PAPER WIND TURBINE

A FUN GROUP ACTIVITY FOR TEENAGERS OR ADULTS

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INTRODUCTION

There are limited ways to involve a new group of people in engineering: the subject is often seen as difficult and impenetrable. This workshop aims to show that engineering is merely practical problem solving. This is achieved by creating a simple problem and providing inexpensive materials to solve it, removing the fear of failure.

The aim of the workshop is that each team (of typically two to five people) should build a tower for a very small wind turbine out of newspaper. Each team is provided with a single newspaper and sellotape to make the tower; and a very small generator with a kitchen roll tube to make the blades. The task is to build a tower to hold the generator high enough to reach a fan (placed on a table). Each team builds their turbine, attaches their blades to the generator and places it in front of the fan. A competition is held and the team which generates the highest voltage wins.

The workshop should be adapted to suit the age of its participants. Young teenagers often need supervision to keep their mind on the task and will greatly enjoy a prize being offered for the winner. Adults are more likely to get most from the experience itself and are less reliant on prize-giving (although personally, I love prizes!). The workshop should take about an hour and a half to run (based on four people per group and four groups).

MATERIALS

YOU WILL REQUIRE THE FOLLOWING MATERIALS

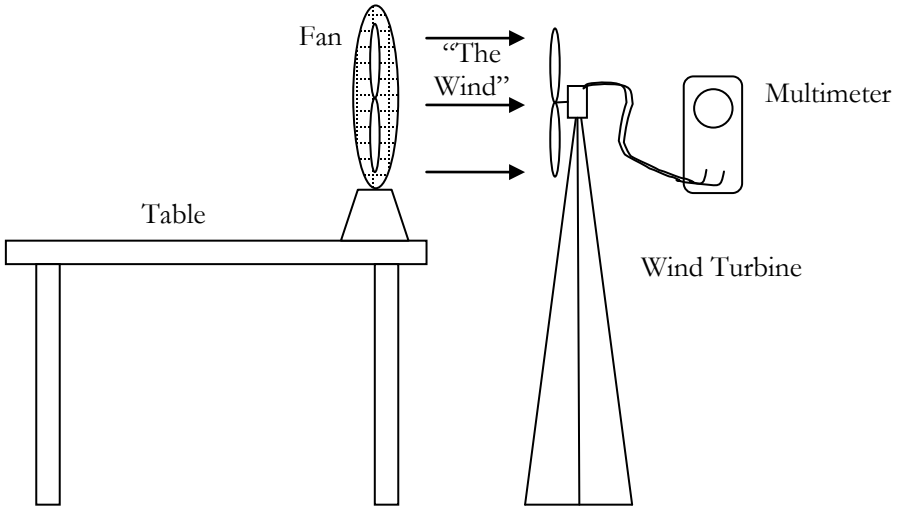
1. A desktop fan
2. A voltmeter or similar (cheap handheld multimeter that measures millivolts is recommended)

EACH TEAM WILL REQUIRE

1. A newspaper (preferably a large format like the Guardian and must not have stapled pages).
2. A pair of scissors
3. A roll of sellotape (a small scotch roll should be sufficient)
4. Paper and pens (for discussing ideas)
5. A kitchen roll tube (for the blades)
6. A wine bottle cork (half a cork cut into two smaller cylinders is sufficient) for attaching the blades. A hole should be poked into one end to allow it to attach to the motor's axle.
7. Three drawing pins (for attaching the blades)

8. A small motor (we use a low inertia 6V 2700rpm motor from Rapid Electronics. Order code 37-0445. About £2 each.)

DIAGRAM



LEARNING OBJECTIVES

This session aims to

1. Inform participants of the need for electricity in third world countries, particularly how even a small amount can mean a lot more to a community that has never had electricity before than it does to us. A separate introduction and discussion during the session should try to draw out this issue, ideally with photos of the technology in action.

2. Demonstrate the difficulties of engineering structures using low cost materials and that triangles lead to better strength than squares.

3. Encourage participants to note the structures they see and the electricity they use and reflect on the engineering that went into producing it.

4. Stimulate interest in engineering as a possible career path (for young people) or interest (for older people).

BEFORE THE SESSION BEGINS

You should ensure you have all the materials listed above. Spares are useful.

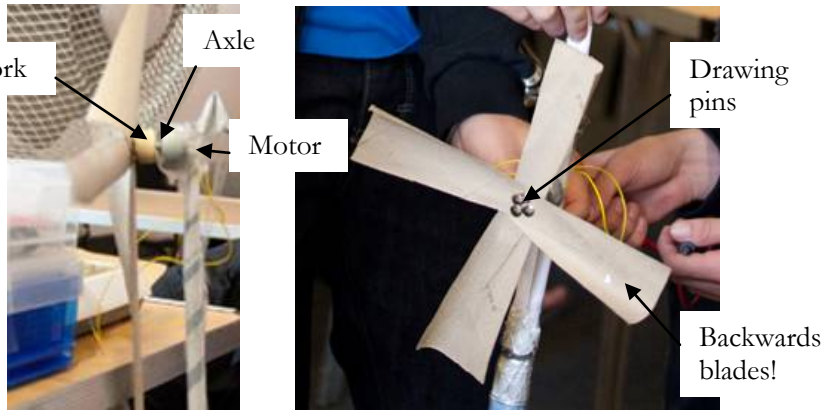
Most of the equipment requires no preparation; however, in the case of the motor you should solder a short wire to each of its terminals (leaving the ends stripped) for each access for the voltmeter. Optionally, you can connect a small (about 0.1μF) capacitor between the terminals to stabilise the output voltage, but this is by no means a requirement.

This is a typical motor. Solder one wire to each of the metal terminals and, optionally, a small capacitor between them.

The handout at the end of this document should be printed and given out to participants. In particular, the way the kitchen roll tube should be cut to make the blades should be explained, as this is not obvious and incorrect cutting may make the tube unusable.

ATTACHING THE ROTOR BLADES TO THE MOTOR

The motor (which is attached to the top of the tower) will have a short axle. A wine-bottle cork is pushed onto it to allow the blades to be attached to it. The blades are pinned on to the cork using drawing pins. In the second photo below, the blades are actually attached backwards (i.e. tips fastened in the centre instead of roots. It actually worked, but produced less power than usual)



HOW TO ORGANISE THE SESSION

AT THE BEGINNING

You'll want to introduce the task. In particular, explain that engineering is just a question of problem solving and the issues affecting the design of their turbine affect real turbine manufacturers. It is also good to discuss the problems of electricity generation in the third world, where low-cost simple material turbines are all that is realistically available. You may want to point out that to generate enough electricity for a single 100 W light bulb would take a much larger turbine (at least 1m diameter on a very windy day or even 2-3m diameter on an average day) or the power provided by a man riding a bike connected to a dynamo. Comparing this to a 10 kW typical electric shower shows how much electricity we use here, but how vital 100 W can be elsewhere (imagine having no lighting at night).

You should introduce the task briefly, but it works well if groups are given minimal formal guidance and just informal pointers during the course of the task.

DURING THE SESSION

You should split your group into teams of ideally three or four. Each should have their own table with each of the items described earlier in the materials section and an information sheet. On a table at the front or other accessible location you should place the fan so that it blows horizontally around waist height.

> *You should give participants the ability to test their turbines before they are finished, throughout the allotted build time. Many will blow over, get stuck, not catch the wind or be the wrong height.*

Set a time limit for the build and remind participants throughout of the remaining time. Typical timings are 10 minutes for introduction, 50 to build the turbine, 20 to test and 10 to wrap up.

Walk around the groups giving advice as you see fit. Refer to our good solutions and bad solutions section, but it is best to let people make their own mistakes as long as don't get stuck. Many people will need reminding that the motor needs to be attached.

AT THE END

After the allotted time, call a halt to the workshop. Then, in turn, ask each group to test their turbine. Placing it on the floor, turn on the fan and measure the voltage generated across the motor (this will typically be from 100 mV to 2000 mV depending on design). You may have to bend the rules a little (for instance, allowing the turbines to be sellotaped to the floor). The highest voltage wins, but secondary prizes could be awarded for novel designs or aesthetics, for example.

GOOD SOLUTIONS AND BAD SOLUTIONS

Although here we give you our experience of good and bad solutions, we recommend you don't pass this on to your participants as it takes the fun out of making mistakes. It is included so you can guide groups that become stuck or help others see flaws in their design (for instance, by encouraging them to test its ability to withstand the fan).

GOOD DESIGN

A good design uses single sheets of newspaper wrapped very tightly into a thin roll (without being bent) and sealed with a piece of sellotape at each end. Many of these 18 inch struts are connected together in a design which uses many triangles and comes to a point at the top, at fan level, where the motor is attached. The blades should be pinned to the cork which is attached to the motor's axle. The base of the tower should be wide enough to avoid blowing over when in front of the fan.

BAD DESIGN

Bad designs typically use loosely wrapped struts, or those of several sheets. These have a tendency to kink or bend and consequently lose their strength. It is also a bad idea to have the motor anything less than horizontal or the blades will catch on the tower. Designs with a lot of paper, especially at the top, are heavy and may crumple or fall over. In general, simple designs with tightly rolled paper struts and a wide base are much more effective.

SUMMARY AND CONCLUSION

This workshop can be used to anyone from a young teenager to a mature adult in practical engineering. Alongside this workshop, the real problems of constructing wind turbines can be discussed with the group, from the mechanical strength of the tower to the difficulty in generating electricity and the reason such large blades are required. We hope you find it useful.

If you do use this workshop, we'd be grateful if you let us know how it went and if you have any suggestions for improvements or comments on what went well and what didn't. We will be delighted to hear from you; contact us at ewb@shef.ac.uk.

HANDOUT

See overleaf for handout to be printed and given to each group.

EWB's Wind Turbine Challenge

The Challenge

To generate electricity from the wind using only newspaper, kitchen roll tubes, a motor, a cork, some drawing pins and some sellotape.

Rules of the Game

1. The "wind" will be provided by a desktop fan from table height, whilst the wind turbine's supporting structure may only rest on the ground.
2. The wind turbines will be judged by the voltage they produce.

Materials

Each group will be given the following materials with which to construct their wind turbine:

- 1x electric motor/generator
- 1x cork
- 1x kitchen roll tube
- 1x roll of sellotape
- 1x newspaper
- 3x drawing pins

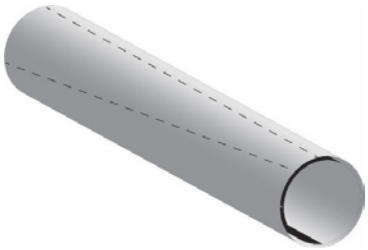
Design Hints

Please ask as many questions as you can and we encourage you to test your design as much as possible to iron out any "design flaws"!

Rotor

A cork will allow you to attach blades onto the motor axle without them slipping.

The drawing pins can hold the blades onto the cork whilst you tape round them.



Cutting the kitchen roll tube like this will allow you to make 4 blades from each tube (remember to cut the diagonal the same way both times or you will have one pair of blades the reverse the other and the wind turbine won't spin!).

Tower

Rolling newspaper tightly can make strong structural poles from which to create a supporting structure. Remember, it must be stable enough not to fall over when the wind blows on the blades at the top of it

GOOD LUCK!