Winds of

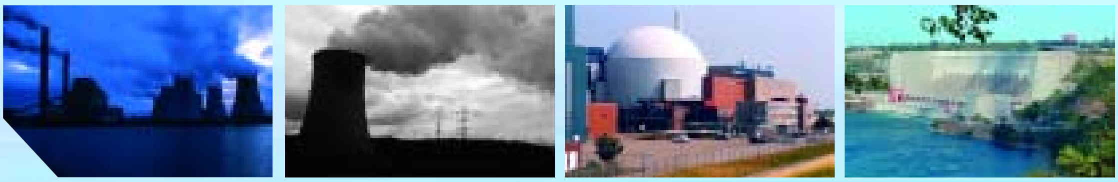
Energy and our understanding of it and use of it has all but disappeared in our D&T National curriculum. It appears elsewhere in the Science curriculum with limited opportunity for practical activity under Energy Resources and Energy transfer at Key Stage 3 and a little more extensively at a quantitative level in Double Science.

Energy and Eco design issues pervade our daily lives in media reports and in our emerging awareness of global issues. To that end D&T remains a highly suitable candidate for teaching and exploring such issues especially as part of a technical challenge or group activity. Among renewable energy sources wind power is highly topical at the moment and has enormous potential as teaching material.

Wind power
Over 1000 turbines operate in the UK with a 40% growth per annum.

Current context

Domestic (UK) energy is provided essentially by fossil fuel and nuclear fuel generation with a minor component being hydro-electric. Attempts have been made since the end of the last century to produce useful amounts of electricity from the wind. However wind turbine technology is the fastest growing sector of renewable technologies worldwide and is a genuine response to need in the developing world as well as developed economies thirst for sustainable fuel sources. There are already over 1000 registered wind turbines operating in the UK to generate networked electricity. Leisure users and self sufficiency communities and individuals also make up a growing un-networked sector of small scale generators.

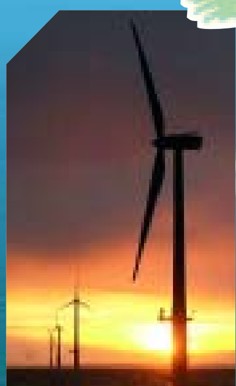


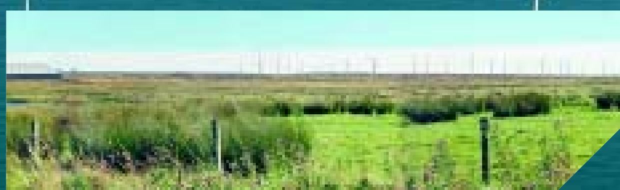
Power plants
Fossil fuel, nuclear and hydro-electric

Growth is currently around 40% per annum and designs and installations have met with a huge variation in acceptance from society. Despite the potentially huge benefits in reduced carbon dioxides and pollutants from fossil fuel burning, wind turbine policy has a few other challenges to meet. Visual acceptance in areas of natural beauty remains controversial as does wind turbine blade noise for residents.

Concern about harmful effects on birds and mammals has also prompted an ongoing study. Interference with the electromagnetic spectrum is well known and radio and TV signals are and can be distorted. Public attitudes do need to be addressed and current surveys indicate over 75% of adults in favour of the technology. Up to 30% of the UK's electrical demand could be satisfied by 2030 if a significant offshore wind farm strategy is pursued now.

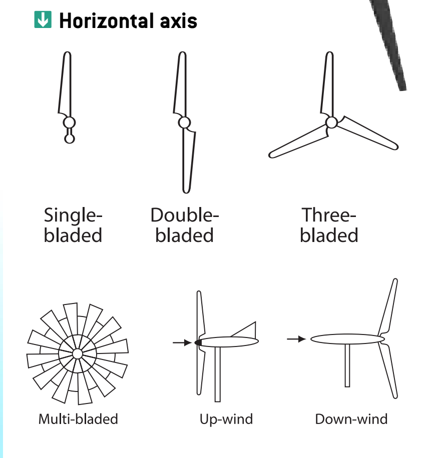
Planning approvals for wind farms is growing, especially in the UK. Some countries like Denmark with no indigenous energy resources have deployed wind power installations extensively, as has Germany. The economic advantage of wind energy 'harvesting' is dependent on a number of factors: annual energy production (linked to performance), capital cost of installation, operational costs (insurance, loans, capital charge). To that end a 'mini' challenge or assignment seeking to replicate some fundamental principles including design, construction and operational issues and acknowledge each of those elements as well as teamwork has great potential in D&T or as a cross curricular activity.

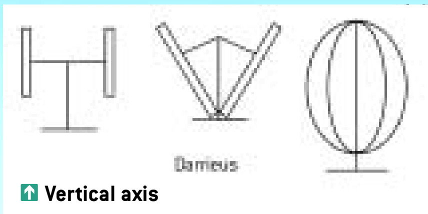




Wind farms
Offshore and inland

change





Design

Turbines (constructionally) fall into two distinctive families: horizontal and vertical axis machines. Horizontal axis machines are mainly axial flow whereas vertical axis machines are 'cross flow'.

Blade design (aerodynamics) number of blades (density) and size are critical factors in the performance and success of wind turbines. High solidity or the density of blades can seriously reduce the performance of a turbine. Harnessing the energy from the wind is essentially about harnessing aerodynamic lift or drag forces generated by the turbine and converting that into simple rotary motion and consequently into electrical energy using a generator. Optimised or rated output will often be at a particular wind speed with lower efficiencies above or below that rated speed.

There are a wide variety of design parameters if this were an actual full scale turbine including Turbine rotor diameter, Power coefficient, Mean windspeed, Tip speed ratio, Number of blades, Radius of station, Angle of attack, Lift coefficient, Drag coefficient, Airfoil , Practical limits on chord width, Centre of mass/lift, Air temperature, Altitude, Air viscosity, Mean windspeed.

Last year TEP spent a few days working with sixth formers and students developing greater awareness of renewable energy issues and focused in particular on a short design, build and test assignment (actually 2 hours). A wide range of possibilities can be explored using budget materials. We used paper roll tubes, corriflute and polystyrene with a range of fasteners and a few hand tools. Unsurprisingly the group experience, topic awareness and team dynamics often emerged as much more interesting than the finished designs. Building turbines is easy using a range of constructional methods with scrap and recycled materials as well as a range of basic tools.

Essentially it is possible to test turbine designs in 'reverse' by loading and treating them as fan dynamometers and ensuring parity and fairness by establishing wind speeds at two points such that you can interpolate a number of points between them and establish a 'critical rating line for the turbine.
A number of design considerations must be made too including, tower design/stability, hub and rotor, blades, yaw (directional) nacelle (cover over hub and generator).

To optimise and temporarily store energy during the generating phase (a 'super' capacitor could be used) a capacitor in parallel with the generator output pins could be used to feed a water pump.
Pumping water is rather more interesting to see as an outcome than simply reading off voltage and current and calculating power for a fixed period. As a 'fall back' strategy if the pump system fails to satisfy you can load the output with a resistor and measure wattage against time to give a value in Joules per second.

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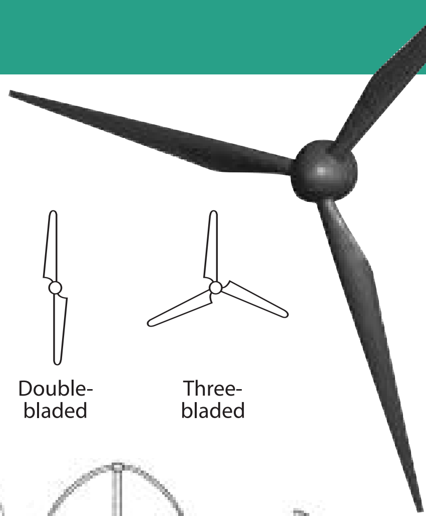
Winds of change

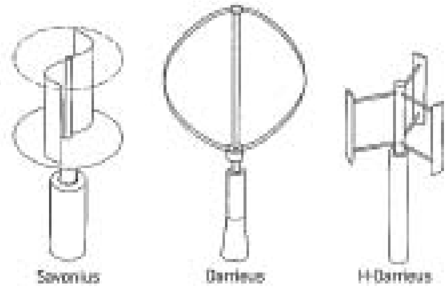


Design types

The most common type of wind turbine is the horizontal axis type, shown above right, which have various considerations. These are so called because the axis of rotation of the blades is in a horizontal position.

There are however another type of turbines available vertical axis wind turbine (VAWT). These are again so called because the axis of rotation of the blades is in a vertical position. There are two main types:

Savonius – uses drag forces to create rotation of the shaft.
Darrieus – use lift forces to create the rotation of the shaft.



The advantage of these types of machine is that they do not have to be faced in any particular direction with respect to the wind. These machines will be equally effective irrespective of wind direction. These types of turbines have not been exploited to any great scale but the Darrieus machines could well be used more in the future.

Project sources

We used two types of electric motor, both geared to provide a suitable output. There are simply loads of motors with integral gearboxes that are ideal for continuous running as generators.

Gearboxes – Inline motor mount
120:1 ratio – Stock code EW2 ECK4
200:1 ratio – Stock code EW2 ECK6
Gearboxes – Perpendicular motor mount
120:1 ratio – Stock code EW2 ECK5
200:1 ratio – Stock code EW2 ECK7

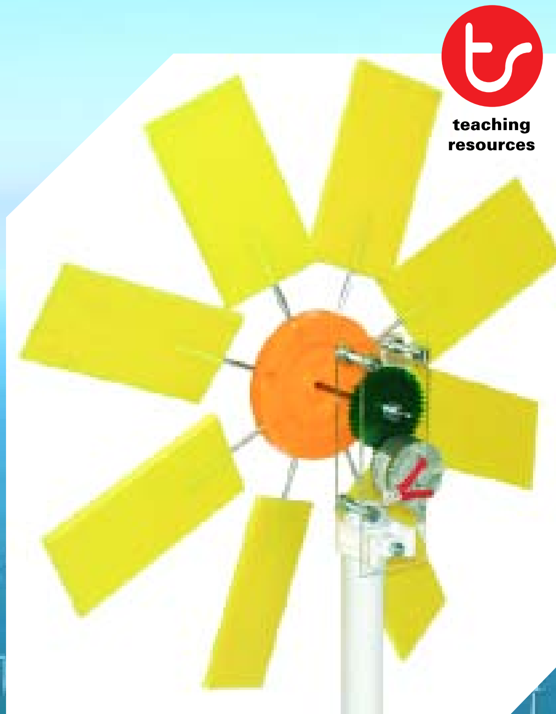
There are some very good publications available including TEPs own **POST 16 ENERGY MODULE**
It features extensive units on Instrumentation, Wind Turbines and Solar panel construction. Equally useful is additional material on wind farm sites, tidal power and a wealth of other material. The full publication is free to download from the TEP website as a PDF or you can purchase the spiral bound copy from Teaching Resources.

Energy Publication – Stock code BB5 033
ISBN 1-8981-26-90-9

An excellent source book is:
Renewable Energy – Power for a sustainable future
OU Press ISBN 0-19-926178-4

This authors favourite is sadly out of print although some libraries may list it:
The Generation of Electricity by Wind Power
by William Golding ISBN 0-419-11070-4

One of the new products from Teaching Resources is a wind turbine kit and could prove a good starting point for exploring ideas. Generating some 'local' wind is also easy - TR also supply budget pedestal and desk fans too.



Wind turbine kit – Stock code BCE 009

A visit to the Centre for Alternative Technology is a truly worthwhile experience and if not possible for students then certainly a staff visit at some point.
Visit the CAT website at: **www.cat.org.uk**

The British Wind Energy Authority have an interesting site too: **http://www.bwea.com**
A useful source is also: **http://www.embracewind.com**

Small scale wind power ideas are also available as a series of free downloads from: **http://www.idtg.org.uk**

We really should be promoting wider understanding and critical awareness about how we use and abuse our earth's resources. Through this kind of assignment there are great possibilities and it will provide a balance to design and make curriculum at all levels.