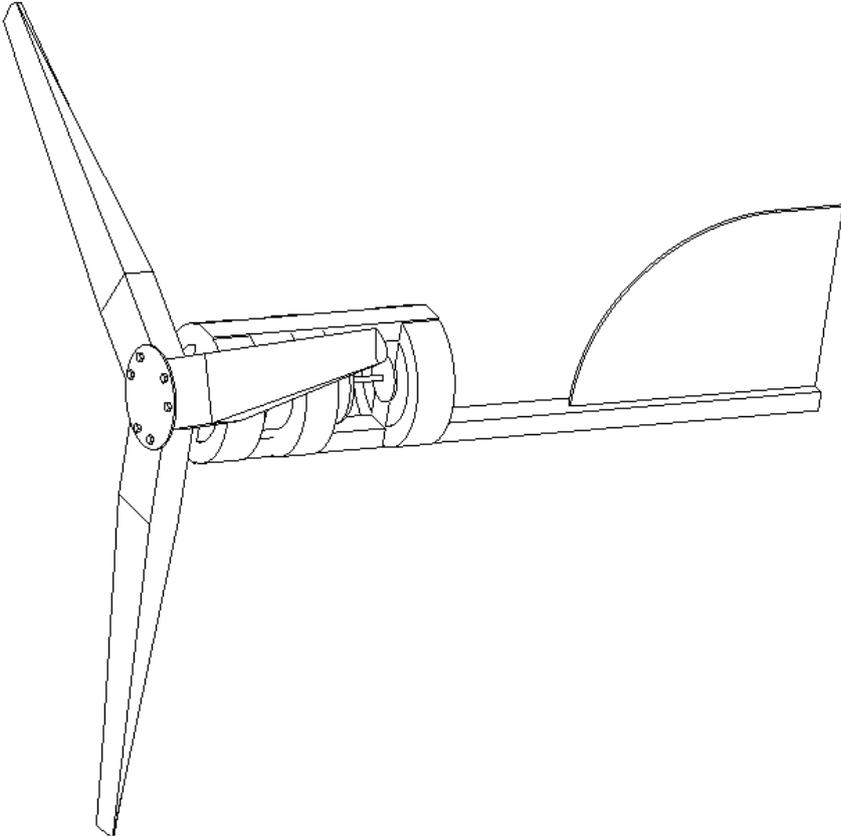


Construction manual for a 100 Watt wind turbine



Construction manual for a 100 Watt wind turbine

The purpose of this manual is to instruct how to build a wind turbine with rated power of 100 watts from cheap and easily available material. Model wind turbine was built in Helsinki University of Technology's engineering design workshop using mostly hand tools.

Material used for the wind turbine

8 magnets (permanent magnet, cylindrical shape, diameter 20mm, height 10mm)
230m 0,25mm copper wire
2 bicycle front wheel hubs
3-4m 2x4" lumber
55cm 8mm thread bar
bolts
nuts
screws
washers
nails
8 metal slabs (counter piece for magnets, 30mm x 30mm x 10mm)
45cm cylindrical shape lumber (diameter 95mm)
20x40cm 10mm plywood
30x40cm 5mm plywood

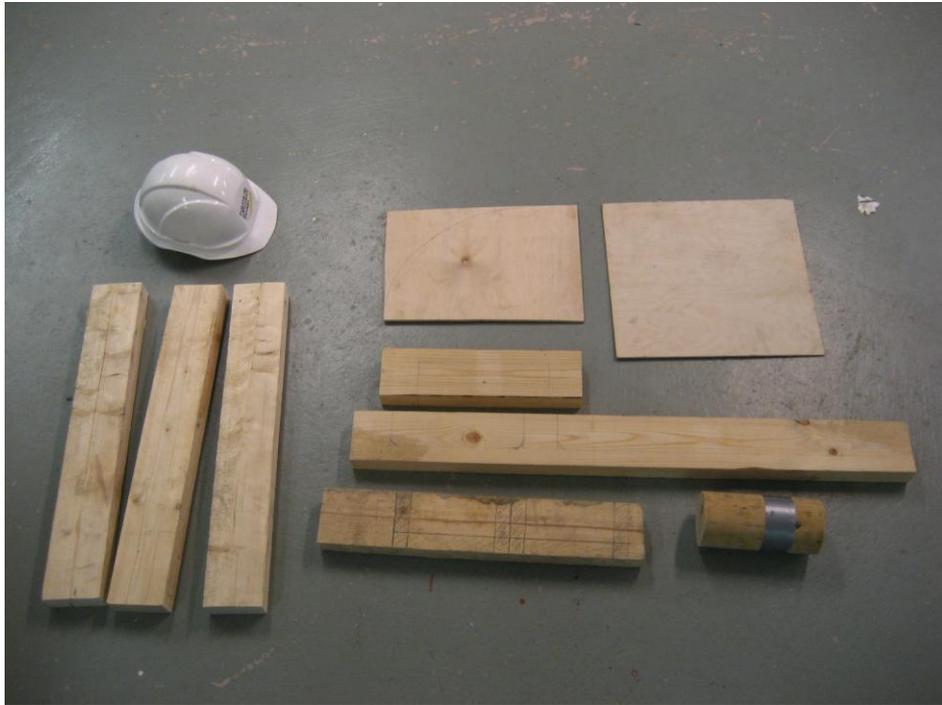
Tools + other equipment

Screwdriver
Saw
Draw knife
Chisel
Grease for axis and bearings
Hammer
Abrasive paper
File
Drill & drill bits (8mm, 3mm...)
Measuring reel
Glue (epoxy + wood glue)
Wood oil

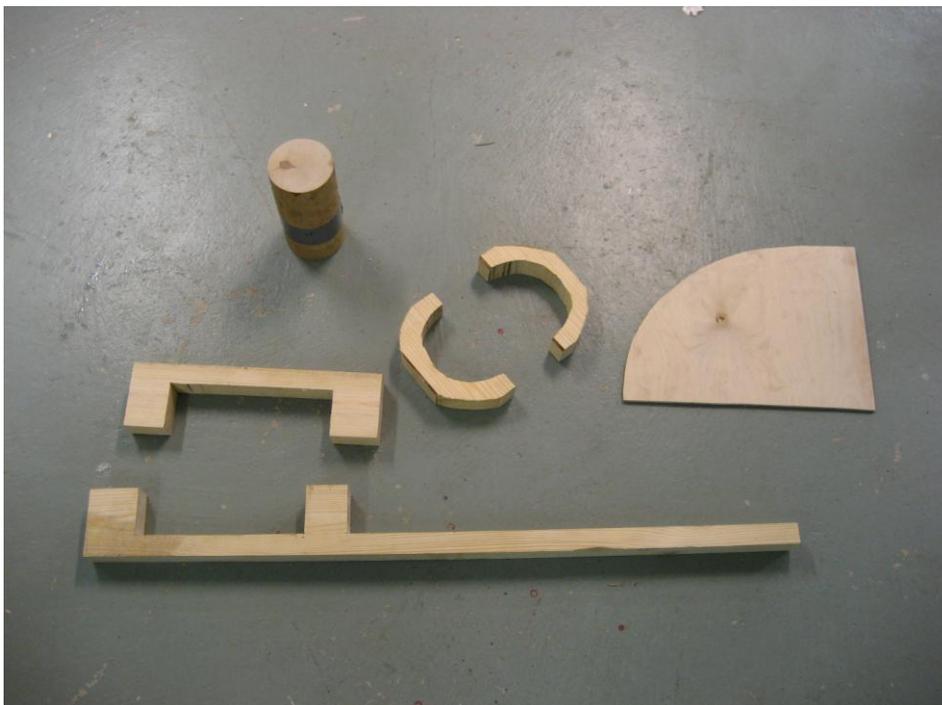
TOTAL COST OF THE MATERIAL USED 50€

Frame

The main frame of the wind turbine is cut from 2" x 4" lumber (we used birch). Take the lumber and cut it into pieces of 1005mm and 370mm. Cut the frame as shown in picture 2. Saw and chisel are useful in cutting the part from the center. Width of the brackets should be measured to match the bicycle hubs (picture 6). Carve some wood off brackets so wheel hubs can be put in. This phase takes some precision. Upper and lower parts of the frame should make a tight fit around the bicycle wheel hubs.



Picture 1: Lumber for the frame



Picture 2: Frame taking shape

Cut a rudder from 5mm plywood and saw a slot (410mm deep) in the lower part of the frame for the rudder. Rudder will be attached with screws. Make sure the slot is wide enough (but not too wide) and there isn't too much tension between frame and rudder as this may break the frame.

Cut 6 U-shaped pieces. Measurements for these are shown in appendix 1. Two of these will become the stator and all of them combined will give strength to the frame once it's assembled. The length of the U shaped pieces should match the height of the upper and lower frame put together.

Axis

Drill eight shallow (the depth of the magnets) holes to the side of the wood so that they go around the wood, these are the holes you will put the magnets in. Use the same size drill bit as the diameter of the magnets. Put some epoxy to the holes and press the magnets in place. You'll probably need a hammer. Magnets should have alternating poles facing out.

Drill an 8mm hole through the cylindrical shaped lumber. If you use different size axis use the same diameter drill bit. Fit has to be tight. Make sure that it holds by using glue. Epoxy is probably the best for this. Put the bicycle wheel hubs through the axis. Try to keep bearings intact so that thread bar will rotate easily inside the wheel hubs. Use axis grease. Use nuts on both sides of the cylindrical wood. Add nuts if needed to make a tight fit when wheel hubs are attached to the lower part of the frame.



Picture 3: Cylindrical wood



Picture 4: Inserting the magnets



Picture 5: Inserting the axis

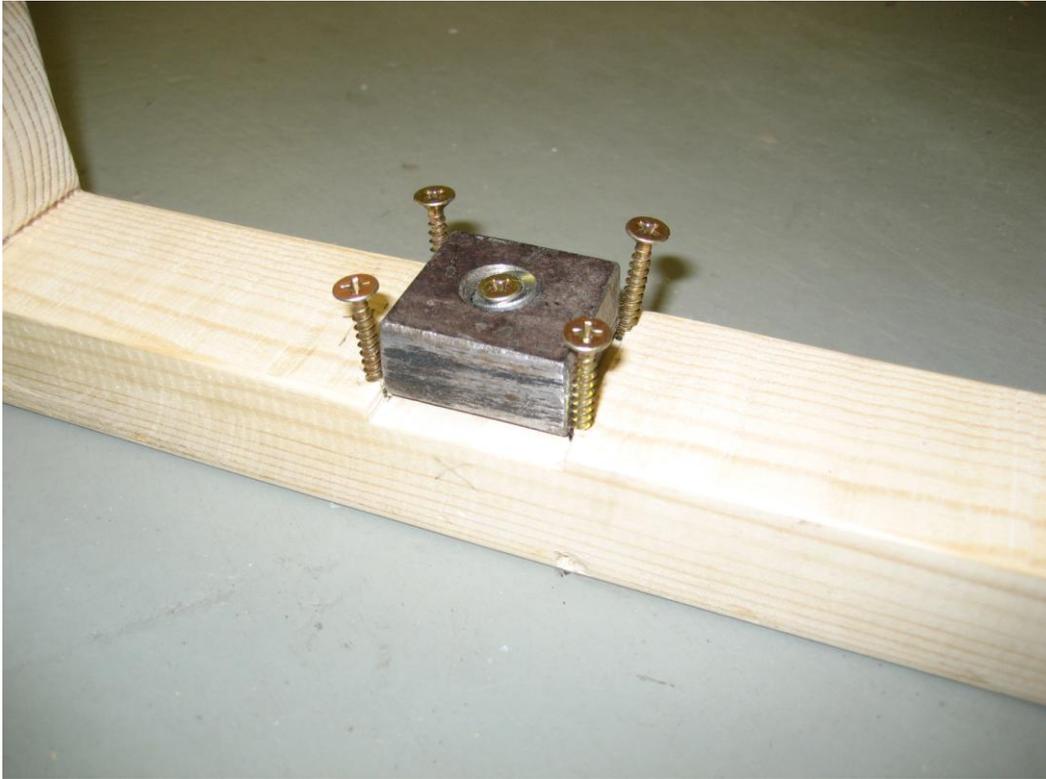


Picture 6: Lower frame and axis in place

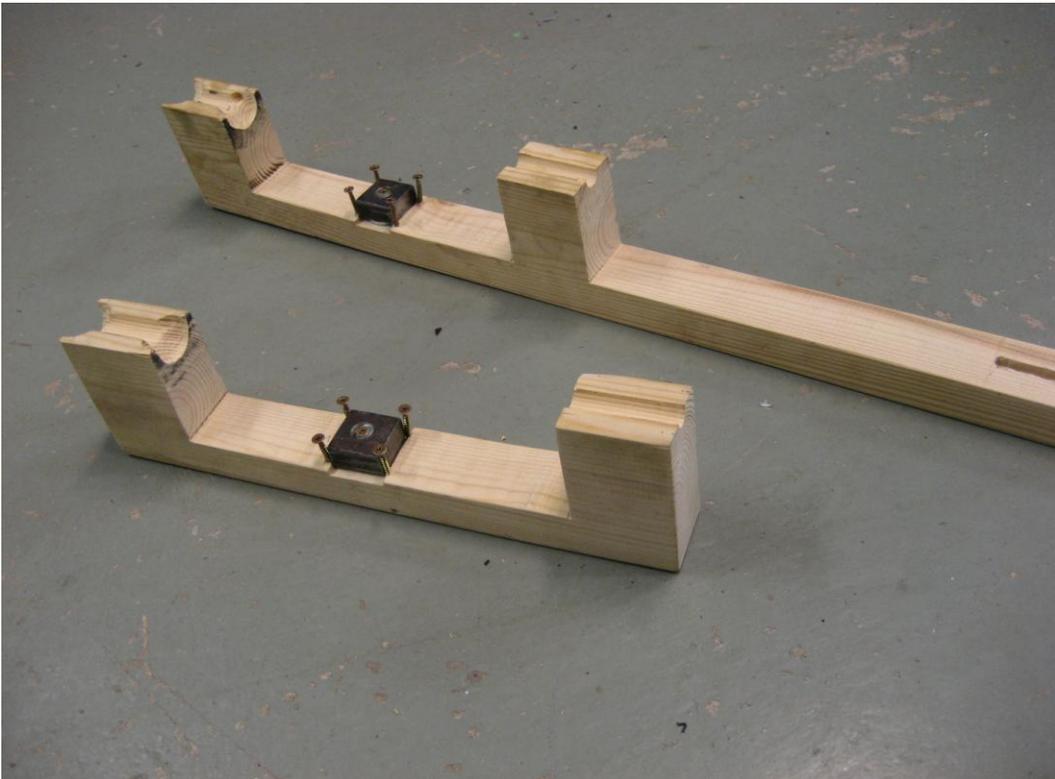
Stator

You will need lumber, plywood, copper wire, metal slabs, screws, nails, washers and glue for this.

First we'll do the wiring for the upper and lower part of the frame. Put the thread bar with wheel hubs in lower frame and upper on top of that. Measure the right spot in the frame so that the metal slabs align with the magnets. Put a screw through the slab and then another four screws around it (near corners). Wind 100 loops of copper wire enclosing the metal slab. Be sure to mark the direction in which you wind the wire. Using magnets instead of metal slabs will create more effective magnetic field and thus generate more electricity.



Picture 7: Metal slab in lower frame



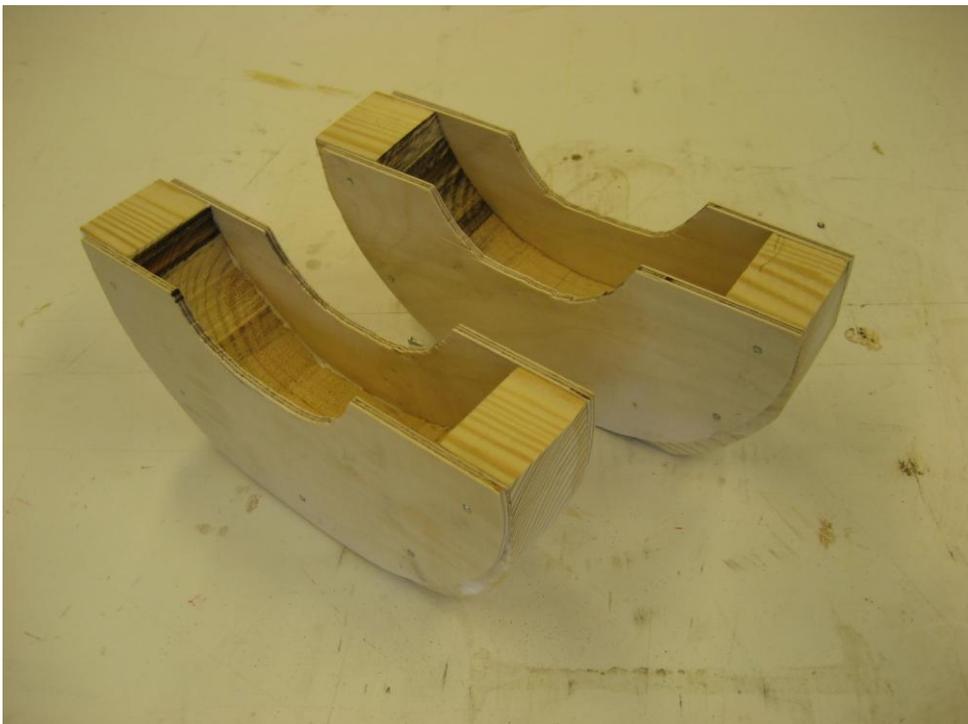
Picture 8: Metal slabs attached to frame

Cut lumber to U shape as shown in picture 9. Saw is a good tool for this, use chisel to finish the work. Cut two pieces of plywood for each lumber piece (four altogether). Inner diameter of plywood should almost touch the cylindrical wood (with magnets). Precision is needed. Put plywood pieces and lumber pieces together using glue and nails. These will hold firmly.



Picture 9: Pieces for the stator

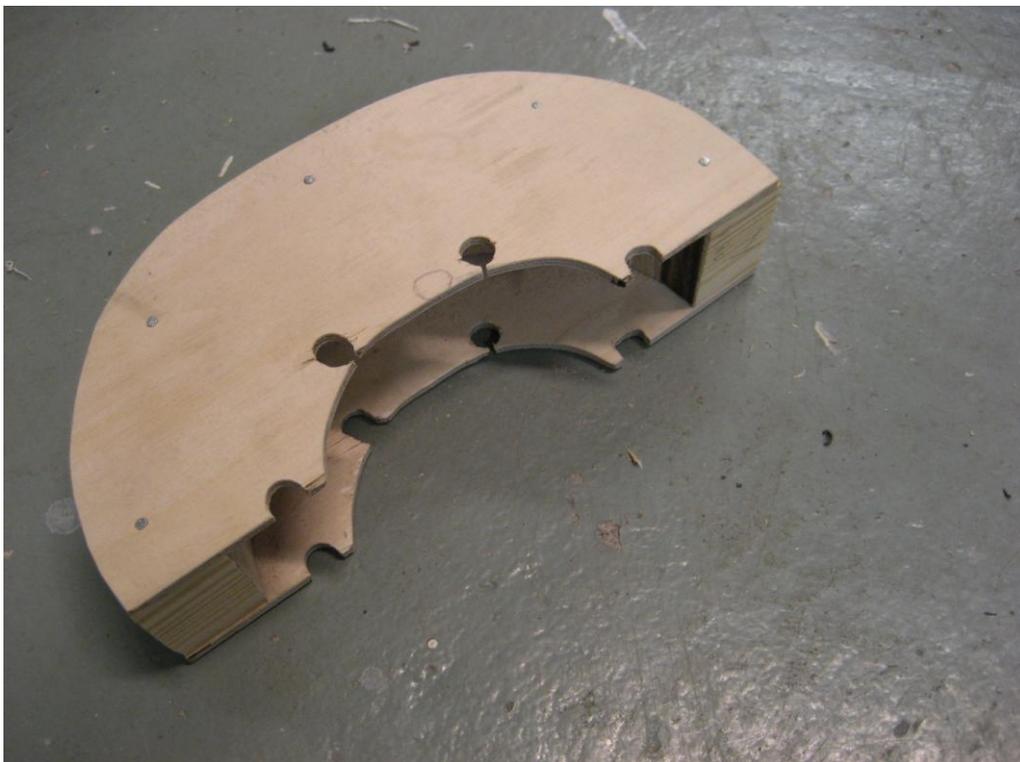
Drill two holes through both plywood pieces attached to the lumber. These will hold the copper wire. Use a file to make slots for the wire at the end of both sides of the piece. You will then have four holes in each plywood piece. See spots in picture 12.



Picture 10: Stator halves

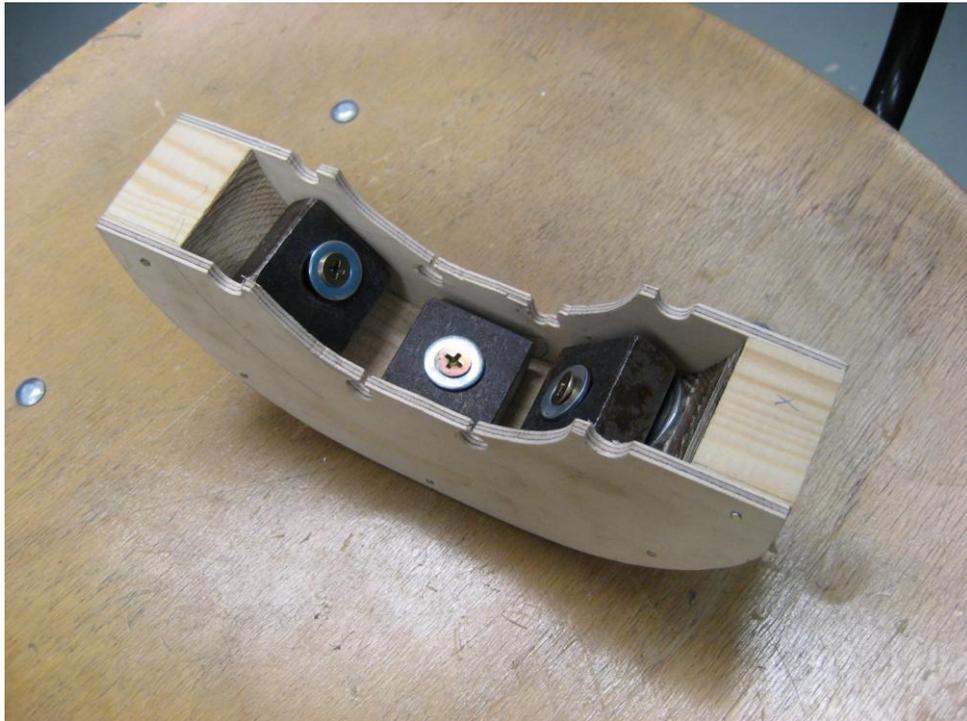


Picture 11: Working on the stator



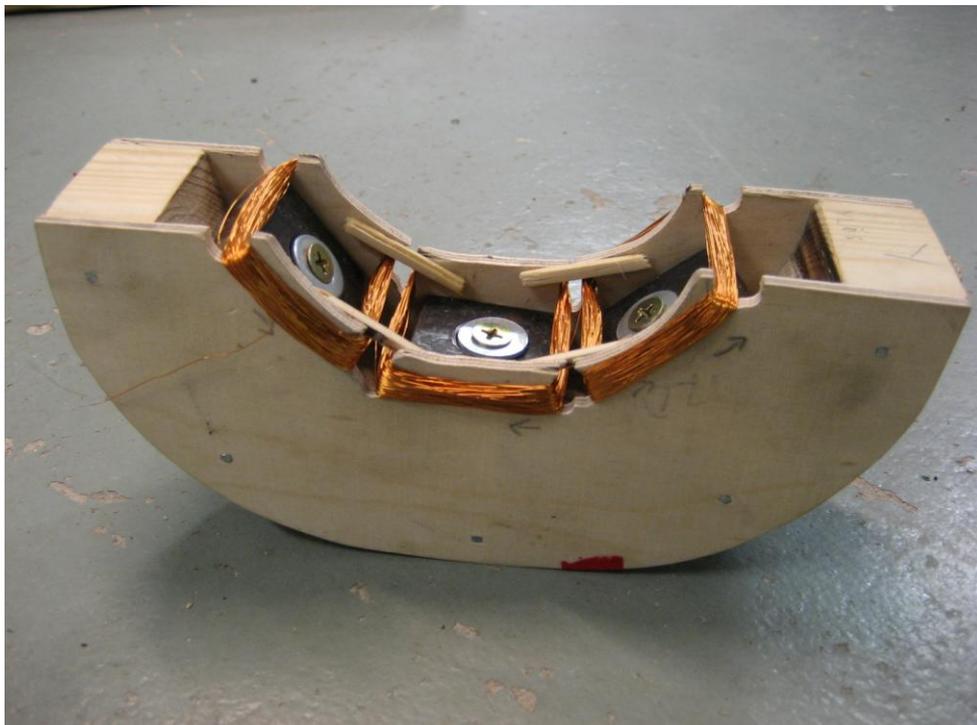
Picture 12: Stator half without coils

Put a metal slab inside the stator half between plywood pieces and fasten it with a screw. Make sure that the slab is relatively close to the inner edge as this makes the magnetic field stronger. Slab should be positioned between the drilled holes so that coils can be wound around it, thus enclosing the slab.



Picture 13: Metal slabs inserted in stator frame

Next take some copper wire and wind the coils. In the model we used 100 turns, coils should be wound in opposite direction every other time (see arrows in picture 14). Keep the wire tight as you wind it. The more turns and thicker wire you use, the more electricity you'll be able to generate. Leave some 20cm extra wire at both ends, you will have to tie these together with the wires attached to the upper and lower parts of the frame.



Picture 14: Finished stator half

Carving the blades

We carved the blades from 2" x 4" lumber. We used birch but lighter weight 'pines', such as white pine, fir, spruce and cedar are probably even better. Wood is good material for rotor blades. It's easy to work with using simple hand tools, it's inexpensive, has good strength/weight ratio and stands up to fatigue well. First saw three 65cm pieces; try to get the length as even as possible, as this is important for the balance. Other end, which will become the hub, should have the end cut to a 120 degree angle so that the blades will fit together. Blades should be narrower at the tip. Use a saw or a plane to do this. Trailing edge (which won't face the wind) can be cut in a straight line. Carve the shape in a seven degree angle. See the shape in the picture 16. Blades should have the thickest part at about one third from the leading edge (front of the blade). Thickness of the blade should be about one eighth of the width of the blade. Try to make the blades as identical as you can. See pictures in Appendix 1 for the measurements.



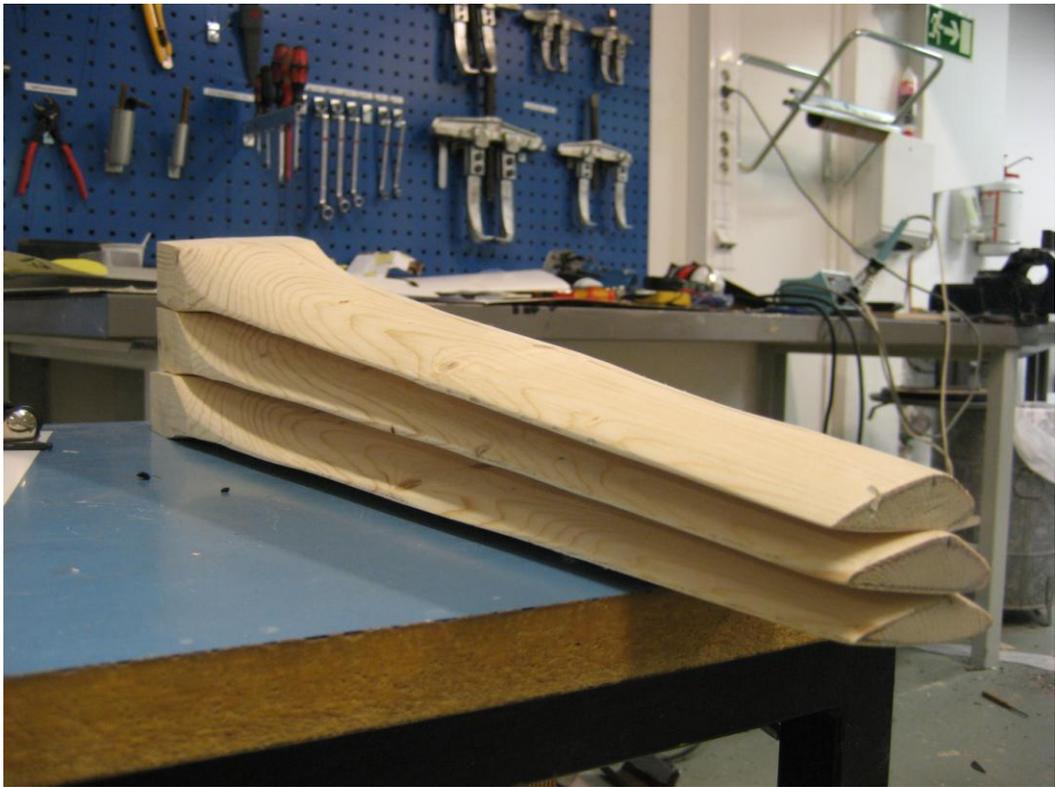
Picture 15: Blades were carved from lumber. We used birch



Picture 16: Draw knife is a good tool for carving



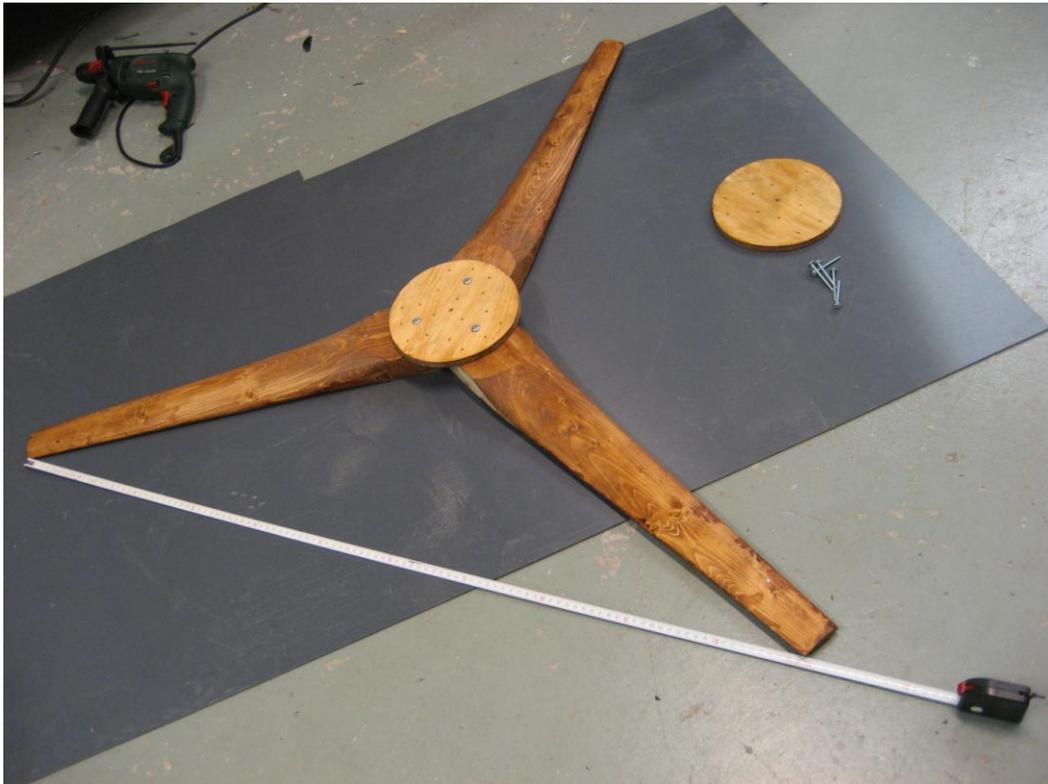
Picture 17: Shape of the blade can be seen here



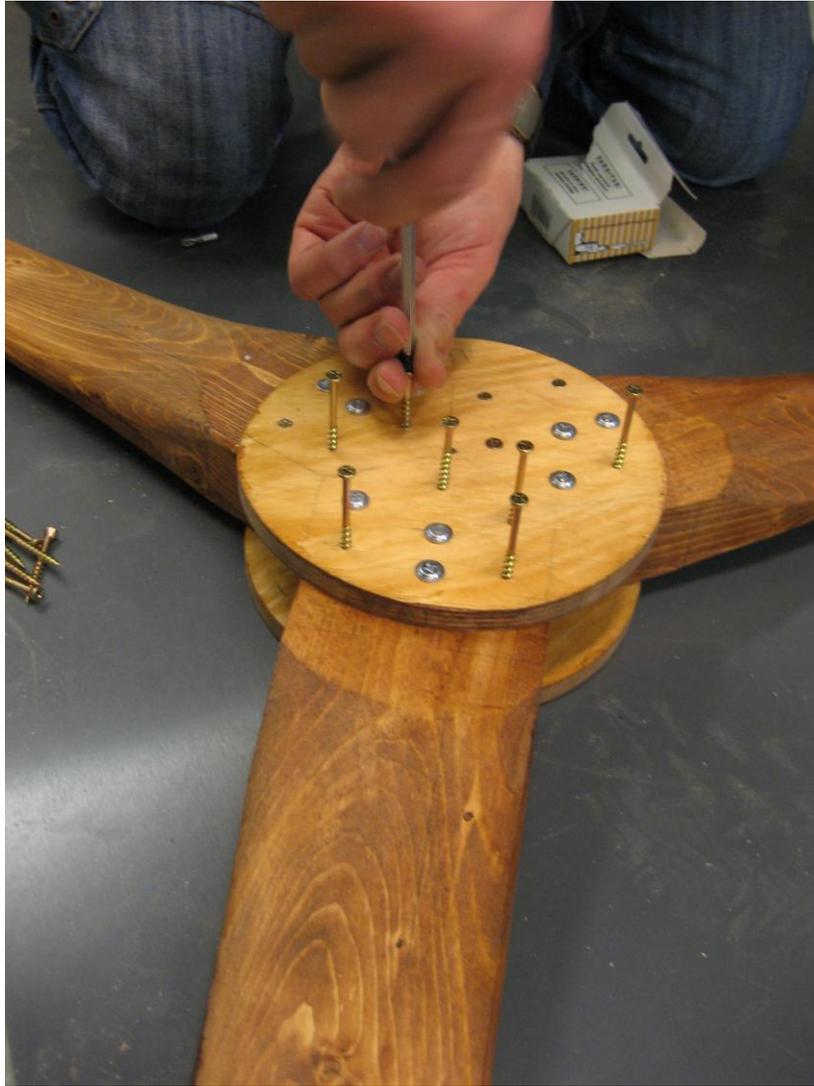
Picture 18: Finished blades

Assembly of rotor

Weight the blades; they should be about the same weight. Cut two round pieces from plywood, diameter should match the part of the blade which is not carved (diameter of 20cm). These will be used as the hub which keeps the blades together. It helps to drill a small hole to the center of the plywood pieces. When the blades are fit together, there should also be a small hole in the center. This makes centering and finding the balance easier. Put a nail through the hole and put the blades together. If the end of each blade is cut in 120 degree angle blades should fit together. Put one screw in through the plywood on each of the blades so that you can lift the rotor. Measure with gauge that the tips of the blades are about the same distance from each other. When you've found good balance, put the rest of the screws in place on both sides. We used 10 screws in the model, six on one side and four on the other which faces the wind. Drill a hole in the center of the rotor, use the same diameter drill bit as the thread bar. (We had 8mm). It's better to have a tight fit.



Picture 19: Measure the width between blade tips

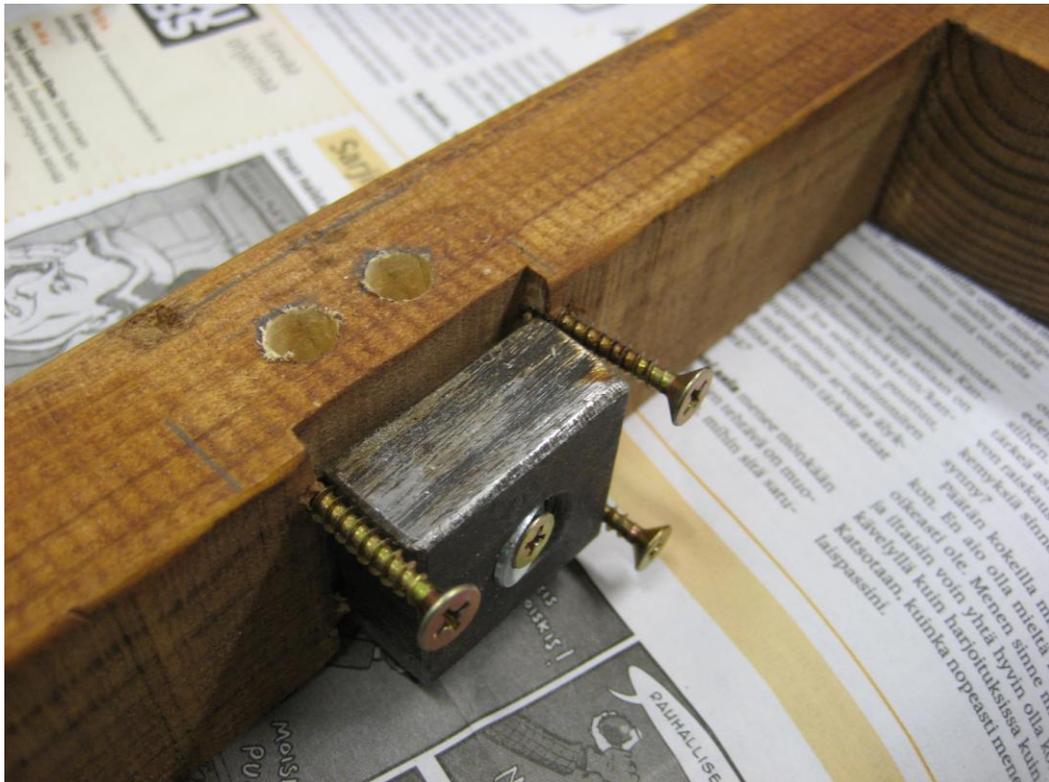


Picture 20: Assembling the rotor

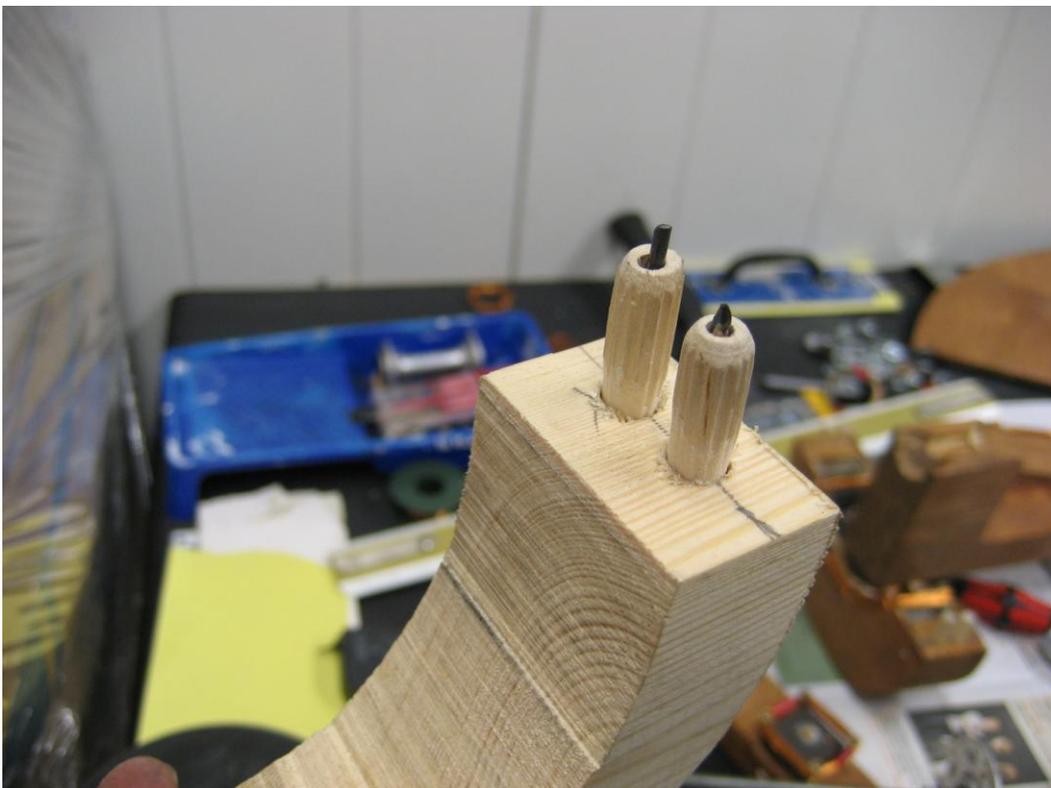
Assembly of the wind turbine

The model presented in this manual can be disassembled since it is not glued together. When one part breaks it can be replaced with a new one. However using glue would make the frame stronger.

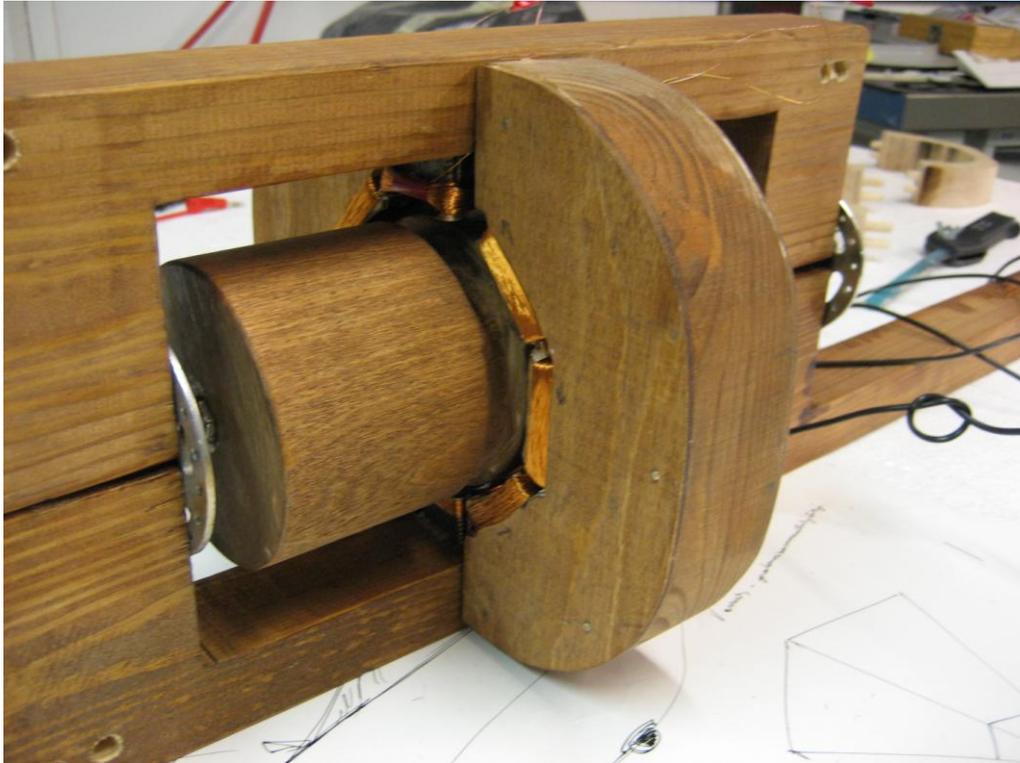
U shaped wood with coils need to be aligned with the magnets. This will be done using wooden plugs. Drill two 8mm holes on each side of the lower frame, upper frame and U shaped wood. Mark the places with a plug and a pen. This requires precision. Put four plugs on the U shaped wood, two on both ends. Then press the pieces to the frame. After this you can tie the ends of copper wire together. Every other loop should be wound in the opposite direction. Use electrical tape to secure the copper wire joints.



Picture 21: Assembling the frame



Picture 22: Pencil tips were used to mark the exact spot



Picture 23: Finished stator

First put the axis with cylindrical wood (with magnets) to the lower part of the frame. They should fit tightly. Then put the upper part of the frame on top of the lower one so that the cylindrical wood can spin freely. Then put the stator coil halves in place.

Put assembled rotor through the thread bar. Try to get the rotor as close to the frame as possible, so that the resonance of the rotating rotor will be small and won't break the wind turbine.

Yaw mechanism in our turbine is simple. Rudder will make the wind turbine face the wind. Turbine is mounted on a tower block inside which there is a bearing that is connected to an axle. Tower block is placed on top of suitable tower.

Wiring

All coils should have 100 turns, coils wound in alternating directions. You might need to scrape some lac off the end of the coils so that electricity can move freely. Attach the ends of coils and secure the joint with electrical tape. Leave two loose ends untied and tie them with two stronger wires. These will be attached to the device you might be using so it's better to have some extra wire. Secure joints with tape.

Painting

All parts were painted with Valtti kalusteöljy wood oil. Three layers will keep water from entering the wood (and it also gives a nice look).



Picture 24: Finished wind turbine



Picture 25

Conclusions and thoughts

The basic concept of the wind turbine was taken from a website with instructions on “how to make a 100 Watt wind turbine”. [1] We were able to generate electricity with our wind turbine but the amount was so small that it will not be useful without some improvements to the turbine. Increasing the swept area by using longer rotor blades is an obvious improvement, but this will also make rotor heavier and thus require a thicker axis. Our 8mm thread bar was barely thick enough to withstand the forces from 1,3m diameter rotor. Using permanent magnets instead of metal slabs will create a stronger magnetic field. Also the distance between magnets should be as small as possible. Enclosure made by copper wire should have a metal core; this would also increase the strength of the magnetic field and electricity output. The number of turns around the core also affects the electricity output, as do the permittivity of the copper wire and the surface area of the loop. Remember to make tight loops with copper wire. Choosing a good spot for the wind turbine is the most important single factor. As wind speed is doubled, generated power is multiplied by eight.

www.otherpower.com has excellent instructions for building a 2 kW wind turbine [2]. Work phases are clearly explained and the wind turbine construction is more compact than ours. However it is also more complicated and requires more expertise, more sophisticated tools and working methods. The cost of our wind turbine was about 50 Euros but the cost of 2 kW Wind turbine is about 1000 Euros. We didn't use glue in our wind turbine (except in axis) so it can be disassembled. However, using glue would make it the construction stronger, but we decided to include the option of taking it apart so the concept would be easier to explain. LED- light requires little electricity compared to the conventional light bulb and dozens of LEDs can be lit with our turbine in good wind conditions.

Wiring for the copper wire can be done in different ways. Wire can be wound simply in a series (single phase). This is easily done but the quality of electricity is not very good. Best option is to make a 3-phase alternator. This is basically the same as single phase with two extra coils slightly out of phase with the first. Better quality electricity will help in recharging the batteries but for our experiment we decided to use single phase electricity, which is good enough for experiment. See examples in www.otherpower.com [2, 3]

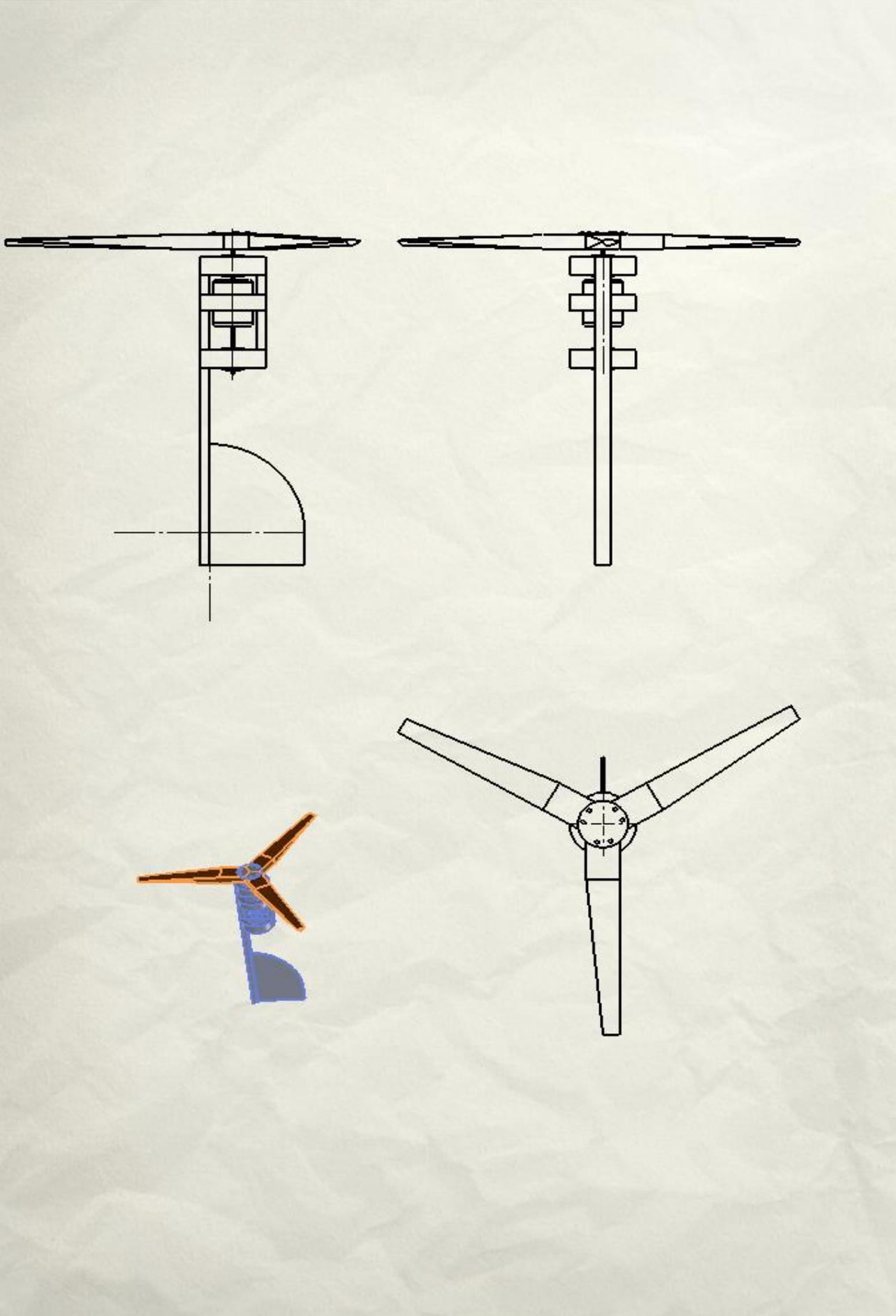
Wind turbines have a mechanism for shutting themselves down when wind speed is too high. This prevents breakdowns. When wind speed is too high rotor will rotate too fast and probably break. If wind turbine can't be removed from the site its rotor blades should turn to a position when wind can't break them. The tower must be high enough to minimize the turbulence caused by the ground and it must be strong enough to withstand high winds. Our wind turbine must be removed from the site during high winds as there is a chance of breakdown.

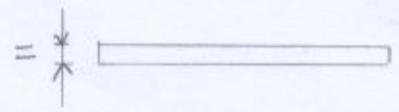
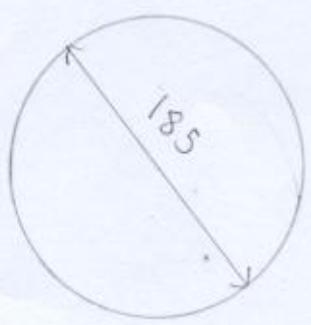
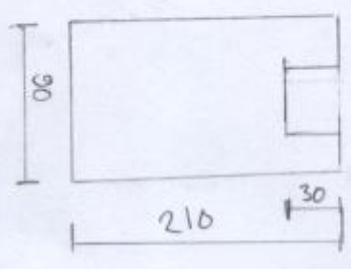
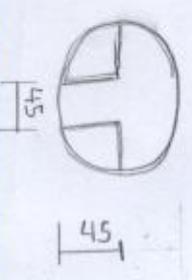
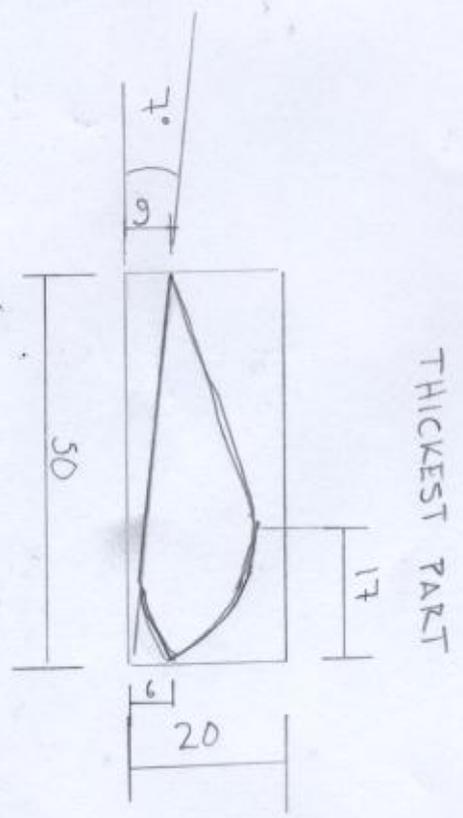
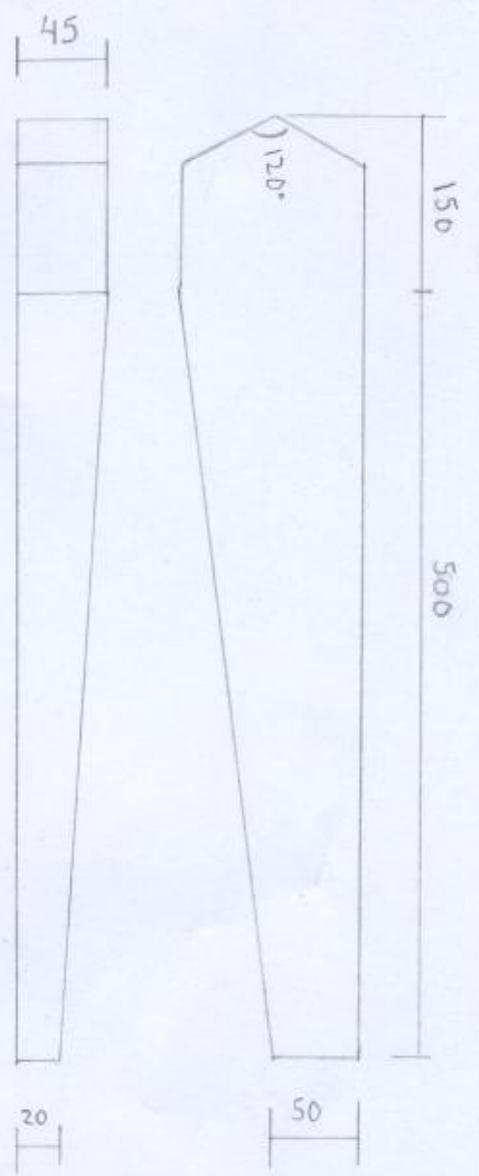
www.windpower.org offers a good and very informative guided tour where one can get acquainted with wind power. Most of the theory can be found there and it's well explained. [4]

REFERENCES

- [1] How to make a 100 Watt wind turbine <http://rinf.com/alt-news/activism/how-to-make-a-100-watt-wind-turbine%E2%80%8F/2152/>
- [2] Homebrew 10' Wind Turbine construction <http://otherpower.com/turbineplans.html>
- [3] 3 phase basics http://www.windstuffnow.com/main/3_phase_basics.htm
- [4] www.windpower.org

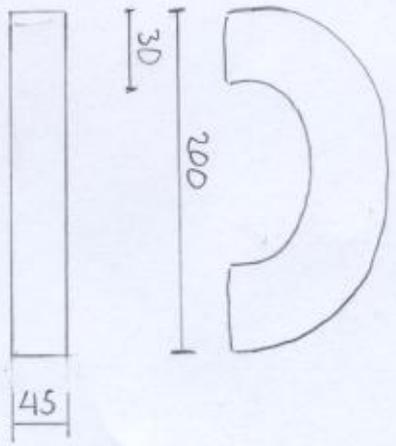
Appendix 1



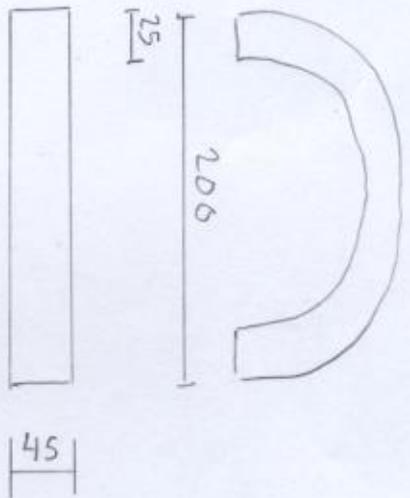


plywood

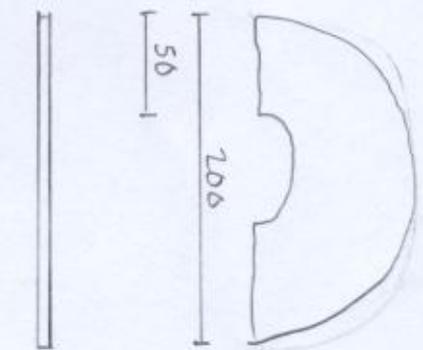
lumber



lumber



plywood



3

