

## **FuturEnergy Wind Turbines**



**Install and operate your own small scale Wind Turbine**

**Incorporates New, unique Permanent Magnet Generator**

**Maximum power on a minimum budget**

## Introduction

With the rapid increase in interest surrounding renewable energy over recent years, we have produced a range of small scale wind turbines for home/work purposes, suitable for many applications. It struck us that most DIY wind turbine kits rely on the user carving their own blades, or winding their own generators, and this simply puts most people off. We realise that not every DIY enthusiast has access to welding equipment or other specialized gear required to fabricate the parts normally associated with making a successful and reliable wind turbine. It is for these reasons that we have developed these turbines.

Weighing in at only 22 kilos our turbines are tower-top ready, and will fit on to a standard 50mm steel tube pole. We don't recommend 'building-mounted' installations other than steel-framed buildings. The neatest solution uses a guy-less free standing tower which can be lowered easily by tilting for maintenance purposes.

This manual covers all aspects of installing a FuturEnergy small-scale turbine, capable of producing up to 1000W in 12.5m/s wind speeds, and assumes a reasonable level of DIY competency in its instructions. We have provided details of how to install all the parts necessary to build your turbine tower, and have assumed that the DIY builder will have access to a range of standard hand tools, including spanners and screwdrivers.

Several of the parts described in this manual can be connected in different ways, and using different products to those suggested. We have done this to allow the constructor to utilise products that they may have available to them already, and this is what makes our designs so versatile, yet simple.

By following these instructions, you should be able to commission your FuturEnergy turbine in less than two days. All FuturEnergy turbines are based on a completely new and unique range of Permanent Magnet Generators, developed in the UK, and set to become a new standard in small scale wind power generation for the years ahead.

We recommend that you read this guide in its entirety prior to embarking on any construction. You should familiarise yourself with each stage of construction, and be fully aware of any warnings or risks that may be involved throughout.

Should you have suggestions on how we could improve these instructions for future installations, please contact us at [technical@FuturEnergy.co.uk](mailto:technical@FuturEnergy.co.uk) where we will be happy to receive them.

## Warnings and Safety Notices

Wind turbines should be considered as a serious piece of engineering machinery, and as such, should be treated with extreme care and respect when constructing, maintaining and operating them. The turbine blades themselves are sharp, flexible and generally unbreakable, and can cause serious personal injury. The power generated from these wind turbines can inflict electric shock, burning and serious personal injury, and as such you should treat all electrical parts as potentially lethal, as you would with 'mains' electricity found in your house/work.

Children should not be allowed to 'play' with these turbines, since serious personal injury and even death could occur. Some parts are heavy, and are mounted high in the air where they pose the potential of becoming a 'falling hazard' in fault conditions or in high winds, and as such, every effort should be made to keep a safe area free from people, animals, buildings and vehicles around your turbine at all times.

You will be required to maintain your turbine, and will have to carry out periodic repairs on it. As a result, this will mean tilting your tower down to ground level on occasions, which should be carried out with the assistance of at least two other fit and able people. Your turbine should NEVER be run without a load connected to it. This could result in the blades breaking, your tower collapsing, bearings being destroyed prematurely, electrocution, personal injury and even death. Turbines require a 'load' to be present to operate within their safe limitations, and the importance of this cannot be overstressed.

FuturEnergy Ltd accepts no responsibility or liability in any form whatsoever, either directly or indirectly, as a result of your use of their turbines. Since we have no control over what you 'the constructor' does when carrying out the instructions described in this guide, we cannot, and will not, be held responsible of any losses, damage to persons or property, injury to persons or animals, or any consequential losses occurring from your use of these instructions.

All material, graphics and text are the copyright of FuturEnergy Ltd, and the use of this guide is based solely on the understanding that you will not attempt to sell in part or in whole any aspect of it to any third parties or businesses, and that you agree to use it for your own personal use only. It should be understood that any breach of our copyright will result in action intended to recover any lost costs, business and reputation, as a result of these terms and conditions being breached in part or whole.

On a lighter note, we do hope that our turbine, and this guide, will help you to begin to enjoy the benefits of joining all those who have embarked on their renewable energy journey, and that you find it both useful and informative.

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## The Tower Base

Your turbine will produce more power the higher it is mounted in the air. In practical terms, this means positioning your tower in an elevated site, clear of obstacles and buildings, to a height which is most practical in your circumstances. When choosing a site, you should be conscious that your turbine will produce noise, which will increase in level with wind speed, which may be audible by either yourself or your neighbours. We suggest that you choose the correct tower to suit your particular site.

To find the site that best suits your turbine, you must consider the space around your tower. The guyed tower kits will have to tilt up into position, and will therefore have to tilt down to allow you to carry out maintenance of the turbine itself. In practical terms, you should leave a space around your tower base equal or greater than 1.5 times the tower height. For a 7.5m tower kit, this would represent a space of  $7.5 \times 1.5 = 11.25\text{m}$  around its base. Clearly not everyone has this area of spare space to utilise in this way, so it is important to create enough space to allow the tower to tilt down without any risk to other buildings or people.

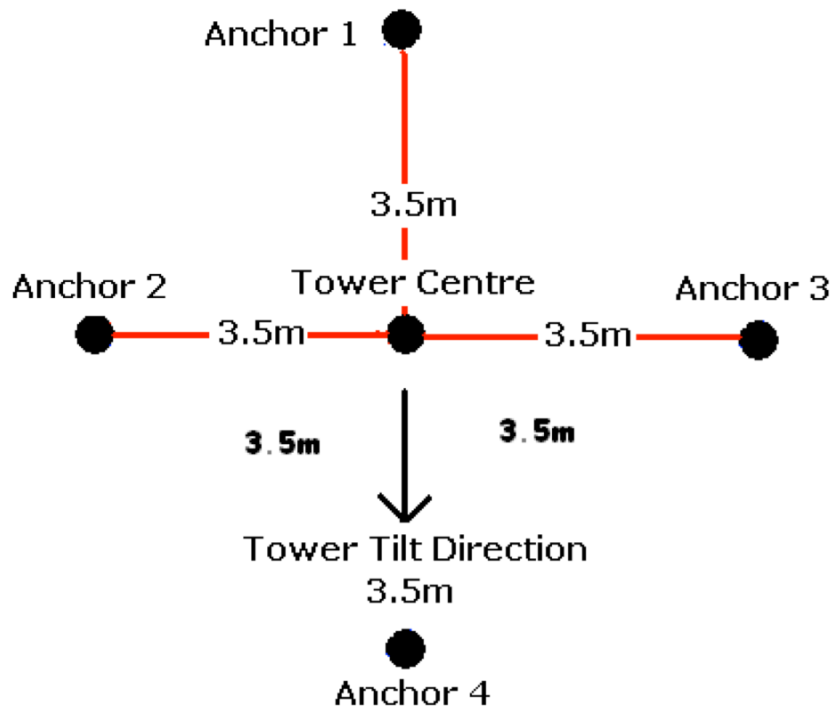
The ideal site for your tower will be on an elevated piece of land, free from trees and buildings, and in an area which satisfies the safe zone mentioned above. Don't position your tower next to a building, or where it will be shielded in any way from the prevailing wind. If in any doubt that your site doesn't have enough wind for a turbine, consider buying an anemometer before installation.

Once you have located the ideal position for your tower, you must prepare the ground for mounting the base, and guy anchor points. Level the ground where possible to make positioning and measurements simpler. Place markers in the positions described overleaf in **Figure 1** to determine where the tower centre and 4 guy anchors will be. Starting in the centre, position a marker to indicate the centre of the tower. Bear in mind the direction that the tower will tilt in order to correctly position the anchor points. Measure 3.5m from the tower centre point to anchor point 1 and place a marker. Measure 3.5m from the tower centre and position the markers for anchor points 2,3 & 4. In order to ensure that the anchor points form a square, measure from anchor point 1 to 2, and compare this measurement to the distance between points 1 & 3, as shown in **Figure 1**. These distances should be equal, at 4.95m. Repeat this process with measurements from points 2 & 4, and 3 & 4, which should also measure 4.95m. This process may take you some time, and can often get frustrating, but is worth while spending the time on, which will make future aspects of the construction simpler.

If you have more space, you can position the anchor points further away from your tower base centre point. Bear in mind that your tower kit comes with 4 lengths of 6mm galvanised steel rope, for use as guy wires, and you should check what length these are before positioning the anchor positions. This will ensure that you have enough steel rope to make the guy connections.

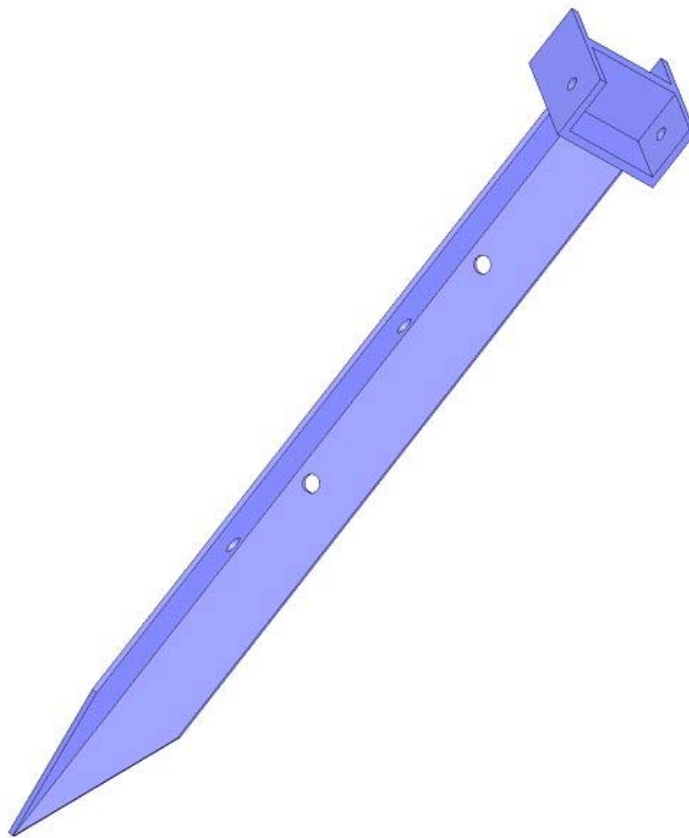
## Positioning the Tower & Guy Anchors

Figure 1



## The Tower Base (installation)

The tower base will be one of two types depending on which tower kit you have purchased. The guyed tower base will be in the form of a heavy steel ground “spike”, while the self-supporting tower base will be a large flat steel plate with reinforcing bars attached to its bottom face. The guyed tower base should be driven into the ground using a heavy “mash” hammer, until its top face is flush with the surrounding ground. Take care to ensure that the tower tilting direction has been noted, such that the tower base is facing the correct direction. This can be achieved by noting the position of the large 15mm hole in the tower base. This side of the base should point in the direction of the tower tilt. The picture below shows what the tower base for a guyed tower looks like. It is 1m long and is constructed of very heavy grade galvanised steel.



If your ground is not sufficiently compacted or dense enough to properly secure the tower base, you should concrete it into position. To do this, your kit is supplied with reinforcing bars which should be fitted through the holes in the “angled section” of the tower base. Dig a hole approximately 750cm deep and 40cm square, leaving the side walls of it in a “rough” state. Insert the tower base into the hole, and hammer it into the ground at the bottom of the hole to secure it in place during the curing process. Mix and pour a concrete mix containing both sand and chips into the hole, and allow it to cure for at least 5 days. The reinforcing bars will prevent the tower base from lifting out of the foundations. For a self-supporting tower, the base needs to be mounted in one cubic meter of C50 concrete mix, and should be left for 2 weeks before use. This will normally require a small “digger” to be used in the foundation preparation.

## **Positioning the Tower Base**

Once you've installed your tower base, and the concrete has cured (if using the concrete method) you are now ready to prepare the tower itself.

Your base is now ready to mount the tower to it. For a guyed tower, the "base tube" section is the one with the 15mm hole at one end. This hole will form the main pivot point for the tower. With the base tube aligned with the tower base, fit the 15mm long bolt through the base, and base tube, until a "tilting hinge" has been created. Attach and tighten the 15mm nyloc nut to the 15mm bolt until it is tight. The tower must be able to tilt up and down with relative ease, so don't over tighten this nut/bolt.

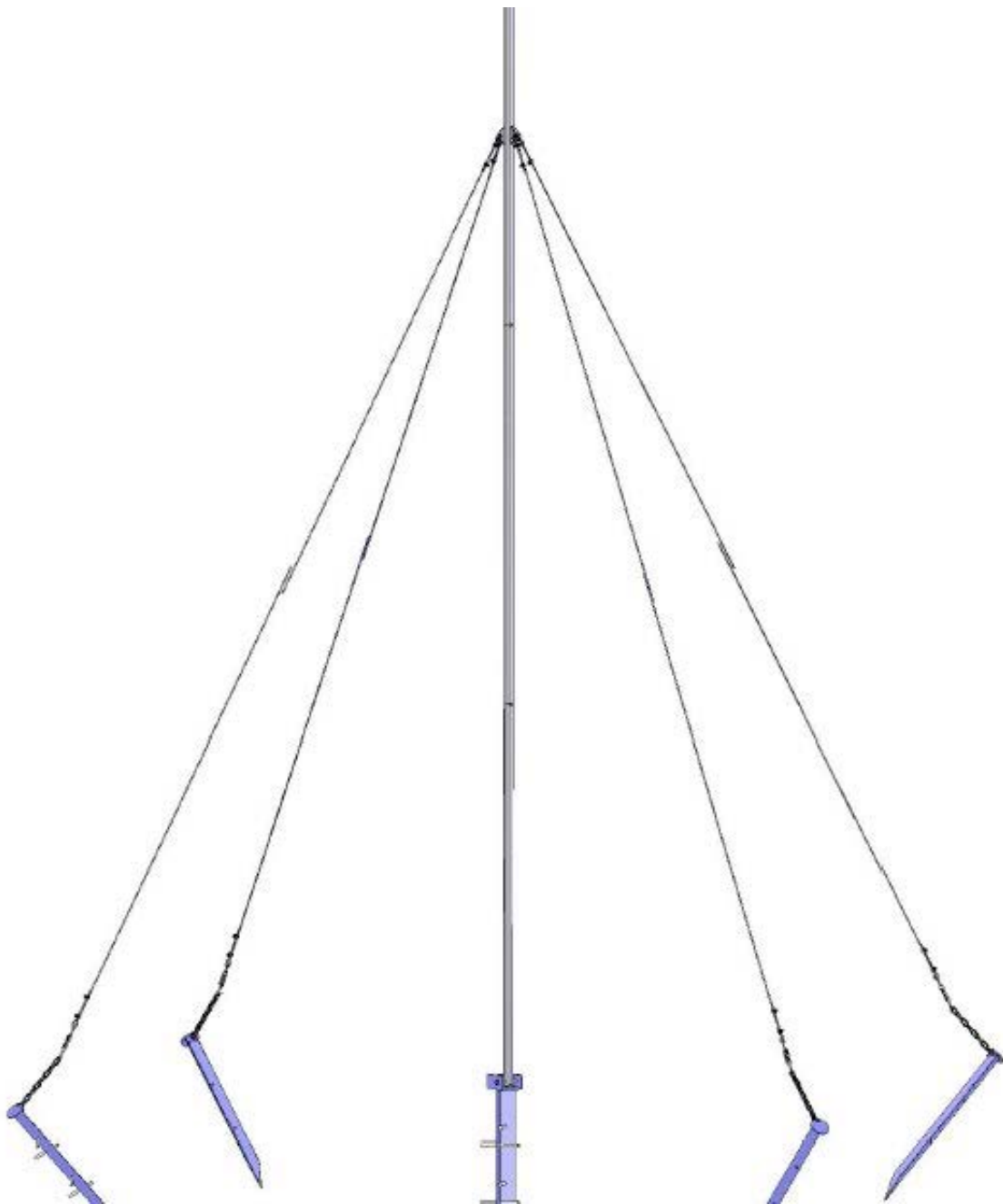
You can now attach the rest of the tower tubes together, using the joining pieces supplied, such that the top tube is the one with the 4 "lugs" attached to it. Follow the instructions supplied with the tower to ensure that all joints are secure and will not "rattle" when the tower is in use.

The tower is now assembled, but before you are able to erect it for the first time, you need to prepare the guy anchor points for connection to the guy wires.

## The Guy Anchors

In order to keep your tower upright in all wind conditions, it is vitally important to provide very secure anchor points for the guy wires to attach to. The instructions supplied with your tower kit will explain in full detail what preparation steps you should carry out prior to erecting your tower.

In summary, the guy anchors should be driven into the ground in the positions shown in Figure 1 earlier, with the “open” side of the angled steel facing towards the centre of the tower base. When driving these into position, they should be inserted into the ground at an angle of 45 degrees. The image below shows the position of the tower anchors in relation to the tower base.

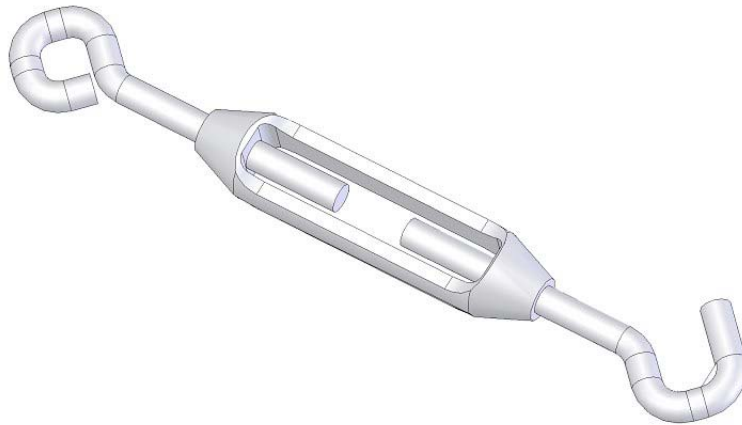


## The Guy Wires

Your tower will only stand upright if it is guy wired to the anchor points which you've now put into position around the tower base. Your tower kit will include all the parts required to make the guy wire assemblies. Follow the instructions to make and attach each guy wire to the top tower section of your tower. Ensure that all nuts, bolts and clamps are fully tightened as described in the instructions.

Your assembled guy wires should now be fitted with the guy tensioning devices, which will allow you to secure your guy wires to the guy anchor points that you have installed. Heavy chain lengths have been included in your kit to allow you to connect your tensioning device to the guy anchors with ease, and will give you some extra latitude when assembling the guy wires (when judging how long to make the guy wire assemblies).

The tensioning device is shown below.



## The Guy Wires : Final Fixing

Now that your tower is ready to be tilted up into position, you will need to adopt the services of at least one other individual. Before tilting your tower up for the first time, make sure that everyone giving you a helping hand understands their role in this process.

Connect the 2 guy wires in positions 2 & 3 as shown in Figure 1 previously. Do not tighten the turnbuckle tensioning devices at this stage. Starting from the end of the tower, furthest from the centre anchor, lift the tower and 'walk' it up till it is fully upright. You should find this fairly straightforward, since there's no heavy weight (no turbine generator) in position at the top of the tower. Once upright, connect the guy rope closest to position 1 (Figure 1), then connect the guy rope to anchor 4. With all guy ropes now attached, the tower will stand upright on its own, but will be "wobbly" at this stage.

In no particular order, begin to tighten the turnbuckles until all 4 guy wires are tight. Adjust each turnbuckle until the tower is vertical. You might like to use a "plumb line" to carry out this part, which you'd need to attach to one of the top guy mounting "lugs" on the top tower section. The plumb line will then hang vertically, and as such, this will give you something to use as a reference when adjusting the turnbuckles. Do not use any spanners or other mechanical assistance to tighten the turnbuckles, since this will result in you over-tightening the guy wires. Use only your hand strength to tighten the guy wires. Once all wires are tight, follow the instructions to "cable tie" or "wire wrap" 3 of the turnbuckles to the anchor chains. Leave only the turnbuckle at position 1 with no permanent securing to the anchor chains.

Your tower can now be lifted and lowered with ease. To do this, simply slacken and disconnect the turnbuckle at position 1 and lower the tower by "walking" it down to ground level. If your tower is taller than 7.5m, you will require the use of a "winch" to safely lower your tower to the ground, and erect it again. Ensure that any winch you use is of the type that cannot "run backwards", which would result in the tower collapsing. A "chain winch" or "tirfor winch" is ideal for this job. Use the ground anchor at position 1 to secure the winch to the ground before disconnecting the turnbuckle from this anchor point, otherwise your tower could rapidly fall to the ground before you get the chance to connect the winch.

As your tower lowers to the ground, the strain on your winch will become very great indeed, and you will require a winch which is able to lift and lower up to 1.5tonnes. Do not use a boat winch, since these are designed for pulling only, and cannot be used safely for lowering a turbine to the ground. To minimise the strain on your winch, it is suggested that you lower the tower on to a "tripod" or "workbench", positioned around 2m from the end of the tower, such that the turbine blades stay clear of the ground when the tower is lowered. This practice will mean that when you decide to winch the tower back up into position, the tower is already sitting at an angle to the ground, thus minimising the strain on the winch during the initial lifting of the tower and turbine.

Should your tower fall, it is vital that nobody is standing under where it will land, as it will probably be travelling at 30+ mph by the time it hits the ground. This would cause serious injury and could result in death. Don't underestimate the energy stored in a turbine tower, and never take unnecessary risks when working with them.

You will now have successfully constructed your tower, and will be ready to mount your turbine to it.

## The Turbine

The main decisions at this stage will be based on what you intend to use your free power for. If you wish to charge 12V battery banks then you would ideally like a turbine that produces a good output at 12V, and similarly you'd want to do the same for 24V and 48V battery banks. At present, there are 3 different turbine models available in the range that make ideal power houses for small scale applications. These turbines are of a new and unique design, and do not incorporate the 'alternator' style of generators normally associated with small DIY turbines. As a result, our turbines don't require to rotate at very high speeds in order to generate power. We see this as an advantage, both in noise reduction, and general bearing wear.

The Wind Turbines in the range are:-

- FE1012. Available from FuturEnergy Ltd, and capable of producing 600W in 12.5m/s winds into 12V battery banks.
- FE1024. Available from FuturEnergy Ltd, and capable of producing 1000W in 12.5m/s winds into 24V battery banks.
- FE1048. Available from FuturEnergy Ltd, and capable of producing 1000W in 12.5m/s winds into 48V battery banks.

All 3 turbines include low RPM 3-Phase Brushless Permanent Magnet Generators and produce their rated output at a much lower rotational speed than alternator style generators. These PMG's have been designed specifically for the turbines described in this guide, and have been extensively tested by us, in order that we can produce realistic operational data for them. The range of PMG's currently available is set to increase, to include larger power output versions at a later date, and we will bring you the best performance PMG's for future turbine designs.

All turbines are supplied part-built from FuturEnergy, and so, you will only have minor assembling to do. The FE Turbine ranges are supplied with an integrated tail-fin as part of their generator mount. The entire turbine mount is powder coated, and comes pre-assembled in the model of your choice, complete with 3-Phase Bridge Rectifier installed and wired. The FE Turbines are being constantly improved, and the accessories available for them are being extended as time progresses. Please visit [www.FuturEnergy.co.uk](http://www.FuturEnergy.co.uk) to keep abreast of the latest developments.

## FE10xx Wind Turbine Assembly



All Turbines will come partly assembled, leaving you to simply assemble and attach the hub and blades. All other parts will be pre-assembled, minimizing the construction you'll have to carry out. No painting of any part is required with these turbines.

Comprehensive assembly instructions are supplied with all turbines, and you should find them easy to follow. Should you require any further assistance when you receive your turbine, please contact FuturEnergy.

## The Blades

We have carried out extensive testing of the set of blades supplied with your Turbine. These blade sets come in multiples of 5 and are manufactured from Glass Filled Polyamide (PAG), and have been designed specifically for small scale turbines. These are available separately, should you wish to use them for your own turbine design. The blades are supplied with a 5-blade hub which is anodized in black, and is very durable. Assembly of the hub and blades requires the user to insert a small “pitch pin” into the root of each blade, then positioning all 5 blades into one half of the hub, and finally placing the other half of the hub to mate with the assembly. All 6mm nuts and bolts are supplied to finalise this assembly. Screws should be tightened using a torque wrench, to 8 Nm. A gap between the hub plates is normal, care should be taken not to over-tighten the screws. Screws should be tightened in the sequence described in the assembly instructions provided.

The completed rotor should be balanced by means of a ‘static balance’ by the user. Weights (washers) can be added to the securing bolts to achieve a good balance. Ensure that the complete rotor is fully balanced before attaching it to the turbine generator. Balancing instructions and a “balancing aid” is also supplied with each turbine.



## Turbine Assembly

All FE10xx turbines can be purchased from [www.FuturEnergy.co.uk](http://www.FuturEnergy.co.uk) (01789 450280) and come complete with anodized adapter plate, PMG, motor mount, tail fin and 3-Phase Bridge Rectifier, all pre manufactured and assembled. When you receive your Turbine, it will include instructions showing you how to assemble and attach the blades and hub to the anodized PMG adapter. Take care to ensure that each blade is mounted as shown in the included instructions.

The Turbine assembly fits over, and is secured to, the top end of the turbine tower and is free to rotate around it when the wind changes direction. Before you fit the turbine to the top of your tower you will need to connect power cables down the tower tube to its base, where you will have access to the power for battery charging etc. The cable to be used for this purpose should be at least 10sq mm cross sectional area, and be made of copper. The cable used to pass the power down your tower should be as thick and flexible as possible, and Halfords sell a range of such cabling, normally used with high powered in-car hi-fi systems. You will also find cable of a similar type in most car accessory specialist stores throughout the UK. You will require at least 2 lengths of 14m of this cable, preferably in two different colours (red and black ideally) such that you can tell which connection is positive (red) and which is negative (black). Halfords also sell various cable crimps and rings, which you may find useful when making connection to the batteries etc. Battery terminal posts are also available from Halfords, and these will also be required to make connection to your battery banks etc.

Tape the two 14m lengths of power cable side by side using insulating tape (or duck tape) at intervals of 50cm or so, to form one 14m length of double cable. Pass this cable down the scaffold tube from the generator end, and make electrical connection to the turbine in accordance with the instructions supplied with your kit. If you have difficulty in passing the power cables down the scaffold tube, then you should attach a weight to some string and drop this down the scaffolding tower to give you a 'pull through' to attach the power cables to. The power cables should be anchored securely to the supplied generator power cables to prevent them from coming loose, or rotating when the turbine changes direction. Connecting and anchoring the power cables is described in the kit instructions.

All turbine models now include 'slip rings' in their design, to enhance the performance in 'changeable' wind directions. The turbine will rotate around 360 degrees if required to do so by the wind, and this would normally put a twist in the heavy power cables inside the tower tube. The inclusion of the slip rings prevents this from happening. As long as the power cables are secured properly at the top and bottom of the tower, then they should remain in good condition for the life of the turbine.

The ends of the two power cables, emerging from your tower base, should be stripped and terminated in terminal clamps to suit your battery bank. It is vital that you connect the positive power output of the turbine to the positive of the battery bank, and the negative to the negative battery connection. If you accidentally connect the power cables round the wrong way, then massive currents will flow up your tower, through the 3-Phase Bridge Rectifier and through the three windings of the 3-Phase Generator. These currents will blow the weakest link in the electrical circuit, which could include the rectifier, or even the generator itself, rendering your turbine useless.

It is for this reason that we suggest placing a 50A fuse in series with the positive connection to the battery bank, which will blow if a fault occurs, and will protect the generator and associated electrical components.

With all connections made, you are almost ready to start using your turbine for the first time. What you must now consider is what you intend to use your free power for. In most cases you will want to store the energy produced by your turbine in batteries, so we'll now look at how this can be carried out.

## Battery Charging

You may intend to use your turbine to produce power for outbuildings, your home, or to operate garden lighting or water features. Whatever your intended application you will almost certainly require to store the power from your turbine in a battery bank of some sort. Advice can be given as to the best selection of batteries for your application from FuturEnergy Ltd or from a wealth of websites containing this information.

As a general rule, the larger the battery bank, the more power you will be able to store from your turbine, and you should select the correct capacity and type of batteries to be used with your setup, after consultation. With small turbines, it is sometimes not required that you incorporate any form of charge control device to take care of your batteries. An example of this would be if you had a very high capacity battery bank, where the chances of overcharging them is much smaller than if the bank capacity was much lower. In general, however, it is always advisable to incorporate some form of charge control device into your setup.

A charge controller does what its name suggests, in that it controls the level of charge passing into your battery bank, and protects the batteries from both overcharge and over discharge. Protecting your batteries in this way is vital for the long term life of them, and the correct selection of charge controller is very important.

Powering other devices from your battery bank can be very straight forward, depending on what you would like to power. For example, you could power low voltage lighting in outbuildings from a 12V system, using 12V halogen lights from your local B&Q or DIY store. The thickness of the cabling required to do this will depend on how far your battery bank is from your outbuildings, and as a general rule, you should use as thick a cable as you can for any low voltage power applications.

If you wish to run 'mains' powered applications from your battery bank, then you should consider the following. There are several very cost effective mains inverters available from internet and shop stores across the world, and you could, for example, operate your house lights and a low power ring main circuit in a power cut using a 500W to 1kW modified sine wave inverter. These inverters are very efficient, and produce power that is suitable for running most household appliances. Some appliances, like TV's and Hi-Fi's may make a strange sound from their speakers and power supplies, but most should operate well despite this. Fluorescent lights tend to give a noticeable flicker when running from a modified sine wave inverter, but they will still operate. The only thing you'll find difficult to power will be your kettle, your electric cooker and an electric shower, which simply require too much power to be run from a small inverter of this type. You should always consult an electrical expert before attempting any connection to an existing 'mains' circuit.

We would suggest that a low powered inverter (300W or so) be used to supply lighting to outbuildings, since this will involve running normal 1.5mm twin and earth cable to your buildings, and using standard incandescent lights and mains switches for the wiring. This saves you running thick, heavy and expensive low voltage cables over any significant distance.

Should you wish to use your turbine to give you hot water for household use, or to provide a supplement to an existing heating system then you will not need to invest in inverters. If you have an immersion heater for example, then you can change the heater coil for a low

voltage one, usually 48V, which will allow you to connect your turbine output directly to a battery bank, and then via a load controller to the element. Since immersion heaters are fitted with thermostats, there is no need to control the power going to them, since they will switch in and out of circuit as and when required. The only problem that this can introduce is that there may be times where your turbine is running 'off load' which can cause it to over-speed and become very noisy in severe wind conditions. To avoid this, you should consider connecting the output of your turbine to an automatic power switch such that if the immersion heater no longer requires power, the power is diverted to another load. This will keep your turbine under continuous load, and will prevent it from being able to run at excessive speeds.

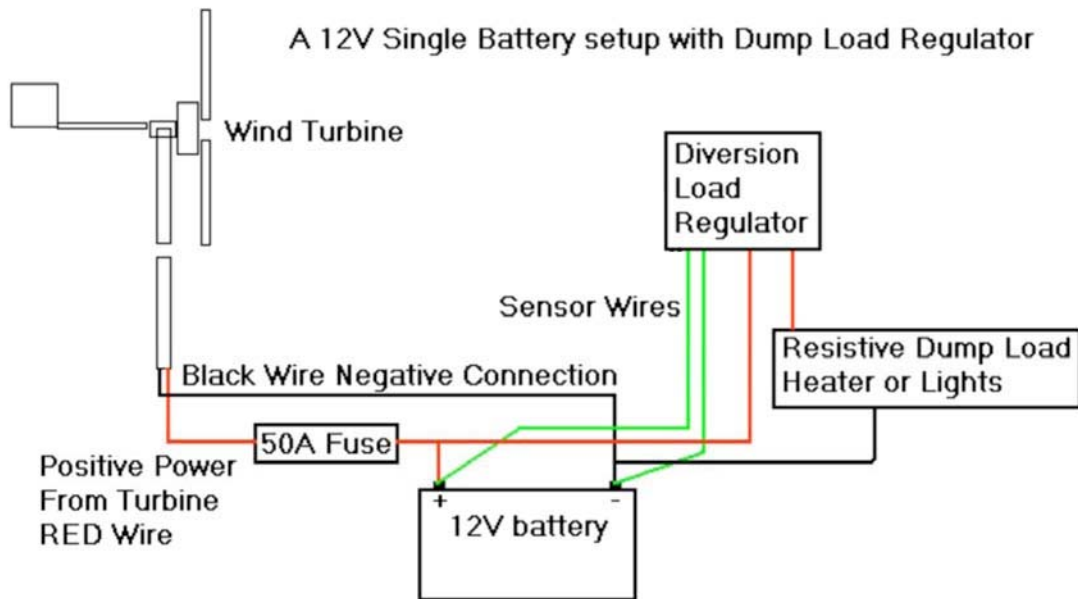
An alternative use for your free power could be to heat an outbuilding or part of your house. This can be achieved by purchasing a resistive 'dump load' from any one of the many internet renewable energy companies across the planet. The dump load is simply a resistor housed in a suitable housing to allow its heat to be dispersed into the surrounding atmosphere. These loads can be connected via a battery bank and load controller, in a similar way to that of the immersion heater mentioned earlier. It's usual for your house to lose heat more in higher winds, so this solution can compensate somewhat to those extra losses.

Should you opt to store the turbine output in a battery bank, then you should consider using Deep Cycle batteries, or better still, Deep Cycle Gel batteries, which can be recharged over 1000 times (up to 1500 times). Under no circumstances should you consider using Car Batteries as storage devices, they are simply not designed for this kind of application.

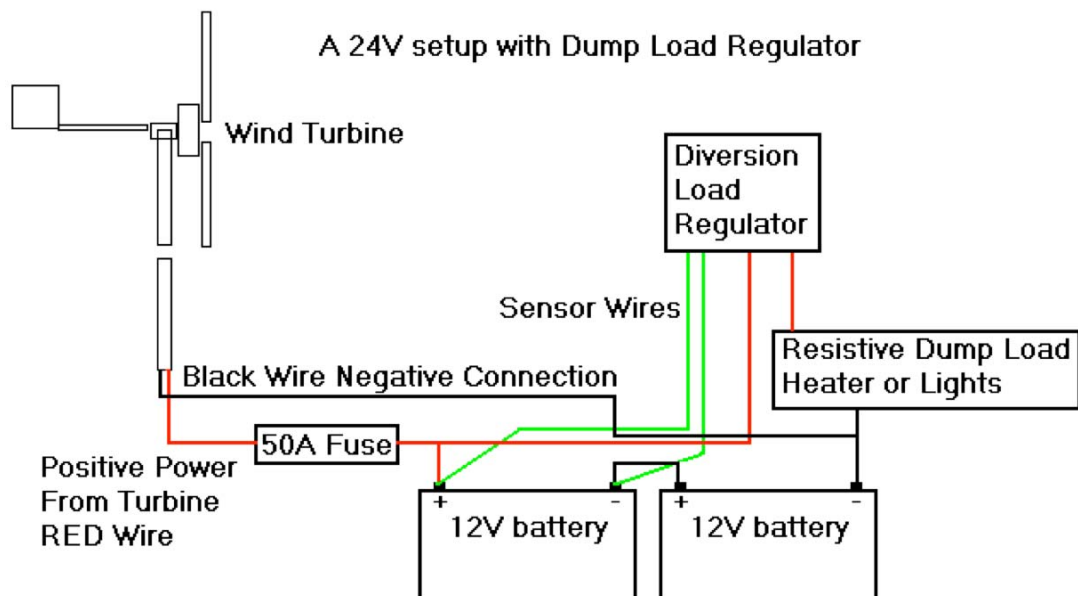
You should house all your batteries and all associated electrical and measurement devices in a suitable weatherproof housing near the base of your turbine tower. This will keep your cable runs as short as possible, and thus your losses will be kept to a minimum. The housing should be vented to allow any excess gasses to escape from your batteries, should they produce any.

Please note that in all battery based systems, you should not discharge your batteries below 50% capacity at any time. This will result in your batteries not being able to be fully charged again, which will result in them becoming defective over time. When using an inverter with your batteries, it should switch itself off when the battery voltage drops to 11V per battery (or equivalent). Most modern inverters do this automatically, but other loads may not, so please be aware of the battery voltage and charge state at all times.

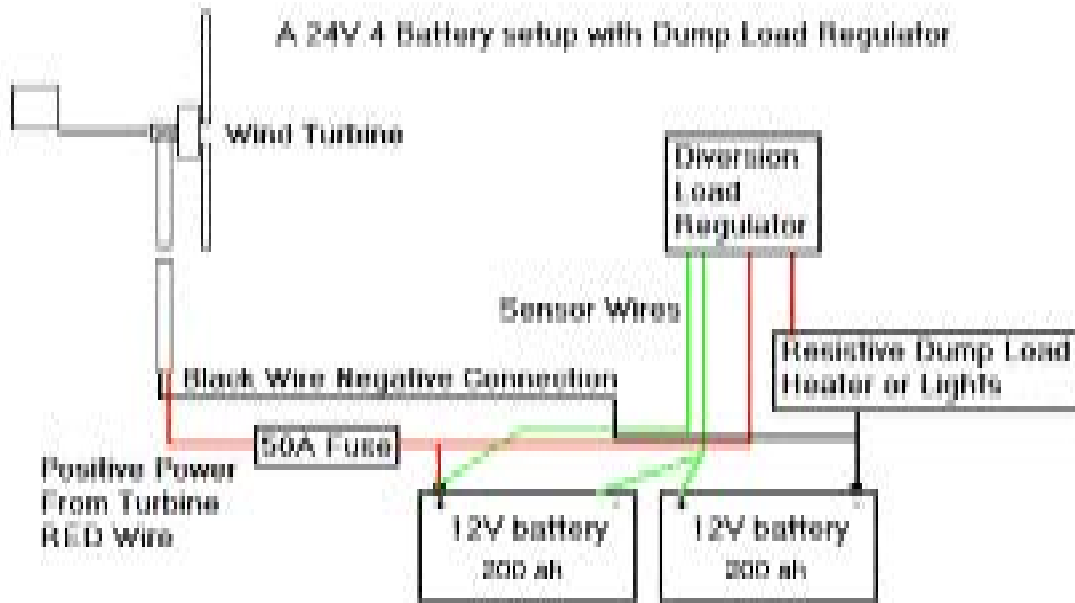
The following diagrams show some of the different ways to connect your batteries together to form banks of batteries for voltages ranging from 12V to 48V. Also shown is a charge controller, and how it should be connected. Use a Xantrex C60 for 12V and 24V applications, and a Xantrex C40 for all 48V applications.



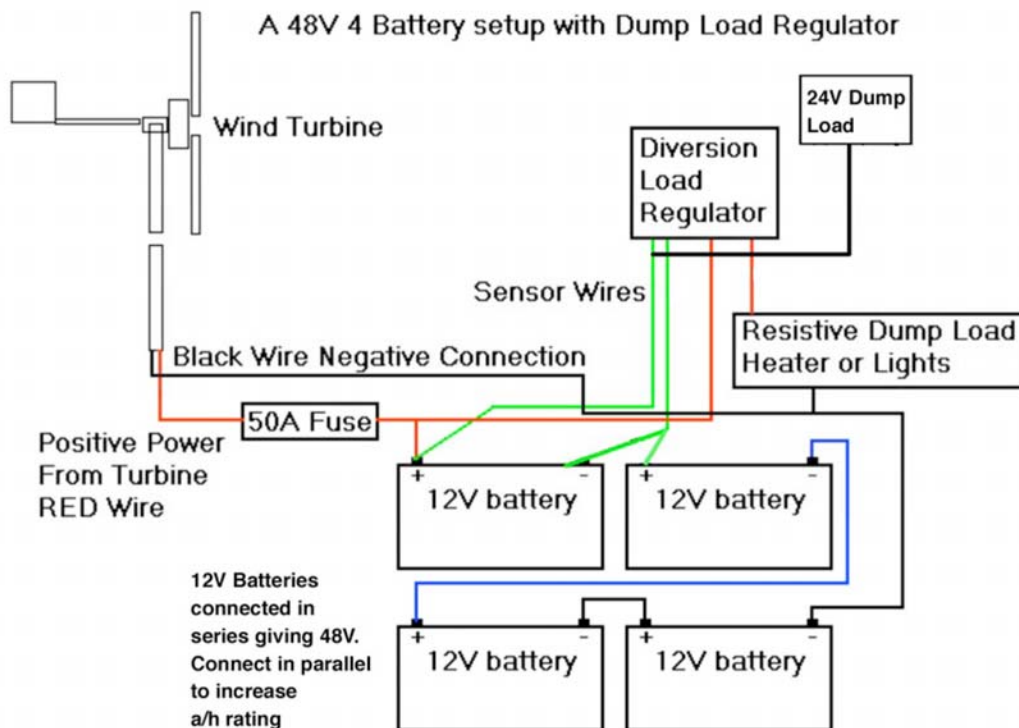
This 12V setup uses just one 12V Battery to provide power storage from your turbine. It incorporates one of the simplest charge control devices, called a diversion load (or dump load) regulator (the Xantrex C60). The regulator will keep your battery at a voltage between 12 and 15V, and any attempt to overcharge it will result in the extra power being diverted to the dump load for consumption. In practice, the dump load could be an air heater, a water heater, or simply a bank of 12V lights.



This setup uses two 12V batteries to form a 24V system, and again uses a dump load regulator to control the battery voltage (Xantrex C60). Use the appropriate Dump Load available from FuturEnergy.



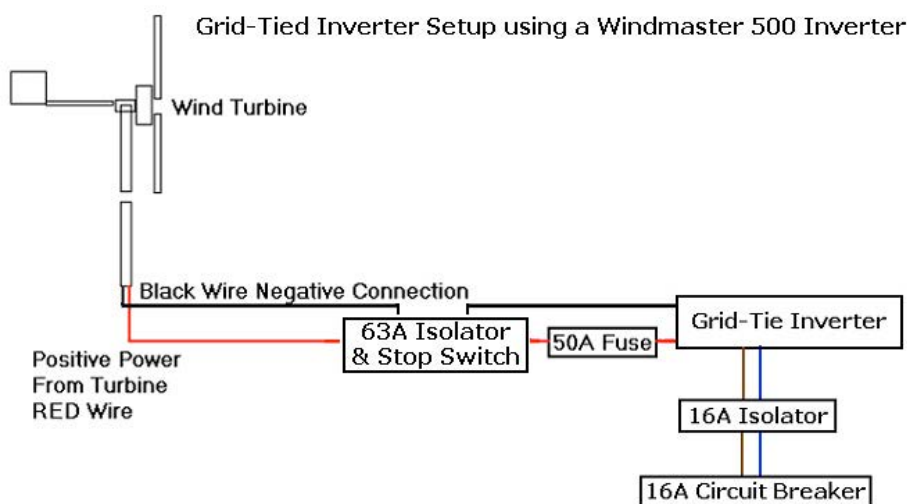
A revision of the standard 24V system just described is shown above. This uses four 12V batteries connected as two banks of 24V as shown. Each bank of 24V is connected in parallel with the other, to double the capacity of power storage. In all cases, use identical batteries for each bank, and do not mix types or capacity ratings, as damage and personal injury could occur. Again use the C60 charge controller for this application. For the 48V system below, use the Xantrex C40 charge controller.



## Grid Tied Inverters

One of the most common types of small domestic wind turbine installations is the Grid-Tied installation. This involves the use of a specialised inverter which has been designed to synchronise its 240VAC output with the Utility “mains” supply to your house/business. This inverter connects directly to your turbine, and converts its DC output to 240VAC. This type of system does not use batteries, and therefore will involve less maintenance by the user or installer.

FuturEnergy are constantly testing new inverters for use with their turbine range, and as they find suitable grid-tied inverters, these will be made available for installation. At present, the Windmaster 500 inverter can be used with the FE1048 turbine to form a grid-tied installation. The Windmaster 500 requires the use of additional switches and fuses as shown in the diagram below, which protects the inverter and allows the user to isolate the system during power cut situations, or in an emergency.



Please note the main components required to complete this setup. The 16A Isolator and the 16A breaker should be positioned together at your consumer unit. A separate 16A Isolator may be required at the inverter site itself, if it is mounted at any distance from the consumer unit. The DC Isolation switch should incorporate a DC Stop Switch, to allow the user to bring the turbine to a halt for maintenance, or in an emergency. The Windmaster 500 can export a maximum power of around 500W on to your mains supply, but with a single wind turbine and inverter installation you are unlikely to export much power back through your main meter on to the grid. We would therefore recommend that you use 2 Windmaster 500 inverters with tech FE1048 turbine, to obtain the best results from your system. In practice you will probably use most of your own power generated from your own turbine leaving very little to be sent out on to the mains supply. You should inform your utility company of the parallel connection you intend to make to the supply to your house, which may require you to give specific details of your installation. Take guidance from your utility company in this respect. The Windmaster 500 inverter is G83 approved for connection to the mains in the UK, which is key to your utility company agreeing to authorising your connection.

## Turbine Performance

Once you've decided how your free power is to be used, and you have connected your batteries or other load to your turbine, you are now ready to tilt your tower up and begin to enjoy the benefits of it.

With the assistance of at least 2 other people, walk or winch the tower up into its vertical position and attach and tighten the main guy wire (to anchor position 1). You will find it easier to have 2 people walking the tower up while the third person pulls on the main guy wire. Take extreme care not to slip or drop the tower, since it now weighs a lot more than it did when you first erected the basic tower. Don't try to erect your turbine in strong winds, this is simply too dangerous. If there is a slight wind blowing at this stage, you should notice the blades beginning to rotate and your batteries will begin to charge.

The power produced by your turbine will depend on the strength of the wind on your site. Below is a chart of the power produced by an FE1024 Generator, with 5 blades, mounted on a 6.2m tower.

Wind Speed (m/s)	Output Power W (24V load)
3.0	26
4.0	55
5.5	135
6.5	227
7.2	296
8.6	450
9.5	558
11.0	768
12.5	1002
14.0	1142

The FE1024 turbine shown above will start to charge a 24V battery bank in 3.0m/s wind speeds, and will start to rotate at only 2m/s wind speeds.

For wind speeds above 12.5m/s, the turbine will continue to produce powers in excess of the 1000W shown, but will start to furl out of the wind to reduce the stresses imposed by the wind on the turbine.

If you selected a different turbine other than the FE1024 for your turbine application, you will be supplied with performance data for it.

For example, the FE1048 turbine will result in a power chart as shown below. These factors should be considered before you order the right turbine for your intended application.

<b>Wind Speed (m/s)</b>	<b>Output Power W (48V load)</b>
3.8	42
4.5	74
5.6	140
6.5	220
8.0	414
9.0	584
10.0	788
11.0	932
12.5	1132
14.0	1472

The FE1048U turbine will start to charge a 48V battery bank in 3.8m/s wind speeds, and will start to rotate at only 2m/s wind speeds.

For wind speeds above 12.5m/s, the turbine will continue to produce powers in excess of the 1100W shown, but will furl out of the wind to protect the turbine when the wind exceeds 14m/s.

## Data Collection

For some people, the challenge of installing their own turbine will not be enough. And for this reason, this section explains how to collect data from your turbine, allowing you to plot graphs of it using your PC or MAC.

The simplest data to collect include the turbine output voltage, its output current and the rotational speed of the turbine blades themselves. Somewhat trickier is the ability to accurately measure the wind speed at the top of your tower. However, should you wish to collect this information then we shall cover this also.

Measuring the voltage produced by your turbine involves the use of a digital multi-meter, available from Maplin Electronics, or RS Components which can cover the DC voltage range which includes your battery bank voltage. Most multi-meters can do this and you should expect to have to pay less than £20 for a reasonable model. The multi-meter should be set to a range of 50V DC or something similar, and the measurement probes should be connected across your battery bank terminals. The meter should read the voltage present across your battery bank, and you will notice this voltage rising when the wind picks up.

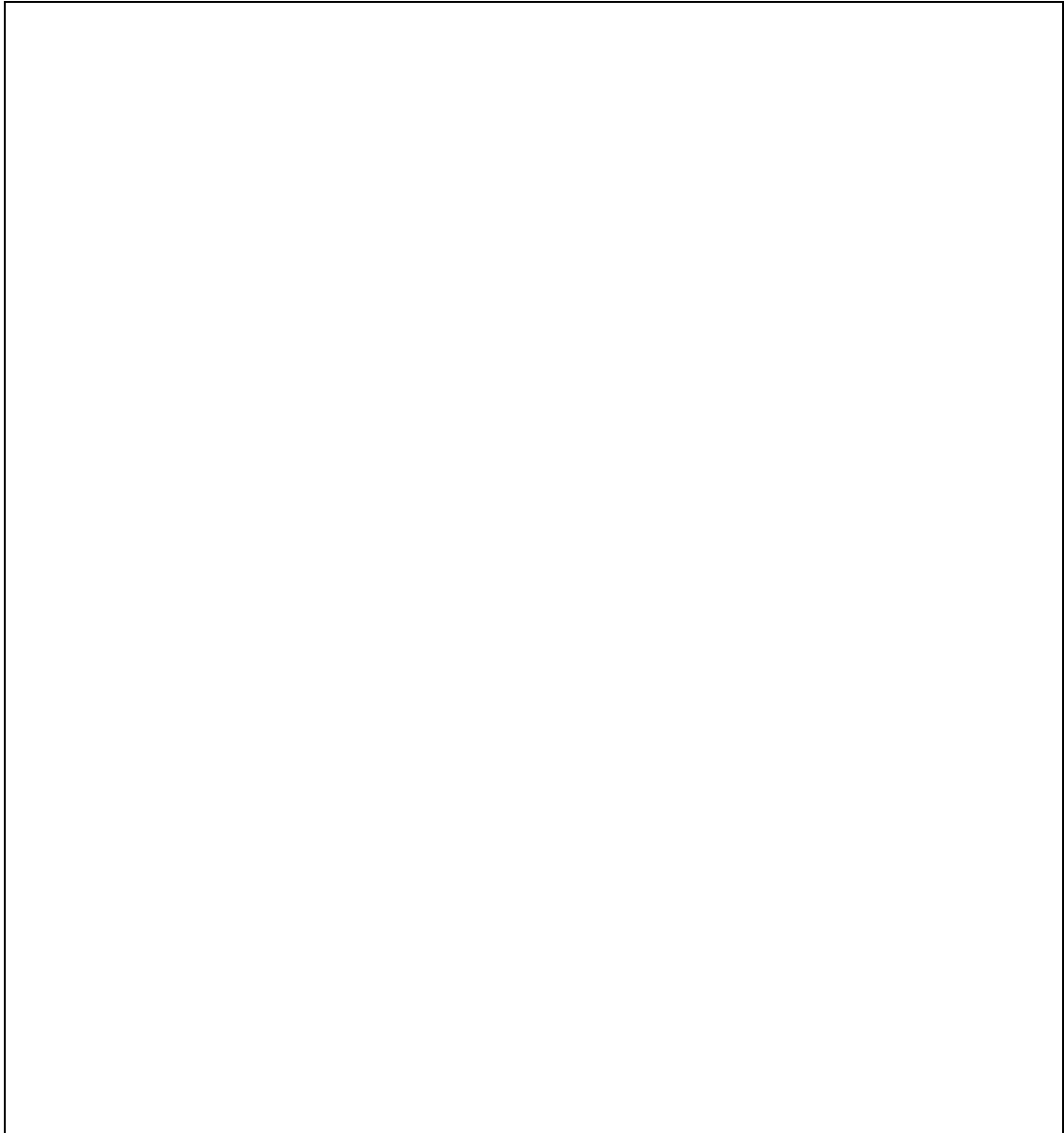
To measure the current flowing into your battery bank, you will require a good old fashioned ammeter. This ammeter should be of the 'moving coil' or 'moving iron' type, and should have a DC range of 0 to 30A. This meter is available from RS Components, or a limited version is available from Maplin Electronics. The meter should be connected in series with the positive supply coming from your turbine to your battery bank. When connected, it should give you a reading of DC current passing into your batteries, and it should rise with an increase in wind speed.

Wind speed is a bit more expensive to measure, since you'll need an anemometer. You'll find these on various websites and they range in price from £40 or so, to several hundred for the more serious ones. If you decide to purchase such an item, then this will fill in the only remaining gap in you data gathering. Mount the anemometer around 20cm below the bottom turbine blade tip to ensure that the turbine will not affect its output reading.

If you create a simple chart which covers the following data, then fill in the blanks from the readings form the various meters etc, you'll be able to calculate all sorts of useful information about your turbine.

Wind Speed(m/s)	Output Voltage	Output Current

## Testing Your Turbine



The diagram above shows how to connect all the test equipment mentioned in the 'Data Collection' section.

## The Completed Turbine

We hope you enjoy many years of satisfaction from knowing that you have done your bit for the future of our planet, not to mention the free power that you've enjoyed along the way.

