

# Wind Turbines

## Testing turbine efficiency

Using RapMan



# Fossil Fuels and Carbon Footprint

- Many power stations burn fossil fuels to generate electricity.
- Burning fossil fuels releases carbon dioxide into the atmosphere.
- Carbon dioxide (CO<sub>2</sub>) is a greenhouse gas that contributes towards global warming.
  
- Try to find out...
- Which fossil fuels are used to generate electricity?
- How much CO<sub>2</sub> is released into the atmosphere by power stations each year?
- To prevent/reduce global warming we need reduce the production of greenhouse gasses. How much?
- What is meant by the term “Carbon Footprint”?
- How big is your carbon footprint?
- What alternative methods of generating electricity have a small carbon footprint?

# Wind Turbines

- You may have seen wind turbines are becoming a more common sight around the countryside and coastlines of many countries. Using the wind energy to generate electricity is seen by many as a clean alternative that has a small carbon footprint.
- There are many different types of wind turbines, large and small. **But which is most efficient at generating electricity?**



# Vertical or Horizontal?

- Which design is best?



Beside the typical "propeller"/"fan" types there are also the vertical ones, here is a start to finding more information.

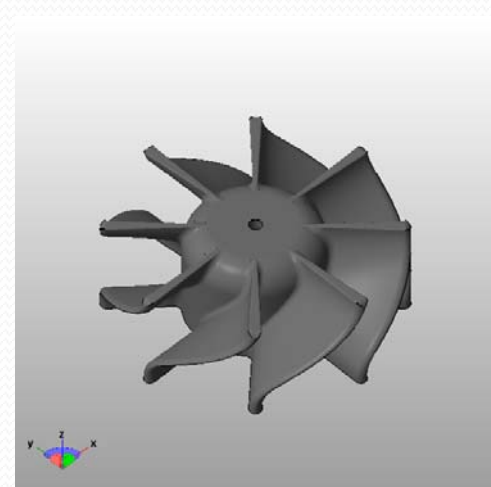
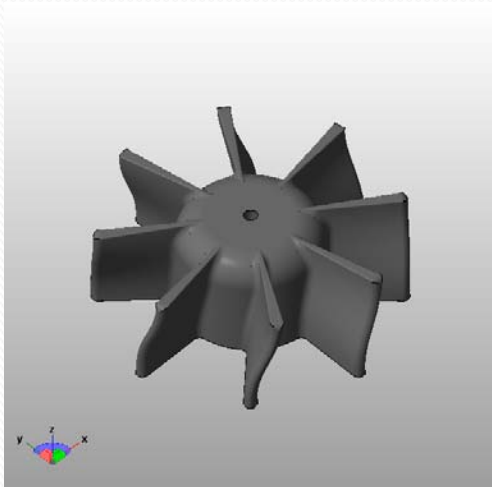
Savonius ([http://en.wikipedia.org/wiki/Savonius\\_wind\\_turbine](http://en.wikipedia.org/wiki/Savonius_wind_turbine))

Darrieus ([http://en.wikipedia.org/wiki/Darrieus\\_wind\\_turbine](http://en.wikipedia.org/wiki/Darrieus_wind_turbine))

Vertical H-Rotor (<http://www.neuhaeuser-windtec.de/en/technology.html>)

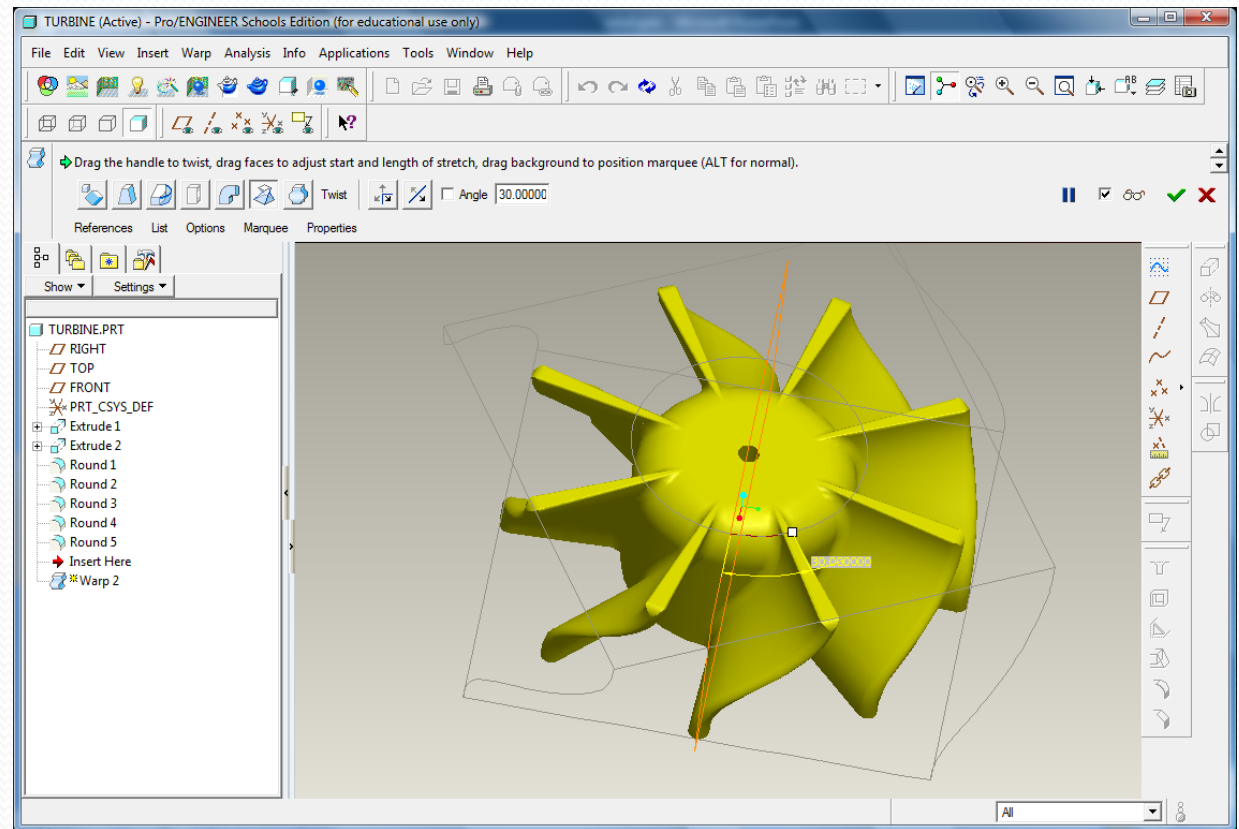
# Twisted???

- Most turbines convert the linear motion of the wind into rotary motion to turn a generator. This is usually achieved by the twist in the blades and/or their aerofoil cross section... But how much twist is needed for the turbine to work efficiently?



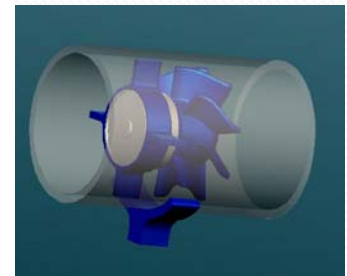
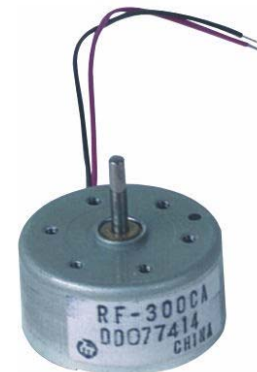
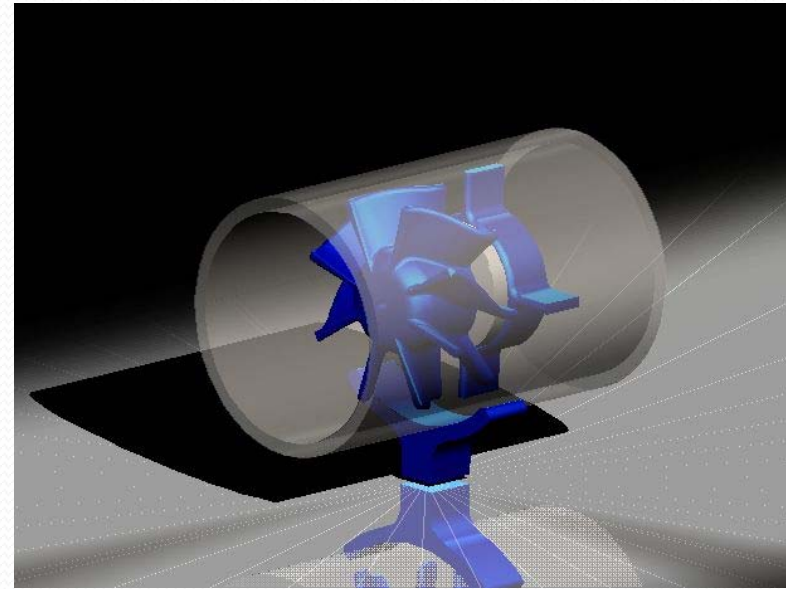
# Design a turbine

- Pro/Engineer can be used to design a turbine.
- Hint. Design the turbine without a twist and use the “warp” feature !
- Using the same basic design you can then experiment with different twists.



# Design a test rig

- If you spin a small electric motor with your fingers it will generate a small amount of electricity. If you add a propeller or turbine to the shaft of the motor the wind will turn it for you..... You now have your own mini electricity power station!
- You could try different propellers/turbines and compare how efficient they are.
- A test rig will help you to hold the motor so you can concentrate on comparing your designs.
- “Solar” motors may be a good choice as they are often good quality and have little friction.



# How to compare.

- To make a fair comparison of the turbine you need to keep some things constant and only change one thing at a time (i.e. how much twist).
- An old CPU fan can be used as a constant wind source, just make sure you always keep it the same distance away from the turbine in each test. Try connecting it to an old phone charger to save using batteries.
- A digital volt meter can be used to measure how much electricity is generated.



# Some simple electronics

- If you only want to measure the relative quality of the blade system (comparing blades / turbines between themselves), apart for having constant wind speed targeting the blades, you can use the voltage generated by the DC motor as a proper value to compare blades relative design quality. In this case - simple DC motor and volt meter will be all you need!

This will not, in any way, give you any information on how much useful energy you managed to get from the wind! The most important fact here is that when loaded the generator (in your case DC motor) will offer resistance that blades need to overcome. To measure the energy taken from the wind you need to calculate how much current you can get. If you have ampere meter connect the it (set to measure DC current) as on the diagram (in series with the 10 ohm resistor) and measure current. You can try also 100 ohm and 1 ohm resistors for better results.

The amount of energy transferred from the wind to electrical is

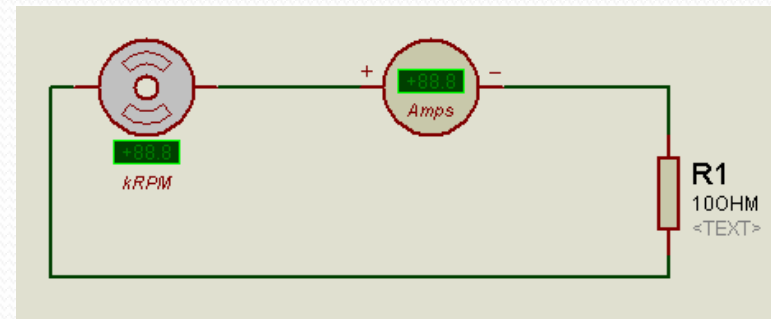
$P = R \cdot I^2$  (i.e. power in Watts equals the resistance in Ohms multiplied by current in Amperes squared)

$E = Pt$  (i.e. energy in Jules =equals power in Watts multiplied by time in seconds)

So by knowing the resistance of the attached resistor and by measuring current (I) and time (t) you can calculate electrical power and energy generated.

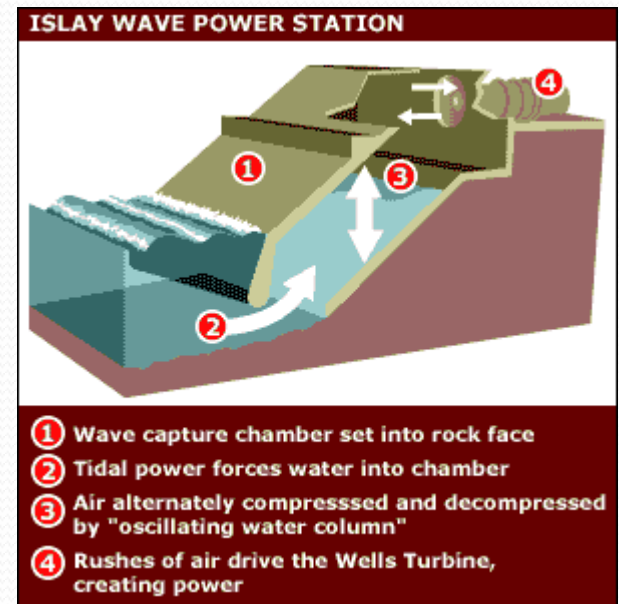
- You will need to experiment, try measurements with 3 different load resistor values. Use 1% metal film resistors. I suggest 1R, 10R and 100R as those are easiest to calculate with !

Thanks to Bogdan Kecman for his explanation of how to make these measurements.



# What next?

- If you are feeling adventurous....Tidal waves generators work almost the same way as Wind Generators. They draw energy from the currents. But this is the advantage of Tidal Generators, Water Density. Water has a thicker density than air. Its density is 832 higher than air. It means that a single Tidal Generator can generate a significant amount of energy at lower tidal flow velocities compared to a Wind Generator.
- <http://green-tech-gadgets.blogspot.com/2008/12/tidal-waves-electricity-generator.html>
- But take care... Water, electricity and students don't mix 😊



# Credits

- I really have to thank the following contributors to the Bits from Bytes forum for their help and advice given to me in preparing this Teaching and Learning resource. They are a great bunch of guys and if you ever need help with anything to do with RapMan and 3D printing try posting on the forum... Help usually arrives within minutes!
- Bogdan Kecman (Serbia)
- Marcus Wolschon (Germany)
- Normdom (Germany)
- John348 (UK)

# RapMan

- RapMan is a low cost 3D printer available from Bits from Bytes [www.bitsfrombytes.com](http://www.bitsfrombytes.com)
- Further assistance can be found on the BfB forum and wiki.

## Forum

<http://www.bitsfrombytes.com/fora/user/index.php>

Wiki <http://www.bitsfrombytes.com/wiki>