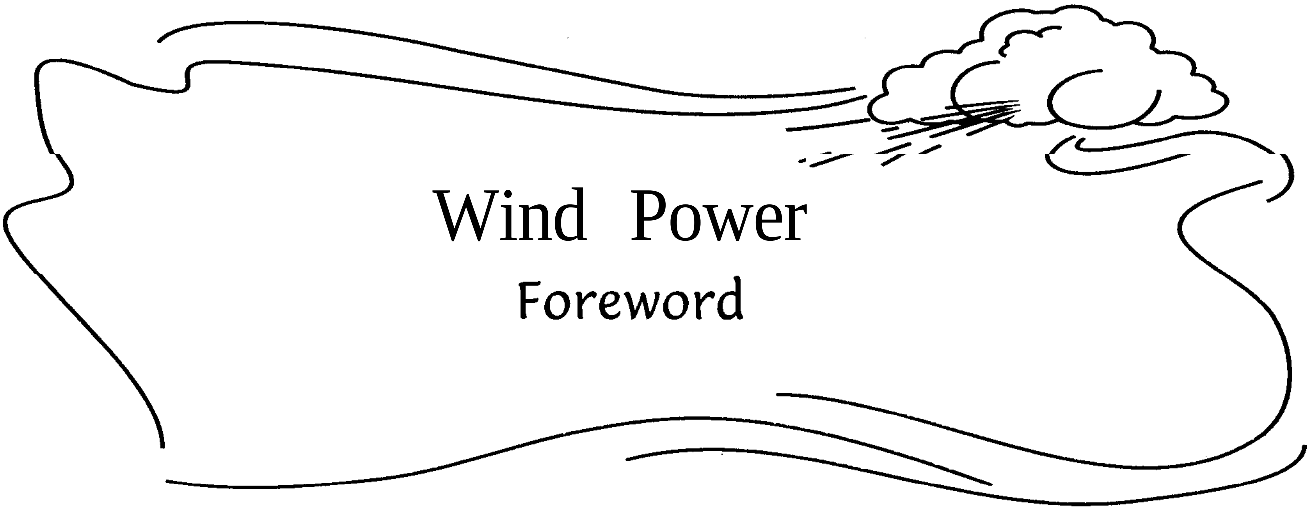
WIND POWER

Key Stage 3/4



Wind Power

Foreword

Clean energy production for the future must be a key priority for any country. No longer can we continue to destroy the environment and inflict on the future inhabitants of the Earth a legacy of unsolved problems. It is down to each one of us to take responsibility for our actions and bring about positive solutions for the future.

As part of the UK's policy the British Government has set targets to reduce the levels of harmful emissions produced. As a renewable energy, Wind power energy is one way to produce electricity without the direct production of any harmful emissions. Wind farms have been constructed throughout the country as part of the UK's policy to develop clean energy production.

Everyone at Border Wind is fully dedicated to work to improve the environment. Over the years we have worked throughout the world advising on and installing appropriate energy supply sources. At present we are fully committed to develop electricity from the wind. We developed our first wind farm at Blyth Harbour in 1991. This first project now supplies enough clean electricity for on average, 1500 households. As a Company we are committed to contributing to the community. We have hosted many visits to our wind farms and talks have been given at schools and other organisations about Blyth Harbour and wind energy in general. We became aware of a need for more teaching material on our area of work. This pack is the result of much work carried out by educationalists and Border Wind. We hope that it will prove of use to schools and contribute to the need for knowledge required to solve our future problems.

David Still

Acknowledgments

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This booklet is one of three produced for different Key Stages with Border Wind. The booklets were produced following teacher placements at Blyth Harbour Wind Farm, Northumberland.

Each booklet investigates Wind Power as an alternative source of Energy and provides information and contacts for teachers to support them in the teaching of Wind Power within the curriculum.

This booklet includes several activities which can be used as an introduction to Wind Power. Each activity can be used within the classroom and is not dependent on a visit to a Wind Farm. The activities consist of a teacher briefing sheet which describes how to organise and run the activity and at least one pupil activity sheet which can be photocopied and distributed to the pupils.

These activities are purely suggestions and can be modified and developed to suit each teacher's curriculum needs. All the activities can be linked directly to the National Curriculum at the appropriate key stage and the booklet includes a National Curriculum reference grid which suggests how to link the activities to the programmes of study.

Wind Power
Pack Contents

Information Sheet

1: Introduction
2: Wind Power
3: Border Wind Limited
4: Wind Turbines
5: Wind Turbine - Diagram
6: Types of Wind Turbines - Diagram

National Curriculum

Reference Grid

Activity: comprises Teacher Briefing Sheet(s) and Pupil Sheet(s)

1a: Make a Wind Turbine
1b: Make a Simple Wind Speed Indicator
2a: Windy City
2b: Blow Me Down
3: Wind Farm Manager
4: Energy Management
5: Public Attitude to Wind Power
6: Land Yachting Race - The Americas Cup
7: At What Cost?

Additional Resources

The Beaufort Scale
Wind Vocabulary
Useful Contacts
Useful Books
Useful Videos
Other Useful Information Sources

Introduction

People particularly in 'western developed countries', have come to need, use and expect to have a continuous supply of electricity. Many areas of the 'developing world' either have a very limited supply of electricity or none at all. It gives power, light and heat in cities, towns and villages all over the world. The process by which electricity is produced is called 'electro-magnetic induction', i.e. a magnet rotating very quickly inside a coil (known as a generator). The magnets are turned by turbines which are made to rotate using the force of the wind, water or steam.

Most power stations have vast steam turbines which work by burning fossil fuels (coal, oil or gas) to heat the water, with some using nuclear fission. The burning of fossil fuels does however cause damage to the environment - acid rain, global warming and the green house effect being the terms most commonly used. Acid rain leads to the pollution of lakes and rivers and can cause severe damage to trees as well as buildings. The greenhouse effect is contributed to by some of the gasses produced in the burning process. This leads to the gradual warming of the earth's atmosphere. Research is ongoing to try and evaluate exactly what impact this will have on our weather, sea currents, crops and agricultural practices and water supplies amongst others. Nuclear power stations produce the steam to drive the turbines using the energy stored in uranium. The most severe side effect of this process is the production of radioactive waste which is extremely dangerous and needs to be stored for centuries before it becomes safe to dispose. Suggestions have been made linking nuclear power stations to clusters of leukaemia (a progressive blood disease) in people who either work or live in the vicinity of these (particularly children). Another factor which needs to be considered in our current energy production is the expected lifetime of known stocks of coal, oil and gas. A number of estimates have been made, some for example indicating that identified stocks of coal will run out in the next 200-300 years.

It is the cumulation of all these factors which has led to the development of alternative, cleaner ways of producing electricity. Possible alternatives use the elements and other natural, free and renewable sources such as hydro-electric, tidal, solar and wind power. This pack focuses on wind power. Wind is a renewable energy source which is safe, cheap (the costs of generation are now very similar to those of fossil fuels - once external costs of environmental pollution are considered wind power becomes more competitive) and free of pollution. There are however some disadvantages associated with wind power: wind strength varies from place to place, from season to season as well as throughout the day. If wind speed drops below a certain level it is not powerful enough to turn the turbines to generate electricity. This is mitigated by the countryside location of windfarms. The visual impact of wind turbines (now up to 60m high at the tip of the blade) has been argued by some as being a form of 'visual' pollution. Careful siting and design aims to minimise sensitive visual impact. The impact on wildlife, particularly birds if the turbines are sited in their migratory flight path has to be carefully assessed. Other issues which are addressed by wind power developments include noise pollution and any electromagnetic interference that may occur (i.e. any effects on TV and radio communications).

Wind Power

In the search for sources of energy people have long harnessed the sustainable forces of nature. For centuries water (also known as hydro power) and wind power have been used for milling and grinding, the most obvious and long standing use of wind power being to power sailing ships. Hydro power has also been used for decades to generate electricity.

The technology to use wind to generate electricity has been available for many years. This is now most importantly being joined by the political will to use and develop wind power. When the wind blows and generates electricity, less burning of fossil fuels is required at power stations. When the wind drops and if more electricity is required, conventional power stations resume their higher rate of burning and generating - just as they would if more loads were switched on, for example at half time when the world cup is broadcast on television. The present National Grid system which collects and distributes all our electricity would be able to accommodate renewable energies supplying up to 20% of Britain's electricity requirements.

Wind power's good fortune is, however a result of the environment's bad fortune. Wind technology is now seen as worth developing because the fossil fuel technologies, upon which we have traditionally relied for our electricity are creating problems we are only beginning to understand and quantify.

Polluting emissions from the burning of coal, oil and gas are causing climate change, acid rain and a host of other problems. At the Earth Summit in Rio in 1992 the world's leaders signed an agreement to take action towards stopping climate change and improving air quality. This is one reason for the blossoming of wind farms. Both in the UK and overseas.

Wind turbines produce energy with no polluting emissions. They can be installed in a green field and will sit happily with grazing sheep and cattle or with crop planting and harvesting. They produce no harmful solids, liquids or gases, no fuel needs to be transported to them nor does any hazardous or toxic waste product need to be taken away for disposal. At the end of their useful life they can be taken down and the steel and other components will be recycled because of their high scrap value.

Compared with other commercial methods of electricity generation, wind turbines sparkle with cleanliness, are sustainable and safe. The wind blows and turns the blades. The turning motion goes through a gear box, is geared up to a faster turning motion and into a generator where it produces electricity which feeds into the National Grid.

For many people a wind farm is a symbol of hope for a cleaner, safer, more sustainable future. With enough vision and political will, we will eventually have wind turbines out at sea and so begin to harness the power of the sea itself. Electricity production from wind technology will never have the tragic consequences summed up in such words as Aberfan, Chernobyl, Exxon Valdez, Piper Alpha, Brent Spar and Milford Haven. Every time we switch on the light, turn on the computer, or put clothes into the washing machine we should consider the environmental consequences of having such a dependable source of power. With wind power what you see is what you get - a small visual impact, not a large invisible hazard.

Border Wind Limited

Border Wind is a wind farm development company which believes in actively working towards a sustainable future. The company consists of three engineers, a financial expert and a planning organiser. Together they deal with all aspects of wind farming; finding potential sites, working out the optimal number and layout for the wind turbines, making planning applications, designing and managing the construction of the wind farm and operating and maintaining it. Border Wind is involved with three working wind farms in England and has more planned throughout Britain.

The personnel of Border Wind have been working together for over ten years on renewable energy projects. These include:

- **Great Eppleton Wind Farm:** Due to be commissioned February 1997. Located South of Sunderland, the four 750kW wind turbines will produce, on average, enough electricity for 1700 homes
- **Blyth Harbour Wind Farm:** Commissioned January 1993. Nine 300kW wind turbines are built on a pier in the harbour north of Newcastle upon Tyne. They generate enough electricity to supply 1500 homes throughout the year. When all the turbines are generating at full output they can supply electricity for 6000 homes.
- **Caton Moor Wind Farm:** Commissioned December 1994. Ten 300kW wind turbines near Lancaster produce enough power for 2000 homes annually or 6700 at peak output.
- **Four Burrows Wind Farm:** near Truro in Cornwall is a fifteen turbine site commissioned in March 1995.
- **Foula:** A wind-hydro-diesel system with pumped storage to serve the fifty strong community on this most westerly of the Shetland Isles.
- **Spain:** Project Zephyr - the design, installation and commissioning of a wind-solar power supply with battery storage for mountain-top telecommunications system.
- **Egypt:** Trouble shooting on a wind-solar electric pumping system supplying water to crops in a desert development centre.

Border Wind constantly receive requests for information from students and from school groups. As a result of the interest shown in wind energy the company approached Northumberland County Council with the idea of producing a resource which could be used in schools around the country. The project has grown and grown. This document is a result of collaboration between many organisations. We thank all of them for their interest in wind energy.

Finally, Border Wind does have an ulterior motive in helping to provide this workbook. We all hope that with the help of the teachers who use this book, today's schoolchildren will be tomorrow's people of vision who promote the use of renewable energy as an important contribution to a better environment for all.

Feb. 1997

Anabel Gammidge, Bill Grainger, David Still, Donna Heeps, Norman Rogers, Sandra Painter

Wind Turbines

As for other machinery, wind turbines operate in different ways depending on the model used. The primary difference lies in whether the wind turbine is regulated by the pitching of the blades, or simply by changes in wind speed.

For the purposes of this pack, we shall be describing a pitch controlled wind turbine which is the type of wind turbine installed at the Blyth Harbour Wind Farm north of Newcastle.

The blades are mounted onto a rotor at the front of the nacelle. The nacelle is the structure at the top of the tower which contains the gearbox, generator and hydraulic components.

The rotational speed is kept constant during generation and controlled by varying the pitch angle of the blades. The gearbox increases the rotational speed and the generator produces 3 phase power AC.

Cables carry the power and control signals to the base of the tower, where the wind turbine control computer is located. This computer controls the turbine and sends and receives information from the central computer over a radio modem link. The turbines can be stopped, started and reset remotely by modem. Any faults automatically set into motion the computer's shut down system and warnings are sent to the control stations - on site or remote.

Below the computer compartment is a transformer which converts the electricity to ll,OOOV AC or 33,000V AC and feeds into a high voltage cable which links each wind turbine to the switch gear building. This then feeds into the National Grid.

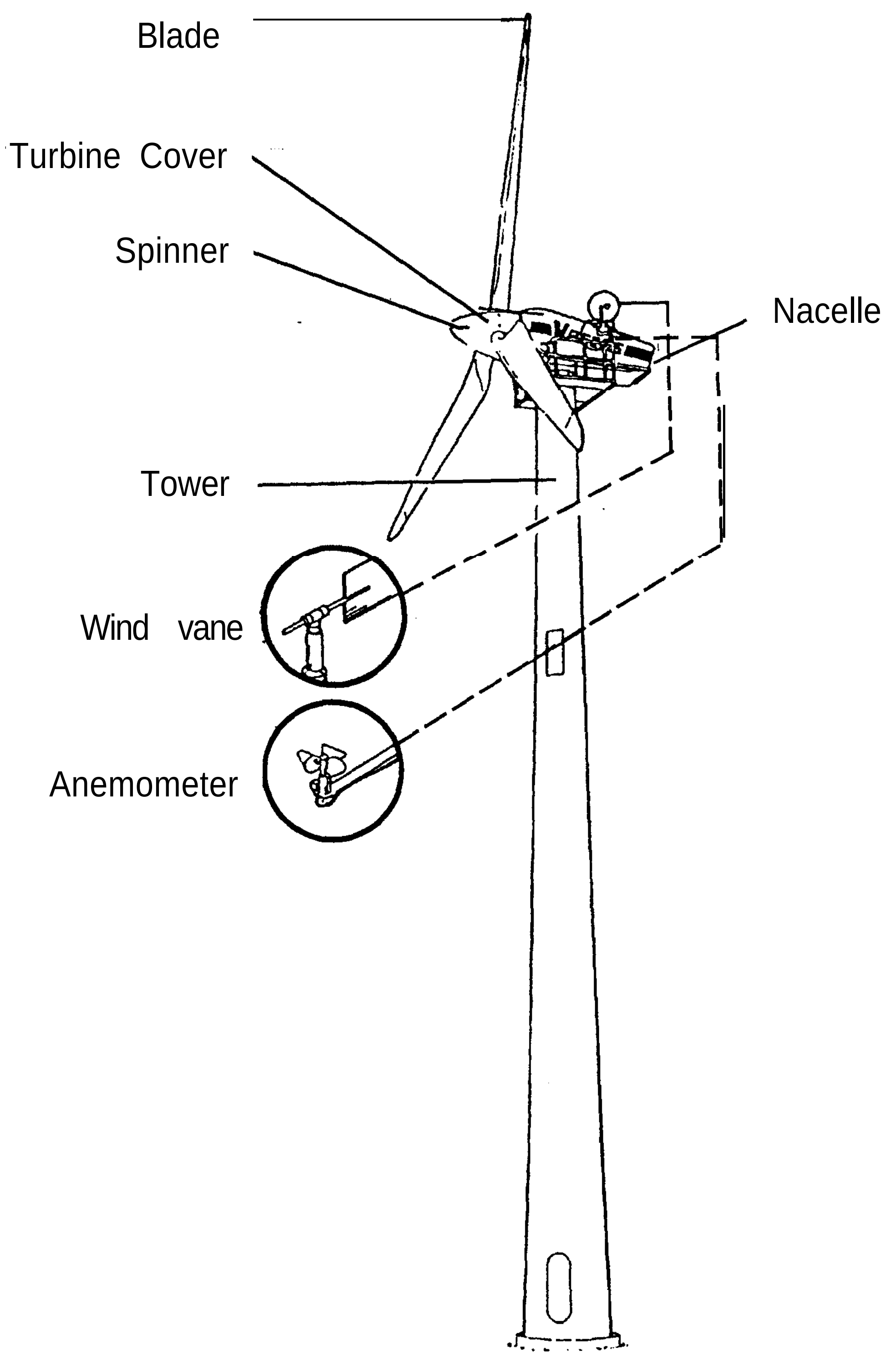
The wind regime will vary across the site of a wind farm. The turbine blades will not all rotate at the same speed - each turbine will produce the maximum energy for its siting.

How do wind turbines generate the electricity?

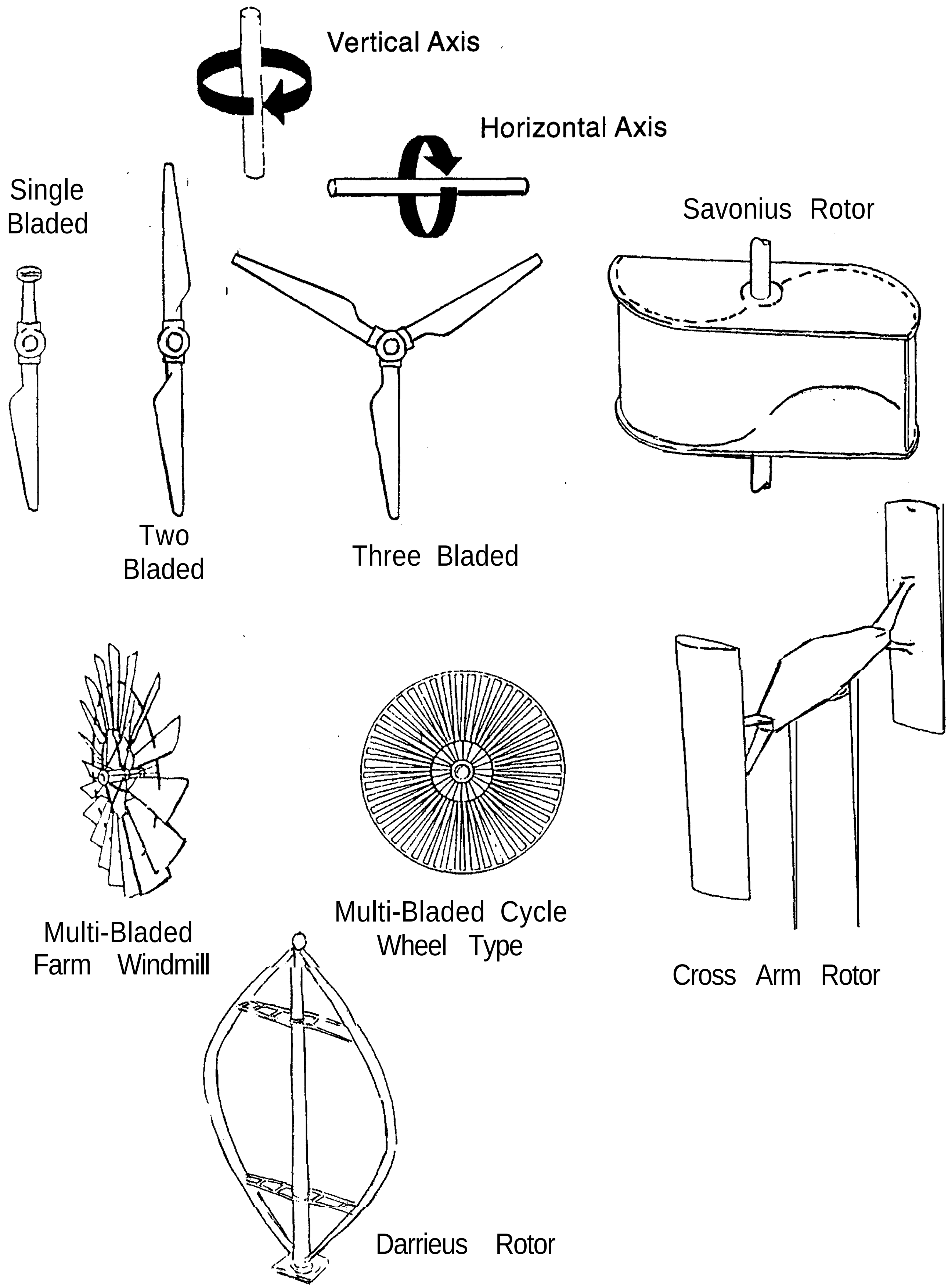
Wind turbines which are used to generate electricity are called aerogenerators. These usually have two or three aerodynamic blades which when 'pitched' (angled) against the wind, can rotate faster than the actual windspeed, giving a tremendous turning force or 'torque'. The turbine is connected to a gearbox which greatly increases the speed of rotation to the generator making it fast enough to generate electricity.

A rudder at the rear of the aerogenerator ensures the blade end always faces the wind, and most use either a computer controlled disk brake or air brake system to ensure the blades don't rotate above a safe speed in strong winds. Computer systems on many aerogenerators can also adjust the angle of the blades to gain optimum performance from changing wind speeds, or to put the blades in line with the direction of the wind to prevent rotation during gales (which would be dangerous) or when the rotors have to be stationary for maintenance work, etc.

A Wind Turbine - Diagram

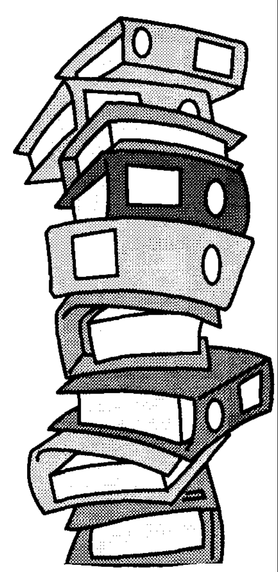


Types of Wind Turbines - Diagram



Reference Grid

	Activity:	Subjects:
1a	Make a Wind Turbine	**Science:** Experimental and Investigative Physical Process, Energy. **Technology** : Making
1b	Make a Simple Wind Speed Indicator	**Technology:** Making
2a	Windy City	**Science:** Experimental and Investigative, Electricity, Forces. **Technology:** Designing Skills **Maths:** Using and Applying, Handling Data
2b	Blow Me Down	*as above*
3	Wind Farm Manager	**Geography:** Economics activity, Environmental Issues **Maths:** Using and Applying, Handling Data.
4	Energy Management	**Maths:** Number, Using and Applying, Handling Data **English:** Speaking and Listening
5	Public Attitude to Wind Power	**Science:** Experimental and Investigative, Energy. **English:** Speaking and Listening, Questionnaires
6	Land Yachting Race	**Technology:** Designing and Making. **Geography:** Skills, Environmental Issues **English:** Speaking and Listening, I.T.
7	At What Cost?	**Science:** Physical Processes **Geography:** Economic activities, Development, Environmental Issues. **English** **Maths** **I.T.**



Make a Wind Turbine.=

No. of pupils: Working in pairs

Resources: Pupil sheet 1, test tubes, motors, pulley, corruflute (4mm), powerful hairdrier, dowelling 4.75 mm, micro ammeter (panel meter/moving meter), sensitive enough to record tiny currents - - 100.

Aim:

This activity demonstrates how to construct a simple but effective wind turbine, using limited resources, at low cost. Once the activities are completed the turbine can be disassembled and components re-used.

Approximate costs of resources for one class set.	
Test hubs pack of 10	*£3.50*
Motors and pulley pack of 10	*£4.50*
Corroflute 61cm x 61cm 10 sheets	*L13.95*
Dowelling 20cm x 60cm lengths	*£2.60*
Microammeters cost varies	*£5.00*

Method:

1. Introduce renewable resources to the pupils - in particular wind power
2. Explain how this wind turbine is constructed.
3. Photocopy and distribute Pupil sheet 1.
4. Ask the pupils to assemble the turbine.

Extension Activities

- Construct strong towers to support the turbines.
- Discuss the potential uses of a low cost turbine constructed using limited resources, eg. third world uses, farming activities such as water pumping/irrigation.
- Does the direction of blade twist affect the direction of rotation?
- Does the amount of twist affect the east of starting the rotor to rotate?

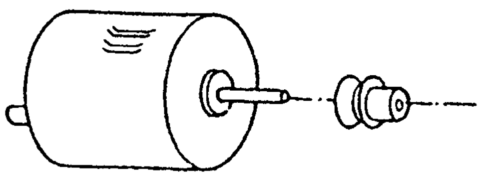
Make a Wind Turbine

Collect these resources:

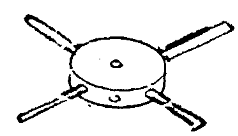
- *corrugated plastic blades*
- *a motor*
- *crocodile clips*
- *dowelling*
- *a test hub*
- *pulley*
- *ammeter*

Assemble the turbine as follows:

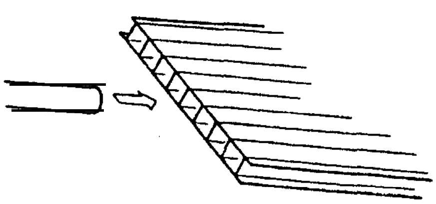
1. Push the small pulley onto the motor shaft.



2. Push 2, 4 or 8 '5cm lengths' of dowel into the test hub.



3. Attach the dowel to the blades, it should fit snugly into the blade.

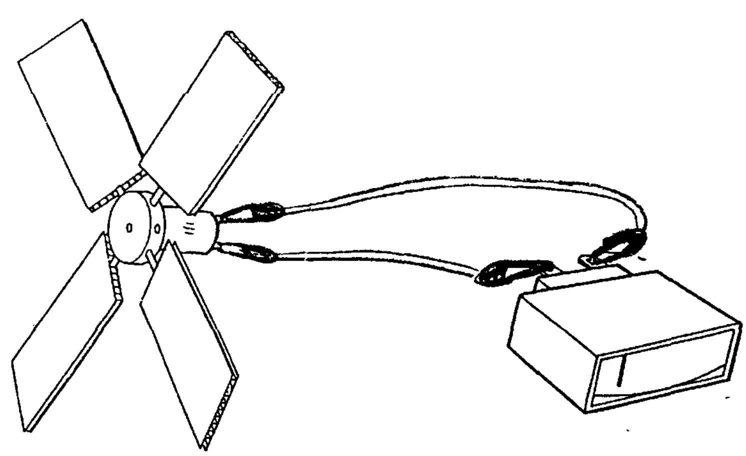


4. Attach the hub and blades to the small pulley and then to the motor.

Connect the ammeter to the motor with the crocodile clips.

5. Your wind turbine should look like this.

Note: all blades have a slight twist

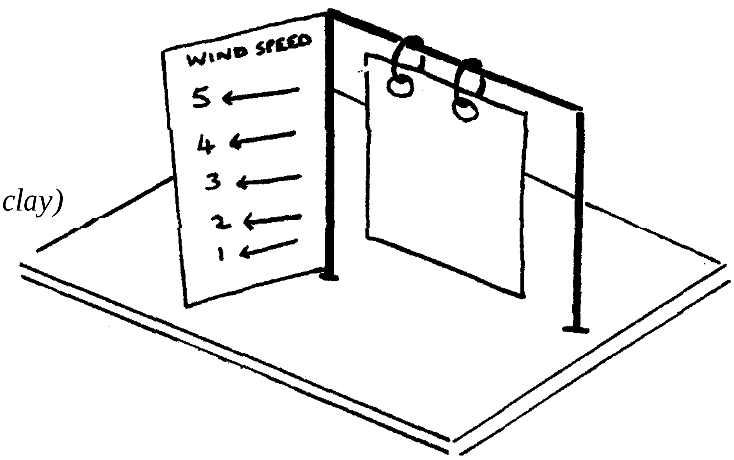


- Hold the turbine and test outside. (The motor only turns one way, swap crocodile clips attached to gain current if it fails to turn).
- Can you construct a strong tower to support your turbine?

Make a Simple Wind Speed Indicator

You will need:

- *stiff card*
- *wire for the frame*
- *wire rings*
- *wooden base (or modelling clay)*
- *card to mark out a scale*



1. Bend the wire into shape. It will depend on the size of your base.
2. Punch two holes into the edge of one piece of card and attach two small (1 cm) wire rings.
3. Slot the rings onto the wire frame and secure the frame to the base (or modelling clay).
4. Position the backing card on to the base having first drawn a scale each line being 20^{0}.
5. You can use the Beaufort wind scale to compare your scale.
6. Devise a simple test to see how effective the Indicator is.

Windy City

No. of pupils: Pairs or small groups

Resources: Pupil sheet 3, wind turbine from Activity la

Aim:

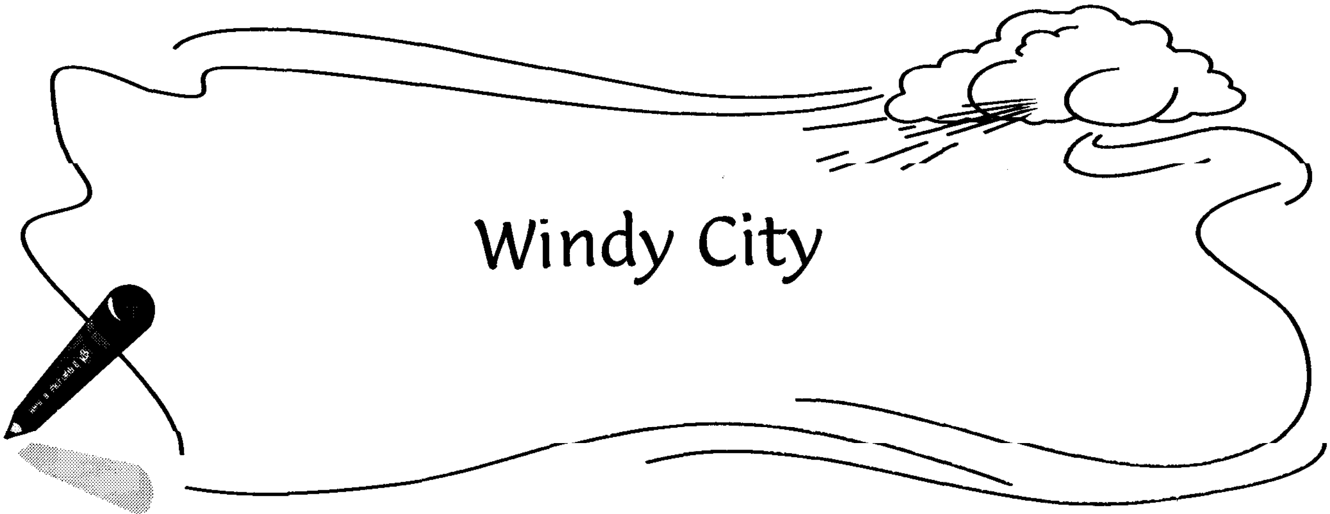
This activity investigates how much electricity can be generated from the wind turbine and whether the turbine design influences the electrical output.

Method:

1. Discuss with pupils how a wind turbine can produce electricity.
2. Explain that the turbine they have made produces very small currents and that the ammeter is sensitive to these small amounts.
3. Photocopy and distribute Pupils sheet 3.
4. Ask the pupils to alter the number of blades used and record their results on the table.
5. Discuss each pair of group's results, whether they are similar, if not what are the reasons for the differences?

Extension Activities

- Investigate issues involved in using more blades
  i) increased cost/weight to support
  ii) ease of starting
- Investigate the visual appearance and aesthetics of each style of turbine. e.g. lattice tower, horizontal axis machines, vertical axis machines.
- Investigate how the scale for sailing ships ease of starting and how circumstances.
- Find out how the Beaufort scale came about (practical and whether it is relevant today). Consider how important it is.



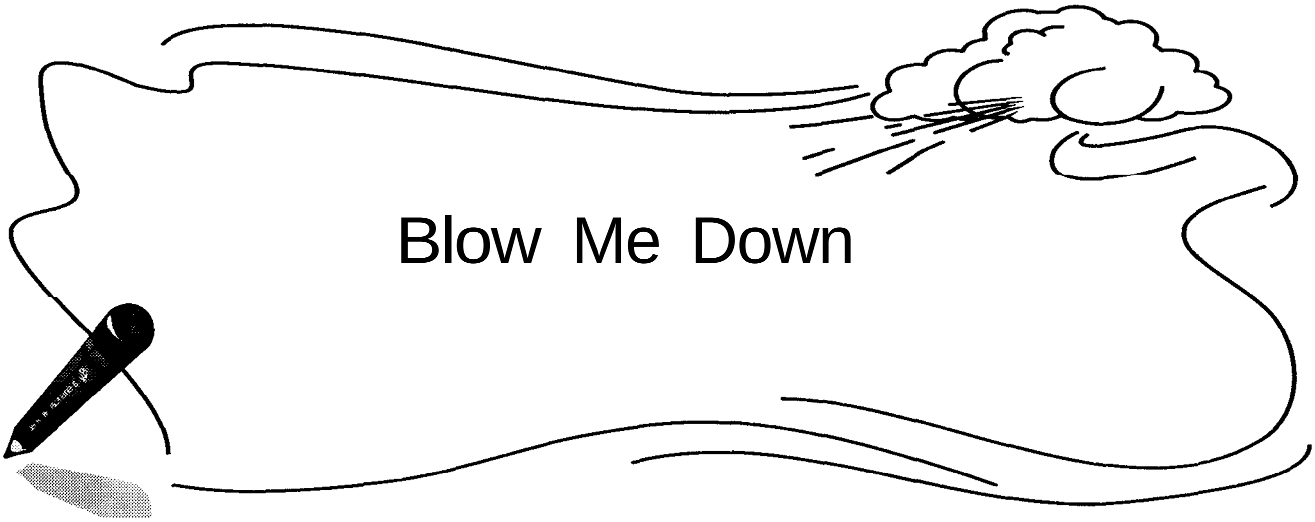
Windy City

Wind power is an important source of renewable energy. As blades of the wind turbine rotate, electricity is generated. Wind power uses only the wind as a fuel so it is very sustainable. The important thing is to **harness** as much wind as possible. There are a variety of styles of wind turbines, some have different numbers of blades.

- Can you investigate which number of blades captures the most wind and so produces the most electricity?
- What are the important factors to consider if you are selling wind turbines?
- How can you make this a fair test?
- Predict what you think will happen
- Complete the table of results:

Number of blades	Current reading on ammeter

- What have you found out?



Blow Me Down

Wind is very variable. Sometimes wind speeds can become very high as in a hurricane or gale. Wind turbines will automatically stop generating in such wind conditions. If there is very little wind the wind turbine will keep testing until the wind picks up. To compensate for this, the blades of the turbine automatically turn into the wind as it changes direction, the blades alter their angle to become more effective.

Using your wind turbine can you investigate the difference it makes to have a variety of angles for the blades.

- What method are you going to use to measure the angles of your blades?

  ....

  ....

  ....

- How many changes to the angles are you going to use? ....

  ....

  ....

- What you think will happen? ....

  ....

  ....

  ....

- What actually happened. ....

  ....

  ....

  ....

Can you design a mechanism to point the turbine into the wind eg. a tail, fan-tails (old fashioned design), manual, wind vane and computer?

Wind Farm Manager

No. of pupils: Whole class in pairs

Resources: Pupil sheet 5, a plan of school grounds, model of wind turbines, information relating to the siting of wind farm and the environmental issues to be considered.

Aim:

This activity investigates the possibilities of siting a wind farm and the requirements for an ideal location.

Method:

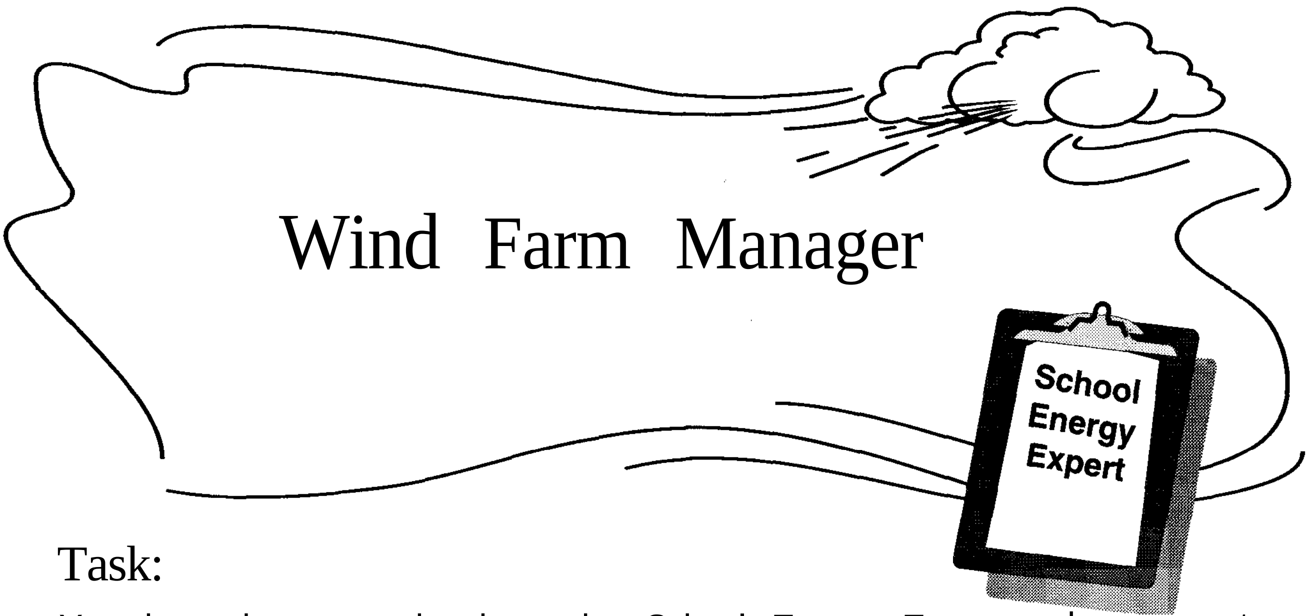
1. Discuss with the pupils a possible wind farm site. Identify areas which are not suitable for investigation and ask them to explain why.
2. Photocopy and distribute Pupil sheet 5 and ask the pupils to use *'their'* wind turbine to investigate a number of possible sites around the school (see Activity 1a)
3. Use a plan or map of the school grounds to mark the advantages and disadvantages of each possible site.
4. Work out a scientific method to test the wind speeds at each site. Identify which is the windiest.
5. Discuss whether one site is more suitable than the others and give reasons.

   Ensure the following factors are considered:

   - where is the nearest electrical connection point - eg. pylons, poles, a substation;
   - is there a wildlife area in the grounds where birds tend to nest, flock, fly; the further from the trees the better etc.

N.B. Constraints include: distance to inhabited buildings for noise - 300m distance minimum

Wind Farm Manager



Task:

You have been appointed as the School Energy Expert, and you must site the proposed new wind farm in the school grounds. The wind farm will provide electricity for the school.

- You will have to draw a plan of the school and grounds if one is not available.
- Use your own wind turbine to find the best position to site your wind farm.
- There are places to avoid, work out where they are and why, then make a list of them.
- Explain why you have chosen your site. You should also be able to identify the least suitable site for your farm and explain why it is so.
- Once you have chosen your site work out how many turbines you will have and where they will be. The turbines are 300 kW. They stand on 30m towers and the blade length is 14.5m It is 15m from blade to tip so the centre of the rotor (i.e. radius of wind capture disk).
- Turbines should be no closer than 8 blade diameters in front of each other in the prevailing wind direction and no closer than 6 blade diameters in rows at 90° to the prevailing wind.
- What are the advantages to you, the School Energy Expert, in having the maximum numbers of turbines?
- What factors might constrain you from having the maximum number theoretically possible?

Energy Mangement

No. of pupils: Small group

Resources: Pupil sheet 6 and 7, pen and paper

Aim:

This activity teaches pupils about energy supply and demand while introducing wider environmental areas for consideration.

Method:

Pupils to complete Pupil sheet 6 questions 1 to 2.

Q1. Straightforward division then multiplication.

Q2. a) technology size (power) x 1000 (kW) x 24 (hours) x 365 (days)

b) as above x % (eg* x 33/100)

c) above figures divided by (E400/7.67p)

d) b) x 7.67 - generation cost - 0.5p)

3. Using the following method, debate the pros and cons of each technology.

- Split up into three groups - one to represent each technology.
- Each group should split into two sub groups - representing the pros and cons. Each individual should find an aspect to debate.
- Each large group should present to the other two groups the arguments for and against the technology they represent. The arguments should be summed up on the board at the end.
- At the end of all three debates everyone has three votes – one in favour of their first choice technology, one in favour of their second preferred technology and the other against their least favourite technology. Abstentions are allowed.

Energy Mangement

Note: one unit' of electricity is one kiloWatt hour i.e. one kiloWatt generated or consumed for one hour.

Imagine you run Windy Town, a town of 10,000 HOMES. Your have to decide which technology you are going to employ to make electricity for the town.

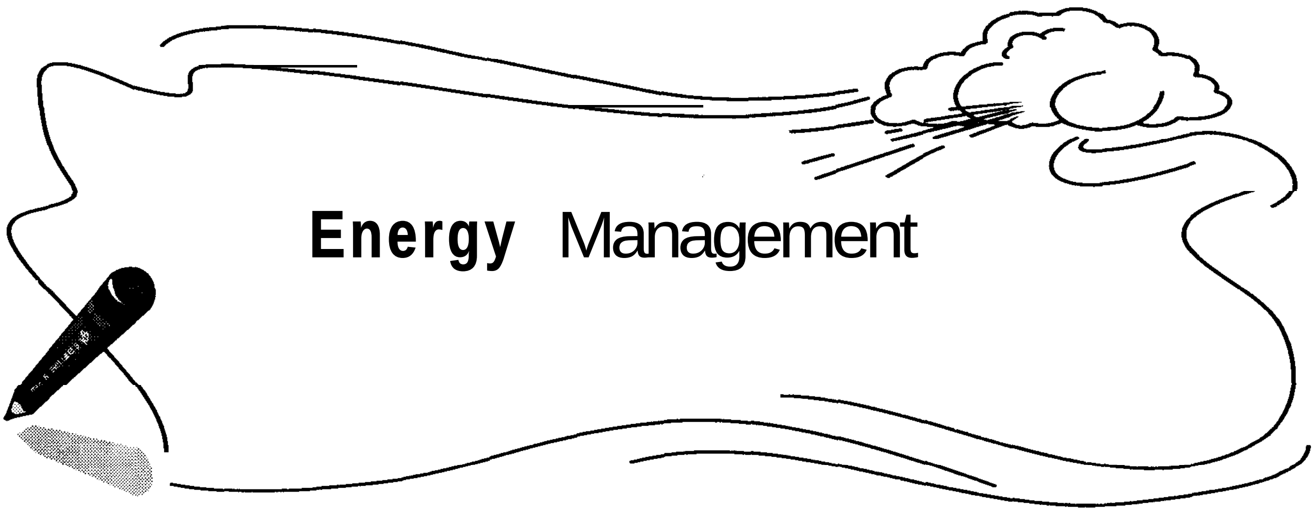
1. Work out how many units of electricity the town needs. Round the number up to whole units.

- Each house pays an average electricity bill of £400 and one unit of electricity costs 7.67p.

In order to build a power supply for the town you must consider several factors.

2. Look at the table below and answer the questions on Pupil sheet 7:

Information	Wind Farm	Coal Fired Power Station	Nuclear Power Station
Size (power)	6MW	1,000MW	1,000MW
Size (area)	12.8 acres	160 acres	several hundred hectares
Min. separation distance between station and homes	300m	500m	1km
Cost per unit (new station)	4.5p	4.5p (includes desulphurisation plant)	6p
Additional costing factors	nil	possible carbon tax, disposal of ash and dust, security of fuel supply	disposal of spent fuel, security of supply, site security
Environmental factors	visual	visual, air quality, cooling water impacts infrastructure for fuel	visual, radioactivity levels, fuel disposal, cooling water quality and impacts, infrastructure for fuel



Energy Management

Answer the following questions using information from the table in Pupil sheet 6:

2.

a) Work out how many units per year you could potentially generate from:
- the wind farm
- the coal fired power station
- the nuclear power station (assume it is not a leap year)

b) Each technology has a limiting factor. Assuming the following factors apply how many units per year could you potentially generate from each technology:
   i) in a year a wind turbine generates one third of the amount it could generate if it ran at full output all year
   ii) in a year coal fired power station generates three quarters of the amount it could generate if it ran at full output all year.
   iii) in a year a nuclear power station generates three quarters of the amount it could generate if it ran at full output all year.

c) Using the figures worked out in b) above work out how many homes could be powered from each station per annum.
   i) how many plant of each type would you need to power the town

d) You own Windy Town Grid Company from whom the householders buy their electricity. To transport the electricity from power station to the homes costs you 0.5p per unit.
   i) Calculate how much profit you will make each year from each technology using the calculations from question b) above.
   ii) which technology is best for your profits?

DEBATE:

3. Work out the pros and cons of each technology and decide which one you would like to build for Windy Town. List the first, second and least preferred technology.

4. How do you supply power when the power station is not available?

Public Attitudes to Wind Power

No. of pupils: Small groups

Resources: Pupil sheet 8 and 9, pen, paper, cardboard

Aim:

This activity teaches pupils what to consider and how to go about gathering information about attitudes and knowledge from the public.

Objectives:

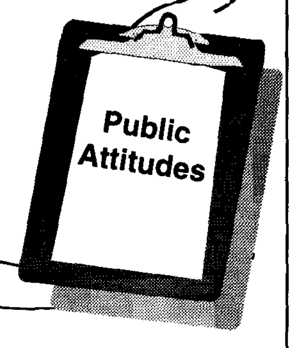
1. Pupils should identify the exact areas on which they wish to have information.
2. Pupils should consider all areas of energy and their own attitudes to them.
   a) what are the problems with fossil fuels?
   b) what other options are there for electricity generation?
   c) are there any difficulties with each renewable technology?
3. Pupils should carefully work out a questionnaire and practice it within the school.
4. Teachers should select careful safe sites for pupils to conduct questionnaires.
5. Analysis and presentation of results should be thought out while the questions are being devised.

Method:

Give the following INSTRUCTIONS to pupils:

1. Work out a questionnaire
2. Make it neat and get as many copies as you need
3. Analyse the results
4. Write a report on your findings
5. Write a press release about your findings for the local paper
6. Analyse your methods and work out what you would change next time.

Public Attitudes to Wind Power



Your task is to write a report on public attitudes to wind power.

Your first task is to devise a **questionnaire** which gives you all the information you need. When you have created your blank questionnaire you should practice it on each other to ensure you are happy with the results you will get. Before you go out onto the streets and gather the information work out how you will put your results into a report.

Below are some questionnaire hints to consider:

Order:

- Think about the order of the questions.
- First, ask what people know about electricity generation and the problems associated with it.
- Second, ask what people do about their own electricity usage.
- Third, ask what people think about wind energy
- Fourth, find out about the person answering the questions.
- Always ask simple questions before difficult ones.
- Always ask general questions about electricity before asking specific questions about wind power.

Make sure you:

- Ask short simple questions
- Ask only one thing at a time
- Use words everyone will understand
- Ask unambiguous questions
- Keep it short 2 - 3 mins.

Make sure you don't:

- Ask biased questions
- Ask leading questions
- Ask questions which require a brilliant memory to answer them

Work out how to record your answers. Be aware of the following:

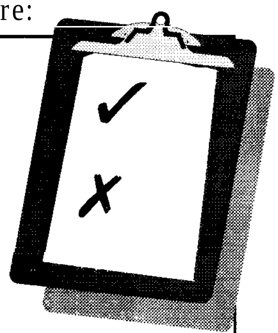
Closed questions: These require a 'yes' or 'no' answer, or give people a choice of answers.

Open questions: These give people the opportunity to give whatever answer they wish. It is time-consuming to read through them and work out the categories into which they should be put. They can, however, provide fuller answers about people's attitudes and views.

Public Attitudes to Wind Power

Scales:

These are often a good way of measuring attitudes. Three examples are:



1. Wind farms have no adverse impacts on the environment
   - *strongly agree*
   - *agree*
   - unsure
   - *disagree*
   - *strongly disagree*
2. Which face sums up your feeling about wind farms?

3. How would you rate a wind farm in the countryside?

	1	2	3	4	5	
Looks attractive						*Looks unattractive*
Should be more						*Should be less*
Want to visit one						*Don't want to visit one*

Be very clear about:

- the point of the report you will write
- the facts you wish to determine
- the accuracy of the facts you wish to report
- the accuracy of the questions which will obtain the facts
- any personal bias you may have

IMPORTANT:
Be sure you remove your own opinions from your mind when you go out onto the street with your questionnaire. Anyone who stops to answer is doing so voluntarily. Do not argue with your interviewee. Always be polite and thank them for their time.

Have a sheet of prepared answers so that you can tell them what it is you are gathering information for. When you have completed your study do send a copy of your questionnaire and report to Border Wind!

Land Yachting - Race (The Americas Cup)

No. of pupils: Small groups

Resources: Pupil sheet 10, per yacht: 2 x axles with wheels, hardboard/ cardboard as base above axles, 2 x mast - dowel, sail area - fabric or paper, a source of constant wind e.g. hairdryer, fan heater.

Aim:

By varying the size and shape of the different parts of a wind yacht assess which factors influence its ability to harness the energy of the wind.

Method:

Get the pupils to do the following:

1. Identify the principles of yachting.
2. Identify the parts they will need to make a yacht.
3. Work out why varying the size, weight and shape of each part will influence its efficiency in harnessing the wind.
4. In groups build a wind yacht.
5. When each yacht is finished position it at a marked spot in front of the wind source and let it go. Measure the speed and distance travelled before coming to a halt.
6. Compare speed and distance measurements to find out which yacht is the winner.
7. Identify the dimensions and design criteria of each yacht and put the results into a table. Analyses the results and draw conclusions.
8. Translate the information learned onto the design of a wind turbine.
9. Write a report on what your group has done and what lessons have been learned.

Extension Activities:

- Add a cost factor to all the materials used - Industrial/business understanding?
- Get a video of the -Americas Cup and work out what each yacht is doing and why!
- Look at the geographical factors of areas where it is possible to race a yacht eg at sea, along a beach - look at friction and resistance across a surface and the wind attributes of different geographical areas.

Land Yachting Race (The Americas Cup)

You are about to build a land yacht. You will be provided with the materials you need and you must make them the size and shape you want then assemble your yacht.

1. Before altering the basic building materials identify why you wish to make each modification and discuss the principles behind this in your group eg high mast or low mast, large sail area or small, whether or not your wish to cover over your wheels.
2. Allocate the following positions within your group:

- **Designer** - responsible for the final design of the yacht
- **Construction Manager** - responsible for building the yacht
- **Analyst** - responsible for the analysis of the group's yacht and working out the factors responsible for the success and failure of each yacht.
- **Company Secretary** - keeps notes of the team's progress and writes the report at conclusion of the experiment.

3. On completion of construction devise a table with the following headings:

Group name	*Factor eg. sail*	*Dimensions*	*Analysis of success rate*	*Comments*

4. As a whole class now work out which are the best features and design and build the best land yacht possible with the combined information.
5. Using the information you have gathered work out how many of these principles can be incorporated into a design of a wind turbine. Now design a wind turbine.
6. Write a report on what you have done, the principles involved and what you have learned from the process. Make the report scientific and then draw conclusions from the results.

At What Cost?

No. of pupils: Whole class in groups

Resources: Pupil sheet 11,12 and 13, pen and paper

Aim:

This activity teaches pupils about the value of energy and looks at new ways of working out how much our electricity really costs.

Method:

1. Give the pupils copies of Pupil sheet 11,12 and 13.
2. Discuss various methods of working out a new way of costing electricity which is relevant to each individual technology
3. Put in some costs and see if you can get a chart which represents the real price.
4. In groups discuss whether it would be a good idea to implement such a cost structure. Discuss the pros and cons and look at the consequences of doing nothing.
5. Discuss which other areas of life ought really to be involved in environmental accounting.

Extension Activities:

- Get pupils to research and then discuss the impact similar measures taken in developed countries might have on developing countries.
- Get pupils to research and then discuss whether environmental accounting is valid/worthwhile/relevant to third world countries.
- Get pupils to research and then discuss how you would go about setting up a group to put pressure on the government to legislate for such changes. Discuss which existing pressure groups you would contact for information and support. Are there any groups already working towards these aims. Are they effective?

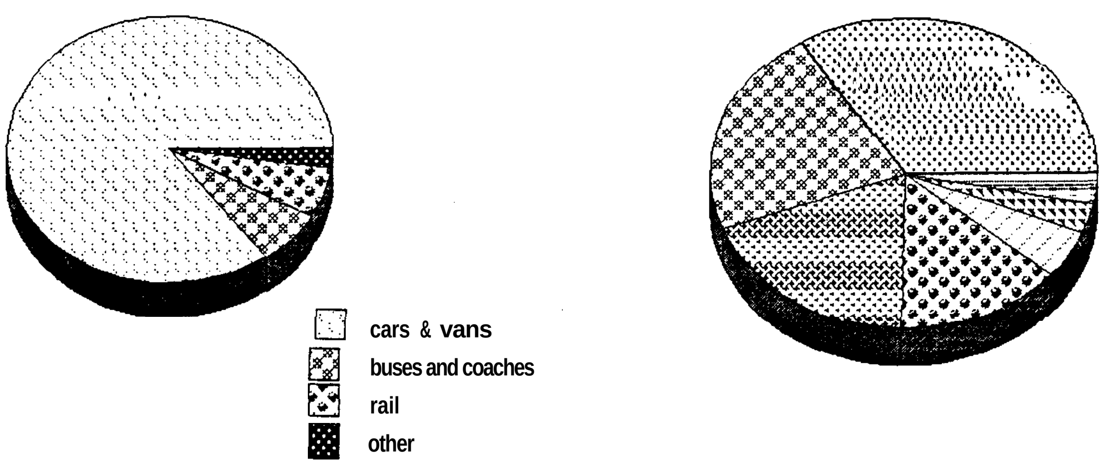
At What Cost?
Information Sheet

In 1992 at the Earth Summit in Rio the leaders of over 150 nations signed a pledge (called the Framework Convention on Climate Change) which stated that they agreed there was growing problem caused by pollution. In signing the document they agreed to work towards reducing the emissions their country contributed towards that problem -global warming. Britain said it would reduce its carbon dioxide and all other major greenhouses gas emissions to 1990 levels by the year 2000.

John Major said: (in Climate Change, the UK programme, HMSO Cm 2427).

"The threat of climate change cannot be tackled by any one county OY group of countries in isolation; it requires a global response. The convention zoe signed at Rio represents an importantfirst step towards providing the framework for such a response. At the same time, the measures required to tackle the problem cannot simply be decreed by governments; they depend on decisions and actions taken by all individual citizens in their daily lives. For this reason, this programme was drawn up after widespread consultation within the United Kingdom. It seeks to harness the efforts of all sectors of our society and the participation of all our people in meeting the challenge for the sake of future generations."

passenger transport in GB, 1990



Some factors which can be included in environmental costing are: conventional air pollution; global warming; disasters and accident related costs eg. oil tanker spills, coal mining accidents, wars e.g. the gulf war, nuclear accidents, dumping of redundant oil platforms.

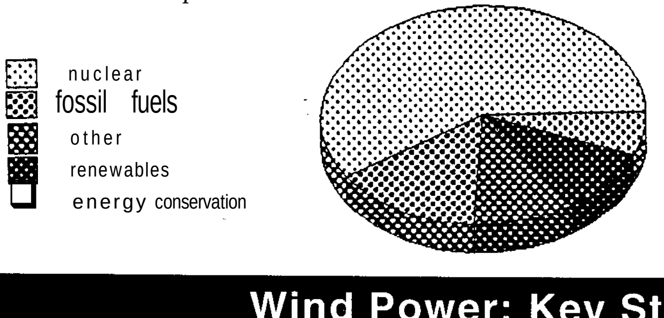
The first report of the **British Government Panel on Sustainable Development** (Jan. 1995) states: *"More detailed work on environmental pricing is necessary. It should relate to the depletion of non-renewable resources, and finding replacements or substitutes for them; to keep renewable resources renewable; and to protecting the capacity of natural systems to absorb pollution. Both economic instruments and regulation should be used to ensure respect for the precautiona y principle and the principle that the polluter should pay."*

"The Panel would support a gradual move away from taxes on labour, income, profits and capital towards taxes on pollution and the use of resources. Currently we tend to tax people on the value they add rather than the value they subtract. In some cases it might be wise and assist public understanding if part of the revenue raised from economic instruments were used for demonstrably environmental purposes."

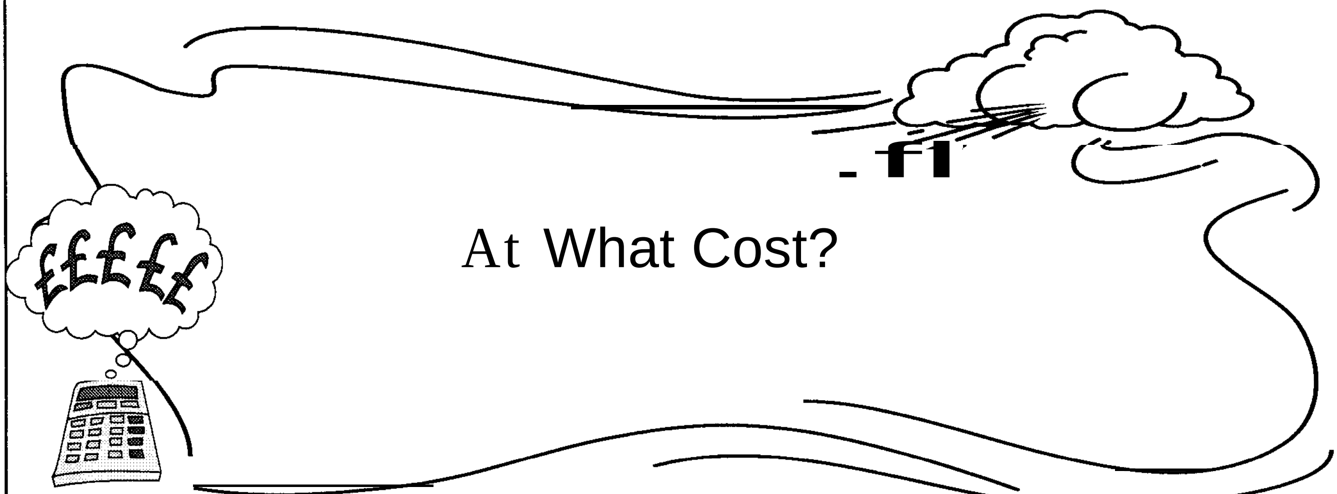
Dr Bill Grainger of Border Wind says: *"We are completely in favour of environmental accounting as it means wind energy and other renewable technologies will be seen in their true light and given all the credits they deserve for safety, cleanliness and sustainability."*

Greenpeace in their report 'Fossil Fuels in a Changing Climate' give the following facts:

- *nearly four times more energy is used today than 40 years ago.*
- *seven of the past ten years have been the warmest ever recorded.*
- *Almost 170 million tonnes f sulphur and nitrogen oxides pour out every year from power stations, cars and other sources.*
- *each year during the 1980s an estimated 18 million barrels of oil devastated Western Siberia, destroying 55,000 km2 of fragile perafrost ecology.*
- *In 1989 1.4 million barrels of oil spewed into the world's oceans, with the Exxon Valdez killing more wildlife than any other spill in history.*
- *The Gulf War's legacy includes the contamination of 700 km of coastline and black soot in the himalayan snow.*
- *85,000 tonnes of oil were spilt from the Braer in the Shetland in 1993. This is consumed evey 55 minutes in the United States.*
- *There are 680 million vehicles on the planet, increasing at the rate of more than one evey second or one new car for eve y two babies born.*
- *Mexico City is so polluted that World Health Organisation smog limits are breached 80% of the year.*
- *After 50 years of devleopment and trillions of dollars, nuclear power meets only five per cent of global energy needs.*
- *The nuclear industry places the death toll for Chernobyl at 40,000 though independent authorities regard this figure as realistically low.*
- *Between 1969 and 1979 there were 20,000 'incidents'at nuclear reactors.*
- *Nearly 150 tonnes of plutonium have been produced worldwide; only 5kg is neededfor a nuclear weapon.*



Breakdown of IEA government energy research and development budgets from 1979 - 1990 (%)



At What Cost?

Discuss the following:

1. What can individuals do to ensure they do not contribute to the problem of global warming? What can households do?
2. Should the government tax the product eg electricity, or the consequences of the method of making it eg a carbon dioxide tax, a nuclear waste tax etc.
3. How would you work out the value of different factor?
4. If new electricity stations were built today the approximate price of one unit of electricity from each would be:

wind power	*coal power*	*gas power*	*nuclear*	*small hydro*
4.5p	*4.5p*	*3.5p*	*6p*	*4.6p*

This price has no environmental factors included. It represents profitability through covering the cost of building the power station.

5. Work out how much credit (discount) on price you would give, and how much debt (increase) in price you would add to the different technologies when considering the factors in the table below. Add any other factors you think are relevant. Now add and subtract these numbers to and from the costs above and work out if the new price is more realistic in your own view.

	Wind power	*coal fired power station*	*nuclear power station*	*small hydro*	*gas power station*
air emissions					
fuel transport					
fuel supply					
solid wastes					
toxic wastes					
accident costs					
asthma & hospital costs					
TOTAL					

The Beaufort Scale

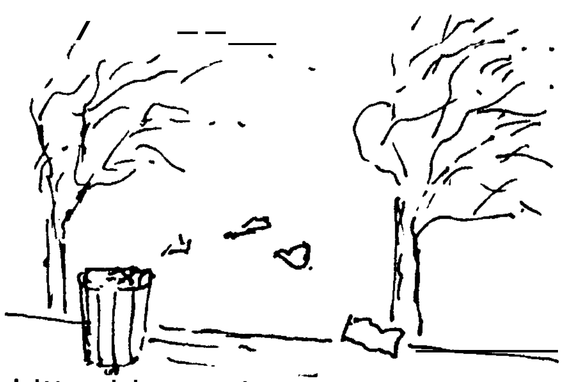
0 Calm

Air is still. Smoke rises vertically.

2 Light Breeze

Leaves rustle. Wind felt on face.

4 Moderate Breeze

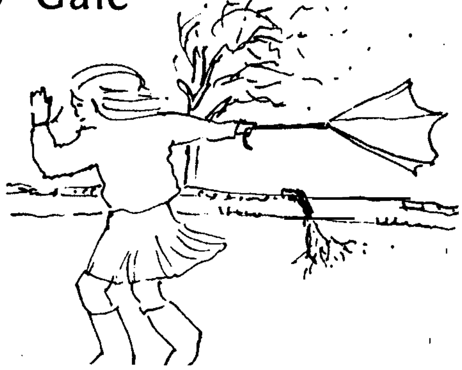


Litter blows about.
Small branches move.

6 Strong Breeze

Large branches move.
Wires whistle.

8 Gale



Walking is difficult.
Twigs break off trees.

10 Storm

Trees blow over.
Damage to buildings.

Wind Vocabulary

ANEMOMETER	a device for measuring wind speed.
BLADES	the 'sails' which turn at the top of the wind turbine.
ELECTRICITY	charged particles which flow producing heat, light etc.
ENERGY	production of motion, heat, light etc.
ENVIRONMENTAL STATEMENT	a document giving details of how a local environment or site will change as a result of a development.
GENERATOR	a machine which produces electricity.
KILOWATT	a watt is a unit of power named after Scottish inventor James Watt. A kilowatt is 1000 watts. 1000 watts produced for one hour is a kilowatt hour or one unit of electricity.
MEGAWATT (MW)	1 MW equals 1000 KW.
NACELLE	the box like compartment at the top of the tower.
NATIONAL GRID	the country's system of power lines for distributing electricity.
NFFO - SRO - NIO	Non-Fossil Fuels Obligation, (England and Wales), Scottish Renewables Obligation, Northern Ireland Obligation - an obligation placed upon regional electricity suppliers to buy a percentage of their electricity from renewable sources.
PHOTOMONTAGE	a photograph with images of wind turbines grafted on the positions in which it is intended they will be erected.
PITCH CONTROLLED	the way the blades angle themselves in and out of the wind to control their speed.
POWER	the rate of production of energy.
RADCOMS	radio communications - television, radio, radio telephone and microwave links.
TOWER	the conical or cylindrical steel structure which supports the nacelle and blades at the required height from the ground.
UNIT	a kilowatt hour of electricity, the pricing blocks in which electricity is measured for billing. One unit costs between 7.21p and 7.67p (domestic consumption).
VISUAL IMPACT	the effect something has upon the eye when viewed in its environment.
WIND ENERGY	the energy in the wind.
WIND FARM	a group of wind turbines which produce electricity to feed into the National Grid.
WIND POWER	the power of the wind.
WIND RESOURCE	the amount of useable energy in the wind at a given site.
WIND TURBINE	a machine for generating energy from the wind (the name for a modern windmill).
WIND VANE	the 'rudder' at the back of the nacelle which detects the wind direction.
YAW	to turn the nacelle in or out of the wind (responding to information from the wind vane).
ZVI	zones of visual influence - the areas around a development, such as a wind farm, from which it is possible to see some or all of a wind farm, usually represented by an overlay which fits a map.

Useful Contacts

BLYTH HARBOUR WIND FARM COMPANY LIMITED
The Old Pilots House, Import Dock
Blyth, Northumberland
NE24 3PA
Tel: 01670 540601

BORDER WIND LIMITED
Haugh Lane Industrial Estate
Hexham, Northumberland
NE46 3PU
Tel: 01434 601224 Fax: 01434 601200
Internet: http://www.bordwind.demon.co.uk

BRITISH WIND ENERGY ASSOCIATION
26 Spring Street
London
W2 1JA
Tel: 0171 4027102 and 01714027107
Internet: http://www.bwea.com

CENTRE FOR ALTERNATIVE TECHNOLOGY
Machynlleth
Powys
SY20 9AZ
Tel: 01654 702400 Fax: 01654 702792
Internet: http://www.foe.co.uk/cat

WIND & SUN
The Howe
Warlington, Oxford
OX9 5EX
Tel: 01491 613859 and 01491 614164

RENEWABLE ENERGY ENQUIRY BUREAU
Energy Technology Support Unit
Building 156
Harwell Laboratory
Oxfordshire
OX11 ORA
Tel: 01235 433302 Fax: 01235 432923

WIND ENERGY GROUP
Taywood House
345 Ruislip Rd.
Southall, Middlesex
UB1 2QX
Tel: 0181575 9428 and 0181575 8318

Useful Books

Wind Power
Ed Catherall (Wayland 1981)

Energy
Donald Clark (editor) (Marshall Cavendish 1978)

Energy Without End
Mike Flood (Friends of the Earth 1986)

Wind Energy
Kovarik, Piper and Hirst (Domus Books 1979)

Future Sources of Energy
Mark Lambert (Wayland 1986)

Energy: A Guidebook
Janet Ranager (Oxford 1983)

Wind Energy : Alternative Energy
Graham Rickard (Wayland 1990)

Wind and Water Power
Philip Sauvain (Macmillan Education Ltd.)

The Winds that Blow - The Facts
Brenda Thompson (Editor) (Sidgewick and Jackson Ltd. 1975) (An ideal children's book giving visual interpretations of the Beaufort Scale)

Fun with Science
Brenda Walpole (Kingfisher 1988)

Onlv One Earth
Barbara Ward and Rene Dubos (Penguin 1972)

Harnessing the Wind
(Free Booklet, UK Department of Energy 1989)

Where the Wind Blows: An Introduction to Wind Energy
B. Horne. Centre for Alternative Technology. 1994 (update due 1997). 28pp

Teachers Guide to Renewaste Energy Projects - Wind power
Education Dept. Centre for Alternative Technology &Junior Activities booklet

Useful Videos

Energy: Turn to the Wind

Zig Zag. Coach Lane Library TP.621.45 ZIG

This video includes a short observation quiz on household appliances which use electrical energy. It includes some good ideas on making windmills. It also has some interesting footage for a coal--red power station and how much coal has to be burned to generate electricity.

Energy: Future Generation.

Technology Programme: Design and Technology No 3 Coach Lane Library TP.600 TEC.

Compares the use of energy sources in Britain and Sweden. Really focuses on the environmental issues related to generating electricity - the pollution and the greenhouse effect. Has some good footage on the effects in Sweden of acid rain caused by burning fossil fuels in Britain. Highlights the debate on nuclear energy and tells about the referendum in which the Swedish people voted to discontinue all nuclear generation because of the dangers.

Energy: Questions of Energy

Technology Programme: Design and Technology No 6 Coach Lane Library TP.600 TEC.

Tries to explain the issues surrounding energy in a simple way for children, although it may still be too advanced for primary school children, Good footage on smoke rising from fossil fuel power stations in Britain. Highlights global warming. Gives comparative timescale (in minutes and seconds) of the effect man has had on the world since starting to generate electricity, and how soon things must change if we are not to destroy the environment.

Energy: An Alternative View.

Technology Programme: Design & Technology No 10 Coach Lane Library TP.600 TEC

Made at the 'Centre for Alternative Energy' in Wales where the whole community depends solely on alternative sources of energy and therefore includes excellent information about all the alternative 'renewable' sources of energy, with a great deal of information on various types of wind generators and rotors. Also some excellent information on energy conservation.

Other Useful Information Sources

BEAUFORT WIND SCALE

Fun with Science
Brenda Walpole, Pub. Kingfisher. **p79**

Be an Expert Weather Forecaster
B Taylor-Cork, pub. Gloucester Press. **p18/19**

Time and Place (Geography 1: Teachers Handbook)
P Harrison and S Harrison, pub. Simon and Schuster. p40
(Also includes a 'Wind Rose' for recording measurements - **p42)**

WIND SONGS

'The Windmill' **'Little Wind**	Flying A Round by D Gadsby and B Harrop. No 54 pub. A and C Black
'Weather Song' **'Who has seen the wind'**	Tinder-Box by S Barratt and S Hodge. No **41** No 44 pub. A and C Black
'Wind in Summer'	Assemblies Round the Year by B Birch, pub. Ward Lock. **P94**

DANCE AND MOVEMENT

'Flying Like the Wind'	Bright Ideas, Dance and Movement by K Harrison, J Lay Ton, M Morris, pub Scholastic. p **18/19**

POEMS

'Mad March Wind'	Bright Ideas Seasonal Activities by Janet Eyre, pub Scholastic. **p13**
'The Wind'	A Puffin Quartet of Poets. **p91**
'The North Wind Doth Blow'	A Puffin Book of Verse, compiled by E Graham.